NILE BASIN INITIATIVE/NILE EQUATORIAL LAKES SUBSIDIARY ACTION PROGRAM

LAKES EDWARD AND ALBERT FISHERIES PILOT PROJECT

CONSULTANCY SERVICES FOR FISHERIES STUDIES AND LAKE MANAGEMENT PLAN PREPARATION FOR LAKES EDWARD AND ALBERT

MID-TERM DIAGNOSTIC REPORT

Submitted to

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ACRONYMS

ALB	Albert (Sampling Station Code denoting Lake Albert)
BOD	Biochemical (Biological) Oxygen Demand
C_aCO_3	Calcium Carbonate
Cl	Chlorine
COD	Chemical Oxygen Demand
DO	Dissolved Oxygen
DRC	Democratic Republic of Congo
DWD	Directorate of Water Development
E	East
GPS	Global Positioning System
HCO_3^-	Bicarbonate
ID	Identification (Code)
km	kilometer
LAT	Latitude
LONG	Longitude
m	meter
MFNP	Murchison Falls National Park
N	Nitrogen
N	North
NEMA	National Environment Management Authority
NH_4	Ammonia
NO_2	Nitrite
NO_3	Nitrate
P	Phosphorus
PNV	*Parc Nationale des Virunga*
PO_4	Phosphate
PO_4^{2-}	Phosphate
QENP	Queen Elizabeth National Park
REE	River Entry into Edward (Sampling Station Code)
RME	River Mouth Exit (Sampling Station Code)
SD	Secchi Depth
S_iO_2	Silicon Oxide
SO_4^{2+}	Sulphate
TDS	Total Dissolved Solids
TF_e	Total Ferrous
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
UCP	Uganda Congo Pelagic (Sampling Station Code)
UL	Uganda Littoral (Sampling Station Code)
UNDP	United Nations Development Programme
UNFAO	United National Food and Agriculture Organization
UTM	Universal Time Measurement

EXECUTIVE SUMMARY

Introduction

The Lakes Edward and Albert Fisheries (LEAF) Pilot Project is a project funded by through the Nile Basin Initiative (NBI). The project is intended to generate relevant technical information necessary for sound fisheries management. The LEAF Pilot Project objective is to avail the Governments of Uganda and the DRC with a sustainable investment and management plan for the joint use of the water and fisheries resources of Lakes Edward and Albert. The pilot project is expected to address poverty issues particularly amongst riparian communities along the lakeshores of Lakes Edward and Albert. The project is expected to suggest ways for harmonization of national policies and laws. It will provide options for regional cooperation in the management of the resources of the two lakes. The project will contribute to improvement of the living standards and working situation of the riparian fishing communities of the two countries. The pilot project, through sensitization will raise the awareness of beneficiaries and other stakeholders on sustainable use of natural resources. The project will also propose mitigation measures for the degraded environment. Further, it is hoped that the project activities will minimize prospects for regional and ethnic conflicts in the lake basins of the two lakes. The LEAF Pilot Project is expected to produce the reports on plans for an improved ecological balance and greater bio-diversity in the lakes system; an environmental and social management plan; plans for strengthening the capacities of the lake-wide fishing communities to co-manage shared resource and infrastructure; an integrated lakes management plan and investment projects; detailed statistics on poverty and fishery activities; and plans for harmonizing fishing policies and regulations.

The LEAF Pilot Fisheries Study is implemented by a consortium of three Firms namely, Development Consultants International Limited (DCI) of Kampala, Environment and Development Associates (EDA) of Kampala in association with Environmental Impact Assessment Network Group in the Great Lakes Countries (EIA-GLC) of Burundi. The project agreement was signed in on 19 September 2006 and the Contract was signed in October 2006. Preliminary activities before implementation of field activities began with mobilization of key personnel, mobilization of national Counterpart staff, conducting Field Reconnaissance Survey, establishment of Field Stations and Sampling Sites, procurement of scientific equipment and gill-nets, recruitment and hiring of field assistants**,** preparation of the inception report and attending Stakeholders Workshop and Technical Workshop. Field data collection was started in earnest from May 2007. The design was that sampling was to be done twice monthly in each lake in selected fixed stations for the water quality, fisheries and biodiversity studies. The social scientists on fisheries socio-economics, biostatistics and policy/laws and institutions as well as the engineering and hydrology components collected their data from various landing sites along the entire lake coastline and from district headquarters. Although field data collection started smoothly in May 2007, the program was seriously hampered in July and August when some of the Consultants were arrested and detained on different occasions by both DRC Government forces as well as militia operating in Vitshumbi and Kyavinyonge respectively. Despite these threats, the consultants managed to undertake field data collection albeit with caution in restricted areas particularly in the DRC.

This is the first Mid-Term Diagnostic Report. It provides highlights of essential initial activities done since the launch of the study. More importantly, the Mid-Term Diagnostic Report focuses on reporting key findings on the **current state** of the two lakes and their basins. It essentially diagnoses threats to the lake ecosystems; identifies constraints to better management of the lakes natural resources particularly fish and examines opportunities which may be available for the sustainable utilization of the two lake basins and their natural resources. Hence, this report is not intended to be the Fisheries Management Plan, nor the Environmental and Social Management Plan, nor the Integrated Lakes Management Plan which are a requirement in the TOR. At this stage, this is a report of the key findings on the **current state** of the two lakes and their basins. It is this basic background information, presented in this report, which will form the basis for formulating an Integrated Lakes Management Plan including plans for improved ecological balance and greater bio-diversity in the lakes system; Environmental and Social Management Plan; Plans for strengthening the capacities of the lake-wide fishing communities to co-manage shared resource and infrastructure; Investment Projects; detailed statistics on poverty and fishery activities; and Plans for harmonizing fishing policies and regulations.

The pilot study had 8 main study themes namely Fisheries Biology and Biodiversity Research; Catchments Environment And Water Quality Studies; Hydrology and Water Resources Studies; Civil Engineering and Infrastructure Studies; Biostatistics Studies; Fisheries Socio-Economics and Policy, Laws and Institutions. The TOR require that the Integrated Lakes Management Plan together with the Environmental and Social Management Plan for the two lakes be formulated on the basis of scientific information and knowledge derived from the thematic studies conducted by the consultants on fish and fisheries, biodiversity, pollution, social setting, policy, legal and ***institutional frameworks.***

Key Findings of the Pilot Study

Chapter 4 of this report provides key findings as baseline information on the ecosystem functions in the two lakes, their fisheries and biodiversity, in-lake pollution status, catchment degradation processes, hydrological processes, fisheries, socio-economics of the fisheries, fisheries biostatistics, fish landing infrastructure, hygiene and fish quality problems and the status of policies, laws and institutions in the basins of the two lakes. Details of key findings are provided below for each theme. Emphasis is laid at the end of each Sub-Chapter on how the information derived can be used to form the basis of remedial actions to be proposed in the Integrated Lakes Management Plan an the Environmental and Social Management Plan.

Fisheries Biology

Fisheries Biology is described in *Sub-Chapter 4.1.* Aspects of the biology of the fish species, their population characteristics, biodiversity, distribution, gill-net catch rates, mean fish weights, length weight relations, size at first maturity and feeding regimes are described for the main fish species.

The fish species caught in experimental gill-nets in Lake Albertat Butiaba and Tchomia included *Lates macrophtalmus, Hydrocynus forskahli, Barbus bynn, Oreochromis niloticus, Auchenoglanis occidentalis, Brycinus nurse, Bagrus bayad, Alestes baremose, Malapterurus electricus, Synodontis schall and Schilbe intrermedius.* Fish species also seen in the commercial catches included *Barbus prince, Leptocypris niloticus, Neobola bredoi, Polypterus senegalus, Sarotherodon gallilaeus, Tilapia zilli, Haplochromis avium, Haplochromis wingatii and Haplochromis* spp. So far, only 19 species of fish have been identified from Lake Albert. There are said to two species of *Lates* in Lake Albert (*Lates niloticus, and Lates macrophtalmus*). An easy identification character that could allow separating them in field conditions is yet to be found. Nile perch is therefore the main commercial species caught in the two locations of Lake Albert. At Butiaba, the catch composition is more diverse, with four other species including *Hydrocynus forskahlii*, *Alestes nurse*, *Barbus bynni* and *Bagrus bayad*. At Tchomia in the DRC, other species after *L. macrophtamus* are *Barbus bynni*, *Oreochromis niloticus* and *Auchenoglanis occidentalis*.

So far, *Lates macrophtalmus, Hydrocynus forskshalli* and *Brycinus nurse,* seem to mature at first maturity at the following sizes.

- 24 cm and 30 cm respectively for males and females of *Lates macrophtalmus,*
- 30 cm and 32 cm respectively for males and females of *Hydrocynus forskahlli;* and
- 7 cm in both sexes in for *Brycinus nurse.*

Ephemeroptera in the lake is the main food for *Lates macrophtalmus*. Other important foods for Lates are the Crustacea *Caridina*, Haplochromines species and other small fish, including fry. *Brycinus nurse*, which feeds mainly on *Povilla*.

The commercial fisheries in Lake Albert use mostly gillnets with mesh size of 4.5 inches on the Ugandan side and longlines to catch the most targeted species. The length frequency distribution and the sizes at first maturity for the various fish species will point the sizes of fish which should be allowed to be caught in order to allow the fish to breed before capture. This is going to be an important tool for controlling fishing effort in Lake Albert. When all the information is fully analyzed, it will be possible to propose minimum mesh sizes for gill nets and hooks to be used in commercial fisheries and recommendations proposed for the sustainable management of the fish stocks in the lakes Edward and Albert. The Fisheries Management Plan which is going to be formulated will therefore make full use of this information to determine the size of fishing effort in terms of number of boats , number of gill-nets and hooks, species to be caught, the minimum size of fish to be permitted to be caught, permissible fishing grounds and aspects of permissible fishing seasons.

Biodiversity

Sub-Chapter 4.2 describes biodiversity with particular reference to aquatic biodiversity and provides informative perspectives on wildlife and the flora of the lake basins. The report presents the main components of the phytoplankton, zooplankton and benthos of Lakes Edward Albert as well as differences of the plankton and benthic communities in the two lakes.

The phytoplankton is dominated by a few common species such as *Microcystis*, *Planktolyngbya*, *Anabaena*, and *Cylindrospermum* which are Blue Greens. Localized sites e.g. at Katwe in Lake Edward appear to be eutrophied with large numbers of algae. *Microcystis* is the most abundant algal species, with more than 5 million individuals per ml followed b*y Planktolyngbya*, *Merismopedia, Cylindrospermum* and *Anabaen* the Katwe sampling station.

The Zooplankton is widely found in the two lakes and in all the sites sampled. Cyclops and Nauplii are the commonest Copepods. *Diaphanosoma* and *Moinaare* are the most abundant Cladocerans. *Keratella* and *Brachionus* are the commonest rotifers. The zooplankton genera in Lake Edward were composed of two Copepods namely, Cyclops and Nauplii. The mollusks are very abundant as components of the benthic fauna. They included gastropods such as *Bullinus*, *Biomphalaria, Mellanoids* and *Bellamy*a. There were also several insects and worms as part of the benthos.

The bottom of the shallow inshore waters of Lake Albert is literally clogged with submerged aquatic weeds which were identified as *Najas pectinata (*Najadacea) and *Vallisneria spiralis* (Hydrocharitacea)

There are several dominant littoral aquatic plants fringing the shoreline of Lake Albert. These were identified as water hyacinth, sedges, Typha,. The larger macrophytes were seen behind the grasses and included the Ambatch, palms and several bushy thickets.

The lake basin areas of lakes Edward and Albert, lie within the moist *Acacia-Combrettum* savannah. This vegetation is characterised by deciduous broad-leaved trees of the Combretaceae family and a grass layer of *Hyparrhenia rufa.* Tree cover is light with abundant *Combretum molle*, *Terminalia glaucescens* and *Albizia* sp. The area contains more than 150 species of plants. In the past there were many species of mammals like the hippopotamus, elephant, buffalo and Uganda kob. The area has in the recent years been subjected to intense grazing with cattle which has reduced grass cover extensively and displaced many wild life species.

Algae play an important role in the aquatic ecosystems the primary producers. They fix carbon dioxide using sunlight to produce carbohydrates in form of sugars. They depend on having sufficient sunlight penetrating the water body for fixing carbon dioxide. They also require nutrients in form of nitrogen, phosphorus and other micronutrients. Components like Diatoms also require silica to form cell walls. The blue green algae have cell walls made of lignin. Lignin is not broken down by digestive chemicals in the stomachs of fish. Hence, blue green algae have for long been known not to be good food for fish. The Diatoms on the other hand have silica made cell walls which allow digestive chemicals to penetrate in order to digest the cell contents which form the food of fish. It is noted that all the other trophic groups in the lake ecosystem depend on the algae for survival. The food chain in the lake ecosystem would then have a pyramid shape with the algae forming the bottom of the pyramid the herbivorous fish forming the center and the predators like the Nile perch forming the apex of the pyramid. In Lakes Edward and Albert, the majority of the important commercial fish species feed on algae. The tilapia/ *Oreochromis* group, the Haplochromis species flock feed entirely on algae. Other fish species like the Nile perch, *Hydrocynus, Bagrus, Protopterus, Clarias* the mormyrids, the electric *Malapterurus* and others which are omnivorous or predators all start life when juveniles by feeding on zooplankton and benthic invertebrates all of which depend on algae for food. Algae are also extremely important in aquatic ecosystem because they remove carbon dioxide from the water and produce oxygen which is essential for all life forms in the lakes. In the Lakes Edward and Albert scenario, sunlight is not a limiting factor for algal growth as the area in a tropical environment. However, algae can be affected through pollution. Chemical pollution can impair the productivity of algae. As noted in the results of the analysis of the Water Quality component of this study, there are not many factories in the Lakes Edward Albert basins emitting chemicals into the water bodies. However, there is a lot of unsustainable agricultural practices which have impacted on algal health in the catchment of the two lakes. There has been widespread deforestation in the basins including poor cultivation methods and use of fertilizers and other agro-chemicals. These activities release nutrients into the rivers which end up in the two lakes. The results of the Water Quality analysis component of this study have also shown that certain areas of the two lakes have very high BOD readings. It has been found that *Microcystis* is by far the most dominant algal species in both lakes. This species can therefore be taken as the indicator species of algal over production or algal blooms in these two lakes. Examples are around Katwe Landing Site in Lake Edward with counts of over 5 million *Microcystis* per ml alone. This gives a clear indication of heavy algal bloom which could lead to eutrophication, light shading and production of toxic gases and anoxic conditions.

From the above observations, it is clear that there are pollution hot spots around fish landings like Katwe in Lake Edward. The landing site has a lot to contribute to this. There is poor management of organic wastes with few latrines leading to release of faeces and other organic wastes into the lake. It was also noted that this area around Katwe had many cattle and hippos. The area had been laid bare by overgrazing by mainly cattle. The effect of this is over fertilization of the immediate waters by cattle and hippo droppings leading to heavy algal growth and a lowered BOD. The other important factor is the influence of Lake George cacthment and the Mweya Lodge Hotel. As noted in the results of the analysis of the Water Quality component of this study, the BOD measurements around the entry of the Kazinga Channel into Lake Edward are extremely. This is the result of drainage of agrochemicals from the agricultural lands around the Lake George catchment as well as the contribution of Mweya Safari Lodge whose domestic effluents enter the lake without treatment.

Catchment Environment and water Quality

Sub-Chapter 4.3 provides measurements of lake water quality and characteristics in both lakes and at selected stations in order to see prospects for pollution threats and pollution hot spots. A total of 1,161 profile measurements were taken from Lake Albert and 268 profiles from Lake Edward for Dissolved Oxygen (DO) Temperature (T), Electrical Conductivity (EC), pH, Total and Faecal Coliforms, Secchi Depth, Chlorophyll ‘a’, TSS, Phenolphthalein Alkalinity (PA), Phosphate (PO_4^{2-}), Nitrogen (TN), Nitrites and Nitrates,
Sulphates (SO_4^{2+}),

The diagnostic results obtained so far from historical records, from observations and from direct profile measurements of the above key parameters from all the selected sampling stations tend to show that the waters of Lakes Edward and Albert are generally unpolluted apart from localized pollution, for instance, at river mouths, the area around Mweya Safari Lodge and near Fishing Villages such as Katwe, Kyavinyonge, Vitschumbi and Mahagi Port.

The DO in most parts of the two lakes is above 4 mg/L level, and they can therefore support the lives of fish and other organisms. The mean value in Lake Edward is 7.4 mg/L with the exception of the area where the Kazinga Channel enters the lake near Mweya Hotel. The mean value in Lake Albert is 8.2 mg/L except for the deeper waters of the lake (over 40 m) where waters indicated de-oxygenation with readings of between 0.15 and 0.51 mg/L. The high oxygen levels appear to reflect high biodiversity in the two lakes as it is prerequisite for aerobic respiration. In addition, the high Temperatur**es** recorded averaging over 26^oC enhances biological activities especially enzymatic and biochemical reactions that are temperature dependent. Besides influencing the solubility of gases in the water, high temperatures also increase the rate of chemical reactions and evaporation.

Chlorophyll ‘a’ measures algal biomass. The values recorded in most parts of Lake Edward ranged from 6.3 to 10 mg/L. This, therefore, does not signify excessive eutrophication, and hence no accelerated nutrient loading from human activities in the Lake Edward catchment. However, very high level of Chlorophyll ‘a’ was recorded at the confluence of Kazinga Channel with Lake Edward at Mweya Lodge Pier of 150.6 mg/L. **Sechi Depth** was also shallowest (21 cm) at this same location. This reflects an accelerated nutrient loading from expanding human activities in the catchments of Lake George that is drained by the Kazinga Channel in addition to indicating serious sewage discharge into the areas from the Lodge. The Total and Faecal Coliform counts at this location were 4000 and 2000 per 100 mls respectively. The nearest counts of 157 and 8 per 100 mls were at the Inshore Station near Katwe Fish Landing. In the case of Lake Albert, Chlorophyll ‘a’ readings ranged from 9.9 to 18.2 mg/L Shallow areas at the entrance of River Semliki into Lake Albert and entrance of Victoria Nile near Wanseko Fish Landing also contain heavy algal concentrations, but these could be due to the swampy environment at these locations in addition to nutrients arriving from the catchments of the two rivers.

Hydrology and Water Resources

Sub-Chapter4.4 describes hydrological data so far collected for this study. This data is listed by type, location and length of record of the data. Detailed data for rainfall and evaporation have been summarized. The data have been tabulated and Flow Duration Curves simulated for discharges of the Mobuku, Waki, Muzizi, Nkusi, Chambura and Wambabya rivers. Attempts have been made to derive rainfall runoff relationship with the NAM model and the Double Mass Curve (DMC).Hence NAM calibration and correlation has been done for the Waki, Mobuku, Muzizi, Mitano, Nkuzi and the Chambura rivers. Significant progress has also been registered in the setting up of the MIKEBASIN Model for purposes of water balance simulation.

Civil Engineering and Infrastructure

Sub-Chapter 4.5 provides information on engineering and fish landing infrastructure. Fish landings visited are given and the nature and state of fish landing facilities are descried for example, floating barges, fish production, marketing and transportation systems, fish handling, processing and preserving facilities, state of access and feeder roads, sanitation, hygienic and social infrastructures, safe and clean water supply, electricity supply, solid waste management, sewage disposal. Stakeholder views on priority issues and facilities for renovation, repair or reconstruction are given. The key findings reported on the state of infrastructure and facilities in the fish landings include information on the population of fish landings. It is reported that the landing site infrastructures are lacking and the few available are in a poor state and need to be rehabilitated. Examples are slabs, shelters, public toilets and latrines. There is a need to build new landing infrastructures in order to meet hygienic and sanitation standards. The fish processing methods used were mostly smoking, salting, sun-drying and some icing. There is need to modernize equipments such smoking kilns and surfaces for drying fish. Access and feeder roads were in very poor condition for all landing sites. Some landing sites like Rwenshama, Kisenyi and Kasenyi do not have feeder roads and housing units. Post harvest losses were very high in all the fish landings and this was due to both the poor condition of landing infrastructure and the poor processing methods used. There is no clean and safe water supply at fish landings except at Katwe and Rwenshama. There is need for extending safe and clean water supply to the landing sites. Health centers and primary schools exist in some fish landings but in others like Wasenko, had no health facilities. There is need to upgrade social infrastructure at most fish landings. There in no electricity supply in all the fish landings except at Katwe. Hence, there is lack of cooling facilities which is affecting fish quality. There are no waste management and sewage disposal facilities at all fish landing sites visited. Stkeholder views on priority issues and possible remedies are indicated as clean water supply, improvement of sanitation system, public toilets and feeder roads improvement.

Fisheries socio-economics

Sub-Chapter 4.6 gives information on fisheries socio-economics. It describes the socio-economic status of the fisheries of Lakes Edward and Albert as seen during the various field visits.

Information provided in this Sub-Chapter includes characterization of fishing communities leadership and organization; demographic characteristics of fishers, processors, traders and other operators in the fisheries; health status of fishing communities; fish production, processing and marketing activities, post-harvest losses and the role of indigenous knowledge; gender and women participation in fisheries; livelihoods, poverty, asset ownership and alternative income sources; economic contribution of fisheries; adoption and impact of fisheries management measures; investments and credit in fisheries and trans-boundary issues.

Fisheries Biostatistics

Sub-Chapter 4.7 presents information and data on Fisheries Biostatistics. The data collected has been processed and includes data from Lake George. The data for Lake Edward/George show a low negative statistically significant trend. In the DRC official statistics on fishery production are available for only 17 years over the period 1950 to the present. The paucity of the data does not allow any meaningful statistical tests for trend. A Frame Survey of the two lakes in the DRC has been carried out and information is provided on existing landing sites, their location and characteristics; taking records of the number of fishing units and their characteristics; and periodicity of fishing activities. The findings of the Frame Surveys show that a total of 19 sites were identified on Lake Edward while 70 were identified in Lake Albert.

Policy, Laws and Institutions

Sub-Chapter 4.8 reviews the policy, institutional and legal frameworks of fisheries in Lakes Edward and Albert. It presents the findings to date of the main policy, legal and institutional issues that impact on fisheries development and management of the two lakes. It is planned to commence similar activities on the DRC side as soon as the security situation normalizes. This Sub-Chapter reports that both the DRC and Uganda have fisheries policies in place as well as basic legislation for fisheries management. The legislations regulates fisheries management including registration of vessels, licensing of activities, fishing gears, prohibited methods of fishing, fish quality standards and their enforcement and prescribes powers of the different officers in fisheries administration. However, most of the legislation is outdated and does not address transboundary aspects of fisheries management arising from shared water resources. The fisheries laws do not operate in isolation and there are points of overlap, convergence and conflict with other national laws related to natural resource management. Both countries are party to a number of regional and international conventions/protocols that promote sustainable natural resource management such as the UNICEF Conventions, the Ramsar Convention and the FAO Code of Conduct for Responsible Fisheries.

The compliance levels with the laws for the regulation of fisheries in Uganda are low and they are even power in the DRC. The Sub-Chapter provides a detailed overview of the policy, legal and institutional framework which will be adopted as a strategy for the development of an integrated lakes management plan and a fisheries management plan for the two lakes. These are analyzed as main issues of interest in the Sub-Chapter.

Planned future activities

Sub-Chapter 4.9 provides information on what future activities are planned. At the stage, it is expected that the pilot study has established factual information on the state of the Lake Edward and Lake Albert ecosystem providing vital baseline data and information on the ecosystem functions in the two lakes; their fisheries and biodiversity; fish quality; hydrology; socio-economics; catchments pollution and status of policies, laws and institutions in the basins.

The next stage of the study will now be mainly formulating an Integrated Lakes Management Plan for the sustainable exploitation of the natural resources. The TOR require that the Management Plan must be formulated on the basis of scientific information and knowledge derived from the thematic studies conducted by the consultants on fish and fisheries, biodiversity, pollution, social setting, policy, legal and institutional frameworks. Hence, the findings in the Mid-Term Diagnostic Report will help estimate and gauge environmental degradation, levels of water pollution, destruction of biodiversity, decimation of fish stocks, destruction of fish habitats, levels of fish catches and the socio-economic setting and its drawbacks to sustainable and equitable livelihoods. It is these studies that will also provide information for the formulation of the plans for Ecosystem Management Strategies which will be formulated at the end of the study. However, there will be need for the study to re-visit certain areas to confirm and verify certain information either in the field or at district headquarters or national capitals. This would be particularly so in view of the fact that quite a large portion of project work could not be accomplished due to insecurity in some areas. The study team would also need to visit selected stakeholders to discuss key findings and the proposed recommendations in order to ascertain accuracy of information gathered. This would also help in ensuring ownership of the findings and the whole report when presented. In accordance with this, there is need, therefore, for individual consultants to undertake follow on studies to verify their findings and complete collection of data and information where necessary. These have been presented for each of the study themes.

Constraints and issues of concern

Sub-Chapter 4.9 gives issues which have been noted by the consultant as constraining the study and for which action will need to be taken to address the disabling situation. There have been incidences of insecurity on both lakes Edward and Albert to which the staff of the consultants have been exposed to. In several cases, the consults have been arrested by rebel forces or Government forces in the DRC. The situation has some times been so bad that the Client has advised the consults not to proceed to certain areas. The Lake Edward area has been particularly unsafe. The result is that the study has been limited to certain safe places and locations for example to the northern part of Lake Edward.

The DRC Counterparts have to cover long distances to travel to the study sites. The absence of road networks in the DRC particularly in areas bordering the lakes has made field investigations very difficult. The study needed a long sampling period of at least 6 months or more to generate reliable data but the time for field data collection and the resources allocated for field work were far too inadequate.

The process of VISA procurement for travel to the DRC for the Consultants proved long and time consuming. The low budget for data collection, resulting in limited coverage; lack of analytical laboratory and field equipment; and difficulties of movement and communication in the field have all made data collection very cumbersome.

1.0 INTRODUCTION

1.1 OVER VIEW OF THE MID-TERM DIAGNOSTIC REPORT

The main objective of the Lakes Edward and Albert (LEAF) Pilot Project is to provide to the Governments of Uganda and the DRC sustainable management and investment plans for the joint use of the waters and fisheries resources of the two lakes. The TOR require that these plans be formulated on the basis of scientific information and knowledge derived from the thematic studies conducted by the consultants on fish and fisheries, biodiversity, pollution, social setting, policy, legal and institutional frameworks. In carrying out the study, the consultants will also elucidate and provide vital baseline information on the ecosystem functions in the two lakes, their fisheries and biodiversity, fish quality problems, hydrology, socio-economics of the fisheries, catchments pollution and status of policies, laws and institutions in the basins of the two lakes.

As expected, it is these findings and observations which will form the basis for the preparation of the Fisheries Management Plan, estimating and gauging environmental degradation, levels of water pollution, destruction of biodiversity, decimation of fish stocks, destruction of fish habitats, levels of fish catches and the socio-economic setting and its drawbacks to sustainable, equitable and amenable livelihoods. It is these studies that will also provide information for the formulation of the plans for Ecosystem Management Strategies which will be formulated at the end of the study.

Progress of the study has been reported in the various monthly reports to-date. This first Mid-Term Diagnostic Report, therefore, now provides highlights of essential initial activities done since the launch of the study. Further, this Mid-Term Diagnostic Report focuses on reporting key observations and findings made in the study of the two lakes and their basins. Hence, this report is not intended to be the Fisheries Management Plan, nor the Environmental and Social Management Plan, nor the Integrated Lakes Management Plan. It is a report of the key findings on the state of the two lakes and their basins. Hence, it is this information which will form the basis for formulating an Integrated Lakes Management Plan including plans for improved ecological balance and greater bio-diversity in the lakes system; Environmental and Social Management Plan; Plans for strengthening the capacities of the lake-wide fishing communities to co-manage shared resource and infrastructure; Investment Projects; detailed statistics on poverty and fishery activities; and Plans for harmonizing fishing policies and regulations.

1.2 STRUCTURE OF THE MID-TERM REPORT

The Mid-Term Diagnostic Report is structured as follows.

Chapter 1 is the introductory chapter which provides briefs on the LEAF Project it self, project objectives and out puts; describes the project study area and the current status of the fisheries of the two lakes.

Chapter 2 describes the pilot study elucidating initial project activities embarked on after signing of the contract. It describes the location of the selected field stations and sampling sites. Further, the process of preparing the Inception Report is described as well as workshops which were called by the Client.

Chapter 3 describes the main data collection activities for the 8 thematic study areas of Fisheries Biology and Biodiversity; Water Quality and Catchment Environment; Hydrology and Water Resources; Civil Engineering and Infrastructure; Fisheries Socio-Economics; Fisheries Biostatistics and Policy, Laws and Institutions.

Chapter 4 is devoted to the description of key findings of the 8 thematic study areas (Fisheries Biology and Biodiversity; Water Quality and Catchment Environment; Hydrology and Water Resources; Civil Engineering and Infrastructure; Fisheries Socio-Economics; Fisheries Biostatistics and Policy, Laws and Institutions).

Sub-Chapter 4.1 is on Fisheries Biology describing fish biodiversity, fish population characteristics, fish species distribution and prevalence, gill-net catch rates, mean fish weights, length weight relations, size at first maturity and feeding regimes.

Sub-Chapter 4.2 describes biodiversity with particular reference to aquatic biodiversity and provides informative perspectives on wildlife and the flora of the lake basins.

Sub-Chapter 4.3 provides measurements of lake water quality and characteristics in both lakes and at selected stations in order to see prospects for pollution threats and pollution hot spots.

Sub-Chapter4.4: This Sub-Chapter describes hydrological data so far collected for this study. This data is listed by type, location and length of record of the data. Detailed data for rainfall and evaporation have been summarized. The data have been tabulated and Flow Duration Curves simulated for discharges of the Mobuku, Waki, Muzizi , Nkusi and Chambura rivers. Attempts have been made to derive rainfall runoff relationship with the NAM model and the Double Mass Curve (DMC).Hence NAM calibration and correlation has been done for the Waki, Mobuku, Muzizi, Mitano, Nkuzi and the Chambura rivers. Significant progress has also been registered in the setting up of the MIKEBASIN Model for purposes of water balance simulation.

Sub-Chapter 4.5: This Sub-Chapter provides information on engineering and fish landing infrastructure. Fish landings visited are given and the nature and state of fish landing facilities are descried for example, floating barges, fish production, marketing and transportation systems, fish handling, processing and preserving facilities, state of access and feeder roads, sanitation, hygienic and social infrastructures, safe and clean water supply, electricity supply, solid waste management, sewage disposal. Stakeholder views on priority issues and facilities for renovation, repair or reconstruction are given.

Sub-Chapter 4.6: This Sub-Chapter is on fisheries socio-economics. It describes the socio-economic status of the fisheries of Lakes Edward and Albert as seen during the various field visits. Information provided in this Sub-Chapter includes characterization of fishing communities leadership and organization; demographic characteristics of fishers, processors, traders and other operators in the fisheries; health status of fishing communities; fish production, processing and marketing activities, post-harvest losses and the role of indigenous knowledge; gender and women participation in fisheries; livelihoods, poverty, asset ownership and alternative income sources; economic contribution of fisheries; adoption and impact of fisheries management measures; investments and credit in fisheries and trans-boundary issues.

Sub-Chapter 4.7 presents information and data on Fisheries Biostatistics. The data collected has been processed and includes data from Lake George. The data for Lake Edward/George show a low negative statistically significant trend. In the DRC official statistics on fishery production are available for only 17 years over the period 1950 to the present. The paucity of the data does not allow any meaningful statistical tests for trend. A Frame Survey of the two lakes in the DRC has been carried out and information is provided on existing landing sites, their location and characteristics; taking records of the number of fishing units and their characteristics; and periodicity of fishing activities. The findings of the Frame Surveys show that a total of 19 sites were identified on Lake Edward while 70 were identified in Lake Albert.

Sub-Chapter 4.8 reviews the policy, institutional and legal frameworks of fisheries in Lakes Edward and Albert. It presents the findings to date of the main policy, legal and institutional issues that impact on fisheries development and management of the two lakes. It is planned to commence similar activities on the DRC side as soon as the security situation normalizes. This Sub-Chapter reports that both the DRC and Uganda have fisheries policies in place as well as basic legislation for fisheries management. The legislations regulates fisheries management including registration of vessels, licensing of activities, fishing gears, prohibited methods of fishing, fish quality standards and their enforcement and prescribes powers of the different officers in fisheries administration. However, most of the legislation is outdated and does not address transboundary aspects of fisheries management arising from shared water resources. The fisheries laws do not operate in isolation and there are points of overlap, convergence and conflict with other national laws related to natural resource management. Both countries are party to a number of regional and international conventions/protocols that promote sustainable natural resource management such as the UNICEF Conventions, the Ramsar Convention and the FAO Code of Conduct for Responsible Fisheries.

The compliance levels with the laws for the regulation of fisheries in Uganda are low and they are even power in the DRC. The Sub-Chapter provides a detailed overview of the policy, legal and institutional framework which will be adopted as a strategy for the development of an integrated lakes management plan and a fisheries management plan for the two lakes. These are analyzed as main issues of interest in the Sub-Chapter. *Sub-Chapter 4.9* presents plans for further work for the completion of the study. *Sub-Chapter 4.10* presents issues of concern and constraints experienced during implementation of the assignment.

1.3 THE LEAF PROJECT

The Nile Basin Initiative (NBI) has developed a Strategic Action Programme for regional development in the Nile Equatorial Lakes basin. One of the projects is the Nile Equatorial Lakes Subsidiary Action Program (NELSAP) under which the Lakes Edward and Albert Fisheries (LEAF) Pilot Project is embedded. The LEAF pilot project is designed to generate the relevant technical information necessary for sound fisheries management.

1.4 THE PROJECT OBJECTIVES

The sector objective of the Nile Basin Initiative is to contribute to poverty reduction and sustainable socio-economic development through equitable utilization of and benefits from the common Nile Basin water resources. The LEAF Pilot Project objective is to avail the Governments of Uganda and the DRC with a sustainable investment and management plan for the joint use of the water and fisheries resources of Lakes Edward and Albert. The pilot project is expected to address poverty issues particularly amongst riparian communities along the lakeshores of Lakes Edward and Albert. The project is expected to suggest ways for harmonization of national policies and laws. It will provide options for regional cooperation in the management of the resources of the two lakes. The project will contribute to improvement of the living standards and working situation of the disadvantaged riparian fishing communities of the two countries. The pilot project, through sensitization will raise the awareness of beneficiaries and other stakeholders on sustainable use of natural resources. The project will also propose mitigation measures for the degraded environment. Further, it is hoped that the project activities will minimize prospects for regional and ethnic conflicts in the lake basins of the two lakes.

1.5 EXPECTED PROJECT OUTPUTS

The LEAF Pilot Project is expected to produce the following outputs:

- Plans for an improved ecological balance and greater bio-diversity in the lakes system;
- Detailed Environmental and Social Management Plan;
- Plans for strengthening the capacities of the lake-wide fishing communities to co-manage shared resource and infrastructure;
- Integrated lakes Management plan and investment projects;
- Detailed statistics on poverty and fishery activities; and
- Plans for harmonizing fishing policies and regulations.

1.6 THE PROJECT AREA

The LEAF project area is shown in **Fig.1.1** which covers Lakes Edward and Albert. These two lakes are rift valley lakes shared by the Democratic Republic of Congo and the Republic of Uganda. Lake Edward is situated at an altitude of 916 m whose western border are the Mitumba - Kyavirimu mountain range (3,117m). The lake is 90 km long and 40km wide. Its average depth is estimated at 34m (near Ugandan shoreline), with a maximum of 117 m towards the Congolese side. Lake Edward basin is about 12,000 square kilometers. The Semliki River is the only outlet with its Rwindi- Rutshuru tributaries. The lake is enclosed by two national parks, the Queen Elizabeth National Park (QENP) in Uganda and the Virunga National Park (PNVI) in the Democratic Republic of the Congo (DRC).

Lake Albert on the other hand is situated at an altitude of 618 m. It is 160 km long and 35 km wide. It is relatively shallow with an average depth of 25 m and a maximum of 58m towards the Congolese border. The lake receives water from Lake Edward through the Semliki River in the south and from the Nile River in the north. The Lake is rich in plankton and primary production is high. The presence of large concentrations of the blue-green algae is thought to cause anoxic conditions in some places resulting in considerable mortality of the Nile Perch.

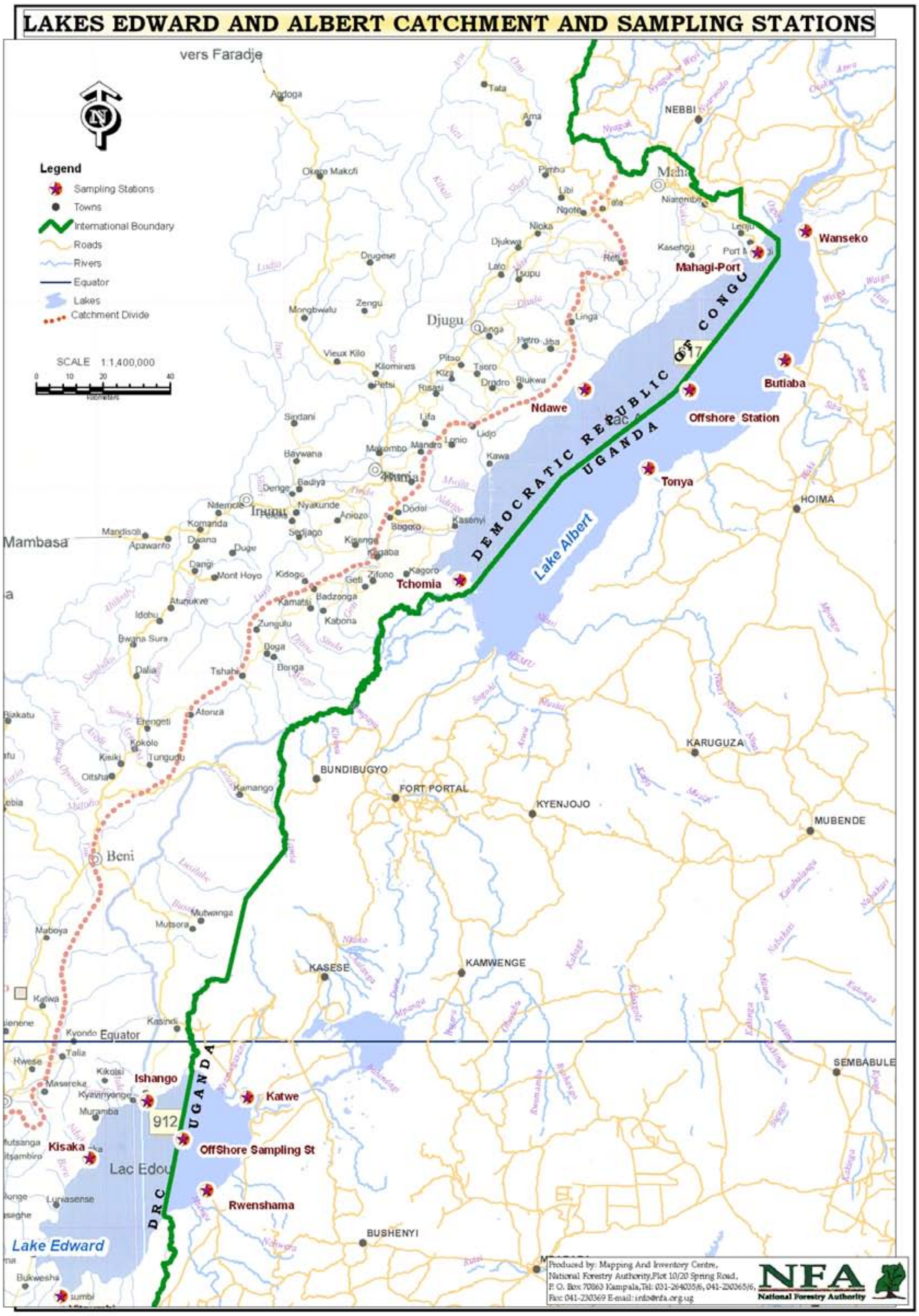


Fig. 1.1: Map of the study area in Lakes Edward and Albert with Sampling Stations

1.7 DEMOGRAPHIC CHARACTERISTICS IN THE LAKE EDWARD AND LAKE ALBERT BASINS

Table 1.1 shows the human population characteristics in lakes Edward and Albert basins. The people on both sides of the two lakes are of the same ethnic stock. The social indicators of the communities in the basin, such as access to health care and safe drinking water, education, nutrition level and sanitation are lower than national indicators. Water supply and sanitation, health and diseases, transportation and communication and the presence of refugees are huge problems; hence poverty has remained rampant amongst the small holder farming and fishing communities.

Table 1.1: Location, Population and Land area of the LEAF Pilot Project.

Riparian country	**Lake Edward**		
	District/Province	**Population**	**Area (km^2)**
DRC	North Kivu	3,564,434	59,483
Uganda		1,275,662	37,966
Uganda Districts	Bushenyi Kanungu Kasese, Rukungiri	376,361 160,708 343,601 394,992	4,026 1,281 31,205 1,454
Lake Edward Total		**4,840,096**	**97,449**
Lake Albert			
DRC	Orientale	5,566,000	503,239
Uganda		1,309,119	
Uganda Districts	Bundibugyo Hoima Kibaale Masindi Nebbi	116,566 197,851 417,218 260,796 316,688	2,338 5,492 1,827 9,236 2,891
Lake Albert Total		**6,875,119**	**21,784**
Total for the two lakes and the two countries		**11,715,215**	**119,233**

1.8 MAIN SOCIO-ECONOMIC ACTIVITIES IN THE LAKE BASINS

Artisanal fishing and subsistence small holder farming are the main economic activities of the riparian communities. About 73% of the people derive their livelihood from fishing. Fishing is mainly traditional and artisanal. The main fishing devices used are dormant gill nets, beach seines, hooks and traps. Most of fishing units use plank canoes (70% in 1988 on Lake Albert), but many traditional fishermen use dug out canoes for fishing. Less than 25% of the boats are motorized and the rest use paddles.

1.9 STATUS OF THE FISHERIES OF LAKES EDWARD AND ALBERT

In the past, Lake Edward provided important fisheries with harvest composed primarily of Tilapia *(Oreochromis niloticus and O. leucosticus)*, Catfishes (*Bagrus docmac and Clarias lazera)*, Lungfish *(Protopterus aethiopicus)* and some minor species such as *Burbus altianalis, Hydrocynus forskalii, Mormyrus kanume* and Haplochromiine spp. Information collected in the early 1990s puts the number of canoes working the DRC side of the lake at 1,041 of which around one third were said to be fishing illegally in closed zones (spawning areas). Production from the DRC sector of the lake within this same period was estimated at 11,400 metric tones. per annum. On the Uganda sector of the lake, returns covering a twenty-five year period ending in 1988 indicate an average catch of around 5,500 metric tones. per annum. Unlike in the DRC, fishing effort is controlled with specified number of canoes with a known number of nets annually. Maximum Sustainable Yield (MSY) for Lake Edward was estimated to lie between 15 metric tones and 16 metric tones per annum.

Lake Albert contains 32 variety of fish species but the commercial catch is dominated by *Alestes baremose, Hydrocynus forsdkahlii, Lates niloticus, Bagrus docmac, Oreochromis niloticus* and some Haplochromiine species. The available statistical information indicates that annual catches in Uganda over a 30 year period (1955- 1986) fluctuated between lows of around 4,000 metric tones. to highs of over 20,000 metric tones. In DRC, the statistical record for the period from the early 1980s to the late 1980s indicates that lake wide annual catches have fluctuated substantially from lows of around 7,000 mt. to highs of over 20,000 mt. In the early 1990s it was estimated that around 5,700 canoes were operating lake wide and that of these some 3,200 were in the DRC. Of the several industrial units that were active in DRC waters in the early 1970s, only one is reported still to be in operation.

Fish in the two lakes is reported to be declining in species diversity, overall production, and the average size of fish caught. While this trend is largely attributed to over fishing and use of destructive fishing gears and methods, the underlying biological and limnological factors are not adequately documented to facilitate formulation of better management strategies. No lake-wide assessment of population structure and dynamics of commercially exploited fish stocks in Lakes Edward and Albert have been undertaken.

2.0 THE PILOT STUDY

The LEAF Pilot Fisheries Study was awarded to Development Consultants International Limited (DCI) of Kampala in consortium with Environment and Development Associates (EDA) of Kampala and in association with Environmental Impact Assessment Network Group in the Great Lakes Countries (EIA-GLC) of Burundi on 19 September 2006 and the Contract was signed in October 2006. Although the LEAF Pilot Fisheries study was signed in October 2006, initial preliminary activities took time to complete before the launch of field work. Details of these activities have been reported in the monthly progress reports for May, June, July and August 2007. A summary of these activities is given below.

2.1 INITIAL ACTIVITIES DONE IN PREPARATION OF FIELD WORK

a. Mobilization of key personnel

The Consortium had by December 2006 recruited and mobilized all the key personnel and staff for the project. The list was provided in the May 2007 Monthly Report.

b. Mobilization of national Counterpart staff

The LEAF Pilot Project identified nationals from the DRC and Uganda as suitable and qualified counterparts to the project early in December 2006. NBI issued letters of appointments to the DRC and Ugandan national counterpart staff in April 2007. The full list of all these counterpart staff was given in the May 2007 Monthly Report.

c. Conducting Field Reconnaissance Survey

Prof John Okedi, the Team Leader and Dr Orach-Meza the Deputy Team Leader undertook field reconnaissance surveys form 30.11.06 to 05.12.06 covering the Ugandan part of Lake Albert and again form from 16 to 19 December 2006 covering Bunia in the DRC. The purpose of the reconnaissance survey was:

i. to familiarize the study team leadership with the project area, communities and stakeholders;
ii. to introduce the study team to the Executive Director of NBI;
iii. to obtain letters of Introduction from the Executive Director of NBI;
iv. to meet the Project Coordinator and his staff at the Project offices in Bushenyi;
v. to meet Counter part staff at the Districts level;
vi. to meet district stakeholders at the District level, BMUs, fisherfolk at the various fishing villages;
vii. to meet NGOs working in the study area; and
viii. to identify suitable office accommodation for the consultants in Bushenyi, Katwe, Buliiza/Butiaba and in Masindi/Hoima.

The reconnaissance field survey proved extremely useful. A letter of introduction was obtained form the Executive Director of NBI. Three housing units were identified as offices for the study in Bunia, Bushenyi and Hoima. Very useful information and documents were obtained from the Project Office, District Headquarters, BMUs and the LAGBIMO Resource Center in Kasese. Key environmental, fisheries and management problems were discussed with stakeholders, fishermen, district officials and members of BMUs along the lake shores. The study team was able to develop better appreciation of the issues in the lake basins, make preliminary plans for detailed studies and surveys. A detailed report of this reconnaissance survey was given in the May Monthly Report.

d. Establishment of Field Stations and Sampling Sites

i. Establishment of Field Stations

Suitable operational field stations have been set up at Bushenyi for operations on Lake Edward; at Hoima for operations on the Ugandan part of Lake Albert and at Bunia for operations on the DRC part of Lake Albert.

ii. Establishment of Sampling Sites

Sampling sites were selected but were reduced to only three per lake due to logistical and security considerations. Geographical Positioning System (GPS) was used to fix the Latitudes, Longitudes, Altitudes and Distances. Depths were measured using a Ten Kilogram stone tied to a scaled rope/tape. These stations are representative of the entire lake ecosystems covering shallow inshore waters, open deep waters, southern and northern portions of the two lakes as well as covering lake areas in the two riparian countries. These sampling sites include the following:

Lake Edward Sampling Sites for Fisheries Biology and Biodiversity Studies

Lake Edward

Lake Edward Sampling Sites at K**atwe (Uganda Part)**

KZ1 - The Littoral sampling station: Latitude 00^{0}08.637’S; Longitude 029^{0}54.412’ E
KZ2 - Shoreline sampling station: Latitude 00^{0}10.136'S ; Longitude 029^{0}53.641' E
KZ3 - Off-shore station: Latitude 00^{0}11.581' S; Longitude 029^{0}47.640' E

Lake Albert

Lake Albert Sampling Sites at Butiaba (Uganda Part)
BZ1-Lagoon sampling station: Latitude 01º 49.82’ N; Longitude 31º 19.919´ E
BZ2- Inshore sampling station : Latitude 01º 47.881’N;Longitude 31º 19.037´ E
BZ3- Off shore sampling station: Latitude 01º 50.902 N; Longitude 31º 13.992´ E;

Kavinyonge Zone (KVZ) on the DRC part of the lake:

Coordinates for Water Quality studies in Lake Edward

No	SITE NAME	SITE ID	LAT/LONG	DEPTH (m)	DISTANCE (km) from Katwe
1	Congo Literal Station - Vitshumbi	CL1	S0 35 45.7 E29 23 44.9	14.8	74.0
2	Uganda Congo Pelagic Station - Congo Uganda Border	UCP1	S0 20 46.1 E29 40 40.4	23.8	32.2
3	Uganda Literal station Station – Katwe	UL1	S0 11 56.3 E29 50 41.9	6.0	7.3
4	River Entry to Edward Station - Mweya Jetty	REE1	S0 11 00.7 E29 54 20.7	3.8	11.7

Coordinates for Water Quality Studies in Lake Albert

No	SITE NAME	SITE ID	LAT/LONG	DEPTH (m)
1	Lake Albert at Entry of R. Semiliki	ALB 002	N01.21107 E030.61395	8.1
2	WRMD point (North of Ntoroko landing site)	ALB 001	N01.32744 E030.46884	3.1
3	Mid Lake	ALB 005	N01.68966 E030.94925	44.7
4	WRMD point (adjacent to R. Hoimo)	ALB 006	N01.73169 E031.15717	43.1
5	Kyoga Nile Entry to L. Albert	ALB 013	N02.18339 E031.36915	1.4
6	Albert Nile Exit from L. Albert (Wang Kado)	ALB 014	N02.26564 E031.34417	3.6
7	Upper lake at Mahagi Port	ALB 015	N02.12035 E031.27439	14.9

e. Procurement of scientific equipment and gill-nets

The Consultant negotiated with the Water Resources Management Department to use their mobile laboratory to move to the lakes to collect water samples using equipment such as the Hydro-lab and waster samplers. Other items of equipment for collection of phytoplankton, zooplankton and benthos were borrowed from other laboratories. Gill-nets for the study were specially fabricated by Uganda Fishnet Manufacturers and permission was obtained from the Commissioner of Fisheries to allow the use of small mesh size gill-nets. Two four wheel drive vehicles were procured by the Lead Firm in April 2007 for field work.

f. Recruitment and hiring of field assistants

Recruitment of Field Assistants to work with the Fisheries Biologists, the Biodiversity experts, the Biostasticians and the Fisheries Socio-economists was done in middle of May during which time they were also trained in various aspects of their work. The

Fishermen were also recruited for Katwe, Kaviynonge, Butiaba and Tchoima Sampling Stations. One Coxswain each was recruited for operating the Project boats based in Katwe and Butiaba.

2.2 PREPARATION OF THE INCEPTION REPORT

The revised version of the Inception Report was submitted to a stakeholder workshop organized by the Client on 28-29 March 2007 at Kolping Hotel, Hoima, Uganda. This Hoima workshop was satisfied with the Draft Inception Report. The Inception Report was further revised and re-submitted to the Client in both English and French in June 2007.

2.3 WORKSHOPS

The following workshops were attended by the consultants for various purposes.

Stakeholders Workshop on 28-29 March 2007 at Kolping Hotel, Hoima:

to discuss the Draft Inception Report amongst other things.

Technical Workshop on Work Plan Preparation on 16-17 April, 2007 at Margherita Hotel, Kasese, Uganda:

to enable individual Consultants and their respective National Counterparts to meet and work out their detailed work plans including the required equipment, chemicals, stationery, data forms, questionnaires, required field assistants/enumerators/data collectors; and to work out specific field data collection and stakeholders' consultations strategies.

3.0 MAIN RESEARCH AND DATA COLLECTION ACTIVITIES

The Consultants had designed data collection and field activities to take place for one week on each lake once a month covering all the six sampling stations in each lake as well as collection of socio-economic and statistical data along the entire coastline of the two lakes. Field data collection started smoothly in May and June 2007. However, the program was seriously hampered in July and August when the Consultants were arrested and detained by both DRC Government forces as well as militia operating in Vitshumbi and Kyavinyonge respectively. Despite these threats, the consultants managed to undertake field data collection as shown below for the various study areas and themes.

3.1 FISHERIES BIOLOGY AND BIODIVERSITY RESEARCH

The Fisheries Biologist and the Biodiversity Expert together with the counterpart staff carried out experimental fishing and collection of phytoplankton, zooplankton and benthos samples in all the six sampling sites shown above in the two lakes. This was done monthly from May to August in order to get information on the following:

a) To determine fish species composition and species diversity in each lake;
b) To determine fish species distribution in each lake;
c) Examine and make an inventory of existing and threatened aquatic biodiversity and map out habitats;
d) Carry out fish stock assessment surveys to determine stock size, abundance, species composition and distribution, breeding grounds, population structure, potential yield and trophic inter-relationships;
e) Conduct taxonomic studies of endangered species;
f) Examine the behaviour and life history of surviving species;
g) To determine phytoplankton, zooplankton and benthos species composition, prevalence/abundance and distribution in the two lakes as well as in the various sampling sites.

Further, the Biodiversity Expert also conducted opportunistic observations along the lake shores as well as along the roads leading to the lakes taken note of shoreline macrophytes, terrestrial vegetation, mammals, birds, insects and any wildlife animals seen along the travel routes. These were noted as seen each time the team were in the study area.

3.2 CATCHMENTS ENVIRONMENT AND WATER QUALITY STUDIES

The Environment Expert together with the counterpart staff conducted catchment environment studies to gather information on the following:

a) Review available literature related to water quality and quantity, selecting and gauging determinants and sampling sites;
b) Prepare sampling schedules, carry out analytical quality control, establish changes, causes and effects of water quality deterioration and catchments degradation;

c) Prepare plans for strengthening national institutions;
d) Draw up plans for management of watersheds of the two lakes;
e) Develop a water balance model for the lakes and formulate investment plans for water resources development management in the area, taking into consideration Lake George which is connected to Lake Edward;
f) Analyze how fishing activities impact on the environment;
g) Analyze the impacts of the Wildlife National Parks surrounding the two lakes;
h) Analyze the impacts of oil prospecting/drilling in the Lake Albert region and propose remedial measures.

The team of experts for this study used the mobile Laboratory belonging to the Water Resources Management Department of the Ministry of Water and Environment, Kampala. The team run monthly expeditions to collect water samples from the six stations in lakes and elsewhere along the shores. They were also able to collect water samples from the northern part of Lake Albert near Wanseko and Mahagi.

3.3 FISHERIES SOCIO-ECONOMICS AND BIOSTATISTICS STUDIES

The Fisheries Socio-Economist and his counterparts conducted studies along the beaches to gather information on the following:

a) Stakeholder mapping and analysis of the fishing communities;
b) Impact of fishing activities on the environment;
c) Nutrition, health and other social amenities of the lake shore communities;
d) The contribution of the fisheries industry to rural household incomes and the national economies of both countries;
e) Consequences of changes in policies on all stakeholders;
f) Gender roles and relations in the fishing communities;
g) Macroeconomic situation in both as well as the institutional arrangements for fishing and trading enterprises; and
h) Issues relating to the micro finance constraints and opportunities at both the central and district levels.

The Fisheries Biostatistician and his counterparts conducted Catch Assessment surveys and Frame Surveys along the beaches to determine gear characteristics and catch rates.

3.4 CIVIL ENGINEERING AND INFRASTRUCTURE STUDIES

The Civil Engineer and his counterparts collected information to capture the state and condition of the following.

a) Fisheries Production Systems;
b) Fisheries Infrastructure; and
c) Extent and causes of post-harvest losses.

3.5 HYDROLOGY AND WATER RESOURCES STUDIES

The Hydrologist and his counterparts studied the following issues using data and information in the archives of the Meteorology Department in Kampala.

a) Water Resources; and
b) Water Balance.

3.6 POLICIES, LAWS AND INSTITUTIONAL ASPECTS

The Policies, Laws and Institutional Expert together with her counterparts conducted studies on the following.

a) The capacity of governments, both human capacities, material and financial capacities for lake management;
b) The legal and regulatory framework for the management of fisheries including funding mechanisms in the sector (formal and informal), customs and taxation systems;
c) Fisheries research structures, priorities, training needs as well as the various on-going and planned donor interventions in the project area;
d) The role of non-governmental organizations in the sector;
e) Constraints restraining better coordination of fishing activities of the two countries;
f) Existing property system, the method of acquisition and management of natural resources (water, fishing rights, land, etc) and conflict resolution around the two lakes; and
g) Issues linked to fish resources ownership, water ownership, links between customary law and modern law as well as relationships between the local and migratory fisher folk.

4.0 KEY FINDINGS OF THE STUDY

4.1 FISHERIES BIOLOGY AND STOCK ASSESSMENT STUDIES

4.1.1 Introduction

This component is expected to generate information on fish biology, fish stocks and biodiversity with recommendations to address the constraints debilitating sustainable development and conservation of the fisheries resources of Lakes Albert and Edward. The study will provide the necessary information on the current status on fish species, population characteristics in the two lakes. Hence the component would provide information on:

- Fish biodiversity and relative abundance in the lakes;
- The characteristics of the fish species in the two lakes, their abundance at different ages, feeding habits and trophic relationships;
- The main factors affecting fish biodiversity and fish populations, notably the fisheries pressure, its characteristics, species caught and catch rates.

4.1.2 Key Findings

A. Current status of fish biodiversity, fish resources, and commercial fisheries pressure in Lake Albert

a) Fish Biodiversity and relative importance of different fish populations

The synthesis of total fish catch in experimental fishing at Butiaba and Tchomia in May, June and July are given in **Table 4.1.1.**

Table 4.1.1: Total fish caught in experimental gill-nets in Lake Albert (in May, June, July) at Butiaba and Tchomia.

		Numbers	Total weight
1	*Lates macrophtalmus*	182	72522
2	*Hydrocynus forskahlii*	73	23750
3	*Barbus bynni*	6	12300
4	*Oreochromis niloticus*	13	12200
5	*Auchenoglanis occidentalis*	5	5100
6	*Brycinus nurse*	260	3580
7	*Bagrus bayad*	1	1000
8	*Alestes baremose*	2	735
9	*Malapterurus electricus*	1	350
10	*Synodontis schall*	1	300
11	*Schilbe intrermedius*	1	30

The species are listed in the order of importance in catches.

For biodiversity purpose, the list of species caught in the beach seines and seen in commercial fisheries is added and gives the picture shown in **Table 4.1.2** below.

Table 4.1.2: Fish species caught in experimental gill-nets, beach seines and seen in the commercial catches

1.	*Barbus perince*
2.	*Leptocypris niloticus*
3.	*Neobola bredoi*
4.	*Polypterus senegalus*
5.	*Sarotherodon gallilaeus*
6.	*Tilapia zilli*
7.	*Haplochromis avium*
8.	*Haplochromis wingatii*
9.	*Haplochromis sp*

So far, only 19 species of fish have been identified from Lake Albert. This does not mean that these are the only species present in Lake Albert. There must be more in other habitats, notably those close to river mouths.

It is said that there are two species of *Lates* in Lake Albert (*Lates niloticus, and Lates macrophtalmus*). An easy identification character that could allow separating them in field conditions is yet to be found. It is likely that most of the individuals caught are *Lates macrophtalmus* (S. Wandera, pers. comm.).

The catches in Butiaba (10 samples) and Tchomia (7 samples) are different in total weight and species composition as shown in **Fig. 4.1.1a** and Fig. **4.1.1b** below.

Nile perch is therefore the main species caught in the two locations of Lake Albert. At Butiaba, the catch composition is more diverse, with four other species including *Hydrocynus forskahlii*, *Alestes nurse*, *Barbus bynni* and *Bagrus bayad*. It should be noted that *Alestes nurse*, which is a small fish, is rarely caught by commercial fisheries. At Tchomia in DRC, the species coming after *L. macrophtamus* are *Barbus bynni*, *Oreochromis niloticus* and *Auchenoglanis occidentalis*.

Fig.4.1.1a: Total Number of fish caught in Butiaba

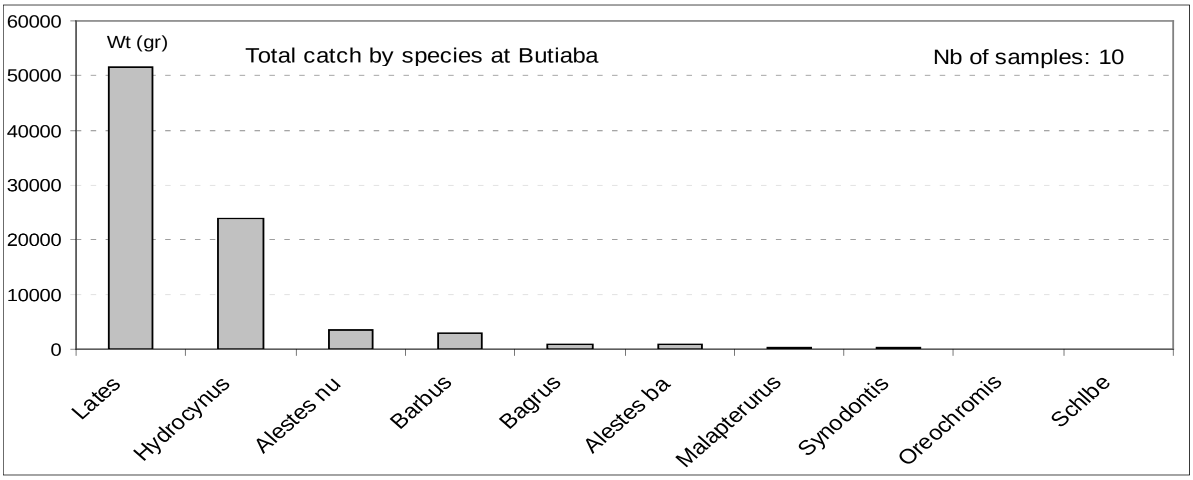
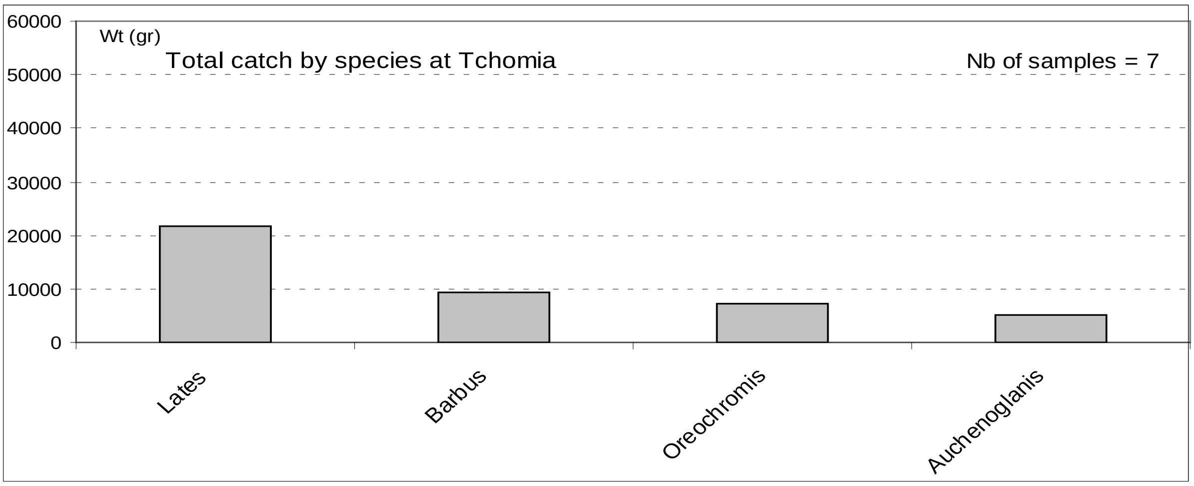


Fig.4.1.1b: Total Number of fish caught in Tchomia



b) Catch by species and by mesh size.

It is useful to know fish catch by mesh size in the lakes. This is important for the fishermen who are interested in the total yield, but also for the manager who needs to now if the fish caught are mature enough to be harvested.

The total catch by species and by mesh size at Butiaba and at Tchomia are shown in **Fig. 4.1.2a** and **Fig. 4.1.2b** below.

Fig. 4.1.2a: Total No. of fish caught at Butiaba by species and mesh size

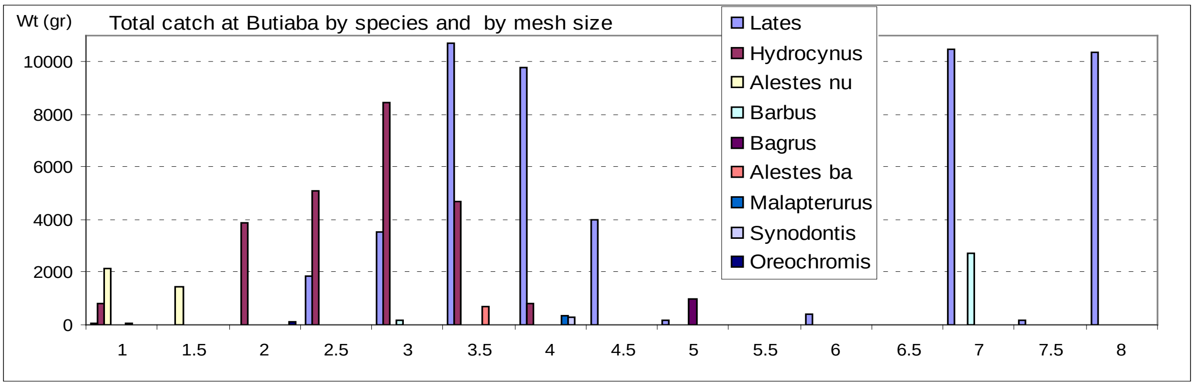
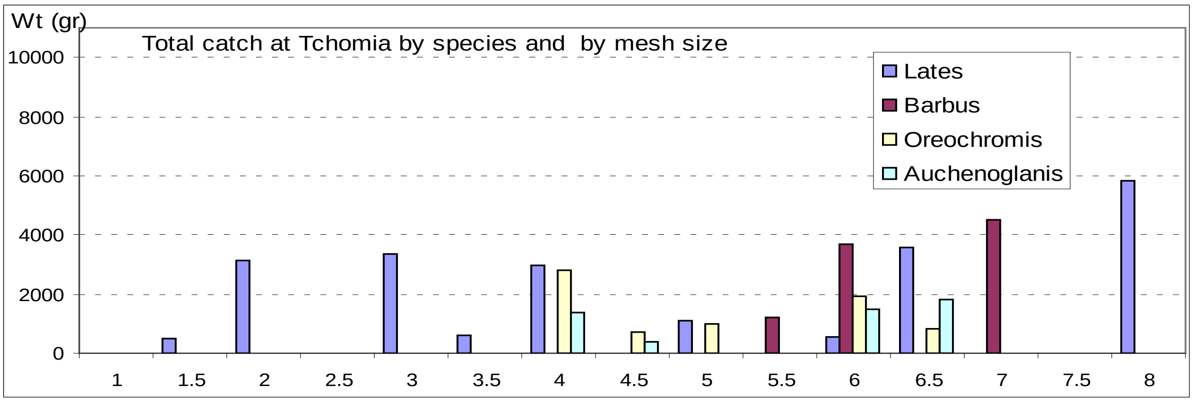


Fig. 4.1.2b: Total No. of fish caught at Tchomia by species and mesh size



At Butiaba where the commercial fisheries uses mostly gillnets with 4.5 inches and above, it was noted that the fish catch is very low from the meshes from 4.5 to 6 inches. The use of mesh size 2.5 and 4 inches allowed getting information on total catches of *Lates* and *Hydrocynus*. Are these fishes mature or not? This will be analysed later.

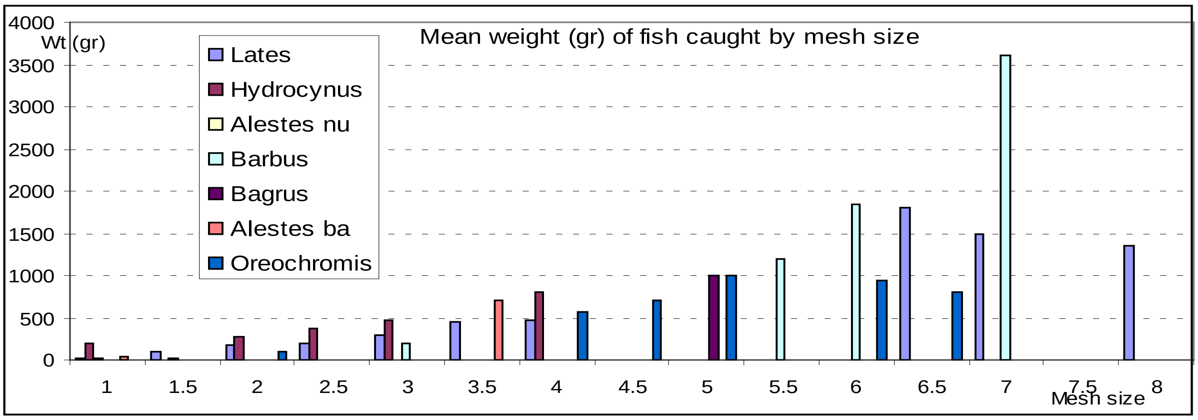
Smaller mesh size (1" and 1.5") catch mostly *Alestes nurse*, which is a small fish. This species lives in the very shallower waters not fishable with gillnets.

At Tchomia where the commercial fisheries use mostly gillnets with 2.5 inches, the fish catches are very poor.

c) Mean weight of fish caught by mesh size in different species.

The mean weight of fish caught by mesh size in the experimental fish nets for the different species in Lake Albert is shown in **Fig.4.1.3.** This picture will improve when more samples are obtained in next sampling sessions. Nevertheless, these data shows which mesh sizes are the most destructive. It is therefore observed that, for example mesh sizes of 4, 4.5 ad 5 inches catch individuals of *Oreochromis niloticus* with respectively 560, 700 and 1000 grams; mesh size of 2.5, 3, 3.5 and 4 inches catch individuals of *Lates macrophtalmus* with respectively 188, 288, 452 and 472 grams. For *Hydrocynus forskahlii*, mesh size of 2, 2.5, 3 and 4 inches catch individuals respectively individual of 279, 369, and 469 grams.

Fig 4.1.3: Mean weights of fish caught by mesh size



d) Length Weight Relationship for the main species.

From the measurements of total length and weight of a number of individual in each species, it will be possible to calculate the growth parameters of the species in the relation as follow:

Log W = log a + b log LT

W being the weight, LT the total length, a and b parameters characteristics of the species

So far, samples are large enough for three species (*Lates macrophtalmus*, *Hydrocynus forskshalli* and *Brycinus nurse*) to show curves with clear trends (**Fig.4.1.4a, Fig.4.1.4b and Fig.4.1.4c).**

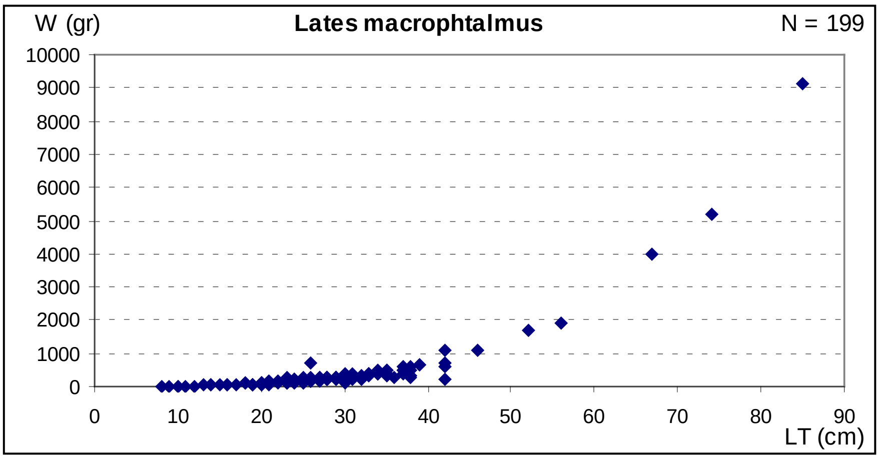


Fig.4.1.4a: Length Weight Relationship for the main species caught in Lake Albert

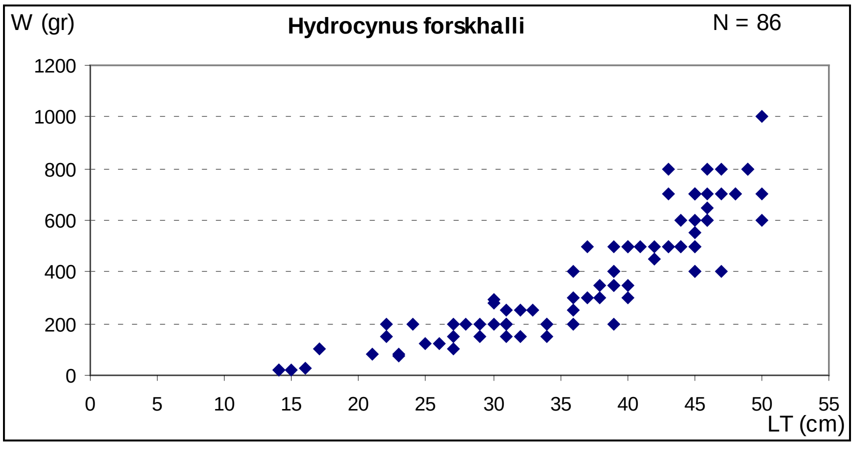


Fig.4.1.4b: Length Weight Relationship for the main species caught in Lake Albert

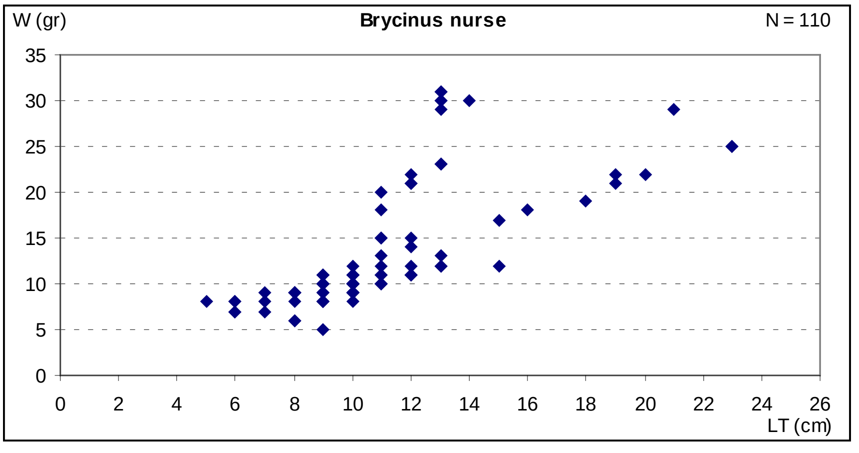


Fig.4.1.4c: Length Weight Relationship for the main species caught in Lake Albert

e) Size at first maturity

From analyses of gonad status in the different species, it is possible to get to know the size of fish species at first maturity and then get a better idea of the size below which this species should not be harvested.

On the field, the gonad status record was recorded as:

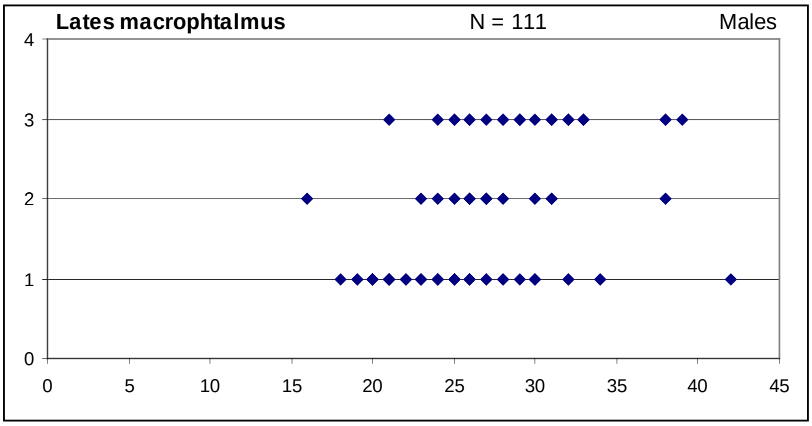
- "immature" for the very young fish where even the sex in not distinguishable with necked eyes;
- "small", when the sex in distinguishable, but gonads still very thin;
- "medium", when the gonads and the eggs are developed but not at their maximum extend
- "large", when the eggs are ripe in ovaries and sperm visible in testes.

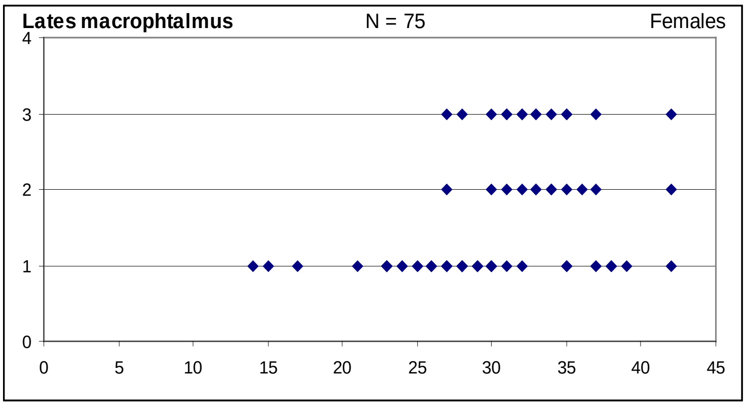
In the **Fig.4.1.5**, we consider only individuals where the sex is distinguishable. The "small" status is indicated here as level 1, "medium" as level 2, and "large" as level 3, separately for males and females.
The smallest size at which level 3 is observed can be considered as the size of first reproduction.

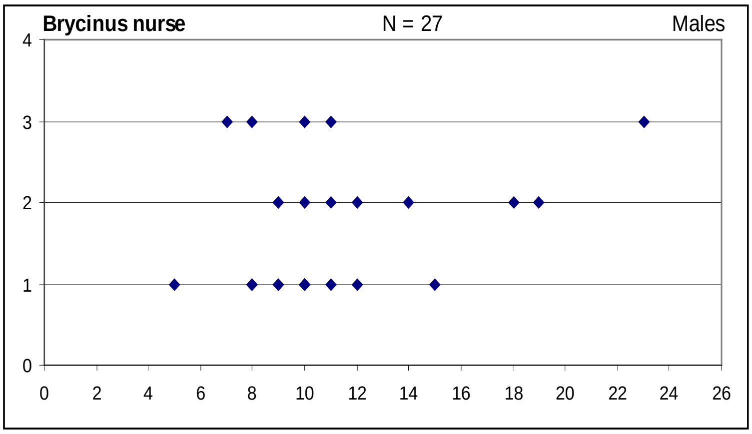
So far, the samples are large enough for *Lates macrophtalmus*, *Hydrocynus forskshalli* and *Brycinus nurse*, to show the first maturity size at about:

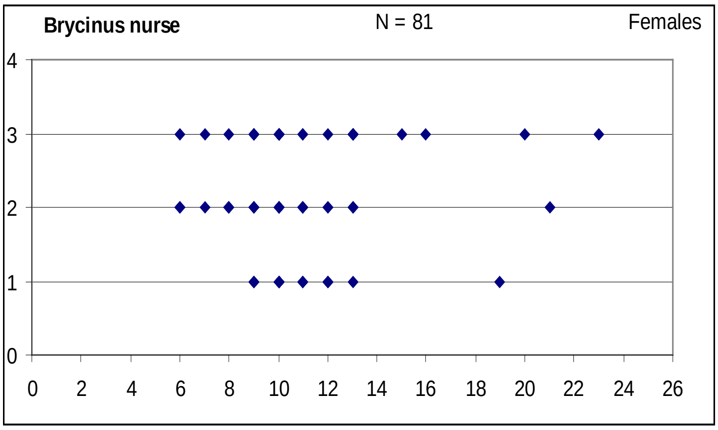
- 24 cm and 30 cm respectively for males and females of *Lates macrophtalmus*
- 30 cm and 32 cm respectively for males and females of *Hydrocynus forskahlli*
- and 7 cm in both sexes in for *Brycinus nurse*

The maturity size of individuals in different species is known by the total length, but it will be possible to convert it to individual weight from the length-weight relationship being built above and from information available in bibliography.




Lates macrophtalmus
N = 75
Females
0
1
2
3
4
0
5
10
15
20
25
30
35
40
45


Brycinus nurse
N = 27
Males
0
1
2
3
4
0
2
4
6
8
10
12
14
16
18
20
22
24
26


Brycinus nurse
N = 81
Females
0
1
2
3
4
0
2
4
6
8
10
12
14
16
18
20
22
24
26

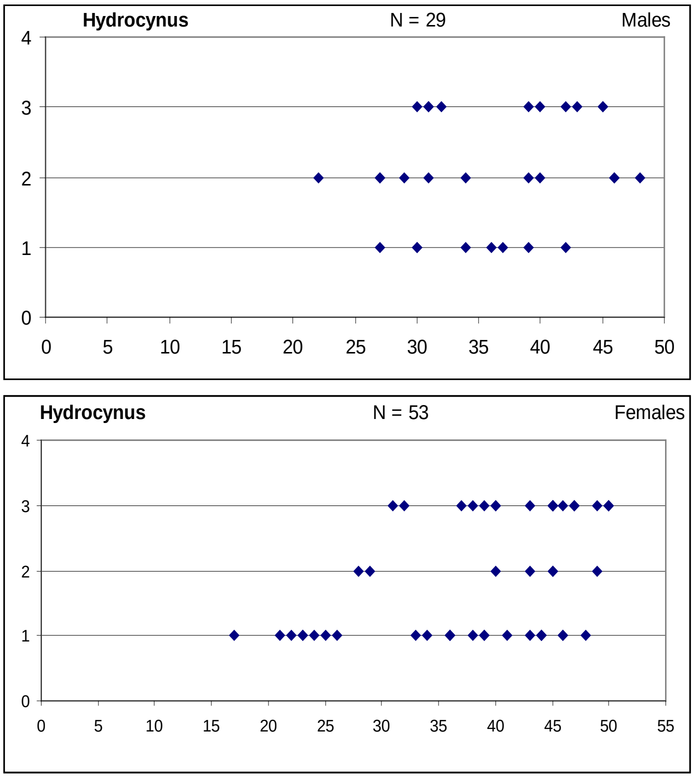
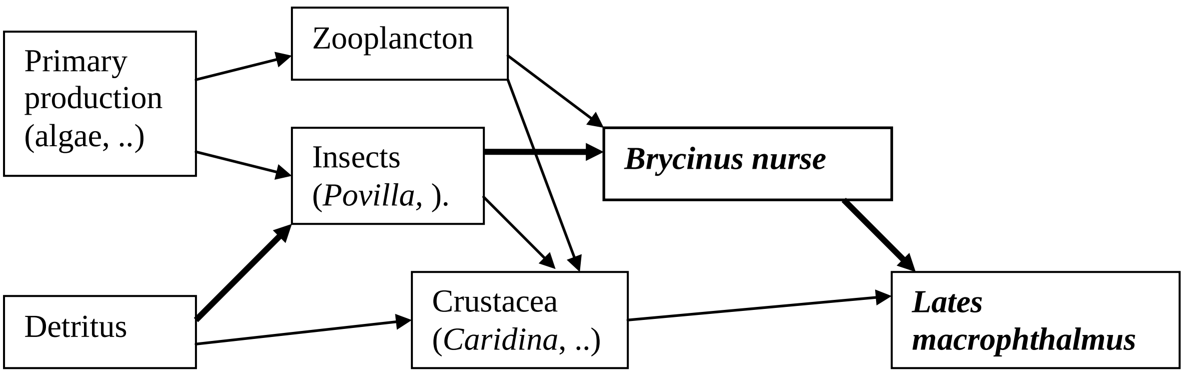


Fig.4.1.5: Gonad status at different size for different species
(1 = Small; 2 =Medium; 3 = large)

f) Feeding regime of different species and trophic relationships

Stomach contents of macrophage species have been examined and the results are shown in **Table 4.1.3.** It appears that *Brycinus nurse*, which feeds mainly on *Povilla*, the most common Ephemeroptera in the lake, is the main food for *Lates macrophtalmus*. Others important foods for Lates are the Crustacea *Caridina*, Haplochromines species and other small fish, including fry.

One of the main trophic and prey/predator relationships in Lake Albert could be drawn as follows:



A thorough analysis will be made in including bibliography information, when more field data is available.

Table 4.1.3: Stomach analyses of some fishes caught in Lake Albert at Butiaba in July 2007

	Species	TL	W	Fullness (in %)	Feeding item and relative importance
1	*Brycinus nurse*	9	5	50	Insect remains 75, Caridina 25
2	*Brycinus nurse*	9	9	50	*Povilla*
3	*Brycinus nurse*	9	9	75	*Povilla*
4	*Brycinus nurse*	9	10	50	*Povilla* 50, Oligochetes 50
5	*Brycinus nurse*	10	9	25	Insects remains
6	*Brycinus nurse*	10	10	25	*Caridina*
7	*Brycinus nurse*	10	10	100	*Povilla* 90, Snail 10
8	*Brycinus nurse*	10	10	25	Insects remains
9	*Brycinus nurse*	10	10	75	*Povilla*
10	*Brycinus nurse*	10	10	75	Insects remains
11	*Brycinus nurse*	10	10	100	*Povilla* 90, Plants 10
12	*Brycinus nurse*	10	11	25	Insect remains
13	*Brycinus nurse*	10	11	75	*Povilla*
14	*Brycinus nurse*	11	11	75	*Povilla* 80, Caridina 20
15	*Brycinus nurse*	11	12	50	Snail
16	*Brycinus nurse*	11	15	75	*Povilla*
17	*Brycinus nurse*	12	21	75	*Povilla*
18	*Brycinus nurse*	12	22	75	Odonata 50; Fish 50
19	*Brycinus nurse*	13	12	50	Snail
20	*Brycinus nurse*	13	23	75	*Povilla*
21	*Brycinus nurse*	13	23	75	*Povilla*
22	*Brycinus nurse*	13	29	100	*Povilla 50, Fish rem 50*
23	*Brycinus nurse*	13	30	75	*Povilla*
24	*Brycinus nurse*	13	31	50	*Povilla*
25	*Brycinus nurse*	14	39	75	*Povilla*
1	*Lates macrophtalmus*	9	15	50	*Caridina*
2	*Lates macrophtalmus*	10	10	75	*Caridina*
3	*Lates macrophtalmus*	11	20	50	*Caridina*
4	*Lates macrophtalmus*	17	53	25	*Caridina*
5	*Lates macrophtalmus*	18	90	50	*Haplochromis*
6	*Lates macrophtalmus*	18	90	100	Haplochromis juvenile
7	*Lates macrophtalmus*	19	80	50	Fish remain 80, Snail 20
8	*Lates macrophtalmus*	20	100	50	*Brycinus*
9	*Lates macrophtalmus*	20	120	50	*Brycinus*
10	*Lates macrophtalmus*	20	100	75	*Brycinus 75, Haplochromis 25*
11	*Lates macrophtalmus*	21	120	50	*Brycinus*
12	*Lates macrophtalmus*	21	120	75	*Haplochromis 50, Bry 50*
13	*Lates macrophtalmus*	21	120	100	*Brycinus 75, Haplochromis 25*
14	*Lates macrophtalmus*	21	120	100	5 Haplochromis
15	*Lates macrophtalmus*	22	150	25	Fish fry
16	*Lates macrophtalmus*	23	100	25	*Caridina*
17	*Lates macrophtalmus*	23	150	25	*Neobola*
18	*Lates macrophtalmus*	23	100	25	*Caridina*
19	*Lates macrophtalmus*	23	200	25	Fish fry
20	*Lates macrophtalmus*	23	100	75	*Caridina*
21	*Lates macrophtalmus*	24	200	75	*Brycinus*
22	*Lates macrophtalmus*	34	400	75	Fish remain 80, Snail 20
23	*Lates macrophtalmus*	34	400	50	Lates juvenile

24	*Lates macrophtalmus*	42	600	50	*Bagrus 50, Neobola 50*
25	*Lates macrophtalmus*	85	9100	75	*Alestes nurse (13 individuals)*
26	*Schilbe intermedius*	17	30	50	*Caridina*
27	*Hydrocinus korskhalli*	26	120	50	*Caridina 50, Fish remains 50*

Table 4.1.4: Stomach analyses of some fishes caught in Lake Edward at Katwe in July and August 2007

		LT	Wt	Fullness (in %)	Feeding item and relative importance
1.	*Bagrus docmak*	10	2000	25	Fish remains
2.	*Bagrus docmak*	20	125	50	Fish remains
3.	*Bagrus docmak*	24	110	100	Haplochromine sp
4.	*Bagrus docmak*	24	80	50	Haplochromine sp
5.	*Bagrus docmak*	25	124	50	Fish remains
6.	*Bagrus docmak*	25	125	100	Haplochromine sp
7.	*Bagrus docmak*	25	105	50	Haplochromine sp
8.	*Bagrus docmak*	25	125	50	Haplochromine sp
9.	*Bagrus docmak*	26	130	75	Haplochromine sp
10.	*Bagrus docmak*	26	110	25	Fish remains
11.	*Bagrus docmak*	26	110	50	Insect remains
12.	*Bagrus docmak*	27	145	100	Haplochromine sp (11cm)
13.	*Bagrus docmak*	27	116	100	Haplochromine sp 90, plant 10
14.	*Bagrus docmak*	28	175	50	Haplochromine sp
15.	*Bagrus docmak*	28	150	50	Fish remains
16.	*Bagrus docmak*	28	150	50	Haplochromine sp
17.	*Bagrus docmak*	29	180	25	Fish remains
18.	*Bagrus docmak*	29	175	25	Fish remains
19.	*Bagrus docmak*	29	150	75	Haplochromine sp
20.	*Bagrus docmak*	29	140	50	Haplochromine sp
21.	*Bagrus docmak*	30	185	75	Haplochromine sp
22.	*Bagrus docmak*	30	175	100	Haplochromine sp
23.	*Bagrus docmak*	30	150	75	Haplochromine sp
24.	*Bagrus docmak*	30	175	100	Haplochromine sp
25.	*Bagrus docmak*	30	150	50	Haplochromine sp
26.	*Bagrus docmak*	31	170	25	Fish remains
27.	*Bagrus docmak*	31	175	50	Haplochromine sp
28.	*Bagrus docmak*	32	210	100	Haplochromine sp
29.	*Bagrus docmak*	36	300	25	Fish remains
30.	*Bagrus docmak*	40	500	50	Haplochromine sp
31.	*Bagrus docmak*	42	400	50	Haplochromine sp
32.	*Bagrus docmak*	48	800	25	Fish remains
33.	*Bagrus docmak*	50	1000	50	Haplochromine sp
34.	*Bagrus docmak*	72	3400	25	Fish remains
35.	*Haplochromis squamipinnis*	13	50	75	Haplochromine sp
36.	*Haplochromis squamipinnis*	14	55	50	Fish remains
37.	*Haplochromis squamipinnis*	14	50	25	Fish remains
38.	*Haplochromis squamipinnis*	15	55	50	Haplochromine sp
39.	*Haplochromis squamipinnis*	15	52	50	Haplochromine sp
40.	*Haplochromis squamipinnis*	16	60	50	Fish remains
41.	*Haplochromis squamipinnis*	18	100	75	Fish remains
42.	*Haplochromis squamipinnis*	18	100	50	Fish remains

4.1.3 Analysis of the Main Issues in Fisheries for the development of an Integrated Lakes Management Plan

A. Fisheries Management Issues

a. Commercial fishing pressure on fish populations in Lake Albert

An analysis of the fish composition and fish characteristics in the commercial fishermen's catches, provides information on the most targeted species as well as the maturity state of the fish caught. This will further provide information on the most vulnerable species. At Butiaba in Uganda, the fishermen use gillnets of mesh size of 4.5 inches. At Tchomia in DRC, the fishermen use gillnets of mesh size beginning with 2.5 inches and longlines. The data collected in May, June and July allows generation of histograms showing the targeted species, as well as the size of individual fish species.

The most important targeted fish species are shown in the histograms in **Fig. 4.1.6a** and **Fig. 4.1.6b** below. *Lates macrophtlamus* is clearly the most important commercial species. The mean weight for individuals caught for this species is 1,345 grams. The second most important species is *Hydrocynus forskahlii,* with a mean individual weight of 381 grams. Larger fish are rarely caught.

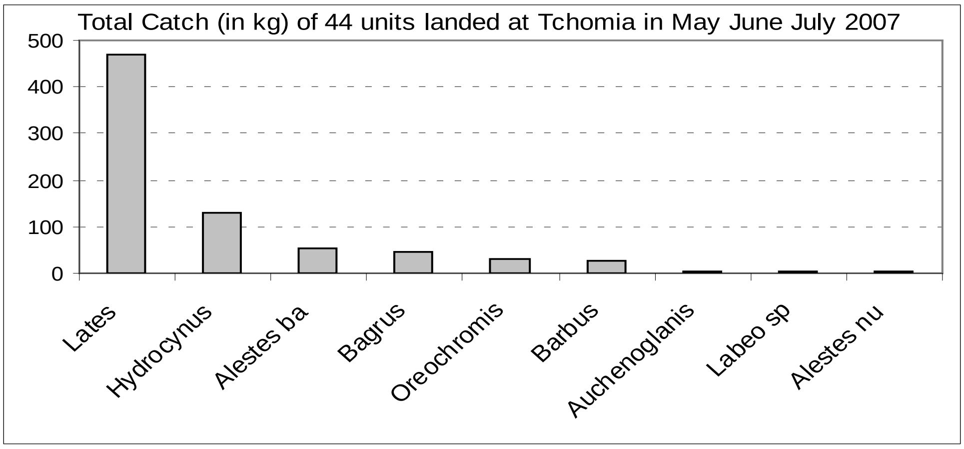


Fig. 4.1.6a: Total fish catch landed at Tchomia in May, June and July

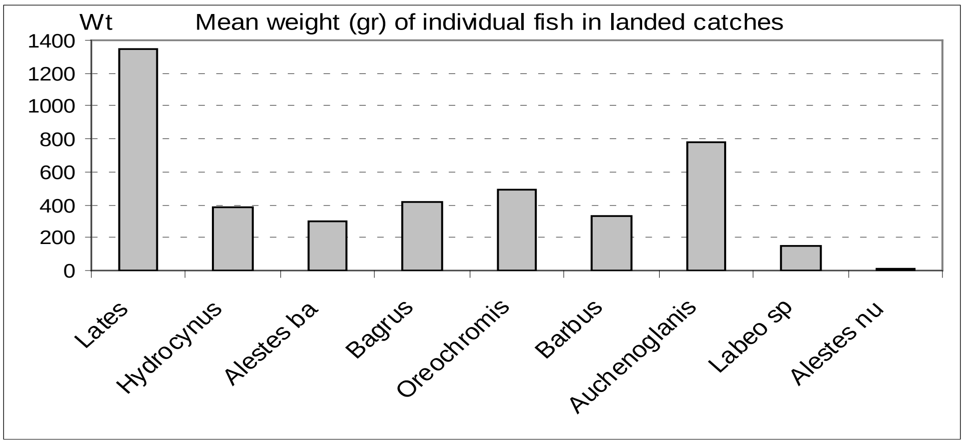
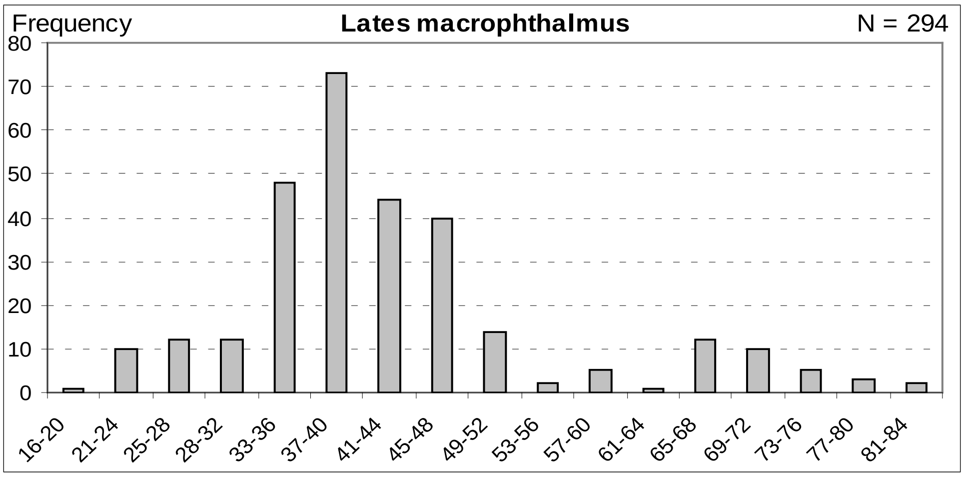
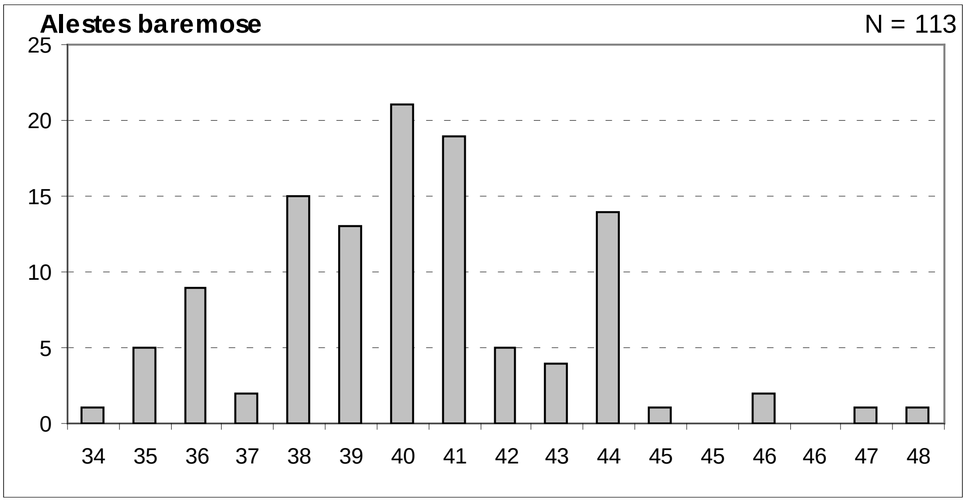
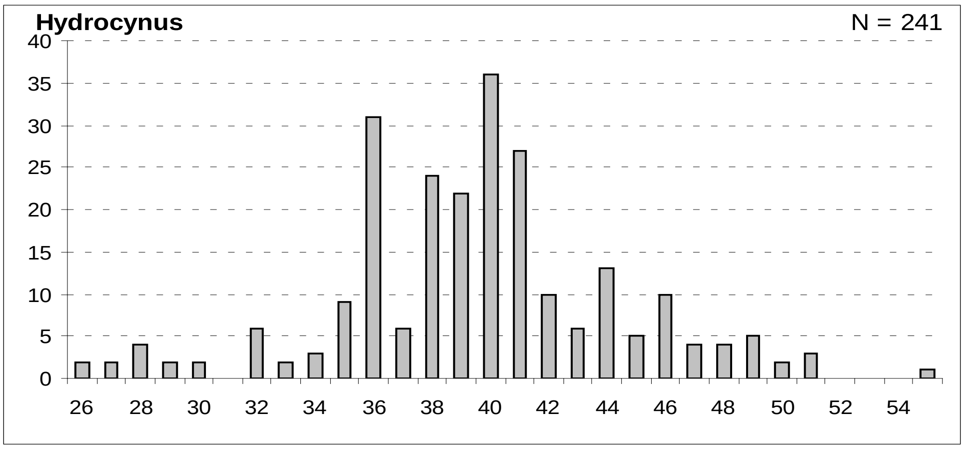


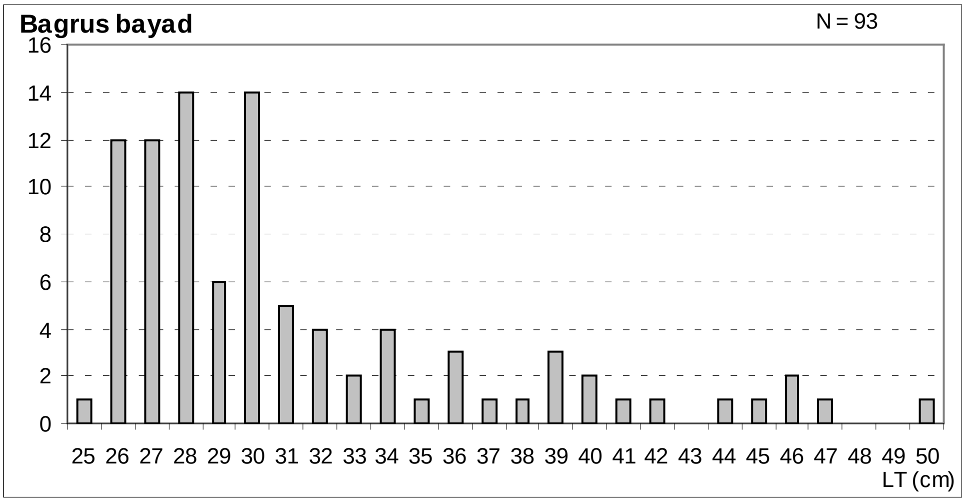
Fig.4.1.6 b: Mean weight of fish landed

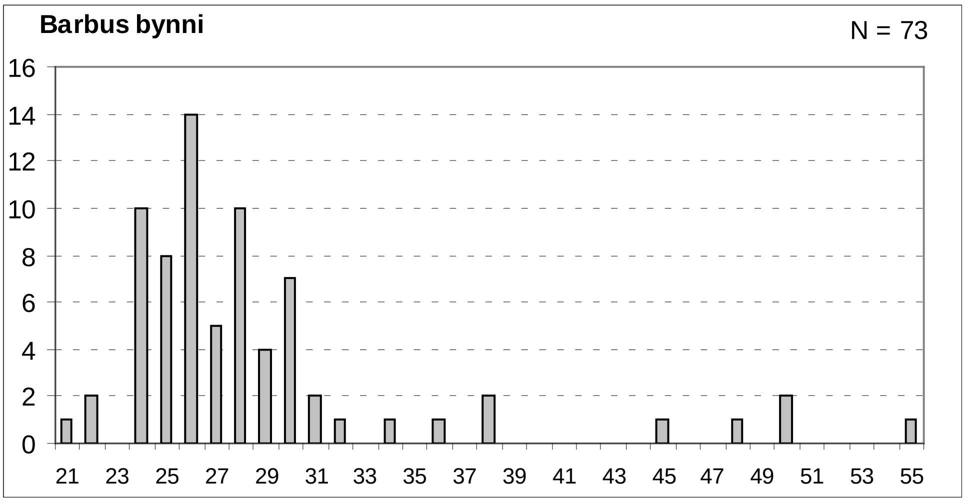
Length frequency distribution of the fish caught is shown in the series of histograms in **Fig. 4.1.7** below. From this, it is possible to obtain information on the size of the fish at first maturity for different species. Hence, it will be possible to know whether the fish caught are likely to have reproduced at least once before they are harvested. So far, it appears that a significant part of the catch of *Lates macrophthalmus* have not reproduced reproduced before being caught.











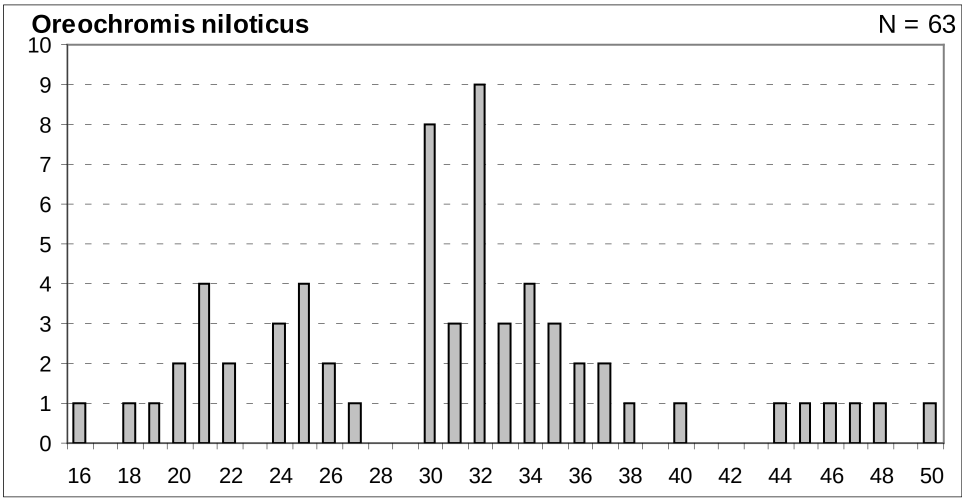


Fig.4.1.7: Length frequencies of different fish species landed at Tchomia

b. Commercial fisheries pressure and Strategies for the Fisheries Management Planning Process

The commercial fisheries at Katwe use mostly gillnets with mesh size of 4.5 inches and longlines.

The available data on catch composition have been collected Katwe in July and August 2007 allows generation of information on the targeted species as well as the size of individuals. These are shown in the histograms in **Fig. 4.1.8** and **Fig. 4.1.9** below for different species.

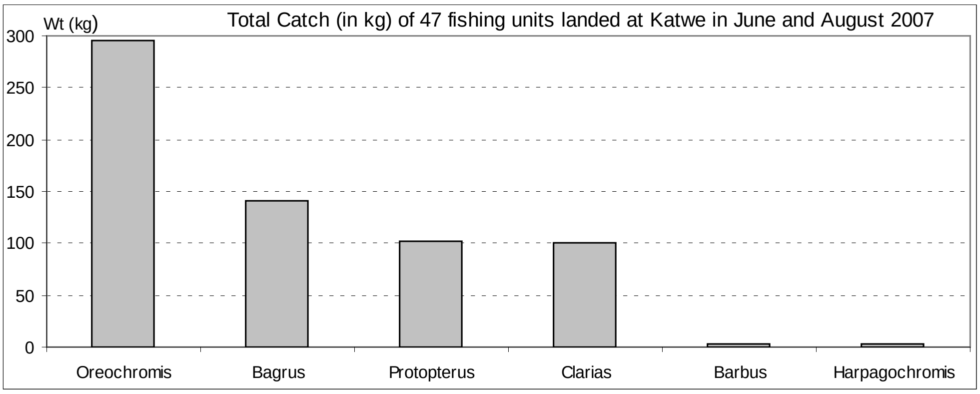


Fig. 4.1.8: Total catch of fish landed at Katwe in June and July 2007

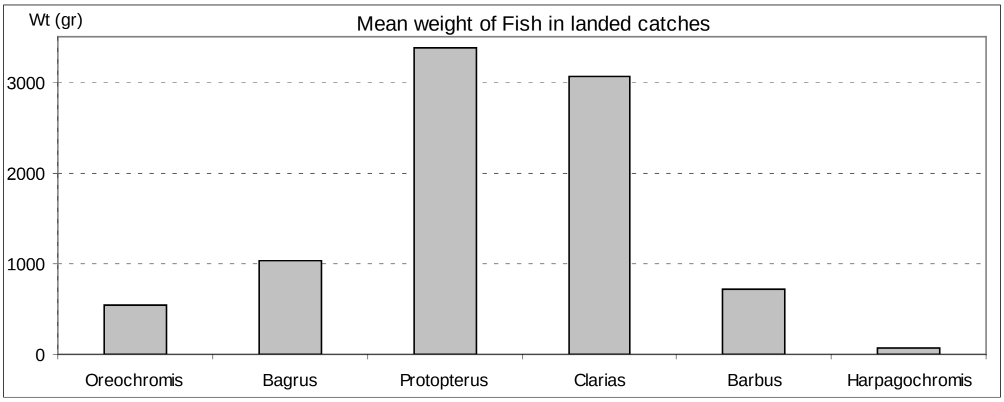


Fig. 4.1.9: Mean weight of fish landed at Katwe Beach

Information on the fish landed in Katwe is further given in the series of histograms in **Fig. 4.1.10** below. This gives information on the size of fish landed and their length frequencies.

This information can help provide information on the size of the fish at first maturity for different species. This is important for knowing the whether the captured fish are likely to have reproduced at least once before they are harvested.

So far, it appears that a significant part of catch of the Tilapias (*Oreochromis niloticus*) landed at Katwe are largely mature whilst some *Bagrus docmak* are not.

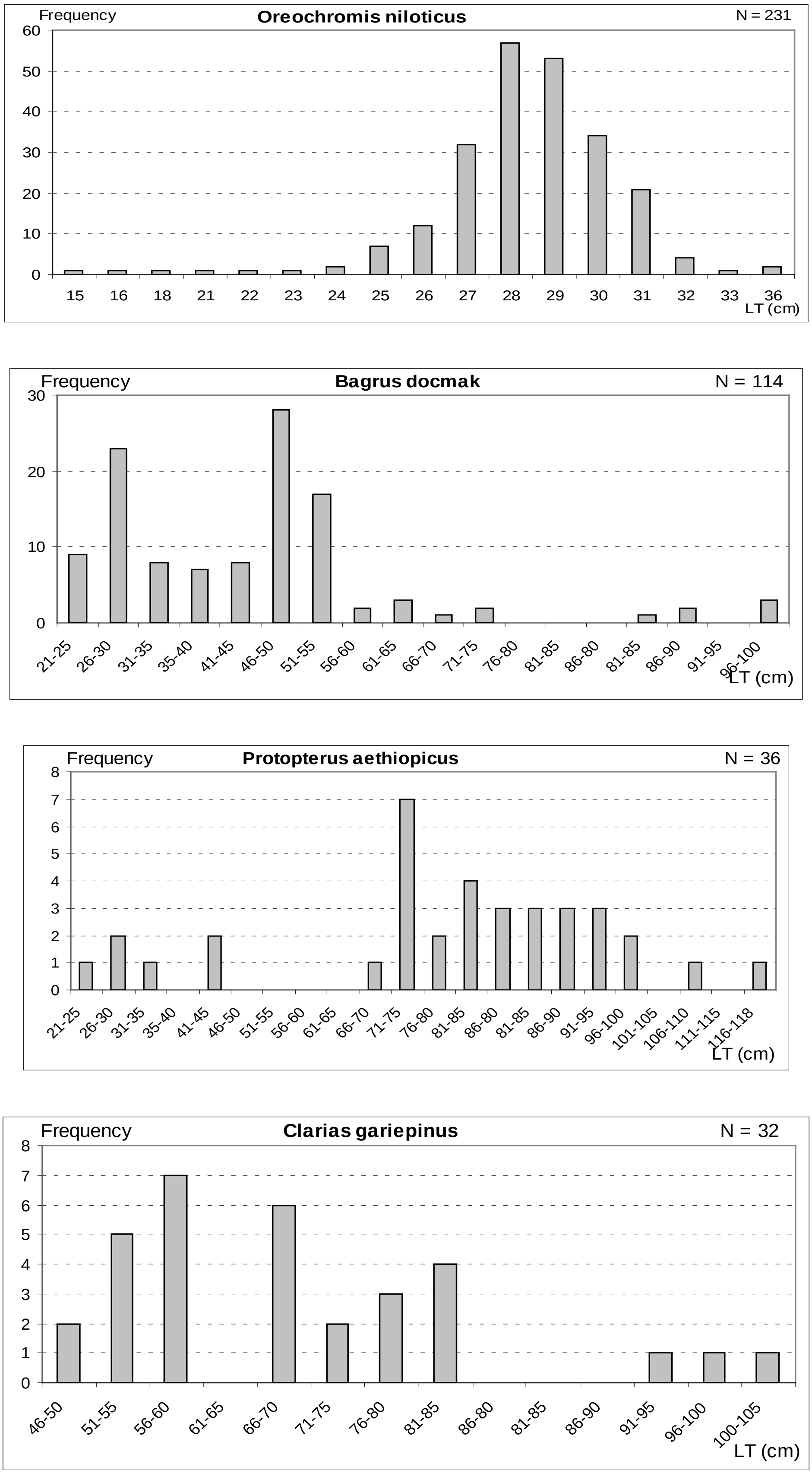


Fig. 4.1.10: Length frequency distribution of different commercial fish species landed at Katwe, Lake Edward

The above data and information shows the species of fish targeted and therefore the species most vulnerable. It further helps to show the length frequency distribution and the possible sizes at first maturity for the various fish species. This is expected to pave better understand of the sizes of fish which should be allowed to be caught in order to allow the fish to breed before capture. More data needs to be collected from all the stations in September. When an additional data is collected, better analyses will be done on fish biodiversity, fish population structure and impact of commercial fisheries on fish populations.

More information from the Fisheries Biostatistics and the Fisheries Socio-economics components of this study will provide better insights into the impact of commercial fisheries on the fish stocks. When all this information is fully analyzed, it will be possible to propose minimum mesh sizes for gill nets and hooks to be used in commercial fisheries and recommendations proposed for the sustainable management of the fish stocks in the lakes Edward and Albert. The Fisheries Management Plan which is going to be formulated will therefore make full use of this information to determine the size of fishing effort in terms of number of boats , number of gill-nets and hooks, species to be caught, the minimum size of fish to be permitted to be caught, permissible fishing grounds and aspects of permissible fishing seasons.

4.2 BIODIVESITY

4.2.1 Introduction

The biodiversity component of the study is expected to provide plans for an improved ecological balance and greater biodiversity in the lakes ecosystem. This would involve conducting fish biology and biodiversity conservation studies. The studies would involve identification of the main factors affecting aquatic biodiversity; making an inventory of existing and threatened aquatic biodiversity and map out habitats; carrying out taxonomic studies of endangered species and publishing taxonomic guides; drawing up plans for a museum collection to be used for information, education and research purposes; preparing plans for propagation of threatened species; studying the behavior and life history of surviving species; carrying out trophic studies in fish to determine lakes productivity and provide models of these relationships; determining the tolerance of surviving species to environmental conditions; drawing up conservation plans; establishing a database on fisheries in the two lakes and preparing plans for training and research in relevant institutions in the two countries.

This section of the biodiversity studies will concentrate on analytical study of aquatic biodiversity of the flora and fauna of the two lakes. It also highlights aspects of terrestrial flora and fauna of the catchment particularly in the littoral parts of the lake basins. Aquatic biodiversity study therefore involved sampling phytoplankton, zooplankton, benthos and some submerged macrophytes. The plankton and aquatic macrophytes were preserved and were later identified in the Hydrobiology Laboratory of the Department of Zoology at Makerere University. Littoral plants and wildlife in the catchment were recorded through opportunistic observations.

At this stage, the main focus of the study is intended to elaborate on the current state of aquatic biodiversity of the two lakes in view of observations made to the effect that there is a large community of blue-green algae which in Lake Albert, cause anoxic conditions in some places resulting in considerable mortality of the Nile Perch. Hence, the study undertook the following:

i. Identifying the main components of the phytoplankton, zooplankton and benthos of Lakes Edward Albert;
ii. Identifying differences of the plankton and benthic communities in the two lakes;
iii. Identifying differences in the plankton and benthic communities in the shallow inshore waters and open pelagic waters;
iv. Evaluating the presence and importance of the “good” algal communities and those termed “bad” algae with potential to cause eutrophication, algal blooms and toxic conditions dangerous to fish, animals and human life;
v. Assessing the potential for algal blooms and therefore the potential impacts of pollution in the two lakes;
vi. Identifying the presence of submerged aquatic macrophytes and their impacts on biodiversity and water quality;
vii. Identifying floating aquatic weeds and their potential impacts on biodiversity and water quality;
viii. Identifying littoral vegetation types and their potential impacts on biodiversity and water quality;
ix. Identifying lake basin vegetation types;
x. Identifying wildlife and avifauna present in the catchment and potential threats to its survival in the wildlife reserves.

Sample collection in the two lakes was based on sampling each of the three sites in each lake according to the design shown above (Lake Albert Butiaba- 3 sites, lagoon, inshore and offshore; Tchomia -3 sites, lagoon, inshore and offshore; Lake Edward Katwe- three sites, lagoon, inshore and offshore; Kyavinyonge- 3 sites, lagoon, inshore and offshore). Insecurity in the DRC sampling stations disrupted sampling thus reducing the number of samples each month from May 2007. However, spot sampling checks were mounted in Mahagi in the DRC part of Lake Albert at the exit of River Nile. The results of the analyses of samples have been aggregated in **Table 4.2.1.** The following observations are deduced from the analyses.

4.2.2 Algae

Lakes Edward and Albert have both a very rich community of algae. Lake Albert has a wider species diversity with many more species than Lake Edward. The shallow inshore waters in both lakes have a richer algal representation than the deeper offshore waters. The phytoplankton of Lake Edward is generally poor in species diversity except around Katwe. The phytoplankton is characterized by a few common species such as *Microcystis*, *Planktolyngbya*, *Anabaena*, and *Cylindrospermum* which are Blue Greens.

Localized sites e.g. at Katwe in Lake Edward appear to be eutrophied with large numbers of algae. The most abundant group are the blue greens in both lakes. *Microcystis* is the most abundant algal species, with more than 5 million individuals per ml followed b*y Planktolyngbya, Merismopedia, Cylindrospermum* and *Anabaena* with concentrations of 10,000-50,000 individuals per ml in Katwe sampling sites. There are many more green algae in Lake Albert than in Lake Edward. *Scenedesmus* green alga is ubiquitous occurring in all the two lakes and in all sampling sites. Diatoms, the preferred diatom for fish food, are quite few in the two lakes and in all the sites. *Nitzchia* is the commonest Diatom but others such as *Diatoma* and *Navicula* occur widely.

The Kvavinyonge in the northern part of Lake Edward, showed a poor representation of both phytoplankton and zooplankton compared to the Katwe area. No conclusion can be made at this stage as there were security problems which upset sample collection in Kvavinyonge. In Mahagi in the northern part of Lake Albert, the algae are dominated by blue green algae, the commonest being *Microcystis, Merismopedia* and *Chrococcus* in that order. There are few species from the rest of the blue green communities. The green algae are represented by a wide spectrum of species including *Chlorococcum, Ulothrix, Ankistrodesmus, Scenedesmus, Pediastrum,Synecocystis* and *Tetraedon.* There are very few Diatoms and the only ones seen are *Nitzchia* and very few *Melosira, Synrdra, Diatoma, Navicula* and *Monostyla.* There are few differences between the Middle of Lake Albert, Entry of the Kyoga Nile into L. Albert, Exit of the Albert Nile from Lake Albert and the Northern part of Lake Albert at Mahagi Port . However, the open lake has more species of algae than the entry nor the exit of the Victoria Nile and the White Nile. At Mahagi, the species representation of algae from the surface waters is not very different from that at 3.5 m depth. The obvious conclusion is that the lake is showing signs of excessive algal growth. However, the sampling period was short, hence, it was not possible to obtain temporal variations in the populations of algae nor the zooplankton.

4.2.3 Zooplankton

The Zooplankton is widely found in the two lakes and in all the sites sampled. Cyclops and Nauplii are the commonest Copepods. *Diaphanosoma* and *Moinaare* are the most abundant Cladocerans. *Keratella* and *Brachionus* are the commonest rotifers. The zooplankton genera in Lake Edward were composed of two Copepods namely, Cyclops and Nauplii. The Cladocerans were few compared to the Rotifers. All in all, the shallow lagoons and the shallow inshore stations had more Zooplankton than the deep off-shore station. Also, Lake Edward (**Tables 4.2.1)** had more zooplankton than Lake Albert.

Table 4.2.1: Zooplankton Species Composition in 3 Katwe Sampling sites
Sampling date: 16.06. 2007
Numbers of organisms identified in a one ml chamber

Zooplankton Genera or Species	KZ1-Lagoon sampling station	KZ2- Inshore sampling station	KZ3- Off shore sampling station	Mean for Katwe-June
Copepoda				
Cyclops	5,600	2,566	62	2742
Nauplii	4,800	5,430	16	3415
Cladocera				
Diaphnasoma	50		2	17
Daphnia				
Moina		10	1	4
Bosmina				
Ostracoda				
Polyathra				
Rotifera				
Brachionus	1100	190	1	430

Keratella	1,450	120	1	523
Asplanchina	50	190	1	80
Euchlanis				
Filinia	----	60		20
Trichocerca	----	10		3
Monostyla	----	20	1	7
Bivalves				

4.2.4 Benthos

It was possible to collect benthos only from the lagoon sampling sites as other stations were too deep for manual collection of benthic samples. The benthos collected from the lagoon is shown in the table below as an example. **T**he mollusks are very abundant as components of the benthic fauna particularly in the inshore stations **(Plate 4.2.1** and **Plate 4.2.2)**. These composed of gastropods such as *Bullinus, Biomphalaria, Mellanoids* and *Bellamy*a. There were also several insects and worms as part of the benthos.

Table 4.2.2: Benthic groups found in Katwe Sampling Site

Sampling date: 16.06. 2007

Numbers of organisms identified

Benthos Genera or Species	KZ1-Lagoon sampling station
Gastropoda- Melanoidae	3
Gastropoda- Gabiella sp	
Bivalves-	2
Povilla nymphs	3
Chironomid larvae	2
Tubifex sludge worm (Oligochaeta)	4
Leeches	3

Plate 4.2.1: A haul of gastropod mollusks (mainly Bellamya) from the shores of Lake Albert in May 2007

Plate 4.2.2: A closer view of gastropod mollusks from the shores of Lake Albert in May 2007

4.2.5 Submerged Aquatic Weeds

The bottom of the shallow inshore waters of Lake Albert is literally clogged with submerged aquatic weeds which were identified as *Najas pectinata (*Najadacea) and *Vallisneria spiralis* (Hydrocharitacea) as seen in **Plates 4.2.3, 4.2.4** and 4**.2.5** below.

Plate 4.2.3: A Sample of Najas pectinata (Najadaceae) submerged water weed being pulled from the shallow bottom of Lake Albert in May 2007

Plate 4.2.4: A sample of Hydrocharitaceae (Vallisneria sp) hauled from the bottom of Lake Albert in May 2007

Plate 4.2.5: A healthy Hydrocharitaceae (Vallisneria spiralis) Aquatic weed isolated from the bottom of Lake Albert in May 2007

4.2.6 Littoral Macrophytes

There are several dominant littoral aquatic plants fringing the shoreline of Lake Albert. These were identified as water hyacinth, sedges, Typha, a type of papyrus amongst the grasses. The larger macrophytes were seen behind the grasses and included the Ambatch, palms and several bushy thickets as seen in **Plates 4.2.6, 4.2.7, 4.2.7, 4.2.8, 4.2.8, 4.2.9, Plate 4.2.10: Plate** and **4.2.11.** These were collected and will be identified.

Plate 4.2.6: Water hyacinth weed swept by wind on to the eastern shoreline of Lake Albert

Plate 4.2.7: Shoreline of Lake Albert with fringing Ambatch shrubs in May 2007

Plate 4.2.8: Fisherman uprooting tall Cyperus dives from a rich stand on a lake side pool on the Lake Albert in May 2007

Plate4.2.9: Shoreline of Lake Albert with mature palm trees, some egrets and other unidentified bird fauna in May 2007

Plate 4.2.10: Shoreline of Lake Albert with a healthy stand of Cyperus dives and some water hyacinth in the foreground in May 2007

Plate 4.2.11: Shoreline of Lake Albert with a strong stand of Typha in the background and a healthy population of water hyacinth in the foreground in May 2007

Table4.2.3: Mean counts (x1000) of Phytoplankton, Zooplankton and Benthos from Lakes Edward and Albert in May, June, July and August 2007

STATIONS	LAKE EDWARD				LAKE ALBERT									
	Katwe			Kyavin yonge	Butiaba			Tchomia		Mahagi				
	SITES													
Plankton/Organism	1	2	3	1	1	2	3	1	2	1	2	3	4	5
Blue Green Algae														
Microcystis	2,160	2,600	215	555	67	2	31	46.6	360	1.02	0.234	1.6	2.2	2.3
Chrococcus	-	2	0.46		3.3	-	-	0.1	-	0.2	0.17	0.36	0.22	0.3
Merismopedia	32	-	0.389		2.8	0.18	0.44			0.164	1.34	0.64	0.4	-
Cylindrospermum	17	6.7	0.48		0.345	-	0.2			-	-	-	-	0.02
Planktolyngbya	50.6	28.6	0.29	2.6	0.006	0.025	0.33	0.24	2.	0.008	0.03	-	0.08	0.08
Linnothrix										-	-	-	-	20
Coelosphaerium					0.33	-	0.06							
Plectonema				0.2										
Ellipsoidon				1.2	-	0.001	-							
Anthrospira					0.002	-	0.001			0.003	-	-	-	-
Aphanothece	-	-	1	4										
Aphanocapsa										0.060	-	-	-	-
Anabaena	33	-	0.11		270	60	13			0.006	-	-	-	-
Cosmarium					0.001	-	-							
Cymbella					0.001	-	0.001							
Pseudanabaena					0.003	-	0.004							
Oscilatoria					0.002	0.007	0.003			0.001	-	-	-	-
Green Algae														
Chlorococcum					0.002	0.005	0.003			0.001		0.04	0.24	0.1
Ulothrix										4	40	-	-	20
Tebelaria					0.001	-	-							
Synedra								400	-					

Ankistrodesmus					0.001	0.013	-	0.02	0.02	-	0.02	-	-	0.02
	1.3	1.3	0.39		1.02	1.46	0.080			0.01	0.09	0.06	0.42	0.36
Agmenellum	-	8	-		-	8	-							
Selenastum	-	4	-		0.004	1.3	0.009							
Actinastrum	-	-	1		-	-	0.33							
Cyclotella								0.02						
Eremosphaera	-	0.2	-		0.002	0.001	0.001							
Pediastrum	1	-	1		0.33	-	0.33			0.039	0.11	-	-	0.020
Synecocystis					0.002	0.003	0.004			-	-	-	0.02	-
Chlorella	0.33	-	0.34		0.33	-	0.33							
Tetraedon					0.001	0.001	0.001							
Ellipsordon								0.02		-	-	-	0.002	-
Crucigenia										-	-	-	-	0.08
Diatoms				1,600										
Nitzchia	17	4.3	5.15		3.4	2.2	2.5	0.02	10	-	-	0.12	0.62	0.08
Melosira						6				3	-	-	-	-
Synrdra										7	-	-	-	-
Diatoma	0.33	0.03	0.03							0.003				
Navicula	-	0.007	0.007					0.02	-	0.001				
Monostyla												0.001		
ZOOPLANKTON														
Copepoda														
Cyclops	2.100	1.100	0.260	0.300	0.210	0.350	0.990	0.038	0.019	0.041	0.205	2.657	12.596	0.141
Nauplii	1.800	1.900	0.050	0.023	1.400	0.460	0. 600	0.462	0.231		0.020	0.001	0.067	1.134
Rotifera									-					
Keratella	0.510	0.077	0.030	0.024	0.022	0.060	0.035	-	0.083	0.002	0.001	0.017		0.007
Brachionus	0.370	0.066	0.001	0.003	0.012	0.016	0.003	-	0.006		0.002	0.021		0.005
Bosmina				0.003	0.001	-	-							
Trichocerca	0.001	0.004	-											
Filinia	-	0.060	-											
Chaoborus				0.003										
Ostracoda	-	-	0.001		0.002	0.002	0.001							

Monostyla	0.001	0.020	0.001								0.002			
Asplanchina	0.002	-	0.013		0.001	-	0.003				0.002			
Cladocera														
Daphnia	-	-	0.001	0.009	0.002	0.002	0.001							
Diaphanosoma	0.018	0.001	0.002		0.002	0.001	0.007							
Moina	0.002	0.003	0.001		0.003	-	0.005			0.001		0.001		
Insects														
Caoborus larvae					0.001	-	0.001							
Ostracoda					0.003	-	0.001	0.005	0.003					
Benthos														
Hexagenia, Ephemeridae	0.001	-	-		0.001									
Gastropoda- Melanoidae	0.015	-	-		0.016			-	0.004					
Gastropoda- Biomphalaria					0.002			-	0.002					
Bulinus	0.007	-	-		0.007									
Gastropoda- Gabiella sp	0.376	-	-		0.132									
Gastropoda- Bellamya spp					0.059			-	0.021					
Bivalves-	0.005	-	-		0.006			-	0.009					
Povilla nymphs	0.003	-	-		0.008									
Chironomid larvae	0.006	-	-		0.009	-	-	0.005	0.003					
Helocordulia (Dragon fly nymph) Libellulidae					0.002									
Tubifex sludge worm (Oligochaeta)	0.004	-	-		0.022									
Leeches	0.003				0.001									

4.2.7 Aquatic birds

There are many species of birds some of which were identified as the white egrets, cormorants, herons, terns and others which will be identified later. Some of these are shown in **Plates 4.2.12** and 4**.2.13**. There is a rich biodiversity of birds totaling several hundred species that is associated with the variety of habitats.

Plate 4.2.12: Some aquatic birds including the white Egrets and Cormorants on a sandy beach on the eastern shoreline of Lake Albert in May 2007

Plate 4.2.13: A group of aquatic birds resting on boats as some feed in the littoral vegetation on the eastern shoreline of Lake Albert I May 2007

4.2.8 Dry land albertine vegetation

The basin surrounding Lake Albert includes thickets, thick bush, forest open grassland, savannah, grassland and swamps as seen in **Plates 4.2.14** and **4.2.15.** Swamp vegetation fills most of the water logged valleys. On the Ugandan part, the area along the western rift valley forms the Bugungu Wildlife Reserve, the Karuma Wildlife Reserve and the Kaiso Tonya Wildlife area. The Lake Edward catchment is very similar and also lies within the Western Rift Valley. According to W.S. Atkins *et al.* (1986) Parker *et al.* (1962) and Langdale-Brown *et al.* (1964), the lake basin areas lie within the moist *Acacia-Combrettum* savannah. This vegetation is characterised by deciduous broad-leaved trees of the Combretaceae family and a grass layer of *Hyparrhenia rufa.* Tree cover is light with abundant *Combretum molle, Terminalia glaucescens* and *Albizia* sp. The area contains more than 150 species. For comparison, Uganda has more than 4,500 flowering plants (NEMA 1996). In the past there were many species of mammals like the hippopotamus, elephant, buffalo and Uganda kob. The area has in the recent years been subjected to intense grazing with cattle which has reduced grass cover extensively and displaced many wild life species.

Plate 4.2.14: A scenic view of Lake Albert nestled between the steep distant DRC hills escarpment in the west and the sprawling Great Western Rift Valley on its eastern side with a splattering of woody acacias amongst expansive grass patches

Plate 4.2.15: Aloe species amongst woody and thorny acacia shrubs in the eastern portion of the rift valley along the shores of Lake Albert

4.2.9 Mammals

Uganda had a rich mammalian fauna but the vast herds of game are no longer found even in the protected areas. Large mammals are great interest for tourism and game viewing. Large mammals include primates, ungulates and large carnivores. Small mammals include terrestrial rodents, insectivores (e.g. moles, shrews and hedgehogs), small carnivores and bats. Small mammals like insectivores and rodents are indicators of habitat change. They are also important as prey food for various animals and birds. **Table 4.2.3** shows the list of mammals that have been recorded in the Western Rift Valley protected areas.

Table 4.2.4: The list of mammals recorded in the Western Rift Valley Cacthment of Lake Edward and Albert

Common Name	Black and White Colobus
Shrews	Olive Baboon
Rodents	Sitatunga
Bats	Bushbuck
Hippos	Uganda Kob
Vervet Monkey	Marsh Mongoose
Patas Monkey	Spot Necked Otter

However, many of these are not easily seen now except the Uganda Cob and the Olive Baboon (**Plate 4.2.16)**. Other wild life species seem to have suffered greatly from encroachment and cattle grazing impacts. It has been reported that there is poisoning of lions by the cattle keepers who have encroached into the protected areas.

Plate 4.2.16: The Baboon is one of the tough mammalian species surviving in the Bugungu Game Reserve along the eastern shores of Lake Albert

4.2.10 Insects

The dry land scrub along the Lake Albert shoreline on its eastern coastline is rich in insects such as butterflies seen in the center of **Plate 4.2.17.**

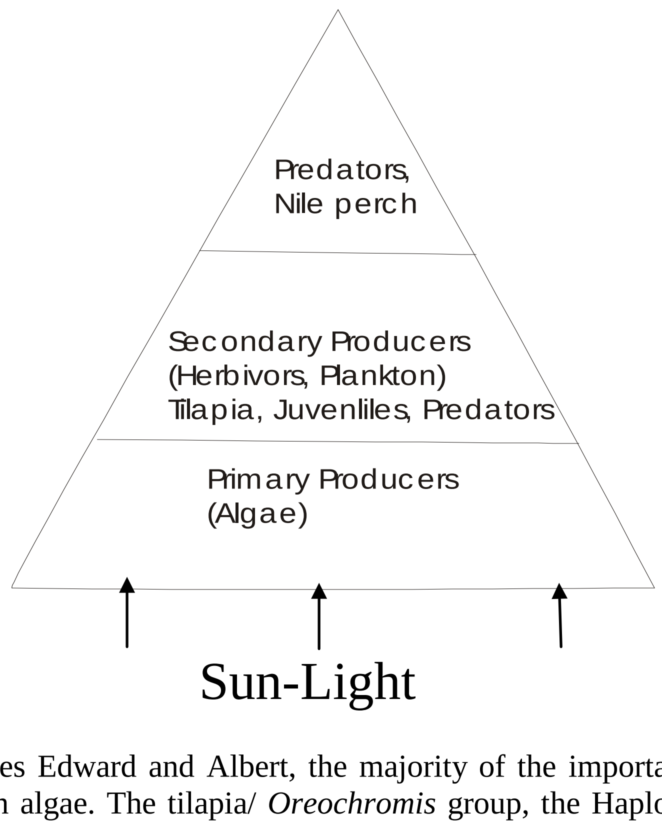
Plate 4.2.17: Butterflies on the eastern shores of Lake Albert in May 2007

4.2.11. Analysis of the Main Issues in Aquatic Biodiversity for the development of an Integrated Lakes Management Plan

Algae are microscopic plants which live in the water. They play an important role in the aquatic ecosystems the primary producers. They fix carbon dioxide using sunlight to produce carbohydrates in form of sugars. They depend on having sufficient sunlight penetrating the water body for fixing carbon dioxide. They also require nutrients in form of nitrogen, phosphorus and other micronutrients. Components like Diatoms also require silica to form cell walls. The blue green algae have cell walls made of lignin. Lignin is not broken down by digestive chemicals in the stomachs of fish. Hence, blue green algae have for long been known to be not good food for fish. The Diatoms on the other hand have silica made cell walls which allow digestive chemicals to penetrate in order to digest the cell contents which are rich in food nutrients.

The algae are called primary producers because they fix sunlight to make food in form of carbohydrates. All the other trophic groups in the lake ecosystem therefore depend on the algae for survival. The food chain in the lake ecosystem would then have a pyramid shape with the algae forming the bottom of the pyramid as shown below.

A Simplified typical Food Web in Lake Edward and Lake Albert



In Lakes Edward and Albert, the majority of the important commercial fish species feed on algae. The tilapia/ *Oreochromis* group, the Haplochromis species flock feed entirely on algae. Other fish species like the Nile perch, *Hydrocynus, Bagrus, Protopterus, Clarias*, the mormyrids, the electric *Malapterurus* and others which are omnivorous or predators all start life when juveniles by feeding on zooplankton and benthic invertebrates all of which depend on algae for food. Algae are also extremely important in aquatic ecosystem because they remove carbon dioxide from the water and produce oxygen which is essential for all life forms in the lakes.

In the Lakes Edward and Albert scenario, sunlight is not a limiting factor for algal growth as the area in a tropical environment. However, algae can be affected through pollution. Chemical pollution can impair the productivity of algae. As noted in the results of the analysis of the Water Quality component of this study, there are not many factories in the Lakes Edward Albert basins emitting chemicals into the water bodies. However, there is a lot of unsustainable agricultural practices which have impacted on algal health in the catchment of the two lakes. There has been widespread deforestation in the basins including poor cultivation methods and use of fertilizers and other agro-chemicals. These activities release nutrients into the rivers which end up in the two lakes. The results of the Water Quality analysis component of this study have also shown that certain areas of the two lakes have very high BOD readings. It has been found that *Microcystis* is by far the most dominant algal species in both lakes. This species can therefore be taken as the indicator species of algal over production or algal blooms in these two lakes. Examples are around Katwe Landing Site in Lake Edward with counts of over 5 million *Microcystis* per ml alone. This gives a clear indication of heavy algal bloom which could lead to eutrophication, light shading and production of toxic gases and anoxic conditions. Kavinyonge in the DRC part of Lake Edward had moderate algal counts with *Microcystis* counts at 0.5 million cells. Butiaba in the central part of Lake Albert in Uganda had low counts (20,000-100,000 cells of *Microcystis* per ml). Similarly, Tchomia in the DRC part of Lake Albert in the south had few counts (46,000-360,000 cells of *Microcystisper* ml). The northern part of Lake Albert has small counts (200-2,500 individual *Microcystis* per ml). The center of Lake Albert is to be considered pristine with a healthy count of 2,300 *Microcystis* cells per ml).   These sites have also been shown to have the highest algal counts as indicated in the tables below.

Phytoplankton Species Composition in 3 Katwe Sites, Lake Edward
Sampling date: 16.06. 2007

Mean Numbers of cells or filaments identified in a one ml chamber from original sample without dilution.

Phytoplankton Genera or Species	KZ1-Lagoon sampling station	KZ2- Inshore sampling station	KZ3- Off shore sampling station
Blue Greens			
Planktolyngbya	150,000	80,000	100
Anabaena	----	-------	1,000
Microcystis	5,500,000	7,500,000	522,000
Cylindrospermum	50,000	20,000	-----
Diatoms			
Nitzchia ?	50,000	10,000	14,200
Green Algae			
Eremosphaera ? Green Alga	-----	200	-----

Phytoplankton Species Composition in Kyavinyonge Sampling Site 1
Sampling date: 22.06 2007

Mean Numbers of cells identified in a one ml chamber in whole sample without dilution

Phytoplankton Genera	TZ1-Lagoon
Blue Greens	
Aphanotheca	4,000
Microcystis	555,000
Planktolyngya	2,600
Ellipsoidon	1,200
Plectonema	200
Diatoms	1,600

Analysis of Plankton Samples from Butiaba Lake Albert 24. 07.2007

Species group	Sampling Site		
	Zone 1	**Zone 2**	**Zone 3**
Blue Green Algae			
Microcystis	100,000		20,000
Chrococcus	10,000		
Merismopedia			1,000
Cylindrospermopsis	1,000		
Planktolyngbya			1,000
Linnothrix			
Anthrospira			
Aphanocapsa			
Anabaena	10,000	150,000	

Analysis of Plankton Samples from the Tchomia, Lake Albert 30.07.2007

Species group	Sampling Site	
	Zone 1	Zone 2
Blue Green Algae		
Microcystis	46,600	360,000
Chrococcus	100	
Merismopedia		
Cylindrospermopsis		
Planktolyngbya	240	2,000

Analysis of Plankton Samples from the Northern and Central Part of Lake Albert in the DRC

Species group	Number of Cells/ Filaments or organisms per ml				
	Sampling Site				
	ALB 013 (1)	ALB 014 (2)	ALB 015- 0.5m (3)	ALB 015- 3.5m (4)	ALB 005- 5m (5)
Blue Green Algae					
Microcystis	1,020	234	1,600	2,200	2,300
Chrococcus	2	170	360	220	300
Merismopedia	164	1340	640	400	-
Cylindrospermopsis	-	-	-	-	20
Planktolyngbya	8	30	-	80	80

ALB 005	Middle of Lake Albert	28/06/07
ALB 013	Entry of the Kyoga Nile into L. Albert	29/06/07
ALB 014	Exit of the Albert Nile from L. Albert	29/06/07
ALB 015	Northern part of Lake Albert at Mahagi Port	29/06/07

From the above observations, it is clear that there are pollution hot spots around fish landings like Katwe in Lake Edward. The landing site has a lot to contribute to this. There is poor management of organic wastes with few latrines leading to release of faeces and other organic wastes into the lake. It was also noted that this area around Katwe had many cattle and hippos. The area had been laid bare by overgrazing by mainly cattle. The effect of this is over fertilization of the immediate waters by cattle and hippo droppings leading to heavy algal growth and a lowered BOD. The other important factor is the influence of Lake George cacthment and the Mweya Lodge Hotel. As noted in the results of the analysis of the Water Quality component of this study, the BOD measurements around the entry of the Kazinga Channel into Lake Edward are extremely. This is the result of drainage of agrochemicals from the agricultural lands around the Lake George catchment as well as the contribution of Mweya Safari Lodge whose domestic effluents enter the lake without treatment.

4.3 CATCHMENT ENVIRONMENT AND WATER QUALITY

4.3.1 Introduction

The purpose of the Catchments Environment and Water Quality Study is to generate relevant data on the status of water quality and sources of pollution as a basis for diagnostic assessment and proposing a joint integrated water quality and catchments management strategy and comprehensive environmental management plan for the ecosystems of Lakes Edward and Albert. It is expected that this component will elaborate on pollution levels, causes and effects of water quality deterioration and catchments degradation. Further, the study will indicate possible impacts of fishing activities on the environment; the impact of wildlife and National Parks on the two lakes. It is hoped that the impacts of oil prospecting/drilling in the Lake Albert basin will be analyzed. Finally, the study will propose plans for strengthening national institutions and the management of watersheds of the two lakes prepared.

Measurements of lake water quality and characteristics were done involving parameters such as recording accurately the locations and position of the sites of the stations, depth, secchi depth, air temperature, water colour and odour. Profiles of temperature, dissolved oxygen, conductivity and pH were obtained in each station. Chlorophyll ‘a’ was measured and in some stations Ekman dredge samples were taken for benthos quantification. Water samples were filtered through glass fibre filters and both the filters and filtrates were stored by freezing and kept below 4^oC for subsequent analysis in the laboratory.

4.3.2 Results and Key Observations

A. On-Lake Measurements

Table 4.3.1 shows the sampling stations, their locations, altitudes, maximum depth, distances from Katwe Fish Landing and the total number of samples taken from each station. CL stands for Congo Littoral, UCP for Uganda/Congo Pelagic, UL for Uganda Littoral, REE for River Entry to Edward and RME for River Mouth Exit. These locations are also shown in **Fig.1.1.**

Table 4.3.1: Positioning of Sampling Stations on Geographical Coordinates

No	SITE NAME	SITE ID	LAT/LONG	UTM
1	Congo Literal Station - Vitshumbi	CL1	S0 35 45.7 E29 23 44.9	35 M 766657 9934063
2	Uganda Congo Pelagic Station - Congo Uganda Border	UCP1	S0 20 46.1 E29 40 40.4	35 M 798086 9961700
3	Uganda Literal station Station – Katwe	UL1	S0 11 56.3 E29 50 41.9	35 M 816703 9977981
4	River Entry to Edward Station - Mweya Jetty	REE1	S0 11 00.7 E29 54 20.7	35 M 823475 9979688
5	River Mouth Exit Station - Kyavinyongo/Semiliki	RME1	S0 08 45.6 E29 36 08.9	35 M 789689 9983846

Distances were measured from the Fish Landing at Katwe in Uganda.

Table 4.3.2 shows similar parameters for Lake Albert. ALB stands for Albert Sampling Station Code. Distances in the Southern Lake Albert were measured from Ntoroko Fish Landing in Uganda; the central stations were measured from Butiaba Fish Landing and those in the North of the lake were measured from Wanseko Fish Landing. The sampling locations are also shown in **Fig.1.1.**

Table 4. 3. 2: Positions of Sampling Stations Based on Geographical Coordinates

No	SITE NAME	SITE ID	LAT/LONG	ALTITUDE (ft)	DEPTH (m)	DISTANCE (km)	SAMPLES (No)
1	Lake Albert at Entry of R. Semiliki	ALB 002	N01.21107 E030.61395	-	8.1	22.0	2
2	WRMD point (Noth of Ntoroko landing site)	ALB 001	N01.32744 E030.46884	-	3.1	42.4	1
3	Mid Lake	ALB 005	N01.68966 E030.94925	-	44.7	44.0	4
4	WRMD point (adjuscent to R. Hoimo)	ALB 006	N01.73169 E031.15717	-	43.1	21.0	4
5	Kyoga Nile Entry to L. Albert	ALB 013	N02.18339 E031.36915	2020	1.4	0.45	1
6	Albert Nile Exit from L. Albert (Wang Kado)	ALB 014	N02.26564 E031.34417	2028	3.6	12.0	2
7	Upper lake at Mahagi Port	ALB 015	N02.12035 E031.27439	2016	14.9	13.0	3

By the time of writing this report, only one set of data was collected from each Sampling Station as shown in **Tables 4. 3.1** and **Table 4. 3. 2** where profiles for Dissolved Oxygen, Temperature, Electrical Conductivity and pH were taken from the surface to the bottom of the lakes at an interval of five (5) seconds.

Profiles of Key Parameters measured

A total of 1,161 profiles were taken from Lake Albert and 268 profiles from Lake Edward for Dissolved Oxygen (DO) Temperature (T), Electrical Conductivity (EC) and pH. Apart from some Micro-biological data on Total and Faecal Coliforms and Secchi Depth and Chlorophyll 'a' measurements, the data for other parameters are still being analyzed and they shall be included in the next monthly report. Data for the profiles included in the **Fig.3.1-Fig. 3.12** were been taken from the surface, mid-water and bottom of the lakes at each of the Sampling Stations.

Tables 4. 3.3 and **Table 4.3.4** show the results of on-lake measurements that are also depicted in **Chart 4. 3.1** which include **Fig.4. 3.1-Fig. 3.12**. These include Dissolved Oxygen (DO) in mg/l, Temperature (Temp) in ^{o}C, pH in units, Conductivity in uS/cm/100, Chlorophyll *a* in ug/l/100, Secchi Depth in cm, Faecal Coliforms in No./100 mls., and Total Coliforms in No./100 mls.

Table 4. 3.3: Profiles of Water quality Parameters (Electrical Conductivity (Cond.), Dissolved Oxygen (DO), Temperature (Temp.) and pH) at Surface, Mid-water and Bottom of Lake Edward **with Microbiological Counts, Water Depth and Secchi Depth Measurements.**

REE 1: KAZINGA CHANNEL ENTRY TO LAKE EDWARD – MWEYA JETTY						
Date	**Time**	**Depth (m)**	**Cond (uS/cm)**	**DO(mg/l)**	**Temp (oC)**	**pH (units)**
16/05/07	11:20:20	0	287	6.79	27.58	10.26
16/05/07	11:21:05	1.8	320	4.19	25.94	9.8
16/05/07	11:22:55	3.8	590	2.39	25.96	9.55
Sechi Depth (cm):			: 21.0			
Chlorophyll 'a' (ug/Litre)			: 150.6			
Total Coliforms (No./100 mls)			: 4000			
Faecal Coliforms (No./100 mls)			: 2000			
RME 1: SEMLIKI RIVER EXIT – KYAVINYONGE, DRC						
Date	**Time**	**Depth (m)**	**Cond (uS/cm)**	**DO (mg/l)**	**Temp (oC)**	**pH (units)**
19/05/07	10:54:48	0.2	892	7.64	26.88	10.17
19/05/07	10:55:58	1.5	892	7.39	26.89	10.17
19/05/07	10:58:43	3.0	892	7.39	26.88	10.18
Sechi Depth (cm)			: 208.0			
Chlorophyll 'a' (ug/Litre)			: 7.1			
Total Coliforms (No./100 mls)			: TNTC			
Faecal Coliforms (No./100 mls)			: 42			
TNTC = Too Numerous To Count						
CL 1: INSHORE WATER – VITSHUMBI, DRC						
Date	**Time**	**Depth (m)**	**Cond (uS/cm)**	**DO (mg/l)**	**Temp (oC)**	**pH (units)**
18/05/07	11:57:26	0.1	892	7.69	27.84	10.41
18/05/07	12:02:26	7.4	896	7.07	26.65	10.23
18/05/07	12:07:41	14.6	945	3.25	26.58	10.42
Sechi Depth (cm)			: 135.0			

Chlorophyll 'a' (ug/Litre)		: 10.0				
Total Coliforms (No./100 mls)		: TNTC				
Faecal Coliforms (No./100 mls)		: 18				
UCP 1: CENTRE OF LAKE EDWARD – DRC/UGANDA						
Date	**Time**	**Depth (m)**	**Cond (uS/cm)**	**DO (mg/l)**	**Temp (oC)**	**pH (units)**
16/05/07	14:40:31	0.1	883	7.51	26.99	9.79
16/05/07	14:44:56	8.0	884	7.17	26.45	9.73
16/05/07	14:50:16	15.6	883	6.77	26.44	9.74
Sechi Depth (cm)		: 168.0				
Chlorophyll 'a' (ug/Litre)		: 6.3				
Total Coliforms (Number/100 mls)		: TNTC				
Faecal Coliforms (Number/100 mls)		: 4				
UL 1: INSHORE WATER – KATWE/UGANDA						
Date	**Time**	**Depth (m)**	**Cond (uS/cm)**	**DO (mg/l)**	**Temp (oC)**	**pH (units)**
19/05/07	17:15:05	0.0	891	8.51	27.64	9.23
19/05/07	17:17:05	2.8	890	8.79	27.10	9.13
19/05/07	17:19:15	5.5	895	5.42	26.22	8.90
Sechi Depth (cm):		: 157.0				
Chlorophyll 'a' (ug/Litre):		: 7.9				
Total Coliforms (Number/100 mls):		: 157				
Faecal Coliforms (Number/100 mls):		8				

Table 4.3.4: Profiles of Water quality Parameters (Electrical Conductivity (Cond.), Dissolved Oxygen (DO), Temperature (Temp.) and pH) at Surface, Mid-water and Bottom of **Lake Albert** with Microbiological Counts, Water Depth and Secchi Depth Measurements.

ALB 001: ENTRY OF SEMLIKI RIVER INTO LAKE ALBERT, DRC							
Date	**Time**	**Depth (m)**	**Cond (uS/cm)**	**Temp (oC)**	**DO (mg/l)**	**pH (units)**	
26/06/07	11:17:57	0.0	637	27.19	9.89	7.37	
26/06/07	11:20:06	4.1	637	26.92	9.86	6.72	
26/06/07	11:22:53	8.1	637	26.87	9.73	5.09	
Sechi Depth (cm):			: 80.0				
Chlorophyll 'a' (ug/Litre):			: 11.2				
Total Coliforms (Number/100 mls):			: NR				
Faecal Coliforms (Numbe/100 mls):			: NR				
NR = Not Required				**ND = Not Done**			
ALB 002: INSHORE WATER OFF NTOROKO FISH LANING, UGANDA							
Date	**Time**	**Depth (m)**	**Cond (uS/cm)**	**Temp (oC)**	**DO(mg/l)**	**pH (units)**	
26/06/07	15:06:07	0.0	635	30.21	9.69	7.99	
26/06/07	15:07:11	1.6	633	26.80	9.20	7.18	
26/06/07	15:09:01	3.1	635	26.62	9.17	4.67	
Sechi Depth (cm)			: 179.0				
Chlorophyll 'a' (ug/Litre)			: 9.9				
Total Coliforms (No./100 mls)			: 5				
Faecal Coliforms (No./mls)			: 0				
ALB 005: OFSHORE – MIDDLE OF LAKE ALBERT (DRC/UGANDA)							
Date	**Time**	**Depth (m)**	**Cond (uS/cm)**	**DO (mg/l)**	**Temp (oC)**	**pH (units)**	

28/06/07	14:58:20	0.0	639	6.69	28.40	9.61	
28/06/07	15:24:27	22.4	640	4.83	27.52	9.53	
28/06/07	15:50:51	44.7	664	0.15	27.53	9.26	
Sechi Depth (cm)			: 250.0				
Chlorophyll 'a' (ug/Litre)			: 10.7				
Total Coliforms (No./100 mls)			: ND				
Faecal Coliforms (No./mls)			: ND				
ALB 006: OFSHORE – MIDDLE OF LAKE ALBERT OFF HOIMO RIVER, UGANDA							
28/06/07	11:15:30	0.0	638	27.74	9.79	5.40	
28/06/07	11:36:10	21.6	639	27.61	9.78	4.42	
28/06/07	11:53:33	43.1	668	27.61	9.52	0.51	
Sechi Depth (cm)			: 250.0				
Chlorophyll 'a' (ug/Litre)			: 13.6				
Total Coliforms (No./100 mls)			: NR				
Faecal Coliforms (No./mls)			: NR				
ALB 013: AT ENTRY OF VICTORIA NILE OFF WANSEKO FISH LANDING							
Date	**Time**	**Depth (m)**	**Cond (uS/cm)**	**DO (mg/l)**	**Temp (oC)**	**pH (units)**	
29/06/07	10:54:34	0.0	110	8.14	26.54	8.43	
29/06/07	10:56:13	0.7	110	8.03	26.53	8.51	
29/06/07	10:58:38	1.4	110	8.21	26.57	8.71	
Sechi Depth (cm)			: Could not be measured				
Chlorophyll 'a' (ug/Litre)			: 14.4				
Total Coliforms (No./100 mls)			: ND				
Faecal Coliforms (No./mls)			: ND				
ALB 014: AT EXIT OF LAKE ALBERT INTO ALBERT NILE, UGANDA							
Date	**Time**	**Depth (m)**	**Cond (uS/cm)**	**DO (mg/l)**	**Temp (oC)**	**pH (units)**	
29/06/07	12:32:02	0.0	123	8.25	28.40	8.98	
29/06/07	12:35:19	1.7	126	7.60	26.85	8.45	
29/06/07	12:38:31	3.6	110	4.88	26.61	8.16	
Sechi Depth (cm)			: 79.0				
Chlorophyll 'a' (ug/Litre)			: 18.2				
Total Coliforms (No./100 mls)			: ND				
Faecal Coliforms (No./mls)			: ND				
ALB 015: INSHORE WATER OFF MAHAGI PORT, DRC							
Date	**Time**	**Depth (m)**	**Cond (uS/cm)**	**DO (mg/l)**	**Temp (oC)**	**pH (units)**	
29/06/07	15:07:17	0.0	622	6.38	27.86	9.79	
29/06/07	15:14:30	7.5	617	6.19	27.76	9.81	
29/06/07	15:22:24	14.9	650	0.08	27.46	9.60	
Sechi Depth (cm)			: 179.0				
Chlorophyll 'a' (ug/Litre)			: 17.4				
Total Coliforms (No./100 mls)			: ND				
Faecal Coliforms (No./mls)			: ND				

Chart 4.3.1:. **Profiles Water quality Parameters (for DO, T, EC and pH) taken from three levels at the Surface, at Mid-water and at the Bottom by Sampling Stations in Lakes Edward shown as Fig.1-5 and Lake Albert as Fig.6-12.**

Fig. 1: Profiles of Parameters by Depth in Lake Edward at Sampling Station REE (Entrance of Kazinga Channel near Mweya Hotel)

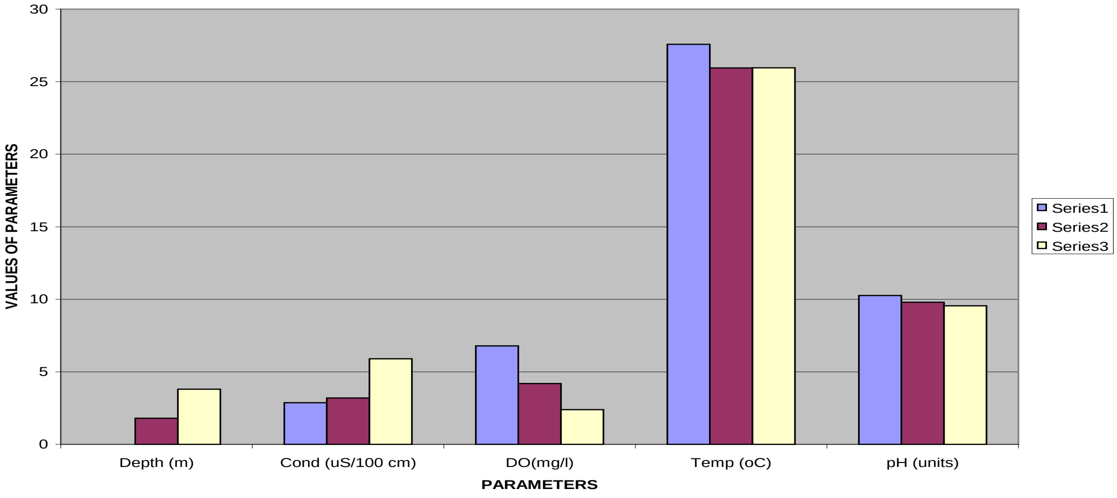


Fig. 2: Profiles of Parameters by Depth in Lake Edward at Sampling Station RME (Exit into River Semliki)

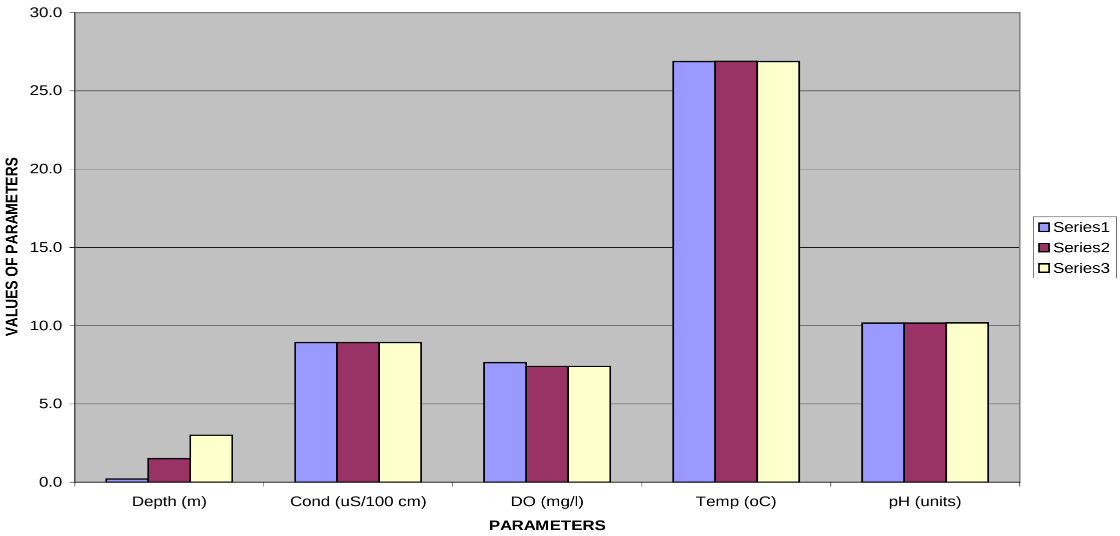


Fig. 3: Profiles of Parameters By Depth in Lake Edward at Sampling Station CL (near Vitschumbi)

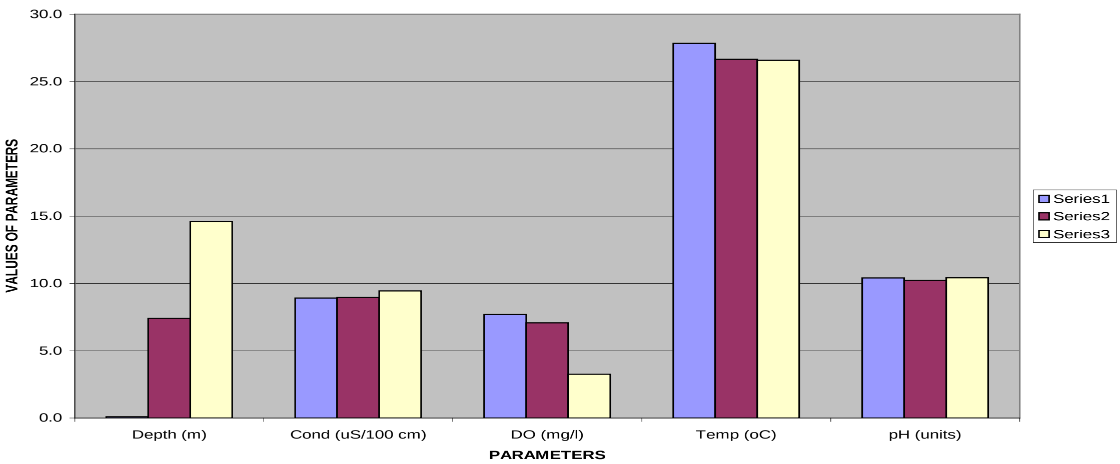


Fig. 4: Profiles of Parameters by Depth in Lake Edward at Sampling Station UCP (Centre of Lake)

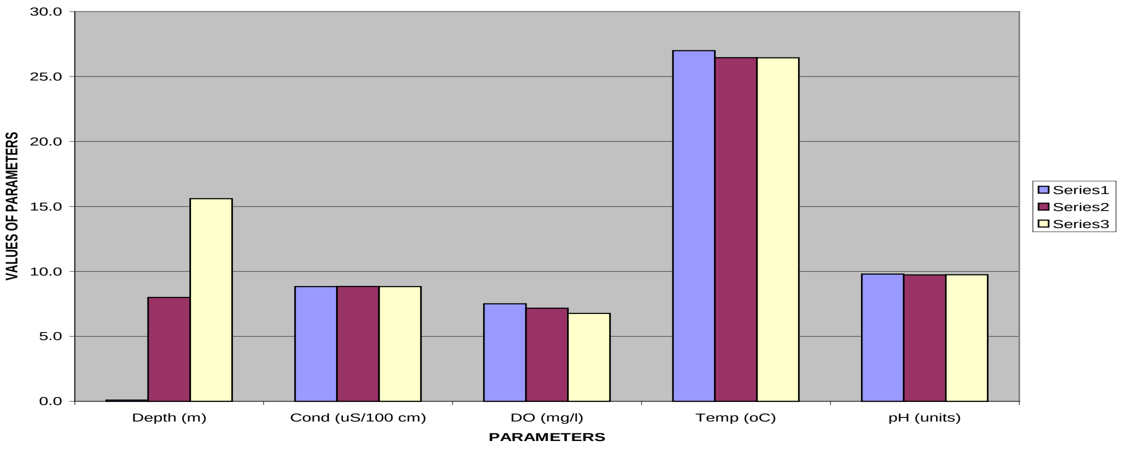


Fig. 5: Profiles of Parameters by Depth in Lake Edward at Sampling Station UL (near Katwe Fishing Village)

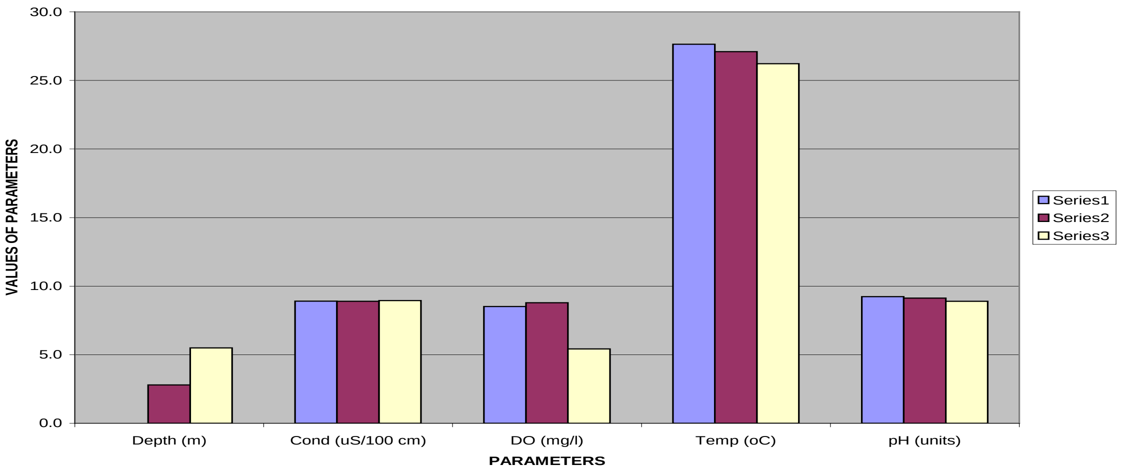


Fig. 6: Profeles of Parameters by Depth in Lake Albert at Station ALB001 (near Kisenyi in DRC)

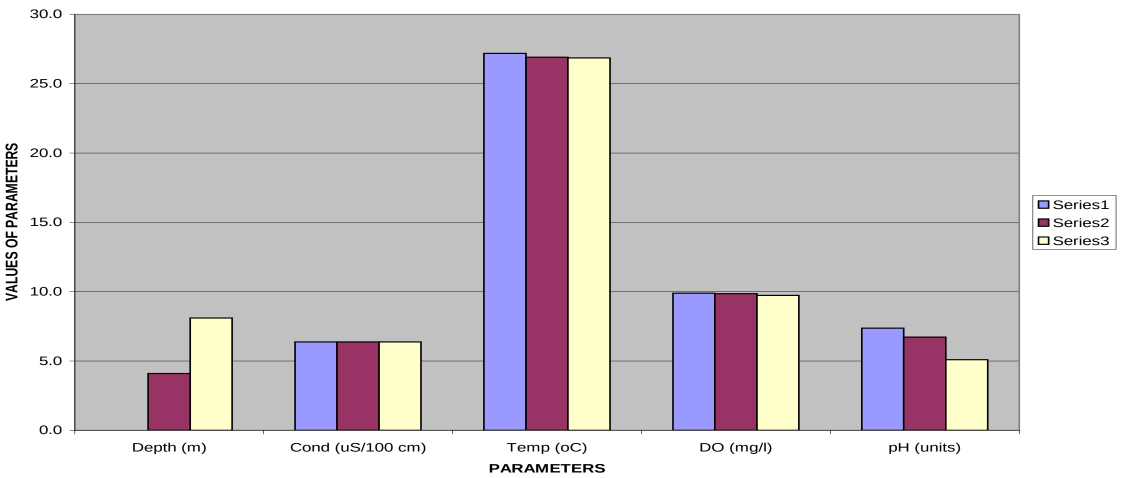


Fig. 7: Profiles of Parameters by Depth in Lake Albert at Station ALB002 (near Ntoroko Fish Laning)

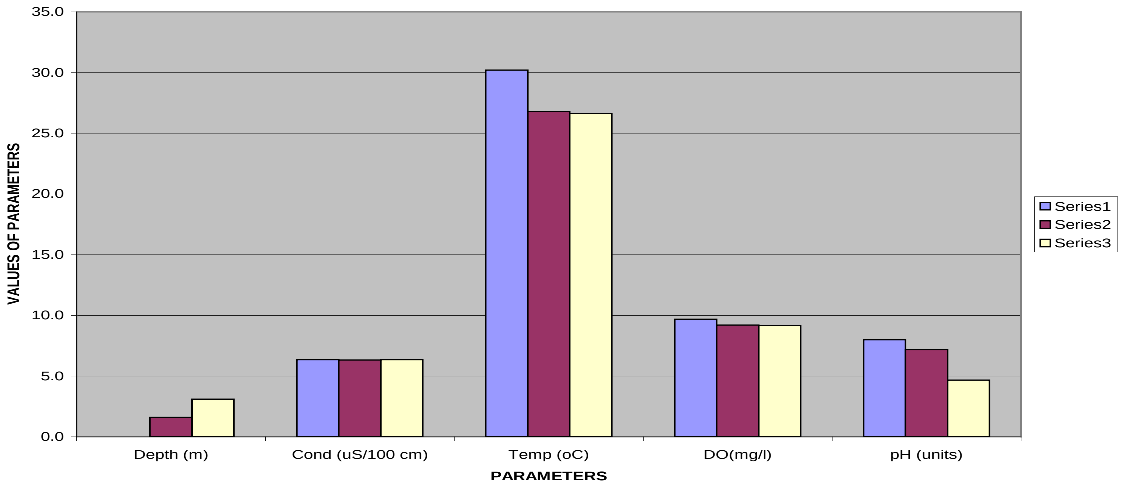


Fig. 8: Profiles of Parameters by Depth in Lake Albert at Station ALB005 (Centre of Lake DRC side)

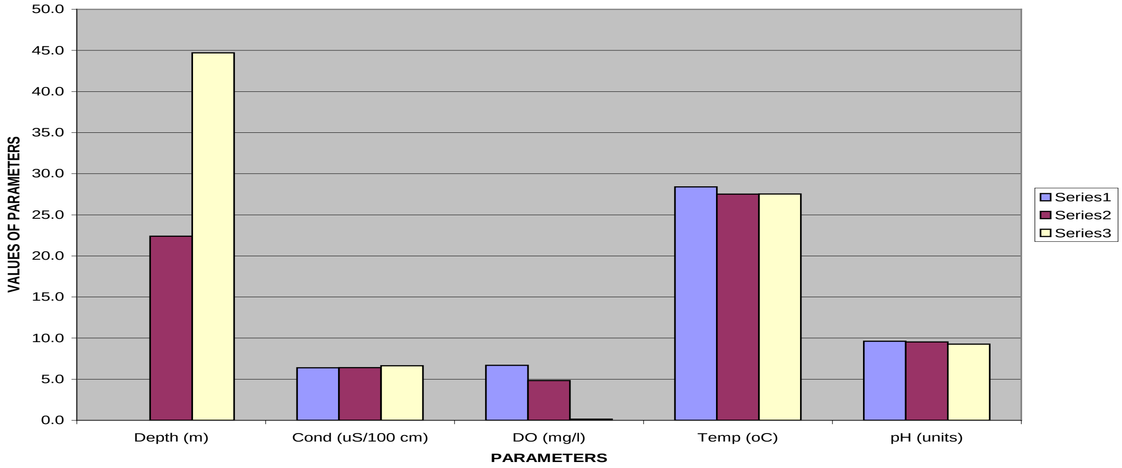


Fig. 9: Profiles of Paramters by Depth in Lake Albert at Station ALB006 (Centre of Lake on Uganda side)

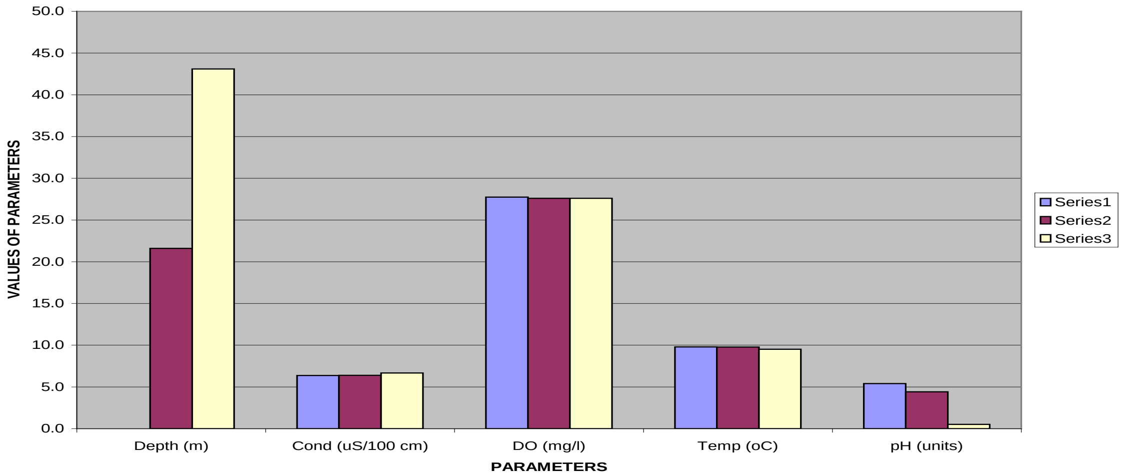


Fig. 10: Profiles of Parameters by Depth in Lake Albert at Station ALB013 (Entrance of Victoria Nile)

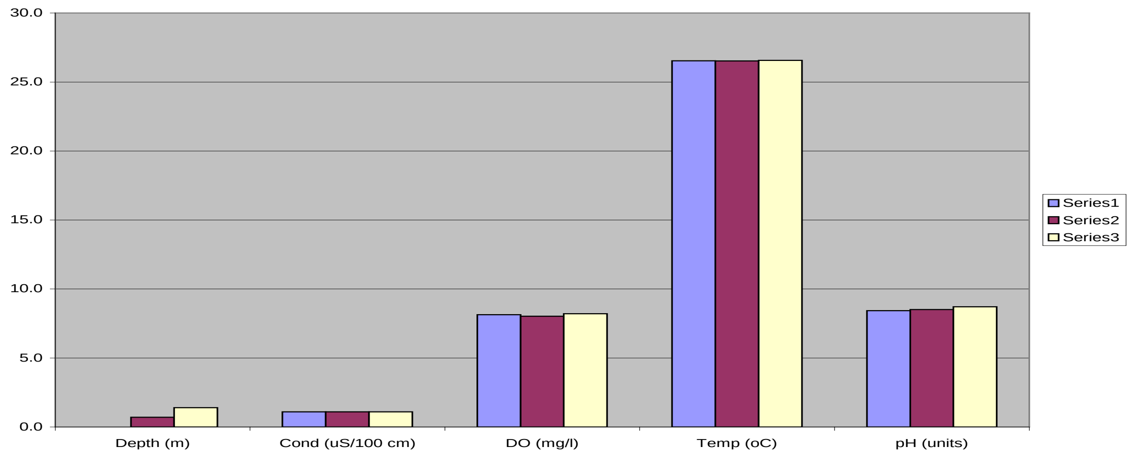


Fig. 11: Profiles of Parameters by Depth in Lake Albert at Station ALB014 (Exit of Albert Nile)

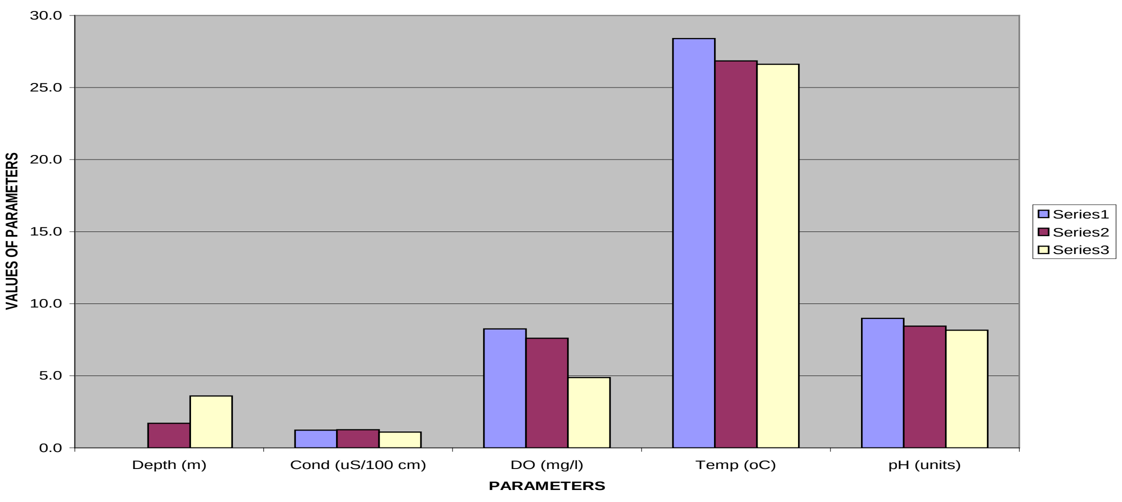


Fig. 12: Profiles of Parameters by Depth in Lake Albert at Station ALB015 (near Mahagi Port in DRC)

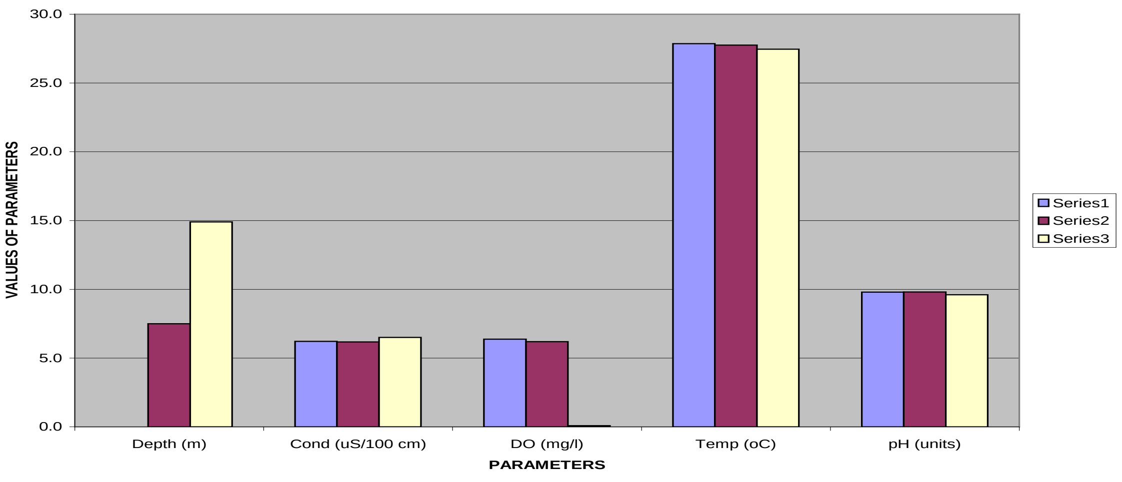


Table 4.3.5: Variation of Parameter Values by Sampling Stations at the (a) Surface (1a) and Bottom (1b) of Lake Edward and Surface (2a) and Bottom (2b) of Lake Albert

(1a) COMPARING MEASUREMENTS BY STATIONS OVER **SURFACE** OF **LAKE EDWARD**						
Station	Conductivity	DO	Temp	pH	Chlorophll a	Sechi Depth
1. REE 1	2.87	6.79	27.68	10.26	15.06	2.1
2. RME1	8.92	7.64	26.88	10.17	0.7	20.8
3. CL 1	8.92	7.69	27.84	10.41	1	13.5
4. UCP 1	8.83	7.51	26.99	9.79	0.63	16.8
5. UL 1	8.91	8.51	27.64	9.23	0.79	15.7
(1b) COMPARING MEASUREMENTS BY STATIONS OVER **BOTTOM** OF **LAKE EDWARD**						
Station	**Conductivity**	**DO**	**Temp**	**pH**	**Names of Locations**	
1. REE 1	5.9	2.39	25.96	10.26	Kazinga entrance at Mweya	
2. RME 1	8.92	7.39	26.88	10.18	Outflow at Semliki River	
3. CL 1	9.45	3.25	26.58	10.42	Inshore at Vitshumbi, DRC	
4. UCP 1	8.83	6.77	26.44	9.74	Centre of the lake, DRC	
5. UL 1	8.95	5.42	26.22	8.9	Inshore near Katwe, Uganda	
(2a) COMPARING MEASUREMENTS BY STATIONS OVER THE **SURFACE** OF **LAKE ALBERT**						
Station	**Conductivity**	**DO**	**Temp**	**pH**	**Chlorophll a**	**Sechi Depth**
1. ALB 001	6.37	9.89	27.19	7.37	11.2	8
2. ALB 002	6.35	9.69	30.21	7.99	9.9	17.9
3. ALB 005	6.39	6.69	28.4	9.61	10.7	25
4. ALB 006	6.38	5.4	27.74	9.79	13.6	25
5. ALB 013	1.1	8.14	26.54	8.43	14.4	3
6. ALB 014	1.23	8.25	28.4	8.98	18.2	7.9
7. ALB 015	6.22	6.38	27.86	9.79	17.4	17.9
(2b) COMPARING MEASUREMENTS BY STATIONS OVER THE **BOTTOM** OF **LAKE ALBERT**						
Station	**Conductivity**	**DO**	**Temp**	**pH**	**Names of Locations**	
1. ALB 001	6.37	9.73	26.87	5.09	Entry of River Semliki	
2. ALB 002	6.35	9.17	26.62	4.67	Off Ntoroko Fish Landing	
3. ALB 005	6.39	0.15	27.53	9.26	At Center of Lake Albert	
4. ALB 006	6.38	0.51	27.61	9.52	Near Center Off River Hoimo	
5. ALB 013	1.1	8.21	26.57	8.71	Entry of Victoria Nile	
6. ALB 014	1.1	4.88	26.61	8.16	Exit of Albert Nile	
7. ALB 015	6.5	0.08	27.46	9.6	Off Mahagi Port	

Measurements of the profiles in the surface and bottom waters were selected because they can provide adequate comparative information on the spatial variation of parameter values. It can be observed that very low values of DO occur in the bottom waters of the confluence of Kazinga Channel and Lake Edward and near Vitschumbi in DRC where high chlorophyll 'a' counts and shallow secchi depth measurements was taken. The bottom offshore water of Lake Albert is also devoid of DO.

Chart 4.3.2:Spatial Variation of Parameter Values by Sampling Stations at the Surface (1a) and Bottom (1b) of Lake Edward (Figs.13-14) and Surface (2a) and Bottom (2b) of Lake Albert (Figs. 15-16)

Fig. 13: Spatial Variation of Parameter Values By Sampling Stations on Lake Edward

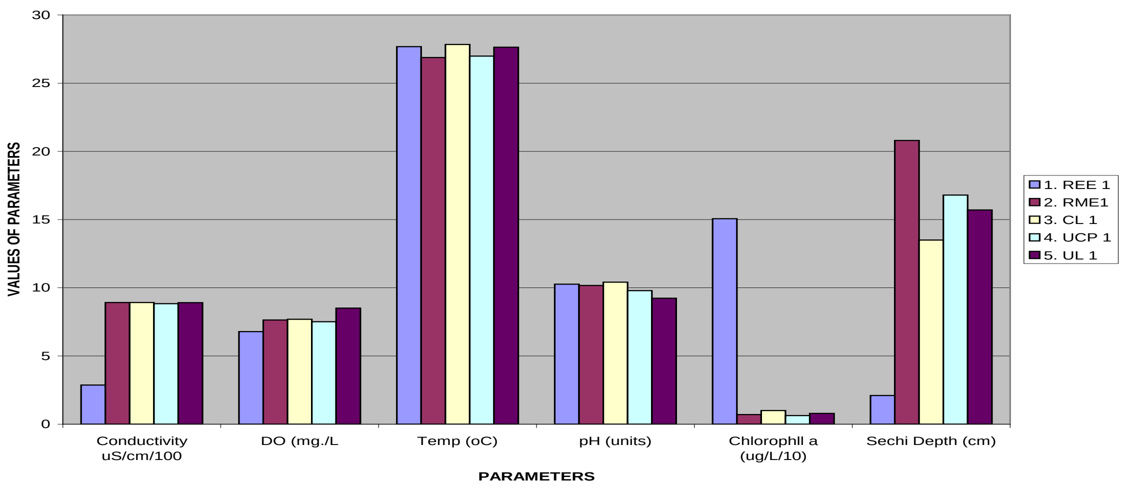


Fig. 14: Spatial Variation of Parameter Values by Sampling Stations near the Bottom of Lake Edward

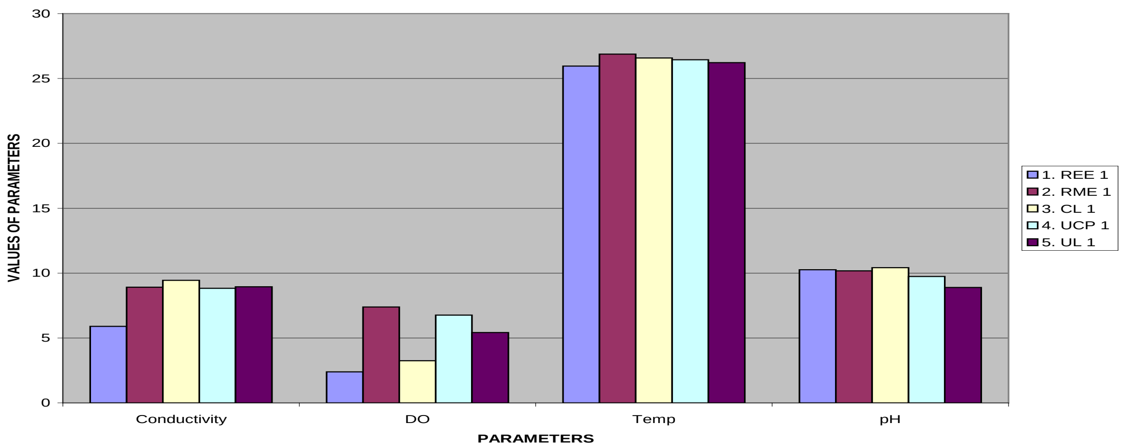


Fig. 15: Spatial Variation of Parameter Values by Sampling Stations in the Surface Water of Lake Albert

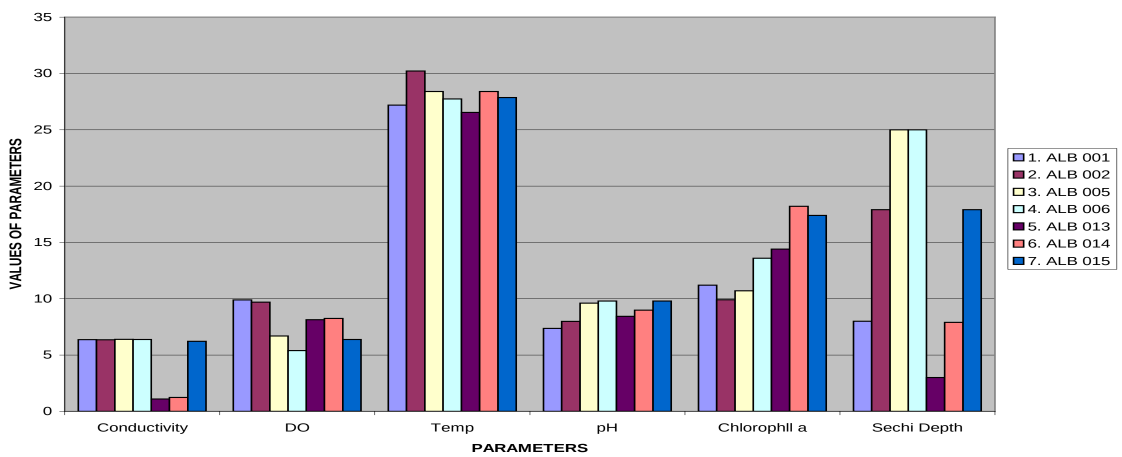
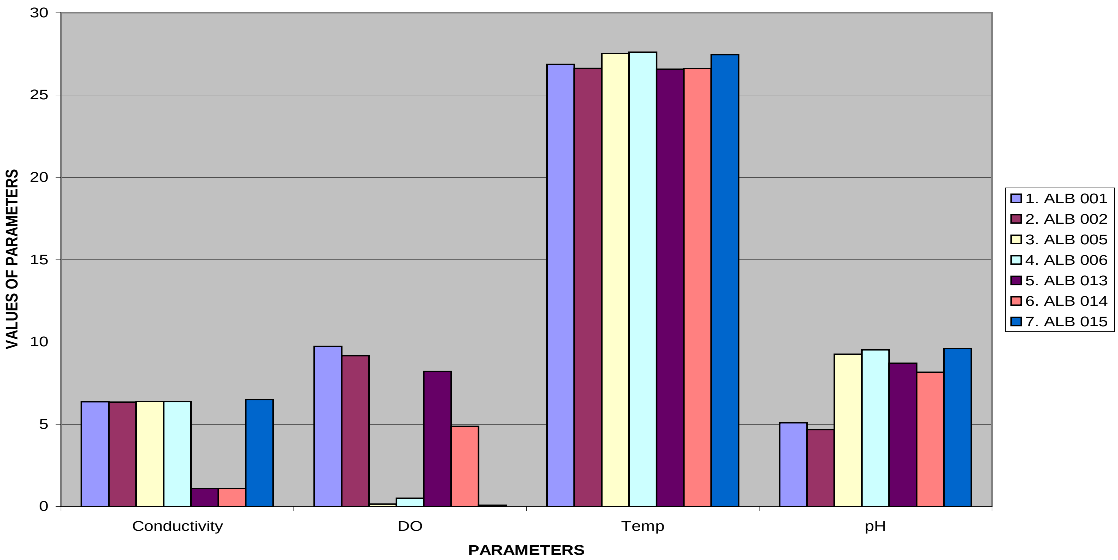


Fig. 16: Spatial Variation of Parameter Values By Stations near the Bottom of Lake Albert



Overall, the results from the profiles of DO, Temp., EC, pH and measurements of Chlorophyll '*a*' and Secchi Depths and laboratory analysis of Total and Faecal Coliform appear to indicate that each of the two lakes reacts homogeneously as both have a small surface area although deep (maximum depth: 120m and 60m respectively). Both lakes appear to be biologically very productive.

Apart from the bottom waters of Lake Albert at the mouth of River Semliki where the conditions are acidic (i.e. values between 4.67 and 6.72 Ph units), the rest of the waters of the two lakes have pH values averaging 8.5 units. This is being attributed to leaching of volcanic soils from the rift valley catchments, and in the case of Lake Albert, also due to inflows from hot springs (Matagi, 2002). The high levels of pH and EC recorded, which are similar to previous records (Talling, 1965 and Matagi, 2002) indicate that the lakes are moderately saline and alkaline. The isolated acidic case in southern Lake Albert could be due to the papyrus swamps through which River Semliki flows before entering Lake Albert.

The DO in most parts of the two lakes is above 4 mg/L level, and they can therefore support the lives of fish and other organisms. The mean value in Lake Edward is 7.4 mg/L with the exception of the area where the Kazinga Channel enters the lake near Mweya Hotel. The mean value in Lake Albert is 8.2 mg/L except for the deeper waters of the lake (over 40 m) where readings showed levels between 0.15 and 0.51 mg/L. The high level of DO concentration appears to reflect high biodiversity in the two lakes as it is prerequisite for aerobic respiration. In addition, the high Temperatures recorded averaging over 26^{o}C enhances biological activities especially enzymatic and biochemical reactions that are temperature dependent. Besides influencing the solubility of gases in the water, this level of temperature also increases the rate of chemical reactions and evaporation.

Chlorophyll '*a*' measures algal biomass. The values recorded in most parts of the two lakes, ranging from 6.3 to 10 mg/L in Lake Edward do not signify excessive eutrophication, and hence no accelerated nutrient loading from human activities in the catchments. However, Chlorophyll '*a*' readings from Lake Albert (9.9 to 18.2 mg/L) are exceedingly high indicating significant progress towards eutrophication. Further, very high level of Chlorophyll 'a' was recorded at the confluence of Kazinga Channel with Lake Edward at Mweya Lodge Pier of 150.6 mg/L. Sechi Depth was also shallowest (21 cm) at this same location. This reflects an accelerated nutrient loading from expanding human activities in the catchments of Lake George that is drained by the Kazinga Channel in addition to indicating serious raw sewage discharge into the Kazinga Channel-Lake Edward areas from Mweya Lodge. The Total and Faecal Coliform counts at this location were 4000 and 2000 per 100 mls respectively indicating serious organic pollution. The nearest counts of 157 and 8 per 100 mls were at the Inshore Station near Katwe Fish Landing. Other areas of the two lakes still appear to be safe. Shallow areas at the entrance of River Semliki into Lake Albert and entrance of Victoria Nile near Wanseko Fish Landing also contain heavy algal concentrations, but these could be due to the swampy environment at these locations in addition to nutrients arriving from the catchments of the two rivers.

B. Laboratory Analyses

Results for Total Coliform and Faecal Coliform as well as that of Chlorophyll '*a'* are shown in **Tables4. 3.3** and **Table4. 3.4** and in **Chart4.3.1** (Figs.1-12) for Lakes Edward and Albert respectively. Results for other parameters for Lake Edward are illustrated in **Table 4.3.6** and in **Chart 4.3.3** which depict measurements for samples collected at 0.5M depth and those at different depths near the bottom of the lake in mg/L. These include Total Suspended Solids (TSS) at 105^{o}C, Total Suspended Solids at 500^{o}C, Total Alkalinity (TA), Phenolphthalein Alkalinity, Total Phosphates (TP), Phosphates (P), Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Total Nitrogen (TN), Sulphates (S), Chlorides (Cl), Nitrites (NO_2) and Nitrates (NO_3).

Table4. 3.6: Values of Parameters Sampled from Lake Edward by Stations at 0.5M, Middle (*except at Shallow Stations*) and near Bottom

Source Name		**REE1 (0.5 M)**	**REE1 (3.5 M)**	**UCP (0.5M)**	**UCP (5M)**	**UCP (20M)**
Lab Number		**E12482**	**E12483**	**E12484**	**E12485**	**E12486**
Parameter	**Units**					
Total Suspended Solid at (105^{o}C)	mg/l	50	54	3.0	9.0	9.0
Total Suspended Solid at (500^{o}C)	mg/l	2.0	12.0	2.0	<1.0	<1.0
Total Alkalinity	mg/l as $CaCO_3$	135	140	415	405	405
Phenolpthalein alkalinity	mg/l as $CaCO_3$	<2	<2	57	54	54
Total Phosphate	mg/l as P	0.37	0.41	0.27	0.21	0.21
Phosphates	mg/l	0.11	<0.08	<0.08	<0.08	<0.08
COD	mg/l	100	79	34	40	40
BOD	mg/l	5.52	5.34	1.50	1.44	1.44
Total Nitrogen	mg/l as N	3.65	4.79	<0.50	1.34	1.34
Sulphates	mg/l	12	13	29	29	29
Chlorides	mg/l	10	10	22	19	19
Nitrites	mg/l as N	0.009	0.006	<0.002	<0.002	<0.002
Nitrates	mg/l as N	0.04	0.02	<0.02	<0.02	<0.02
Continue with Results from the following Sampling Stations						

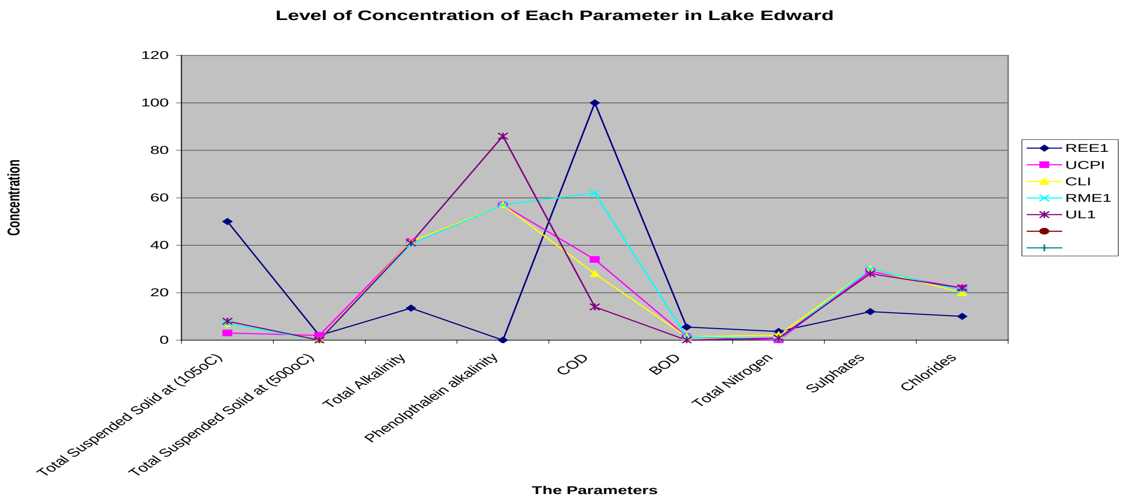
Source Name		**CLI (0.5M)**	**CLI (3M)**	**CLI (14M)**	**RME - 1 (0.5M)**	**RME - 1 (2.5M)**
Lab Number		**E12487**	**E12488**	**E12489**	**E12490**	**E12491**
Parameter	**Units**					
Total Suspended Solid at (105^oC)	mg/l	7.0	9.0	9.0	7.0	7.0
Total Suspended Solid at (500^oC)	mg/l	<1.0	<1.0	2.0	<1.0	<1.0
Total Alkalinity	mg/l as $CaCO_3$	415	415	400	405	415
Phenolpthalein alkalinity	mg/l as $CaCO_3$	57	56	63	57	72
Total Phosphate	mg/l as P	0.24	0.26	0.23	ND	0.16
Phosphates	mg/l	<0.08	<0.08	<0.08	<0.08	<0.08
COD	mg/l	28	22	15	62	1.0
BOD	mg/l	1.45	0.70	1.09	1.44	1.66
Total Nitrogen	mg/l as N	2.19	0.95	1.14	0.49	0.51
Sulphates	mg/l	30	31	29	30	28
Chlorides	mg/l	20	20	22	21	23
Nitrites	mg/l as N	<0.002	<0.002	<0.002	<0.002	<0.002
Nitrates	mg/l as N	<0.02	<0.02	<0.02	<0.02	<0.02

<u>Continue with the Results of the Following Sampling Stations</u>:

Source Name		**UL1 (0.5M)**	**ULI (5.0M)**
Lab Number		**E12492**	**E12493**
Parameter	**Units**		
Total Suspended Solid at (105^oC)	mg/l	8.0	12
Total Suspended Solid at (500^oC)	mg/l	<1.0	8.0
Total Alkalinity	mg/l as $CaCO_3$	410	415
Phenolpthalein alkalinity	mg/l as $CaCO_3$	86	55
Total Phosphate	mg/l as P	0.27	0.34
Phosphates	mg/l	<0.08	<0.08
COD	mg/l	14	6.0
BOD	mg/l	ND	1.76
Total Nitrogen	mg/l as N	0.86	2.3
Sulphates	mg/l	28	28
Chlorides	mg/l	22	23
Nitrites	mg/l as N	<0.002	<0.002
Nitrates	mg/l as N	<0.02	<0.02

Generally, Lake Edward has low level TSS (> 15 mg/L) except for the high level of over 50 mg/L encountered at the entry of Kazinga Channel into the lake at Mweya Hotel (Station REE1). Since TSS is associated with plankton abundance, the high level obtained at REE1 indicates localized eutrophication at REE1. The high figures (> 400 mg/L) of Total Alkalinity obtained at all Sampling Stations except at Station REE1 is a sign that the lake is saline or has dilute saline water. This is pertinent in that the values of Phenolphthalein Alkalinity (PA) were found to be high (between 50 and 90 mg/L) at all stations except REE1 where it measured less than 2 mg/L.

Chart 4.3.3: Distribution of Parameter Concentrations in mg./liter *at 0.5M Depth* in Lake Edward Shown as Figs. 17 and 18



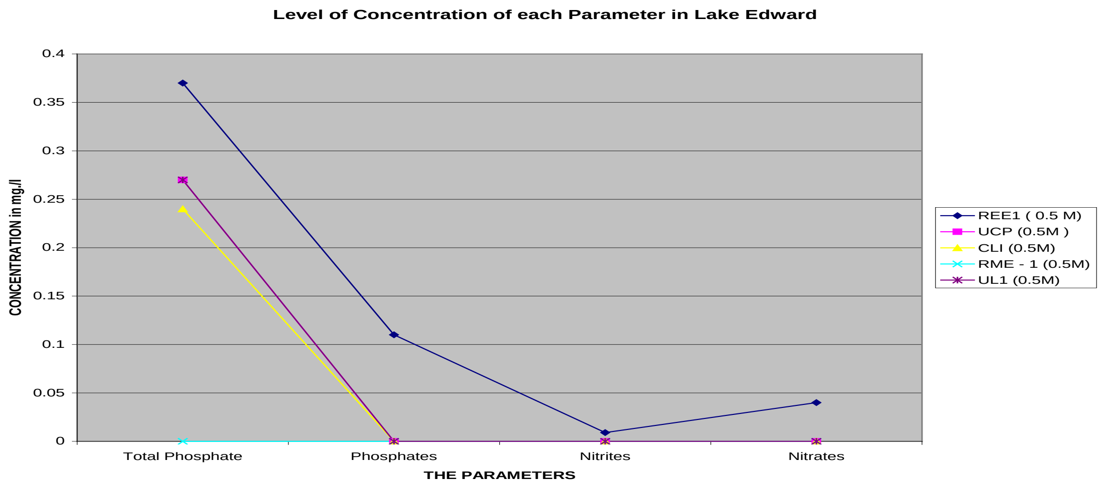
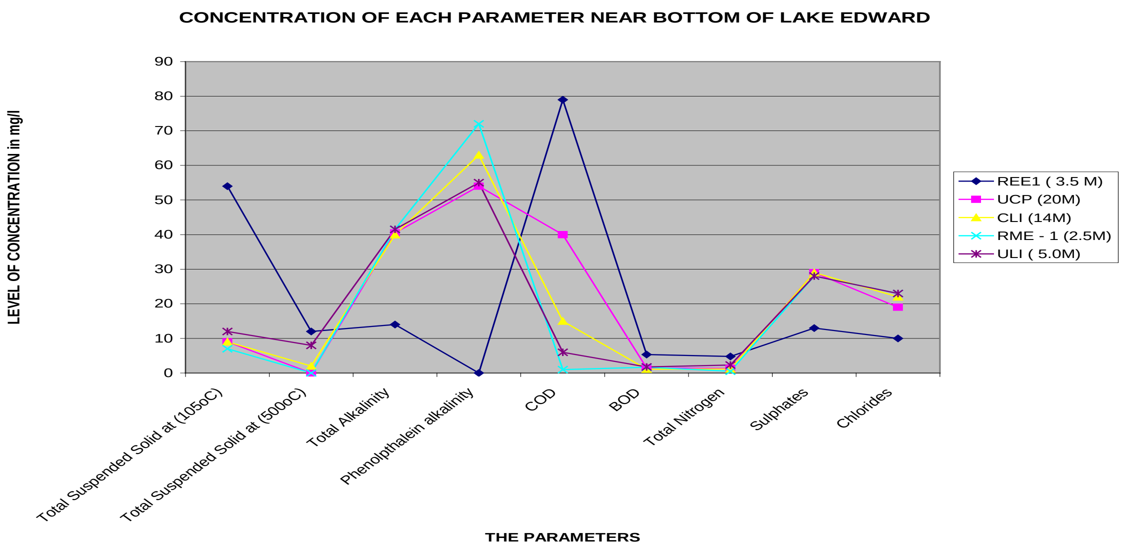
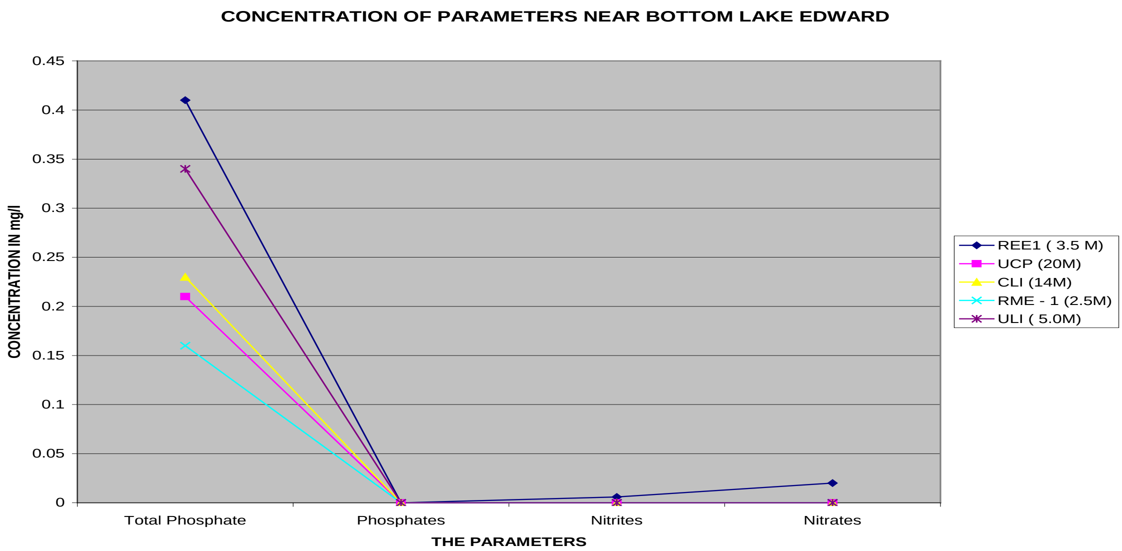


Chart 4.3.3: Concentrations of Parameters in mg. /liter at Depths Indicated *near the Bottom* of Lake Edward Shown as Figs. 19 and 20





The high pH in other parts of the lake other than Station REE1 is a sign that Bicarbonate (HCO_3^-) is the favoured alkaline ion and hence the lake is in a dilute state.
The mean value of Phosphate (PO_4^{2-}) for the lake was in the ranged of 0.08 mg/L which is higher than the 0.001 mg/L for pristine water but falls within the range of natural surface waters which is 0.005 – 0.02 mg/L (Chapman, 2006). Mean values for Total Phosphorus (TP) ranged between 0.21 and 0.41 mg/L which means Lake Edward is Oligotrophic although some eutrophic lakes are known to have such low values of TP because most of it may be locked up in algal biomass (DWD, 1998).

The BOD value for unpolluted water is 2 mg/L (five day) (Chapman, 1996) but the BOD for Lake Edward averaged 1.5 mg/L which mean very little organic accumulation in the lake except at REE1 where the value was recorded at 5.4 mg/L which is a sign of high accumulation of organic material and an on-going eutrophication around the mouth of Kazinga Channel within the vicinity of Mweya Hotel. The COD value for unpolluted water is 20 mg/L (Chapman, 1996), but apart from the samples taken from Station UL1, i.e. off Katwe Fishing Village which was 14 mg/L in the surface water and 6 mg/L in the bottom water, the rest of the stations revealed higher figures. Station REE1 near Mweya Hotel had 100 mg/L at the surface and 79 mg/L at the bottom which is localized. The other stations showed a range between 22 mg/L and 69 mg/L but there appears to be no serious sign of pollution.

Total Nitrogen (TN), Nitrites and Nitrates were found to range from 0.5 to 2.19 mg/L. TN was 0.002 mg/L for Nitrite and 0.02 mg/L for Nitrate at all the Sampling Stations except at REE1 where it was 4.2, 0.008 and 0.03 mg/L for TN, Nitrite and Nitrate respectively. These are the direct indicators of agricultural, industrial, and domestic sewage runoffs from the catchments. In the case of Lake Edward, the values observed do not reflect serious pollution or high decay of algae except for the green soup of algae near Mweya Hotel.

Measurement of Sulphates (SO_4^{2+}) averaged at 30 mg/L at practically all Sampling Stations in Lake Edward. Although Sulphates are major components of proteins, they are not generally associated with eutrophication directly, and they are easily broken down to Hydrogen Sulphide (H_2S) in water.

C. Observations on Catchments Environmental status

a. Lake Edward

Field observations were conducted within the Lake Edward Basin on both Uganda and DRC sides of the lake. Lake Edward Basin is a region of varied habitats that includes open grassland, grassland with thickets, thick bush, forest, swamp and lakeshore. It is connected to Lake George through the Kazinga Channel. The elevation of the area varies from about 910 m at the lake level to 1,390m in the area north of Katwe Town which comprises a scenic area of explosion craters, some containing salt lakes formed by volcanic activity some 10,000 years ago. The climate is cool with mean maxima near $28^{o}C$ and the mean minima around $18^{o}C$ in all months. The Basin in Uganda was declared Queen Elizabeth National Park (QENP) way back in 1925 and that in DRC was declared Parc National des Virunga (PNV) in 1935. According to the records of the QENP (1995), there are 66 species of mammals in addition to other species such as squirrels, bats, rats, and mice. The main biomass contributors are hippopotamus, elephant, buffalo, Uganda kob and topi. Intense grazing and trampling by the larger animals such the hippopotamus and elephants tend to reduce grass cover in some instances to bare earth for several miles inland of the lakes and large wallows that are both aesthetically unsightly. There is a profusion of bird life totaling 545 species (QENP, 1995) that is associated with the variety of habitats. Apart from fish and aquatic invertebrates that are listed elsewhere, other vertebrates and invertebrates are less known. Within the lake basin, five fishing enclaves (Kayanja, Katwe, Kazinga, Kisenyi and Rwensama) were curved out in Uganda and three in the DRC although six more seem to have come up of recent in the DRC. Some of these, like Katwe, Rwensama, Kyavinyonge and Vitschumbi have become public town council enclaves. The total population in the Lake Edward basin is given as about five million people. Major towns include Rukungiri, Bushenyi and Kasese in Uganda and none within the basin in the DRC. Industrial establishments include Hima Cement Factory, Cobalt Processing Plant and some mining on the Ugandan side.

b. Lake Albert

Lake Albert Basin is similar to the Lake Edward region with varied habitats that includes open grassland, grassland with thickets, thick bush, forest, swamp and lakeshore. It is connected to Lake Edward through River Semliki in the south in addition to eleven (11) smaller rivers on the Ugandan side and ten (10) on the DRC side draining into the lake. Victoria Nile joins the lake on the northern part and the only outlet is through the Albert Nile. The elevation of the area varies from about 910 m at the lake level to 1,390m at the top of the escarpment on the Ugandan side while it goes as high as 2,420 m on the DRC side which comprises a scenic area of mountains formed from volcanic activity some 10,000 years ago. The climate is cool with mean maxima near $28^{o}C$ and the mean minima around $18^{o}C$ in all months. The northern catchments in Uganda were declared Murchison Falls National Park (MFNP) way back in 1925. The central section in Uganda became the Murchison Falls

National Park Conservation Area and the southern portion became the Kabalega Game Reserve while that in DRC was declared Parc National des Virunga (PNV) in 1935. According to the records of the MFNP (1995) and PNV (1988), there are 66 species of mammals in addition to other species such as squirrels, bats, rats, and mice on both sides of the lake. The main biomass contributors are hippopotamus, elephant, buffalo, kob and topi. Intense grazing and trampling by the larger animals such the hippopotamus and elephants tend to reduce grass cover in some instances to bare earth for several miles inland of the lakes and large wallows that are both aesthetically unsatisfactory but also create severe soil erosion, although hippopotamus do have positive qualities in the maintenance not only of rangeland but also of the aquatic food chain. There is also a profusion of bird life totaling 545 species (MFNP, 1995) that is associated with the variety of habitats. Apart from fish and aquatic invertebrates other vertebrates and invertebrates are less known. Within the lake basin, there are many fishing enclaves such as Ntoroko, Tonya, Butiaba, Bugoigo, Wanseko and others which were curved out in Uganda and as many others in the DRC including Mahagi, Mahagi Port, Tchomia, Kisenyi and Ndowe. Some of these, like Ntoroko, Tonya, Butiaba, Wanseko, Panyimur, Mahagi, Tchomia and Kisenyi have grown to become town councils. The total population in the Lake Albert basin is given as about twelve million people. Major towns include Bundibugyo, Hoima, Masindi and Bulisa in Uganda and Mahagi Port in the DRC. Industrial establishments include oil exploration, agricultural and fish processing and mining.

The lake supports an important community of fishermen who depend entirely on the maintenance lake and its the ecosystem. The catchments provide a landscape where agricultural activities, deforestation and overstocking of livestock are a major feature alongside the key protected areas of global significance described above. There is, at the moment, no integrated catchments management system for this area. Consequently, this seems to have lead to conflicting initiatives that have translated into soil erosion, deforestation and loss of soil productivity particularly in the rift valley. Climatic changes have, further, exacerbated the problems by adversely affecting biodiversity and particularly water sources. For the first time, River Nkusi in Uganda dried up before it reached Lake Albert about two years ago and this has become an annual event. Similarly decreased water quantity was observed in the other rivers draining into the lake. The quality of the water appeared to be deteriorating as the water flowing in the various rivers looked brown in color apparently due to high sediment loads. Crops were seen growing on the river banks and some on dried river beds. The use of pesticides and herbicides on crops was not confirmed. Some of the permanent wetlands along the road from Hoima to Busi have been encroached upon and set on fire to support pastoralists' livestock and to act as refugia for cultivation during the dry season. This is obviously one of the ways the wetlands lost their purifying and water storage capacity and hence the visible deterioration of water quality in the rivers and the lake.

One significant observation was that the catchment of Lake Albert is experiencing an influx of immigrants from highly populated areas like Kabale and West Nile in Uganda and Goma and Bunia in the DRC. The situation is being compounded by the influx of refugees from the DRC fleeing political strife. Government authorities allocated vacant land that is of great importance to conservation of biodiversity and maintenance of the authentic integrity of the catchments area for refugee settlements. Because the new arrivals have no attachment to the land and yet they have to survive, they ended up degrading the environment by deforestation, poor soil husbandry, pit sawing, cultivating near rivers and poisoning wildlife including Lions. Influxes of refugees, poor hygiene and congestion in settlement areas particularly fish landing sites, have led to the outbreak of water borne diseases like cholera, typhoid and dysentery.

It was observed that the water quality of Lake Albert was facing an ever increasing rate of deterioration. There have been reported cases of algae blooms and poisonous *cynobacteria* (Blue-green algae), an indication of nutrient enrichment and a clear sign of eutrophication (DWD, 1998).

Ferralitic, ferrisol and hydromorphic soils are the main types of soil found in the catchments (Harrop, 1960). Ferralitic soils cover a vast part of the catchments. The soils are mainly yellowish-red clay loams on sedimentary beds. Highly leached, reddish brown clay loams are found towards Masindi and Hoima on the plateau. There are also dark brown, black loams found along the axis of the warp. The soils of recent origin that consist of quartzite are found along the escarpment.

The vegetation of the area can broadly be classified into forest, savannah, grassland and swamps (NEMA, 1998; Plumptre *et al.* 2003). Forest vegetation covers most of the areas. Vegetation cover includes broad-leaved riverine tropical high forests trees and plantations with species such as pine. Budongo Central Forest Reserve in Uganda is located on the top of the escarpment east of Lake Albert on the edge of the western rift valley. This is the biggest forest in East Africa (Masindi District Environment Profife, 2005). The great Ituri Forest in the DRC lies on the western side of Semliki River. Other reserves include Bugoma Central Forest Reserve, Bugungu Wildlife Reserve and Karuma Wildlife Reserve which are in the Ugandan catchments and the Virunga National Park in the DRC. According to information received from the Forest Department in Uganda, some natural forest cover in the reserves has been lost due to illegal charcoal burning, timber harvesting and desire to create land for cultivation and settlement. Honey extraction is also practiced by honey bunters who have on several occasions felled big trees in central forest reserves in search for honey. In the process, they set fires ending up burning whole forest afreas. There are also cases of periodic wild fires during the dry seasons that affect natural regeneration especially in grassland patches of the natural high forest thus impeding re-colonization process.

4.3.3. Analysis of the Main Issues in Water Quality and Catcment Environment for the development of an Integrated Lakes Management Plan

The selection of water quality parameters for study in this component is an important step in determining lake water pollution levels and the setting up of a water quality monitoring programme (Chapman and Kimstach, 1996). For this purpose, the following has been considered in the selection of target parameters for determining water quality.

- Parameters were selected because they are an indicator of the purity of the aquatic environment;

- Parameters that act as indicators of the impact of human activities on the aquatic environment and therefore, reflecting pollution and deteriorating environmental quality; and
- Parameters can be used in the management of the catchments through an integrated water resource approach.

Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD):
BOD is a direct measure of the amount of biologically degradable organic matter present in a water sample. It is a measure of the amount of organic pollution in rivers and lakes. It is an indirect indicator of the purity of an aquatic environment. COD is widely used as a measure of the susceptibility to oxidation of organic and in organic matter present in a water body. It is a direct indicator of pollution.

Colour and Turbidity determines the depth to which light is transmitted. They, in turn, control the amount of primary productivity. Natural minerals like ferric hydroxide and humic acids give colour to water. In a degraded environment where soils are exposed and erosion occurs it is an indication of siltation.

Dissolved Oxygen (DO) is the most important parameter in aquatic ecosystems after water itself (Wetzel, 1980). It is a prerequisite for aerobic respiration and is responsible for self-purification processes in natural waters. Its abundance and saturation often directly reflects high biodiversity in aquatic ecosystems. Conditions below 4mg/l cannot support many fish species, and fish kills are observed at below 2mg/l for most fish. It is also a direct measure of organic pollution. The oxygen content of natural water varies with temperature, salinity, turbulence, atmospheric pressure and photosynthetic activity.

Electrical Conductivity (EC), Salinity and Total Dissolved Solids (TDS): EC is a measure of the ability of water to conduct an electric current. It is related to concentrations of TDS and major ions in water by a factor between 0.55 and 0.75. Its continuous monitoring in rivers is useful in the management of temporal variations in TDS and major ions. TDS is directly proportional to electrical conductivity and influences salinity.

Hardness, Bicarbonate, Carbonate, Carbon Dioxide: Hardness is an important parameter to measure and water can be classified into soft or hard water. Hard water has economic implications of causing scales in boilers and poor lather formation in laundry. It is an indirect determination of Ca^{2+} and Mg^{2+} - its major cation constitutes. The main anions that contribute to hardness are CO_3^{2+} and HCO_3^-. These also influence alkalinity. CO_2 and HCO_3^- are important sources of carbon for algal photosynthesis. These parameters provide general information above the water ionic content and buffering capacity.

Major Cations and Anions: Major cations include Ca^{2+}, Mg^{2+}, Na^+ and K^+, while the major anions are CO_3^{2-}, HCO_3^-, SO_4^{2-} and Cl^-. These parameters control or influence EC, hardness, alkalinity and pH which in turn influence the limno-chemistry of aquatic environments.

Microbiological Indicators: The presence of coliform bacteria and faecal coliform bactieria is a confirmation test of the presence of human and animal waste contamination. Since the catchments have water borne epidemics like cholera, typhoid and dysentery, the measurement of these tests enables the provision of information on the linkage between water contamination and out breaks of epidemics.

Nutrients: The major algal nutrients are nitrogen and phosphorus. Nitrogen occurs as nitrogen gas (N_2), ammonia (NH_4^+), nitrite (NO_2^-) and nitrate (NO_3^-), while phosphorous occurs at phosphate (PO_4^{2-}). These are measured in order to evaluate the extent of anthropogenic activities on aquatic environments. They are direct indicator of agricultural, industrial and domestic sewage runoff from the catchments. Their measurements enable the establishment of the trophic status of an aquatic ecosystem. Sulphates are nutrients needed in the synthesis of proteins. Their absence or low values in river water need further investigation, in order to understand the nutrient dynamics in the tropical aquatic environments.

Odour in water is a result of a volatile substance in water. Its presence suggests higher than normal biological activity and is a simple test for the suitability of drinking water. Warm temperatures increase the rate and production of odour-causing metabolic and decay products.

pH, Acidity and Alkalinity influence many biological and chemical processes in water bodies. pH is a measure of the acid balance of a solution and is defined as the negative of the logarithm to the base 10 of the hydrogen ion (H^+) concentration. The pH scale runs from 0 and 14 (i.e. very acidic to very alkaline), with pH 7 representing a neutral condition. At a given temperature pH (or the hydrogen ion activity) indicates the intensity of the acidic or basic character of a solution and is controlled by the dissolved chemical compounds and biochemical processes in the solution. Acidity and alkalinity are the base and acid- neutralising capacities (ANC) of water and are usually expressed as $mmol^{-1}$. The acidity of water is controlled by strong mineral acids, weak acids such as carbonic, humic and fulvic and hydrolysing salts of metal (e.g. iron, aluminium), as well strong acids. The alkalinity of water is controlled by the sum of the carbonate (CO_3^{2-}), bicarbonate (HCO_3^-) and hydroxide (OH^-), but may include contributions from borate (BO_4^2), phosphates (PO_4^{2-}), silicates (SiO_4^2) and other basic compounds.

Secchi Depth (Transparency) is a measurement of visibility in the water. It is determined by the type and concentration of suspended matter. Suspended matter consists of silt, clay, fine particles of organic and inorganic matter, soluble organic compounds, plankton and other microscopic organisms.

Temperature is a prerequisite for biological activities especially enzymatic and biochemical reactions that are temperature dependent. It affects physical, chemical and biological processes in water bodies which influence the concentration of parameters which, in turn determines the chemical composition of water. Increase of temperature increases the rate of chemical reactions and evaporation. It also influences the solubility of gases in a water body.

Total Suspended Solids (TSS) of a water sample corresponds to non-filterable and filterable residues. Total Suspended Solids is directly proportional to turbidity, colour transparency and secchi depth. TSS is also a direct measure of siltation in rivers which drain heavy cultivated catchments.

Zooplankton, Phytoplankton, Secchi Depth and Chlorophyll "a": The determination of these parameters enables the establishment of the trophic status of a lake. Chlorophyll "a" provides an indication of suspended algal biomass in the water and can be used to determine the susceptibility of a water body to algal blooms.

The diagnostic results obtained so far from historical records, from observations and from direct profile measurements of the above key parameters from all the selected sampling stations tend to show that the waters of Lakes Edward and Albert are generally unpolluted apart from localized pollution, for instance, at river mouths, the area around Mweya Safari Lodge and near Fishing Villages such as Katwe, Kyavinyonge, Vitschumbi and Mahagi Port.

Apart from the bottom waters of Lake Albert at the mouth of River Semliki where the conditions are acidic (i.e. values between 4.67 and 6.72), the rest of the waters of the two lakes have pH values averaging 8.5. This is being attributed to leaching of volcanic soils from the rift valley catchments, and in the case of Lake Albert, also due to inflows from hot springs (Matagi, 2002). The high levels of pH and EC recorded, which are similar to previous records (Talling, 1965 and Matagi, 2002) indicate that the lakes are moderately saline and alkaline. The isolated acidic case in southern Lake Albert could be due to the papyrus swamps through which River Semliki flows before entering Lake Albert.

The DO in most parts of the two lakes is above 4 mg/L level, and they can therefore support the lives of fish and other organisms. The mean value in Lake Edward is 7.4 mg/L with the exception of the area where the Kazinga Channel enters the lake. The mean value in Lake Albert is 8.2 mg/L except for the deeper waters of the lake (over 40 m) where waters indicated de-oxygenation with readings of between 0.15 and 0.51 mg/L. The high oxygen levels appear to reflect high biodiversity in the two lakes as it is prerequisite for aerobic respiration. In addition, the high Temperatur**es** recorded averaging over 26^{o}C enhances biological activities especially enzymatic and biochemical reactions that are temperature dependent. Besides influencing the solubility of gases in the water, high temperatures also increase the rate of chemical reactions and evaporation.

Chlorophyll 'a' measures algal biomass. The values recorded in most parts of Lake Edward ranged from 6.3 to 10 mg/L. This, therefore, does not signify excessive eutrophication, and hence no accelerated nutrient loading from human activities in the Lake Edward catchment. However, very high level of Chlorophyll 'a' was recorded at the confluence of Kazinga Channel with Lake Edward at Mweya Lodge Pier of 150.6 mg/L. **Sechi Depth** was also shallowest (21 cm) at this same location. This reflects an accelerated nutrient loading from expanding human activities in the catchments of Lake George that is drained by the Kazinga Channel in addition to indicating serious sewage discharge into the areas from the Lodge. The Total and Faecal Coliform counts at this location were 4000 and 2000 per 100 mls respectively. The nearest counts of 157 and 8 per 100 mls were at the Inshore Station near Katwe Fish Landing.

In the case of Lake Albert, Chlorophyll 'a' readings ranged from 9.9 to 18.2 mg/L Shallow areas at the entrance of River Semliki into Lake Albert and entrance of Victoria Nile near Wanseko Fish Landing also contain heavy algal concentrations, but these could be due to the swampy environment at these locations in addition to nutrients arriving from the catchments of the two rivers.

The other target parameters that are still being analyzed in the laboratory shall reveal more information for further interpretation of the water quality status of the two lakes.

4.4 HYDROLOGY AND WATER RESOURCES

4.4.1 Introduction

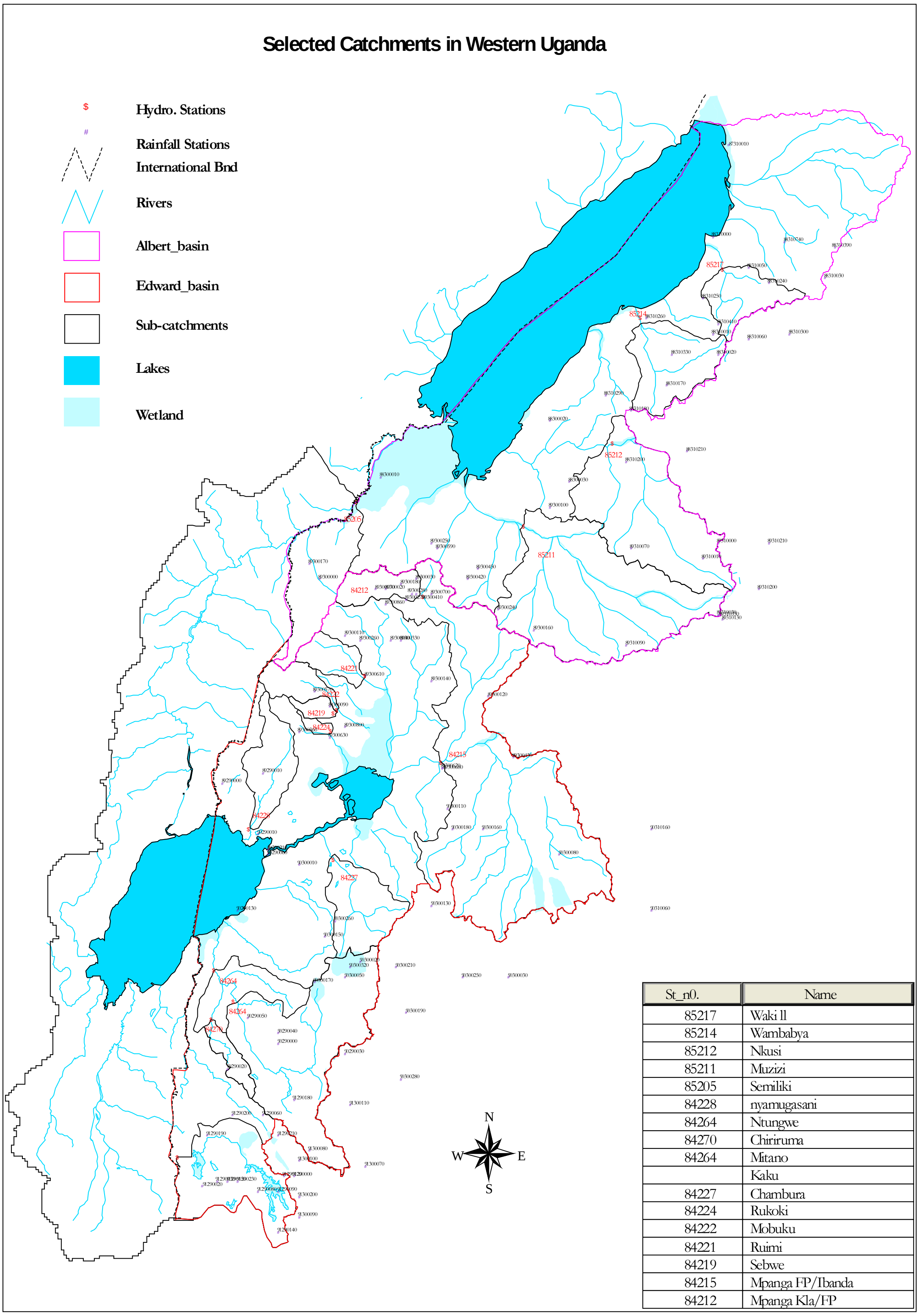
This diagnostic progress report covers the period January – July 2007 and describes major activities undertaken under the Lakes Edward and Albert Fisheries (LEAF) Pilot Project that are related to water balance modelling. The strategic objective during this period has been to prepare the necessary data required to develop an estimate of the total water balance for the lakes Edward, Albert and George over the period of 30 years and if possible to 50 years which involves compiling the following information:

- Rainfall onto, and evaporation from the lake surfaces.
- Discharges to the lakes from all gauged rivers around the lakes.

During this reporting period, the emphasis has been compilation and quality control of hydro-meteorological data. **Fig. 4.4.1** illustrates the major basins and location of gauged rivers in Uganda. It also indicates location of rainfall stations for which has been collected.

Detailed analysis of rainfall and runoff data has been carried out for the following 7 gauged catchments.

Station Number	Name of river
84222	Mobuku at Fort-Portal Kasese Road
85217	R. Waki II at Biiso - Hoima
84212	R. Mpanga at Kampala Fort Portal Rd
84215	R. Mpanga at Fort Portal Ibanda Rd
84267	R. Mitano at Kanungu Rwensama Rd
85211	R. Muzizi at Kyenjojo Hoima Rd
85212	R. Nkussi at Kyenjojo Hoima Rd
85214	R. Wambabya at Buseruka
84227	R. Chambura



St_n0.	Name
85217	Waki ll
85214	Wambabya
85212	Nkusi
85211	Muzizi
85205	Semiliki
84228	nyamugasani
84264	Ntungwe
84270	Chiriruma
84264	Mitano
	Kaku
84227	Chambura
84224	Rukoki
84222	Mobuku
84221	Ruimi
84219	Sebwe
84215	Mpanga FP/Ibanda
84212	Mpanga Kla/FP

Fig. 4.4.1: Drainage map of the Project Area

4.4.2 Data

The data that has so far been collected for this study is listed by type, location, length of record of data below for purposes of informing the stakeholders about the constraints or limitations and to justify the proposed approach. The details for rainfall data in **Fig. 4.5.1** are summarized in **Table 4.4.1** below.

Table 4.4.1: Rainfall

Station	Name	Climatic zone	Longitude	Latitude	Altitude	Mean annual rainfall (mm)	Years of record	Proportion of record that is complete (%)
89300000	Bundibujo	MW	30.067	0.700	1095	1293	1928 - 1966	37.1
89300010	Butiti	MW	30.067	0.700	1095	1350	1943- 1962	50
89300120	Nkoma	MW	30.617	0.317	1305	1031	1943 - 1977	73.3
89300140	Bigodi	MW	30.433	0.367	1350	1233	1943 - 1996	76
89300170	Nyaruru	MW	30.067	0.700	1095	1350	1943 - 1974	75
89300680	Bihanga prison Farm	MW	30.467	0.083	1333	1012	1965 - 1986	63.6
89300700	Rwebitaba	L	30.433	0.650	1425	1510	1969 - 1998	63.3
89300710	Kanyawara	MW	30.367	0.583	1667	1541	1968 - 1982	60
89300720	Bundibugyo	MW	30.050	0.700	1041	1276	1969 - 1985	64.3
89300860	Kinyamasika TTC	MW	30.283	0.617	1683	1347	1978 - 1999	27.3
89300360	Kilembe Mines	MW	30.000	0.200	1350	1504	1951 - 1997	81.8
89300450	Kikumiro	L	30.583	0.733	1440	1408	1952 - 1983	80
89300570	Mobuku HEP	MW	30.050	0.333	1392	1480	1957 - 1981	76
89300630	Kasese Met	MW	30.100	0.183	691	884	1964 - 2000	85.7
89300640	Mubuku Irr Scheme	MW	30.117	0.200	945	948	1965 - 1998	85.7
89300800	Mubuku Prison Farm	MW	30.150	0.217	1275	696	1971 -1993	60.9
90290010	Katwe	MW	29.867	-0.133	900	808	1943 - 1967	60.9
90290060	Mweya	MW	29.900	-0.200	945	697	1954 - 1976	60.9
90290210	Uganda Inst of Ecology	MW	29.900	-0.183	945	825	1964 - 1989	53.8
90290290	Ishasha River Camp	MW	29.650	-0.617	930	859	1973 - 1985	20
88300020	Kyangwali	L	30.817	30.817	1050	1140	1943 - 1982	63.9
88300040	Kasonga HM	L	30.783	1.183	1155	1245	1972 - 1977	66.7
88310000	Butiaba HM	K	31.350	1.817	615	757	1904 - 1977	79.5
88310010	Dwoli Estate	L	31.350	1.500	1200	1519	1915 - 1957	81
88310020	Hoima	L	31.367	1.433	1140	1425	1909 - 1962	68.9
88310050	Busingiro Forest	K	31.467	1.717	1080	1479	1933 - 1960	62.5
88310060	Bulindi Farm	L	31.467	1.483	1020	1338	1935 - 1996	69.9
88310140	Kinyala Estate	K	31.567	1.667	1080	1359	1943 - 1998	86.7
88310150	Kijunjubwa	L	31.767	1.467	1100	985	1943 - 1953	90.9
88310170	Kizirafumbi	L	31.200	1.333	1050	1319	1943 - 1979	75
88310180	Kabwoya	L	31.083	1.250	1200	1410	1943 - 1964	45
88310250	Kigorobya	K	31.317	1.617	1080	1200	1943 - 1967	66.7
88310260	Biseruka	L	31.133	1.550	600	930	1947 - 1977	77.4
88310290	Bugoma CFR	L	31.000	1.300	1050	1267	1963 - 1979	81.3
88310330	Bugambe Tea Estate	L	31.217	1.433	1079	1405	1965 - 199	71
88310340	Rwabikondo Estate	L	31.183	1.433	1051	1312	1965 - 1981	68.8
88310360	Nyamolobyo Estate	L	31.167	1.433	1061	1300	1965 - 1978	78.6
88310380	Siba	K	31.383	1.650	1021	1334	1966 - 1979	78.6
88310390	Kihonda Estate	K	31.750	1.783	1125	1333	1965 - 1994	64
88310410	Wampanga	L	31.367	1.533	1260	1597	1968 - 1995	60.7
88310520	Kisindi Group Farm	I	31.767	1.800	1050	1350	1968 - 1978	72.7
88310740	Kigumba Farm	K	31.583	1.800	1200	1142	1950 - 1985	79.4
88310780	Muntme Fatima Parish	L	31.167	1.317	1080	1491	1975 - 1985	54.5

Station	Name	Climatic zone	Longitude	Latitude	Altitude	Mean annual rainfall (mm)	Years of record	Proportion of record that is complete (%)
91290000	Kabale Met Station	CW	29.983	-1.250	1869	1021	1943 - 2000	86
91290040	Karengere	CW	29.800	-1.217	2400	1248	1943 - 1999	82.4
91290050	Kisizi Health Centre	CW	29.933	-1.000	1975	1149	1947 - 1953	28.6
91290060	Mafuga Forest	CW	29.883	-1.050	2205	1197	1948 - 1998	76.5
91290080	Bufundi Dispensary	CW	29.867	-1.300	2100	1226	1948 - 1994	55.2
91290090	Bwama Island	CW	29.933	-1.300	1890	997	1948 - 1994	70
91290100	Bukimbiri	CW	29.683	-1.183	1950	1352	1949 - 1956	75
91290120	Kachwekano DFI	CW	29.950	-1.250	2235	1016	1949 - 1995	72.7
91290140	Rubaya Dispensary	CW	29.933	-1.433	2280	1031	1954 - 1977	71.4
91290150	Chananke	CW	29.767	-1.267	2040	1217	1957 - 1985	75
91290160	Kashambya	CW	29.967	-1.050	1650	999	1957 - 1962	83.3
91290180	Nyarushanje	CW	29.983	-1.000	1950	1078	1962 - 1993	77.3
91290190	Rushanga Forest	CW	29.700	-1.117	2100	1427	1962 - 1994	71
90290000	Nyakibale	CW	29.933	-0.817	1560	1330	1943 - 1979	64.5
90290020	Kanungu	CW	29.767	-0.900	1560	1386	1943 - 1998	65.5
90290030	Kayonza	CW	30.150	-0.850	1020	1855	1948 - 1968	81
90290050	Bugangari Dispensary	CW	29.833	-0.733	1230	1186	1949 - 1987	71.8
90290130	Rwenshama Police Stn	MW	29.800	-0.383	900	675	1956 - 1978	53.8
90290140	Burema	CW	29.750	-0.850	900	1319	1957 - 1977	30
90290150	Rulind Swamp Inlet	CW	29.967	-0.983	900	1002	1957 - 1967	81.8
90290170	Kihihi Tractor Hire	CW	29.683	-0.750	1110	1235	1957 - 1997	70.6
90290200	Kitahulira Forest Station	CW	29.700	-0.983	1590	1552	1962 - 1980	68.8
90290270	Kaniabizo	MW	29.800	-0.683	1020	1237	1969 - 1974	50
91290220	Sabinio Forest Station	CW	29.633	-1.383	2700	1796	1966 - 1980	78.6
91290240	Muko Forest Station	CW	29.817	-1.200	2117	1162	1969 - 1977	88.9
91300020	Kitanga	CW	30.017	-1.117	1800	1029	1943 - 1961	78.9
91300070	Kamwezi	CW	30.217	-1.217	1500	946	1948 - 1973	73.9
91300080	Mparo Dispensary	CW	30.033	-1.167	1800	870	1948 - 1997	61.9
91300090	Kamuganguzi	CW	30.000	-1.383	1800	855	1948 - 1999	67.6
91300100	Bukinda Dispensary	CW	30.000	-1.200	1800	1012	1948 - 1998	82.1
91300140	Kitumba	CW	30.000	-1.300	1800	1060	1956 - 1964	88.9
91300200	Muembe Girls S. S	CW	30.000	-1.317	1830	886	1975 - 1999	68
91290020	Kisoro Police Station	CW	29.683	-1.283	1950	1163	1943 - 1998	75
91290030	Mutolere S.S.Sl	CW	29.733	-1.267	1845	1241	1943 - 1999	75
91290200	Ruhiza Forest Station	CW	29.783	-1.050	2310	1432	1962 - 1991	70
91290210	Kiriima Forest Station	CW	29.933	-1.117	1890	1156	1962 - 1999	73
91290230	Echuya Forest Station	CW	29.800	-1.267	2500	1144	1977 - 1999	57.1
90290040	Rukungiri Dispensary	CW	29.933	-0.783	1620	1229	1949 - 1985	55.6
89310000	Bukumi W Fr M	ME	31.367	0.817	1400	1231	1909 - 1957	71.7
89310010	Kakumiro Variety TC	ME	31.317	0.767	1350	1317	1944 - 1983	92.5
89310130	Kasenyi	ME	31.383	0.567	1320	1223	1943 - 1965	68.2
89310330	Mubende Hydromet	ME	31.367	0.583	1290	1238	1972 - 1999	59.1
90300080	Nyabusozi Saza Hqs	ME	30.850	-0.200	1350	917	1943 - 1974	58.6
90300160	Kanoni Gombolola Hqs	MW	30.600	-0.117	1350	929	1950 - 1998	54.2
90300180	Ibanda	MW	30.500	-0.117	1500	1010	1950 - 1993	70

It should be noted that there large gaps in the records, varying from one month to many years. The source of data is the Hydrology Departments of the Ministries responsible for water in & Meteorology Departments in Uganda. No data has been obtained from the DRC as yet and not much is expected. To illustrate the problem, we refer to **Fig. 4.4.2** below.

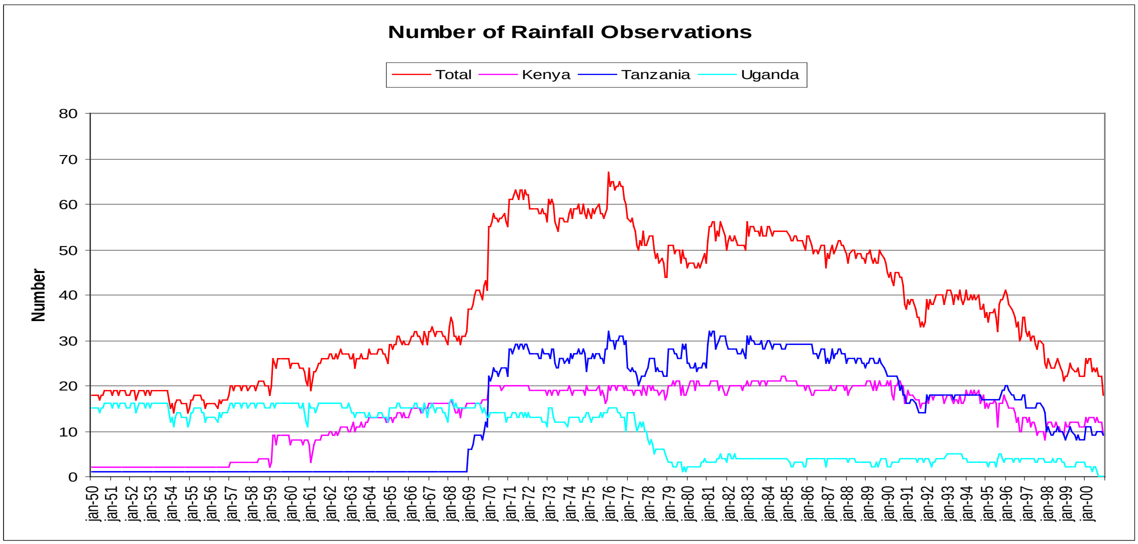


Fig.4.4.2. Number of rainfall observations 1950 –2000: Source – LVEMP Integrated Water Quality/Limnological Study.

The findings from this study with particular reference to Uganda are also relevant and similar to those tabulated for the project area. The figure shows clearly that the largest number of stations with observations occurs in the prior to 1950 to 1980, which was the period of the HYDROMET Project. The situation is the same with respect to Evaporation data. All stations in the project area have 5-7 years of data collected during the period 1977 – 1978 or 2000 –2002 at Masindi, Mbarara and Kabale. According to the archives of the Water Resources Department at Entebbe taken from HYDATA, the flow records that are available for gauges streams and lake level observations are tabulated below.

Table 4.4.2: Summary of Discharge Records

Station	Name	Drainage area (km²)	Years of record	Remark
84212	R. Mpanga at Kampala Fort Portal Rd	401	1956 – 1981, 1998 – to-date	Station was rehabilitated in 1998 and has been operational since then.
84219	R. Sebwe at Kasese Fort-Portal Rd	83	1968 – 1979	No current data
84221	R. Rwimi at Fort-Portal Kasese Rd	266	1952 - 1983	No current data
84222	R. Mobuku at Fort-Portal Kasese Rd	256	1952 - 1983	No current data. Presently, large scale abstractions and diversion to distributaries by Kasese Cobalt Company
84224	Rukoki at Fort Portal Kasese Rd	181	1954 - 1984	No current data
84228	R. Nyamugasani at Katwe – Zaire Rd	507	1954 – 1979 2000 – to-date	Re-established in the year 2000 and has since been operational
84264	R. Ntugwe at Katunguru – Zaire Rd	2,426	1958 - 1985	No current data
84267	R. Mitano at Kanungu Rwensama Rd	1,746	1958 – to date	Relatively long record
84270	R. Chiruruma at Katete – Kihihi Rd	162	1964 - 1997	Ok
84278	R. Chambura	1,183	1964 – to date	Ok
85205	R. Semliki at Bweramule	23,621	1950 - 1978	Current data available for year 2006 only
85211	R. Muzizi at Kyenjojo Hoima Rd	2,602	1956 – 1979 1997 – to date	Re-established after 1997
85212	R. Nkussi at Kyenjojo Hoima Rd	2,839	1956 – 1980, 1997 - todate	Re-established after 1997
85214	R. Wambabya at Buseruka	808	1969 - 1979	No current data

Station	Name	Drainage area (km^2)	Years of record	Remark
85217	R. Waki II at Biiso - Hoima	343	1967 – 1979 1997 – to date	Re-established after 1997
83209	Kyoga Nile at Paraa	349207	1963 – 1966, 1997 – to date	Nile inflow to Lake Albert. To be supplemented with Lake Kyoga Outflow at Kamdini & Masindi Port
87222	Albert Nile at Panyango	413046	1969 – 1979 1996 – to date	Nile outflow from Lake Albert. To be supplemented by data at Laropi
84206	L. Edward at Katwe	-	1965 – 1979 2000 – date	Water level station
84207	L. George at Kasenyi	-	1965 – 1978 2000 – to date	Water level station
85201	L. Albert at Butiaba	-	1950 – to date	Water level station. Relatively long with a few years of missing record
85206	L. Albert at Ntoroko	-	1966 - 1978	Water level station. Use to check consistency of Butiaba records

In addition, supplementary Runoff data has been compiled from annual reports of the Department of Hydrological Survey (1955, 1959, and 1960). Five river gauging stations for stations which do not exist in the archives of the Department of Water Resources Management are available are given in **Table 4.4.3** below.

Table 4.4.3: Supplementary Discharge Records

Station/Gauge No.	Name	Situation
842/01	Kazinga Channel	Levels in Kazinga channel Katunguru
842/02	Semliki	Flow data from Ishango at outlet of lake Edward in the DRC
842/03	Semliki	Flow data at Ngamba in the DRC
842/04	Semliki	Flow data at Bweramule
842/45	Kaku	Flow data below Mumwalo swamp- outlet of lake Mutanda

Relevant evaporation data (**Table 4.4.4**) has been extracted for relevant stations from the publication; Potential Evaporation in Uganda (Rijks, Owen & Hanna, 1970) and summaries of meteorological data observed over the HYDROMET Project area (1991).

Table 4.4.4: Evaporation Data

Station No.	Name	Year of available record/ status
09029008	Nyakatonzi	1960 – 1968
08930063	Kasese	1962-1968
08831003	Masindi	1962-1968, 1968 – 1981. Fragmented with many gaps
9129000	Kabale	1961- 1981. Fragmented with many gaps
8930079	Kyenjojo	1961- 1981. Fragmented with many gaps

4.4.3 Methods

The rainfall measurements registered within each of these catchments have been subjected to various quality control checks to identify erroneous data. The QC methods that have been adopted are:

- Visual examination of raw and plotted data.

- Calculate statistical properties (means, running means, max, min, standard deviation etc)
- Comparison with data at adjacent stations.
- Calculate accumulated mass curve to identify changes in measurement technique and changes in instrument location.

For each catchment, one or more reference stations have been chosen. These are normally the stations with the longest, continuous, high quality record in the area. The "double mass" curve method has been adopted to evaluate a given subject station against the reference station, and a trend line has been fitted to the curve. The equation of the trend line is used to fill as many gaps as possible in the subject station record. The process is illustrated in **Fig.4.4.3** below.

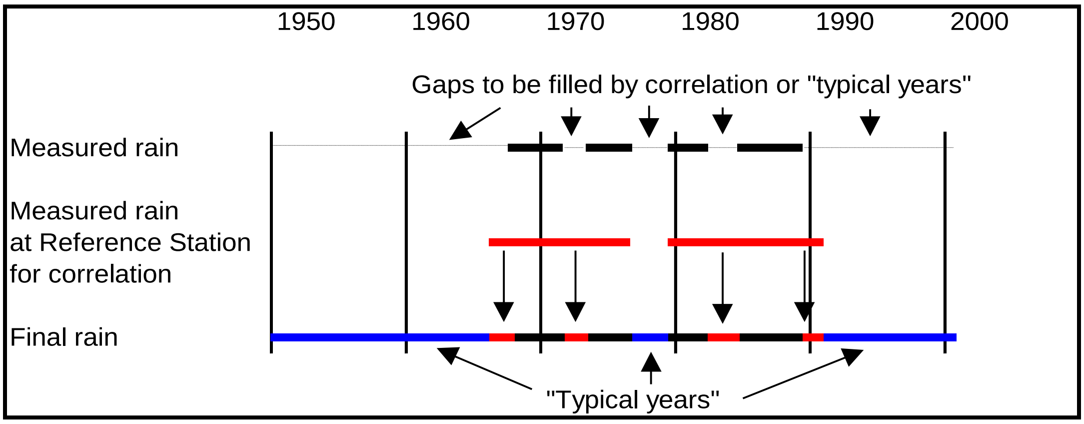


Fig.4.4.3: Procedure for filling gaps in rainfall records

A similar approach has been utilized to assemble the evaporation data. Discharges have been generated on the basis rating curves and the measured daily gauge heights (river water levels). Rating curve data at each gauging station (measurements of level and flow) have been quality controlled to remove outliers and erroneous data. Gaps in the record will be subsequently filled by rainfall-runoff modelling. The procedure is illustrated in **Fig.4.4.4** below:

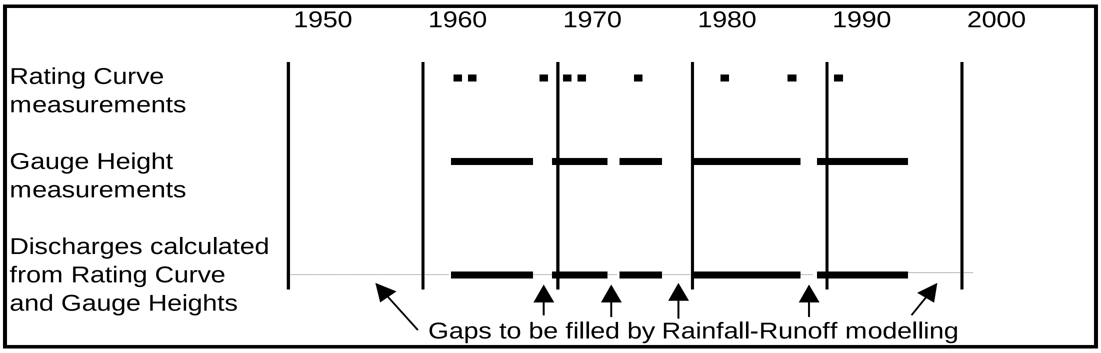


Fig.4.4.4 : Procedure for computation of river discharges

Since the main interest in the project is the discharge of water to the lakes, it is natural to concentrate on the stations nearest the mouth. However, in instances where the main catchment is also gauged upstream, discharges have also been computed from the various sub-catchments of each river with a view to finally determine the distribution of the runoff at later stages of this assignment.

In the inception report that was submitted to the client in March this year, a number of models rainfall runoff models such as the Sacramento Soil Moisture Accounting Model (SAC-SMA) or the NAM model were proposed for application. According to comments made to the 1st draft document of the inception report, the client expressed a preference for the NAM model. NAM is, like the Sacremento model, classified as a Conceptual Model with the following characteristics:

- Lumped (the entire catchment is considered as a single unit with uniform properties).
- The flow of water through the system is conceptualised into a number of reservoirs.
- The parameters partly reflect the physical properties of the catchments.

The structure of NAM is illustrated in **Fig.4.5.5** below.

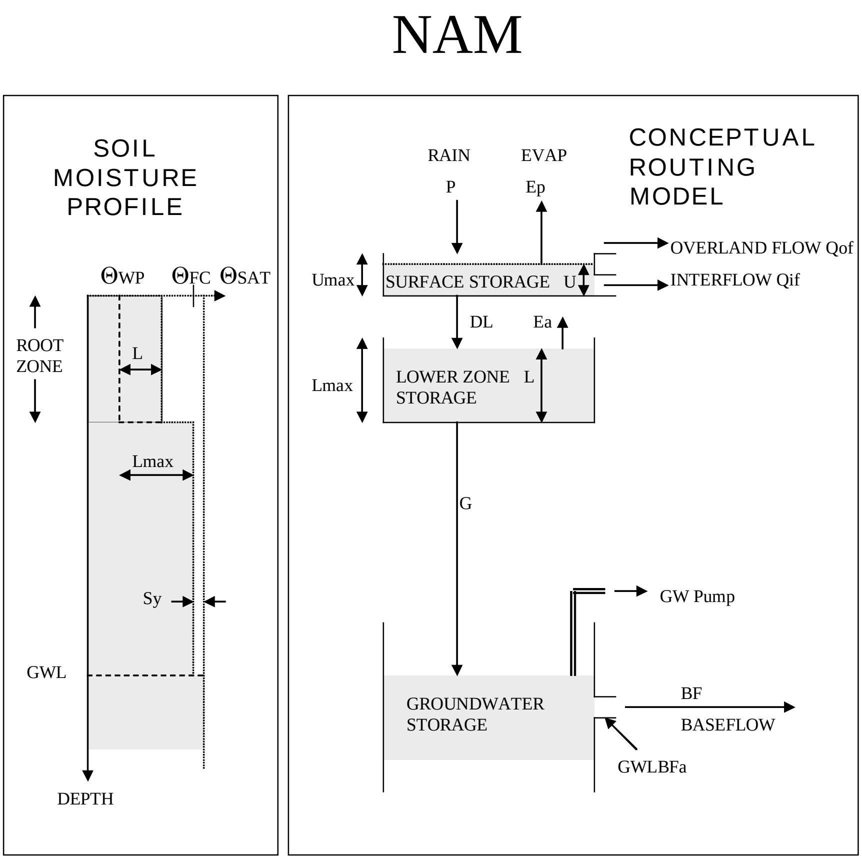


Fig 4.4.5: The structure of the NAM

The NAM model is calibrated on a period when there is simultaneous measured data for rainfall, evaporation and river discharges. The period should be at least 4 years long. **Fig.4.5. 6** illustrates the selection procedure for a catchment with two rainfall stations and one evaporation station.

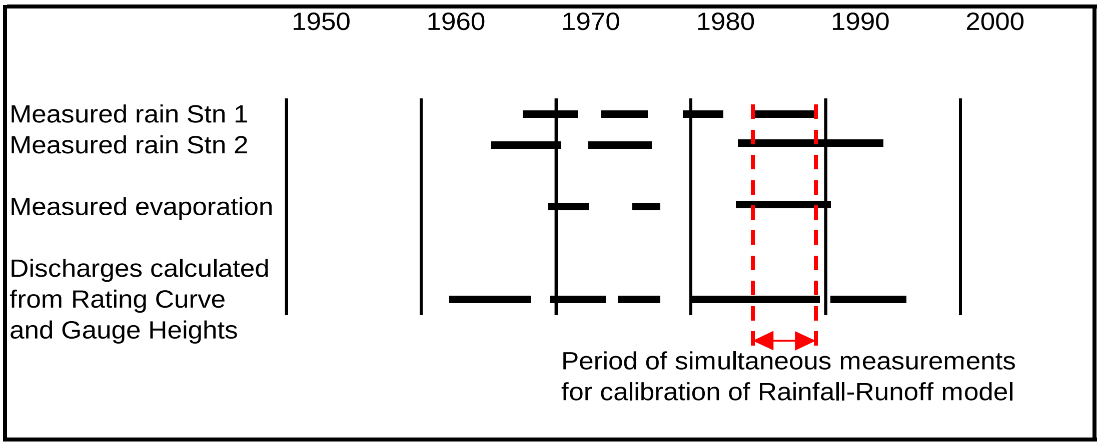


Fig.4.4. 6: Selection of calibration period for the NAM model

The next step is to apply the calibrated model to compute the runoff at the gauging station for a given period depending on the availability of data. The application uses the final rainfall and evaporation according to figure 6 below, can be generated for example, for the period 1950-2000.

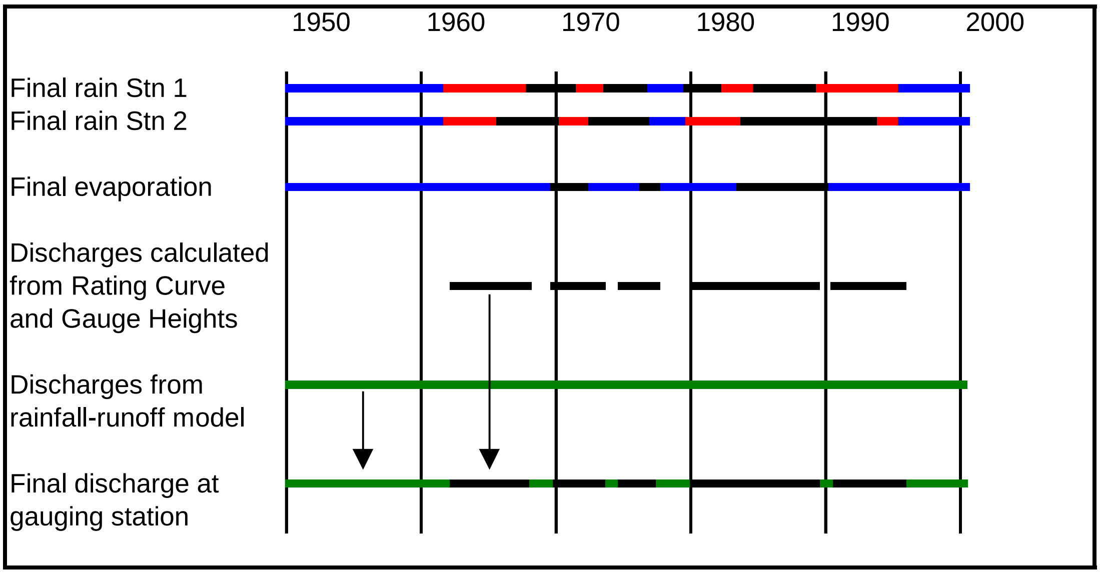


Fig.4.4.7:Application of the NAM model to obtain final discharges at a gauging station

4.4.4 Key Findings

A. River Mitano

Initially, a correlation between the discharges of the Mitano and Mpanga catchments was investigated. Mpanga was chosen because it is the closest catchment with a similar topography, aspect (flowing west) and shape, although it is more than twice the size of Mitano. The time series of the discharges where they overlap in time is illustrated under shown in **Fig. 4.4.8.**

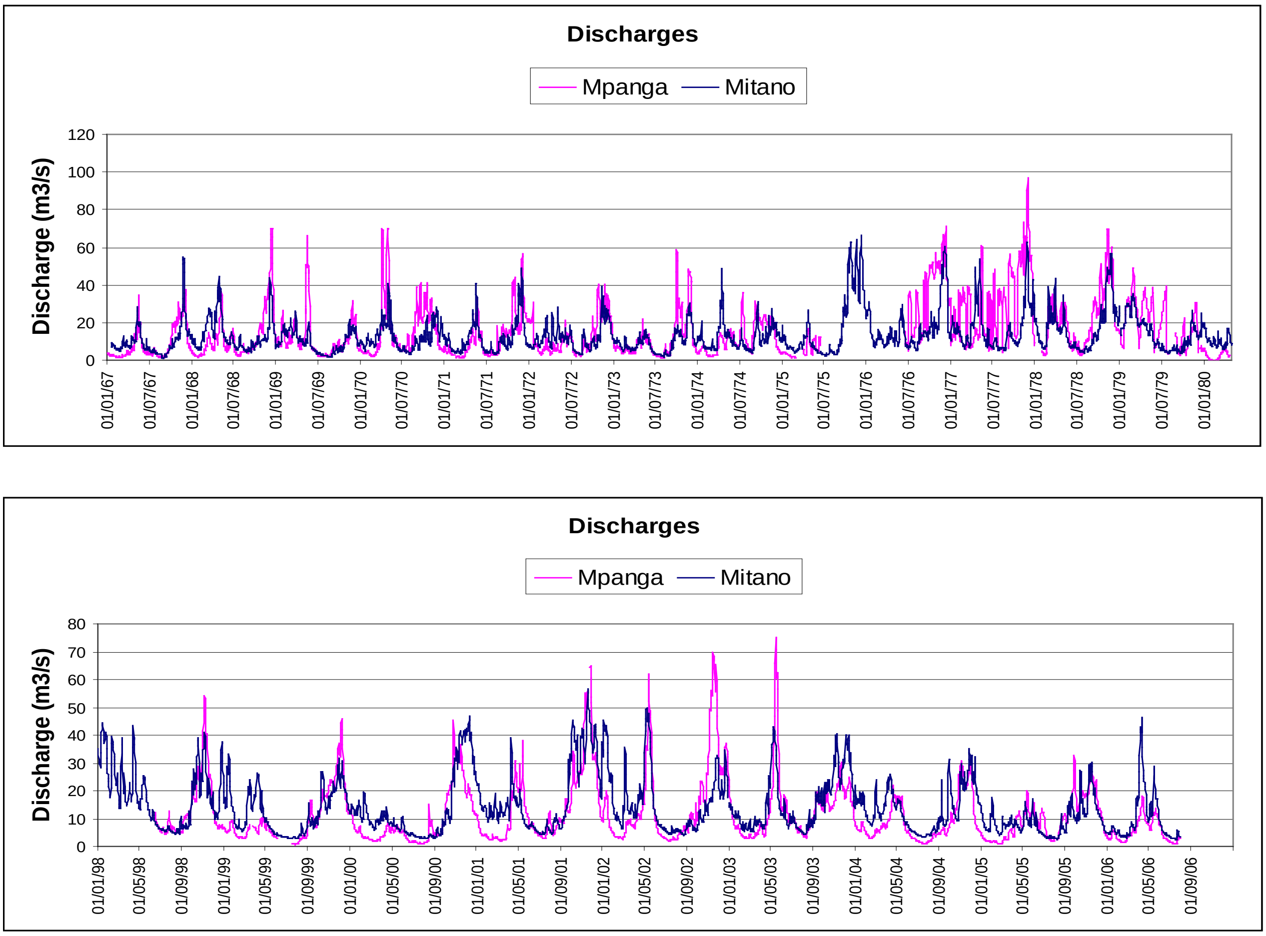


Fig. 4.4.8. The Mpanga and Mitano Discharges

It is evident that there is a serious difference in the discharge patters in the period July 76 to Dec 77. It can also be seen that the Mpanga catchment shows greater extremes, i.e. lower low flows and higher flood flows. A similar patter is evident when a comparison of the flow duration curves for the two catchments is prepared (**Fig. 4.4. 9**).

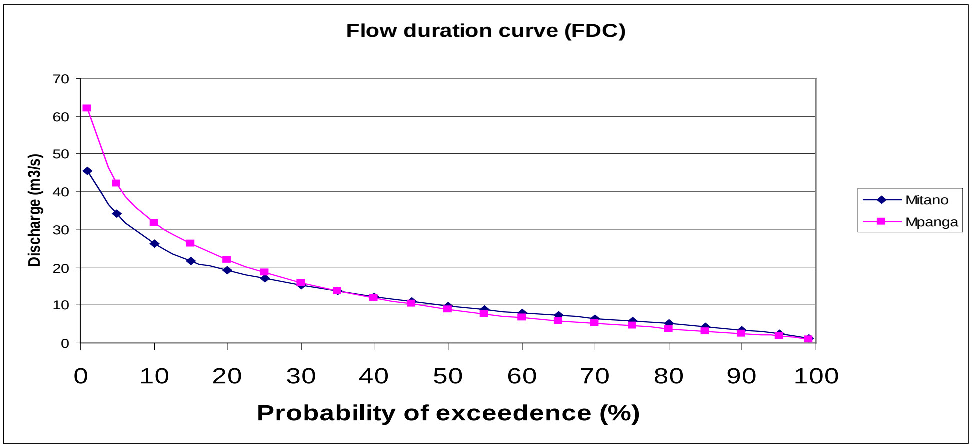


Fig. 4.4.9: Comparison of flow duration curves between Mitano and Mpanga

The Double Mass (DM) curve for two periods i.e. before 1975 and after 1998 were also compared (**Fig.4.4.10**). Neither of the two proved to be an acceptable as a basis for correlation.

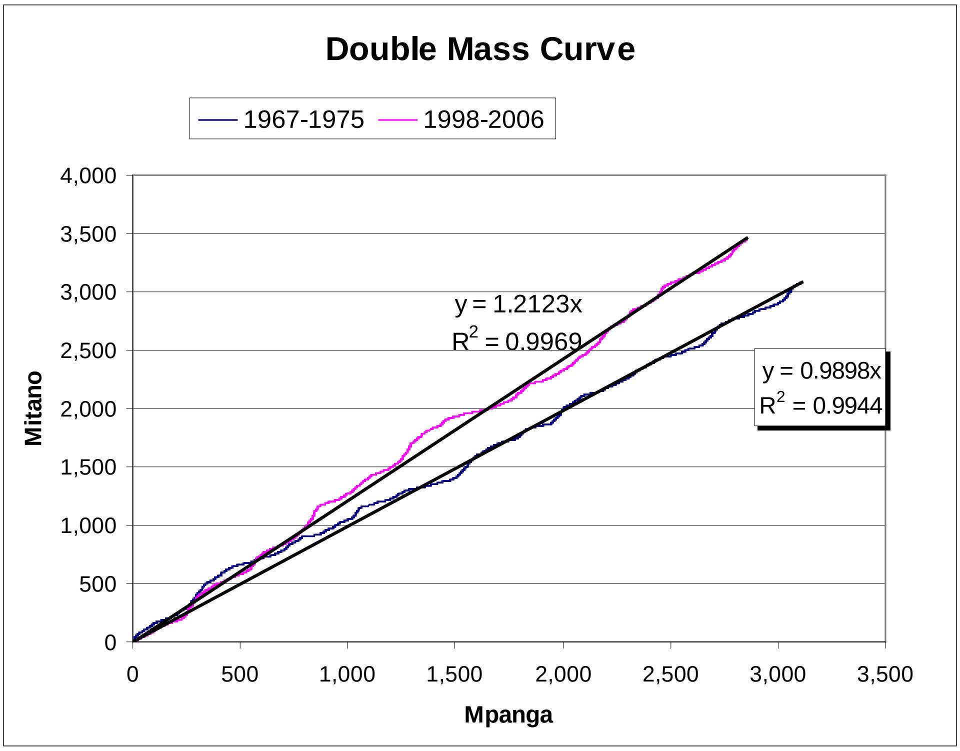


Fig.4.4.10: Comparison of Double Mass Curves – Mitano and Mpanga

Gap-filling of five rainfall stations within the catchment was carried out. These were at:

- Kitabi
- Rukungiri
- Kayonza
- Nyarushanje
- Mparo

The reference stations used for the gap-filling by correlation were Kitabi, Rubare and Bushenyi. An attempt was also made to gap-fill Bugangari, but the data at this station was found to be unreliable. There is only one evaporation station in the area which could be used, namely Kabale. It is at the same altitude which is an important factor. It has only about five years of measured data in the early 1970's and was gap-filled by correlation to Entebbe DWD data and with daily averages. Average rainfall over the catchment was obtained by the Thiessen polygon method. The NAM model was calibrated with data from 1967 to 1977 and applied to a test period of gap-filled rainfall and evaporation data from 1950 to 2003.

The final calibration results for Mitano catchment are illustrated in a composite manner under **Fig. 4.4.8.** The top figure compared measured and simulated discharges while the lower figure shows the compares the simulated and observed accumulated runoff. A comparison of the simulated and observed Flow Duration Curves is also presented under **Fig. 4.4.11**. It is clear that the low flow section of the curve is reasonably well reproduced by the model.

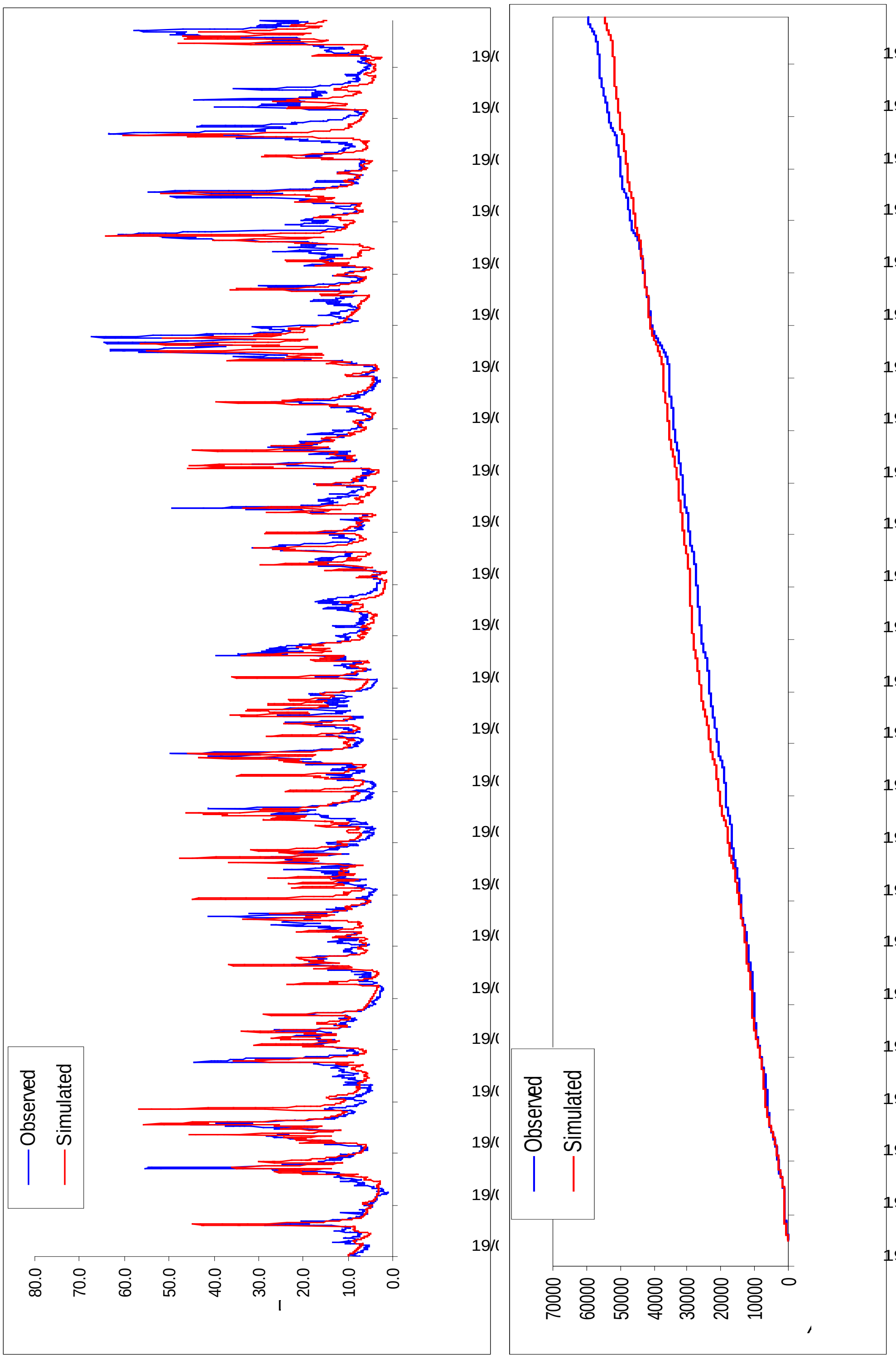


Fig. 4.4.11: Results of the NAM model calibration for the Mitano catchment

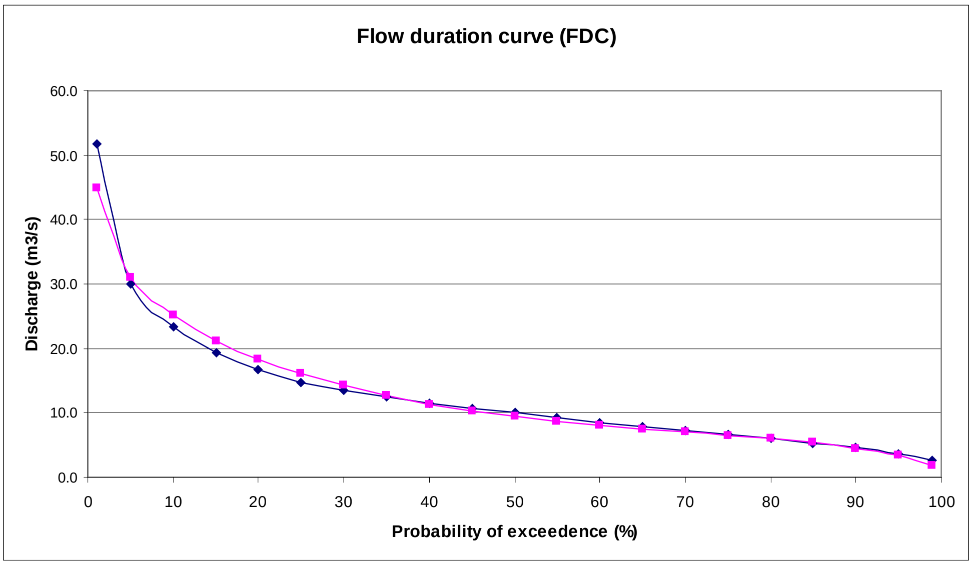


Fig. 4.4.12: Comparison of measured and modelled flow duration curves for the Mitano

The calibration process was very instructive in revealing errors in the rainfall data. These were:

- Kayonza rainfall data proved to be very high compared with the other stations and resulted in a runoff which was 50% higher than measured. No possible combination of calibration parameters could correct the problem hence Kayonza was deleted as a catchment rainfall station.
- An unrealistic high discharge occurred in June 1974, the dry season. An examination of the rain data showed very high rainfall at Kitabi but not at any other stations. It was concluded that the Kitabi record for this month was in error and it was replaced by correlation to Rubare.

NAM was then applied to the 54 year period 1950-2003 using the fully gap-filled rainfall and evaporation data. Comparison with the measured runoff showed once again some general errors in the data as follows:

- In general the there were significant discrepancies between observed and simulated runoff after the year 1980. The reason for this was established to be that the number of operational rain records was reduced dramatically after 1980. Utilisation of long-term average daily record of observed evaporation and detection of differences in the pattern of rainfall between stations in the northern part of the catchment as opposed to those in the southern part also improved the results
- Kitabi rain data was found to be unreasonably higher than all neighbouring stations in Jan-Apr 1994 and was consequently improved by correlation to Rubare. A similar occurrence was observed in May to Oct 2003 and rectified by correlation to Bushenyi.

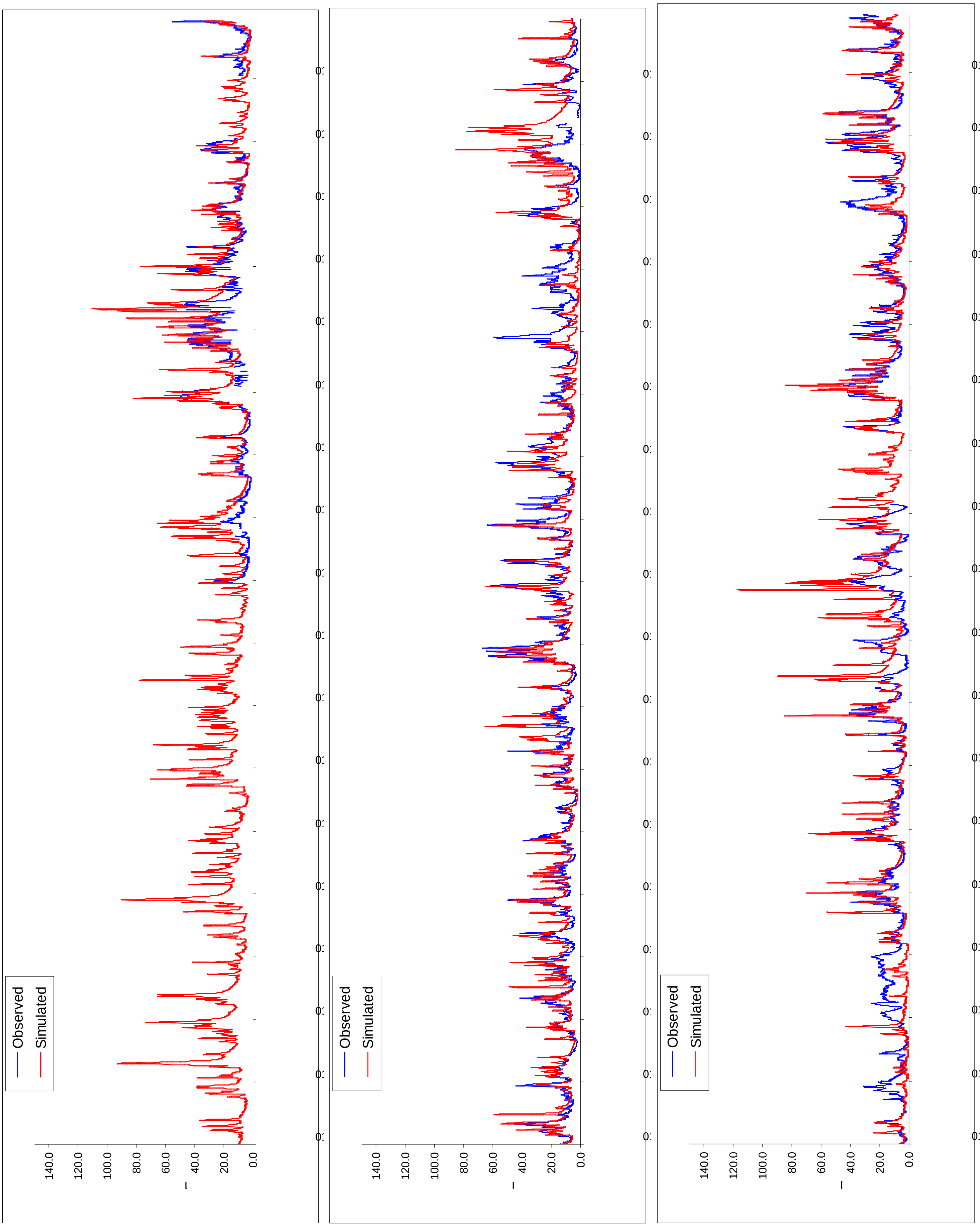


Fig. 4.4.13NAM application to Mitano for 1950-2003. Results after correction of rainfall and evaporation errors

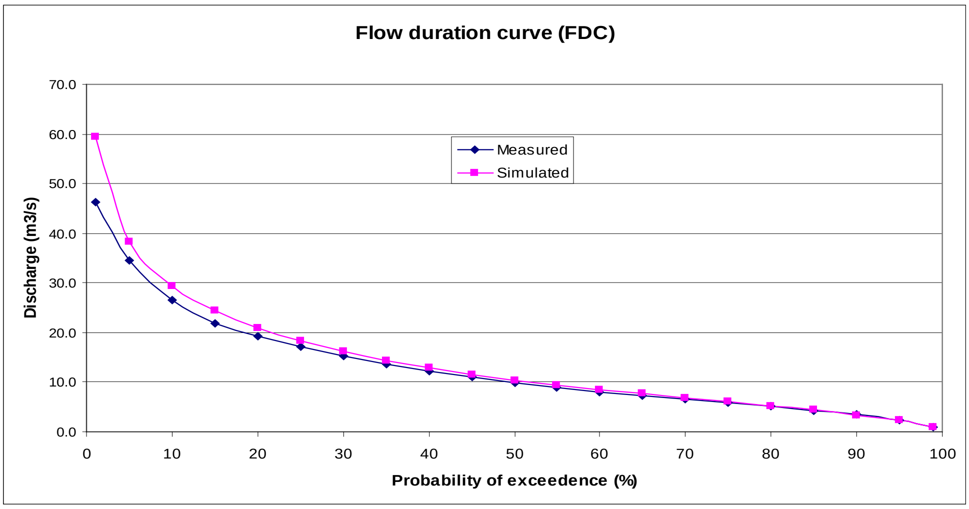


Fig. 4.4.14:NAM application to Mitano for 1950-2003. Comparison of measured and simulated Flow Duration Curves after correction of rainfall and evaporation errors

B. The Mobuku River

A brief examination of the discharge record (1954-1971) was undertaken as there is a long break in the record until recently in 1999 when gaugings were resumed.

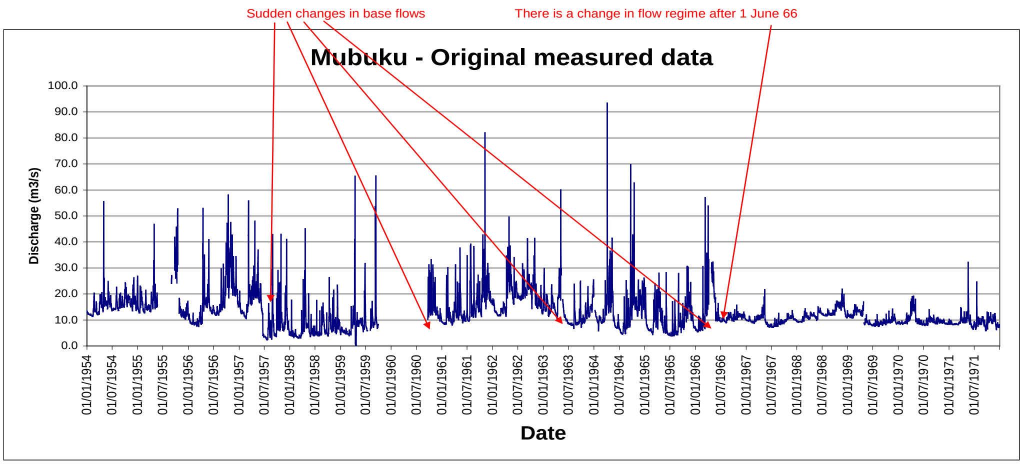


Fig. 4.4.15: **Discharges at Mobuku**

There are sudden changes in base flow and a change in flow regime after 1996. There is only one rainfall station in the catchments. Attempts to derive a meaning full rainfall runoff relationship with the NAM model were not successful. The lone rainfall station is not sufficient to collate with the measured runoff. This is due to the fact that the rainfall station is at foot of the Rwenzori Mountains where less rainfall is registered in comparison to the highlands. When the rainfall totals were arbitrarily increased by 50% (**Fig. 4.4.16**), simulated accumulated runoff compared well with simulated values.

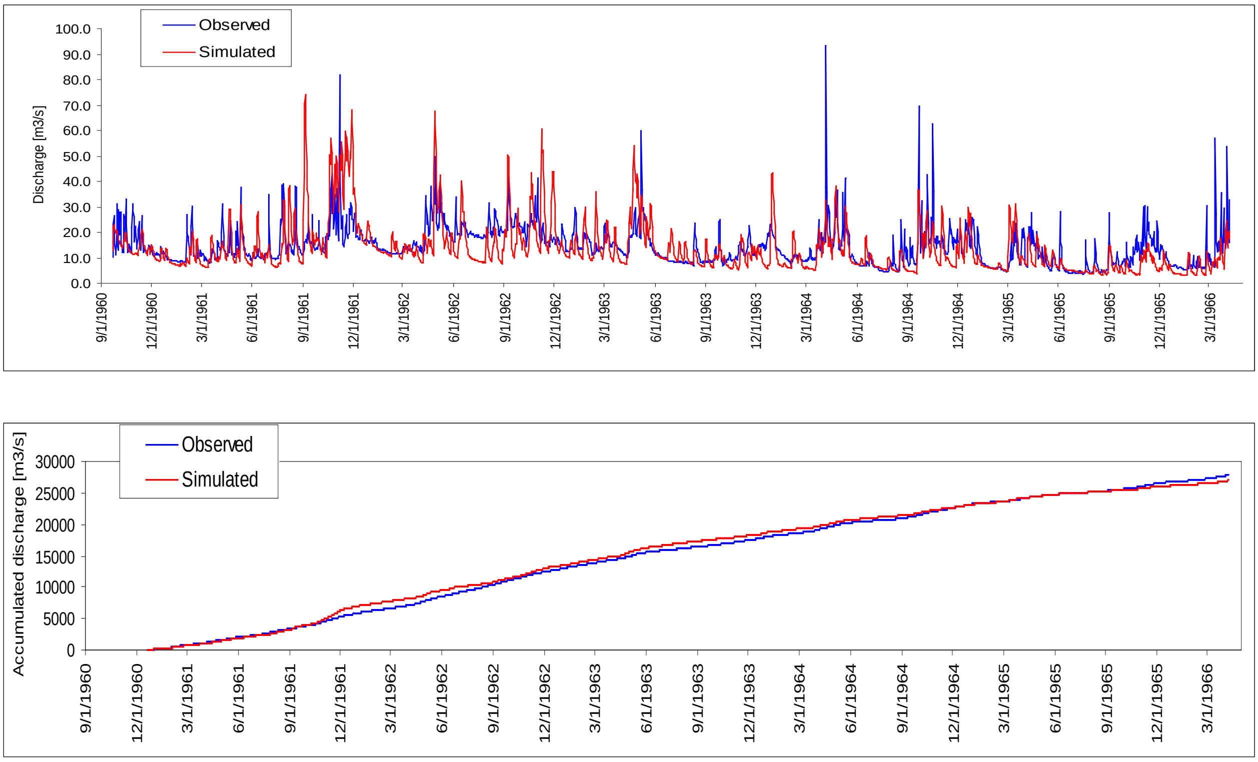


Fig. 4.4.16: Calibration of Kasese discharges with NAM after adjusting catchment rainfall by 50%

Effort will be made to collect additional rainfall data that is more representative of catchments in order to make estimates of discharges from this catchment to Lake George during the period of missing record.

C. The Waki River

The at Waki discharge was recorded in two periods, 1968-80 and 1997 to 2006. The time series plot **(Fig. 4.4.17)** shows different flow magnitudes in the two periods. The first period was chosen for further analysis since rainfall data is only available for that period.

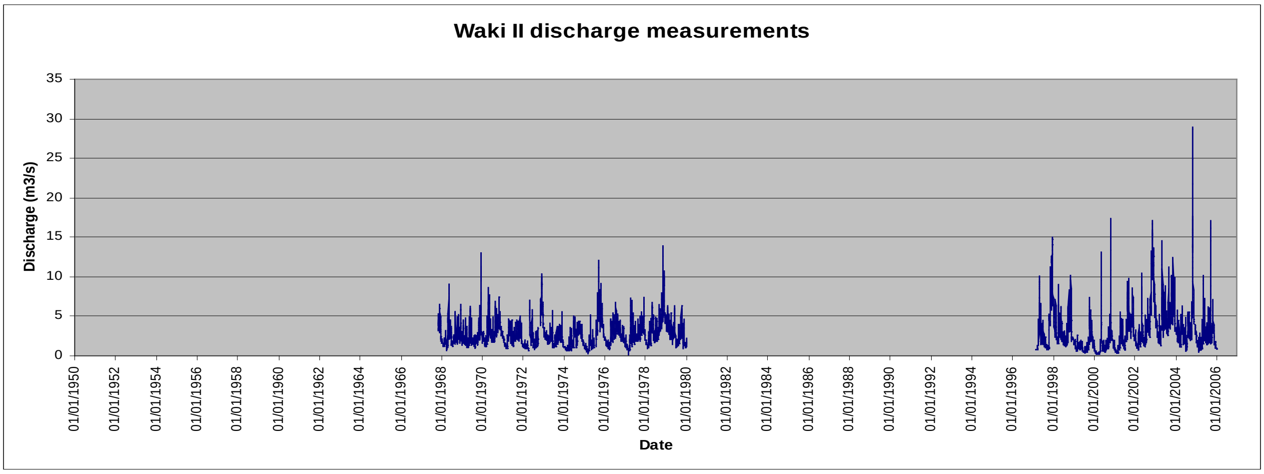


Fig. 4.4.17: The River Waki discharge measurements

Rainfall stations processed for NAM Rainfall-Runoff modelling for this catchment were Bulindi, Nyabyeya, Kigorobya and Wampanga. Evaporation data was taken from the neighbouring station at Masindi. The period 1st November 1967 to 31st March 1972 was selected for calibration. The best calibration results **(Fig. 4.4.18)** were obtained by utilising rainfall at Bulindi and Nyabyeya with a 50% weighting of values from each station to derive the composite rainfall over the catchment.

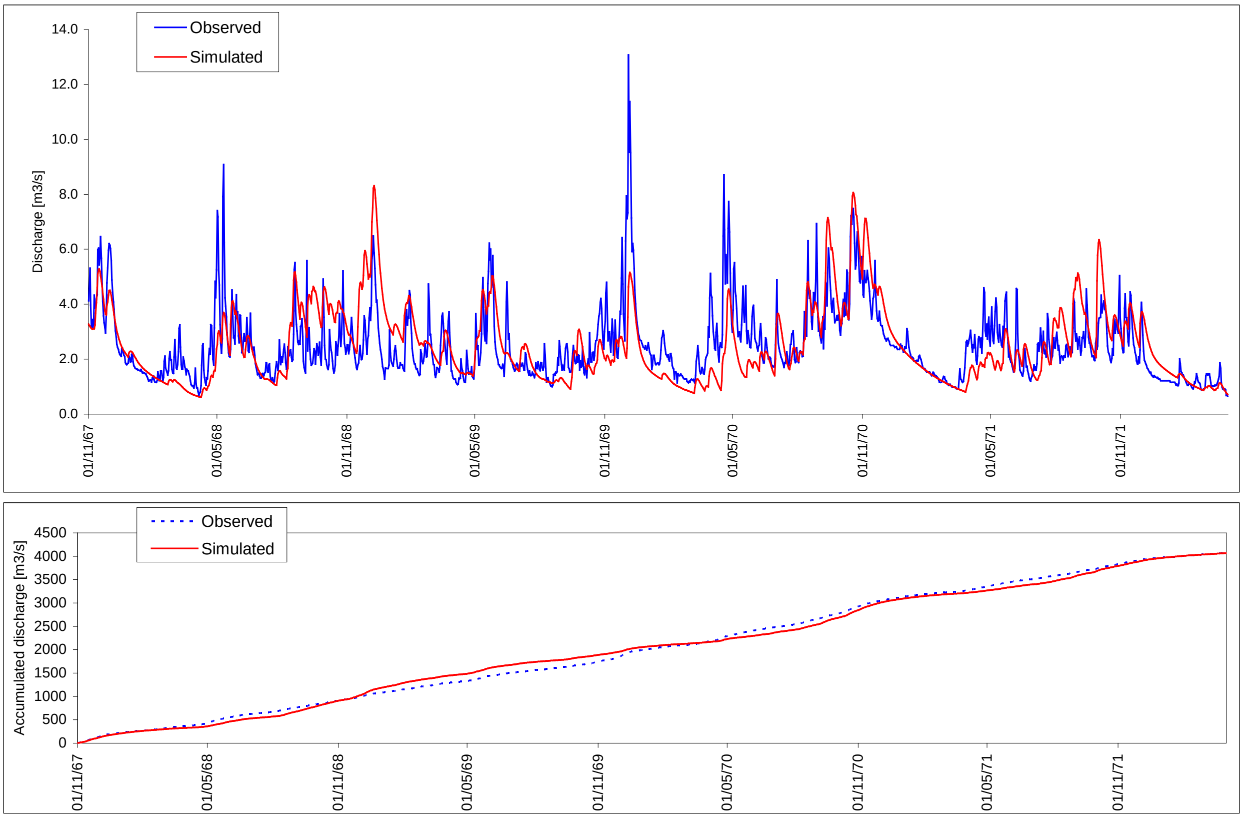
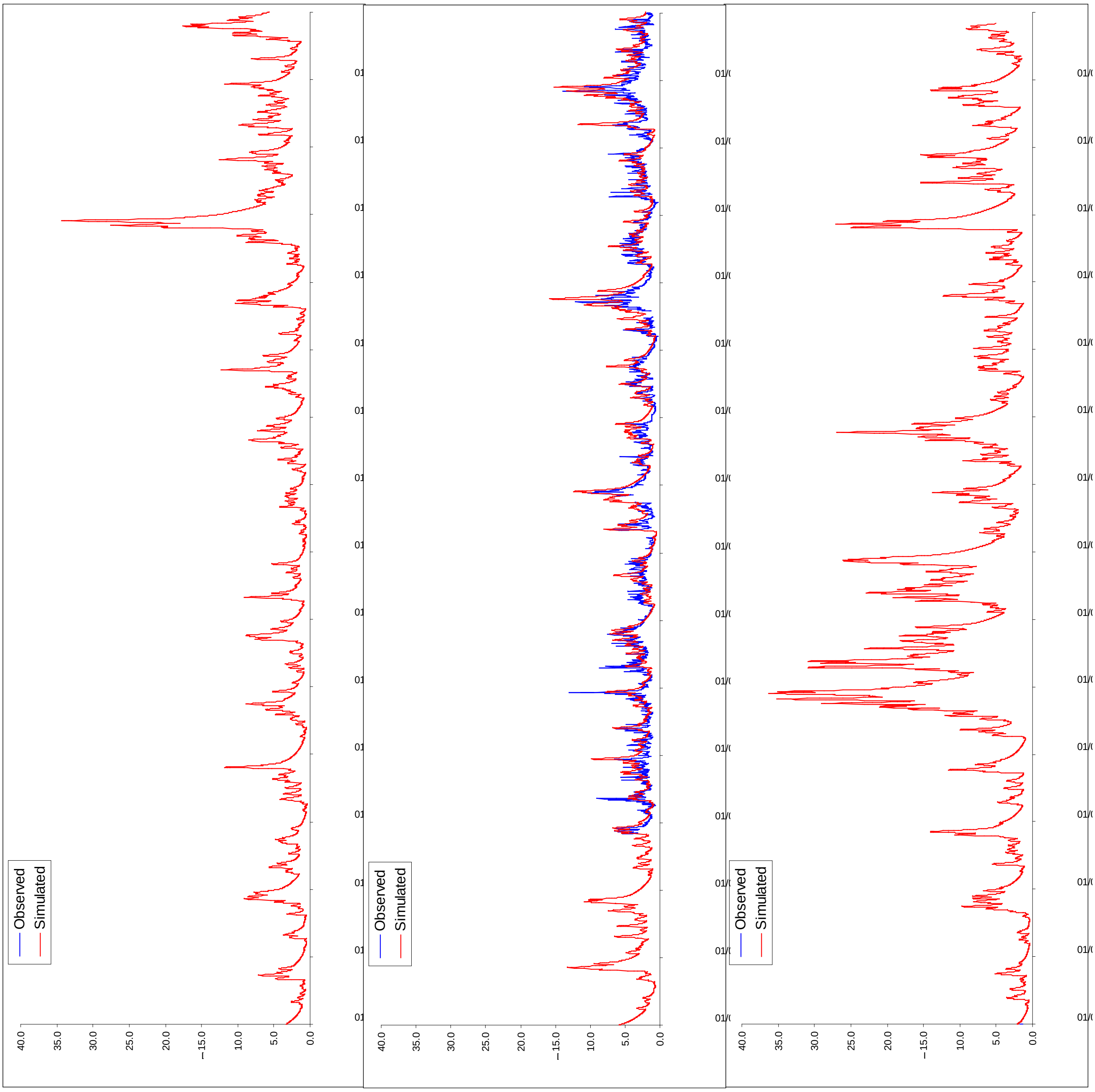


Fig. 4.4.18: AM Calibration for Waki catchment

These results were verified by simulating with a second period (1st Aug 1975 to 31st Dec 1979. The results obtained were reasonably good. Using the calibration parameter values the NAM model was applied to the period 1950- 1994, and the results are shown in **Fig.4.4.19.** There is the expected high discharge at the end of 1961 and the good comparison between observed and simulated discharges in the 70's. However, after 1984 the discharges become unrealistically high. If the rainfall-runoff relation before 1984 is correct (and there is strong evidence that it is) then the rain after 1984 is probably unreliable. It is expected that unreliable measurements in the rainfall are common for all catchments after 1983. This implies that estimation of discharges to the lakes after 1983 is difficult. Accurate establishment of the water resources potential for Waki catchment should therefore be based shall be based on the 35 year period 1950 to 1984.

Fig.4.4.19: Calibration of the NAM Model for the period 1950-1994



D. The Muzizi River

The discharge was recorded in two periods, 1957 to 79 and 1998 to 2006. The time series plot **(Fig. 4.4.20)** shows that the data in the period 1998-2003 is clearly in error.

The pattern seems to be correct but the low flow discharge is raised to 10-20 m^3/s and the peaks are far too high. Therefore it looks like an incorrect rating curve, or an incorrect application of the rating curve. The data was deleted in further analysis.

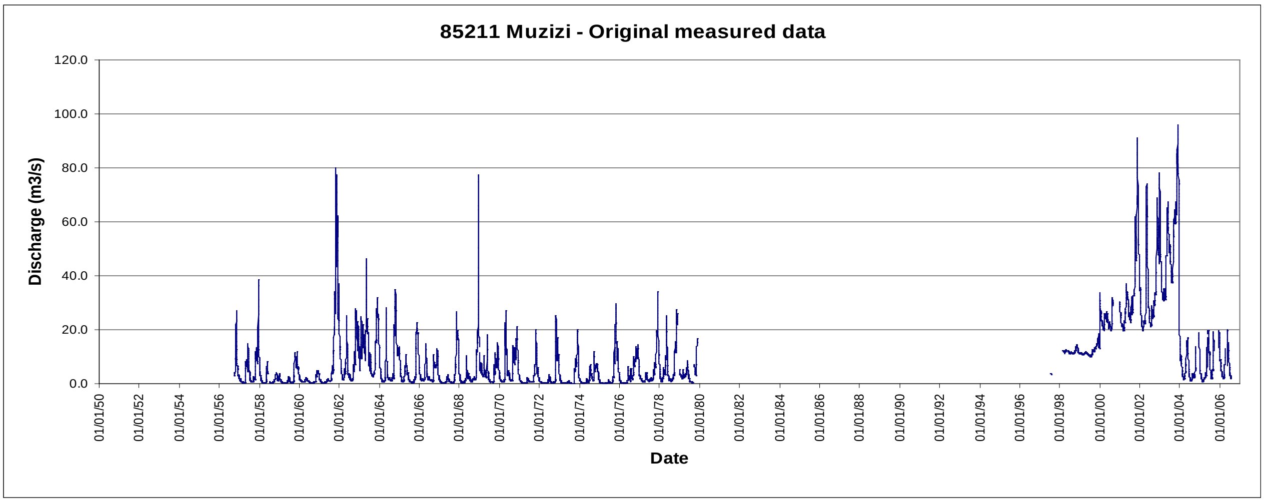


Fig. 4.4.20: **Muzizi discharge measurements**

The Nkusi catchment is lies adjacent to Muzizi and has a similar size, shape, aspect (flowing towards NW) and topography. This provides a good opportunity to investigate the possibility of gap-filling the discharge record by correlation between the two discharge records. The time series of the discharges at the two stations are shown in **Fig. 4.4.21** for the two periods of record. The similarity of the flows confirms that the two stations should show an excellent correlation.

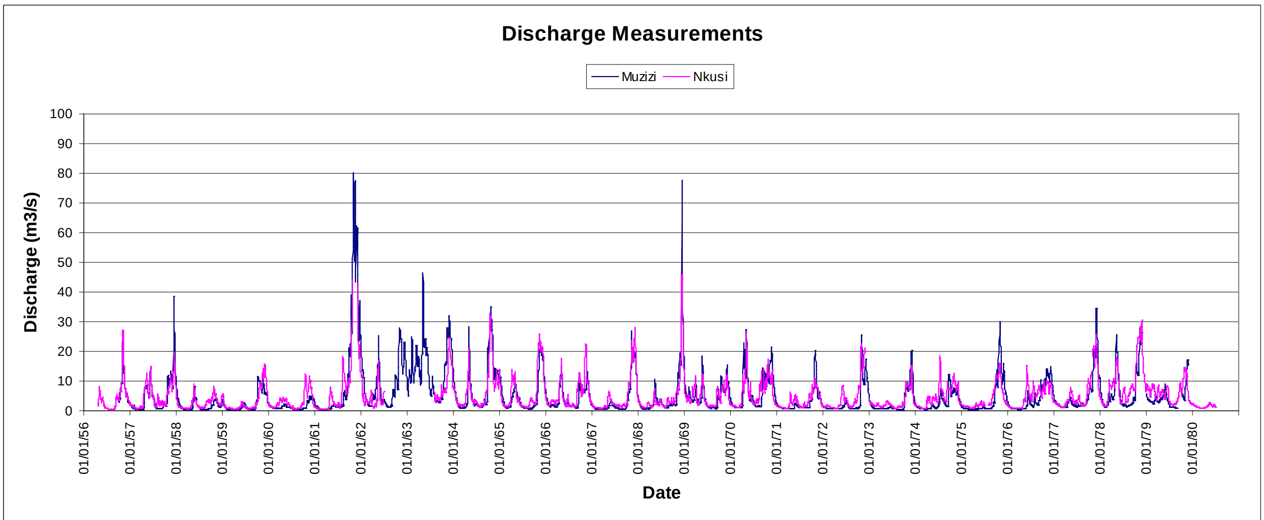


Fig. 4.4.21:The Muzizi and the Nkusi discahrges

A plot of the normalised Flow Duration Curves **(Fig. 4.4.22)** also confirms that the flow regimes at the two stations were very similar.

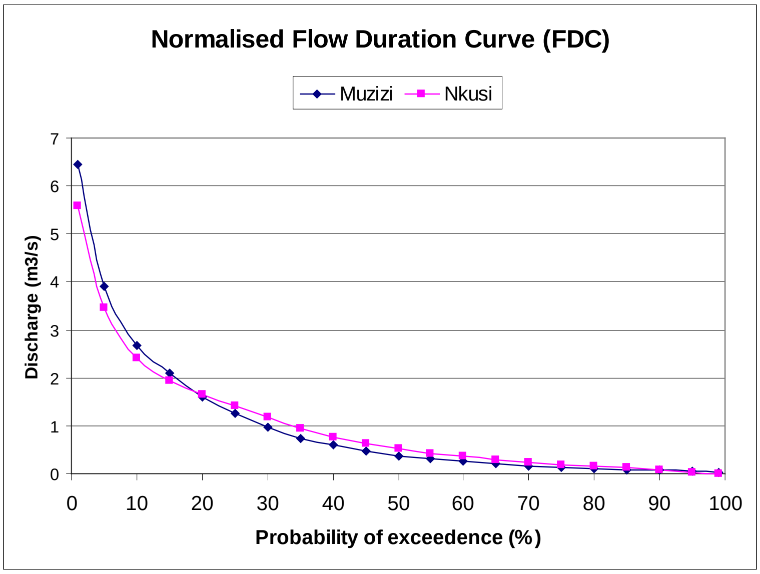


Fig. 4.4.22 Normalised Flow Duration Curves for Muzizi and Nkusi

Two types of correlations between the two discharge records were carried out to find the most suitable method. The correlation types used were a double scatter plot of monthly average discharges and a double mass plot of the daily discharges. The preferred method of correlation is the double scatter plot of the monthly average discharges as daily discharges are very variable and a double scatter plot almost always shows a huge cloud of points with poor correlation. Monthly average discharges filter out the daily variability and generally show a much improved correlation. Further, correlations of wet and dry season months can be made separately to show any differences in the correlations for the two seasons. The plots are shown in **Fig. 4.4.23** and **Fig. 4.4.24.** The similarity of the correlations by the two methods is striking The slopes of the trend lines differ by less than 3%, and the discharges in the two catchments are virtually the same. To fill gaps it can be assumed that Muzizi = Nkusi.

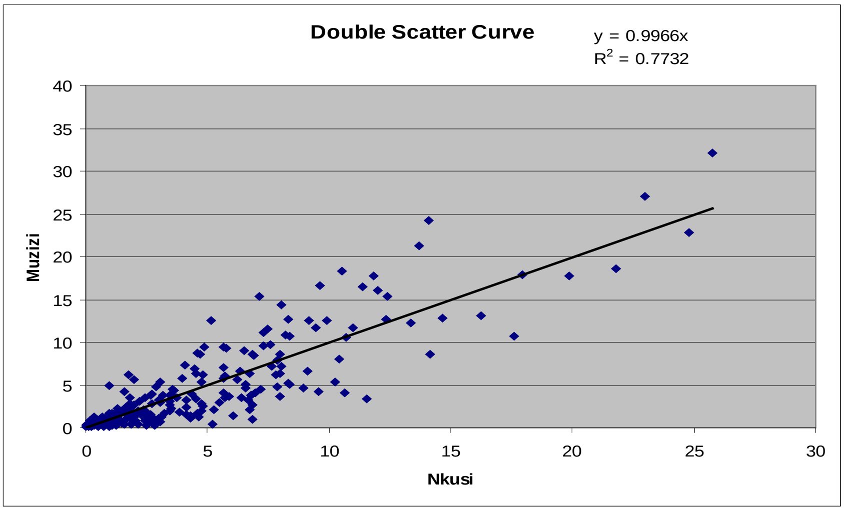


Fig. 4.4.23: Double scatter plot based on monthly average discharges

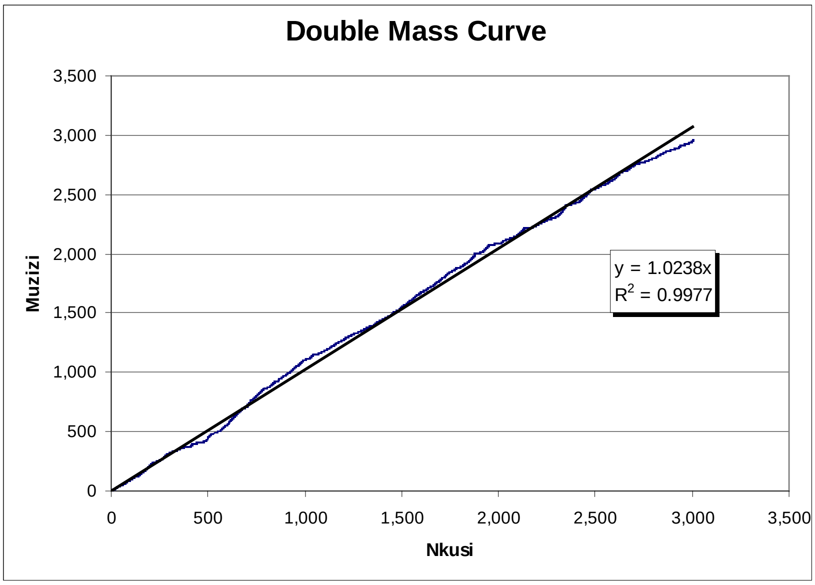


Fig. 4.4.24: Double Mass curve for discharges

Rainfall-runoff will be required to gap-fill the periods 1950 to 1957 and 1977 to 1998. The rainfall stations which can be used for the Muzizi catchment are:

- 89300100 - Kagadi
- 89310070 - Buyanja
- 89310330 - Mubende
- 89310090 - Kyegegwa
- 89300160 - Matiri
- 89300240 - Kyenjojo
- 89310030 - Mubende

There is good coverage of data for the period 1950 to 1977. The gap-filling exercise indicates that an almost continuous record could be established for the period 1950 to 1982 after which there are gaps which would have to be filled by more approximate methods. Therefore it can also be concluded that water balance modelling should be based on the period 1950-1982.

E. The Wambabya River

Discharges for river Wambabya at Buseruka have been recorded over a relatively short period; July 1969 to Dec. 1981 with short gaps, and only March and April in 1997. The time series plot **(Fig. 4.4.25)** shows the variation of observed flow magnitudes.

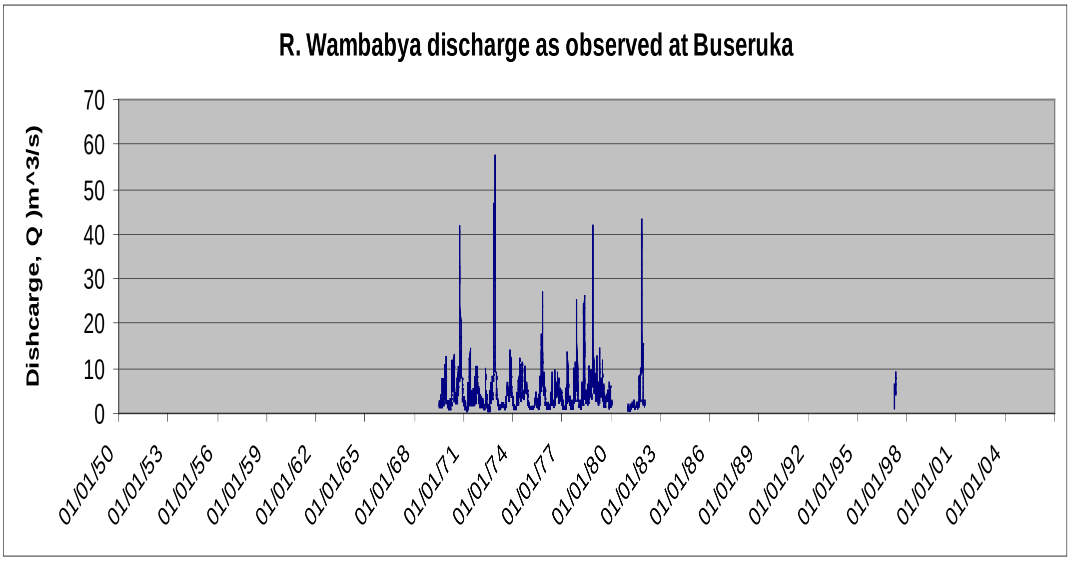


Fig. 4.4.25: Wambabya discharge time series

Since River Wambabya is close to and similar in shape to River Waki II, it may be feasible to derive a continuous discharge time serried for periods during which no data are available by correlation with a data from River Waki. To investigate the possibility of such a course of action A double mass plot for the two discharge stations was attempted **(Fig. 4.4.6)**. The results indicate that there is sufficiently good correlation between the two stations.

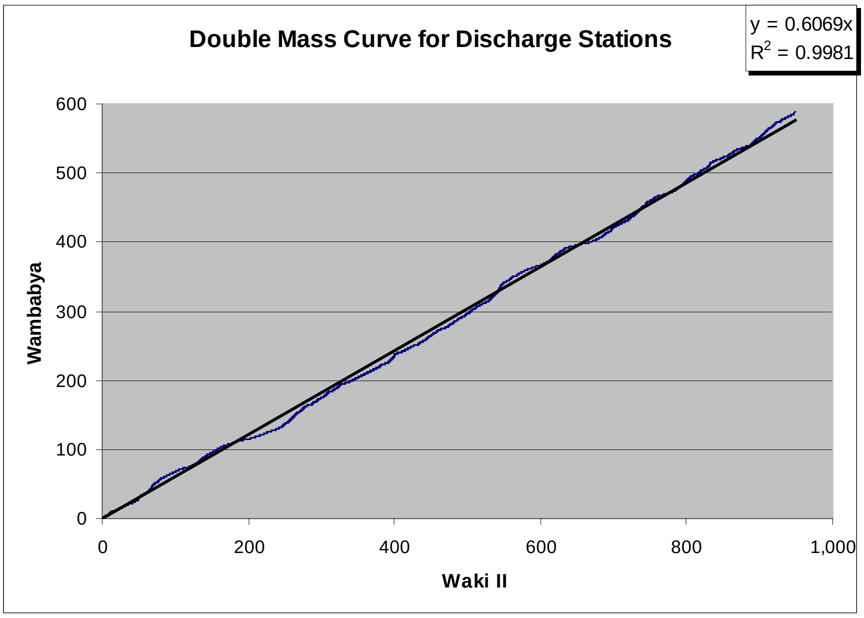


Fig. 4.4.26: Double Mass Correlation of Wambabya and Waki II

For purposes of extending the record at Buseruka during periods where there is no data at river Wambabya, it is necessary to calibrate a NAM model for the river Wambabya using the rainfall and evaporation data. Preliminary results from the calibration exercise are illustrated below.

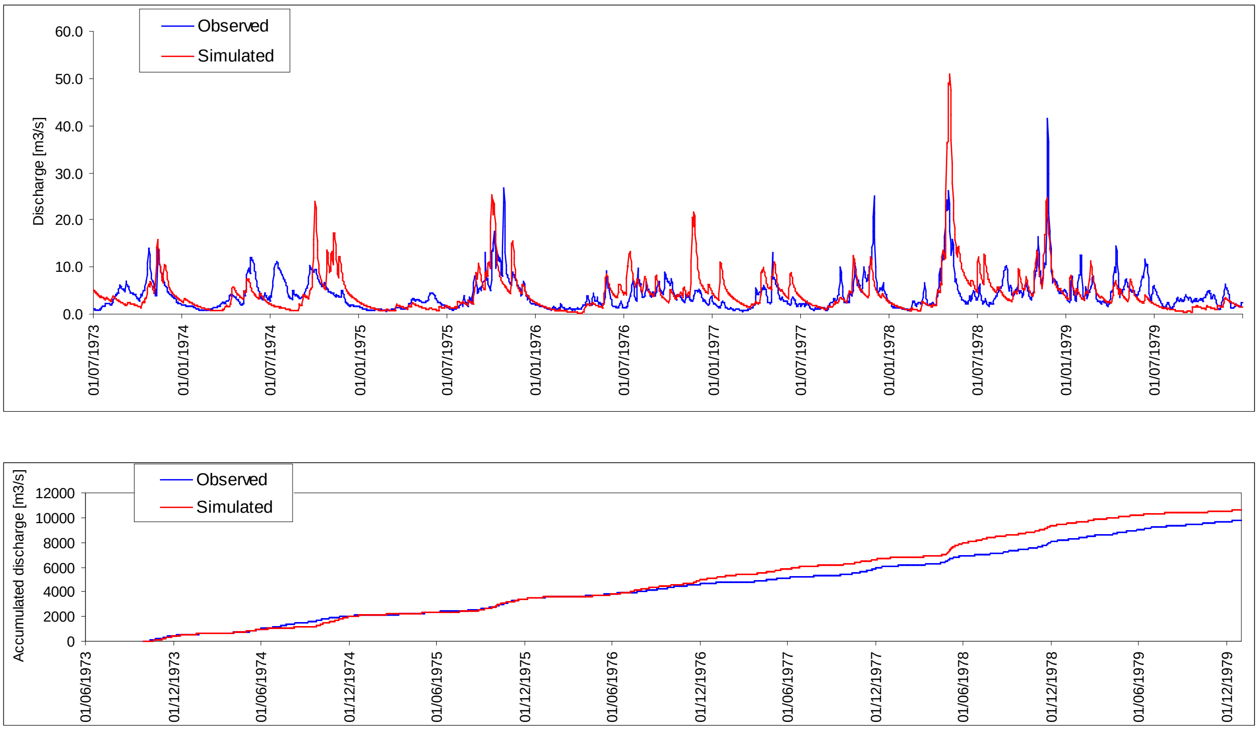


Fig. 4.4.27: Preliminary results from Wambabya - application of NAM model

F. The Chambura River

Similar analyses are now reported for Chambura catchment where runoff data is available in two major periods; Feb. 1954 to Aug. 1980 and July 1997 to Nov. 2006. The time series plot is shown in **Fig. 4.4.28.**

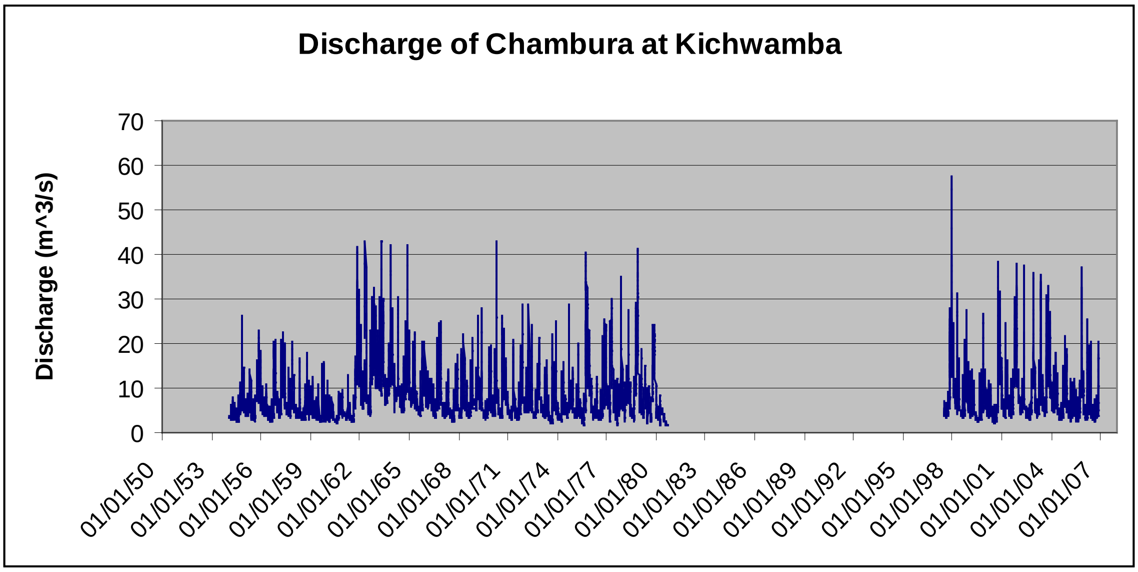


Fig. 4.4.28: Chambura discharge time series

Preliminary results arising out of calibration of the NAM model for this catchment for the period 7th May 1962 to Nov. 1968 are illustrated below:

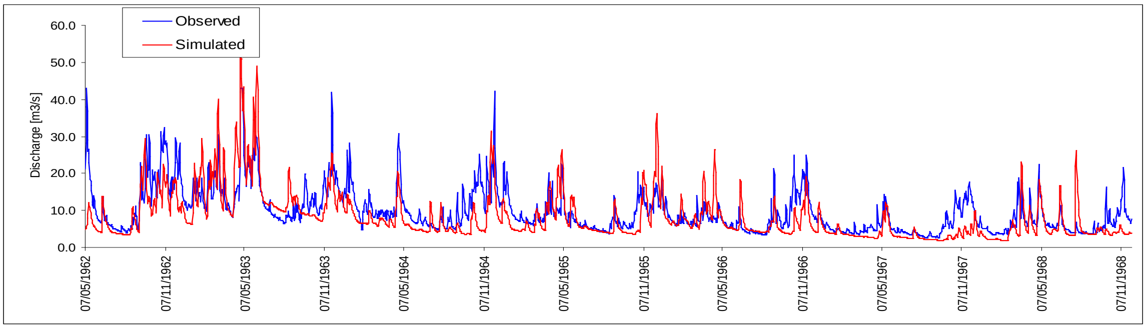


Fig. 4.4.29: Preliminary results from Chambura - application of NAM model

4.4.5 MIKEBASIN Model Setup & Future tasks to be covered

Significant progress has also been registered for the sub-task of setting up of the MIKEBASIN Model for purposes of water balance simulation. Shape files for locations of rainfall stations, evaporation and discharge have been prepared and overlaid. The catchment boundaries in Uganda and the DRC have also been determined and the framework for preparation of runoff maps is now in place. Figure 30 illustrates this. Quality controlled and gap filled data completed for catchments at Mitano, Wambabya, Chambura, Waki, Muzizi and Nkusi have been entered into the Model. The status of model set up is illustrated under **Fig. 4.4.30** below.

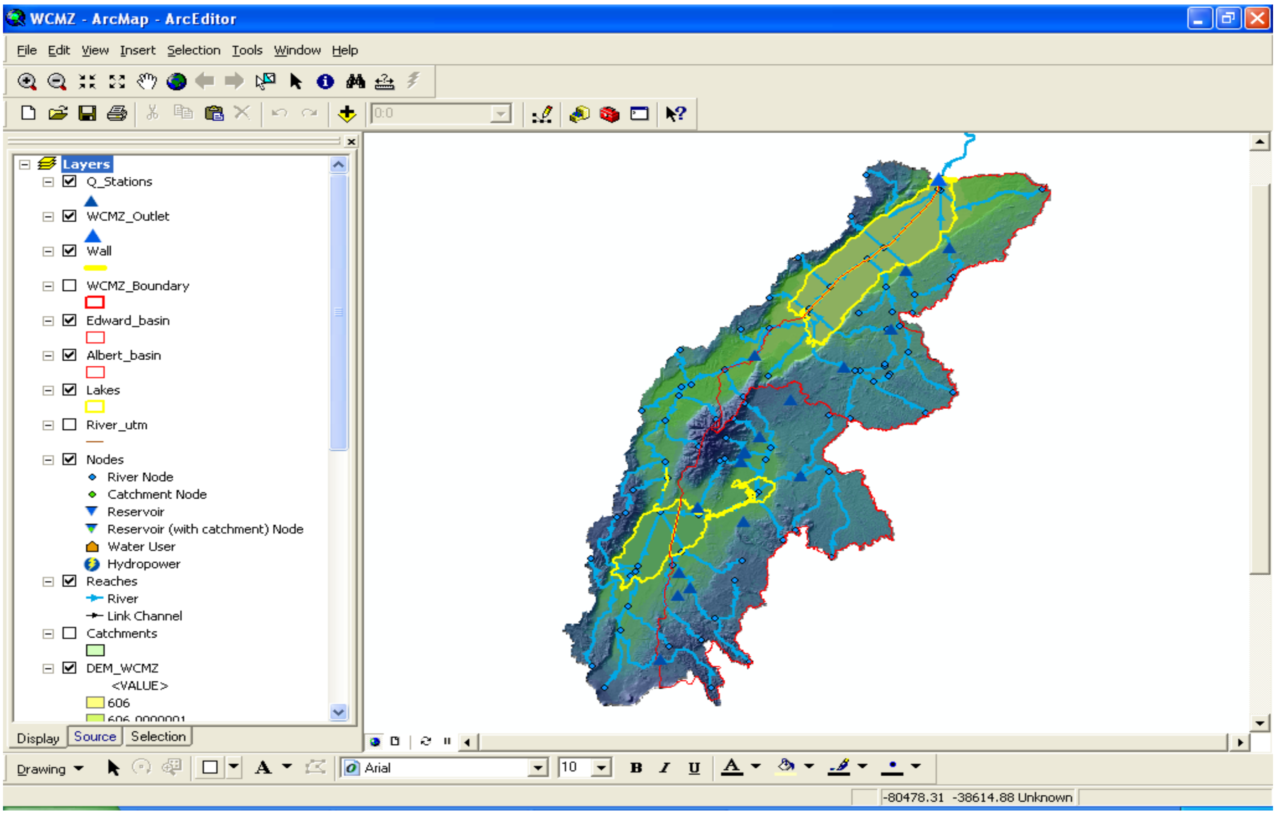


Fig. 4.4.30: Status of MIKEBASIN Model setup for the Project Area

4.5 CIVIL ENGINEERING AND INFRASTRUCTURE

4.5.1 Introduction

According to the Terms of Reference, the objectives of the Civil Engineering component of these studies were to:

i. Analyze the current situation of basic and fisheries infrastructure at the principal landing sites;
ii. Analyze the current production system with a view to propose improvements. In particular the consultant will arrange for the design of required infrastructure to meet the public health and hygienic requirements at the principal landing sites on Lakes Edward and Albert;
iii. Propose procurement methods for the acquisition of the required equipments and infrastructures; and
iv. Identification of the required infrastructure developments in consultation with the communities and respective central and district authorities.

In order to fulfil aspects of this component, there was need for the consultant to undertake intensive consultations with the stakeholders to identify and verify the state of the fish landing infrastructure; to obtain the views of the stakeholders on what renovations/repairs or new construction would be required. Hence, both in Lake Edward both the Uganda and DRC sides were covered. Similarly in Lake Albert the Uganda and the DRC shorelines were visited.

During the visits to the sites, specific engineering counterparts were some times not available but other counterparts on the team often assisted as in the case of the environment counterpart M. Asa Kule who arranged appointments with the civil servants in charge of infrastructure at Kasese District and Katwe –Kabatoro Town Council. Hence, information was collected using consultative meetings and interviews as demonstrated in **Plate 4.5.1.**

Plate 4.5.1: Mobilisation of people during consultations included women as seen at Wanseko Landing Site, Lake Albert, Uganda

During consultations and visits, the focus of the study was on finding out the state of infrastructure, facilities and equipment at the fish landings and the views of the stakeholders on the remedies required. Hence, the visits involved physical checking and identification of existing infrastructures. On the basis of this, the following information was obtained on the main civil works, facilities and equipments required at the landing sites.

A. Infrastructure needs of fish landings

- Floating barges,
- Landing platforms,
- Jetties and piers,
- Slipways,
- Slabs and canopy,
- Access and feeder roads,
- Housing units,
- Markets and shops,
- The road network,
- Sewage disposal systems,
- Safe water supply for drinking and other uses,
- Electricity supply,
- Schools and health centres, and
- Fencing and dust proof environment.

B. Facilities needed at fish landings

- Hygienic fish handling and storage facilities including stainless surface slabs and canopy,
- Stores and fuel storage and handling facilities,
- Fish processing facilities,
- Fish processing effluent (liquid) disposal systems and facilities;
- Solid waste management facilities and equipment, and
- Toilets facilities.

Equipments needed at the fish landings

- Kilns for smoking,
- Stainless or plastic equipment to prevent lake pollution,
- Ice for chilling fish,
- Crates for carrying fish,
- Protective wear including gum boots, and
- Weighing scales.

The following landing sites were visited and the necessary information obtained.
Katwe Landing site, Kasese District; Rwenshama Landing site, Rukungiri District; Kisenyi Landing site, Bushenyi District; Butiaba Landing site, Buliisa District; Ntoroko Landing site, Bundibugyo District; Wanseko Landing site, Buliisa District; Kasenyi Landing site, Ituri Distinct and Tchomia Landing site, Ituri District.

The following issues were commonly raised and discussed with the stakeholders who in all cases prioritized the issues.

- State of floating barges and security on board

- Existing infrastructure on the landing sites
- Fish production, marketing and transportation
- Fish handling , processing and preserving facilities
- Roads network
- The state of access and feeder roads
- Sanitation , hygienic and social infrastructures
- Public toilets
- Safe and clean water supply
- Electricity supply
- Dust proof of environment
- Solid wastes management
- Sewage disposal
- Improvement of current infrastructures
- New infrastructures needed

4.5.2 State of fish landing infrastructure

Many of the fish landings have very poor infrastructure and lack essential equipment. **Table 4.5.1** provides details of the state of infrastructure in the fish landings visited. These conditions are well illustrated in **Plate 4.5.2, Plate 4.5.3, Plate 4.5.4, Plate 4.5.5, Plate 4.5.6** and **Plate 4.5.7.**

Table 4.5.1: The state of infrastructure at the landing sites							
		Lake Edward (Uganda)			Lake Albert (Uganda)		
N°	**Current infrastructure on landing sites**	**Katwe**	**Rwenshama**	**Kisenyi**	**Butiaba**	**Ntoroko**	**Wanseko**
1	Floating barges (fleet) State of barges	130 boats variable	60 boats variable	40 boats variable	1000 boats variable	470 boats variable	320 boats variable
2	Piers , jetties	-	-	-	-	-	-
3	Slab for washing fishes	poor	-	-	-	-	poor
4	Storage facilities	poor	-	-	-	-	-
5	Shelter	poor	poor	-	-	-	-
6	Stores	poor	-	-	-	-	-
7	Clean and safe water supply	fair	fair	-	-	-	-
8	Electricity supply	fair	-	-	-	-	-
9	Access road	fair	poor	poor	fair	fair	poor
10	Feeder roads	poor	-	-	very poor	very poor	very poor
11	Sanitation and hygiene	poor	poor	very poor	poor	very poor	very poor
12	Schools	poor	fair	poor	poor	poor	poor
13	Health centre	poor	fair	poor	poor	fair	-
			Lake Albert (DRC)				
N°	**Current infrastructure on landing sites**	**kasenyi**	**Tchomia**	**Mahagi port**	**Ndawe**		
1	Floating barges (fleet)	500 boats	1800 boats	1050 boats	700 boats		
	State of barges						
2	Piers , jetties	-	very poor	-			
3	Slab for washing fishes	-	-	-			
4	Storage facilities	-	-	-	poor		
5	Shelter	-	-	-	-		
6	Stores	-	poor	-	-		
7	Clean and safe water supply	-	-	-	-		
8	Electricity supply	-	-	-	-		
9	Access road	fair	fair	poor	very poor		
10	Feeder roads	poor	very poor	very poor	very poor		
11	Sanitation and hygiene	very poor	poor	poor	poor		
12	Schools	poor	poor	fair	fair		
13	Health centre	poor	fair	fair	-		

(-) Denotes non existence

4.5.3 Key Findings

The following provides the state of infrastructure and facilities in the fish landings that were visited.

i. The population of the fish landings visited was as follows: Katwe (10,000), Rwenshama (4,000), Kisenyi (1,500), Wanseko (8,000), Butiaba (10,000), Ntoroko (8,700), Kasenyi (24,000), Tchomia (50,000), Mahagi port (61,000) and Ndawe (150,000). These figures are as estimated by people questioned at the landing sites.

ii. Landing site infrastructures are lacking and the few available are in a poor state and need to be rehabilitated. Examples are slabs, shelters, public toilets and latrines. There is a need to build new landing infrastructures in order to meet hygienic and sanitation standards.

iii. The main activities of people in the landing sites were fishing and trading but other fish related activities such as repairing boats, setting and repairing nets and fish processing.

iv. The number of licensed boats fluctuated from 40 to 1800 both for transport and fishing. These boats are poorly equipped; they have no lifejackets on board and many of them do not have engines.

v. The fish process methods used were mostly smoking, salting, sun-drying and some icing. There is need to modernize equipments such smoking kilns and surfaces for drying fish.

vi. Access and feeder roads were in very poor condition for all landing sites. Some landing sites like Rwenshama, Kisenyi and Kasenyi do not have feeder roads and housing units.

vii. Post harvest losses were very high in all the fish landings and this was due to both the poor condition of landing infrastructure and the poor processing methods used.

viii. There is no clean and safe water supply at fish landings except at Katwe and Rwenshama. There is need for extending safe and clean water supply to the landing sites.

ix. Health centers and primary schools exist in some fish landings but in others like Wasenko, had no health facilities. There is need to upgrade social infrastructure at most fish landings.

x. There in no electricity supply in all the fish landings except at Katwe. Hence, there is lack of cooling facilities which is affecting fish quality.

xi. There are no waste management and sewage disposal facilities at all fish landing sites visited.

4.5.4 Priorities infrastructure claimed

The following was a prioritization list drawn up by stakeholders in all the fish landings visited.

i. Clean water supply,

ii. Improvement of sanitation system,

iii. Providing public toilets at the landing sites,
iv. Landing site infrastructure to be built or improved and modern equipments to be provided, and
v. Feeder roads improvement.

4.5.5 Required urgent remedial actions

The following require urgent remedial repair or rehabilitation actions in the fish landings visited.

i. Some houses and latrines located near some landing sites may should be moved to prevent contamination of water and pollution of the lakes;
ii. Garbage particularly plastic wastes should be collected and managed to avoid pollution of the environment; and
iii. Training of the people in order to increase awareness on hygiene and sanitation is urgently needed.

Plate 4.5.2: Kasenyi Fish Landing Site (Lake Albert, DRC side) showing complete lack of any infrastructure

Plate 4.5.3: Fish handling and cleaning at Tchomia, Lake Albert DRC, showing poor hygiene

Plate 4.5.4: Poor state of fishing washing canopy, slab and stores at Katwe Fish Landing Site, Lake Edward Uganda

Plate 4.5.5: Poor access road and houses at Kisenyi landing site, Lake Edward Uganda

Plate 4.5.6: Ntoroko Fish Landing Site, Lake Albert Uganda, showing lack of good fish handling facilities

Plate 4.5.7: Poor garbage collection and handling at Ntoroko, Lake Albert, Uganda with very poor latrines

4.6 FISHERIES SOCIO-ECONOMICS

4.6.1 Introduction

The fisheries economics and fisheries socio-economics have been fused together into one major component within the Lake Edward and Albert Fisheries (LEAF) Pilot Project. The overall goal of the component is to contribute to poverty alleviation and sustainable fisheries resource use by the riparian communities and nations on Lakes Edward and Albert.

The studies would provide a framework for planning and monitoring the participation of the fishing communities in fisheries management, how they respond to the different management measures and the impacts of implementing a fisheries management plan on their livelihoods.

The interim diagnostic report presents activities undertaken so far, achievements made and the results generated. On the basis of these findings, an interim diagnosis of the state of the fisheries of the lakes is elaborated.

The objective of the diagnostic studies is to identify the areas of development concern within the fisheries of the lakes, their potentials and the constraints which may exist. The studies would also help to identify any issues which may require policy clarification. This would be achieved by assessing the socio-economic conditions of the major stakeholders dependant on the fisheries of Lakes Edward and Albert and thus provide an informed basis for the formulation of investment projects and management plans for Lakes Edward and Albert.

As expected out put, a technical report would be produced on the socio-economic status of the fisheries of Lakes Edward and Albert, covering:

a) Leadership and organisation of fishing communities
b) Demographic characteristics of fishers, processors, traders and other operators in the fisheries
c) Health status of fishing communities
d) Fish production, processing and marketing activities, post-harvest losses and the role of indigenous knowledge
e) Gender participation in fisheries
f) Livelihoods, poverty, asset ownership and alternative income sources
g) Economic contribution of fisheries
h) Adoption and impact of fisheries management measures
i) Investments and credit in fisheries
j) Trans-boundary issues

4.6.2 Highlights of Key Findings

Much of the data was captured using a questionnaire, which was entered and analysed and the preliminary information is available. The Key Informant Interviews (KIIs) and consultations held also revealed considerable information on Lakes Edward and Albert, Uganda and is included in the summarised results presented in this report.

A. Leadership and organisation

The fishing communities were under the leadership of LC1s and LC2s, Fisheries staff, BMUs, Centre Masters, the Police and LDUs and border security personnel. The park authorities, under the UWA, also had considerable influence over the landing sites. At Katwe, there was also a Town Council under which the landing site fell. In Panyimur, the landing site was adjacent to the Sub-county headquarters and part of a regional fish market, which was managed by a tenderer.

The presence of multiple agencies in the leadership of the landing sites calls for clear definition of roles and separation of powers, with strong co-ordination between the agencies. However, this is often not the case, resulting in conflicts between the BMUs or Centre Masters and the other agencies at the landing sites.

B. Demographic characteristics

Population sizes at the landing sites were reported to fluctuate according to catch seasons, ranging between 1,000 and 4,000 people. However, at Katwe on Lake Edward and Panyimur, the number often rose to 10,000 people (**Table** 4.6.1).

Table 4.6.1: Population of selected landing sites, Uganda

L. Edward			L. Albert			
Katwe	Kisenyi	Rwenshama	Tonya	Sibagolo	Walukuba	Panyimur
4,000 to 10,000	1,000 to 2,000	1,000 to 4,000	1,200	1,800	1,200	8,000 to 10,000

Fluctuations in populations at the landing sites were caused by in and out migrations of short and long term nature. Migration was primarily a livelihood strategy adopted by the communities to access sources of food and income. The main factors responsible for migrations among the fishing communities were as follows:

a) Catch fluctuations, when people were attracted to the landing sites during high seasons and they depart during low seasons.
b) Search for better market for catch.
c) Crop seasons, when people returned to their villages to attend to their crops during planting, weeding and harvesting seasons.
d) For mukene fishers, lunar cycles determined whether the fishers would be active at the landing sites during the dark phase of the moon, or were unable to fish and move out during the full phase of the moon.
e) Episodes at the landing site or elsewhere, such as cholera outbreak or insecurity in the neighbouring country.

However, migration also has negative effects on fisheries management and development as outlined below:

a) Hinders effective planning and provision of social services to the communities, such as health and education.
b) Constrains fisheries management as fishers often move with illegal fishing gears and methods from one place to another.
c) Hinders the operations of BMUs as their stability is affected by the frequently changing memberships.
d) Often leads to insecurity and theft of gears as the migrants may include criminal characters.

Table 4.6.2: Selected demographic characteristics

	L. Edward	**L. Albert**
Percentage of fishers who were males	80%	83%
Mean age of respondents in years	38.5	38.9
Main tribes among fishing communities	Munyankole (39.0%) Mutoro (25.4%)	Alur (50.0%) Munyoro (30.0%)
Where most fishers were born	Within the same villages	In other districts
Respondents with Incomplete Primary education	40.0%	39.8%□
Respondents able to write local languages	12.7%	4.2%□
Respondents who were married	74.1%	81.8%□

The majority of the fishers were adult males while women constituted a very small percentage. Their ages ranged between 25 to 60 years and most of them were married. The dominant tribes on Lake Edward were the Bakonzo and Banyankole while on Lake Albert, the main communities were Alur and Banyoro, with sizeable immigrants from DRC.

Most of the respondents had gone to school but had only attained incomplete primary education. Many report being literate but the literacy level for most of them was limited to reading in local languages, writing ability being quite limited. Ability to read and write in English was still low among the fishers. Low levels of education and literacy hinders their capacity to understand issues relating to fisheries management, environment management, fish quality and fish business management. It also limits their capacity to acquire the skills necessary to modernise their fishery operations.

Table 4.6.3: Average number of children in the households and their educational status

	L. Edward	L. Albert
Male children below 18 years	2.3	2.4
Female children below 18 years	1.8	2.4
Male children above 18 years	1.4	1.3
Female children above 18 years	1.1	0.9
Children not in school	1.7	2. 4
Children in Primary	2.8	3.0
Children in Secondary	1.6	1.2
Children in University/Higher Institution	0.5	0.7
Children in other institutions	0.2	3.2

On average, the households had 2-3 male and 1-4 female children of below 18 years and fewer children of above 18 years. Most of them were in Primary schools but a few were not in school and others in Secondary and higher institutions (Table 4).

Table 4.6.4: Respondents' average years in the fisheries

	L. Edward	L. Albert
How long respondents were involved in their main fishery activities	13. 7	14.3
How long respondents worked on the lake	13.9	13.8
How long respondent worked at the beach	12. 6	12.4
At how many beaches respondent work last year (2006) (No. of beaches)	1.4	1.1

Table 4.6.5 reveals the number of years respondents were in the fisheries. The table shows that they spent most of their time on the same lake and at the same beaches.

C. Training received

Table 4.6.6 provides information on the areas in which training was received by respondents and those where training is desired. It shows that generally more respondents on Lake Edward received training than those on Lake Albert. Similarly, more fishers on Lake Edward desired training (**Table 4.6.5**).

Table 4.6.5: Percentage of respondents who received and/or desire training

Training areas	**Received Training**		**Desire Training**	
	L. Edward	L. Albert	L. Edward	L. Albert
Fisheries laws and regulations	72.4%	64.2%	80.8%	67.6%
Fishing gears and methods	71.2%	65.2%	82.7%	62.1%
Size of fish to be harvested	72.9%	65.7%	81.6%	63.6%
Health and sanitation	67.8%	48.5%	96.0%	78.6%
Environmental protection	64.4%	37.7%	92.3%	82.1%
BMUs	62.7%	41.7%	86.0%	81.3%
Fish handling and processing	69.5%	53.2%	90.2%	77.8%
Fish marketing	63.2%	15.3%	88.2%	93.9%
Book keeping and fish business management	44.4%	15.3%	70.0%	93.9%

The majority of the respondents were boat owners, followed by crew members and fish processors/traders (**Fig.4.6.1**).

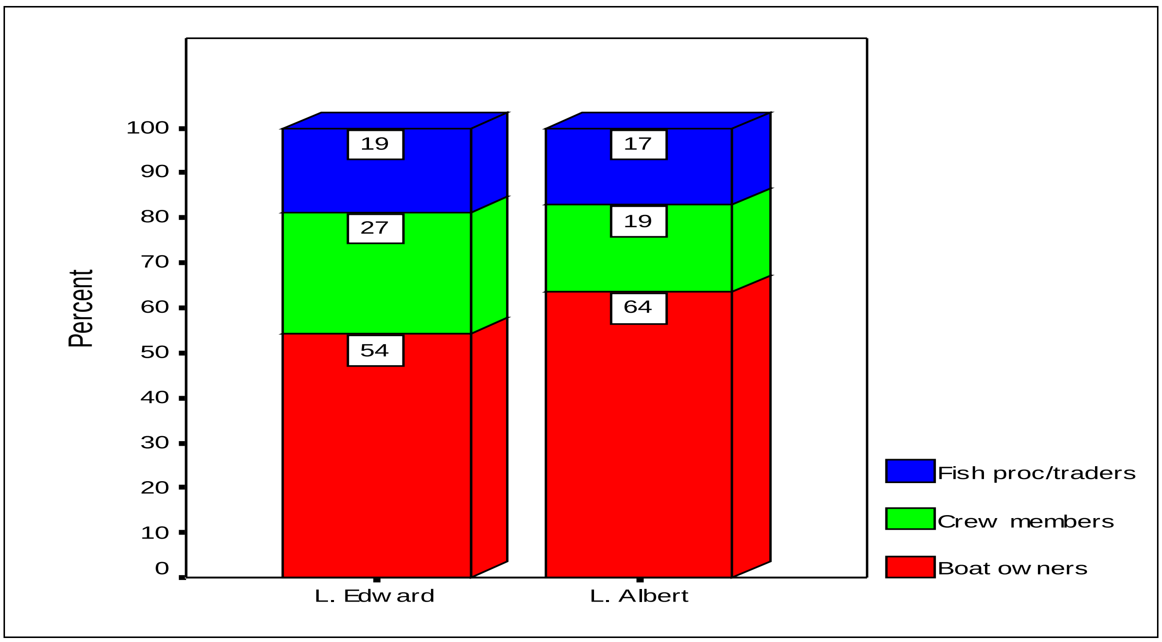


Fig. 4.6.1: Main activities of respondents

The species targeted by most respondents were tilapia and ragoge/muziri for Lakes Edward and Albert respectively (**Table 4.6.6**).

Table 4.6.6: Main fish species targeted

	Nile perch	Tilapia	Angara	Ngasia	Ragoge/Muziri	Others	Total
L. Edward	--	96.7%		--	--	1.7%	100.0%
L. Albert	29.4%	23.5%	7.1%	1.2%	38.8%	--	100.0%
Total	17.9%	53.8%	4.1%	1.4%	22.8%	--	100.0%

Most of the operators sold their fish to local traders, followed by direct consumers (**Table 4.6. 7**).

This shows that there were buyers for their fish.

Table 4.6.7: Main buyers of fish

	Direct consumers	Local traders	Processors	Factory agents	Regional traders	Others	Total
L. Edward	25.0%	70.0%	--	--	5.0%	--	100.0%
L. Albert	11.5%	58.6%	1.1%	13.8%	11.5%	3.4%	100.0%
Total	17.0%	63.3%	.7%	8.2%	8.8%	2.0%	100.0%

The majority of the respondents sold their fish at the same landing sites where they operated, or in another village (**Table 4.6.8**). This means that market was readily available to them at their places of production.

Table 4.6.8: Places where respondents sold their fish.

	Same landing site	Another village	This Sub-county	This District	Another District	Total
L. Edward	85.0%	6.7%	1.7%	5.0%	1.7%	100.0%
L. Albert	83.0%	5.7%		3.4%	8.0%	100.0%
Total	83.8%	6.1%	.7%	4.1%	5.4%	100.0%

The main constraint on both lakes was scarcity of fish, followed by lack of fishing gear and low fish prices on L. Edward and L. Albert respectively (**Fig. 4.6.2**).

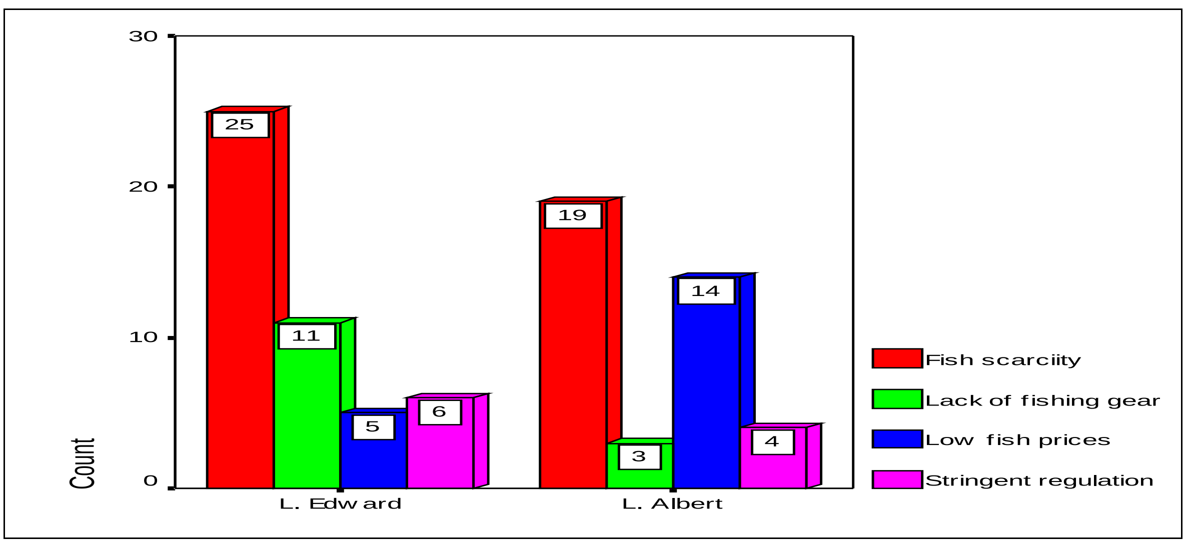


Fig. 4.6.2: Main constraints to fishery activities

D. Landing sites

The landing sites were of different categories and especially on Lake Albert, the range was quite high, indicated by number of boats.

On Lake Edward, the number of licensed boats were reported to be 120 for Katwe and 60 each for Kishenyi and Rwenshama (**Table 4.6. 9**). However, boat count revealed much higher numbers at all the landing sites. The fishing was not motorised, and the few outboard engines observed on the lake were used for transportation.

Table 4.6.9: Number of boats at selected landing sites, Uganda

L. Edward			L. Albert			
Katwe	Kisenyi	Rwenshama	Tonya	Sibagolo	Walukuba	Panyimur
120	60	60	50	180	92	137

D. Boat ownership, fish catches and prices

Most of the respondents who owned or rented boats owned/rented flat bottomed boats on Lake Edward, with a mean of 1.1 boats while on Lake Albert, the majority owned/rented the Congo barque with a mean of 1.7 boats (**Table 4.6.10**).

Table 4.6.10: Ownership of boats

	L. Edward		**L. Albert**	
	N	Mean	N	Mean
No of flat bottomed boats owned or rented	21	1.1	--	--
No of Congo barque boats owned or rented	--	--	53	1.7
No of Kabalega boats owned or rented	4	1.0	1	2.0
No of Parachute boats owned or rented	--	--	1	3.0
No of Dugout boats owned or rented	--	--	--	--
No of Other boats owned or rented	7	1.1	--	--

The main means of propulsion of the boats was hand paddle, with hardly any outboard engines used of r fishing on Lake Edward but just few on Lake Albert.

The type of gear used by the majority on Lake Edward was gill net, with a mean of 43.1 while on Lake Albert it was the hook, with a mean of 3,008.9 (**Table 4.6.11**).

Table 4.6.11: Types of gear used

	L. Edward		**L. Albert**	
	N	Mean	N	Mean
No of Gillnets used	27	43.1	16	59.9
No of Hooks used	9	323.3	17	3,008.9
No of seines used	--	--	--	--
No of Cast nets used	--	--	--	--
No of Scoop nets used	--	--	7	1.1
No of Traps used	1	5.0	2	1.0
No of Other gears used	--	--	17	1.8

The sources of gear to the fishers varied. On Lake Edward, gear was obtained mainly from outside the district. On Lake Albert, however, most fishers obtained them from the same village where they operated (**Table 4.6.12**).

Table 4.6.12: Sources of fishing gear

	Within this village	Another village nearby	This District /Province	Another District/Province	Another Country	Total
L. Edward	18.8%		28.1%	43.8%	9.4%	100.0%
L. Albert	54.0%	10.0%	12.0%	24.0%	--	100.0%
Total	40.2%	6.1%	18.3%	31.7%	3.7%	100.0%

The average daily catches for the different species vary considerably from season to season and from lake to lake. Tilapia was the common species between the two water bodies. There were higher catches reported for tilapia on Lake Edward than on Lake Albert (**Table 4.6.13**)

Table 4.6.13: Average daily fish catches during high, ordinary and low seasons

	L. Edward			L. Albert		
	High season	Ordinary season	Low season	High season	Ordinary season	Low season
Nile perch (Kg)	--	--	--	201	43	16
Tilapia (head)	9,429	7,826	218	91	33	15
Angara (head)	--	--	--	122	25	5
Ngasia (head)	--	--	--	--	--	--
Mukene/ragogi (basin)	--	--	--	49	17	4
Other species (head)	13	5	3	--	--	--

The main fish species on Lake Edward were tilapia, *Bagrus*, *Portopterus* and *Clarias*. However, sizeable populations of mukene were hardly exploited due to cultural beliefs. Lake Albert had a wide range of fish species but the main ones were Angara, Ngasa, Nile perch, ragogi/mukene and tilapia.

Variations were noted in fish prices between the seasons. For tilapia, the common species, the prices were a little higher on Lake Edward than on Lake Albert (**Table 4.6.14**).

Table 4.6.14: Expected fish prices during high, ordinary and low seasons

	L. Edward			L. Albert		
	High season	Ordinary season	Low season	High season	Ordinary season	Low season
Nile perch (Sh/Kg)	--	--	--	1,400	1,610	1,865
Tilapia (Sh/head)	1,692	2,368	2,857	858	1,737.5	1,133
Angara (Sh/head)	--	--	--	1,733	1,900	2,000
Ngasia (Sh/head)	--	--	--	1,200	1,500	2,500
Mukene/ragogi (Sh/basin)	--	--	--	2,676	2,850	3,477
Other species (Sh/head)	2,300	3,400	7,700	1,880	3,600	3,800

E. Boat crew

The average number of crew per fishing boat was 3.5 on Lake Edward and 2,8 on Lake Albert. Highlights of the crew data are given in **Table 4.6.15** below:

Table 4.6.15: Highlights of crew payments

	L. Edward	L. Albert
Proportion of crew on percentage share payment	100.0%	90.0%
Proportion of crew members who are paid after costs are deducted	64.3%	84.2%
Percentage of the money that goes to the crew where costs are deducted.	50%	80%
Percentage of the money that goes to the crew where costs are not deducted.	30%	50%
Proportion of the crew where crew share is divided equally between all crew members	100.0%	86.4%
Proportion of crew who get fish to eat in addition to the payment	100.0%	42.9%
No of boats crew work on last year (2006)	2.7	1.3

F. Fish processors

The data on fish processing revealed that smoking continued to be the most important processing method on Lake Edward, while on Lake Albert, it was salting/sun-drying. Processed products were kept mainly in the house, reflecting lack of storage facilities. Wood and salt were the most commonly used processing materials (**Table 4.6.16**).

Table 4.6.16: Fish processing methods, assets and materials

	L. Edward	L. Albert
Fish product form processed most	Smoked (50%)	Sun-dried (46%)
Processing assets owned most	Smoking kiln (50%)	Drying racks (36%)
Where processed fish is stored most	In the house (50%)	In the house (58%)
Processing materials most used	Wood (75%)	Salt (100%)

G. Fish traders

Most of the traders dealt in fresh fish, the majority obtaining their supplies directly from fishers and trading within short distances. They used public transport and had access to good access roads, weighing scales and some forms of stores (**Table 4.6.17**).

Table 4.6.17: Highlights of trader data

	L. Edward	L. Albert
Percentage of traders who dealt in fresh form	53.8%	50.0%
Traders who bought fish from fishers	61.5%	84.6%
Average distance to the market (Km)	2.7	2.0
Means used most to transport fish to market	Public vehicle (72.7%)	Public vehicle (23.1%)
Number of trips to market per week	4.6	3.3
Quantity of fish per trip (Kgs)	208.5	137.3
Buying prices for main fish species (Shs/Kg)	2,827	5,123
Selling prices for main fish species (Shs/Kg)	3,012	6,550
Traders with availability of access roads	87.5%	84.6%
Traders with access to weighing scale	75.0%	64.3%
Traders with availability of stores	62.5%	38.5%

H. Gender participation in fisheries

Within the households, allocation of responsibility for the different fishery activities was identified as tabulated below, indicating a still lower but increasing participation of women in the different fishery functions (**Table 4.6.18**).

Table 4.6.18: Share of responsibilities between men and women in fisheries activities

Activities	Functions	L. Edward		L. Albert	
		Men	Women	Men	Women
Fishing	Repairing boats	61.8%	3.6%	98.0%	--
	Repairing nets	66.1%	3.6%	98.1%	--
	Setting nets	66.1%	1.8%	98.3%	--
	Cleaning fish	21.4%	53.6%	46.7%	46.7%
	Grading	48.9%	40.4%	16.7%	66.7%
	Icing	13.0%	8.7%	100.0%	--
Processing	Smoking	24.1%	44.4%	--	100.0%
	Salting	12.0%	46.0%	20.0%	80.0%
	Sun-drying fish	12.2%	46.9%	9.1%	88.6%
	Frying	4.2%	56.3%	--	100.0%
Marketing	Buying fish	51.7%	31.0%	52.0%	44.0%
	Retailing	12.2%	44.9%	76.3%	21.1%
	Wholesaling	37.5%	27.1%	72.2%	27.8%
	Transporting	52.0%	20.0%	80.0%	20.0%
	Packaging	41.7%	29.2%	71.4%	28.6%
	Loading/ Unloading	57.1%	4.1%	88.2%	11.8%
Management	Decision making	64.4%	28.8%	86.7%	13.3%
	Paying expenses	63.2%	31.6%	83.7%	16.3%
	Keeping earnings	63.8%	31.0%	81.3%	18.8%

Participation of women in fisheries was not considered to be hindered by religion, tradition or lack of education (**Table 4.6.19**).

Table 4.6.19: Influences of religion, tradition and education on women participation in fisheries

	L. Edward	L. Albert
Respondents who consider religion not to hinder participation of women	91.2%	97.6%
Respondents who consider tradition not to hinder participation of women	66.7%	97.6%
Respondents who consider lack of education not to hinder participation of women	96.5%	96.3%

Women were also reported to be sharing in the benefits accruing from fisheries activities, mostly through food, medical expenses and clothing (**Table 4.6.20**). There is need to encourage more fishers to allow women to share in cash and to be able to remit some of the cash to their families.

Table 4.6.20: How women share in the benefits from fisheries activities

	L. Edward	L. Albert
Respondents who shared in cash with women	82.4%	78.9%
Respondents who shared in food with women	96.3%	98.6%
Respondents who shared in clothing with women	94.1%	98.6%
Respondents who shared in medical expenses with women	92.5%	98.6%
Respondents who shared in remittances to by women their families.	80.5%	91.0%
Estimates of wives' share of benefits from household fisheries activities	34.9%	38.3%

Overall, the estimates of wives' shares of benefits from household fisheries activities were reported to be 30-40%.

I. Access to social services

A growing level of facilities and services were available at many of the landing sites, including schools, health centres and water supply, provided under the broad policy of Government under PEAP. These facilities are not limited to fishing communities but serve the entire villages, parishes or sub-counties within which they are located. Most of them are within distances of less than 5 km from the landing sites.

Among the most effective policies is UPE, under which Government committed itself to providing free primary education to all school going age children in Uganda. **Table 4.6.21** gives indication of the enrolment of children at schools within the vicinity of selected landing sites on Lake Albert.

Table 4.6.21: School enrolments at selected landing sites, Lake Albert

	Tonya	Sibagolo	Walukuba	Panyimur
Enrolment	600	300	530	3,100

J. Health status of the fishing communities

The main food types for fishers were cassava (**Table 4.6.22**), flour and matoke, consumed with fish and beans. Generally, there was limited food production at the landing sites. This was because either the landing sites were within the game parks where agriculture was not allowed or the soils were unsuitable for crop production.

On Lake Edward, the main food supply sources to the landing sites were Kasese, Bunyaruguru and Rukungiri. Similarly, on Lake Albert food came from farming areas several kilometres away from the landing sites.

Table 4.6.22: Respondents' feeding practices

	L. Edward	L. Albert
The usual number of meals eaten in the household in a day	2.8	2.9
The main staple food in the households	Cassava (55.2%)	Cassava (85.2%)
The main sauce in the households	Fish (84.5%)	Fish (89.7%)

Food availability fluctuated from season to season, with more people having lass than sufficient food during the months of January to March on Lake Albert and July to September on Lake Edward (**Table 4.6.23**).

Table 4.6.23: Food availability by season

	L. Edward	L. Albert
Respondents who had less than sufficient food during January-March	43.9%	45.3%
Respondents who had less than sufficient food during April-June	35.6%	32.6%
Respondents who had less than sufficient food during July-September	64.4%	18.6%
Respondents who had less than sufficient food during October-December	25.9%	23.5%

With respect to diseases, most families suffered from malaria, followed by diarrhoea on both Lakes Edward and Albert (**Table 4.6.24**).

Table 4.6.24: Diseases suffered by families in 2006

	L. Edward	L. Albert
Households were a member suffered from Kwashiorkor last year	5.1%	13.3%
Households were a member suffered from Malaria last year	94.8%	92.0%
Households were a member suffered from Bilharzia last year	6.8%	48.8%
Households were a member suffered from HIV/AIDS last year	3.4%	13.9%
Households were a member suffered from Diarrhoea last year	49.2%	65.9%
Households were a member suffered from Typhoid last year	39.0%	24.7%
Households were a member suffered from Cholera last year	18.6%	12.7%

Different categories of health facilities were identified within the fishing communities, including private, NGO and public facilities as well as traditional and spiritual healers. However, most respondents reported receiving health services from public and private health facilities (**Table 4.6.25**). Performance of public health facilities was reported at the landing sites was hindered by the long distances and poor access roads to the District Hospitals where drug replenishments were obtained and lack of willingness of staff to serve at these remote landing sites.

Table 4.6.25: Where respondents received health services

	L. Edward	L. Albert
Respondents who received health services from private health facilities	86.1%	97.4%
Respondents who received health services from NGO health facilities	6.1%	--
Respondents who received health services from public health facilities	94.8%	96.7%
Respondents who received health services from traditional medicine man	15.0%	20.0%
Respondents who received health services from spiritual healers	10.3%	20.0%

To most of the respondents, the public health facilities were less than 5 kms both on L. Edward (89.7% of respondents) and on L. Albert (91.7%), implying that they were accessible.

The main sourced of drinking water to the households were piped water for Lake Edward (48.3%) and the lake for Lake Albert (45.2%). Other sources included shallow well, piped/tap, spring/river and rainwater.

With respect to sanitation, ownership and use of latrines were examined. The data revealed that the majority of the respondents had latrines and those who did not have them used the bush (**Table 4.6.26**).

Table 4.6.26: Access to latrines at home

	L. Edward	L. Albert
Respondents who had latrines at the houses where they stayed	92.6%	93.1%
Where those who did not have latrines went	The bush (69.2%)	The bush (66.7%□)

K. Wealth status and livelihood opportunities

Fishers owned a variety of types of wealth assets. A few reported owning houses, mostly of the semi-permanent types but some also owned permanent and temporary houses (**Table 4.6.27**).

Table 4.6.27: Ownership of houses

	L. Edward	L. Albert
Respondents owning permanent houses	43.3%	6.8%
Respondents owning semi-permanent houses	61.7%	27.3%
Respondents owning temporary houses	21.7%	69.3%

The radio was the most commonly owned wealth item but others included bicycles, land and vehicles (**Table 4.6.28**).

Table 4.6.28: Ownership of wealth

	L. Edward	**L. Albert**
Respondents who owned vehicle	4.1%	4.6%
Respondents who owned land	66.0%	43.4%
Respondents who owned bicycle	29.4%	65.9%
Respondents who owned radio	93.1%	84.5%

Among those who owned land, the majority put it to crop production while other uses included grazing animals and leasing for the use of others. Some land also remained unused. Most fishers reported owning chickens and ducks but others also owned goats and sheep, pigs and cattle (**Table 4.6.29**).

Table 4.6.29: Average land holding and livestock owned

	L. Edward	L. Albert
Average size of land owned (ha)	2.9	15.4
Mean number of cattle	3.4	6.5
Mean number of goats & sheep	4.4	9.3
Mean number of pigs	0.8	3.2
Mean number of chickens and ducks	4.6	13.3

The expenditure patterns of the fishers revealed that food, health care and education were given high priority; shelter was given medium priority while investment was given low priority. Most fishers slept on mattresses alone but others used either beds plus mattresses or papyrus mats. Firewood was the most common fuel for cooking, followed by charcoal and paraffin.

Concerning alternative income sources, it was difficult for fishers on Lake Edward to identify and take advantage of alternative livelihood opportunities. This was because the landing sites were in the game park were important activities such us cattle rearing and farming were prohibited under the game park regulations. The available alternative livelihood sources included trade in mixed merchandise, apiary, goat, poultry and duck rearing. Utilization of these alternative income sources was, however, hindered by lack of knowledge and lack of capital.

Even on Lake Albert where the landing sites were not in a game park, fishers took little advantage of alternative income sources to supplement fishery incomes, despite expressing desires to do so (**Table 4.6.30**).

Table 4.6.30: Respondents involved in activities to contribute to their household incomes

	L. Edward	L. Albert
Fishing income from boats and gear owned	67.2%	72.1%
Fishing employment (wages and salaries)	52.7%	52.3%
Fish trading & processing	29.8%	72.3%
Net making or repairing	16.1%	18.8%
Boat building and repairing	1.8%	
Non-fishing employment (wages and salaries)	3.5%	6.9%
Trading in other food commodities	22.4%	21.9%
Trading in non-food items	10.9%	16.1%
Farming (Crops and Horticulture)	33.3%	68.6%
Livestock Farming	38.0%	60.0%
Remittances or Transfer payments	6.1%	--
Rental income	17.4%	11.1%

To enable them begin alternative income activities, the fishers required training. Other resources identified included capital, source of energy and good access roads.

L. Information and communication

Development of a community depends very much on the efficiency and effectiveness of the information and communication services available to it. In this respect, most fishers reported that they listened to the radio every day while others listened most days of the week. The radio stations listened to most were Radio West and Voice of Tooro for Lake Edward and BBS and Radio Paidha for Lake Albert.

Most fishers reported that they never read newspapers (**Table 4.6.31**).

Table 4.6.31: Access to the media

	L. Edward	L. Albert
Respondents who listened to the radio everyday	61.4%	84.1%
Respondents who never read newspapers	54.9%	59.3%

The best way of getting information about fisheries was said to be meetings/baraza followed by the radio on Lake Edward while on Lake Albert, it was the radio, followed be meetings/baraza(**Table 4.6.32**).

Table 4.6.32: The best way of getting information about fisheries

	Brochures	Radio	TV	Meetings/baraza	Total
L. Edward	--	25.9%	1.7%	72.4%	100.0%
L. Albert	4.9%	56.1%	--	39.0%	100.0%
Total	2.9%	43.6%	0.7%	52.9%	100.0%

M. Adoption and Impact of fisheries management measures

Many fishers believed that they were aware of the main fishing regulations governing fish sizes, gear sizes and types, methods of fishing and licences (**Table 4.6.33**).

Table 4.6.33: Respondents' awareness of regulations

	L. Edward	L. Albert
Catching Nile perch of less than 50cm is prohibited	--	89.4%
Catching tilapia less than 25cm is prohibited	98.3%	88.4%
Using gillnets of less than 5" is prohibited (4" for Lake Albert)	94.6%	88.1%
Using fish poison is prohibited	97.9%	87.1%
Using unlicensed boat is prohibited	100.0%	92.4%
Fishing without license is prohibited	100.0%	90.1%
Use of beach seines is prohibited	94.4%	85.2%
Using cast netting is prohibited (tupa tupa)	100.0%	84.8%
Beating water (tycooning) is prohibited	100.0%	83.6%
Basket trapping is prohibited	92.0%	84.6%
Use of monofilaments is prohibited	100.0%	82.4%

Most of the respondents reported complying with the regulations. However, many admitted to failing to adhere to some of them for reasons including the costs involved in acquiring acceptable gear, productivity considerations and the rampant theft of gears on the lake.

Fishers were aware that the responsibility for enforcing these measures lay with BMUs, Fisheries Officers and Police. Memberships of the BMUs ranged between 700 at Rwenshama to 1,000 at Katwe. Members supported their BMUs by attending meetings, voting, contributing fish and sometimes cash under specific appeals. No lake wide organisations were in place, although the idea was being discussed.

Many fishers believe that the management measures have had an impact on their activities, through higher fish catches, bigger fish and better fish prices.

N. Investments and credit in fisheries

The levels of investments in fish catching, processing and trading was generally low. The equipment used were of low value and this was attributed to lack of capital and the low returns on fishery activities given the drastic catch declines experienced on the lakes in recent years. Most fishers raised their capital from their own savings previously accumulated, while others obtained loans or received transfer payments from relatives.

Various forms of saving and credit schemes were reported at the landing sites but these were generally unsatisfactory due to lack of capital and poor management. An exception was the Village Bank at Panyimur, which was considered adequately funded, with donor support, and properly managed. However, the response of fishers to the services provided was reported to be poor. Most fishers did not have bank accounts and for the few who had, the accounts were either at the district headquarters or in another district altogether (**Table 4.6.34**).

Table 4.6.34: Respondents' banking information

	L. Edward	**L. Albert**
Respondents who used own savings as sources of capital for their activities	62.5%	62.0%□
Respondents who had bank accounts	42.6%	27.9%□
Respondents who had access to savings and credit schemes	84.8%	60.2%□

In order to ensure that their fish businesses did not collapse but flourished, the most commonly taken measure was to provide good management. (**Table 4.6.35**).

Table 4.6.35: Measures taken to ensure that fish business did not collapse but flourished

	Ensure good management	Good use of resources	Use of skills	Find good market	Others	Total
L. Edward	56.1%	21.1%	5.3%	17.5%		100.0%
L. Albert	60.5%	10.5%	2.6%	3.9%	22.4%	100.0%
Total	58.6%	15.0%	3.8%	9.8%	12.8%	100.0%□

The main constraint to investment in fisheries reported was scarcity of fish (**Table 4.6.36**).

Table 4.6.36: Main constraints to investment in the fisheries

	Scarcity of fish	Lack of market	High fish prices	Low fish prices	Lack of energy	Lack of credit	Others	Total
L. Edward	75.9%	13.8%		3.4%		6.9%		100.0%
L. Albert	37.8%	1.2%	1.2%	7.3%	1.2%	6.1%	45.1%	100.0%
Total	53.6%	6.4%	.7%	5.7%	.7%	6.4%	26.4%	100.0%□

O. Economic contribution of fisheries

Fish provided the main source of income to the household and landing site communities. Considerable revenues were also generated from the landing sites through landing site tenders, landing fees, fish movement permits as well as boat license fees.

Revenues from the landing sites contributed significantly to the sub-county and district revenues.

P. Trans-boundary issues

Lakes Edward and Albert fisheries are trans-boundary resources, exploited by users from both Uganda and DRC. Fishers from the riparian countries were reported to cross the border regularly in search for fish. However, a number of cross border issues associated with these activities were reported, the main ones being:

a) Unclear border demarcations

b) Differences in fisheries regulations between riparian countries

c) Theft of gear

d) Insecurity

e) Spread of diseases, and

f) Environmental threat posed by the practice of salting fish on the lake.

To address the cross-border issues, fishers recommended that the laws and regulations within the riparian countries be harmonised and their methods of implementation streamlined under a regional lake-wide organisation.

4.6.3 Analysis of the Main Issues in Fisheries Socio-economics for the development of an Integrated Lakes Management Plan

A diagnosis of the preliminary findings of the studies reveals a number of development concerns within the fisheries of Lakes Edward and Albert which need to be addressed in the formulation of the fisheries Management Plan.

a) Cases of conflict within the leadership of the fishing communities, involving BMUs, LCs, Fisheries staff, Market tenderers, Police etc., which retard development and could be resolved through definition of roles and co-ordination of the different agencies operating at the landing sites.
b) Rapid migration of fishers, which hinders the operations of BMUs, fisheries management and planning of service provision.
c) Unplanned settlements that do not allow for proper housing and sanitation conditions at the landing sites.
d) Low levels of education and literacy among fishers, limiting their capacity to adopt fisheries, environmental and business management practices.
e) Distant educational facilities and low school enrolment rates at some landing sites.
f) Poor access roads and means of transport to many landing sites and unsafe transport boats that hinder the marketing of fish and delivery of supplies to the fishing communities.
g) Rampant water born and communicable diseases and limited drugs at most public health facilities to deal with them.
h) Low fish catches for most periods of the year.
i) Low fish prices received by fishers at many of the isolated landing sites
j) Limited exploitation of mukene stocks on Lake Edward, due to socio-cultural reasons.

k) Conflict between fishers of ragoge/muziri and Nile perch/tilapia over the use of light fishing on Lake Albert.
l) Inadequate training received by fishers, processors and traders.
m) Poor and unreliable supply of fishing inputs, particularly on Lake Edward.
n) Significant post harvest losses, reflected in fall in fish prices, loss of quality and loss of products.
o) Limited participation of women in the various fisheries activities.
p) Low share of women in the benefits from fisheries activities.
q) Low levels of wealth accumulation, including savings, among fishing communities.
r) Limited alternative income generating opportunities on Lake Edward.
s) Low involvement by fishers and their wives in alternative income generating activities, even where they exist.
t) Over reliance on the radio as the only medium for receiving fisheries information.
u) Lack of reading culture and limited reading materials for the information to fishers.
v) Limited knowledge of and compliance with fisheries management regulations.
w) Unclear positive impacts of fisheries management measures to the fishers.
x) Limited facilities for savings and credit available to fishing communities.
y) Unregulated cross-border fishing and fish marketing on the lakes.
z) Lack of harmonisation in fisheries laws and regulations between Uganda and DRC and mechanisms for co-ordination.

4.7 FISHERIES BIOSTATISTICS

4.7.1 Existing Fisheries Statistics

A. Uganda

From its formation in 1961 to 1997 the Fisheries Department was responsible for compiling fish production and marketing data from monthly and annual returns from Districts. Fisheries Assistants/Fisheries Development Officers posted to the fish landing sites together with the District Fisheries Officers, who were all answerable to the Fisheries Department, were responsible for fisheries extension services to the fisherfolk and the collection of fisheries statistics which were compiled by the DFO and submitted to the Fisheries Department Headquarters in Entebbe. From time to time the Fisheries Department carried out periodic surveys for on spot ground ‘truthing’.

Following decentralisation in 1998, the fisheries sector was put fully under the charge of the various districts. The data collection function has since become ineffective because of the low response of Districts, which cite under-facilitation and under-staffing as the reasons for this. Reliable data has thus since become difficult to compile.

Available data is shown in **Table 4.7.1** below and in **Fig. 4.7.1** and **Fig. 4.7.2** for better visualisation. It should be noted that data for Lake George are always combined with those of Lake Edward. As explained above, information for the most recent years is not available as since the onset of Decentralisation Districts no longer collect/submit such information. The data show considerable fluctuation from year to year. The data for Lake Albert show a low positive, but not statistically significant trend. The data for Lake Edward/George show a low negative (i.e. downward), statistically significant trend.

Table 4.7.1: Fish landed in Uganda in ('000 Metric Tonnes)

YEAR	L.ALBERT	L.EDW/GEO
1961	11.8	12.5
1962	12.2	12.1
1963	12.5	12
1964	10.2	10.2
1965	12.4	12.6
1966	13.6	10.9
1967	13.2	12.9
1968	13.5	13
1969	10.4	11.8
1970	24.2	10.5
1971	9.5	11.7
1972	10.5	12.3
1973	13	11
1974	13.5	10.5
1975	18.7	13.2
1976	12.3	12.5
1977	20.6	12
1978	20.6	11.8
1979	17	9.6
1980	13	7
1981	6	5
1982	10	6.9
1983	6	6
1984	6	6.5
1985	2.3	6
1986	4.9	6.3
1987	8.9	6.2
1988	12.5	5.9
1989	13.9	5.6
1990	19.48	5.5

1991	20.53	10.93
1992	18.7	10.6
1993	17.55	10.7
1994	16.4	10.8
1995	16	9
1996	22	5
1997	19	6
1998	19.1	5.6
1999	29.06	7.43
2000	19.38	5.22
2001	19.6	6.4
2002	19.38	5.22
2003	19.46	5.86

Fig. 4.7.1 Fish Landed at Lake Albert in Uganda

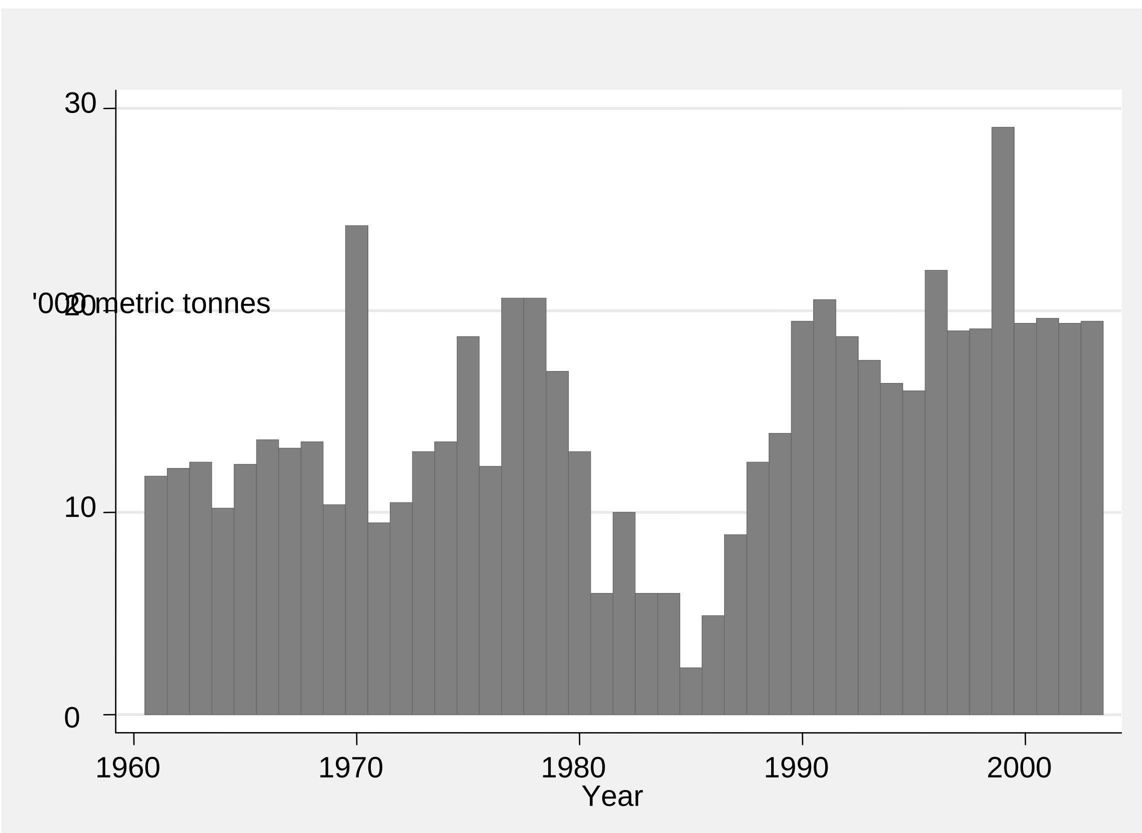
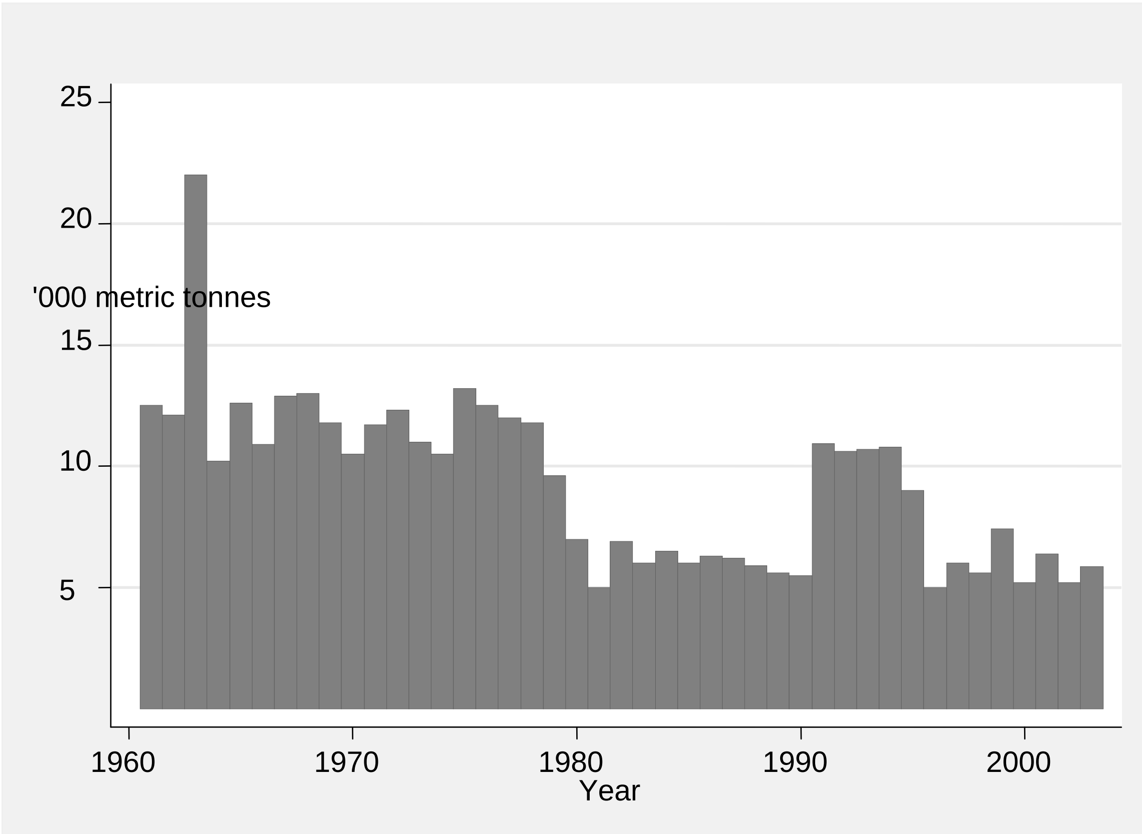


Fig. 4.7.2 Fish Landed at Lakes Edward/George in Uganda



B. The Democratic Republic of the Congo (DRC)

Official statistics on fishery production are available for only 17 years over the period 1950 to the present, as indicated in **Table 4.7.2** below. The same data are shown graphically in **Fig. 4.7.3** and **Fig. 4.7.4** further below. The paucity of the data does not allow any meaningful statistical tests for trend.

Table 4.7.2 Fish Landed In DRC in (Metric Tonnes)

Year	L. Edouard	L. Albert
1950	1773	1794
1951	2127	2500
1952	2062	3240
1953	2836	4092
1954	3241	6167
1955	3001	7770
1956	3108	8943
1957	2920	11674
1958	4211	9061

1984	4000	3800
1986	3470	4700
1990	3986	19440
1991	5021	8400
1992	3623	10073
1993	4146	7844
1994	6520	8688
1998	4990	10010

Fig. 4.7.3 Fish Landed at Lake Albert in DRC

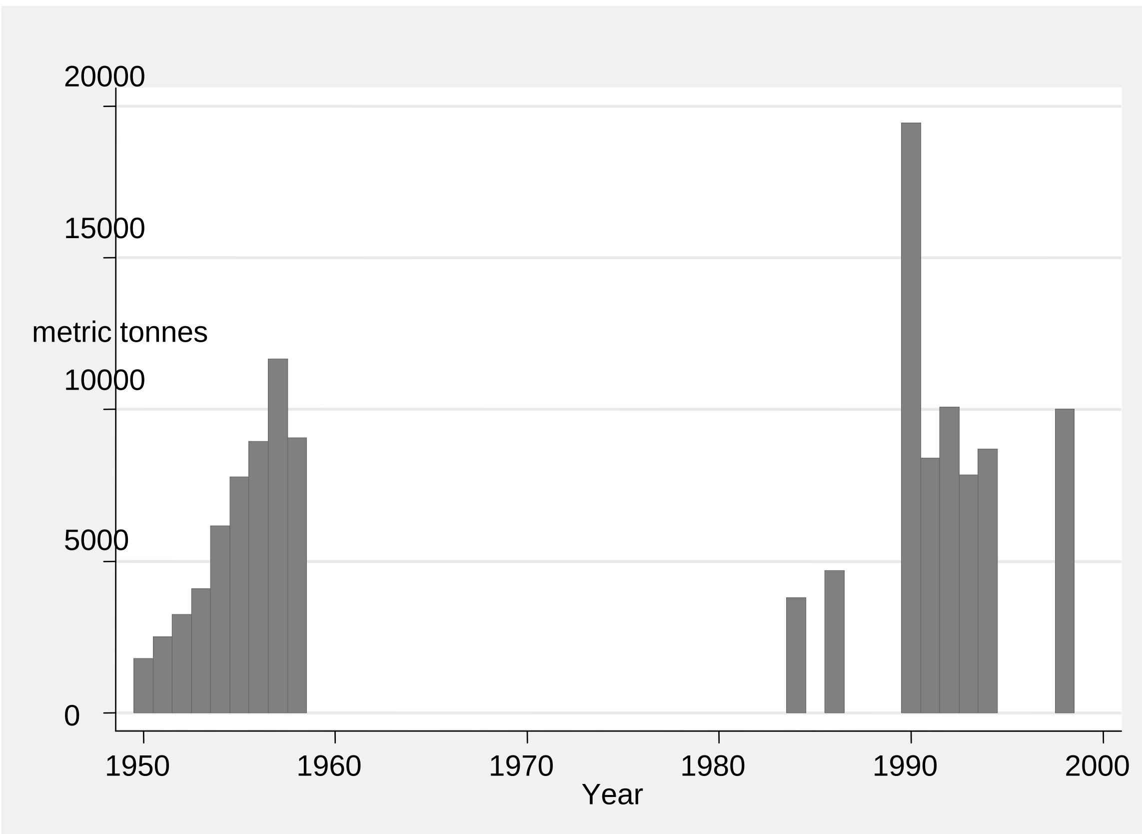
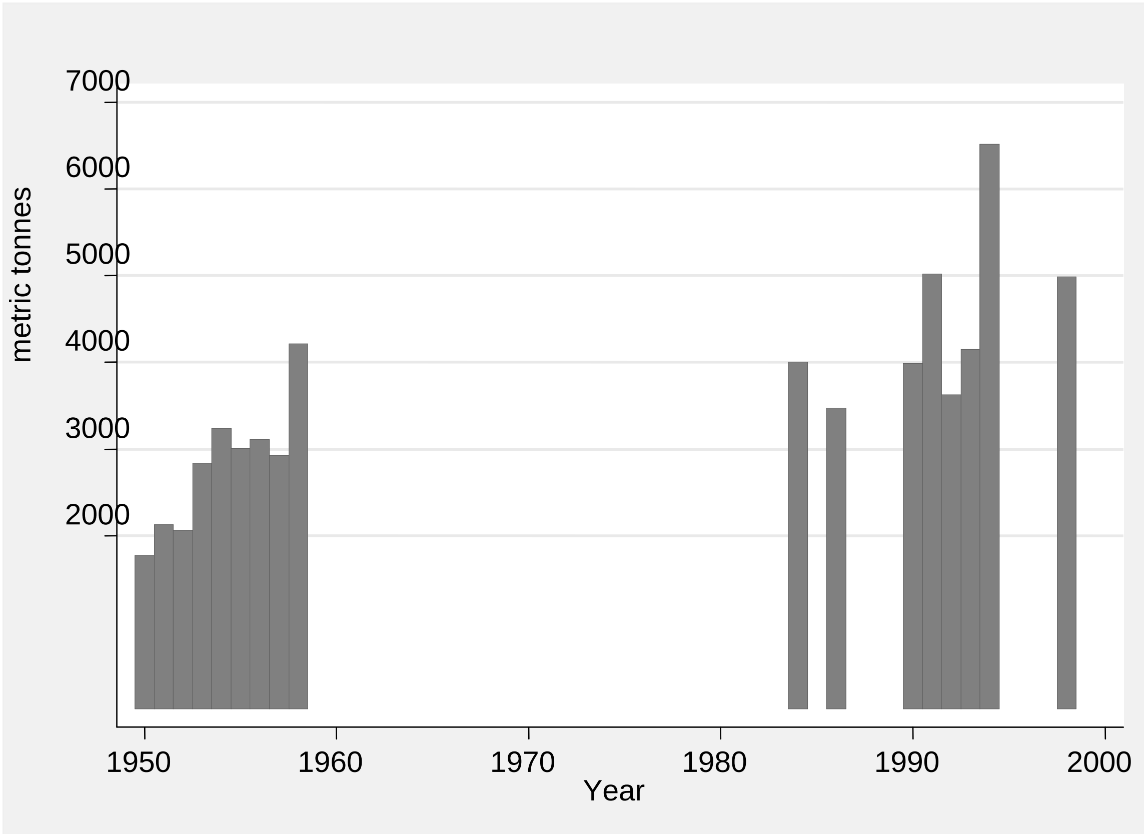


Fig. 4.7.4 Fish Landed at Lake Edward in DRC



4.7.2 Frame Surveys

It was established that FIRRI have recently (January 2007) carried out a Frame Survey of both Lakes Albert and Edward on the Uganda side. Arrangements are being made to access this data. Accordingly, we have not carried out a Frame Survey of the two lakes on the Ugandan side.

Since we have not carried out a Frame Survey on the Ugandan side, we took the opportunity during the launching of the Catch Assessment Survey on Lake Edward in Uganda to ascertain the number of fishing boats on the Ugandan side of Lake Edward by inquiring from the BMUs. The numbers we have ascertained so far are as in **Table 4.7.3** below.

Table 4.7.3: Number of Fishing Boats on Lake Edward (Uganda)

Landing Site	**Number of Boats**
Rwenshama	72
Kishenyi	60
Kazinga	36
Katwe	120
Kayanja	36

A Frame Survey of the two lakes in the DRC has been carried out. The Frame has been constructed by carrying out a complete enumeration of the two lakes, collecting information on:

i. Existing landing sites and their location and characteristics (Fish species, facilities, etc);
ii. Number of fishing units and information on their components, such as fishermen, fishing boats, fishing gear per landing site; and
iii. Periodicity of fishing activities.

The approach to the Frame Surveys was by road. Temporary data gatherers were trained and used to carry out a landing site by landing site coverage of the shorelines of the two lakes while filling in a questionnaire designed for this purpose. Local Government officials and fishing Cooperatives were the respondents for completing the questionnaire.

The findings of the Frame Surveys are set out in **Tables 4.7.3** and **Table 4.7.4** below. In short, a total of 19 sites were identified on Lake Edward while 70 were identified in Lake Albert.

Some of the landing sites on Lake Edward were inaccessible due to the presence of rebel groups.

Table 4.7.4: Fish landing sites on L Albert in DRC

Site	Number of Boats
Adu	12
Ajanngwa	22
Anoke I & II	22
Apee	13
Aruko	46
Awey	24
Cafe	70
Camp Kasenyi Port	63
Camp Katho	33
Camp Lako	95
Camp Mugumba	93
Camp Ndrigi	16
Datule	21
Dhui	17
Galima	25
Gobu	87
Gobu-Muke	15
Hii	25
Jbii	75
Joo	100
Kakokwa	21
Kalingwa	237
Kamtasi	24

Kamusonga/Ndawe	44
Kango	25
Karitas	14
Kaswa I	82
Kaswa II	18
Kisinja	150
Kiza	43
Kolokoto	74
Kwero	40
Malonga	42
Mbogi I	30
Mbogi II	54
Mbuse	30
Muchanga	61
Muganga	48
Muguma	68
Mukashi	110
Musekere	49
Muzugu	130
Myasoro	25
Nana	70
Nvodu	25
Nyagisi	47
Nyamamba	51
Nyamavi	17
Nyamondra	14
Nyamusasi	35
Nzonzo	50
Sabe	63
Songa I	50
Songa II	33
Songa-Ndaro I	60
Songa-Ndaro II	70
Sora-Nzuda	30
Tagba	66
Tchomia	93
Terabolo	67
Torges	25
Ubonga-Adji	7
Ulikingi	29
Uri I	55
Uri II	39
Voo	75
Wasisi I & II	62
Wath’Nyok	27

Wikiddi I	121
Wikiddi II	36

Table 4.7.5 : Fish landing sites on Lake Edward in DRC

SITE	Number of Boats
Kasindi Port	60
Mahigha	6
Kyavinyonge	153
Muramba	35
Kisaka	198
Musenda	85
Katundu	100
Lunyasenge	94
Musuku	
Muyirimbu	
Talihya	25
Kamandi	130
Kyanika	
Vitshumbi	394
Kavale	
Mutimatsanga	
Nyakakoma	137
Kagezi	
Kihangiro	

4.7.3 Catch Assessment Surveys

A Catch/Effort survey aiming at collecting current information on total catch and fishing effort is being carried out, beginning with Lake Albert. A spatio-temporal sample is being used for data collection.

The following sites were purposively selected for the Catch Assessment Survey:

Lake Albert	Uganda	Wanseko, Butiaba, and Ntoroko.
	DRC	Mahagi and Tchomia
Lake Edward	Uganda	Katwe and Rwenshama
	DRC	Kyavinyonge and Vitshumbi

The operational steps in the sample design of the Catch Assessment Survey have involved the selection of the sample of landing sites (sampling in space) and the selection of the sample days (sampling in time). A temporal sample of one day per week over a period of two months has been selected for obtaining the required information from a sample of boat landings within the sample landing sites.

For field operations during a Catch/Effort Survey, recorders have been trained and assigned to the survey on a temporary basis.

Because all the selected landing sites were large (>= 200 boats), a one in ten sampling scheme was adopted.

Weights of catches are obtained by weighing all the fish using scales provided, by species.

The data are recorded on the form provided in **Annex I** below.

Supervisors have been assigned and used to check on the errors and biases due to either incomplete or inaccurate recording by the statistics gatherers.

The next activity will be to retrieve the completed CAS forms from the landing sites, beginning with the Ugandan side of Lake Albert in August 2007.

In this study Catch will be defined in terms of weight of fish landed while Fishing Effort will be measured in fishing boat-days.

Catch Per Unit of Effort will then be computed as catch per fishing boat per day.

Annex I

LEAF PILOT PROJECT LAKE ALBERT CAS 2007

Form No.		Sub-county	
Date		Parish	
District		Water body (Lake/River)	
Recorder(s) Name		Landing site Name	

Fishing Craft at landing Site

Type	Powered	Not powered
1. Dugout boat		
2. Parachute		
3. Sesse pointed at both ends		
4. Sesse pointed at one end		
5. Rafts		
6. Congo baki (CB)		

Sample boats (1 out of every 10)

Day 1 8,18,28,38,48,58,68,78,88,98,108,118,128,138,148,158,168,178,188,198,208,218,228,…

Day 2 3,13,23,33,43,53,63,73,83,93,103,113,123,133,143,153,163,173,183,193,203,213,223,…

Day 3 6,16,26,36,46,56,66,76,86,96,106,116,126,136,146,156,166,176,186,196,206,216,226,…

Day 4 9,19,29,39,49,59,69,79,89,99,109,119,129,139,149,159,169,179,189,199,209,219,229,…

Day 5 4,14,24,34,44,54,64,74,84,94,104,114,124,134,144,154,164,174,184,194,204,214,224,…

Day 6 2,12,22,32,42,52,62,72,82,92,102,112,122,132,142,152,162,172,182,192,202,212,222,…

Day 7 1,11,21,31,41,51,61,71,81,91,101,111,121,131,141,151,161,171,181,191,201,211,221,…

Day 8 5,15,25,35,45,55,65,75,85,95,105,115,125,135,145,155,165,175,185,195,205,215,225,…

LEAF PILOT PROJECT LAKE ALBERT CAS 2007 CODE SHEET

EXPLANATION OF CODING

CRAFT TYPE

1. Dugout boat
2. Parachute
3. Sesse pointed at both ends
4. Sesse flat at one end
5. Rafts
6. Congo baki (CB)

Length: Measured in metres using a tape measure or a rope with knots tied at 1 metre intervals

PROPULSION: Method of propulsion: - State main type

1. Outboard motor
2. Paddles
3. Sail

HP: If PROPULSION is inboard or outboard engine state the Horse power, e.g. 15

CREW: Number of crew who normally accompany the boat on a fishing trip

MO: Mode of operation of gillnets 1. Active 2. Passive 3. Drift (Tembea)

GEAR TYPES

GN Gill Net: State number

LL Long Lines: State number of hooks

BS Beach seine: state number of complete sets

CN Cast net: State number

HL Hook and Line: State number of lines

TR Traps: State number

MF Monofilament: state number of complete sets

LN Lift net: State number

SN Scoop net: State number

SS Small seine / Lampara targeting Mukene: State number of complete sets by mesh size range (mm)

Others Other gear not specified above: State type and Number

SPECIES TARGETED

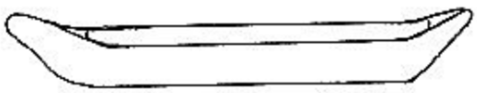
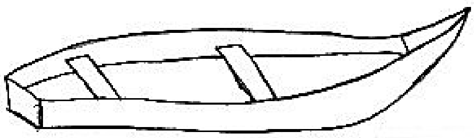
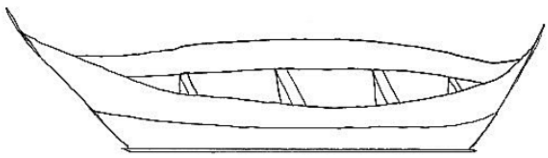
1. *Lates* (Mputa)
2. *Rastrineobola/Neobola* (Mukene)
3. Tilapiines (Ngege)
4. *Clarias* (Male)
5. *Protopterus* (Mamba)
6. *Synodontis* (Nkolongo)
7. Haplochromines (Nkejje)
8. *Bagrus* (Semutundu)
9. *Labeo*
10. Barbus (Kisinja)
11. *Scilbe*
12. *Malapterurus*
13. *Alestes* (Angara)
14. Brycinus
15. *Auchenoglanis* (Bubu)
16. *Hydrocynus* (Ngassia)
17. Other (Name)

Form Part C – Fishing Operations

Form No.		Sub-county	
Date		Parish	
District		Water body (Lake/River)	
Recorder(s) Name		Landing site Name	
		Boats landed today	

Use separate rows for each gear type and species. Ensure that hours fished with each gear type is recorded

VESSEL DETAILS								GEAR / EFFORT DETAILS				FISH CATCH DETAILS			
Serial Number	Day/Night fishing	Reg. No.	Vessel type code	Length (m)	Propulsion code	Number of Crew	Days the boat fished in the last one week	Gear type code	Number of units	Mode of operation Code	Hours fished	Species name or Code	No. of fish (large spp) No. basins /buckets (Dagaa/ Mukene and Nkejje/Furu)	Catch wt (kg) large spp Wt (kg) 1 basin/ bucket (Dagaa/Mukene & Nkejje/Furu)	Price (shs/kg) large spp. Price 1 basin/bucket Dagaa/Mukene & Nkejje/Furu

Vessel type	Description
1. Dugout boat 	▪ Curved out of a whole log of a tree. ▪ Common size, 4 to 5 m long ▪ Entirely propelled by paddle ▪ Operated exclusively in the littoral areas targeting Nile tilapia ▪ The main fishing gears used are gillnets and basket traps
2. Parachute 	▪ Constructed from planks of timber ▪ Flat bottomed ▪ Common size, 4 to 6 m long ▪ Entirely propelled by paddle ▪ Operated exclusively in the littoral areas targeting Nile tilapia ▪ The main gears used are gillnets, cast nets and basket traps
3. Sesse pointed at both ends 	▪ Constructed from planks of timber ▪ V-shaped bottom with a keel ▪ Common size, 6 to 10 m long ▪ Propelled by paddle or sails ▪ Operated in the littoral and sub-littoral areas, up to about 3 km from the shore ▪ Largely unspecialised, i.e. used in the Mukene/Dagaa /Omena fishery with small seines; in the Nile tilapia fishery with gillnets, cast nets and basket traps; and in the Nile perch fishery with gillnets, beach seines, long lines and hand lines
4. Sesse flat at one end 	▪ Constructed from planks of timber ▪ V-shaped bottom with a keel ▪ Common size, 5 to 12 m long ▪ Propelled by paddle, sail or out board motor ▪ Largely unspecialised, i.e. used in the Mukene/Dagaa /Omena fishery with small seines; in the Nile tilapia fishery with gillnets, cast nets and basket traps; and in the Nile perch fishery with gillnets, beach seines, long lines and hand lines

4.8 POLICY, LEGAL AND INSTITUTIONAL ISSUES IN LAKES EDWARD AND ALBERT

4.8.1 Introduction

One of the objectives of the Lake Edward and Albert Fisheries (LEAF) study is to provide plans for harmonized fishing policies and regulations between the governments of Uganda and the Democratic Republic of Congo under the Nile Equatorial Lakes Subsidiary Action Program (NELSAP) of the Nile Basin Initiative (NBI).

The review of the policy, institutional and legal frameworks of fisheries in Lakes Edward and Albert will result in a detailed report with the following key outputs:

- Identification of the gaps overlaps and conflicts in the existing policies and legislation on fisheries, water resource and environmental management in the two countries in the context of the regional agreements and international conventions.
- Proposals to address the shortcomings identified in the policy and legislative framework in the two countries.
- Identification of the underlying conflicts relating to acquisition of rights to the fishery resources of Lakes Edward and Albert.
- Identification and assessment of the capacities of the key institutions relevant to the management of fisheries of Lakes Edward and Albert. This will cover administrative and financial capacities, research structures, roles of NGOs/CBOs and donor interventions.
- Proposed Regulatory Framework for the policies, institutions and legislation of the two countries to promote effective sustainable management of the fishery resources of Lakes Edward and Albert.

This interim report presents the findings to date of the main policy, legal and institutional issues that impact on fisheries development and management of Lake Edward and Albert. At this point of the study, interviews and field visits have been done only on the Ugandan side. The interim report will therefore be based largely on activities conducted so far by the consultant in Uganda. It is planned to commence similar activities on the DRC side as soon as the security situation normalizes.

Hence, so far the study has involved review of the main documents and references from the FAO Country status reports on Fisheries Management; State of Environment Reports; Documents relating to the Nile Basin and related ecosystems; recently concluded and existing management projects; reports from various stakeholders such as Ministries of Agriculture, Animal Industries and Fisheries, Water and Environment, National Environment Management Authority and Research Institutions such as NAFIRI, MUIENR and MISR and research papers and papers presented at various workshops. The data sources included private, public and research institutions, as well as reports of various water resource and basin management projects, fisheries sector reforms, management plans and related concerns. However, it should be pointed out from the outset that there was a paucity of current documented information relating to the fisheries sector in Congo and it is hoped this deficiency will be remedied by visits to DRC.

This review of existing literature helped guide the development of the questionnaire for the stakeholder interviews, planning of which key institutions to visit, as well as determining the field itinerary. The respondents were not required to fill in the questionnaire which was used as a guide for the Consultant to ensure that when conducting interviews the main aspects were covered in a structured manner. The questionnaire used is attached in Appendix 1.

Interviews were held with key stakeholders currently involved in fisheries management within the study area coverage. These included Government Agencies, Research Institutions, professionals involved in fisheries research and management.

The use of focus groups proved important where the questionnaire would not capture all the necessary information and where time limitations would not allow participation of all potential respondents. To address this problem, qualitative information was collected from respondents to supplement information collection from questionnaires and face to face interviews. This was applied to technical staff at the district headquarters and the Beach Management Unit leaders at the landing sites. The focus groups were made of people purposely selected by the consultant to share their knowledge, views, perceptions and experiences.

The field visits facilitated first hand observation of the physical environment and assessment condition of the fisheries resources, catchment land use, activities of the local fisher folk communities, compliance efforts by regulated communities and to triangulate findings from documents reviews. The field visits made so far have been limited to the districts around the Lake Edward and Lake Albert basins; namely Rukungiri, Bushenyi and Kasese districts; Rwenshama landing site in Rukungiri district; Kishenyi landing site in Bushenyi District; Katwe landing site in Kasese District; Ntoroko Landing site in Bundibugyo District; Wanseko Landing site in Buliisa District, and Butiaba Landing site in Buliisa District. The Ugandan counterpart staff for legal and institutional aspects joined the consultant during the field visits and provided valuable technical backup and support. Unfortunately, the DRC counterpart has been unwell and has not been able to participate actively in the field activities done so far.

4.8.2 Key Findings

The key issues/findings mentioned here below are based on the literature reviewed, stakeholder discussions and field visits to date. It should be noted that some of these issues are subject to further verification or amendment as the study progresses.

A. Policy and Legal Issues

Both the DRC and Uganda have a fisheries policy in place as well as basic legislation for fisheries management. The legislation of the two countries regulates similar aspects of fisheries management including registration of vessels, licensing of activities, fishing gears, prohibited methods of fishing, fish quality standards and their enforcement and prescribes powers of the different officers in fisheries administration.

However, most of the legislation is outdated and does not address transboundary aspects of fisheries management arising from shared water resources. The current fisheries legislation of both countries is based on the premise that fisheries resources are to be exploited as a food resource and for income generation.

In both countries, the fisheries laws do not operate in isolation and there are points of overlap, convergence and conflict with other national laws related to natural resource management. These include legislation on wildlife, environment, water, forests, land mining, public health and local government.

A comparison of the two country laws reveals that the Ugandan legislation on environment and water resources management is more comprehensive and advanced than that in DRC. However, the Ugandan fisheries law does not address the environmental issues of the fish habitat. In addition, while both Uganda and DRC have in place decentralisation laws and policies, Uganda has a longer experience with decentralisation (since 1995 under the Constitution and implemented through the Local Government Act of 1997). The new Constitution of DRC adopted a decentralized system of governance granting local governments (provinces) legislative powers however, the decentralisation process is still on-going and is expected to be completed in 2009.

It is further noted that the legal systems of the two countries are fundamentally different. Uganda’s legal system is based on Common Law, whereas the DRC Legal System is based on Civil Law and Customary Law. The legal processes, procedures and structures vary in form and substance, with implications for the effective harmonisation of laws and policies. In regard to the differences in legislation between the two countries, respondents pointed out that while Ugandan fishermen on Lake Edward are regulated in respect of the time they spend on the lake fishing, their colleagues in DRC do not have this restriction and therefore spend the whole day and night fishing and even process the fish (by salting) when they are still on the lake leading to pollution of the waters. Another difference in legislation pointed out by respondents was that while Ugandan law regulates mainly by prescribing the fishing gear the Congolese laws regulate mainly by fishing grounds. It was further noted that the prescribed size of mesh nets in the two countries in respect of the same lake is different with the nets of the Congolese being smaller than those allowed by Ugandan law.

On the Ugandan side, respondents raised the issue that the Fisheries law was seen as far removed from the ordinary people since they did not contribute to it. Although the Local Government Act allows communities to make bye-laws on natural resource management, none of the districts interviewed had made any such bye-laws and the only ones availed to the consultant were draft bye-laws prepared by the Kasese Environment Office.

Both countries are party to a number of regional and international conventions/protocols that promote sustainable natural resource management such as the UNICEF Conventions, the Ramsar Convention and the FAO Code of Conduct for Responsible Fisheries. This common heritage is important in so far as it can serve to provide set of common standards and a policy framework that both countries can adhere to for sustainable fisheries management for Lakes Edward and Albert.

In regard to the Uganda, the compliance levels with the laws for the regulation of fisheries in Uganda are low. This is party due to the obsolete penal provisions under the Fish Act that provide a general penalty of a minimum of a fine of Ug. Shs 500/= and a maximum of Ug Shs 10,000 or imprisonment not exceeding two years or both. On Lake Edward gazetted landings have been established as a means of controlling the number of canoes and the disposal of fish. The Fishing Rules also require that all fish landings for all national waters take place only between the hours of sunrise and sunset however, the budgetary allocation by local governments to enforcement was too low to provide a deterrent effect since the patrols are infrequent.

An overview of the policy and legal framework relating to fisheries management in DRC and Uganda is provided here below.

a. Democratic Republic of Congo (DRC)

The DRC Fisheries policy emphasizes the need to increase fish production to provide animal protein for local populations and thus ensure food security. In regard to the general environmental laws, there is no central environmental law however there are many isolated legal texts. The DRC has a new Constitution that adopted a decentralized system of governance, and local governments (provinces) have been granted legislative powers.

The main fisheries legislation in DRC includes the following:

- 1932 Decree on Exclusive Fishing Rights.
- 1937 Decree on Fishing and Hunting as amended for its fisheries provisions by a decree of 17 January 1957, a legislative ordinance No. 52/273 of 24 June 1958 and a decree of 27 June 1960).
- Ordinance No. 432/Agri. of 26 December 1947
- 1981 regulation of fishing devices.
- 1979 ordinance (amended 1983) on fees and license categories.
- The Ordinance No. 432/Agri. of 26 December 1947 (as amended in 1952 and 1954) provides for the status and powers of fish controllers.
- A regulation of 1981 prohibits fishing by means of electrical devices, explosives or toxic substances and provides for the seizure by the authorities of any such articles and any catch caught by such means.
- A 1979 ordinance (as amended by a regulation of 1983) provides for the rate of fishing permits fees and determines the various issuing authorities.
- In 1985, a draft law providing a general legal framework for both marine and inland fisheries was devised with the assistance of FAO It is a comprehensive piece of legislation composed of 70 articles primarily directed at regulating inland fisheries.

At the international level, DRC has ratified a number of international conventions/ protocols on the environment. These include the Phytosanitary convention for sub-Saharan countries (1962), Convention for the Prohibition of the development, production and stockpiling of bacteriological and toxic weapons (1975), African Convention on Natural resources and nature conservation (1976), UN Convention on Law of the Sea (1989), Convention on Wetlands (Ramsar) (1994), Convention on World Cultural and Natural Heritage (1975), Migratory species of wild fauna (1994), Ozone depletion (protocols of London & Montreal) (1994), Global warming (Greenhouse effect) (1994), Convention on Biological diversity (1994), Transboundary hazardous wastes transportation (Bamako) (1994), Tropical timber (1990), Sea, coasts and estuaries (1989), Basel on hazardous wastes transport and treatment (1994), CITES (1994) and UN Framework Convention on Climate Change (1995).

b. Uganda

The Fisheries Policy in Uganda has been shaped by a number of policy initiatives at national level, including the Constitution of Uganda, 1995, the National Environment Management Policy (1994), the National Policy for the Conservation and Management of Wetland Resources (1995) the National Water Policy (1999) and the decentralization and privatization policies. The Fisheries Policy recognizes the need for sectoral development to proceed according to principles of ‘rational exploitation’ and ‘sustainability,’ and to achieve a balance of benefits between domestic food and employment provision requirements, and generation of foreign exchange through export sales.

The main fisheries legislation, and other related legal instruments, includes the following:

- The Fish Act (Cap. 228, Rev. 1964).
- The Trout Protection Act (Cap. 229, Rev. 1964).
- The Fishing Rules (No. 8, 1964).
- The Fish and Crocodiles (Amendment) Act (1967).
- The Fish and Crocodiles (Immature Fish) Statutory Instrument No.15 of 1981.
- The Fish and Crocodiles (Limitation on Number of Licenses) Statutory Instrument No.29 of 1981
- The National Environment Act, 1995 and Regulations there under which include:

    - The Environmental Impact Assessment Regulations, 1998;
    - The National Environment (Standards for Discharge of Effluents into Water or on Land) Regulations, 1999;
    - The National Environment (Waste Management) Regulations, 1999;
    - The National Environment (Wetlands, River Banks And Lake Shores Management) Regulations, 2000;
    - The National Environment (Hilly And Mountainous Areas Management) Regulations, 2000; and
    - The National Environment (Minimum Standards for Management of Soil Quality) Regulations, 2001.

- The Local Government Act, 1997
- The Water Act, 1995 and the Water Resources Regulations and Water (waste discharge) Regulations, 1998.
- The Mining Act, 2003
- The Public Health Act (1964)
- The Fishing (Quality Assurance) Rules (No. 8, 1998).
- The Uganda Wildlife Act, 1996
- The Fish (Beach Management) Rules, 2003
- The Fish (Aquaculture) Rules, 2003

At the international level, Uganda has ratified a number of international conventions/protocols on the environment. These include the African Convention on Natural resources and nature conservation (1977), Convention for the Prohibition of the development, production and stockpiling of bacteriological and toxic weapons (1987), UN Convention on the Law of the Sea (1990), Convention on Wetlands (Ramsar) (1998), UN Convention to combat Desertification (1997), Convention on World Cultural and Natural Heritage (1987), Vienna Convention for Protection of the Ozone Layer (1988), Montreal Protocol on Ozone depletion (1998), Global warming (Greenhouse effect) (1994), Convention on Biological diversity (1993), Basel on hazardous wastes transport and treatment (1999), CITES (1991), Lusaka Agreement on Co-operative Enforcement Operations Directed at Illegal trade in Wild Fauna and Flora (1996) and UN Framework Convention on Climate Change (1993).

B. Institutional Mechanisms

Both countries have Fisheries departments under the Ministry responsible for agriculture. However while in Uganda, the fisheries department is responsible for both regulation, law enforcement and fisheries management services, DRC has two separate institutions; the fisheries department that handles law enforcement and the National Service for Promotion and Fishery development that handles fisheries management services.

The fact that other national institutions have a stake in fisheries management gives rise to conflicts. Respondents stated that one of the major causes of conflicts in Uganda is the protection of wildlife by the Uganda Wildlife Authority in Queen Elizabeth National Park and the activities of the fishing communities and fisheries staff at local government level to regulate and enforce fishing practices. At all the three landing sites visited the fisher folk complained bitterly of the aggressive mechanisms employed by the wildlife enforcement personnel who arrest persons carrying out illegal activities and charge them under the Wildlife Act whose penalty provisions are more stringent than those under the Fish Act. The animals that were mentioned by respondents that cause destruction of food and life in the fishing villages were baboons, elephants, lions and crocodiles. An illustration of some of these animals in provided in Appendices 10 and 11.

From the interviews with stakeholders a key observation was that the judiciary who play an important role in enforcement of the Fish Act do not take offences under this law as serious offences. An example given by most respondents was that when Non Ugandans (Congolese in particular) are arrested without the required licenses they are simply deported which to them is not a punishment. While the fisheries laws in Uganda empower the fisheries officers to conduct prosecutions for fishery related offences, all the three District Fisheries Officers interviewed stated that they had not done so since they have never received any training on the law and rules of evidence.

Another source of conflict raised mentioned by respondents in Uganda on Lake Edward was the theft of fishing gear by the Congolese. In some incidences the community leaders through the Beach Management Units had held discussions with their Congolese counterparts that had resolved such incidents but in other cases the conflicts remained largely unresolved. The role of the political leadership from both sides was acknowledged in the resolution of such disputes particularly the Resident District Commissioners in Uganda who often took up such cases with their Congolese counterparts. It was however noted that there were no formal dispute resolution mechanism and there was a need for disputes arising out of fishing activities and practices to be resolved in a timely, peaceful and cooperative manner.

It was observed that the Decentralisation Laws and Policies of the two countries have direct implications for coordinated implementation and supervision. On the Ugandan side, respondents raised a number of challenges that decentralisation poses for fisheries management. In Kasese District it was noted that while the local Government recognises fisheries as an avenue for income generation it does not reciprocate by ploughing back sufficient funds in fisheries management in spite of the fact that the fisheries sector provides 90% of the food sources to the communities. In Uganda, the fisheries sector at district level contributes to the revenue required by local government since the right to fish requires a fishing vessel permit (FVP) and a fisherman's licence. The FVPs and the fisherman's licenses are issued annually by the district fisheries departments at a fee.

The decentralisation of fisheries staff without adequate budgetary provisions by the local governments impacts negatively on their ability to provide technical back up services, for all stakeholders, build capacity at local government level and monitor local communities. It was noted that in most cases the fisheries staff rely on the Wildlife enforcement personnel to provide patrol and monitoring facilities. The district staff in any case were too few and poorly equipped to manage all the landing sites effectively. In Bushenyi District it was noted that the total District Fisheries staff were 4 with I DFO and 3 FOs one of whom was a NAADS Coordinator and another a volunteer. The staff had only two boats and two engines to supervise the four landing sites in the district. In Kasese district it was noted that they had more fisheries staff a total of six with some at the sub-county level but on Lake Katwe alone there were three landing sites.

Respondents raised the issue that credit facilitation was lacking in many fishing communities due to lack of collateral and deterrent high interest rates charged by banks, as well as lack of available banks in some areas. However, at Kishenyi landing site, the fisherfolk community headed by the BMU leaders had formed themselves into a cooperative society that provided short term loans to members. The Cooperative society had also managed to acquire a building that was used for capacity building of the community and meetings of the Cooperative Society members. From this case study it is clear that it is necessary for the other communities in the study area to identify new or emerging forms of credit institutions that apply user friendly methods such as non collateral based loans and other incentives in order to enhance access to credit. An illustration of the building is provided in Appendix 7 and leaders of the Kishenyi Cooperative society are depicted in Appendix 8.

In regard to the roles of non-governmental organizations (NGOs) and community-based organizations (CBOs) it was noted that there was currently no NGO assisting or making major interventions for the fishing communities in respect of the Ugandan side of Lake Edward. However, there had been spillover benefits from earlier donor interventions such as the Integrated Lake Management (ILM) Project that had since ended.

It was observed that the BMUs were playing their role in mobilizing and sensitizing local people for active participation in managing fisheries activities and thereby supplementing the efforts of the public sector and advisory services or extension. The BMU respondents interviewed however raised the issue of the urgent need to have projects that could attract financial interventions that could be channeled through the BMUs for the benefit of the fishing communities. The District Fisheries Officers interviewed expressed some skepticism about the effectiveness of BMU leaders in regulating their fellow fisherfolk especially since they were elected and therefore were constrained to be popular by turning a blind eye to the illegal fishing practices. Respondents also pointed out the conflicts between the local council leaders and the beach management leaders since all of them were elected by their communities.

In regard to education, training and research institutions, it was noted that in Uganda training in fisheries management and resource exploitation is under the Ministry of Education. Key institutions include the Fisheries Training Institute and the Zoology Department of Makerere University. Research is open to any interested party or as may be commissioned by the interested party, but fisheries research in the public interest is vested in the government’s Fisheries Resources Research Institute (NAFIRRI). However, it was noted that the collaboration between fisheries research and fisheries management was weak since there was no legal obligation on researchers to share or disseminate their research findings.

An overview of the institutional framework relating to fisheries management in DRC and Uganda is provided here below:

a. Democratic Republic of Congo (DRC)

In DRC, there exist two different institutions dealing for fisheries management i.e. the Fisheries Department that is part of the Ministry of Agriculture and the National Service for Promotion and Fishery Development (SENADEP -- Service National pour le developement des Peches). The Fisheries Department deals with taxes and law enforcement while SENADEP deals with capacity building, backstopping strategies and support to fisheries communities.

SENADEP is represented within each of the country's eight regions by a 'regional coordinator.' At the sub-regional level there are SENADEP 'heads of office,' and at the lower zone level by there are 'supervisors.' However, SENADEP is hindered by a number of problems such as: isolation between stations and central establishment (remote areas, deteriorated infrastructure, and civil war zones); insufficient or nonexistent budget; low staff motivation (poor or nonexistent pay); inadequate staffing and training at all levels of administration; lack of basic office and field equipment and facilities; inability to enforce regulations; and absence of reliable data.

Other government ministries and departments in DRC with a stake in fisheries management include:

- Ministry of Agriculture and Livestock.
- Ministry of Environment, Nature Conservation and Tourism.
- Ministry of Planning (National Water & Sanitation Action Committee)
- Ministry of Energy (Water Supply Corporation).
- Ministry of Transport
- Ministry of Public Health
- Universities and research centres.

There are conflicts in the sectoral management of water resources reflecting a lack of collaboration amongst the different institutions. Of recent an Inter-Ministerial Committee for Environment, Nature Conservation and Tourism was set up to coordinate and advise on proposals needed to strengthen environmental management.

The armed conflicts the country has experienced has resulted in heavy human settlements in the eastern part around the two lakes and thus contributed to more pollution of the waters and lawless exploitation of the fisheries resources.

b. Uganda

In Uganda, fisheries management is still vested in the central government ministry responsible for fisheries (Ministry of Agriculture, Animal Industry and Fisheries). The competent authority under this agency is the Department of Fisheries Resources, headed by the Commissioner for Fisheries. The Fish Act of 1964 entrusts the power of regulation and enforcement in the civil head of the department responsible for fisheries, currently the Commissioner for Fisheries, heading the Department of Fisheries Resources.

There are three levels at which fisheries management services in Uganda are provided within the decentralization framework. They are; the national level, the district level and the community level. At national level, there is the Fisheries Resources Department, headed by the Commissioner for Fisheries and in whom the Fish Act of 1964 entrusts the power of regulation and enforcement as well as responsibility for fisheries administration and management.

At the district level, there are District Fisheries Officers who carry out district based fisheries administration and a few management functions. Fisheries staff are responsible for monitoring of fishing activities, law enforcement, collection of statistics, rehabilitation of fisheries resources, and extension work. Extension is primarily carried out by Fisheries Assistants, who work at the local landing site level. At the community level, Beach Management Units that are community groups of the fisher folk provide community management functions that include local enforcement of rules and the administration of landing sites.

The private sector is regarded as the engine for growth in fisheries development. All production activities for profit-making, according to government policy, have been left to the private sector. Such roles include management of landing sites, ownership and operation of production units, fish trade, and commercial and intensive fish farming. Training in fisheries management and resource exploitation is under the Ministry of Education. Key institutions include the Fisheries Training Institute and the Zoology Department of Makerere University. Research is open to any interested party or as may be commissioned by the interested party, but fisheries research in the public interest is vested in the government’s Fisheries Resources Research Institute (FIRRI).

Other related governmental institutions in Uganda with a stake in fisheries management include:

- Ministry of Water and Environment,
- National Environment Management Authority,
- Wetlands Inspection Division.
- Fisheries Resources Research Institute,
- Department of Environmental Health in Ministry of Health,
- National Water and Sewerage Corporation,
- Government Analytical Laboratory,
- Uganda National Bureau of Standards and
- Makerere University.

The inter-governmental organizations in the fisheries sector include the Committee for Inland Fisheries, East African Community and Lake Victoria Fisheries Organization

(LVFO). The non-governmental organizations include Uganda Fish and Fisheries Conservation Association, Uganda Fisheries Allied Workers Union, Private-sector commercial agencies, Uganda Fish Processors and Exporters Association and fisher-folk area-based organizations.

4.3.8.1 Analysis of the Main Issues in Policies, Laws and Institutions for the development of an Integrated Lakes Management Plan

This interim report reveals policy, legal and institutional issues relating to the fisheries sector that need to be addressed in the development of an Integrated Lakes Management Plan. The major issues arising from the above findings are the following:

a) There is urgent need in Uganda to overhaul the regulatory framework under the current Fish Act by enacting the proposed Fish Bill that seeks to address the identified regulatory gaps by providing for included stricter control of access (licensing of individual operators and gear in addition to vessels); establishing restricted fishing areas, closed areas and seasons; authorized landing sites; gear capacity restrictions; minimum size regulations for target species; more stringent penalty provisions and enhancing the ability of fisheries officials to collect statistical information.
b) There is need to have uniform provisions or one code of conduct regulating the fishing practices on Lakes Edward and Albert including rules for fishing gear and equipment, fishing methods and fishing time. This should be under a regional body established by the two riparian countries to oversee the fisheries management of the transboundary water resources of Lake Edward and Albert. Another key aspect of the proposed regional body would be dispute resolution by instituting regular cross border meetings
c) The Local Governments should revisit the budgetary allocations to the Fisheries departments and ensure that some of the income collected from the fisheries sector is re-invested in fisheries management activities. In particular local governments should ensure that all landing sites are provided with sanitary facilities and hygienic fish handling infrastructure.
d) There is need for the Districts that have fishing communities living in the protected area of Queen Elizabeth National Park to enter into Memoranda of Understanding with Uganda Wildlife Authority to ensure that potential causes of conflict are minimized.
e) Fishing gears and equipment of Ugandan and Congolese fishermen should be marked with national colours and registration numbers for easy identification. Beach leaders on either side should issue identity cards to their fisher folk. The Buoys that used to identify the geographical boundaries on the lakes should also be re-instated.
f) Fisheries Officers should be properly trained and gazetted by the Director of Public Prosecutions to allow them to prosecute fisheries related offences.
g) Since fisheries research facilitates fisheries management, the linkage between the two should be strengthened and research findings should be made public. Data collection facilities and fish inspection at fish landing sites should be made mandatory and enforced.
h) The transboundary nature of the Lakes Edward and Albert requires that any regulatory regime to be proposed should involve the concerted efforts of all relevant

stakeholders in law enforcement, security, immigration, trade, taxation, environment, health etc. There is need to streamline the operations and roles of the other stakeholders in Uganda and DRC with the personnel responsible for fisheries management and enforcement of the fisheries legislation.

i) Stakeholders interviewed have pointed out the futility of enforcing different laws on fisheries in the Uganda and DRC side. It is noted that harmonisation of the legislation of the two countries may not be feasible since they also share other water bodies with other countries. There is therefore need to find a common approach or regulatory system for fisheries management of the two transboundary water bodies. Since both DRC and Uganda have ratified the FAO global Code of Conduct for Responsible Fisheries which establishes principles and standards applicable to the conservation, management and development of all fisheries. This code in addition to the other international treaties ratified by both countries could form an important basis of developing a common regulatory framework for Lakes Edward and Albert**.**

j) To minimize on cross border conflicts, there is need to reinstate the border separators on the lakes using floaters as well as set up formal institutionalized dispute resolution centres at local and district level. It is also necessary to provide avenues for redress where conflicts occur during the implementation of the wildlife protection and fisheries management legislation.

k) The fishing communities need capacity building to organise them selves into cooperative societies or some other similar vehicle that can easily make them access credit financing to develop their small scale fishing practices into larger viable ones that are in conformity with the law. There is need to revisit the BMU concept to ensure that they are empowered to perform their roles. Further the technical staff at the district need facilitation to support the roles of the BMU and provide technical assistance to the fishing communities.

l) The legal instruments that have been deployed for the regulation of the fisheries of Uganda and DRC have not met with high levels of compliance. For instance although on Lake Edward the gazetted landings have been established as a means of controlling the number of canoes and the disposal of fish there are incidences of fish landings that take place outside the gazetted hours of sunrise and sunset, and this frustrates the collection of statistical data.

m) District authorities are not implementing the decentralized policy as acting as the primary link to the centre. This is due to limited funds allocated to the fisheries departments. The BMUs are looked upon as the focal point of development assistance aimed at reducing poverty through improved governance. It is at this level that the day-to-day hands-on interaction with fisheries communities and their institutions occurs.

n) Security agencies (Police – marine unit, Intelligence and Army) are playing a more active role in the security at the lakes due to the political cross border conflicts. This has partly marginalized Fisheries regulation enforcement by the local authorities and BMUs.

o) Extension work is primarily carried out by Fisheries Assistants, who work at the local landing site level; however they are poorly equipped to cover all the landing sites under their control. They need to be targeted for re-tooling and capacity building to ensure they have the basic gear to use and other support infrastructure.

p) The Judiciary need to be targeted on sensitization on the Fish Act and its interpretation against any offences committed under this law and other related laws regarding fisheries exploitation, conservation, development and management.

q) The local governments should be assisted to look into options for revenue generation that could be targeted for financing the fisheries sector. However, the Local Government Act (1997) does not provide for the imposition of landing charges. If these charges were to be imposed by the local communities, it would either require that communities formulate a by-law legalizing the option. The option of community bylaws will require that the communities are trained on hoe to formulate and enforce bye –laws for natural resource management.

4.9 PLANNED FUTURE ACTIVITIES

At the stage of the Mid-Term Diagnostic Report, the project is expected to have established factual information on the state of the Lake Edward and Lake Albert ecosystem. At this stage of the study, therefore, vital baseline information on the ecosystem functions in the two lakes, their fisheries and biodiversity, fish quality problems, hydrology, socio-economics of the fisheries, catchments pollution and status of policies, laws and institutions in the basins of the two lakes should be availed from the research investigations. Essentially, the state of the two lakes and their catchments, the state of the fisheries and other aquatic biodiversity as well as the state of socio-economic livelihoods of the fishing communities should be clearly elaborated. It is this information which has now been collected by the various components of the consultancy that will be use by the consultant to propose plans for an improved Ecological Balance and greater Biodiversity in the lakes system; detailed Environmental and Social Management Plan; plans for strengthening the capacities of the lake-wide fishing communities to co-manage shared resource and infrastructure; an Integrated Lakes Management plan and Investment Projects; detailed statistics on poverty and fishery activities; and plans for harmonizing fishing policies and regulations. Further, all threats, constraints and challenges in the management of the lakes natural resources should be elaborated to assist in planning for strategic remedies in the Integrated lake Management Plan.

The next stage of the study will now be mainly formulating an Integrated Lakes Management Plan for the sustainable exploitation of the natural resources. The TOR require that the Management Plan must be formulated on the basis of scientific information and knowledge derived from the thematic studies conducted by the consultants on fish and fisheries, biodiversity, pollution, social setting, policy, legal and institutional frameworks. Hence, the findings in the Mid-Term Diagnostic Report will help estimate and gauge environmental degradation, levels of water pollution, destruction of biodiversity, decimation of fish stocks, destruction of fish habitats, levels of fish catches and the socio-economic setting and its drawbacks to sustainable and equitable livelihoods. It is these studies that will also provide information for the formulation of the plans for Ecosystem Management Strategies which will be formulated at the end of the study. However, there will be need for the study to re-visit certain areas to confirm and verify certain information either in the field or at district headquarters or national capitals. This would be particularly so in view of the fact that quite a large portion of project work could not be accomplished due to insecurity in some areas. The study team would also need to visit selected stakeholders to discuss key findings and the proposed recommendations in order to ascertain accuracy of information gathered. This would also help in ensuring ownership of the findings and the whole report when presented. In accordance with this, there is need, therefore, for individual consultants to undertake follow on studies to verify their findings and complete collection of data and information where necessary. These are therefore provided below as follow on activities for each component of the study.

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In **Fisheries and Biodiversity,** it is planned to continue sampling at the identified sites, twice a month where security permits up to end of December 2007. Factors affecting aquatic biodiversity will be identified. Plans for management of the fisheries, training and research in relevant institutions in the two countries will be proposed. The consultants will spend some time in libraries in Uganda to complete studies on the taxonomy and identification of fish, plankton, benthos, aquatic macrophytes and other fauna and flora.

In **Water Quality and Cachment Environment** study, the following activities will be completed up to October-December 2007.

i. Completing analysis of water samples;
ii. Completing entry of data from the questionnaires into the computers;
iii. Completing data analysis for catchment pollution;
iv. Establishing changes, causes and effects of water quality deterioration AND catchment degradation;
v. Drawing up integrated management plans of watersheds of the two lakes; and
vi. Preparing plans for strengthening capacity of national institutions.

In the **Hydrology and Water Resources** the remaining tasks up to December 2007, shall be carrying out the following activities.

i. Stakeholder consultations with Protos and WWF Lake Albert Eastern Catchments Management Initiative to see where there are gaps or synergies that can be of use in formulation of management strategies.
ii. Inventory of water resources utilization in the catchments.
iii. Collection of supplementary data from the Meteorological Department and in the DRC.
iv. Complete the setting up of the MIKEBASIN Model, derive the balance components and prepare runoff, evaporation and rainfall components of the water balance for each catchment and lake.
v. Formulating hydro-meteorological monitoring requirements and schedules including costs.

In **Engineering and Infrastructure**, the following activities will be implemented from August to December 2007:

i. Entering data into computer;
ii. Data analysis;
iii. Final consultation with the local communities, BMUs, Fisheries Officers and district authorities at selected landing sites to discuss and reach consensus on required infrastructure and equipments which should be recommended for implementation;
iv. Studies to determine the extent and causes of post-harvest losses and proposals for ways of reducing losses;
v. Preparing plans for training and policy changes; and
vi. Preparation of the final diagnostic report, investment projects with costs.

In **Fisheries Socio-Economics**, the following activities are planned for the period September – December, 2007.

i. Continuation with training of interviewers in DRC on Lakes Edward and Albert;
ii. Continuation of field data collection under the sample survey using the questionnaire in DRC on Lakes Edward and Albert;
iii. Data in-putting;
iv. Assessing the contribution of the fish industry to rural household incomes and the national economies of both countries;
v. Data analysis and report writing;
vi. Consultations with Local Governments, beach leaders and DFR on investment priorities;
vii. Developing of investment profiles; and
viii. Synthesis of information for management plan and investment projects.

In **Policy, Laws and Institutions,** the following activities are planned for the period up to December 12007.

i. Analysis of global macroeconomic situation in both countries as well as the institutional environment concerning fishing and trading enterprises; issues relating to micro finance constraints and opportunities at both the central and district level;
ii. Analysis of the capacity of the government administration (human capacities, material and financial capacities, organization, activities) for management of the lake fisheries;
iii. Examining the legal and regulatory framework (modern/traditional, regional/international) of fisheries, funding mechanisms in the sector (formal and informal), customs and taxation systems;
iv. Analysis of the role of non-governmental organizations and the constraints to better coordination of fishing activities of the two countries;
v. Analysis of issues linked to insecurity and its direct and indirect implications on fishing activities;
vi. Elaborating existing property system, the method of acquisition and management of land, and conflict resolution;
vii. Examining global issues linked to fish resource ownership, water ownership, links between customary law and modern law as well as relationships between the local and migratory fisherfolk; and
viii. Making concrete proposals for improved use of fisheries grounds, in order to avoid conflicts.

4.10 CONSTRAINTS AND ISSUES OF CONCERN

There have been incidences of insecurity on both lakes Edward and Albert to which the staff of the consultants have been exposed to scary situations. In several cases, the consults have been arrested by rebel forces or Government forces in the DRC. The situation has some times been so bad that the Client has advised the consults not to proceed to certain areas. The Lake Edward area has been particularly unsafe. The result is that the study has been limited TO certain safe places and locations for example to the northern part of Lake Edward.

The DRC Counterparts have to cover long distances to travel to the study sites. The absence of road networks in the DRC particularly in areas bordering the lakes has made field investigations very difficult. A good example of this is the long distance needed to reach Kyavinyonge from Bunia which invariably takes four days.

The study needed a long sampling period of at least 6 months or more to generate reliable data but the time for field data collection and the resources allocated for field work were far too inadequate.

The process of VISA procurement for travel to the DRC for the Consultants proved long and time consuming. The Embassy of the DRC in Kampala had made it clear that obtaining an entry Visa did not automatically authorize the Visa holder to move and work around in the DRC and that it was essential to obtain Government of the DRC specific authorization and clearance to enable the LEAF Study team to move around the catchment of the two lakes doing their various studies. This would help the consultants to obtain security coverage from the DRC official system. The first attempt to obtain DRC Visa was made in December to enable the Team Leader and the Deputy Team Leader travel to Bunia and the lake basins for reconnaissance. It took one week to obtain the Visas at a cost of US$ 55.00 each. Thenceforth, the consultants have had to pay for the VISA each time there was travel to the DRC. This aspect of expenses was not budgeted for during project preparation.

The following other issues were identified as constraints to the study: low budget for data collection, resulting in limited coverage; lack of analytical laboratory and field equipment; and difficulties of movement and communication in the field.

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