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FINAL REPORT

LAKE ALBERT EASTERN CATCHMENT MANAGEMENT INITIATIVE, UGANDA

Norad Project no.: UGA-04/193, WWF project no.: UGA 0028 / 5010

BASELINE STUDY ON WATER QUALITY MONITORING PROGRAMME, AUGUST / SEPTEMBER 2005

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Abbreviations

ANC	Acid- Neutralising Capacities
BFCDO	Budongo Forest Community Organisation
BMU	Beach Management Unit
BOD	Biological Oxygen Demand
Ca^{2+}	Calcium
CAO	Chief Administrative Officer
CBO	Community Based Organisation
CCWRP	Catchment Water Resource Plans
Cl^{-}	Chloride
CO_3^{2-}	Carbonate
COD	Chemical Oxygen Demand
CWMO	Catchment Water Management Office
DLG	District Local Governments
DO	Dissolved Oxygen
DRC	Democratic Republic of Congo
DWD	Directorate of Water Development
DWE	District Water Engineer
DWO	District Water Officer
EC	Electricity Conductivity
EIA	Environmental impact assessment
FAO	Food and Agricultural Organization
FIRRI	Fisheries Resources Research Institute
GEMS/WATER	Global freshwater quality monitoring network. Sponsored by WHO and UNDP
GIS	Geographical Information System
GIS	Geographical Information System
HCO_3^{-}	Bi-carbonate
HYDROMET	Hydro Meteorological Survey
ICAC	Interim Catchment Advisory Committees
IDC	Irish Development Cooperation
IFAD	Intentional Fund for Agriculture
IGAS	Income Generation Activities
IGG	Inspectorate General of Government
IRC	International Reserve Committee
IWRM	Integrated Water Resources Management
K^{+}	Potassium
LCS	Local Council
LG	Local Government
LGDP	Local Government Development Program
MAAIF	Ministry of Agriculture, Animal Industries and Fisheries
MDED	Masindi District State of Environment Report.
MDGs	Millennium Development Goals
Mg^{2+}	Magnesium
MPS	Members of Parliament
MW	Mega Watt (1 MW = 1,000 kW)
MWLE	Ministry of Water Lands and Environment
N_2	Nitrogen gas
Na^{+}	Sodium
NAADS	National Agriculture Advisory Services
NARO	National Agricultural Research Organisation

NEMA	Natural Environment Management Authority
NFA	National Forestry Authority
NGO	Non Government Organisation
NH_4^+	Ammonium
NO_2	Nitrite
NO_3	Nitrate
NPK	Nitrogen, Phosphate, Potassium
NWSC	National Water and Sewerage Corporation
PEAP	Poverty Eradication Action Plan
ppm	parts per million
PO_4^{2-}	Phosphate
SAIP	Strategic Action and Investment Plans
SFG	School Facility Grant
SIDA	Sub-county Integrated Development Association
SO_4^2	Sulphate
SWOT	Strength Weakness Opportunities Threats
TBAS	Traditional Birth Attendants
TDS	Total Dissolved Solids
TN	Total Nitrogen
TSS	Total Suspended Solids
UNICEF	United Nations International Child Emergency Fund
URDT	Uganda Rural Development and Training Programme
WHO	World Health Organisation
WMZC	Water Management Zone Coordinators
WPC	Water Policy Committee
WRM	Water Resources Management
WRMD	Water Resources Management Department
WWF	World Wide Fund for Nature

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Executive Summary

The aim of this report is to propose a water quality monitoring programme for the Lake Albert Eastern Catchment Management Initiative and present the findings of the reconnaissance survey conducted between 25th - 31st August 2005 on the hydro-meteorological, water quality and social economic analysis of the project area.

The finding of this survey show that poor cultivation practices, fertilizer application in agriculture, overgrazing, over fishing and indiscriminate felling of trees are the main anthropogenic activities that degrade the environment. Poverty, a rapid increase of population as a result of influx of Congolese refugees and immigrants, lack of alternative source of livelihood and low education are the main drivers of environmental degradation. The scenario in the catchment depicts the classical description of UNDP world human development report which asserts "the poor are the causes and victims of environmental degradation." The rural poor tend to over exploit natural resources. In the process they damage the environment. Having no alternative livelihood they continue to degrade the environment and because they have nowhere else to go they end up being the very victims of environmental degradation they have caused.

The hydrological records in the catchment are scanty, too fragmented and therefore not useful for trend analysis. However rivers Muzizi, Nkusi and Waaki have received considerable attention. Only Nkusi and Waai are active stations routinely recorded by Directorate of Water Development. It is recommended that the project rehabilitates the already existing hydrological stations and sets up the new ones on rivers Hoimo and Wambabya at a cost of US$ 38,846. Siltation loads in River Waaki is 39.4 tons/day. The water utility potential of the area shows rivers do not have sufficient quantity for irrigation, although their water quality is suitable because of low sodium concentration. Lake and groundwater have little potential as irrigation water because they have a high sodium content and hardness, which would cause salination. Therefore the catchments will have to depend on rain fed agriculture. However, this type of agriculture may not be sustainable if trends in climatic change and prolonged drought persists. Only rivers Muzizi and Wambabya have hydro-electrical potential for medium hydro electrical stations of 10 MW each. A hydro-meteorological data base and collaboration the Nile basin initiative on the Nile Equatorial lakes fisheries project of Lake Albert and Lake Edward is recommended.

Limnological findings show that Lake Albert was a high electrical conductivity compared to its river inflows by a factor of 7. Lake water has moderate hardness and salinity, while river waters in the catchment have soft water of low salinity. Both river and lake water has high total suspended solids (TSS) Biochemical oxygen demand (BOD) and chemical oxygen demand (COD) an indication of organic pollution from surface runoff for rivers and organic matter accumulation as a result of eutrophication in the case of the lake. Kinyara Sugar Works; its sugarcane plantation; it's out growers and small scale peasant farms which grow tobacco have been identified as pollution hot spots. They are responsible for vegetation cover removal, forest conversion, poor cultivation practices like digging near river banks, use of fertilizers and pesticides. As result the water quality in the rivers have deteriorated leading to high colour, turbidity, suspended solids, BOD and COD. The lack of sanitary facilities and poor sanitary habits, human excreta ends up contaminating drinking

water. Therefore it is not a surprise that catchment has epidemic outbreaks of water borne diseases like cholera. At the time of the survey, Butiaba fish landing site had lost six people to cholera, while 40 had been hospitalised and discharged.

The limnology of Lake Albert shows evidence of eutrophication. The oxygen profile has decreased with depth, seechi depth has decrease over the decades and TSS has increased over the years an indication of organic matter accumulation. The phytoplankton community is mainly composed of cynobacteria (blue-green algae). This is evidence of the eutrophic state of the lake.

In order to reverse the deteriorating environmental quality, a water quality monitoring programme for the catchment is proposed as an entry point the Integrated Water Resources Management of the catchment. This programme will encompass both surface and ground water quality monitoring. The over all goal will be determine the impact of anthropogenic activities on water quality on the rivers that drain the eastern catchment of Lake Albert, establish an infrastructure for the monitoring programme and at the some time design a water conservation strategy for the catchment. The specific objectives of the programme are: i) to establish baseline conditions of the water quality in the catchment. A comparison will be made between past and present results to determine trends over the years and seasonal variations; ii) to assess the present and further risks of the anthropogenic activities on water quality of the rivers and how this in turn affects lake water quality; to establish a sustainable water quality monitoring infrastructure for the eastern catchment of Lake Albert; to design and implement an integrated water resources management strategy focused on pollution control. The monitoring should cover rivers Muzizi, Nkusi, Wambabya, Hoimo, Waaki and Kasokwa; Lake Albert at Butiaba and groundwater at Hoima Hospital. Water samples will be collected from the bridge on these rivers. Water parameters that determine the pristiness, pollution, hence environmental stress and those that can be used in the management of the catchment have been selected. Monthly water samples should be collected for analysis. However in order to cover the flush events during the rain season bimonthly samples have been recommended for rivers, while diurnal samples are expected to be collected both in the wet and dry seasons for the lake. Implementing the programme will come at a cost of US $ 115,000 to cover analytical costs, logistic, personnel and infrastructure development.

1 INTRODUCTION

1.1 The Client WWF

WWF is the world's largest independent conservation NGO with about 2,000 projects in 100 countries. It plays a big role in conservation issues worldwide and it is participating in the implementation of the United Nations Millennium Development Goals. Founded in 1961, it has been in East Africa for decades implementing many conservation projects. Under its Freshwater Programme in the recent past WWF has implemented the following projects in Kenya; River Malewa Initiative Project, Lake Nakuru Integrated Conservation Project, Lake Bogoria Community Based Wetland Conservation Project, Mara River Basin Management Initiative and the Ruaha River Basin Management in Tanzania. All these projects have been and are implemented through community-based catchment approaches leading to progressively developed participatory management plans with all stakeholders. Central and local governments, NGOs, local CBOs and private sector have been also integral players/implementers within these projects. WWF's presence on the ground over a long period of time gives the organisation credibility, both at local level and among decision-makers.

With lessons learnt from these projects WWF started implementing the Lake Albert Eastern Catchment Management Initiative in late 2004/early 2005. This project is broken in two phases. The first phase is called the pilot phase. It is exploratory in nature and was planned for 2004 and 2005. The pilot phase will engage key stakeholders in the eastern part of the catchment of Lake Albert in dialogue, collect relevant data, initiate environmental education awareness, capacity building of local people to diversify their incomes sources and thus increase their incomes, and prepare for a larger and longer duration phase. Considering the extent of the basin and the political conflict in the Democratic Republic of Congo (DRC), the programme will limit its activities to eastern part of the catchment in Uganda. Depending on the outcomes of the pilot phase and lessons learnt a $3^1/_2$ year second phase with a detailed project implementation will be developed. The purpose of the Project is to facilitate participatory and sustainable integrated natural resource management initiatives for the conservation and sustainable use of freshwater resources, biodiversity and associated natural resources in the eastern part of the Lake Albert catchment for the benefit of the local people**.**

The Project will achieve the above purpose by implementing the following seven outputs:-

i. District and other authorities and organisations facilitated to collect important information on catchment conditions, with particular emphasis on physical and environmental conditions.
ii. Increased awareness of catchment natural resource issues, including status, trends, degradation and possible opportunities.
iii. Stakeholder dialogue facilitated so that problem identification and ranking as well as opportunities and solutions identification are carried out.
iv. Capacity building needs identified and priority capacity building carried out.
v. Implementation of identified action needs in the catchment in terms of natural resource management in output 3 above.

vi. Management of Kabwoya Wildlife Reserve and Kaiso-Tonya Community Wildlife Area improved.
vii. Water resources management framework at community/district levels in Hoima, Kibaale and Masindi Districts improved.

It is in light of this background that a water quality baseline study was initiated as an element in the implementation of the Project. The water quality baseline study will help to operationalise the project by contributing to the following project activities: -

Activity 1.1 – Data collection on water quantity and quality for the four main river (Muzizi, Nkusi, Wambabya, Hoimo, Waki and Lake Albert),

Activity 1.2 – Assess historical trends in water resources, forests, biodiversity and other natural resources using qualitative methods.

Activity 6.7 – Assist in developing supply of water and fuel wood for lakeshore communities (e.g. borehole, wood lots).

Activity 7.1 – Assess in more detail the feasibility of implementing integrated river basin management in the districts concerned.

Activity 7.2 – Integrate the principles of integrated water resources management at the various appropriate levels in the eastern sub-catchment of Lake Albert.

Activity 7.3 – Based on the result of 7.1, institute an appropriate management process at different administrative levels in the eastern part of the catchment.

This report is based on the results of the study that was carried in the project area from August 25th to 31st August, 2005. The executive summary gives an overview of the work carried out, the methods used, conclusions and recommendations drawn from the findings. Chapter 1 Introduces the client, the consultant, elucidates the problems in the catchment, monitoring strategy and gives background literature of the project area, Chapter 2 outlines the methods used Chapter 3 describes the water resources of the area, Chapter 4 concentrates on the results of the water quality assessment, Chapter 5 is the socio- economic analysis, while Chapter 6 is stakeholders views, Chapter 7 is dedicated to the SWOT analysis of policies, legal and institutional framework, Chapter 8 gives a recommendation of how the water quality programme should be implemented while Chapter of 9 is recommendations for an integrated water resources management hydro meteorological monitoring programme.

1.2 The Consultant

In August 2005 WWF Uganda Projects Office presented by Mr. David Duli commissioned Samuel Vivian Matagi of Savimaxx Limited a premier indigenous environmental consulting firm in Uganda to undertake consultancy services for setting up a Water Quality Monitoring Programme for the Lake Albert Eastern Catchment Management Initiative. A consortium of the following consultants was then assembled and carried out the water quality baseline study:

Table 1.1 Water quality baseline study team.

Name of Consultant	**Position**
Mr. Samuel Vivian Matagi	Team Leader/Water Quality Specialist
Mr. Benon Tumukedde Zake	Hydrologist
Ms Elizabeth Aisu	Anthropologist
Ms Ritah Akinyo	Socio-economist

1.3 Problem Assessment

Lake Albert and its catchment area is a very important area from both a conservation and rural development. Lake Albert supports an important community of fishermen who entirely depend on the maintenance of the ecological integrity of the lake, while its water catchment area corresponds to a landscape where agricultural activities, deforestation, over stocking of livestock are a major feature alongside key protected areas of global significance. The protection of the catchment area is therefore a priority to reconcile rural development priorities and conservation priorities at both national and global levels.

There is however no integrated catchment management for this area, leading to conflicting initiatives that translate into deforestation, soil erosion and loss of soil productivity in the catchment area as well as risks of decreased fish productivity in Lake Albert. This has been compounded by global warming further causing water stress in the catchment area. Poor water quality and reduced water availability is likely to be increasing if the current trends in deforestation, poor land use practices, exceeding livestock carrying capacity and no catchment approach to management of the natural resources in the various sub-catchments of Lake Albert continues.

Climatic change in the catchment area has further exacerbated problems by adversely affecting biodiversity and water resources. For the first time, River Nkusi dried up before it reached Lake Albert about two years ago and now this is an annual event. Similarly decreased water quantity has been observed in the other rivers draining into the lake. The quality of the water has also deteriorated and the water flowing in Muzizi and Wambabya Rivers is brown in colour due to the high sediment loads. These problems arise because of drought facing the catchment leading to farmers cultivating rice and tobacco on the riverbanks and on the riverbed. This has brought in a new silent problem of pesticide and herbicides in water, further deteriorating the water quality.

Furthermore, the seasonal and permanent wetlands have been set upon fire and encroached upon to support pastoralists' livestock and act as refugia for cultivation during the dry season. In the process the wetlands have lost their purifying and water storage capacity and hence the visible deterioration of water quality in the rivers and the lake.

The catchment is experiencing an influx of immigration from people from high-populated areas like Kabale and West Nile. The situation has been compounded by influx of refugees from the Democratic Republic Congo fleeing the political strife. Authorities located vacant land, usually pristine areas that are of great importance to conservation of biodiversity and maintenance of the authentic integrity of the catchment area. Because the new arrivals have no attachment to the land and they have to survive they end degrading the environment, by deforestation, poor soil husbandry, pit sawing and cultivating near rivers.

The influx 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. Lack of formal water user associations which are associated with providing portable water, forces the communities to use contaminated water.

The water quality of Lake Albert is facing an ever increasing rate of deterioration. There have been reported cases of algae blooms of poisonous cynabacteria (Blue-green algae), an indication of nutrient enrichment and a clear sign of eutrophication (DWD, 1998). This has been accompanied by deoxygenation especially at the lake bottom and fish kills especially of young fish. All this indicates a deteriorating catchment environment that needs a management intervention.

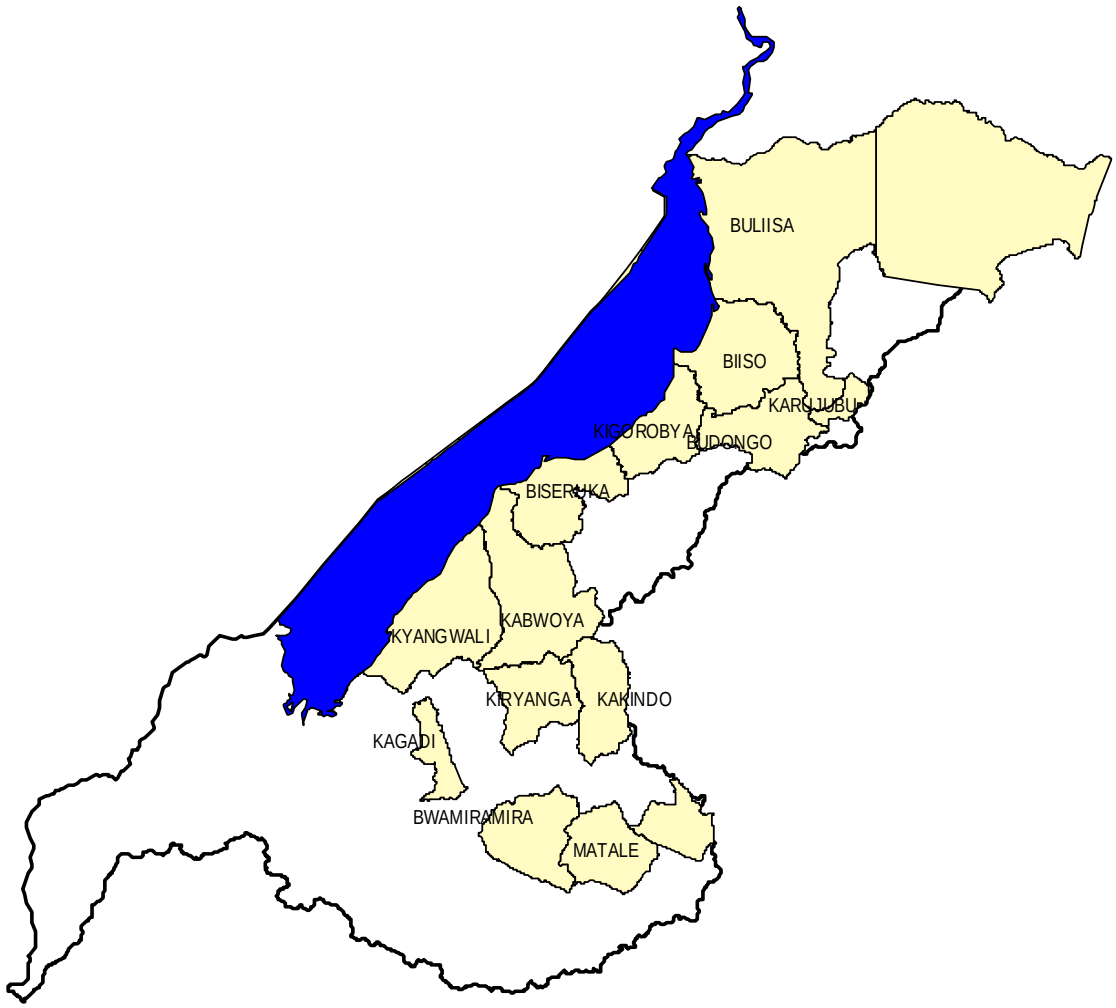
1.4 Total Lake Albert Catchment

Lake Albert catchment area, shared between Uganda and the Democratic Republic of Congo, is located at the northern tip of the western rift valley. On the Ugandan side, it stretches from the slopes of the Rwenzori Mountains in the Southwest, through the escarpment of Albertine Rift Valley down to the Victoria Nile delta in the north-eastern end of the lake. The spatial extent of this catchment is a total area of 18,037 km^2 (DWD, 2003). Lake Albert covers an area of 5,270 km^2 of which 2,850 km^2 (54%) is on the Ugandan side. At an altitude of 615 m it lies between two parallel escarpments, that on the western side rising abruptly to nearly 2,000 m above the water surface. Like most large rift valley lakes, the lake is ribbon shaped lying in the northeast southwest direction and runs approximately 160km in length and is 35km at its widest point. The lake is relatively shallow with an average depth of 25m and maximum depth of 58 m, and has a total volume of about 280 km^3. The lake is not regulated and has a normal range of annual water level fluctuation of about 0.5m. The main rivers flowing into the lake are the Semliki, Nkusi, Wambabya, Waaki, Musizi and Hoimo. Details of lake sub-catchments can be found in Section 2.1.

1.5 The Project Area

The three project districts cover 13,528 km^2 or about 75% of the Ugandan part of the Lake Albert catchment. The Project activities will be restricted to Kibaale, Hoima and Masindi Districts, leaving out Mubende and Kyenjojo Districts in Uganda and the part of the catchment that is in DRC. Detailed project activities will be focussed in a limited number of sub-counties and parishes in each district. Figure 1.1 illustrates the extent of Lake Albert Catchment extent in Uganda and defines the project area and

sub-counties the project is considering as candidates for work. Field implementation will be at parish level. The priority parishes have not yet been identified.



Key: Shaded area are Sub-countries within Lake Albert Catchment, Unshaded area are out side the catchment

Figure 1-1: 16 Priority Sub-counties of the Project Area for the Lake Albert Eastern Catchment Management Initiative.

1.6 Topography, Landscape and Geomorphology

The catchment area lies in the central plateau of Uganda with an altitude of about 680-1,400 metres above sea level (m.a.s.l). The lowest point in Uganda is Butiaba fish landing site on Lake Albert, 682 m.a.s.l. There are a number of undulating hills with wide valleys that are covered by wetlands. In the western fringes of the catchment lies the Western Rift Valley an area that is largely covered by the Semliki flats, Lake Albert and the Escarpment (NEMA, 1996).

The morphology of landscape is strongly related to processes of denudation that, in turn, greatly influences pedogenic processes. The landscape of the western part of the region has a typical representation of waylands peneplain, which occurred during the tertiary era. This was later followed by gradual uplift of the land surface whereby up warped surface was formed and are adjacent to the rift. The up warped surface and weathered detritus that had accumulated prior to faulting has been removed by post rift valley geological erosion to form sediments on terrace like steps. Within the rift valley, the terrain is generally rolling with occasional prominent ridges (Combe & Simmons, 1983).

The lowland surface is thought to date from early Oligocene era and reached maturity in the Miocene era. This surface is still widespread in the pre-cambian terrain and has been deeply incised by rejuvenated rivers. Small areas are covered by infill especially along rivers and streams. The first stages of rivers have been dissected by rejuvenated drainage cutting back from the Rwenzori Mountains. However, during the late stages uniform planations have been formed where rivers meander through swamps resulting in areas of infill (NEMA, 1998).

The mountainous scenery associated with the rift valley and its conspicuous features above the generally low plateau and valley include unique features such as ridges and scarps, presents a tourism and recreational potential (NEMA, 1998).

In Kibaale District, the hilly and rocky relief presents challenges during construction and maintenance of roads, building and agricultural production. The rift valley terrain in Mpeefu Sub County and its associated features make service delivery to the lakeshore communities very difficult. Road construction to the lakeshores in Kibaale and Hoima Districts is still a big challenge due to the rift valley terrain. Accessibility to the landing sites in those two districts is very difficult (Kibaale Districts Development Plan 2005-2008 (2004) and Hoima Districts Development plan 2005-2008 (2004).

1.7 Climatic data & rainfall distribution over Lake Albert Catchments

Rainfall over Lake Albert catchment is lowest over the lake (700mm), gradually increasing outwards towards the escarpments on both sides to over 1,400 mm Fig. 1.2.

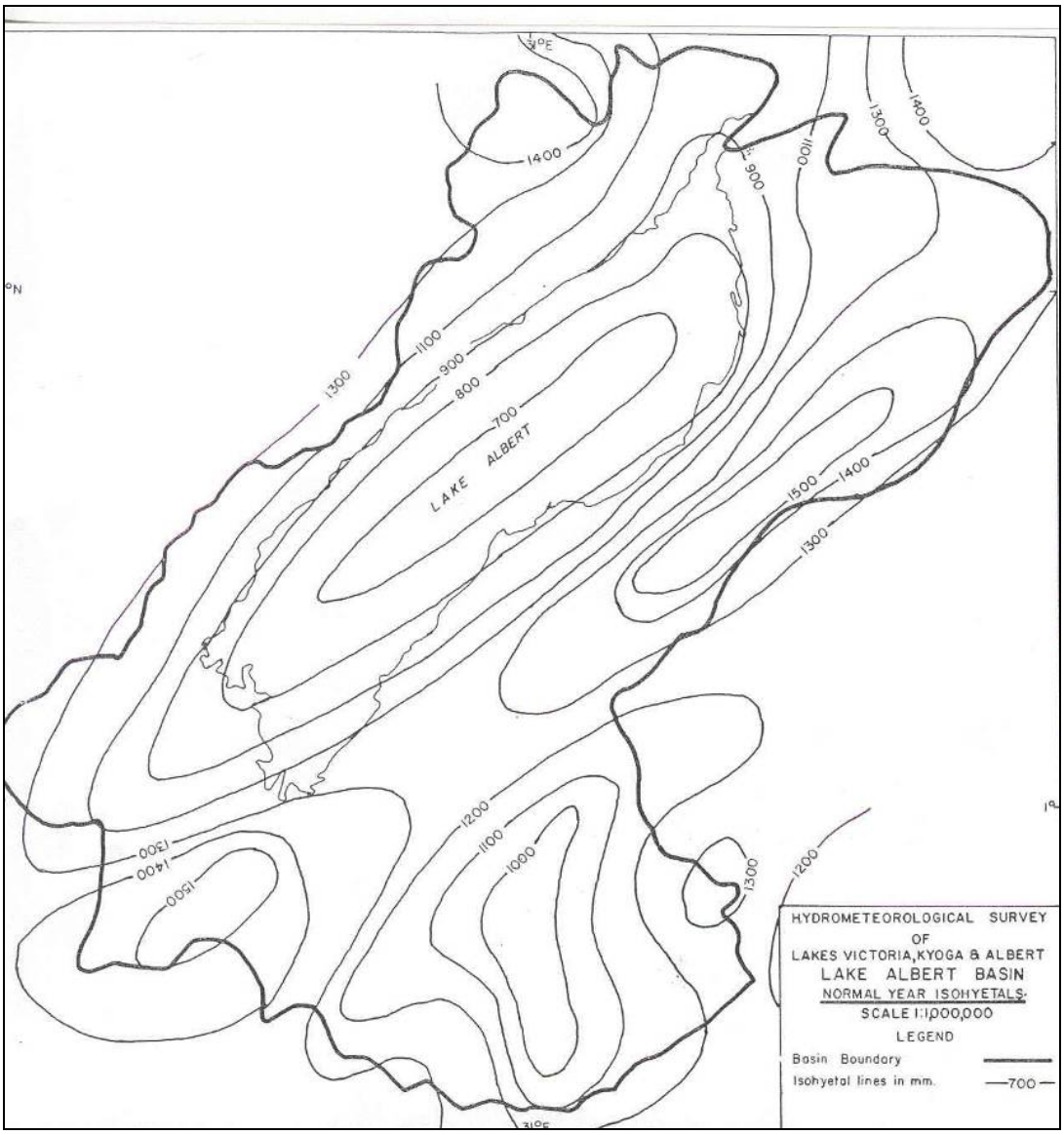


Figure 1-2 Rainfall distribution over the Lake Albert Basin (UNDP & WMO, 1974)

Under a hydro-climatic study carried out by the Water Resources Management Department on the Uganda side of the catchment DWD (1999), spatial variation of rainfall can be categorised under two zones within which rainfall characteristics are similar. **Zone K** includes western Masindi and receives an average annual of 1,259 mm of rainfall, with high variability, from ~ 800 mm within the Lake Albert Basin to ~ 1,500 mm over the western parts. The rainy season is 8 months, late March to late November with the main peak August to October and a secondary peak in April/May. These areas have one long dry season of about 3½ months, December to about mid March. The driest months are December to

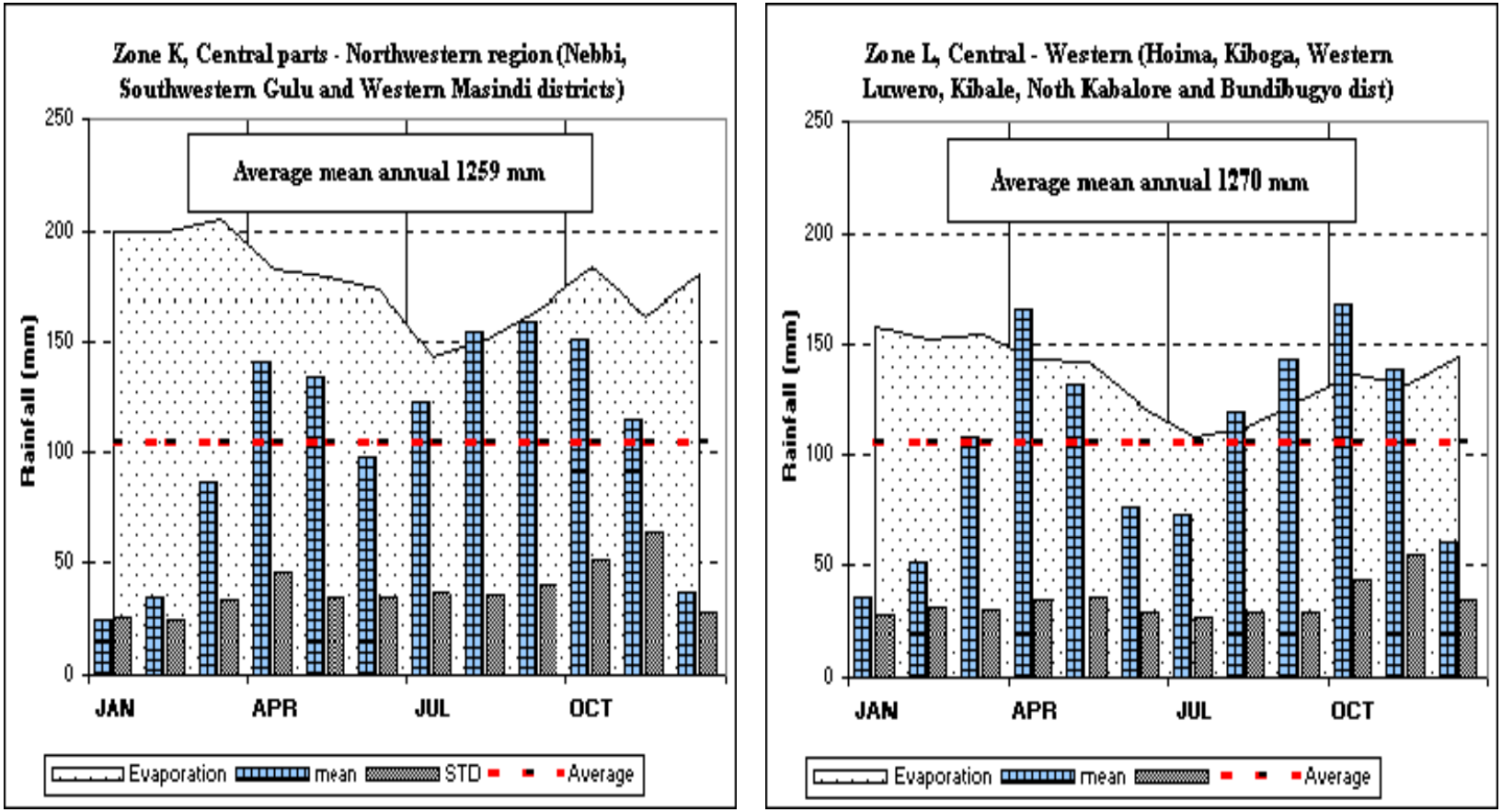


Figure 1.3 Zonal characteristics for rainfall over project area through the year (Source: DWD, 1999)

February. Evaporation is greater than rainfall by a factor of ~ 5 during the dry months.

Zone L includes the districts of Hoima and Kibaale. Its annual average is 1,270 mm, with high variability, from ~ 800 mm over Eastern L. Albert parts to ~ 1,400 mm over the western parts. It gets two rainy seasons. The main season starts from August to November, peaks in October while the secondary season starts in March to May with the peak in April. Main dry season is December to about mid March. There is a secondary dry season between June & July and Evaporation is greater than rainfall by a factor of ~ 5 during the dry months Fig. 1.4.

Additional climatological data e.g. temperature, wind-speed, evaporation, humidity for stations in the project area is presented under Tables 1.1, 1.2, 1.3 and 1.4.

Table 1-1 Meteorological Stations in Waki - II (Source: UNDP & WMO, 1974)

Sr. No.	Name	Met. No.	Type	Latitude	Longitude	Altitude/ft	Start date
1	Waki	8831150	Rainfall	$1^0$43'N	$31^0$22'E	3,250	5.7.68
2	Karongo	8831062	Rainfall	$1^0$41'N	$31^0$30'E	3,550	6.9.70
3	Nyantonzi	8831065	Rainfall	$1^0$39'N	$31^0$29'E	3,600	5.9.70
4	Bubwa	8831149	Rainfall	$1^0$37'N	$31^0$27'E	3,500	4.7.68
5	Kisabagwa	8831048	Rainfall	$1^0$32'N	$31^0$24'E	3,900	3.7.68
6	Siba	8831038	Rainfall	$1^0$39'N	$31^0$23'E	3,400	1968
7	Nyabyeya	8831024	Hydromet	$1^0$40'N	$31^0$32'E	3,900	-
8	Bwinamira	8831056	Rainfall	$1^0$38'N	$31^0$32'E	3,550	18.4.70
9	Budongo	8831057	Rainfall	$1^0$39'N	$31^0$34'E	3,650	15.4.70
10	Nyankwanzi	8831060	Rainfall	$1^0$37'N	$31^0$34'E	3,650	17.4.70
11	Kitonozi	8831064	Rainfall	$1^0$38'N	$31^0$39'E	3,850	4.9.70
12	Kyabagenyi	8831063	Rainfall	$1^0$38'N	$31^0$35'E	3,550	9.9.70
13	Kikobwa	8831066	Rainfall	$1^0$38'N	$31^0$38'E	3,750	2.9.70
14	Kimanya	8831068	Rainfall	$1^0$35'N	$31^0$31'E	3,700	4.9.70
15	Kangoire	8831059	Rainfall	$1^0$35'N	$31^0$33'E	3,700	16.4.70
16	Bulyango	8831067	Rainfall	$1^0$38'N	$31^0$33'E	3,600	10.9.70
17	Kabango	8831058	Rainfall	$1^0$39'N	$31^0$35'E	3,650	14.4.70

Key
(Sr. No. : Sampling Station Number, Met. No: National Meteorological Station Number)

Table 1-2 Climatological Statistics for Masindi Town (Source: UNDP & WMO, 1974)

	Data Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Maximum Temperature (deg. C)	1931-1954	30.9	31.2	30.4	29.1	28.2	27.9	26.9	26.9	27.7	28.4	29.0	29.3
Mean Temperature (deg. C)	1931-1954	23.8	24.1	24.0	23.3	22.9	22.3	21.6	21.5	21.9	22.5	22.9	22.9
Mean Minimum Temperature (deg. C)	1931-1954	16.7	17.1	17.6	17.6	17.5	16.7	16.3	16.2	16.2	16.7	16.8	16.4
Rainfall Amount (mm)	1907-1962	29	55	103	157	148	99	111	141	143	144	118	44
Average wind speed (m/s)	1938-1962	[1]4	4	4	4	4	3	3	4	4	4	4	4
		[2]10	9	9	7	7	7	7	7	7	8	8	8
Monthly evaporation (mm)	1962-1968	149	135	146	128	137	121	116	117	127	131	119	131
Relative humidity 1200 GMT (%)	1931-1954	41	43	49	59	64	64	63	65	63	60	53	51

[1] 0600 Hrs GMT
[2] 1200 Hrs GMT

Table 1-3 Climatological Statistics Butiaba. (Source: UNDP & WMO, 1974)

	Data Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Maximum Temperature (deg. C)	1931-1954	30.1	30.2	30.1	29.6	29.3	29.0	28.3	27.8	28.8	29.1	29.3	29.6
Mean Temperature (deg. C)	1931-1954	26.1	26.5	26.5	25.9	25.7	25.3	24.8	24.5	25.1	25.5	25.6	25.7
Mean Minimum Temperature (deg. C)	1931-1954	22.2	22.7	22.9	22.3	22.1	21.7	21.3	21.3	21.4	21.8	21.9	21.8
Rainfall Amount (mm)	1904-1962	14	31	56	101	96	55	68	86	75	84	72	27
Average wind speed (m/s)	1938-1962	[3]4	5	3	3	3	4	5	5	5	4	4	4
		[4]7	7	7	6	6	6	6	6	6	6	7	6
Relative humidity 1200 GMT (%)	1938-1954	66	67	68	70	70	69	70	70	70	71	69	67

1.8 Geology

The geology of the region comprises of the Bunyoro series, Pleistocene (sediments, alluvium) and undifferentiated gneisses. The dominants rocks in the southern part of the catchment are Porphyritic granites and gneissic complex which have undergone geomorphologic processes for a very long time. The rocks are mainly classified under pre-Cambrian era, cretaceous period and the present rock formations, which are as a result of sedimentation (Combe & Simmons, 1983).

The Rift Valley and the associated geology occur in areas affected by rift valley faulting. Their distribution follows the weathered detritus that had accumulated prior to faulting which has been removed by post rift valley geological erosion. Therefore the rock consists of quartzite stones. Other rocks affected by post rift valley include quartzite, granites and schist (Pritchard, 1979).

Along Lake Albert shores there is a broad tract of river and lake alluvium land down as rift valley floor deposits. At Kaiso Tonya in the Albert rift, a fossiliferous ferruginous bed occurs in sediments making a period of recession during inter pluvial phase when Lake Albert was formed. In Uganda the oldest deposits are the Kaiso beds (NEMA, 1998).

[3] 0600 Hrs GMT
[4] 1200 Hrs GMT

1.9 Soils

The practical application of geomorphology is in its use to interpret soils in a given environment. The nature and age of the earth's surface, the type and magnitude of processes operating on the surface and the length of time to which it has been exposed have some bearing on the depth of weathering and soil formation.

Ferralitic, ferrisol, and hydromorphic soils are the main types of soil found in this region (Harrop, 1960). Ferralitic soils cover a vast part of the catchment. The soils are mainly yellowish-red clay loams on sedimentary beds. Highly leached, reddish brown clay loams are found in the extreme east of the Masindi District. These are of low to medium productivity. There are also dark brown, black loams (Bugangari series) found along the axis of the warp and these are mainly of low to medium productivity. The soils of recent origin that consist of quartzite are found along the escarpment. Their depth depends on the vegetation cover and land use. They are suitable for coffee and maize (Harrop, 1960).

Soils on high land areas developed on pediment fans are lateritised. They are red clay loams *(kitonya catena)* derived from K.A phyllites. They are of medium to high productivity especially for coffee and maize. On the other hand, greyish-black sands are base deficient, acidic and generally occupy rivers and valleys floors. These alluvial soils are of low productivity which includes Wasa Complex, Kifu and Bukora Series (NEMA, 1998).

1.10 Vegetation

The vegetation of the area can be broadly be classified into forest, savannah, grassland and swamps. The main functions for vegetation include providing water catchments, food and being rich in biodiversity, climate modification and ecological indicator (NEMA, 1998; Plumptre *et al*. 2003).

Forest vegetation covers most of the areas boarding Budongo forest and throughout the medium altitude forest zone. Small patches of original forest, forest regeneration stages, and the early herbaceous stage of the succession following the abandoned cultivation of the area are characteristics of the vegetation.

Vegetation cover includes broad-leaved plantations with species such as pine as well as riverine tropical high forests. Budongo Central Forest Reserve 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 Profile, 2005). Other reserves include Bugoma Central Forest Reserve, Bugungu Wildlife Reserve and Karuma Wildlife Reserve, which are in the catchment.

Savannah vegetation constitutes of cauline-leaved perennial grass not exceeding 80cm in height, scattered trees and shrubs. The dry savannah lies contiguous to the Lake Albert and with the increasing altitude up the escarpment, turns into wet savannah and grassland. Swamp vegetation fills most of the water logged valleys (Brown and Osmaston 1964).

The management of the forest resources is under the Central Government under National Forestry Authority (NFA), the Bunyoro Kitara Kingdom, Nyabyeya Forest College and private ownership. The District Forestry Services are supposed to manage sustainably with the communities and private landowners. However, the natural forests have over time been degraded due to pressure on land. Human activities have had a great influence on the natural vegetation in the district. Such as deforestation, wetland degradation and many others (Masindi District Environment Profile, 2005).

According to the Forest Department, some natural forest cover in the reserves has been lost. This has been due to illegal charcoal burning, timber harvesting and desire to create land for cultivation and settlement. There is licensed pit sawing taking place in some of these reserves. However, there is a problem of not replanting (Masindi District Environment Profile, 2005).

Timber cutting and selling has become a lucrative business in the region and many people are engaged in the lumbering activity. Pit-sawing and chain sawing have been common both in gazetted central forest reserves and forests on private lands. Charcoal burning activity is being carried out in both gazetted forest reserves and forest on private lands. High demand for charcoal is as a result of rapid urbanization in the districts and the mushrooming trading centres in the region (Masindi District Environment Profile, 2005).

Agricultural encroachment and settlements in the forest reserve have resulted in massive deforestation. Almost no gazetted central forest reserves have clear boundaries. This has prompted immigrants and the indigenous people to cultivate in the forest reserves especially tobacco and sugarcane growing. Tobacco growing requires virgin land for high yield production. There is therefore annual clearing of forestland for tobacco growing. And this has drastically reduced on the forest cover in the past few years. People have settled in some areas of the reserve land with semi-permanent houses constructed (Masindi District Environment Profile, 2005).

Grazing of livestock along the forest reserves for instance pastoralists were sent out of the Kaiso-Tonya Community Wildlife Area, and instead went to the savannah woodland reserves like Bujawe Central Forest Reserve. Others came close to Bugoma Central Forest Reserve boundaries, made enclosures outside the Reserve, but grazing of animals is done inside. This is affecting natural regeneration (Masindi District Environment Profile, 2005).

Honey extraction by honey hunters who have on several occasions felled big trees in central forest reserves in search for honey. In the process, they set fire in the dry branch wood ending up burning the whole tree. There are also cases of periodic wild fires during the dry seasons affects natural regeneration especially in grassland patches of the natural high forest thus impending colonization process. All the above explains the high rate of depletion of vegetation cover in the region (Masindi District Environment Profile, 2005).

2 MATERIALS AND METHOD

2.1 Introduction

The methods used in this study included search, collection, acquisition and gleaned of literature. Strength, Weakness, Opportunities and Threats (SWOT) analysis was carried out on the policies reviewed. A field visit to the project area was made between 25th and 31st August 2005. Hydrological, water quality and socio-economic methods were used both in the field and analytical laboratories. Details of these methods are given below. The collected data was analysed and synthesised and is presented in this report.

2.2 Hydrological Methods

Hydrological information was obtained from past records and studies. The main source of information was from the Hydro meteorological Survey of Lakes Victoria, Kyoga and Albert that was carried out in the late sixties and early seventies (UNDP& WMO, 1974). Recent data was obtained from The Directorate of Water Development data bank using computer aided programmes like *Hydata*, *Clicom* and *Access* at the Directorate of Water Development.

2.3 Water Quality Methods

Water samples were collected from the project area between 25th to 31st August 2005. Standard methods for the examination of water as recommended by (APHA, 2000; Bartram and Balance 1996 and Chapman 1996) were used. Temperature, dissolved oxygen, pH, electrical conductivity, colour and turbidity were measured on site. The water was then fixed and kept under ice and taken to the Central Laboratory, National Water and Sewerage Corporation, analytical laboratory were it was analysed. Details on the sampling sites, water quality parameter measured and the results of water quality status of lake are presented in Chapter 5.

2.4 Socio-economic Methods

Qualitative methods of data collection were used to gather information about socio-economic status. Questionnaires were designed on the basis of the TOR and pre-tested. Focus group discussions (FGD) and key informants were conducted with the communities on socio-economic matters affecting them that have a bearing upon the improvement of water quality in the catchment area.

The FGD was held with the farmers, fishing, lumbering and herding communities in the catchment area. The key informants were District Planners, Forest Officers, Agricultural Officers, Environmental Officers, Water Officers, Veterinary Officer and Nyabyeya College Administration.

3 WATER RESOURCES IN THE CATCHMENT

3.1 Drainage & Runoff

Inflows into Lake Albert can be considered into three main parts (UNDP & WMO, 1974): -

- Inflow from the Semliki River from the south
- Inflow from the Kyoga Nile.
- Inflow from the rest of the catchment

The Semliki River is the main river flowing into Lake Albert at its southern end. It comes from Lake Edward through the western edge of the great Ituri rain forest in the Democratic Republic of Congo, augmented by streams from the northern slopes of the Rwenzori Mountains in Uganda. On its course through the forests are several kilometres of rapids that are effective barriers to faunal interchange from Lake Albert to Lake Edward. Semriki River has been gauged regularly from 1940, first by the Egyptian Irrigation, then by the Uganda Water Development Department up to the present day Water Resources Management Department (WRMD). The high salinity of Lake Albert (200 p.p.m) is mainly attributed to the Semliki River which contributes about 63 per cent of the inflow into Lake Albert, apart from the inflow from the Kyoga Nile (UNDP & WMO, 1974).

Of the land catchment of the Lake Albert, excluding the Semliki River and the Kyoga Nile, only 30 per cent of the area is gauged, including the portion in DRC. Most of the lateral inflows into the Lake from the escarpments are seasonal and contribute very little, since their catchments are small. During the Hydro-Meteorological Survey Project of the Catchments of Lakes Victoria, Kyoga and Albert (1974), it was established that during the period 1948-1970, run off amounted to 2,702 milliards m^3 or 503 mm over the lake. The mean annual runoff coefficient for the basin was computed as 12.37 per cent (UNDP & WMO, 1974).

Runoff from the catchment reaches the lake in two peaks, a small one in May and a more distinct higher peak in November-December, which gives a lag of one month between the rainfall seasons and the runoff yield. Figure 2.1 illustrates the wider Lake Albert Basin and its sub catchments (UNDP & WMO, 1974).

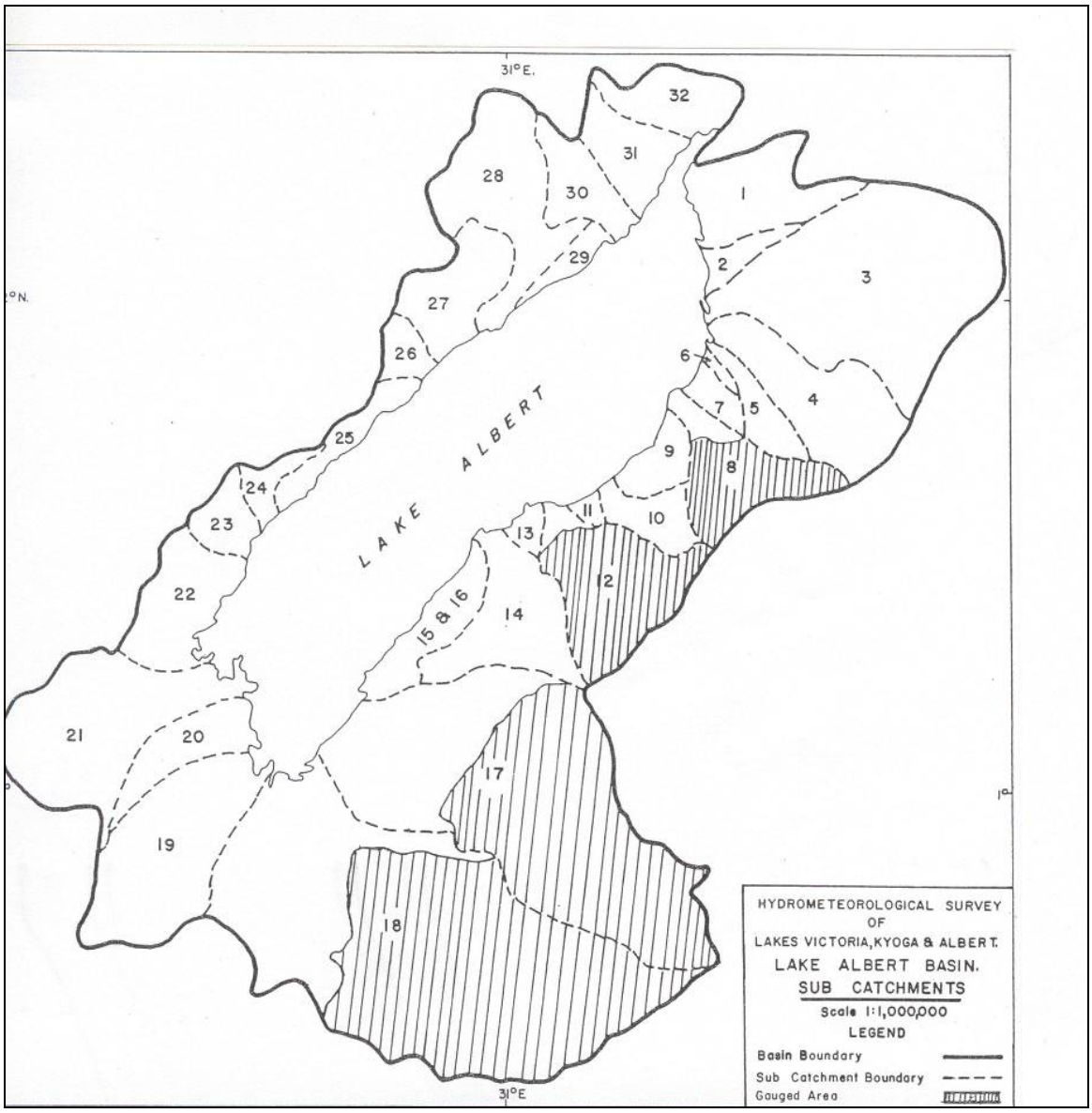


Figure 3-1 Overview of Lake Albert Basin sub catchments, excluding Kyoga Nile Catchment. For more details see Table 3–1 (source: UNDP & WMO, 1974).

Table 3.1 lists the sub-catchments presented in Fig 3.1 and provides figures for Normal Annual Land Runoff for the period 1948-1970 for the constituent sub-catchments.

Table 3-1 Annual runoff –Lake Albert sub-catchments (source: UNDP & WMO, 1974)

Name of River	Slope of Channel (%)	% age of Runoff	Area (Km^2)	Rainfall (mm)	Runoff (mm)
1. Victoria Nile	.0025	2.1	540	1,060	22.3
2. Sambiyer	.0047	9.1	250	965	87.8
3. Weigo	.0069	12.0	1,325	1,252	150.2
4. Waisoke	.0092	14.5	595	1,331	193.0
5. Sonsono	.010	15	202	1,359	203.8
6. ----------	.014	17	30	900	153.0
7. Bubwe	.019	18.5	120	1,000	185.0
8. Waki	.010	15	523	1,379	206.9
9. ----------	.017	18	150	1,150	207.0
10. Hoima	.007	12.6	202	1,283	161.7
11. ----------	.016	17.7	40	900	159.3
12. Wambabya	.006	11.3	808	1,354	153.0
13. --------	.016	17.7	75	830	146.9
14. Howa	.009	14.3	666	1,175	168.0
15. ----------	.020	18.8	191	937	176.2
16. ----------	.020	18.8	114	937	176.2
17. Nkusi	.0042	8	2,900	1,174	93.9
18. Muzizi	.0035	6.1	3,850	1,170	71.0
19. Wasa	.0055	10.5	910	1,324	139.0
20. ----------	.022	19.2	394	923	177.2
21. Lower Semliki	.022	19.2	1412	1,100	209.0
22. Samuti	.037	22.5	412	1,108	244.9
23. Muita	.043	23.5	202	1,070	250.7
24. Mboge	.057	25.5	203	1,001	255.4
25. -----	.16	34.8	238	1,000	348.0
26. --------	.08	28.3	63	1,100	311
27. Tshoda	.05	23.6	460	1,150	256.4
28. Kabole	.02	18.8	681	1,249	234.8
29. ----------	.08	28.3	120	1,000	283.0
30. Ori	.028	20.2	245	1,193	240.9
31. Rengo	.03	20.5	227	1,122	230.0
32. ----------	.02	18.8	182	1,200	225.6
Total	**-**	**-**	**18,330**	**-**	**-**
Mean	**-**	**12.37**	**-**	**1,192**	**147.4**

3.2 Runoff

The eastern shore of Lake Albert is drained by a number streams and the hydrological network included measurement stations on the Waki, the Muzizi and the Nkusi Rivers. Besides these, there are other small streams like the Howa, Hoimo, Sambiye and many others that have up to now not been possible to measure individually. Under the HYDROMET project, the Waki was selected for intensive observations for purposes of estimation of total inflow from un-gauged rivers flowing into Lake Albert in order to determine their water balance of this system. The yearly variation of flows of within the project area is compared under the Fig 3.2.

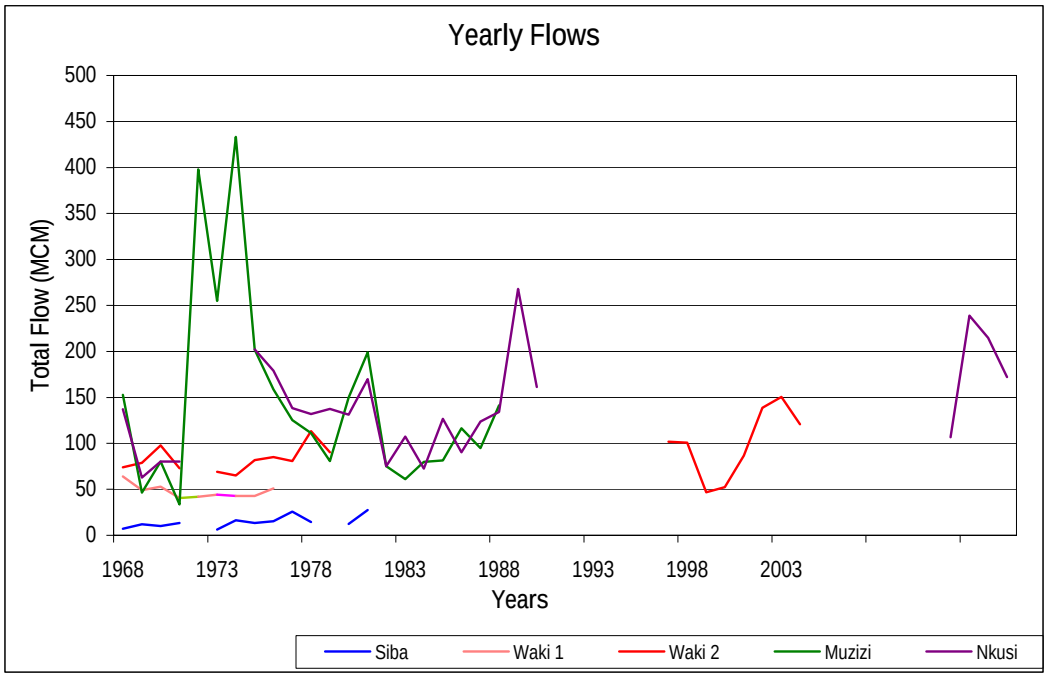


Figure 3-2 Historical variations of gauged rivers in the Project Area (Source: Hydata2005).

Generally speaking, existing records are scanty, too fragmented and are therefore not useful for trend analysis. However, total annual flow in rivers Muzizi and Nkusi appears to be strongly correlated but it is striking to note that intensity of gauging in the project area is still poor with only Nkusi and the Waki II as the only active stations.

Waki catchment has an area of 475 km^2 up to Waki II hydrological station and it lies between longitudes $31^0$18'E and $31^0$39'E and latitude $1^0$40'N and $1^0$28'N. Its sub-catchments are Waki- I (238km^2) and Siba (83km^2). The topography of the Waki catchment is such that it is steep at the southern part of the watershed but drops gradually to the Wali II hydrological station. The maximum elevation is about 1,402m and the lowest is 991m. Soils of the Waki catchment are mostly of various gradations of red clay loam. Its geology is composed of two types of rock formations as follows:

Undifferentiated gneiss – 36.9%
Bunyoro series and Kyoga series – 63.1%

During the early 1970s, 47.7% of the catchment was forested. Semi-deciduous forests accounted for 26.6% while the rest comprised of savannah. The catchment was also extensively instrumented, with a total of 17 meteorological stations and 3 hydrological stations.

3.3 Sediment and Water Quality

Under the HYDROMET study (UNDP & WMO, 1974), sediment data was collected at Waki and it was shown that sediment load varied between 2.2 and 39.4 tons/day for discharge values lying between 0.63 and 3.90 m^3/s; the sediment concentration ranging between 30 and 117 mg/l. Two samples subjected to grain size distribution showed the sediment to be fine, 92-95% of the sediment being smaller than 0.063 mm diameter. Sediment load (C-tons/day) was plotted against river discharge (Q-m^3/s) and from these plots it appeared that sediment load is a function of river discharge. The correlation obtained was:

$C = 2.76\ Q^{1.90}$ ……(i)

The salinity determined at various places and at mid and bottom points shows that it lies between 480-500 mg/l and this remains fairly constant. There is practically no data available on the suspended sediment content of rivers or streams in the project area other than data collected for Waki during the HYDROMET project (UNDP & WMO, 1974).

3.4 Ground Water

Ground waters contained in the Precambrian rocks east of the escarpment that parallels Lake Albert occur in zones about 1,500 feet above the level of the Lake. These zones are not in hydraulic continuity with sediments in the rift valley. WRMD has monitored water levels, rainfall and abstraction levels for a motorised borehole at Hoima Hospital. The Fig. 3.3 illustrates the variations in time series.

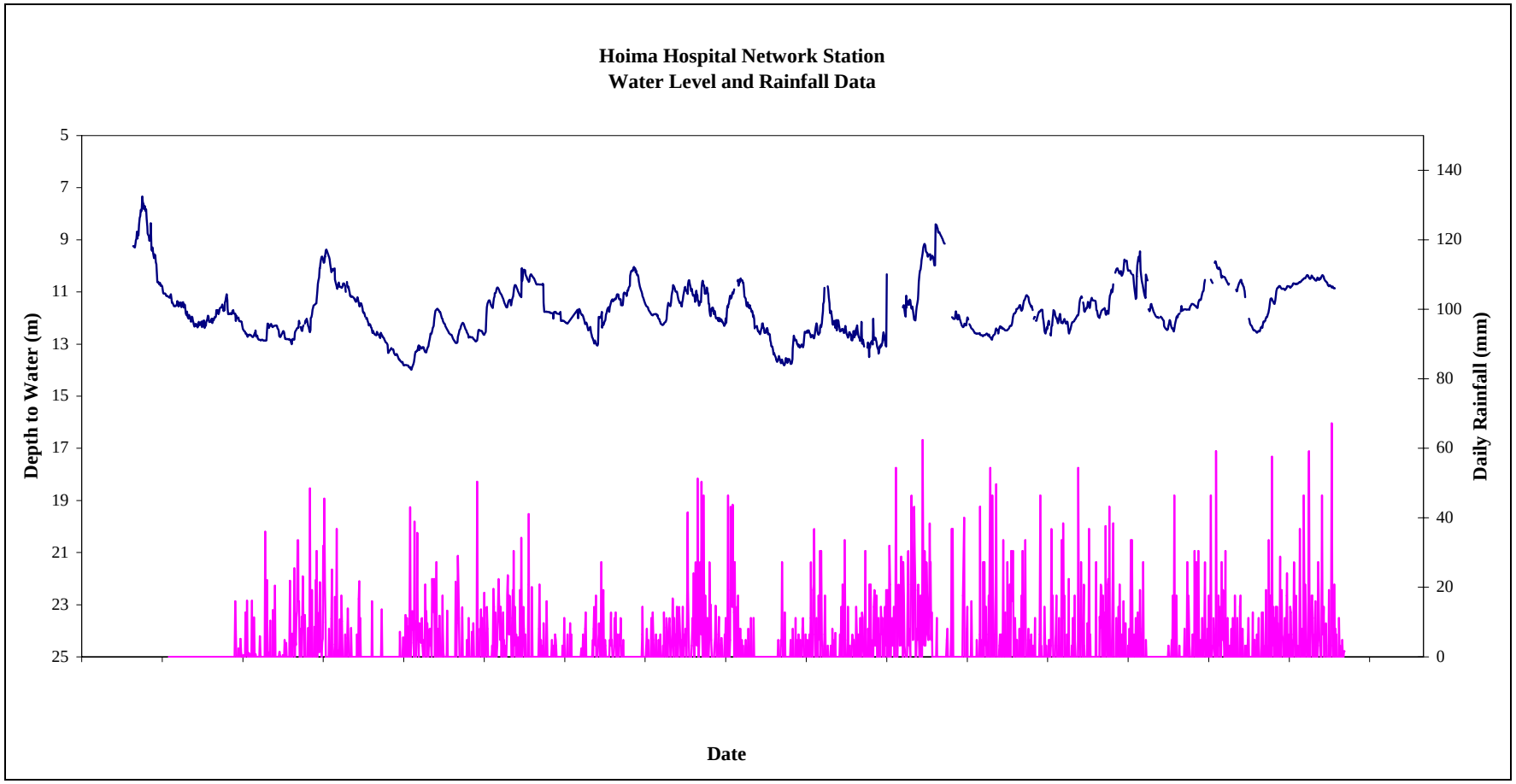


Figure 3-3 Trends in Ground water levels (upper curve) and rainfall (lower bars) at Hoima Hospital, Hoima District.

The Fig 3.3 indicates that water levels respond to rainfall variations and the fluctuation varies around an almost constant mean and is rugged in nature due to abstractions.

3.5 Water Resources Utilization

Under the Water Action Plan District Studies, water uses and demands were compared to available water resources in terms of quality and quantity DWD (1995). The findings for Hoima, Masindi and Kibaale Districts indicated that the vast majority of the population are mainly depending on agriculture. Fishery on Lake Albert is another major source of income. The National Rural Water Supply Atlas, 2001 states that district service coverage of safe water in Hoima, Masindi and Kibaale is 60%, 56% and 59% respectively. The major water sources exploited are protected springs, deep boreholes and shallow wells. According to the Water Permit database of the Department of Water Resources Management, bulk water abstractions of registered water users for the year 2003 in Lake Albert Basin, 1,500m^3/year was abstracted from surface water while groundwater abstraction accounts for 63 m^3/year.

Irrigation potential in Uganda in concentrated around Lakes Victoria, Kyoga and the Albert Nile river. Therefore there is no significant potential for irrigation within the project area (DWD, 1995) and therefore no substantial anticipated use of water for irrigation utilisation. According to rapid water resources assessment carried out under the Water Action Plan (DWD, 1995), projected figures for the year 2010 for other consumptive water uses were as indicated in Table 3.2 below.

Table 3-2 Consumptive use in Lake Albert sub-catchments. All figures are in 000 m^3 (Source DWD, 1995).

Consumptive Use Category/(m^3)	**District**		
	Hoima	**Masindi**	**Kibaale**
Urban	158	496	113
Rural	2,577	3,142	3,739
Livestock	3,564	4,217	5,250

A survey financed by the United Nations Department of Technical Corporation for Development in 1988 (Gibb, 1989) identified the following two small hydro-power sites within the project area.

Table 3-3 Hydropower potential within the project area

Site	**River**	**District**	**Estimated Capacity (MW)**
Muzizi	Muzizi	Kibale	10[5]
Biseruka	Wambabya	Hoima	10

[1] Recent surveys show it is possible to generate up to 60 MW at Muzizi site depending on the configuration used.

4 WATER QUALITY OF LAKE ALBERT EASTERN CATCHMENT

4.1 Water Quality Sampling Sites

In the Preliminary Reconnaissance Survey for water quality monitoring, sites listed below were chosen along the Kyenjojo-Hoima-Masindi axis on the Kyenjojo-Hoima-Masindi road, whose details are in Table 4.1. This axis was chosen because of the following reasons: -

(i) It had a road network that crossed all the major rivers in the catchment.
(ii) Accessibility to the sites was every easy because they were located on the bridges along the road.
(iii) The sites were already in the national hydrologic and water quality monitoring stations under the Directorate of Water Development.
(iv) The sites have been monitored since Uganda's colonial era; hence data was available for comparison between the past and present, making it achievable to predict future trends.

Site 1. River Muzizi, Upstream
The site is located (North 36N 0293265; UTM 01772791). River Muzizi is the most polluted river in the catchment. This site was chosen to determine whether there is self purification as the river flows down stream. The location was on a bridge of a small feeder road that links Kyenjojo-Kibaale Districts at Kitutu. The site had rooted *Phargamites* vegetation with a clear water surface at the bridge where the water sample was collected. The sample was bright brick red in colour a visible indication of silt and perhaps iron oxide. It's un gauged and is not on the DWD national monitoring network. There is serious deforestation around the sampling site where forests are converted into farmland.

Site 2. River Muzizi Downstream
This station (North 36N 024736; UTM 024736) is on the national monitoring network for hydrologic and water quality monitoring as station 85211 and Swr022 respectively. It is located about 50km downstream of site No. 1, along the Kyenjojo-Hoima Road Bridge. The site topography is fairly flat with the river flowing sluggishly. The vegetation is massive *Papyrus cyprus* that covers the entire river course with a clear open water surface towards the bridge. The river banks have been reinforced with stone gabion to protect the bridge and river bank from floods. The water sample was red in colour with reddish suspended solids.

Site 3. River Nkusi
This river station (North 36N 027644; UTM 0124911) is on the national monitoring network for both hydrologic and water quality monitoring as station 85212 and Swr021 respectively. Located on the Kyenjojo-Hoima Road Bridge it has a typical fast flowing river with the river course covered by riverine vegetation. The water was brown in colour.

Site 4. River Wambabya
Located on the Hoima Biseruka Road Bridge (North 36N 0290268; UTM 0124911), at the time of sampling the water volume was low compared to the river width and the height of the bridge. The river is being monitored because of its mini hydroelectric generation potential downstream. The water colour was greyish/black a reflection of grey volcanic soils. DWD has decommissioned the gauging station.

Site 5. River Hoimo
Located on the Hoima-Biso Road Bridge it is a major river in the catchment (North 36N 0300799; UTM 0173573). It has never been monitored; therefore it is un gauged and has no historical data. It is a fast flowing river which was turbid, greyish/black in colour. Its river banks have a riverine vegetation and the catchment is heavily cultivated.

Site 6. River Waaki
This site is located along Hoima-Biso Road Bridge (North 36N 0319381; UTM 0189025). The river forms a boundary between Hoima and Masindi Districts. Its catchment drains Kinyara Sugar Works and its extensive sugar cane plantation making it prone to pollution. The river is fast flowing river with brown colour water. The vegetation along the river bank and the catchment has been intensively cultivated.

Site 7. Kinyara Sugar Works Factory Effluents
This sample was taken from the final factory effluent of Kinyara Sugar Works (North 36N 034485; UTM 0183587). This sampling site was not in the original terms of reference but was chosen because stakeholders insisted it was of interest for investigation because of the obnoxious smell along river Kasokwa which receives factory effluents outfall. It was treated as a pollution hot spot.

Site 8. River Kasokwa
This sample was taken from about 3km down stream of the Kinyanra Sugar Works effluent outfall, on the Masindi-Butiaba Road culvert (North 36N 0345156; UTM 0181390). Although originally not in the terms of reference the purpose of picking a sample from this site was to quantify its parameters and confirm or disapprove complaints from stakeholders that Kinyara Sugar Works was polluting the environment. A sample from this site would determine the extent of effluent plume in the river. Self purification would also be determined. At the time of sampling (29/08/2005 17:48:30hrs) there was an obnoxious smell of molasses in the air that stretched three kilometres on either side of the culvert.

Site 9. Hoima Hospital Borehole
This site is located at the surgical ward of Hoima Hospital in Hoima Town. It is a representative sample of groundwater in the catchment. It is on the national monitoring network. Unfortunately at the time of sampling the borehole was out of operation since 2003, therefore no water sample was taken.

Site 10. Lake Albert at Butiaba

This site (North 36N 0204044; UTM 0204048) is gauged and has been monitored since the 1920's. It's serial number on the national hydrologic and water quality monitoring are 85201 and Sw1007 respectively. The site is located mid north in the Lake, mid way between the Uganda-Congo boarders. Butiaba is a fishing village located on floor of rift valley; it has a compelling scenic beauty sight from the top of the rift valley escapement.

Table 4-1 Water Quality Sampling Sites in the Lake Albert Eastern Catchment August 2005.

No.	Name	DWD No.	Longitude	Latitude	GIS Readings		Altitude (m asl)
					North	UTM	
1	River Muzizi Upstream	Kitutu			36N 0293265	01772791	1,283
2	River Muzizi Down Stream, at Kyenjojo-Hoima Road	85211, Swr022	30^{o} 73000	0^{o} 87000	36N 024736	0096327	1,161
3	River Nkusi, at Kyenjojo-Hoima Road	85212, Swr021	31^{o} 00000	1^{o} 14000	36N 027644	0124911	1,070
4	River Wambabya,	Decommissioned			36N 0290268	0169190	986
5	River Hoimo, Hoima-Biso Road	Un gauged			36N0300799	0173573	980
6	River Waaki, Hoima-Biso Road	85217			36N 0319381	0189025	
7	Kinyara Sugar Works Effluent				36N 0345156	0181390	1,114
8	River Kasokwa, After Factory Effluent Outfall				36N 034485	0183587	1,113
9	Hoima Hospital Borehole, Hoima Town	Gw016	31^{o} 33900	1^{o} 44100			
10	Lake Albert at Butiaba	Sw1007	31^{o} 32000	1^{o} 81800	36N 0204044	0204048	625

4.2 Water Quality Status of Lake Albert Eastern Catchment

Water samples were collected from the above sites from 25th to 31st August 2005. They were analysed in the laboratory using methods outlined in 2.3. Below are discussions of the results obtained during this survey, where possible comparison has been made between the findings of this reconnaissance survey and those from DWD data base and Talling and Talling (1965).

Table 4-2 Mean values of Water Quality Parameters of Lake Albert Eastern Catchment

PARAMETER	River Muzizi Upstream	River Muzizi F/Portal -Hoima Road	River Nkusi at F/Portal - Hoima Road	River Wambabya Hoima - Bisereko Road	River Hoimo Hoima -Biso Road	River Waaki Hoima - Butaiba Road	Kinyara sugar works effluents	River Kasukwa down stream of factory out fall	Ground Water Hoima Hospital	Lake Albert at Butaiba	Uganda National Standards for Portable Water	[a] WHO Standards for Potable Water
Secchi Depth (m)	-	-	-	-	-	-	-	-	-	2.74	-	-
Temperature (C)	-	24.00	21.10	-	-	-	-	-	-	-	-	-
pH*	5.81	6.40	7.10	7.49	7.27	7.54	5.61	7.04	7.20	8.90	6.5 – 8.5	6.5 – 8.5
Electrical Conductivity (µS/cm)	78.00	85.90	80.42	77.00	28.00	65.00	267.00	238.00	411.00	632.11	1000	+
Total Dissolved Solids (mg/l)	51.00	78.20	5.00	49.00	18.00	42.00	171.00	152.00	275.00	392.29	700	+
Colour (PtU)	895.00	591.25	239.67	117.00	140.00	329.00	608.00	135.00	-	25.33	15	15
Turbidity (NTU)	7.80	33.07	68.98	9.10	16.40	49.10	26.30	8.80	17.00	3.30	5.0	5.0
TSS1 (mg/l) Spectrophotometric	21.00	18.50	18.75	14.00	27.00	46.00	50.00	11.00	7.00	4.20	0	+
TSS5 (mg/l) Gravimetric	-	7.93	9.92	-	-	-	-	-	-	3.09	0	+
Na^+ (mg/l)	8.63	10.29	14.00	12.00	14.85	19.74	28.63	29.96	10.40	78.95	+	200
K^+ (mg/l)	1.61	2.47	1.40	1.20	0.54	5.13	4.84	6.16	1.90	43.98	+	+
Ca^{2+} (mg/l)	6.40	4.80	9.60	6.40	3.20	9.60	22.40	17.60	-	11.24	+	+
Mg^{2+} (mg/l)	1.90	2.00	5.80	19.20	12.50	6.70	11.40	13.40	-	32.21	75	+
Cl^- (mg/l)	2.2	7.03	3.69	1.40	2.00	1.60	3.20	2.40	7.00	21.27	250	250
SO_4^{2-} (mg/l)	0.0	21.49	17	0.0	0	0	29.00	0.00	-	17.89	200	250
F^- (mg/l)	-	0.46	0.163	-	-	-	-	-	6.00	0.68	1.5	1.5
P alkalinity (mg/l)	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	36.42	500	+
T alkalinity (mg/l)	19.53	54.16	80.00	60.00	28.00	56.00	104.00	224.00	235.00	319.67	500	+
Ca Hardness (mg/l)		31.73	17.55	-	-	-	-	-	135	29.15	+	+
Total hardness (mg/l)	24	66	35.54	24.00	60.00	52.00	102.00	100.00	220.00	145	+	+
DO (mg/l)	-	1.670	6.238	-	5.800	2.000	-	4.600	-	7.669	+	+

PARAMETER	River Muzizi Upstream	River Muzizi F/Portal -Hoima Road	River Nkusi at F/Portal - Hoima Road	River Wambabya Hoima - Bisereko Road	River Hoimo Hoima -Biso Road	River Waaki Hoima - Butaiba Road	Kinyara sugar works effluents	River Kasukwa down stream of factory out fall	Ground Water Hoima Hospital	Lake Albert at Butaiba	Uganda National Standards for Portable Water	[a] WHO Standards for Potable Water
BOD (mg/l)	8.1	4.77	4.25	8.10	3.90	4.40	28.10	6.40	-	6.217	+	+
COD (mg/l)	110	75.5	68.67	110.00	10.00	48.00	55.00	194.00	-	31.60	+	+
NH_4 (mg/l)	0.34	0.185	0.150	0.340	0.050	0.010	0.290	1.820	0.005	0.106	+	1.5
NO_2 (mg/l)	0.0	0.007	0.0593	0.000	0,000	0.001	0.009	0.029	0.640	0.002	5.0	1.0
NO_3 (mg/l)	0.0	0.033	0.034	0.000	0.013	0.023	0.090	0.040	-	0.030	5.0	11.0
T nitrogen (mg/l)	1.52	1.72	3.04	2.18	0.220	1.020	1.960	3.040	0.000	0.570	+	+
PO_4 (mg/l)	0.021	0.161	0.129	0.020	0.003	0.046	0.002	0.206	-	0.087	+	+
T phosphorus (mg/l)	0.103	0.249	0.246	0.211	0.163	0.349	0.343	0.564	-	0.140	+	+
SiO_2 (mg/l)	6.080	6.730	13.400	6.080	9.680	17.080	16.880	18.180	-	1.363	+	+
Total Fe (mg/l)	12.920	6.490	13.770	12.92	28.85	11.570	19.000	7.900	1.090	0.133	0.3	0.3
Chlorophyll a	-	-	-	-	-	-	-	-	-	0.034	+	+

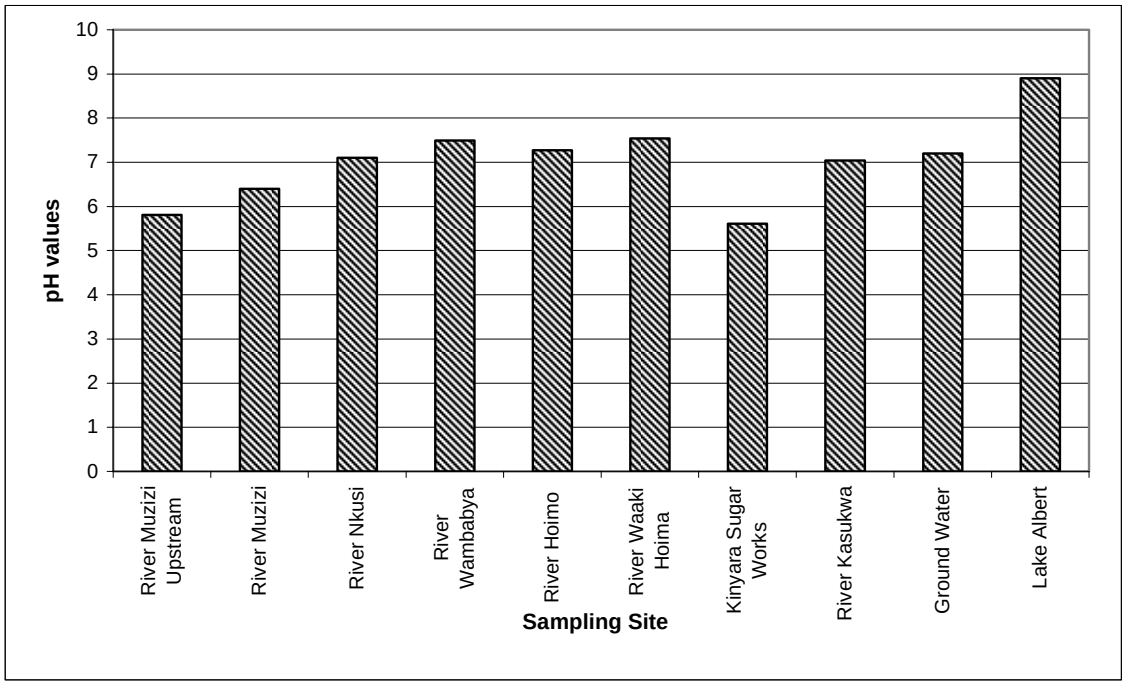
Key
* pH values are median values
- Not done
+ Standard not given

[a] WHO (1993)

pH

The results of pH show that all river inflows to Lake Albert are slightly acidic (low pH 5.81). The high lake pH values (8.90) are attributed to leaching of the volcanic soils from the rift valley catchment and inflows from hot springs. River Muzizi had the most acidic water with median pH value of 5.81 (Fig 3.1). The low pH value of the river is attributed to the papyrus swamp that occupies the river course. Papyrus swamps are acidic because of the humic acid from the decomposing papyrus mat. A comparison of pH for Lake Albert Rivers Muzizi and Nkusi since 1922 Fig 3.2 showed no trend. However, there was a correlation between pH and alkalinity.

Figure 4-1 A comparison of pH median of Lake Albert and its inflows in August 2005.



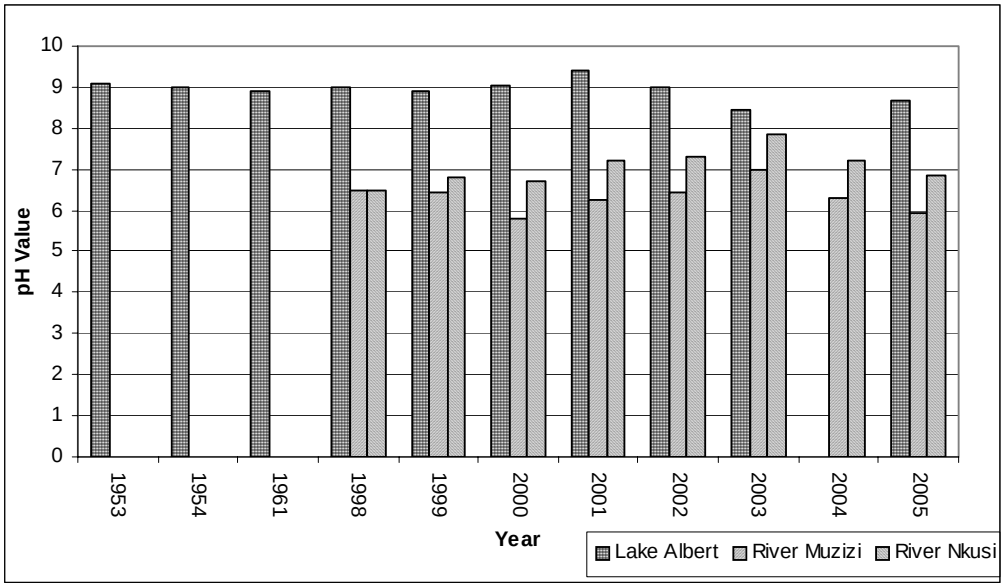
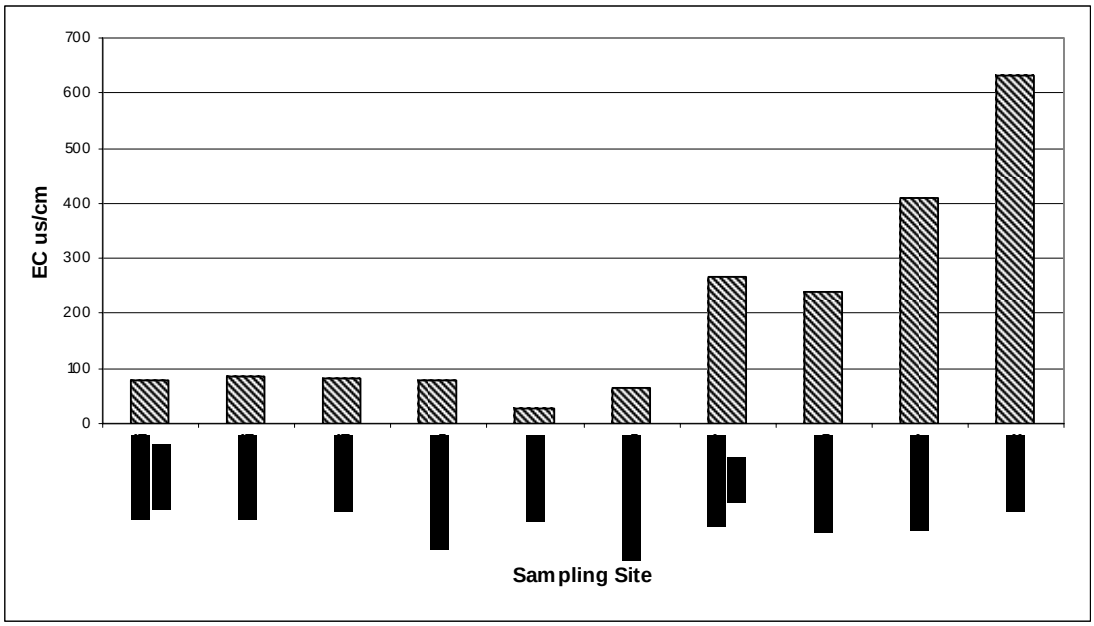


Figure 4-2 A comparison of pH median of Lake Albert and its inflows between 1953 and 2005.

Electrical Conductivity (EC)

The lake had higher electrical conductivity (EC 632 µS/cm) than its inflows (80 µS/cm) by a factor of 7 (Fig. 4.3). The lake is classified as moderately saline (Talling and Talling, 1965, Matagi, 2002). The high EC of the lake is attributed to the leaching of the volcanic soils of the rift valley, hot springs inflow, evaporation far exceeds inflows and the relative internal drainage of the lake allowing little water to leave the Lake. This allows the accumulative of total dissolved solids (TDS) hence high values of lake EC. The EC of the river waters was low (the lowest was River Hoima with 28 µS/cm). Hence the rivers are classified as dilute fresh water. Ideally the EC of a lake is supposed to be equal to its inflows. The apparent high difference of EC of Lake Albert and its inflows is accounted for in the difference in the geology of the underlying rocks. The rivers drain predominantly ferralitic rocks, while the lake is surrounded by volcanic soils of the rift valley. Total dissolved solid, was directly proportional to EC. Comparison of the variation of EC of Lake Albert since 1922 showed no increase over the years Fig 4.4.

Figure 4-3 A comparison of the mean electrical conductivity (EC) of Lake Albert and its inflows in August 2005.



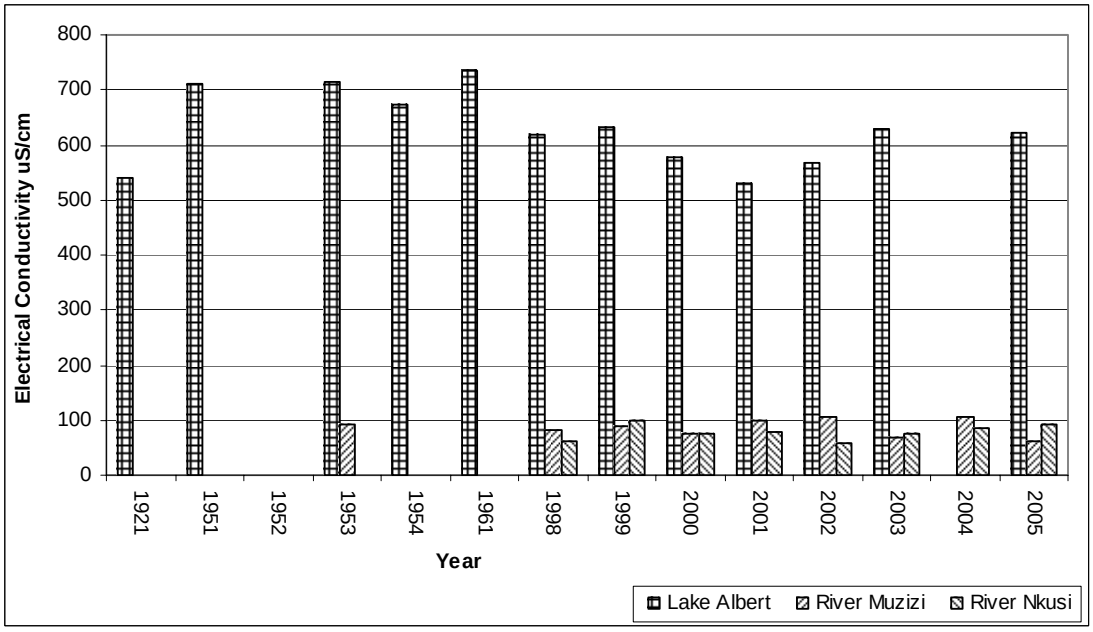
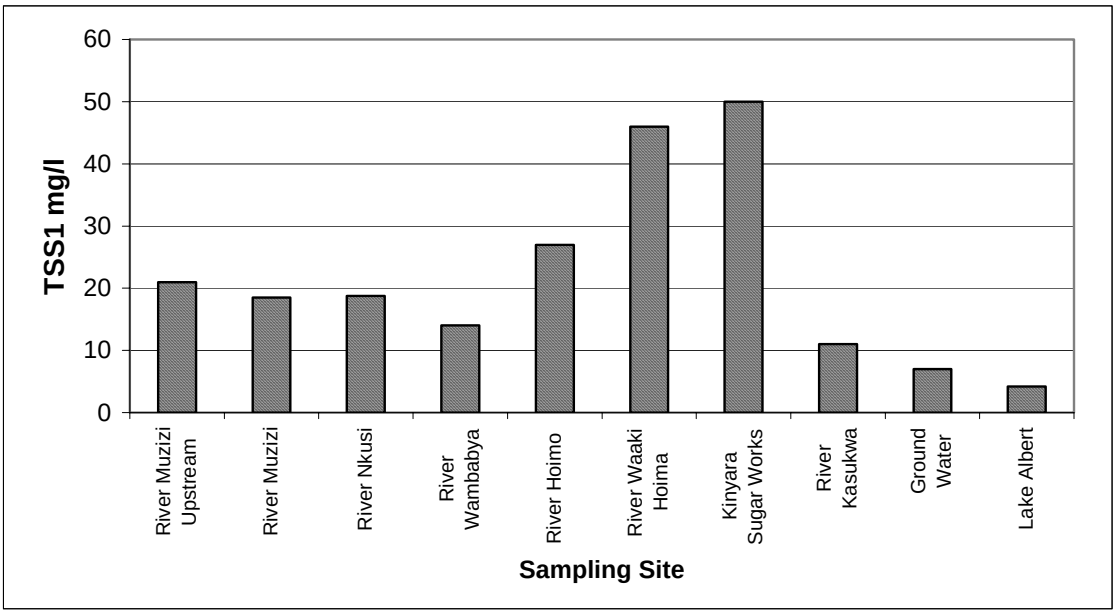


Figure 4-4 A comparison of electrical conductivity (EC) of Lake Albert and its inflows between 1921 and 2005.

Colour, Turbidity and Total Suspended Solids

All river samples had high colour (highest 895 PtU Up Stream River Musizi), turbidity (highest 86.98 NTU River Nkusi) and total suspended solids TSS (highest 27 mg/l River Hoimo). The water quality of the rivers and are not suitable for direct human consumption as compared to WHO (1993) Guidelines and Uganda National Standards Table 4.2. The most polluted river with the least aesthetic value was R. Muzizi with a colour of mean value of 895 PtU.

Figure 4-5 A comparison of Total Suspended Solids of Lake Albert and its inflows in August 2005.



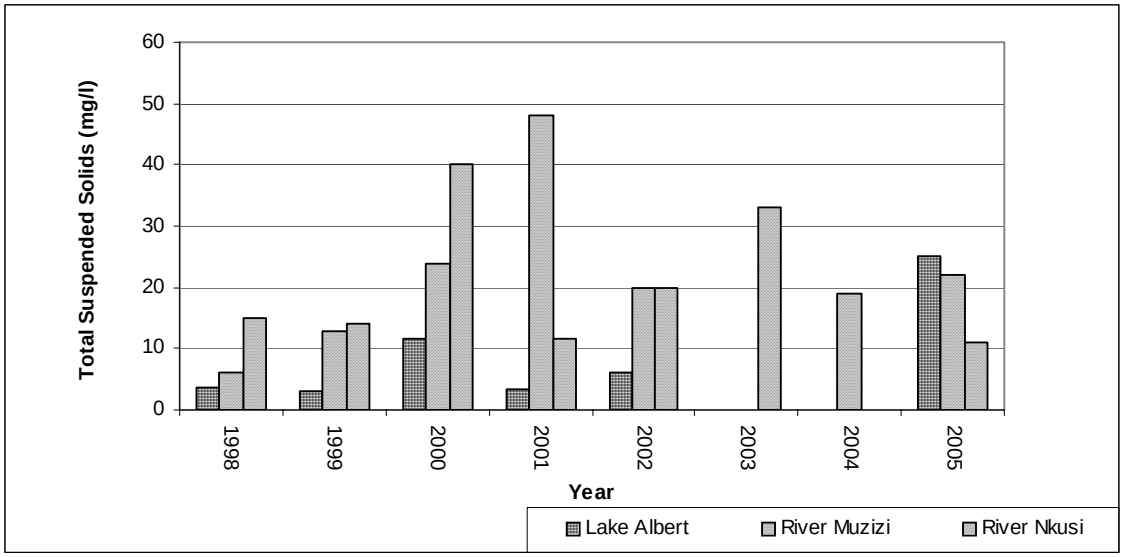


Figure 4-6 A comparison of Total Suspended Solids of Lake Albert and its inflows between 1998 and 2005.

The high values of the 3 parameters are due to:-

(i) High iron values which leaches out from the ferralitic soils of the upper catchment. River Hoimo had the highest mean value of iron 28.9mg/l Table 4.2.

(ii) Solid erosion that contributes most of the silt that makes up TSS. River Waaki had the highest TSS 46mg/l. This is because it drains a catchment that is under intensive agriculture i.e. the sugar plantation at Kinyara and the numerous peasant tobacco farmers that grow tobacco along its bank. This cause soil erosion, which end up silting up river water.

A comparison of the variation of TSS between the lake and its inflows showed that the rivers had high values, but the lake's values have progressively increased since 1998 (Fig 4.6). TSS in lakes is closely associated with plankton abundance. Hence increase in TSS in Lake Albert is a direct indicator that the lake is undergoing eutrophication. Kinyara Sugar Works contributes a significant amount of TSS to River Kasokwa, which is tributary of River Waaki.

Major Cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}) and Hardness

The major cations[6] in fresh water are calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}) and potassium (K^{+}). This survey confirmed the earlier work of Talling and Talling (1965) who found sodium is the major cation for Lake Albert and its inflows. In African inland waters the principle cation is Sodium. This accounts for the differences in the limnology of tropical and temperate lakes, because in the latter calcium is the principle cation (Talling and Talling, 1965). Calcium was the next most abundant cation. River Waaki had a high mean value of K^{+} (5.13mg/l) compared to other rivers. This is attributed to the intensive use of NPK fertilizers in the sugar plantation and tobacco growing in its catchment. This is further empirical evidence that anthropogenic activities in the catchment are impacting the water quality of the rivers and in turn this is linked to the deterioration of water quality of Lake Albert downstream.

Calcium and Magnesium are two major cations that contribute to hardness. River waters had very low value of Ca^{2+} and Mg^{2+} (3.2mg/l and 1.9mg/l respectively), which in turn influenced hardness to be low (the lowest 24mg/l in River Wambabya), hence river waters are classified as soft water. Lake water had higher values of hardness (147mg/l) compared to the inflows because of the high concentration of Ca^{2+} and Mg^{2+} (11.24mg/l and 32.21mg/l respectively). Hence lake water is classified as moderately hard water.

The low values of the major cations particularly Na^{+} (the lowest 12 mg/l in River Wambabya) makes river water quality suitable for irrigation, although the quantity is not sufficient to support large irrigation schemes. The sodium content of lake water is high (78.95 mg/l) and this would cause salinity if used for irrigation. Ground water at Hoima Hospital is not suitable for irrigation because of its high conductivity, alkalinity and hardness (275mg/l, 235mg/l and 220mg/l respectively) it would cause salination.

Major Anions (HCO_3^-, SO_4^{2-}, Cl^-) and Alkalinity

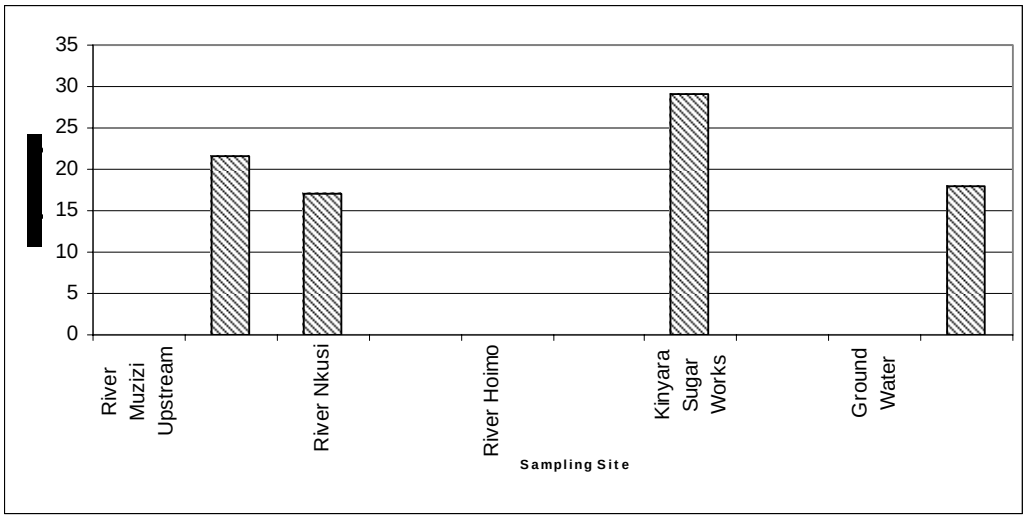
The major anions[6] in fresh water are bicarbonate (HCO_3^-), sulphate (SO_4^{2-}) and chloride (Cl^-) (Talling and Talling 1965; Wetzel, 1980). This survey confirms the early work of Talling and Talling (1965) who found bicarbonate as the most dominant anion, in Lake Albert and its river inflows. The low or absence of Phenolphthalein Alkalinity indicates the absence of carbonate in river water samples. Total Alkalinity was low (lowest was 19.52 mg/l River Muziziz Up stream); a direct indication of low HCO_3-, CO_2^{2-} and OH^- implying that the river waters had low buffering capacity hence susceptible to alternations in pH.

Relative amounts of CO_2^{2-}, HCO_3^- and H_2CO_3 are responsible for total alkalinity influenced by pH (Chapman, 1996). In fresh water pH between 4-6 favours CO_2, pH 6-9 favour HCO_3^-, while a pH range of 10-12 favour CO_3^{2-}. Fresh water most often has a pH range 6-8.2, hence HCO_3^- becomes the most dominate ion. For CO_3^{2-} to become dominant the pH must be above 9 which occur rarely in nature (Chapman, 1996).

Sulphate

Sulphate (SO_4^{2-}) is an important plant macronutrient. Sulphur is a major component of protein. It is not generally associated with eutrophication because it is rapidly broken down to H_2S in water. Generally river waters had low levels of sulphate compared to lake water. In this survey river waters had nil values (0.0mg/l), a further investigation is recommended. Kinyara Sugar Works had high values of SO_4^{2-} because of the SO_2 used in sugar bleaching Fig. 4.7. There was no trend established in sulphate levels on Lake Albert since 1928 (Fig. 4.8).

Figure 4-7 Comparison of the variation of Sulphate (SO_4^{2+}) of Lake Albert and its inflows in August 2005.



[6] **Anions:** These are negatively charged ions. **Cations:** These are positively charged ions

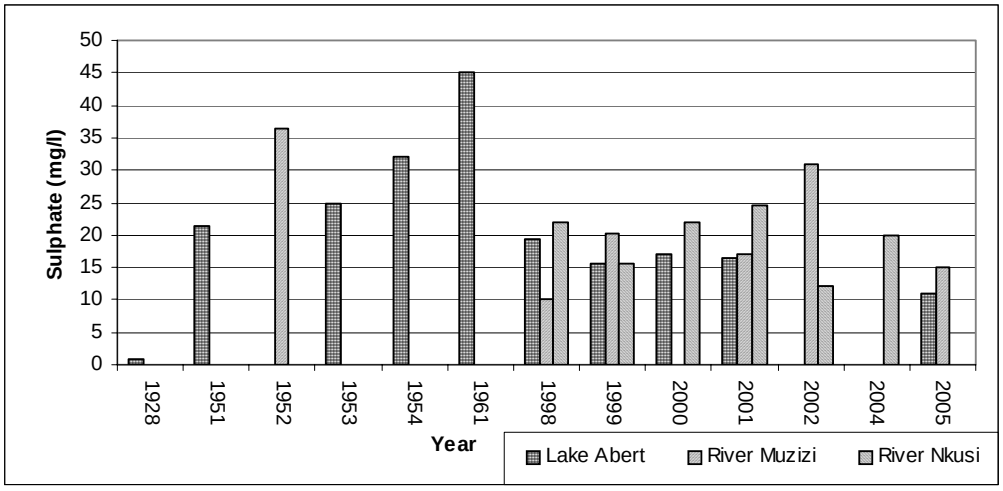
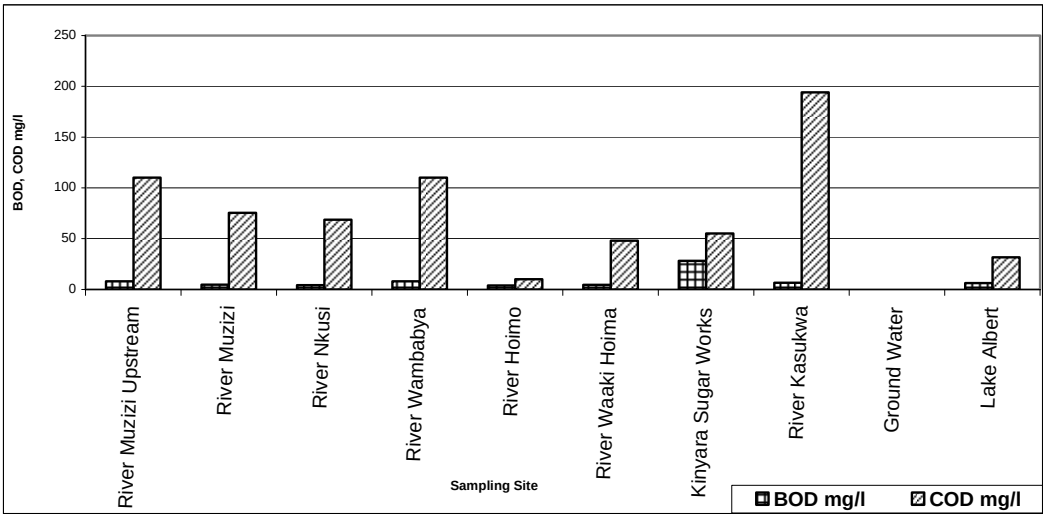


Figure 4-8 A Comparison of Sulphate (SO_4^{2+}) of Lake Albert and its inflows between 1928 and2005.

Dissolved Oxygen (DO), Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD)

The dissolved oxygen (DO) levels of the fast flowing rivers i.e. Nkusi, Wambabya, Hoima, Waaki and Kasokwa was high because of turbulence that allows aeration. River Muzizi had low DO (1.67mg/l) because of the papyrus vegetation that occupies its course. This prohibits aeration and the deposition of debris consumes oxygen as papyrus decomposes. A comparison of BOD and COD of river and lake water showed that rivers had high values than lake water (Table 4.2, Figs 4.9 and 4.10).

Figure 4-9 A Comparison of biological oxygen demand (BOD) and chemical oxygen demand (COD) of Lake Albert and its inflows in August 2005.



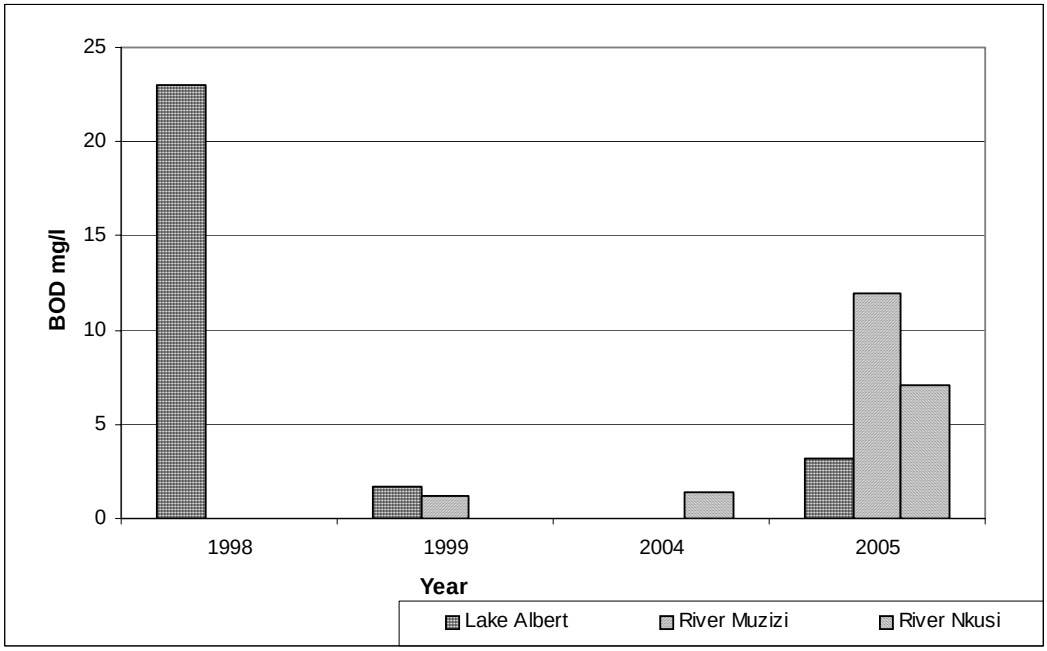


Figure 4-10 A comparison of variation of biological oxygen demand BOD of Lake Albert and its inflows between 1998 and 2005.

The BOD values of unpolluted water is 2mg/l or less (Chapman, 1996). However, the BOD of both river and lake samples were above 2mg/l direct evidence that the rivers are getting substantial organic pollution from catchment runoff, while the high value in the lake means an accumulation of organic matter is an indicator of the after effects of eutrophication. Although the BOD and COD of Kinyara Sugar Works met national standards for discharging into a receiving environment (i.e. below 50mg/l for BOD

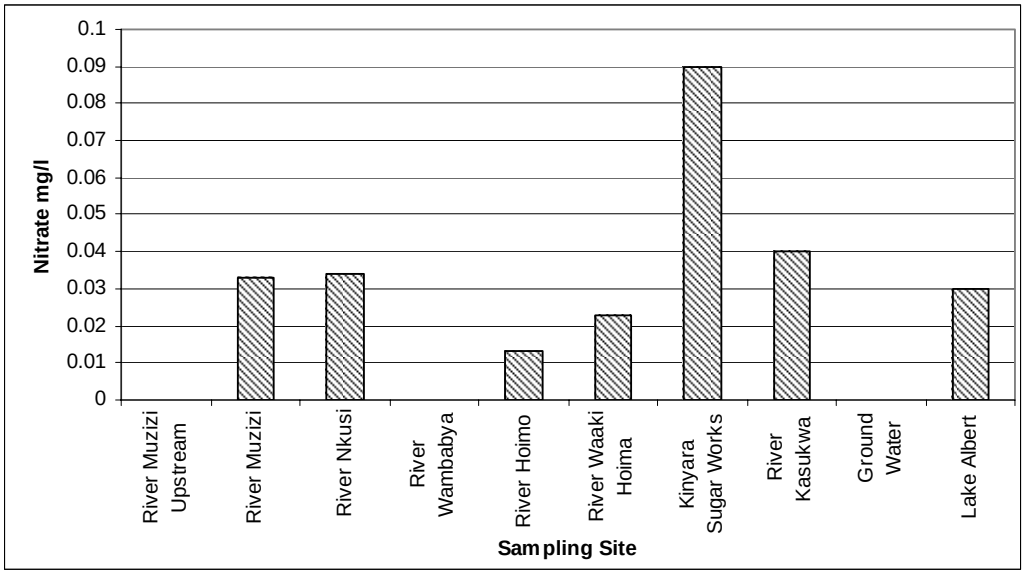
and 100mg/l for COD respectively), COD of the receiving River Kasokwa 5km downstream was high (194 mg/l) Fig 4.9. This confirms earlier studies which stipulate that rivers receiving factory effluents have COD of up to 200 mg/l (Chapman, 1996). The COD of unpolluted waters is 20mg/l or less (Chapman, 1996). Although the COD for both river and lake water was above this limit, pollution is not severe apart from River Kasukwa which receives effluents from the sugar factory.

Residents near Kinyara Sugar Works factory complained about the obnoxious smell along River Kasokwa; where the factory discharges its effluent. They further complained that the smell was unbearable particularly during the dry season. This prompted the team to visit the area and collect samples. At the time of the visit there was a mild obnoxious smell along River Kasokwa which would be detected 2km away. The offensive smell was from the decomposition of the waste water from the factory.

Inorganic Nitrogen (NH_4^+, NO_2^-, NO_3^-, TN and N_2)

Nitrogen is an important plant/algal nutrient used in the build up of proteins and enzymes. NH_4^+ was very low in both in the rivers' and the lake waters. In unpolluted water NH_4^+ is 0.1mg/l or less. In the case of lakes high values of NH_4^+ are expected if there is death and decay of algae. There was no algae bloom at the time of the visit.

Figure 4-11 A Comparison of nitrate (NO_3^-) levels of Lake Albert and its inflows in August 2005.



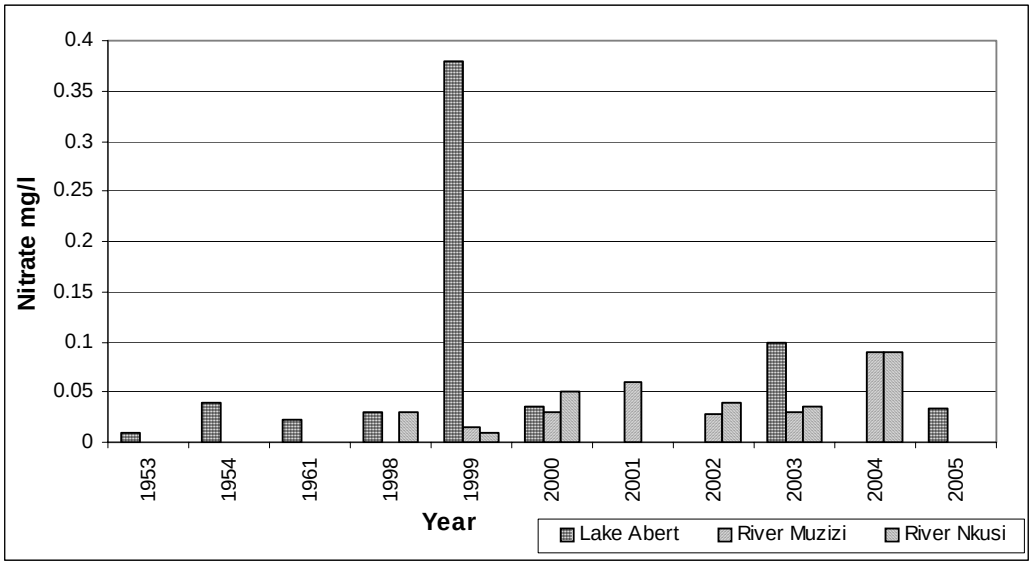


Figure 4-12 A comparison of nitrate (NO_3^-) levels of Lake Albert and its inflows

Nitrite (NO_2^-) and nitrate (NO_3^-) values were very low or in some instances non existent (i.e. 0mg/l) for both river and lake water Figs 3.11 and 3.12.

In African lakes nitrate unlike phosphorus is the limiting factor for algal productivity. In eutrophic lakes nitrates values are known to be very low/nil at times because there are rapidly taken up by the prolific growth of the algae. Therefore it does not necessary mean low values of nitrogen (nitrates) that the lake is not eutrophic. Nitrite on the other hand was not detected in the samples because it is immediately converted into nitrate. A comparison of nitrates since 1943 (Fig. 3.12) show a sharp rise in 1999 in Lake Albert, the year after the reported algal blooms on the lake (DWD, 1998).

An ecosystemic classification of freshwater environments can be described from the amount of growth limiting nutrients Total Nitrogen and Total Phosphorus (Smith *et al*, 1999). Table 4.3 below shows classification of lakes, streams and coastal marine waters based on their trophic status. From Table 4.3 the rivers were oligotrophic in terms of Total Nitrogen and the lake mesotrophic. However, notwithstanding tropical freshwaters are known to have low values of Total Nitrogen because of the high temperature compared to the temperate lakes because most TN is composed of ammonia and N_2 gas which evaporates at high temperatures found in tropical lakes.

Table 4-3 Average characteristics of lakes steams and coastal marine waters of different trophic states (Adopted from Smith et al, *1999)*

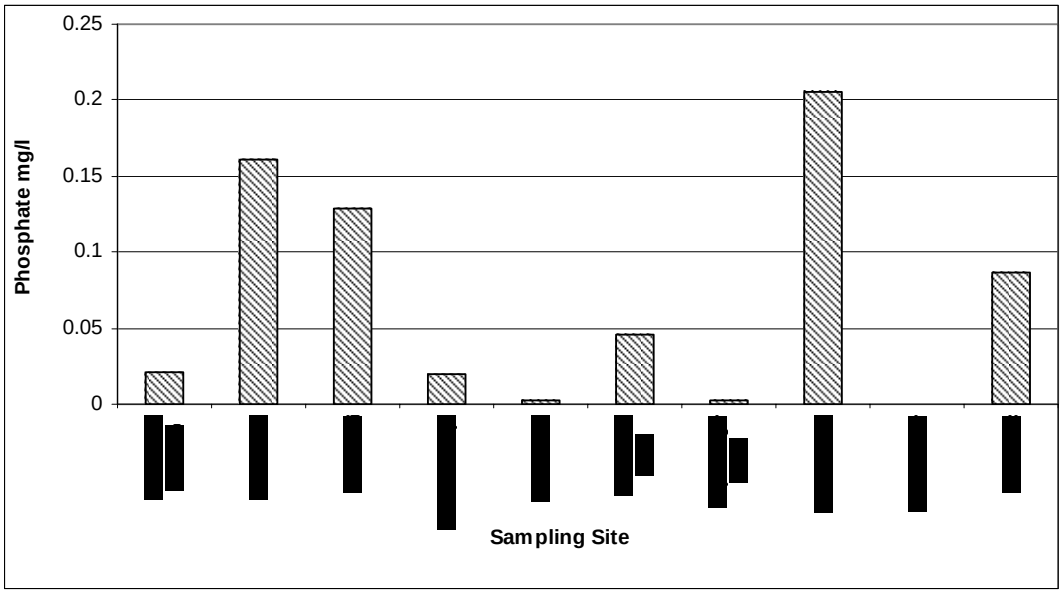
Source	Trophic State	TN (mg m^{-3})	TP (mg m^{-3})	Chl a (mg m^{-3})	SD (m)
Lakes	Oligotrophic	<350	<10	<3.5	>4
	Mesotrophic	350-650	10-30	3.5-9	2-4
	Eutrophic	650-1200	30-100	9-25	1-2
	Hypertrophic	>1200	>100	>25	<1
Streams	Oligotrophic	< 700	<25	<10	
	Mesotrophic	700-1,500	25-75	10-30	
	Eutrophic	>1500	>75	>30	
Marine	Oligotrophic	<260	<10	<1	>6
	Mesotrophic	260-350	10-30	1-3	3-6
	Eutrophic	350-400	30-40	3-5	1.5-3
	Hypertrophic	>400	>40	>5	<1.5

Key: Total Nitrogen TN, Total Phosphorous TP, Chlorophyll a Chl a and Secchi Depth SD.

Phosphate and Total Phosphorus

The mean values of phosphate (PO_4^{2-}) for both river and lake water range from 0.003 to 0.129mg/l (Table 4.2). This falls in the range for natural surface waters which is 0.005-0.02mg/l (Chapman, 2006). However all the values were higher than the 0.001 mg/l for pristine water, an indication of perturbed aquatic environment. Total phosphorus for the lake was 0.14 mg/l an indication that the lake is oligotrophic. However, notwithstanding eutrophic lakes are known to have low values of Total Phosphorus because most of it may be locked up in the algal biomass (DWD, 1998).

Figure 4-13 A comparison of phosphate (PO_4^{2-}) levels of Lake Albert and its inflows in August 2005.



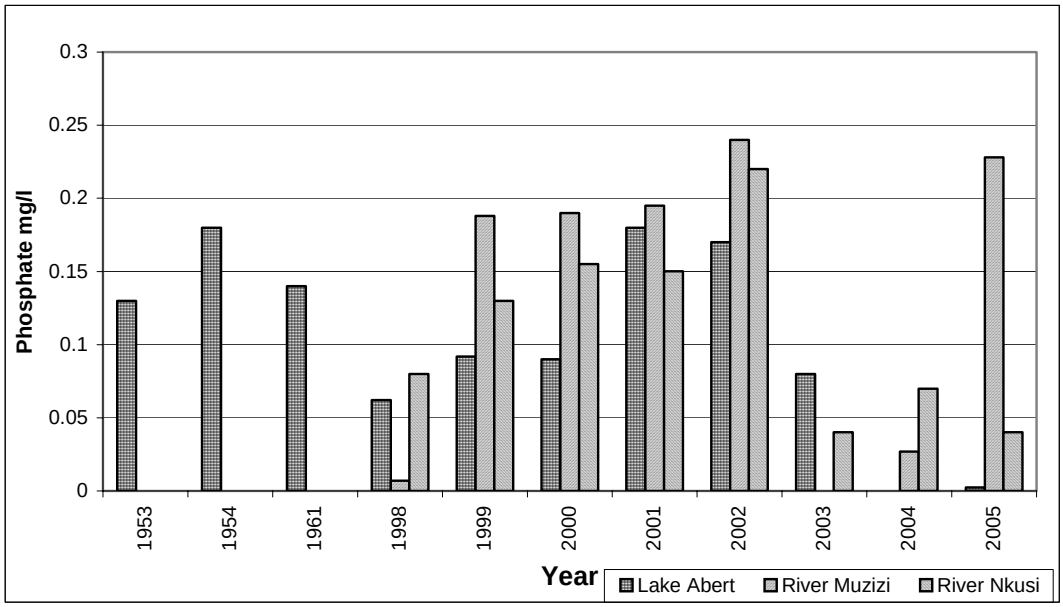


Figure 4-14 A comparison of phosphate (PO_4^{2-}) levels of Lake Albert and its inflows between 1953 and 2005.

Microbiological parameters

Surface water was contaminated with faecal coliform bacteria as shown in Table 4.4. The World Health Organization (1998) Guidelines and Uganda National Standards for Drinking water recommend nil coliform bacteria per 100ml. Both river and lake waters should not be used as a direct source of drinking water, before disinfection. The faecal contamination of surface water accounts for the prevalence of water born

diseases in the catchment such as cholera. At the time of the visit 6 people had died of cholera and 40 had been hospitalised at Butiaba fish landing site. Butiaba had been under a cholera quarantine which was lifted a week prior to this reconnaissance visit.

Table 4-4 Faecal contamination in rivers of Lake Albert's catchment in August 2005.

Sampling Site No.	Source	No. of faecal coliform bacteria per 100ml
1	River Musizi	80
8	River Kasukwa	128
6	River Waaki	160

Phytoplankton, zooplankton, secchi depth[7] and chlorophyll "a"

The results of the phytoplankton sampling show low genera and species diversity (Table 4.3). However, the species are comparable to those found by DWD (1998). Lake Albert is having an emerging dominance of blue-green algae, an indicator of eutrophication. This is further confirmed by a low secchi depth of 2.74m which falls within the eutrophic status of lakes. The zooplankton community is impoverished, with low numbers in terms of genera, species and individuals. Most of the zooplankton is composed of detritus filter feeders such as *Ankisfrodesmas falcatus, Agmerellum glauca and Ankisfrodermas convolutes* (see Table 4.4). Chlorophyll "a"[8] a long the vertical profile of the lake is low (0.1 mg/l) (Table 4.5). The low levels zooplankton can be attributed to the fact that at the time of sampling there were no algal blooms, the main source of food. The photosynthetic zone of the lake stops at a depth of 5m because at this depth there was no algae hence no chlorophyll 'a' which further confirmed by the absence of zooplankton which are grazers at this depth (Table 4.5 & 4.6).

[7] Secchi depth: is the distance at which a secchi disc disappears in water. It is directly proportional to light penetration in a water body.
[8] Chlorophyll 'a': is directly proportional to the amount of algae in a fresh water body. It is a direct measure of the tropic status of aquatic ecosystems.

Table 4-5 Phytoplankton analysis of Lake Albert water sample vertical transect taken at Butiaba Station 10 in August 2005.

Phytoplankton Species	Group*	Species No. per 10ml of sample					
		Surface (0m)	1m	2m	3m	4m	5m
Ankisfrodesmas falcatus	G	6	8	1	0	0	0
Ankisfrodermas convolutes	G	2	1	0	1	1	0
Agmerellum glauca	BG	3	3	1	1	0	0
Anabaena spiroides	BG	7	2			1	0
Arabaena flos-aqiae	BG	3	0	0	1	0	0
Navicula lanceolata	D	0	0	0	0	0	0
Gomphosphaeria aponia	BG	2	0	0	0	0	0
Staurastrum paracoxum	G	0	1	1	0	0	0
Sceretesmas dimorphus	G	0	3	2	1	0	0
Asterionella formosa	BG	2	1	2	0	1	0
Asterionella formosa	D	0	0			0	3
Synedra capitata	D	0	0	0	2		1

Key: Group* BG Blue Green algae, G Green algae, D Diatom.

Table 4-6 Zooplankton analysis of Lake Albert water sample vertical transect taken at Butiaba Station 10 in August 2005.

Zooplankton genera species	Species No. per 10ml of sample					
	Surface (0m)	1m	2m	3m	4m	5m
Copepoda, Calanoids	1	1	0	0	0	0
Copepoda, Cyclopoids	0	2	1	0	0	0
Copepoda, Happacticoids	1	0	0	0	0	0
Cladocera, Daphnia	1	1	1	0	0	0
Cladocera, Bosmina	0	1	0	0	0	0
Cladocera, Chydoris	0	2	0	0	0	0
Ostracoda	0	0	0	0	0	0

Table 4-7 Vertical profile of Chlorophyll "a" at at Butiaba Station 10 Lake Albert, August 2005.

Sample	Surface (0m)	1m	2m	3m	4m	5m
Chlorophyll-a µg/l	0.10	0.11	0.08	0.02	0.01	0.00

Conclusion

Lake Albert and its river inflows differ markedly in the concentration of their major ions. The electrical conductivity of Lake Albert is higher than its inflow rivers by a factor of 7. Hence the lake is classified as moderately saline and alkaline, with moderate hardness. The combined effect of low concentration of the major ions i.e. Na^+, K^+, Ca^{2+}, Mg^{2+}, HCO_3^-, SO_4^{2-} and Cl^-, low alkalinity and the absence or

negligible carbonate in the rivers makes them to be classified as dilute fresh water. The difference between the chemical constitute of Lake Albert and its inflows is attributed to the difference in the geology of the parent rocks they drain. While the rivers have a catchment of the highly leached ferretalic soils, the lake is surrounded by mineral rich volcanic soils of the rift valley. Furthermore, the lake has limited outflow (internal drainage) and evaporation far supersedes inflow leading to salt accumulation (Talling and Talling, 1965; Matagi, 2002).

Pristine aquatic environments are known to have BOD and COD below 2mg/l and 20mg/l respectively. Both lake and river waters exceed these limits. The rivers are getting considerable organic pollution from surface runoff, while the lake is having organic accumulation, an indication of eutrophication. TSS is high in both river and lake waters. In the case of rivers this is an indication of deforestation, poor methods of cultivation and siltation, while in the lake it is due to algae, an indirect indicator of eutrophication.

Nitrate (NO_3^-) and phosphate (PO_4^{2-}), the major algal macronutrients, are low in both river and lake waters. Sulphate (SO_4^{2-}) is negligible or absent in the rivers. The low levels of nutrients in the lake may be attributed to the rapid uptake by algae.

The composition of the phytoplankton community confirms an emerging dominance of blue-green algae, an empirical evidence of eutrophication.

Both river and lake waters are contaminated by faecal coliforms, an indication of poor sanitary facilities and open defecation. This explains the prevalence of water borne diseases in the catchment, particularly cholera which is endemic at the lake shore. At the time of the survey, Butiaba was just recovering from a cholera outbreak, six people had died while 40 people had been hospitalised.

Lake Albert has been monitored since 1922 (Beadle, 1932). However, the monitoring has been intermittent and most results are scantly in literature (Talling and Talling, 1965). Furthermore, over the years liminological methods have changed and accuracy in the measurement of parameters have changed making comparison difficult. Therefore this has made comparison of the present and past trends difficult. However, despite disparity in the data collected over the years, comparison show that there has been increase of TSS, BOD, COD and change in phytoplankton composition in Lake Albert, all leading to eutrophication.

Pollution hotspots have been identified, the most localised ones are Kinyara Sugar Works and its extensive sugar plantation and out growers and tobacco growing. Although the sugar factory effluents meet national standards for discharging into the receiving environment, there is an obnoxious smell long the river where it discharges its effluents. This irritates residents. The factory should spend time and resources to solve this problem. They should invest in waste stabilisation ponds or constructed wetlands. Tobacco nurseries are located at the river banks, this has led to soil erosion, siltation, runoff that has fertilizers and pesticides. Further, studies are needed on these two commercial activities in order to quantify their impacts. In this survey River Waaki was the most polluted because most of these activities are concentrated in its catchment.

The quality of river water is suitable as a source of drinking water and irrigation. But it needs treatment (coagulation, flocculation, filtration and disinfection) before it meets WHO and National Standards for drinking water. For irrigation the sodium content is low and will not cause salination. Both lake water and ground water are not suitable for irrigation because of their high salt content, which would cause salination.

5 SOCIO-ECONOMIC ANALYSIS

5.1 Economic activities

5.1.1 Agriculture

Crop farming is the main economic activity in the catchment area that supports 75% of the population. It is characterised by subsistence farming with women providing the biggest agricultural labour force, smallholder out-growing, and plantation. The region enjoys favourable climate conditions and fertile soils that make it possible to grow a variety of food and cash crops.

The main food crops grown include: maize, cassava, bananas, sweet potatoes, beans, vegetables, millet, sorghum, simsim, groundnuts, Irish potatoes, soybean, and upland rice, beans, groundnuts, and fruits. These are grown for home consumption and for commercial purposes. The cash crops are sugar cane, tobacco, Distillation bananas, coffee, cotton, tea and cocoa.

The region receives a bi-modal type of rainfall with peak period of March to May and September to mid November that is favourable weather condition for crop production. However, crop production is well short of its potential because of the following: Banana wilt disease (panama wilt), coffee wilt disease, soft rot of Irish potatoes, fungal injection of citrus, high costs of inputs, limited access to agricultural credit, inadequate extension services, poor management practices and lack of an organised marketing system.

However, there is an enabling environment for agriculture in the region due to the strength of government policies that focus on poverty eradication, government's allocation of funds to PPAs among which agriculture is part. The existence of donor support to agriculture by IFAD/BSF, Irish Aid, Collaboration with NGOs and CBOs working in the region, presence of investors and development partners like Rwenzori Highland Tea Company, Tobacco Companies, Kinyara Sugar Works and the presence of technical staff at sub county level.

5.1.2 Livestock keeping

Livestock keeping and rearing is common along the river and lakeshores where there is high carrying capacity. The rivers and the lake are the main drinking points for the animals. Buliisa sub-county in Masindi is the major cattle keeping area while in Hoima district cattle reared in a traditional nomadic way. In Kibaale, very few cattle are kept. The main types of cattle kept are sanga (Ankole and Zebu). Other animals reared are goats, sheep, pigs and chicken. Grazing of animals is done communally on the savannah woodlands, and forested areas during dry seasons.

The livestock sector is faced by the following problems: epidemics like CBPP, foot and mouth diseases, inadequate water supply, poor pasture and rangeland management, low animal genetic performance and poor livestock market facilities. Tsetse flies used to be a big problem in Hoima, and Masindi before the herdsmen

started using pesticides that kill both ticks and tsetse. In Kibaale district however, there are few cattle kept due to tsetse flies infestation. Goats have been preferred by majority of the people because they are resistant to tsetse flies.

The veterinary sector in the districts is faced with the following problems: Inadequate staff in the department, inadequate and irregular release of vaccines, low yields per livestock unit, lack of transport to enforce veterinary rules and regulations.

5.1.3 Saw milling and pit sawing

Saw milling and pit sawing is one of the biggest and most profitable economic activities around most of the forests. It takes place within and outside gazetted forests. Many people (mainly men) are employed in these activities. The high demand for hard wood timber encourages illegal timber harvesting and trade.

Timber harvesting has had significant negative impact on biodiversity. It disturbs the ecosystem and habitats for animals like chimpanzees and birds, decrease the coverage of valuable timber species and destroys trees and undergrowth due to the falling trees. Some of the methods of harvesting are not efficient and material is wasted, such as power saws, though they are still the preferred methods.

5.1.4 Fishing

Fishing is one of the main economic activities in the lakeshores of Hoima, Masindi and Kibaale districts. The sector provides employment, income to those engaged in the fishing process, distribution and marketing. It is also a source of protein for many families within and other districts in the country.

Masindi district is popular for the production of salty delicious fish in Uganda that is caught in Lake Albert. The fish types that are caught include Tilapia, Nile perch, Nganya, Semutundu, Malapterurus electricus and cat fish. Gillnets are the most common type of fish gears used by fishermen and the mostly used gear size is 3.5 and 5 inches. Fishing boat types that are commonly used are the “Barike” and “Kabalega”. Salting is the most common method of processing of fish in the area, followed by smoking.

The main fishing villages on Lake Albert are; Butiaba, Walukuba, Bugoigo Karakaba, Kabolwa, Wanseko and Kalolo. Minor fishing villages include Nyamukuta, Bisoma and Kamagongolo.

The local traders and the truck traders carry out fish trading at the lakeshores. The local traders supply major markets and the surrounding rural areas. While the later supply fish to processing factories for export to outside countries and production of fishmeal for poultry respectively.

However, the fishing activity has resulted in environmental sanitation problems on the landing sites and exerted pressure on the fragile ecosystem on lakeshores and in the

rift valley. This therefore, requires constant and instant attention to ensure sustainable harnessing of fish resources and satisfactory human habitation.

5.1.5 Institution management of the fishery

At the lake there are three beach management units (BMUs) that have been formed on Butiaba, Bugoigo and Wanseko landing sites. These are legal fisher community institutions that are meant to co-manage the fisheries resources with government. They collect revenue on behalf of the government, ensure use of appropriate fishing methods, sanitation at landing sites, settling dispute, register boats, nets and new entrants, ensure security, prohibit fishing of juvenile fish and issue fish movement permits.

The fishery management is faced with the problems of inadequate staff, lack of financial and material support, lack of legal backing from the government, which is an important tool in enforcement processes. This makes it hard to solve boarder related cases especially those concerning fishing grounds and theft of gear, which is very common on the lake.

5.1.6 Distillation

Distillation of waragi is a major income generating activity for the locals in the area. Distillation is commonly done along the river and the wastes are disposed off into the water. The raw materials used for making waragi are banana, molasses, maize and cassava. Originally banana was the main raw material but due to the banana wilt, molasses are commonly used. Kibaale district supplies the greatest quantity in the region. Trucks pick up the distilled waragi from the trading centres.

5.2 The culture and social organization of the Banyoro

People of different ethnic origins who follow varied traditions; culture and religion inhabit the region. The three districts of Hoima, Masindi and Kibaale are closely linked to the history and culture of the Banyoro tribe's people in Uganda. The Banyoro/ Bagungu are the dominant tribe and they belong to the Kinyoro cultural group that has a very organized cultural system. However, as a result of interaction with immigrants, Europeans and Asians, the traditional cultural values have been changing. This coupled with the abolition of kingdoms in the 1960s led to the fall in cultural attachment and exposure to alien cultural influence. In the eastern part of the catchment area, the following cultural sites exist:

i. Historical sites at Lukungu, Baker's view, and Mwenda
ii. Royal tombs spread in the districts of Kibaale and Hoima
iii. Principle Pleistocene fossil localities at Kaiso on the shore of Lake Albert
iv. Stone age sites near Hoima town, Kagadi, Ibaje, and Paraa Pits
v. Forts: Fort de Winton, Roddy, Briggs, and Grant in Kibaale District; Lugard, Kaduna, and Baramwa in Kiboga District;

Kitanwa and Kibiro in Hoima District, Londu, Kisuga, Miruli and Masindi Forts in Masindi District.

5.3 Demography

The three districts of Hoima, Masindi, Kibaale have a total population of 1,232,422. The population in the area consisted of a heterogeneous ethnicity, comprising Banyoro/Bagungu as the dominant tribe, Alur, Bakiga, Lugbara, Acholi and Buruli. The immigrants include the Congolese, Rwandese, Sudanese and Kenyans.

The majority of these people's livelihood is dependant on natural resource like fisheries, forestry, agricultural resources and their activities have greatly affected the water quality of the lake. There is increasing population in the region due to resettlement of people from densely populated districts by government resettlement schemes, high fertility rates, employment opportunities on tea estates, sugar plantations, and civil strife within and outside the country, especially the Democratic Republic of Congo and the Sudan. The main demographic indicators are indicated in the Table 5.1.

Table 5.1 Main Demographic indicators of the region

Deomographic indicators	**Masindi**	**Hoima**	**Kibaale**
Population density	56	97	93.7
Population growth rate	4.9%	4.7%	5.2%
Urban growth rate	6%		
Population urban	6.2%	9.2%	1.2%
Household size	4.7	5	4.8
Sex ratio	100	102	97

Source: Uganda Bureau of Statistics, 2002 Uganda population census

Table 5.1 shows that there is a high population growth rate in all the three districts, with Kibaale district having the highest growth of 5.2%. Hoima and Kibaale have high population densities of 97 and 93.7 respectively. The mean household sizes of Masindi, Hoima and Kibaale by 2002 were 4.7, 5 and 4.8 respectively. Masindi had a larger household size compared to the national one of 4.7. The sex ratio of the region was relatively higher than the national average of 96. Only 1.2% of Kibaale's population was urban. This indicates that much of the population lives close to nature and they depend on it for their livelihood. Therefore the rate of degradation is high in Kibaale district.

5.4 Poverty

Poverty is defined as lack of basic needs and services such as food, clothing, beddings, shelter, paraffin, basic health care, roads, markets, education, information and communication. In addition the lack of opportunities for survival and employment, and having limited or no productive assets such as farm tools and land. According to MDED (2005), poverty has many dimensions including low and vulnerable levels of

income and consumption, physical insecurity, poor health, low levels of education, unemployment and isolation.

According to UNEP (1999), poverty has been and remains a major cause and consequence of the environmental degradation and resource depletion. The poor are both agents and victims of environmental degradation. They entirely depend on the environment resources for the satisfaction of their basic needs. For instance the poor may stick to fragile soils in lakeshore areas or to extract fuel wood from the forests.

It is further evident, that degrading the environment hurts the poor class. This is particularly so in such societies where people are most dependent on common property like lake fisheries, common grazing land, forest reserves and so on.

The linkages between poverty and the environment are complex. It is generally known that poor people have a tendency of over-using resources like land, forests and water thereby degrading them. It is even said that poverty is the greatest polluter.

In the catchment area however, the major causes of poverty in the household include lack of productive assets like land and cattle, death of a family bread winner, high expenditure on human, crop and animal diseases matched with low incomes, high education expenses, sale of household assets in times of distress, lack of markets for agricultural produce, ill health especially malaria, Acute Respiratory Infection and HIV/AIDS, lack of education and vocational skills. In addition, a poor family background whereby one is unable to inherit property, negative attitudes to manual work, poor time management and planning, ignorance and lack of cooperation.

The major effects of poverty have been household food insecurity, inability to meet basic needs, sale of assets, intermittent borrowing sometimes without repaying, alcoholism, inability to pay tax and death. Poor crop yield as a result of crop diseases, which have attacked both coffee and banana, and degraded soils has made the people in the catchment area to search for alternative source of livelihood to make up for the shortfall. For instance in Masindi district there is virtually no alternative income generating opportunities for people living near the forest reserves. Therefore these people are forced to carry out illegal felling of trees, burning of charcoal and brick making for a livelihood.

The main source of fuel for lighting and cooking is firewood. The use of the traditional three-stone fireplace for cooking is common throughout the region. This cooking method consumes a lot of fuel wood thus the high demand for wood.

5.4.1 Poverty Indicators

Despite the general growth of the Country's economy at GDP rate of 6%, controlled inflation and Government and Donor interventions in form of infrastructure investments, a large percentage of population lives below the poverty line as shown by the human development indices below:

Table 5.2 The human development indices of Hoima and Kibaale

Indices	Hoima	Kibaale	Uganda
Child mortality rate		205/1,000	203/1,000
Infant mortality rate	120/1,000 live births	122/1,000 live births	97/1,000 live births
Maternal mortality rate	520/100,000	550/100,000	500/100,000
Safe water coverage	65%	69%	56%
Safe and adequate latrine coverage	54%	54%	55.7%
% population within 5 km. walking distance from a health facility		60%	52%
HIV/AIDS prevalence		6.4%	6.2%

Source: *Kibaale, DDHS' office and Hoima DDP2005-2008*

5.4.2 Poverty and vulnerability

The main causes of poverty in the recent past have been crop pests, diseases and vermin, high morbidity and mortality among others. The majority of the poor people are generally located in the rural communities, particularly along lakeshore villages while women and children are the most vulnerable across the whole region. Below is the sector poverty analysis by underlying causes, effects and strategies to improve the present situation.

No.	Poverty Indicators Health and Nutrition	Underlying Causes	Effects	Strategies
1	High mobility	Increased incidence of epidemic. Inadequate knowledge about preventive measures. Poor hygiene and sanitation. Low incomes. Inadequate of health facilities.	Reduced labour force. Increased mortality. Reduced household income.	Disease control/prevention messages. Sensitization of communities about proper hygiene. Construction of health units and procurement of drugs. Home improvement campaigns.
2	Stunted ness	Inadequate food quality and quantity. Unbalanced diet. Poor childcare. Inadequate knowledge about nutrition requirement.	Poor academic performance.	Improve food production of animal protein. Provision of agricultural extension services. Educate communities on causes, signs, effects and prevention of malnutrition. Promote integrated childcare practices. Improve access to health services and management of early childhood illnesses.
3	High infant and child mortality	Poor pre-natal care. Lack of proper management of early childhood illnesses. Poor sanitation.	Reduced population. Increased deaths among children. Increased fertility	Training of medical personnel in proper management of infant and early childhood illnesses. Immunization campaigns. Promotion of Primary Health Care.

No.	Poverty Indicators Health and Nutrition	Underlying Causes	Effects	Strategies
		Exposure to accidents. Lack of parental care. Poor feeding practices.	rates.	Sanitization of parents about parental care. Introduction of drug distributors e.g. HOMAPAK to increase accessibility to drugs.
4	High maternal mortality	Lack of antenatal and postnatal care. Lack of skills among medical personnel. Deliveries without trained personnel. Early and late (above 35years) pregnancies.	Increased number of orphans. Reduced productivity. Reduced population. Increased cases of polygamy.	Training TBAs and equipping them with necessary materials. Staffing and equipping health units. Training medical personnel. Encourage girl child education through advocacy and sensitization. Sensitization of both mothers and fathers about antenatal and postnatal care.
5	Low doctor-patient ratio	Inadequate number of qualified doctors. High disease burden. Lack of equipment in available health centres.	Increased morbidity and mortality. Reduced productivity. Increased expenditure on better medical treatment. Lack of enough drugs.	Recruitment and deployment of qualified doctors. Elevate more health centres to health centre IV rural areas.

No	Education	Underlying Causes	Effects	Strategies
1	High drop-out rate	Early pregnancies. Low household income. Low morale among pupils and parents in school affairs. Long distance to schools. Poor infrastructure at schools. Poor performance. Need for child labour to participate in domestic work. High education costs. Irregular attendance.	Low levels of literacy among the youth. Unemployment. Increased immorality. Early marriages and their related complications. Increased child abuse.	Enforcement of defilement laws. Establishment of more schools in isolated areas. Promotion of adolescent reproduction health education. Encourage teacher-parent relationship through PTA/school management committees. Increasing household income through IGAs. Sensitization of the community on children's rights. Improvement of school infrastructure.
2	High pupil-text book ratio	Few textbooks. Big number of pupils especially in U.P.E programme. Inadequate facilitation from the government. Mismanagement of the available textbooks.	Poor academic performance. Drop- out from school.	Free supply of textbooks by the government. Proper management and maximum utilization of the available textbook.
3	Low literacy levels among males and females.	Boys' education preference. Participation of girls in domestic work. Low decision making	Economic dependence among women. Increased early marriages.	Increase women's participation and performance at all levels of education. Adaptation of laws regarding matrimonial rights.

No	Education	Underlying Causes	Effects	Strategies
		among girls. Lack of knowledge on women's rights. Historical factors like lost counties.	Women's health is put at risk in this era of AIDS. Social discrimination and exclusion. Women's health is affected by their workload. Inferior access to services due to low incomes. Unemployment levels are increased. Low adaptability to modern practices thus retarding development.	Promoting female enrolment at all levels of education. Sensitization of communities about women's rights. Intensifying F.A.L. Introduction of labour saving technologies in order to reduce the workload women are subjected to.

No.	Water and sanitation	Underlying Causes	Effects	Strategies
1	Inaccessibility to safe and clean water	Geological setup. Inadequate funding. Negative attitudes among the community. Low levels income. Long distance travelled to protected water sources. Poor maintenance and management of water sources. Vandalisation of water sources.	Water-borne diseases. Time wasting and long ques in search for and at safe water sources. Inadequate water supply.	Having functional water user committees. Home hygiene education campaigns through radio messages. Having appropriate determination of location of new communal water points. Establishment of communal water tanks for places with no natural water sources.
2	Poor latrine coverage	Negative attitudes. Poor landscape/terrain. Ignorance. Poor leadership. Limited extension services.	Increased incidence of diseases like diarrhoea, cholera and dysentery. Poor health and hygiene. Poor household sanitation.	Sensitization of communities about the importance of proper disposal of solid wastes. Increased facilitation of extension workers.

No.	Agricultural Development	Underlying Causes	Effects	Strategies
1	Poor and low yields	Poor methods of farming. Poor supply of agricultural inputs and equipments. Poor adaptability to modern agricultural practices by peasants. Pests, diseases and parasites. Changes in seasons.	Reduced incomes. Reduced produce. Hunger. Fluctuating/low prices.	Distribution of agricultural inputs. Seminars and exposure visits should be carried out. Enhancement of modern agricultural practices. Continued NAADS services. Changing the Land Act of 1998.

No.	Agricultural Development	Underlying Causes	Effects	Strategies
		Land conflicts. Ignorance on the proportionate usage of agricultural inputs. Inadequate extension service. Poor land ownership resulting into limited land and insecurity.		
2	Limited markets	Production on small scale. Low produce that is insufficient for both consumption and sale. Lack of crop diversity by households. Seasonal markets.	Moving long distances to access markets. High prices for the produce and exploitation of buyers. Low levels of household income.	Avail more markets in sub counties. More frequent operation of markets. Efficient methods of delivery and provision of services to communities.

No.	Employment	Underlying Causes	Effects	Strategies
1	High dependence ratio	High percentage of population in the economically unproductive age group. Scarcity of jobs. Poor education system. Population that is vulnerable to diseases. Early retirement age. Lack of artisan skills. High levels of fertility.	Low investments and savings at household level. Neglect of responsibility. Increased crime and other illegal activities. Low income levels.	Establishment of Income Generating Activities. Change of the education system to a more practical one through establishment of technical institutions. Encourage both informal and formal social security systems. Encouraging family planning practices through sensitization. Distribution of contraceptives.

5.5 Land Tenure

Land tenure refers to the way in which land is owned, occupied, used and disposed of within a community. For sustainable development to be achieved, a well-defined land tenure system is very important. There are four types of land tenure systems in the region: customary, mailo, leasehold and freehold.

5.5.1 Customary tenure

Customary tenure is the most common type of land tenure system and it is found both on mailo and public land. Customary system is well established and understood and the majority of the people affected are not subjected to annual payments of ground rent. The right of land under customary tenure is regulated by the local customs. The main disadvantage with it is that no records are kept, often making it difficult to resolve land use conflicts. In this system of land ownership, land fragmentation is very common as land is passed on to the next generation. It also discourages investment in

the land, land cannot be used as collateral security for credit facilities, there is soil degeneration as the population increases on the land and yields are generally low.

5.5.2 Mailo Tenure

Mailo Tenure was introduced as result of the 1900 Buganda Agreement, under this agreement; land was divided between the Kabaka of Buganda, other notables and the Protectorate Government. The basic unit for the sub division was a square mile. Originally there was private and official mailo. The later was transformed into public land in 1967 whereby land is held in perpetuity and a certificate of title is issued. This minimizes on land conflicts and encourages investment in the land.

In this tenure system, landlords oversee proper land management practices by tenants over large blocks of land. However, in practice and reality, the system has encouraged the existence of absentee landlords whose interest is focused on rental income to the detriment of appropriate land management. The actual users of the land, the tenants, do not have sufficient security to encourage investment. For instance, much of the mailo land in Kibaale is under utilized.

5.5.3 Leasehold.

Leasehold tenure system is whereby land is held based on an agreement between the lesser and the lessee. There are two types of leasehold arrangements: private leases given to individual landlords and official or statutory leases given to individuals and/or corporate groups under public act terms. The advantage with this system is that the leaser can attach conditions to the leases and has the right to revoke ownership in case of abuse. For example government can specify how a given landholding could be developed and to attach specific user or environmental conditions to the lease. In Uganda, however, environmental conditions have rarely been attached to leases and have contributed to urban decay and corruption.

5.5.4 Freehold

After the crown Land Ordinance of 1903, the Protectorate Government granted land to some special interest groups such as the protestant and catholic churches to cater for both their religious and commercial needs. For example land was granted to the church at Bukumi, Karugunzi, Bwikara and Kagadi. Under freehold tenure, a certificate of title is issued and the interest in land also goes on in perpetuity just like is the case with mailo land. The title can act as an asset to offer for collateral security for credit facilities. The main disadvantages are that transfers of sub-divided holdings have led to excessive fragmentation extensive soil degradation in the areas where population densities are high.

6 STAKEHOLDERS VIEWS

6.1 Institution

The Consultants visited Nyabyeya Forest College located in Budongo Forest in Masindi district and had a discussion with the Deputy Principle. The environment and natural resources found in the area are vegetation cover that includes central and public reserves and wildlife. In the protected areas man is seriously encroaching through felling of trees, cultivation and expansion of farmlands.

The magnitude of the above activities cannot be easily established unless remote sensing is carried out. But the majority of the people are small-scale farmers so the effect is wide spread. During rainy season most of the rain water is brown. Siltation is very evident. Erosion at the school is checked by sacks filled with soil and placed in galley erosion paths. A lot of silt is always removed after the rain. Soil erosion is as a result of cultivation on slopes whereby poor farming methods like harrowing and planting crops in lines instead of following contours is being practiced.

The buffer zone should be 100 meters but people want to settle 60-70 meters away from the forests. The riverine forest that used to be 100 meters away from the river are disappearing. Expansion of the sugarcane and tobacco growing has forced people to encroach on the riverine vegetation. Trees have been burnt and the land was converted to agriculture. An Indian investor is using the local community to cut trees by giving them an incentive to cultivate free of charge provided the land reverts back to him, hence encouraging shift cultivation.

Some of the stakeholders reported to be involved in forest management include: Central Government, Masindi District Local Government Councils, Secretary Production and Environment, Nyabyeya Forest College, Budongo Forest Community Organization (BUFOCO) Budongo Forest Project, Budongo Eco tourism Development Project, Wildlife Authority, Kinyara Sugar Estate, Kinyara Sugarcane out growers and Lake Albert Catchment Initiative Project.

The Deputy Principle was asked to give suggestions on how to manage the catchment area, he suggested that:

- All user groups (Cultivators, brick makers, livestock, lumbering community, Administrators, and Local Government departments) should be invited by the project for a meeting to seek their opinions on how they would want to utilize the resources in a sustainable manner.
- Most of the ideas should come from the local community so that they feel a sense of ownership.
- People should be educated about the effects of environmental deterioration. Human beings are interdependent in a number of ways and therefore they should work together and live in harmony with the environment.
- The local community should be sensitized on good farming methods like fallowing, growing cover crops, control of bush burning, encourage few animals, use improved seed, crops and livestock.

However he mentioned that the Project should have answers of how they will be successful since other initiatives have failed.

Nyabyeya College pledged to get involved in the Lake Albert Catchment Initiative Project by providing infrastructure and human resource, the pilot scheme areas of the college would be used for demonstrations and the college could help document the experiences obtained from the workshop and demonstrations.

6.2 Fishing folk

The Consultants met with two groups of the fishing community at Butiaba on Lake Albert in Masindi district. These groups were the Male and Female fishing community. The main economic activities of the male respondents were fishing, arranging the nets, loading and unloading fish and raring animals. While the female were engaged in trading in mukene fish species that is taken to Kampala, Distillation a potent spirit waragi (*bungu*), selling cooked food in kiosks, making porridge that is used as a bait for fish, cleaning and processing fish. Fish species that are commonly caught include *Angara*, Tilapia, Nile Parch, Yellow fish, Cat fish, Electric fish, *Mukene, Egasia, Enkeje.*

Human Activities Impact on Environment

The respondents mentioned the following human activities as impacting on the environment, which in turn affects the water quality. Communities living at the lakeshores use the lake as their main dumping ground for all the waste. These wastes include; residue from waragi distillate, fish offal's, human faeces and used condoms. The lodges at the lakeshores lack disposal containers for used condoms and they are usually seen floating in the lake. All these have resulted to frequent prevalence of diseases like cholera (which killed about 6 people and a total of 40 cases were discharged from Butiaba Hospital in the month of August).

Latrine construction is a very big problem due to poor soils around the lake shores. Latrines have been constructed very close to the water shores. The few pit latrines that are constructed still get filled very fast due to the big numbers that use them. Another big problem mentioned was that some tribes do not want to use even the existing few, they would rather use the bush. Congolese settlers were identified as the main group with very poor hygienic practices.

Another human activity impacting on the water quality is the fishing methods that necessitate fishermen spending two to four weeks in the lake fishing. During this period, all the wastes are deposited into the water thus polluting the lake. Congolese fishermen were mentioned as the lead group in this type of fishing.

A lot of cow dug is deposited at the lakeshores as pastoralists take their animals to the lake to drink especially during the dry season. In the process lake water gets contaminated.

Factories such as Kinyara Sugar Works in Masindi, Bugambe and Bujumbura ginneries in Hoima dispose off their wastewater into the river tributaries that fed the main rivers that end up in the lake.

Packaged Waragi is commonly drunk among the fishermen who disposal of the polythene in the lake as they fish. Also polythene (kavera) used as the main packaging materials are disposed off in the lake the polythene is literally seen floating on lake.

Respondents also mentioned that Petroleum oil found at Kibero on the lakeshores sips out during high temperature. Fish that is caught around that area spends only one hour before it gets rotten.

The fishermen use salt for preserving fish while fishing and the remaining salty water waste is poured into the lake.

Effectiveness of the laws in environmental conservation

The fishing community said that the patrol police, the LCs and BMU are agents of implementing the laws. However, there is only one boat for effective monitoring of the lake. Sometimes they lack fuel for running the boat. Most of the fishermen are from Congo, which makes it difficult to enforce the laws. The respondents however suggested that for effective enforcement of the law, all the enforcing bodies should work together and massive sensitization of the local community.

Level of awareness of the project

The fishing community was asked if they had never heard about the Lake Albert Catchment Initiative Project, all of them said no. However, there have been other projects on conservation in the area. These include the Fisheries Resources Department who have developed the Beach Management Unit (BMU). BMU has a team composed of fifteen members and their roles are to conserve fish, prevent poor fishing methods, collect revenue, register fishermen and boats at the landing site and to improve sanitation.

How community would want the project to help them

This community suggested the following ways in which the project would help them:

The project should sensitize and educate the local community of how water gets contaminated and who is responsible for this. This will help check on the level of ignorance of the majority of the people.

The project should construct public latrine in the landing sites, which people could pay for so that they are well maintained. Eco san type of latrines would be preferred.

Provision of other sources of safe water like piped water or gravity flow water because currently the lake is the main source of water.

The project should involve them in micro projects, which have favourable payback period not weekly as it is currently being done.

The community should be provided with water purifying tablets (pure supplied by PSI Uganda).

6.3 Agricultural community

This community was met at Bombo trading center in Kigorobya Sub County in Hoima district. The main economic activities of this community were cultivation of maize, beans, cassava, upland rice, distillation of Waragi, brick making and trading in consumer goods and clothing. Cultivation is done on subsistence bases and for commercial purposes.

The respondents mentioned the following activities as those that impact on the environment, which in turn affects the water quality:

Fishing activity together with the settlement along the lakeshores has affected the environment along the lake and the water quality. Cutting of trees for drying fish is a common practice in those areas. The fishing community lack toilets facilities and defecate in the open that eventually end up being washed into the lake. Also fish wastes are thrown into the lake due lack of proper disposal areas. This community has often suffered from diseases like cholera, typhoid and dysentery, which are as a result of using contaminated water.

Cultivation along the rivers banks has resulted to a lot of soil being eroded along the steep slopes of the river. On the slopes, farmers dig the land from down hill to up hill, which forms trenches through which water can easily flow. As the water flows through these trenches, soils are washed down into the river resulting to siltation of streams and rivers.

Distillation of waragi is a major income generating activity in the area. Distillation is commonly done along rivers and the wastes are leased into the river water.

Livestock keeping along catchment area heavily depends on rivers and lake as the main source of water for the animals. Animal deposit cow dug into the river as animals drink, soils are loosen during animal movement and are washed and blown into the river thus polluting the water. Also due to over stocking, over grazing is common along the river line which leaves the soils bear and are easily washed away. This is common among the Bahima who have large herds of cattle along the rift valley slopes.

Most of the cattle deeps are located along the rivers. The wastewater from these deeps is usually emptied into the river. Pesticide used for the control of pests by the pastoralists, ends up being washed by rain into the rivers.

Effectiveness of the laws in environmental conservation

The agricultural community said that they just hear about the laws on radio. These laws are not effectively followed.

"Government is very ineffective in enforcing the laws. It is the very government officials who are involved in the cutting down of trees. These officers buy power saws and cut down trees in the reserve."

"Since the law enforcers are involved in the cutting down of trees, the locals are not just watching the forests get finished, they are involved in the stealing."

"If one cannot fight the officers, then join them in the cutting."
(Agricultural community Hoima district)

Asked how the laws could be effectively enforced this community suggested that, power of control of the forest should be given to the local community. This in a way would make them own the forests and guard them jealously. They further contended that the forest resources are being allocated to well off people who come from Kampala. This act makes the local community feel cheated since they are within the forests reserves and are not rich enough.

How community would want to be involved in the project

The agriculture community suggested the following ways in which they would get involved in the project:

They mentioned that the project should first sensitize the local people of its main objectives and what it expected of them in the implementation. Thereafter, the community can make informed decisions on what they expect to benefit.

The project should involve them in the planting of trees along the river. This will have a direct benefit to the individuals along the rivers and an overall benefit to the catchment area.

The project should involve them in micro projects since their livelihood has been dependant on the utilization of natural resources.

They further suggested that the project should construct for them other sources of water such as boreholes, which they can have control and act as alternative source of water for their animals.

The community also suggested that the project provides them with alternative sources of fuel this would save deforestation.

6.4 Lumbering community

The lumbering community of southern Budongo in Masindi district mentioned that their main economic activities were cultivation of maize, beans, cassava, tobacco, cotton and matooke, which are grown on subsistence basis. Lumbering, trading in timber, clothing and consumer goods are other activities.

The forest provides firewood, building poles, medicinal plants, ropes, fruits and attracts rainfall. The forest reserve covers much of the land area and people are settled

in a small area. Land for cultivation is small and hilly, and the harvests are mainly consumed. Banana wilt that has resulted to poor banana yields has robbed the local community of it main source of income. The community carries out illegally lumbering in order to raise money to buy basic needs and send their children to school.

The lumbering community had doubts about the relationship between their activities and rate at which the lake water quality is deteriorating because there is no nearby stream that flows to the lake.

Effectiveness of the laws in forest conservation

The forest department is helping in the conservation of the forest. They are enforcing the laws on illegal lumbering. However, the lumbering community feels that they should also be allowed to harvest the forest since their livelihood depends on the forests. Cheaper license should be provided for the local community.

How community would want the project to help them

The community suggested that the project would help them be massive sensitization of the local community of how trees harvesting is done involve them in micro projects.

6.5 District Officials

5.5.1 Environment Officers

Environment and Natural Resources:

The following are the natural and environmental resources mentioned to be in the catchment area Lake Albert, Various types of wetlands, Riverine forests – most of which has been cleared, Salt pan, Hot springs, Vegetation – tropical high forests, Savannah scattered vegetation, Thorns and bushes, fisheries, sand stone, quarries mine granite, rocks associated with hills, land and soils, ground water

Impact of Human activities on water quality

The main human activities that were reported to be impacting on the water quality in the catchment area were:

Agriculture is the main economic activity in the region and most of the population in the catchment area depend on subsistence agriculture which involves use of poor farming methods some of which were reported to be: clearing wetlands up to the river banks hence siltation and run off, Tobacco nurseries are usually made at the valley banks and the chemicals used in tobacco farming are washed down the lake. Sugar cane plantations of Kinyara sugar works and out grower schemes use a lot of chemicals that end up being eroded into the rivers. The sugar factory also discharges its wastewater into R. Kasokwa tributary of River Waaki.

Deforestation rates are so high because of land conversion, lumbering, and charcoal burning and fuel wood. Communities use old methods of farming that is cut and burn, the ash and soils are washed down the river. Soils have are exposed and hence easy to erode. Political interference was reported as one of the problems fuelling deforestation

"We t*he technical people don't have much to say. The forest officers are working with their hands tied by MPs and big men in Kampala"* (Environment Officer)

Land tenure systems where people have their own rights and do whatever they want one can't stop them from cutting trees.

Overgrazing along rivers and lake shores was said to have left the ground bare due overstocking which causes Soil compaction and water pollution from the cow-dug.

Poor sanitation along the lakeshores was mentioned as one of the human activities affecting the environment, fishing villages do not have latrines because the soils are sandy hence construction of pit latrines is not easy. Human beings and animals depend on the lake directly yet some cultural groups do not want to use pit latrines hence the frequent out breaks of cholera. For example in Mansidi district there is 40% latrine coverage, this is even worse in Budongo which has many ethnic groups especially people from DRC.

Challenges faced by Environment Departments.

Some of the challenges faced by the District Environment Officers include; being under staffed, lack of extension staff at the sub county, non-functional District Environment Committee, lack of funds for meetings, lack of coordination among departments at the district, contradictions on reporting channels at the centre, out dated Laws and Regulations, lack of facilitation fund leading to problems being identified but left on paper. Another challenge is the implementation of the environmental laws and regulations which needs a lot of sensitization to both the law enforcers and the community. However, NEMA has trained some officials (Police) to help enforce the law of wetlands regulations.

Strategies for management of the catchment area

The environmental officers suggested the following as strategies for management of the catchment area:

i. Community involvement through participatory planning so that they own the project by setting up management plans and build up teams for those specific areas.
ii. Coordination with other departments and have clear channel that connect with the centre.
iii. There is need for information feed back especially to lower levels.
iv. Sensitization of communities in the use of forests especially the cultivation at the forests edges.
v. Encourage people at the lower levels local government sub county get LGDP funds directly, trying to encourage them to incorporate or integrate environmental issues.

vi. Encourage tree planting of even local tree spices so as to encourage existence of indigenous spices.
vii. Community resolutions integrated in the development plans.
viii. District level LGDP help in funding on some of the identified problems.
ix. Help local governments to come up with by laws which are developed by the communities.
x. Provide alternative sources of livelihood.
xi. Gazette district forest reserves.
xii. Enforce laws on the management of lakes and hilly areas.
xiii. Capacity building into already existing structures training on basics enforcement of laws.
xiv. The technical people and politicians should talk the same language.

The Establishment Water Quality Monitoring Programme.

The environment officers suggested the following should be put in consideration while establishing a water quality-monitoring programme; Washing bays are away sneer streams, valleys where tobacco nurseries are established, construction along the river (poor settlement pattern) and latrine near the rivers.

Stakeholders

Some of the stakeholders identified by the environment officers include; Central government, Local government, Local communities, NGOs such as BUCODO, Action AID, World Vision, CBOs such as VIRUDI and BUWA, Nyabyeya Forest College and Religious Organizations.

6.5.2 District Water Officers

Water resources identified by the water officers in the catchment area include:
Streams most of which are permanent, rivers Wambabya, Hoimo, Waaki, borders Masindi and Nkuse borders Kibaale, lake Albert, spring wells, boreholes, shallow wells, gravity flow schemes in Kitooba sub county Bugaya county – Kawairiri, Kabanda and Kitooba in Hoima district. In Kibaale district, rivers Nguse and Musizi, rain water, boreholes, springs, Lake Albert manmade fish ponds.

Water Quality

The water quality was said to be generally of poor quality and dependent on seasons during rainy season the water is brown due to surface run off and during the dry season its clear but livestock contaminates the water. Swamps are also believed to contaminate water with papyrus rotten debris which drains into the river making the water colour brown.

Impact of Human activities on the quality of water in the catchment

Agricultural activities like poor farming methods, farming along river banks without living some distance as required by law causes a lot of siltation, tobacco nurseries close to the streams and river banks moreover with heavy use of fertilizers like NPK were reported to have greatly impacted on the quality of water. River Waaki is fed by tributaries that flow around Kinyara sugar works factory, which is reported to have high phyio-chemical characteristics like high nitrogen, phosphates.

Persistent deforestation due high demand of land for agriculture, timber for cash and fuel wood have left most land bare hence soil erosion into the water sources. This was reported to have caused river Nkuse to dry up in January and February – this had never happened before.

Overgrazing was reported to cause surface hardening by livestock movement causing high silt courage and distillation to the water resources.

Distilling of the local gin (waragi), one of the major economic activities in the catchment using poor methods in which waste is discharged directed into the lake and rivers is one of the human activities believed to be impacting on quality of water.

The activity of washing bays within the urban areas was identified as one of the human activities that drain contaminated water to the swamps and river tributaries

Human waste disposal by cesspool emptier which dispose off waste anywhere in river forest coupled with the poor sanitation at the landing site communities have greatly contributed to the deterioration of water quality in the catchment area.

Stakeholders

The following were identified as the main stakeholders by water department officials:

- NGOs like World Vision, WWF, Action Africa Hiafe, (Kyangwali Refugee settlement, landing sites), Tugende Omumaiso Hoima Catholic Diocese, URDT (Kagadi).
- The Local Government at the districts; District water office, Environment office, District Forest Office, District Agricultural Office, District Director of Health Services, Community Development Office,
- Communities, CBOs like Village based development Initiative project, EMESCO.
- Donors IFAD, BSF, Kibaale district support Project, Irish Government Aid through Ireland Development Cooperate IDC, UNICEF.

Majority of the stakeholders are reported to be involved in provision of safe water, sanitation, bridge and culvert laying, development of low cost water points, protection of swamps, rain water harvesting and shallow well construction, protection of springs, construction of boreholes, provision of rain water catchment using water jars.

Training needs

Some of the training needs recommended by the water staff include: Water quality assessment, Chemical analysis, Hydrological surveys, policy matters, roles of different

stake holders, mobilization techniques and establish a laboratory shared by Masindi, Hoima and Kibaale.

Water quality monitoring

The water officers suggested the following considerations while setting up water quality monitoring.

i. Monitoring water quality in major rivers
ii. Monitoring protected water sources
iii. Monitoring water quantity in the major water sources
iv. Monitoring Rainfall pattern needs to be supported in terms of equipment
v. Monitor all water sources
vi. Establish check points
vii. Establish the distance
viii. Monitoring water quantity at river mouth
ix. Check parameters, NPK, Bacteria, Chemicals, pests
x. Use economically cheaper methods and avoid accidents
xi. Monitor the human activities along the water sources
xii. Monitoring operations havoc
xiii. Maintenance of water sources
xiv. Frequencies would depend on seasonal sampling

Strategies for management of water quality in the catchment area

The water officers emphasized the strategy of community participation they said:

"Do not leave the project hanging right from the inception involve the community from the beginning."(Water Officer Hoima)

"Water point drilling and developing water sources by districts, applied in Kibaale but it would belong to the district but where they were involved they have now owned the projects. Politicians are asked to commission these water sources but once it is broken then the communities say government borehole is broken" (Kibaale Water Officer)

Other strategies suggested include provision of alternative water sources for the people at the landing site like piped water, reduction of human activities along the rivers by enforcing the law, encourage use of ecosan type of latrines especially at the landing sites, train/sensitize communities on the environmental issues in general, facilitate officers to deliver their work, the need for orientation workshops for all stakeholders and appreciation/token in terms of salaries. They further suggested that riverbeds be developed into infiltration galleries then develop wells along the rivers but not directly in the rivers, train communities on improved farming methods to increase productivity thus output per unit area by use of improved seeds, minimum/zero tillage, organic farming and Agricultural officers: farmers ratio 1:1500 should be reduced.

Kinyara sugar works factory was identified as one of the major polluters, the water officers therefore suggested the factory be investigated and advised to have a reservoir.

Finally, they suggest that the project should come up with a kit package i.e. the way the project wants the information to be collected and the need for collaboration with district leadership, administrators, politicians and implementers.

6.5.3 District Planners

Economic resources found in the catchment area include:

Land resources: mainly used for Agriculture, livestock forest resources and construction. In Hoima district there are 3 agriculture zones: coffee, cotton, cassava, matooke, tobacco, rice and maize: Lake Shore zone; cotton and cassava zone – central and southern part of the district: Coffee banana zone Kigorobya and Kabohe sub-counties.

Livestock resources, Water resources inland lake and Rivers, Manufacturing and agro processing, Fishing, Natural resources, Natural Park like Bugungu Game Reserve, Forests like Budongo, Timber Trade, Vegetation, Wetlands, grass, quarrying, stones, clay sand, and Distillation of crude waragi which is widely carried out by use sugar molasses, the banana wilt destroyed all the beer bananas the new varieties introduced are being resisted by the farmers.

Impact of human activities on water quality

Agriculture
Poor agricultural methods mainly subsistence type which encourages soil erosion, digging along the lake shores, vegetable cover removal for agriculture, tree cutting for curing/drying tobacco bush burning method of opening up land leaving the land bare coupled with minimum effort to stop erosion by use shifting cultivation methods.

Livestock mainly along the shores, free range type of grazing, Water stressed areas-animals go down during the dry seasons and pitch camp along the shores or forest areas and poor sanitation at Lake Albert shores.

Forests
Timber sales being a major sources of income is one of the activities leading to abuse of forests, Forest conservation is limited in terms of government coming in, conflict of interest more lorries loaded more effect deforestation, construction, burning of clay bricks due to the booming industries of classroom construction

Another major human activity mentioned by the district planners was the distilling of crude waragi which is carried out along rivers, the water is used as a coolant and the residue disposed off into the water sources.

Stake holders identified by the district planners include; NGOs like SOMED, AA, IRC, FINCA and VURIT. Others are private enterprises and the communities.

Strategy for water quality management in the catchment area

The district planners like their counterparts emphasized the need for active participation by community through community sensitization on proper utilization of

resources and involve community leadership to over see the projects. Encourage participatory planning by getting views from the grass roots (bottom-top approach).

Sensitization the communities to form groups for savings and credit and create awareness through radio programmes in radios like Kagadi Kibaale Community Radio, Liberty Broad Casting Services, through drama groups, direct sensitization and use of IEC materials.

They added that the project should strengthen existing institutions in the catchment areas such as the parish development committee, and integrate its activities in the Parish Development Committees.

There will be need for constant technical support to these communities by the project office by involvement of the technical staff for guidance for example in defining the difference between needs and wants. They urged though Government is trying to create awareness and encourage participatory planning this is thin on the ground so there need to supplement by involvement of change agent.

Other strategies suggested include; integrate the project with key areas under PEAP, promote alternative IGAs, promote use of beer bananas instead of molasses, take measures on livestock keepers around the escarpment, emphasize impact assessment and encourage collective measures like tree planting for creation of jobs through the development of nursery beds.

Water quality

On improving of the water quality, the district planners suggested that there is need to review the 1995-96 water master plan to suit the current situation, improve on sanitation especially at the fish landing sites and construction of a road to see that the Lake Albert.

6.5.4 Forestry Department

Forest Resources include the government gazetted forests, forests on private land and forests on Bunyoro Kingdom land.

Some of the forest activities mentioned includes; Licensed pit sawing, charcoal burning and Tree planting to raise seedlings for sale though the district has nursery beds and give free seedlings to the community.

Human activities that were reported to be impacting on the environment are the high rate of deforestation due to land conversion for agriculture, immigrant and refuge resettles by government with no control of their deforestation activities from Mpokya Forest Reserve (30,000 people) and the increasing numbers Tanzanians and Bakiga resettled in Bugagaizi about 3000 people in 1992-3 but since the number has increased to over 200,000 people.

Strategies

The forest officers suggested sensitization of the people on cultivation and exploitation of resources in the catchment area for sustainable use. They added that there is need to carry out inventory/census survey along the two rivers Nguse and Musizi, this involves the count the spices, biodiversity of tree spices, the condition of the forests if deteriorating, worth of use, turned into another use, location of the river, find out the encroachers, relationship between ecosystem and surrounding communities nevertheless this requires funds.

6.5.5 Veterinary Department

Resources

The livestock resources are cattle, goats, pigs, sheep, poultry and very few rabbits. The veterinary officers could not establish the stocking rates due to communal grazing and the lack of land ownership system, however the sub-counties in the catchment area that are heavily stocked include; Buliisa in Mansindi District and Mpefu, Nkooko and Kisiita in Kibaale district.

Human activities affecting water quality were reported to be; Poor grazing methods thus nomadic type of cattle keeping, overgrazing living the land bare hence soil erosion, following the lake shores while grazing and pollute water with cow dung, poor sanitation at the landing sites and the use permanent streams for cattle drinking hence a lot of siltation.

Other activities mentioned include; Farmers who block the rivers to trap water there by disorganizing the natural flow, public ownership of land hence three is no respect for environmental control especially in tree cutting for charcoal and fish smoking using charcoal or firewood.

Strategies for the management of the catchment area were said to be; mobilize the communities to identify the challenges together and identify the solutions with them, work out activity plans with the communities, work in partnership with the local communities in disease control.

Other strategies include; Marketing structure and control of the marketing system to improve on the quality, control of overstocking, land management by issue of land titles, pastures management by control of bush burning, improvement of delivery services by training farmers and management of cattle dips should be communal.

6.5.6 Agricultural Department

The crops found in the catchment area include; Tobacco, coffee, sugar cane, maize, ground nuts, cassava, sweet potatoes, upland rice, cotton, beans, sim-sim, cow peas, pumpkins, water melon, oranges.

Impact Human activities on Water Quality

Main human activities reported to be impacting on the environment are;
Encroachment of wetlands for agricultural land has led to the dry up of some rivers for example, River Waaki waters level have gone down due to increased evaporation caused by land clearance and deforestation around its catchment area.

Growing of tobacco as already mentioned by several district entails the use of a lot of fertilizers and pesticides which run off to the lake. Apart from bush clearing for virgin land for better crop harvest, tobacco curing by use trees fire curing encourages cutting logs of a specific tree Omuko, there is also construction of tobacco stores using poles, reeds, twines, rafters and grass all from the environment.

Cattle corridor along the lake shores has suffered overgrazing causing soil compaction, over drinking, soil erosion deposition of cow dung, siltation and eventual dry up of rivers.

Kinyara sugar works – clearing of bushes, especially the out growers scheme, use a lot of fertilizers, herbicides, pesticides, the factory also disposes off its waste water into river Kasokwa which now has a bad smell due the pollution.

Strategies suggested are; discourage the wetlands encroachment, encourage use of organic farming by use humus manure, encourage reforestation and encourage irrigation systems for the nurseries in the upland.

7 SWOT ANALYSIS ON POLICY, LEGAL AND INSTITUTIONAL FRAMEWORK

A strength, weakness, opportunity and threat analysis was carried out to get the perceptive of the district officials and other stakeholders in the district. Below is tabulated summary of the findings.

7.1 Environment

Environmental Policy

Policy: • National Environments Management Policy, 1994 • The National Policy for the Conservation and Management of Wetlands Resources, 1995	
Achievements: • managed to high light issues of environment to the public • It has become a major framework for other policies like infrastructure development, health, road construction and investment.	
SWOT Analysis	
Strength	• Tried to capture most of the issues but has more of the weaknesses more focused on the environment act
Weaknesses	• Not translated into the local languages • Lack coordination/linkages between the sectors • Not in harmony old policies • In balance between land and forestry *"kibanja land and forests environmentalists say don't cut tress but the owners says the land is his so he cuts the trees even uses the wet lands"* • Top– bottom approach of policy formulation • The communities are not involved – *made by the Kampala people who are in another world different from the one down the community.* • Have policies in books but don't refer to them so much • Distribution of information is still poor due to lack of funds/facilitation • Policy on bush burning not clear • Punishment not deterrent • Difficult to enforce deforestation laws on private land
Opportunities	• It is a mandate of the people up, translated up there • At international level no problems the policy can only be referred to in case a need arises e.g. the immigrants fluctuating the place from DRC • Gives the district powers to put up ordinance and by laws hence empowering local governments
Threats	• If nothing is done soon everything will be cleared • There is no priority given to environment in PEAP issues disappear somewhere.

Constraints /Challenges

- Policy remains on paper but nothing is happening on the ground
- Enforcement still a big challenge, even the police officers are not conversant with the environmental law. NEMA has trained some but there is need to train even at district level.

Environmental Legal Framework

Legal frameworks • District environment and production ordinance • District environment action plan	
Achievements: • managed to constrain rapid degradation of the environment • constrained deforestation • constrained wetlands degradation	
SWOT Analysis	
Strength	• Several ordinances enacted at district level • Availability of the District environmental plans • Creation of environmental committees at different local government levels
Weaknesses	• limited awareness of the community about the legal frame works • Limited information dissemination about the legal framework to the community even up to the district levels. • Re-enforcing is still lagging behind due to lack of awareness.
Opportunities	• At district level not really referring to it. • Districts are empowered to develop their own by laws
Threats	• districts seem not be aware of the opportunity to enact by laws • District ordinance on the number the of cattle the compliance is not very good
Constraints /Challenges • Lack of funds at the districts to involve communities in formulating these ordinances.	

Environmental Institutional framework

Institutional framework • Ministry of Lands, Water and Environment • National Environment Management Authority • District Environment Office • Local Council Environmental Committees (LC 1, LC111 & LCIV)	
Achievements: • law enforcement • reduced on environmental damage • the public has become conscious of environmental issues • environmental crimes are now reported both in the popular press and courts of laws	
SWOT Analysis	
Strength	• Come up with legal framework • Funding – office equipment • Coordinate al environment officers and other sectors • Mainstream environment to local government.

Weaknesses	• Poor monitoring • Inadequate funding • Problems of coordination NEMA and Ministry of Land, Environment and Natural Resources. • No clear way of implementation • Too theoretical e.g. wetlands belong to private owners difficult to control • Institutions like the environment committees are not functional at all • District environment action plan- EPED environment protection and development • Politicians committees made out of councillors – expect to be paid after every sitting
Opportunities	• Natural resource sector merged hence work together
Threats	• No proper information flow because the district is very thin –big up thin on the ground • More work load with limited people.
Constraints /Challenges • most of the laws and policies are in books and are not referred to so much they are more focused on the environment act	

7.2 Water

Institutional Framework

Since independence, Uganda has followed a centralized water resource management. In Integrated WRM, the Water Policy Committee (WPC) established by the Water Statute is supposed to play an essential role in addressing equitable and sustainable management and development of the nation's water resources. As the secretariat for the WPC, WRMD (under the Directorate of water Development in the Ministry of Water Lands and Environment) plays a pivotal role in ensuring that WPC meetings take place regularly and is the key authority in national WRM. The WRMD is charged with the responsibility of providing advice and support to NEMA who are responsible for setting standards and guidelines. Local Governments also benefit from the technical capacity of NEMA through the Environmental Officers in the Districts to perform environmental impact assessments and to regulate pollution among other aspects.

Catchment management and management of wetlands are cross-sectoral issues where water plays an important role. Regulation regarding sustainable use of wetland resources is assigned to the Wetlands Inspection Division in MWLE and the practising of wetland management is basically a local challenge, which relies on the response materialising in the District Environment Plans.

Urban pollution control and urban catchment management is a primary responsibility of the NWSC since they operate urban sewerage treatment plants which often include the receipt and control of industrial waste water. Under the conditions laid down by DWD-WRMD in abstraction and discharge permits, NWSC is actually the custodian of urban and industrial pollution and are often the entry points for minimising water

pollution from these sources which also relates to the alleviation of inter-district water resource conflicts.

However, it has long since been recognised that Districts are the main units for decentralised WRM although proposed LG structures do not include WRM specifically. The existing structure in the water sector is also organised in a six-tier structure operating from village (LCI), Parish (LCII), Sub-county (LCIII) County (LCIV) through the district (LCV) to national level. However, County and Parish level do not have there own budgets. This management structure is as follows:

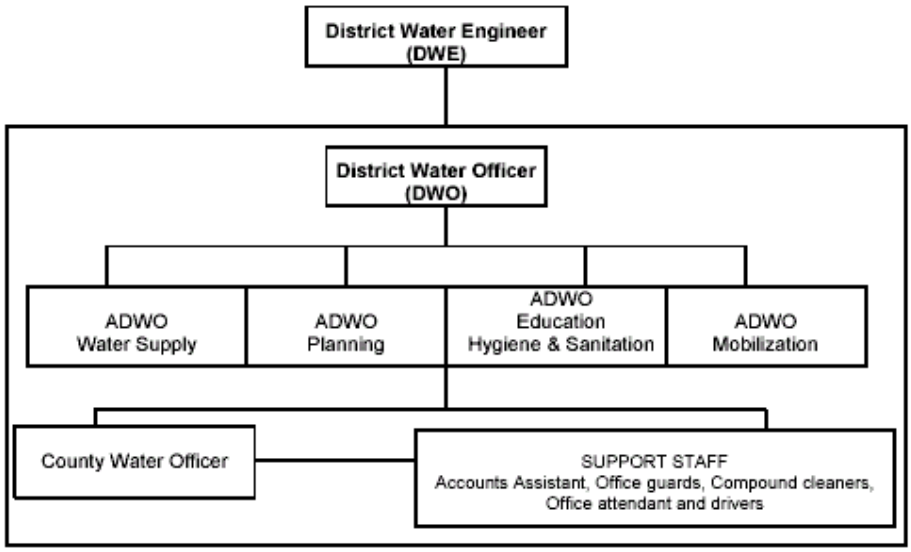


Figure 7-1 Water Resources Management Structure at District Level

Study reforms have been completed in the water sector, guided by new policies and legislation and water management is one of the core recommendations of the Water Resources Management sub-sector reform study for Uganda. It shall be oriented towards Catchment Based Water Resources Planning and Management. The major components of the Strategic Action and Investment Plans towards 2015 (SAIP) that are of interest to Lake Albert Eastern Catchment Imitative are as follows: -

- WRMD shall guide and promote decentralized and Catchment Water Resources Management through establishment of Catchment Water Management Offices (CWMOs)

- Operational support to the CWMOs

- Enhanced District participation in WRM shall be achieved through integration of WRM functions and capacity building in District Local Governments (DLGs). The District Environmental Officer was the recommended host of WRM at District Level and not the District Water Officer who represents the water service development and provision authority. The study also recommended assigning the overall WRM responsibilities to the Environmental and Natural Resource

Management family of the DLGs and that District Water Resources planning & Management should be embedded in the District Environmental action Plans

- Performance of Agreed WRM functions by DLGs

The project area is proposed to be clustered under the Western WRM zone which comprises of catchments discharging into Lake Edward and Lake George and catchments downstream of Lake Albert discharging into Lake Albert.

The main authorities and actors involved in Catchment Based Water Resources Management are:

- Water Policy Committee (WPC) giving overall policy and strategic direction

- WRMD will host and interact with Water Management Zone Coordinators (WMZCs) who will manage and coordinate decentralisation activities. These coordinators will play a key role in interacting with the districts in preparation of Preliminary Catchment water Resource Plans (CCWRPs) and establishment of future Catchment Water Management Offices (CWMOs)

- Interim Catchment advisory Committees (ICACs) will represent the district clusters in preparing the ground for CWMOs that will in due course be upgraded to Catchment Water Management Offices (CWMOs)

- A demand driven, consultative and long-term approach to the development of centralised water resources management will generally be pursued, driven by the SAIP to 2015.

Legal Framework

Natural resources for instance lakes and rivers are under the constitution 1995, the Land Act 1998 and the Water Statute 1995 vested in government or local government. The National Environment Statute requires that the central government collaborates with the local governments in the management of local water resources, wetlands, hilltops and mountainous areas, forests, range lands and in conservation of biological resources and land use planning. These issues are specifically selected because of their immediate relevance to community use and hence the need to involve local communities. Specifically use of lakeshores and river banks and access to lakes for livestock watering and other activities is regulated by the National Environment (Wetlands, river Banks and Lake Shores Management) Regulations, These Regulations prohibit any activities within protected zones of either a river or lake without the permission of the Director of DWD. The regulations require each local environment committee in respect of each river or lake to determine watering points and routes for animals to have access to water. In practice these regulations have not been easy to enforce due to lack of capacity on the part of the environment committee and no byelaws have been enacted.

In addition to these provisions relating to management of natural resources, the Environment Statute contains important provisions on the control of pollution. The Statute provides for mechanisms to establish environmental standards and where a person

wishes to exceed the set standards, such a person must apply for a pollution license under part VIII of the Statute. Standards for the control of pollution are being formulated.

Under the Water Statute 1995, Water Resources (Waste Discharge) Regulations (32/98) have also been enacted. These allows the Director of DWD to prohibit certain activities in sensitive areas where, for example, the discharge of certain wastes might be harmful to public health or the environment or where existing water uses might need to be pro-rated or otherwise restricted. Through the Sewage Regulations (1999), the Statute requires water supply or sewerage authorities to enter into performance contracts with the Minister to ensure the proper discharge of their functions, and provide remedies if they do not comply with these contracts and has established penalties for pollution, and enables the Government to recover the costs of major environmental damage from polluters.

The Water Resources Regulations 1998 also assume special significance in catchment management of Lake Albert. They require that extraction of water from a borehole or water way, weir, dam, tank or any other work capable of diverting an inflow of more than 400 cubic metres of water in any period of 24 hours is subject to the requirement of a permit issued by the Director of DWD.

The protection and management of wetlands are embedded in the National Environment (wetlands, river Banks and Management) Regulations of 2000, and Environment Impact Assessment regulations 13/98.

On a regional level, Lake Albert Eastern Catchment Initiative is compelled to work within the framework of the Draft Agreement on the Nile River Basin Co-operative Framework. According to this agreement, Basin states undertook to protect and improve water quality within the Nile river Basin, ensure through environment impact assessments and environmental audits, that projects undertaken are environmentally sustainable and to ensure that any projects are consistent with management, development and protection of the Nile Basin and its resources within the basin wide framework.

Duplicating roles of NEMA and DWD in pollution control.

The Environment Statute, 1995 provides for mechanisms to establish environmental standards and where a person wishes to exceed the set standards, such a person must apply for a pollution license under part VIII of the Statute to the Executive Director of National Environment Authority, NEMA. While the Water Statute 1995 requires that any person wishing to discharge waste may apply to the Director of Water Development for a permit. The Water Statute anticipated that NEMA would delegate its functions under the Environment Statute to Director of Water as the competent lead agency, but this has not been effected. Which means both institutions have the power under their respective laws to license pollution. In practice DWD is recognized by NEMA which refers applicants on case by case.

Lack of awareness and/or interest in WRM by key stakeholders. There is limited understanding and appreciation of the need for WRM amongst the private sector. Contacts with development workers, women and community-based organisation in the project area still identify poverty as a more critical problem for redress than WRM.

Capacity and Structural gaps in local Governments, lack of appropriate skills for WRM and insufficient tools

Legislation relating to Integrated Catchment Management appears to be scattered in several pieces of statutory instruments, codes and standards relating to water, environment and land. The affect of this is that there is a level of inconsistencies and possible overlaps that may affect immediate understanding and efficient implementation of the regulatory regime. A number of necessary supportive legislative instruments for existing legislation in the form of statutory instruments, formats of notices, codes, guidelines and directives relevant to water resource management and integrated catchment management have not yet been issued by the relevant local government authorities and institutions. For example, while the local Government act gives lower level councils judicial powers, tribunals have not been implemented due to lack of resources.

Powers and Functions under the Water Statute and related Statutory Instruments tend to be too centralised and concentrated as between the Minister and the director and may be susceptible for abuse. There may be need for new institutional arrangements and re-allocation of powers to the lowest appropriate level

Limited experience in trans-district co-operation in WRM. Our review has not identified any legislative instruments or experiences from any applicable practices that may be used to enforce trans-district co-operation in Integrated Catchment Management

Lack of a Water Quality Strategy. The country lacks a national strategy on water quality.

A SWOT analysis on water policy, legal frame and institutional framework is give below

Water Policy

<table>
<tr><td colspan="2">Policy:
• The National Water Policy 1999</td></tr>
<tr><td colspan="2">Achievements
• Protection of water sources
• Extraction of water for production and human use
• Construction of micro valley dams
• Irrigation – Kigorobya, Maseruka, Kyangwali
• Submit periodic reports to DWD and line Ministry</td></tr>
<tr><td colspan="2">SWOT Analysis</td></tr>
<tr><td>Strength</td><td>• The mandate given to DWD
• Reorganizes that DWD is accountable to the people
• In line with other government departments – integrated
• Policy mainly backed by acts and regulations</td></tr>
<tr><td>Weaknesses</td><td>• Few copies hence not widely read
• Not circulated down to the people
• Not sure whether the community was involved
• Not disseminated of the policy is weak at community level e.g. the land act is not clear in the water policy
• Implementation of strategic plans quite difficult because centre has not decentralized activities
• Land management is left to the people, the community need to be</td></tr>
</table>

	guided in the utilization of land.
Opportunities	• Involving the communities e.g. the formation water source committees • sensitizing the communities on policy issues through the water source committees
Threats	• under funding for district implementation • not periodically reviewed
Constraints /Challenges • dissemination of the policy to the communities constrained due to lack of funds	

Water legal framework

Legal framework • District water master plan 1994-95	
Achievements: - • development of the districts water master plans • increase of water supply by trying to achieve the MDGs	
SWOT Analysis	
Strength	• By laws at the district level • Followed the National guidelines at the district level and at Sub-county and committees have been guided to form water source committee and have by laws.
Weaknesses	• Difficult to enforce especially if the water source in private land • Discrepancies between water resources and land ownership • Responsibilities of water quantity monitoring to Entebbe but the district could be doing this kind of work. • No active participation e.g. rain gauges for information collection
Opportunities	• engage district staff in water quality and quantity monitoring • build capacity of district staff by training them in several areas • Dissemination of policies to the department then to the local people.
Threats	• Private – difficult to enforce may construct a well in the compound
Constraints /Challenges • Legal issues • Integration of gender issues in water management. • Enforcement of laws and regulation is not done • Difficult to enforce the laws on public building. • Waste disposal by cesspool emptier difficult to monitor	

Water Institutional framework

Institutional framework • Ministry of Lands , Water and Environment • Directorate of Water Development • District Water Department • Local Council Water Committees (LC1, LC111 & LCIV)
Achievements: • development of water committees at different local government levels • increase safe water supply • Increase in water production and accessibility to local communities

SWOT Analysis	
Strength	• Water user committees (every water point has 7 members; chair person, secretary, treasurer, caretaker, 3 committee members all trained on rules and responsibilities, operations and gender mainstreaming recently trained and are active.
Weaknesses	• Still very difficult to enforce the law • There are no refresher courses for staff. • There are no funds run most of the activity
Opportunities	• National level: national sanitation education and community, water regulatory rural water and urban water, water for production rural water and agriculture, • Streamline inter-sectoral coordination
Threats	• continued deterioration of water quality and quantity in the catchment area • continued depletion of natural resources by the ignorant communities
Constraints /Challenges • Works sector at district level: water, roads, engineering, building not working in harmony. • Functionality of water monitoring system may be affected especially if women are used because they may marry off or divorce.	

7.3 Economic

Economic policies

Policy: • Poverty Eradication Action Plan • Decentralization policy • Investment Policy	
Achievements • UPE classroom construction on average 90 classrooms per year use a lot of bricks and local materials • Decentralization of health services • Micro finance institutions availing funds to the poor • Liberalization of the economy which is determined by market forces	
SWOT Analysis	
Strength	• PEAP being as a guide for LG, strength in poverty eradication, key sectors- education, water, roads, health • Participation planning: decision making, resource mobilization, implementation of projects, legal framework, people make their own by-laws (power of the people – don't make the best decision regarding land utilization) • District make roads • Stopping animals from taking water fro rivers banks
Weaknesses	• once institutions are put in place it becomes very difficult to reverse elected speaker difficult to remove – district service commission easily passed by a simple majority but increasingly need 3rd • Councils misuse their powers e.g. the IGG recommended that a council member to removed but the council refused. • Some big authority can be used to ruin district issues. • left out other sectors- planning, finance etc

Opportunities	• the policy is there and people are slowly but surely learning • the influence of people giving the funds is overriding the purpose e.g DWSP – IFAD 2 billion for safe water the condition was that the water must be borehole water, if it had been used for protecting spring wells • SFG schools – equity per sub/county but no similar needs • Training –health sector education, capacity building • Bridge the financial gap – get grants
Threats	• many services were decentralized but are constrained no funds e.g. the land act 5 years down the road but many of the clauses have not been instituted due to lack of resources – sub-county committees, village committees – ideas have been abandoned . • Many functions decentralized but have been choked by lack of funds LG can't get funds. • Resource base LG don't have funds and human resources – many things remain not implemented • Donor program – if they pull out then it will collapse • Policy on capacity building
Constraints /Challenges • Population pressure – forces people to forests, wetlands • Road construction affects water resources like wetlands, bridges construction, land cover, protection of springs effects on the wetlands • Donor, central – comes with conditionality, limits people's power in decision making hence encourages dictation by the technical people- no bottom up approach.	

Economic Institutional framework

Institutional Framework • Ministry of Finance, Planning and Economic Development • The District Planning Unit • The Private Sector • Money Lending Institutions	
Achievements – • overall, planning and monitoring executive committee sectoral committees supported by technical arm- CAO DTPC – planning, monitoring, mentoring • Major agencies of government – there to ensure harmony in terms of policy and to avoid duplication of resources	
SWOT Analysis	
Strength	• Micro Finance Institutions – SIDA (Sub-county Integrated Development Association) – money lent to a base of farmers of over 3 billion • District created an autonomous body called BUTO Rural Development Company – management assisted by sub-county, women 70% men 30% to mobilize savings and credit, separation of powers to ensure that it succeeds
Weaknesses	• conflicting policies • depend on community volunteers • structural adjustment failures • Private sector- loosely connected to the government sect
Opportunities	• open more avenues of economic activities like non traditional export crops • globalization • increased market opportunities

Threats	• getting fatigue – CHW, TBA CNV- big tasks now its dying out • World Vision e.g. school construction insists on communities' participation for materials, unskilled labour, sub-county for transport but government contracts out its projects to one person. • Water – government insists that the communities be involved cash WRC • World Vision – gives already finished products in terms of water resources – different methods confuse communities
Constraints /Challenges • methods of work by the different players is not properly harmonized – education, health, environment • keeping in pace with globalization • accessibility to markets • meeting international quality standards	

Economic Legal frameworks

Legal framework • Investment code • Local Government act of 1987 for planning • Decentralization act • Uganda Revenue Act • Private Sector Act	
Achievements • Economic growth of 6% for the past twenty years • Diversification of the economy • Liberalization of the economy	
SWOT Analysis	
Strength	• Guide to decentralized LG planning • Harmonized participatory planning guide • Mentoring/planning guide
Weaknesses	• continued poverty despite the interventions • continued high infant and maternal mortality • continued high fertility rate • continued degradation of environment • continued high illiteracy rates
Opportunities	• an excepted member of the international community • access to AGOA
Threats	• continued foreign exchange fluctuation drain
Constraints /Challenges • continued corruption • lack of work ethics among the employed • negative impacts overshadow positive impacts	

7.4 Forestry

Forestry Policy

Policy: • The National Forestry Policy	
Achievements: • sets out national guideline for forestry management • encouraged tree planting on private land • encourages development of tree nurseries	
SWOT Analysis	
Strength	• Encourages community participation
Weaknesses	• limited Funding lacks sufficient capacity and resources to effectively manage forests • lack of clarity on the land tenure systems • inability to implement policies, ordinances and by laws • total lack of incentives for protection of forests on private land • Difficult to advice people
Opportunities	• can be applied, advise people on planting trees and use them sustainable • need to share resources between the central and lower local governments
Threats	• People are not interested in buying the seedlings. • The districts and lower authorities have played little role in the conservation of forests
Constraints /Challenges • The policy of controlling forestry resources at the central without involving the district and local communities.	

Forestry Legal Framework

Legal framework • The Forestry Act	
Achievements: • Management of forest catchment areas • Routine patrols • Inventory to know tree spices and stock • Restoration of tree planting	
SWOT Analysis	
Strength	• provide guidelines and regulations on forestry management
Weaknesses	• prohibited tools were not mentioned in the act it was just an order by the Minister • The Act does not give National Forestry Authority a regulatory role. It only gives it power to manage Central Forest Reserve on behalf the Government. • does not provide for public participation in forest management
Opportunities	• Private Forest Motion • Collaborative Forestry Management with local communities.
Threats	• Government is interfering in the management of forest reserves by de-gazettement.

Constraints /Challenges • gaps in the district concerning the management of local forests • the forest act does not decentralize the management of forests to districts

Veterinary and Animal Industries

Policy:	
Achievements: • disease control move with documents to cross to other areas	
SWOT Analysis	
Strength	• Gave people the power to put in laws which are relevant to them • Active participation
Weaknesses	• Hard to enforce
Opportunities	• Up date the policies to national acts to meet the current situation • Sensitize communities in the laws • An integrated approach in the Environment management as a whole
Threats	• Cattle from Congo are not vaccinated
Constraints /Challenges • Some of the policies should not have been decentralized because resources and remedies require financial obligations, which local councils cannot raise.	

Legal frame work

Legal framework • District ordinance on the number the of cattle • Animal Disease Act, Meat Act, Rabies Act, Hides and Skins Act, Cattle Traders Act, Animal Straying Act	
Achievements •	
• SWOT Analysis	
• **Strength**	•
• **Weaknesses**	• Penalty not deterrent • Most of them are outdated
• **Opportunities**	•
• **Threats**	•
• **Constraints /Challenges**	

7.5 Agriculture

Agriculture Policy

Policy • Policy: Plan for Modernization of Agriculture	
Achievements • Agricultural extension – improve and increases on productivity more land being used, use of better farming methods rate of adoption is very low.	
SWOT Analysis	
Strength	• Food security • Poverty eradication • Increase in house hold incomes • Improve on nutrition
Weaknesses	• Facilitation no logistics for implementation fuel and maintenance • Funds
Opportunities	•
Threats	• If not implemented the people will remain poor and children will re

	An assumption of community participation e.g. NAADS – farmers have no capacity to implement speed and quality may not be as expected • main unhealthy
Constraints /Challenges	

7.6 Fisheries

Fisheries Policy

Policy: The National Fisheries Policy, 2004. Sustainable management and development of the fisheries. Fisheries will be managed and developed to promote socially, economically and environmentally sustainable use and development of the resources so as to meet the needs of present generations without compromising the ability of future generations to meet their needs.	
• **Achievements:** - Establishment of Beach Management Units (BMU), - Co-manage the fisheries resources with the government, -Collect revenue on behalf of the government, -Ensure use of appropriate fishing methods, -Sanitation at landing sites, -Settling dispute, -Registration of boats, nets and new entrants, -Ensure security, -Prohibit fishing of juvenile fish , -Issue fish movement permits	
• **SWOT Analysis**:	
• **Strength**	• Formation of BMUs • Availability of the police and LCs to enforce the law • Availability of the boat for effective monitoring of the lake
• **Weaknesses**	• Inadequate staff, • Lack of financial and material support, • Lack of legal backing from the government, This makes it hard to solve boarder related cases especially those concerning fishing grounds and theft of gear, which is very common on the lake.
• **Opportunities**	• Sensitization of the local communities on better hygiene and sanitation practices. • Capacity building for the BMUs in terms of training, finance and provision of equipment. • Construction of Ecosan type of latrines • Provision of safe water source such as pipe water or gravity water flows. • Construction of public pay latrines at the landing sites. • All the enforcing bodies should work together. • Provision of micro finance services and IGAs to the community.
• **Threats**	• Over fishing especially by the fish exporters • Fish net • Deteriorating condition of the lack • Poor hygiene and sanitation at the landing site • Lack of sensitization and education the local community of how water gets contaminated

- **Constraints /Challenges**

-Latrine construction is a very big problem due to poor soils around the lakeshores.
-The few latrines have been constructed very close to the water shores.
-The few pit latrines that are constructed still get filled very fast due to the big numbers that use them.
-Cultures of some tribes that prohibit them from using the latrine and encourage use of bush and lake for defecation e.g. the Congolese settlers.

-Poor Fishing methods that necessitate fishermen spending two to four weeks in the lake fishing. During this period, all the wastes are deposited into the water thus polluting the lake.
- Poor hygiene and sanitation at the landing site e.g. dumping of used condoms in the lake.
-Over drinking of packaged Waragi is commonly drunk among the fishermen who disposal of the polythene in the lake as they fish. Also polythene (kavera) used as the main packaging materials are disposed off in the lake the polythene is literally seen floating on lake.
-Poor and traditional preservation methods like salting
-Contamination of the lake by petroleum oil that sips in the lake from Kibero
-Most of the fishermen are from Congo, which makes it difficult to enforce the laws.

The Legal Framework

The substantive law provides for the regulation of the regulation of the Uganda Fisheries is the Fish Act 1964 (Cap 228). A new Act is in the offering. It is now considered to be inadequate to cope with those domestic and international changes in fisheries administration and the latest policy thinking. The Act by current standards is neither comprehensive enough nor flexible enough to provide for the proper management and conservation of fisheries.

8 RECOMMENDATIONS FOR WATER QUALITY MONITORING PROGRAMME

The Lake Albert Eastern Catchment Management Initiative is an ambitious undertaking. However, it is timely because the catchment is facing escalating deforestation, over grazing, over fishing, poor methods of cultivation, deterioration of water quality and influx refugees from the Democratic Republic of Congo and immigrants from south western and northern Uganda. These impacts are being felt because poverty has driven the rural poor to over exploit the natural resources in a way that is damaging to the environment. As a result the water resources, particularly the rivers, have dwindled; the water quality has deteriorated, while the lake ecosystem health is showing signs of environmental stress.

In order to reverse this trend an integrated water resources management (IWRM) strategy is needed. This chapter presents a draft proposal for a water quality monitoring programme as an element of IWRM in the catchment. The overall purpose of the programme will be to determine the magnitude and impact of anthropogenic activities on water quality establish a monitoring programme, make recommendations that will mitigate anthropogenic activities that are responsible for the deterioration of water quality and design a water conservation strategy for the catchment.

The specific objectives of the programme are:

i. Assess the present and likely further risks of the anthropogenic activities on water quality of the rivers and how this in turn affects lake water quality.

ii. Establish a sustainable water quality monitoring infrastructure for the eastern catchment of Lake Albert.

iii. Provide input to an integrated water resources management strategy focused on pollution control.

8.1 Selection of sampling sites

As outlined in Chapter 4, the selected sites used in the reconnaissance survey should continue to be basis for the water quality monitoring programme. However, because River Waaki has been identified as pollution hot spot it is recommended that additional longitudinal sampling sites along its tributaries be included to capture the immediate impact of run off from the sugar cane plantation and tobacco peasant farms. Kinyara Sugar Works makes an interesting study case. It is recommended that the project enlists the support and active participation of the management of Kinyara Sugar Works into the integrated management of the catchment. More sampling sites are required a long river Kasokwa to determine impacts of wastewater from the sugar factory. British American Tobacco Uganda Ltd a multi-national tobacco company that contracts peasant farmers in the catchment should also participate in the integrated management of the catchment.

One sampling point at Butaiba fish landing site is adequate to provide the necessary information on Lake Albert. However, depending on the availability of funds and personnel a longitudinal profile along the south-north axis with sampling stations near River Semuliki, and Buhaka, Tonya and Wanseke fish landing sites would give comprehensive information on lake limnology. Vertical profiles of the lake are necessary to determine lake stratification.

8.2 Practical relevancy and justification of selected water quality monitoring parameters

The selection of water quality parameters is an important step in the setting up a water quality monitoring programme (Chapman and Kimstach, 1996). In the selection of the parameters below the following was considered:-

- Some parameters were selected because they are an indicator of the pristiness of the aquatic environment.
- Some are an indicator of the impact of human activities on the aquatic environment, hence reflecting pollution, a stressed environment and/or deteriorating environmental quality.
- Some parameters were selected because they can be used in the management of the catchment through an integrated water resource approach.

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, influences 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.

Colour and Turbidity determines the depth to which light is transmitted. This, in turn, controls 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.

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.

Odour in water is a result of a volatile substance in water. It presence suggest 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.

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.

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 Total Dissolves Solids 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. Total Dissolved Solids is directly proportional to electrical conductivity and influences salinity.

pH, Acidity and Alkalinity influences 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.

Dissolved Oxygen 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 also a direct measure of organic pollution. The oxygen content of natural water varies with temperature, salinity, turbulence, atmospheric pressure and photosynthetic activity.

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 leather 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.

Zooplankton, phytoplankton, secchi depth and chlorophyll "a"

The determination of these parameters enables to establish the trophic status of the lake. Chlorophyll "a" provides an indication of suspende algal biomass in the water and can be used to determine the susceptibility of a water body to algal booms.

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 catchment has water borne epidemics like cholera, typhoid and dysentery the measurement of these

tests will enable to provide information on the linkage between water contamination and out breaks of epidemics.

Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD)
Biological oxygen demand (BOD) is a direct measure of the amount 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 pristiness of an aquatic environment. Chemical oxygen demand (COD) is widely used as an measure of the susceptibility to oxidation of organic and in organic matter present in a water body. It is a direct indicator of pollution.

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 catchment. 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 under the nutrient dynamic in the tropical aquatic environments.

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.

8.3 Analytical Methods

The monitoring programme will focus on surface water in rivers draining into Lake Albert, Lake Albert itself and ground water, particularly the borehole at Hoima Hospital. However, depending on the need and availability of funds water should be collected and analysed for physical, chemical, xenobiotics (agrochemicals), heavy metals, plankton, macro-benthos and microbiological parameters. Water samples should be analysed for Temperature, pH, Electrical Conductivity (EC), Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Alkalinity, Hardness, Carbonate (CO_3^{2-}), Bicarbonate (HCO_3^-), carbon dioxide (CO_2), Calcium (Ca^{2+}), Sodium (Na^+), Magnesium (Mg^{2+}), Chloride (Cl^-), Reactive Soluble Phosphate (RSP), Total Phosphorus (TP), sulphate (SO_4^{2-}), ammonia (NH_4^+), nitrate (NO_3–N), Total Nitrogen (TN), Chlorophyll “a”, Pesticides, Plankton and Faecal Coliforms. Standard methods for examination of water and wastewater as recommended by the American Public Health Associations (APHA, 2000) are recommended for both filed and laboratory analysis. Arsenic (As), Mercury (Hg), Lead (Pb), Cadmium (Cd) and Chromium (Cr) should be analysed using Atomic Absorption Spectro-photometer in order to determine baseline levels of heavy metal contaminations. Analysis of samples should be in triplets and the analytical laboratory should have a quality assurance system.

8.4 Duration, Frequency and Timing of Sampling

Since the monitoring programme is to establish baseline conditions in the catchment, it is a recommendation that the sampling protocol should last for one calendar year for the following reasons: -

i. One year of sampling will enable to establish seasonal trends. Although studies for a complete calendar year are known to have been done, results are not in the main domain and hence cannot be referred to. With additional information from the catchment and that of seasonality, appropriate management interventions can be made for the catchment.

ii. The project duration is 3–4 years. Therefore one year is within the duration of the project.

iii. The standard recommended duration for a water quality monitoring programme is one year.

The Global Freshwater Quality Monitoring Net Work GEMS/WATER project of the WHO (1992) recommends an optimum annual sampling frequency of 24 (bimonthly) for establishing a river basin baseline physical-chemical conditions and a minimum of 4 samples (quarterly). For purposes of this water quality monitoring programme 12 samples collected monthy will be adequate. However, for rivers a sampling campaign will be needed too detect flush events during the rainy seasons. It is recommended that bimonthly samples be collected during March, April and May (short rains) and August, September and October (long rains). Pesticides and heavy metals should be analysed quarterly to cover the wet and dry seasons, while diurnal events in the lake should be measured quarterly to cover both dry and wet seasons. A summary of recommended sampling frequency is given in Table 8.1.

Table 8-1 Recommended Sampling Frequency

Source	**Routine monthly sampling frequency**	***Campaign sampling frequency**	**Total**
Rivers	12	6	18
Lakes	12	4	16
Ground water (Borehole)	12	0	12

* Wet seasons for rivers and diurnal for the lake.

8.5 Who monitors water quality in Uganda?

There are a number of institutions involved with water quality monitoring in Uganda. These include but not limited to the following: -

(i) Directorate of Water Development DWD
(ii) National Water and Sewerage Corporation NWSC
(iii) Government Chemist
(iv) Makerere University (Zoology, Chemistry, Food Technology, Botany, Civil Engineering and Institute of Environment and Natural Resources)
(v) The Private Sector (Chemiphar Uganda Ltd)

(vi) District Water Development Offices
(vii) Uganda National Bureau of Standards
(viii) National Environment Management Authority
(ix) Fisheries Resources Research Institute

The Directorate of Water Development (DWD) is responsible for the management and enforcement of laws in the water sector in Uganda. It has a water quality monitoring laboratory in Entebbe. It monitors surface and ground water throughout the country. The results on water quality from 1998-2005 in Chapter 3 were obtained from the laboratory data base. The laboratory has the required analytical facilities, personnel and logistics like a mobile water quality laboratory. However, it is under funded and like all government departments it is constrained by bureaucracy and red tape. The project should establish a working relationship with the laboratory.

National Water Sewerage Corporation (NWSC) has the mandate to supply water and sewage services in urban areas in Uganda. It runs an excellent water quality laboratory at Bugolobi. It specialises in water pollution issues. It has the required analytical facilities, logistics, funds and the staff has the right attitude. However, all transactions are strictly commercial. Dealings with the laboratory are business oriented and have an urgency to keep the customer satisfied.

The Government Chemist is under the Ministry of Internal Affairs. Its mandate is in criminal investigation. They have excellent facilities for measuring pesticides and heavy metals in Uganda. Like any government department they are constrained by funds and bureaucracy.

Fisheries Resources Research Institute (FIRRI) Jinja is under the National Agricultural Research Organisation (NARO). It has an excellent water quality research laboratory. Their mandate enables them do research on water bodies in Uganda. The results on water quality in chapter 3 from 1950-1970 were extracted from the scientific papers written by expatriate staff based at the institute at that time. The strength of the institute lies in lake limnology. The Project should collaborate with the institute on issues that have to do with limnology of Lake Albert.

Makerere University Departments of Botany, Zoology, Civil Engineering, Chemistry, and Food Science, Institute of Environment and Natural Resources all run water quality laboratories. The academic staff in the various departments offers specialistic services in water pollution, identification of zooplanktons, phytoplanktons and water quality modelling. Collaboration with individual professors within these departments may be necessary for the Project.

The private sector has entered water quality analysis. Chemiphar (U) Ltd located in Kasanga offers a wide range of analytical services. Their competence lies is analysis of pesticides. All engagements with Chemiphar are strictly commercial.

District water officers throughout the country have field water quality analytical kits. District Water offices have space at the water treatment works which can be converted into a laboratory. Masindi and Hoima have space at the water treatment works which can be used by the Project. However, the infrastructure and analytical equipment in the districts are rudimental.

8.6 Approaches / options for executing the water quality monitoring programme

After a review of the project proposal and taking into account of the desired out comes; the gleaned literature, reconnaissance survey and in depth interview with stakeholders it is the considerate opinion of the consultant that the project has 5 approaches / options in which it may be executed. The rational behind these proposed options are based on the manpower requirements. These options have been arranged in order of priority include the following: -

(i) Using district water officers and their staff
(ii) Using DWD staff at the water quality laboratory in Entebbe
(iii) Contracting a full time consultant / staff
(iv) Using a commercial laboratory like NWSC
(v) Using a post graduate student

The advantage, disadvantages and consequences of each option is given in Table 8.2

Table 8-2 Water quality monitoring options considered for a monitoring programme.

No	Approach / option	Advantages	Disadvantages	Likely consequences
1.	District water officers for Masindi, Hoima and Kibaale	(1) Willing to participate (2) Easy access to sampling sites (3) Water officers are available (4) Have basic training (5) Project will establish local ownership	(1) Need to facilitate staff (2) Need to supervise staff (3) Need to train which is time consuming (4) Need to employ a third party to analyse and interpret data and write final report. (5) Need to provide logistics (motor cycles) (6) District bureaucracy.	1. The project staff will spend time and funds to follow-up implementation. 2. The programme may not be finished in time.
2.	Directorate of Water	1. Highly experienced staff	1. Staff need motivation	The quality of work will be good but will

	Development (DWD)	2. Have logistics capabilities 3. Have a Data Bank 4. Good laboratory	2. Located far from the project site 3. Government bureaucracy and red type.	be more expensive than option 1.

No	Approach / option	Advantages	Disadvantages	Likely consequences
3.	Contracting a full time consultant /staff	1. The quality of work will be okay 2. No need to supervise 3. The programme will be executed in time 4. No time lag in training	1. Expensive 2. No local authority or community partnership nor ownership.	1. Expensive, but most practical way of implementing the Project 2. The Project will meet its expectation.
4.	Using a commercial laboratory (NWSC)	1. Good quality work. 2. No need to supervise 3. The programme will be executed in time.	1. Expensive 2. No local authority and community partnership nor ownership.	Expensive, but the outcomes will meet the project expectations.
5.	Using a post graduate student (Ph.D)	1. A research approach will be used. Hence comprehensive results will be generated. 2. High quality results 3. No need to supervise 4. The programme will be finished on time. 5. The student will be in the project area for 3 years hence there will be institutional memory capacity building.	1. A need to go through lengthy university formalities 2. A need to identify a student with the qualifications	Quality results will be obtained but there may be delay.

Table 8.2 cont.d Water quality monitoring approaches

8.7 Infrastructure, analytical and personnel requirements

Districts can provide free space to accommodate a laboratory. Some rooms in the buildings at the water treatment or abstraction points can be converted into a laboratory. The Project can provide funds for furnishing the laboratory. DWD, NWSC and the consultant have well established laboratory facilities at no additional costs. The student will need district facilities.

The Project will have to buy all analytical equipment and chemical reagents if it uses the district or student option. This is part of capacity building and local ownership.

At the end of the day despite, who ever collects the data, it has to be analysed by an expert. The district option falls short; hence a third party will be required. DWD, NWSC, an independent consultant or student has adequate skills to analyse the results.

8.8 Cost implications

Table 8.3 shows the costs implications of each option. Option 1 and 2 means buying all laboratory equipments and reagents for the three districts. The personnel cost at the District does not include the training of personnel.

Table 8-3 Cost in US $ for various water quality monitoring options.

No	Approach/option	Analytical	Logistics	Laboratory infrastructure	Personnel	Total
1.	District water officers	70,000	40,000	5,000	10,000	150,000
2.	DWD	15,000	10,000	0	5,000	30,000
3.	NWSC	20,000	10,000	0	5,000	35,000
4.	Consultant	20,000	10,000	0	5,000	35,000
5.	Graduate student	70,000	10,000	5,000	15,000	120,000

9 RECOMMENDATIONS FOR AN INTEGRATED WATER RESOURCES MANAGEMENT (HYDRO METEOROLOGICAL MONITORING)

9.1 State of meteorological network

The existing meteorological network in Lake Albert is composed of 2 synoptic stations at Masindi and Butiaba and a total of 21 Climatological stations. Climatological stations when operational are equipped to record rainfall with simple gauge cylinders and manned by individual volunteers or institutions. The synoptic stations gather data for use in forecasting and are permanently staffed.

Table 9.1 summarizes the status of these stations. Additional details can be read from Table 9.2 which must be read in conjunction with Fig. 9.2.

Table 9-1 Status summary of meteorological network in the Lake Albert Eastern Catchment area.

Station Type	Equipment	No. Operational	No. Non-Operational
Synoptic	Pan evaporimeter, Stevenson's screen, thermo hydrograph, simple rain-gauge, pan water thermometer, sunshine recorder, windspeed and direction recorder, anemometer, barometer, Max, Min, Wet & dry wall thermometer, hydrometer,	1	1
Climatological	Simple rain gauge	5	16

Climatological stations that are not operational have been primarily affected by lack of rain-gauges and lack of inspection visits from core staff from Uganda Meteorological Department due to inadequate budgets and unavailability of inspection vehicles. Fig. 8.2 illustrates the spatial spread of stations while Table 4.2 provides the status of the meteorological monitoring networks in the project area.

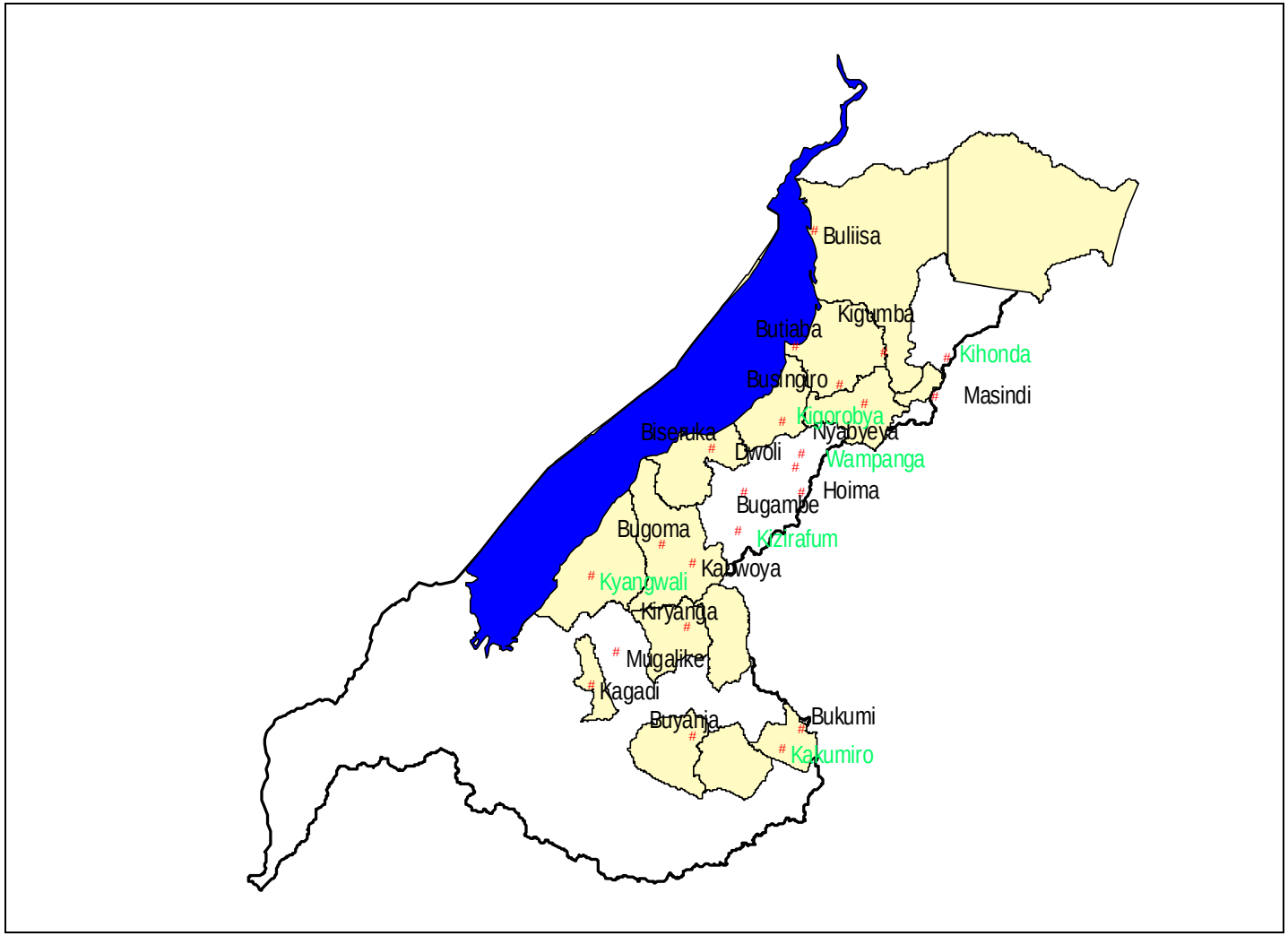


Figure 9-1 Historical spread of rainfall stations in Lake Albert Eastern Catchment Management Initiative project area.

Table 9-2Status of meteorological network in the Lake Albert Eastern Catchment Management Initiative project area.

Met No	Name	Start	End	No of Years of record	Long.	Lat	Alt	Annual Rainfall	Status
87310010	Buliisa	1943	1977	18	31.4000	2.1170	615	830	Not Operational
88310180	Kabwoya	1943	1964	20	31.0830	1.2500	1200	1410	Not Operational
88310290	Bugoma	1963	1979	16	31.0000	1.3000	1050	1267	Not Operational
88300020	Kyangwali	1943	1982	36	30.8170	1.2170	1050	1140	Not Operational
88300030	Mugalike	1943	1979	37	30.8830	1.0170	1200	1299	Not Operational
88310000	Butiaba	1904	1977	73	31.3500	1.8170	615	757	Not Operational
88310010	Dwoli	1915	1957	42	31.3500	1.5000	1200	1519	Not Operational
88310020	Hoima	1909	1962	45	31.3670	1.4330	1140	1425	Operational
88310030	Masindi	1906	2000	93	31.7170	1.6830	1147	1317	Operational
88310050	Busingiro	1933	1960	24	31.4670	1.7170	1080	1479	Not Operational
88310170	Kizirafumbi	1943	1979	36	31.2000	1.3330	1050	1319	Not Operational
88310200	Kiryanga	1943	1964	22	31.0670	1.0830	1200	1044	Not Operational
88310240	Nyabyeya	1944	1984	41	31.5330	1.6670	1170	1501	Not Operational
88310250	Kigorobya	1946	1977	30	31.3170	1.6170	1080	1200	Not Operational
88310260	Biseruka	1947	1977	31	31.1330	1.5500	600	930	Not Operational
88310330	Bugambe	1965	1999	31	31.2170	1.4330	1079	1405	Operational
88310390	Kihonda	1965	1994	25	31.7500	1.7830	1125	1333	Operational
88310410	Wampanga	1968	1995	28	31.3670	1.5330	1260	1597	Operational
88310740	Kigumba	1950	1985	34	31.5830	1.8000	1200	1142	Not Operational
89300100	Kagadi	1943	1976	28	30.8170	0.9330	1200	1240	Operational
89310000	Bukumi	1909	1957	46	31.3670	0.8170	1400	1231	Not Operational
89310010	Kakumiro	1944	1983	40	31.3170	0.7670	1350	1317	Not Operational
89310070	Buyanja	1943	1980	31	31.0830	0.8000	1365	1351	Not Operational

9.2 State of Hydrological network

At present the gauging networks in Lake Albert Basin are still not as good as they were during the HYDROMET surveys. Index catchment studies in the Waki have not been followed up since this project wound up therefore flow monitoring at Waki I and Siba ceased. The station at Wambabya needs to be rehabilitated. Since the year 2002, quality of data from river Muzizi (downstream) seems to be affected by a change in the rating and a decision must be made to possibly shift the station to another location.

However, stations at Butiaba, Waki II, Nkusi, Muzizi and Semliki are operational. Fig. 9.2 illustrates the spread of the existing hydrological network and the proposed additional stations for improvement of the water quality monitoring network.

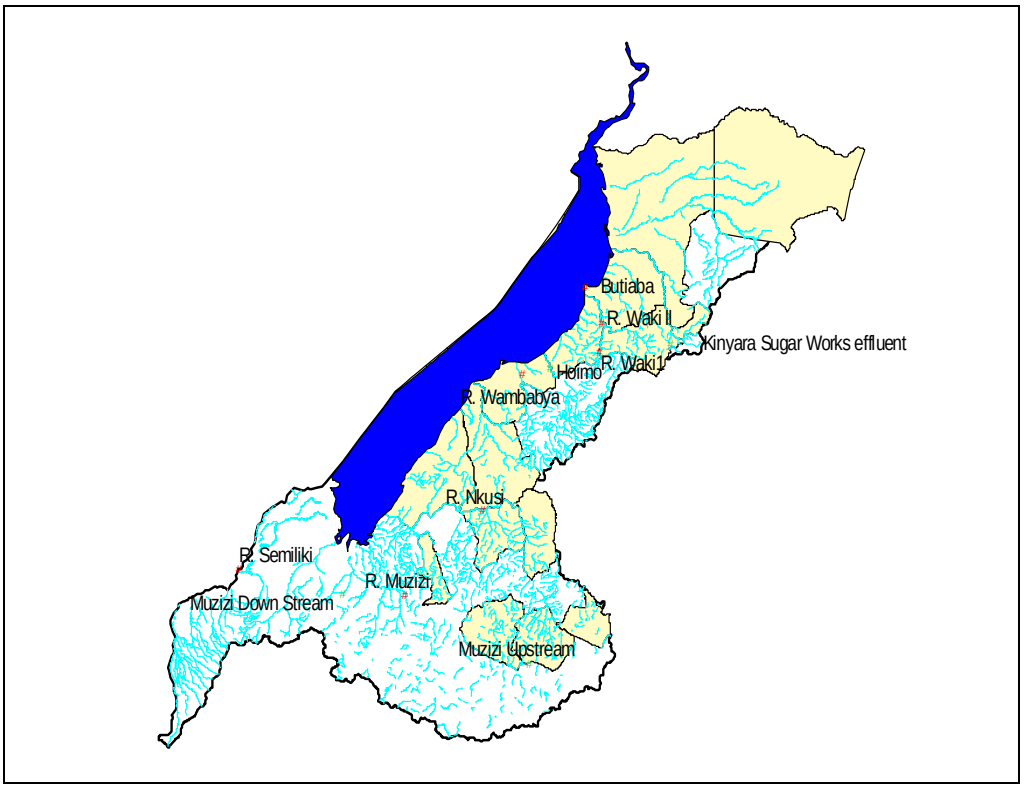


Figure 9-2 Existing and proposed flow monitoring network

9.3 Physical and Human Capacity needs for along term hydrological monitoring

9.3.1 Equipment needs

In view of recommendations and designed water quality monitoring network, equipment needs for an integrated monitoring network are summarised in Table 9.3.

Table 9-3 Equipment needs for hydro-metrological data collection.

Item no.	Description	Requirements/specifications	Estimated cost in USD
1	One synoptic station capable of measuring evaporation, temperature, sunshine hours humidity etc.	Synoptic station to be equipped with the following: Pan evaporimeter Stevenson's screen Max & Min thermometer Self recording rain-gauge sunshine recorder Wind-speed recorder Wind direction Each complete station costs $2,600	2,600
2	Rehabilitation of 16 climatological stations	16 self recording rain-gauges at US $ 160 each	2,560
3	Provision of Three Automatic Water Level Recorder stations (Hoimo, Wambabya, Muzizi)	R20 strip chart water level recorder, complete with recorder housings, floats, counter weights, ink and charts. Each costs $795	2,385
4	Provision of ---- motorbikes (one for each of the districts staff)	Honda or Yamaha 125 cc Each costing approx. $1,500	
5	3 sets of OTT C31 Universal Current Meters 3 sets OTT C2 small current meter Wading equipment e.g boots, suits etc.	Preferably OTT make, each complete with weights etc. (3 X $ 745) (3 x $ 695)	2,235 4,170 3,000
6	10 staff gauges & enamel plates	Complete with posts struts, to be constructed from concrete and equipped with I metre length plates each suitably calibrated (at $ 134 @)	1,340
7	Communication equipment to relay	3 Computers, software and communication facilities	12,000

Item no.	Description	Requirements/specifications	Estimated cost in USD
	data to central archives and data processing equipment		
8	3 sets of HACH water quality testing kits	Multi parameter water quality meter at $ 2,850 @	8,550

9.3.2 Human capacity and Training needs

Our general observation during field surveys is that due to the nature of their qualifications and training which is biased towards water supply development, all the District Water Offices lack the basic knowledge required to operate the networks and require substantial support. One strategy to overcome this human resources handicap would be to train County Water Officers to assist with local supervision and monitoring of the proposed Networks.

After acquiring the necessary capacity, district staff would be able to engage in the following activities;

Immediate and quick response to flood measurements
Pollution control and water quality monitoring activities
Twice daily discharge measurements for an expanded and improved hydrological monitoring network
Transmit 3-hourly weather data at synoptic stations and build daily records of rainfall data at climatic stations
Carry out delegated functions of enforcing limits of water abstraction, ensuring compliance with waste water discharge limits and preliminary assessments for issuance of water rights

The capacity gaps that need to be addressed are as follows:

Data base maintenance
Meteorology, Hydrology and Water Resources Engineering
Operational and maintenance of the network
Water quality data collection procedures

9.4 Creation of a common hydro meteorological Data Base

Ultimately, all data collected must be stored in a uniform format and desirably be linked to the existing national and international databases. The idea of creating common databases of hydro-meteorological and water quality data is not entirely a new one. In fact, two FAO supported projects have already done a significant amount of work towards the achievement of this objective.

The project GCP/RAF/268/ITA "Operational Water Resources Management and Information System in the Nile Basin Countries" implemented in 1996-1999 aimed at establishing the information base that would provide objective support to negotiations concerning sharing and development of common water resources. This was followed by another project; GCP/RAF/752/ITA "Capacity Building for Nile Water Resources Management" implemented in 2000-2004. Under the latter project, national geo-referenced databases were established based on a decentralized information system where data reside in the individual Nile Basin countries. Data include hydro-meteorological parameters, water use information, spatial layers containing hydrographic features, land use, land cover and soil type. Operational Data-GIS units have been established in all the Nile Basin States. Ideas for creation of a database for the Lake Albert Eastern Catchment Management Initiative should be based on the principals taken into consideration for the development of the national and the wider Nile Basin database.

9.4.1 Database Framework

The project should rely on the existing databases and extend them to cover areas of the project area that are presently not served. The database to be initiated must be closely interrelated and structured for easy integration and retrieval. In order to be identical to the national databases it should take the form of specialised data archival and processing software such as HYDATA, CLICOM, and ACCESS.

The data should be pooled into a common MS Access database structure and be stored at the lowest possible level (daily/sub-daily). It may not contain any additional build-in tools for data analysis, besides the ones that are being provided by the MS Access software itself. The only "tool" that may be incorporated is the functionality to calculate the runoff on daily basis by using the water level data and the Rating Curve Parameters.

The standards agreed upon for the Nile Basin should also be adopted for the project in order to duplicate definition of contents, formats and quality of the information. Figure 9.3 and 9.4 provide an overview of the existing design and structure of hydro-meteorological Nile Basin Database. The objective is to illustrate the structure and desirable features that could be adopted by the project.

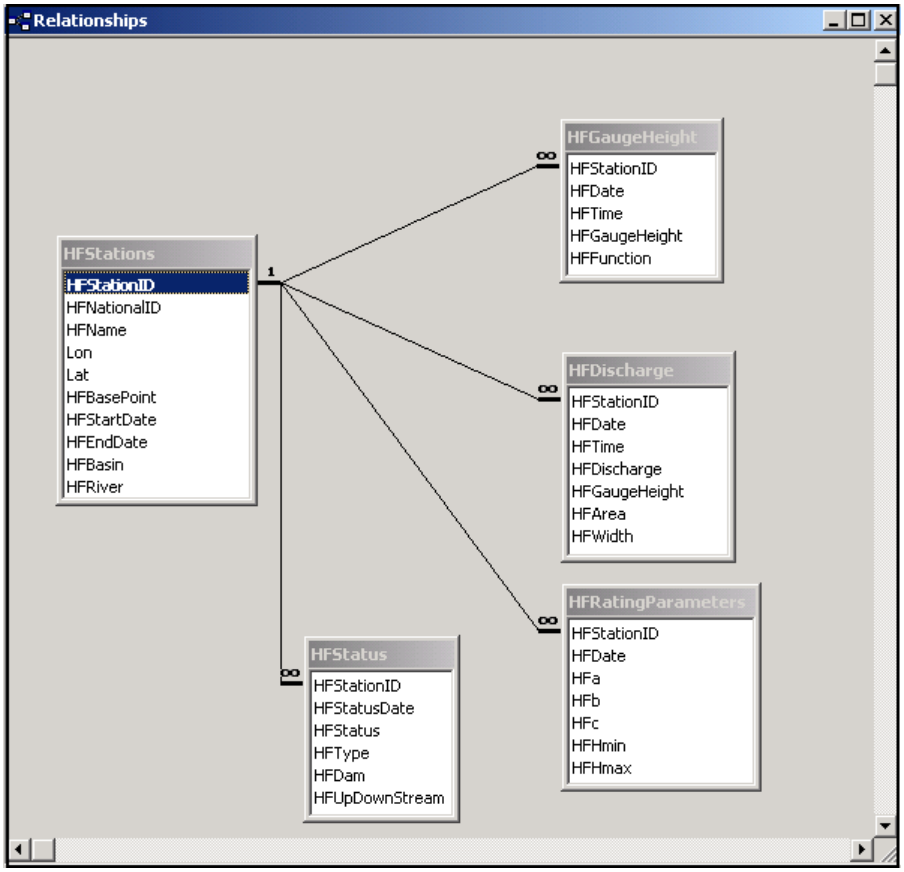


Figure 9-3 Design and structure of the hydrological database

The hydrological database shall contain a stations table (HFStations) and four other tables that contain the following information; water levels (daily or sub-daily), measure discharges, a set of Rating Curve Parameters and the status of the station (type of station, status etc).

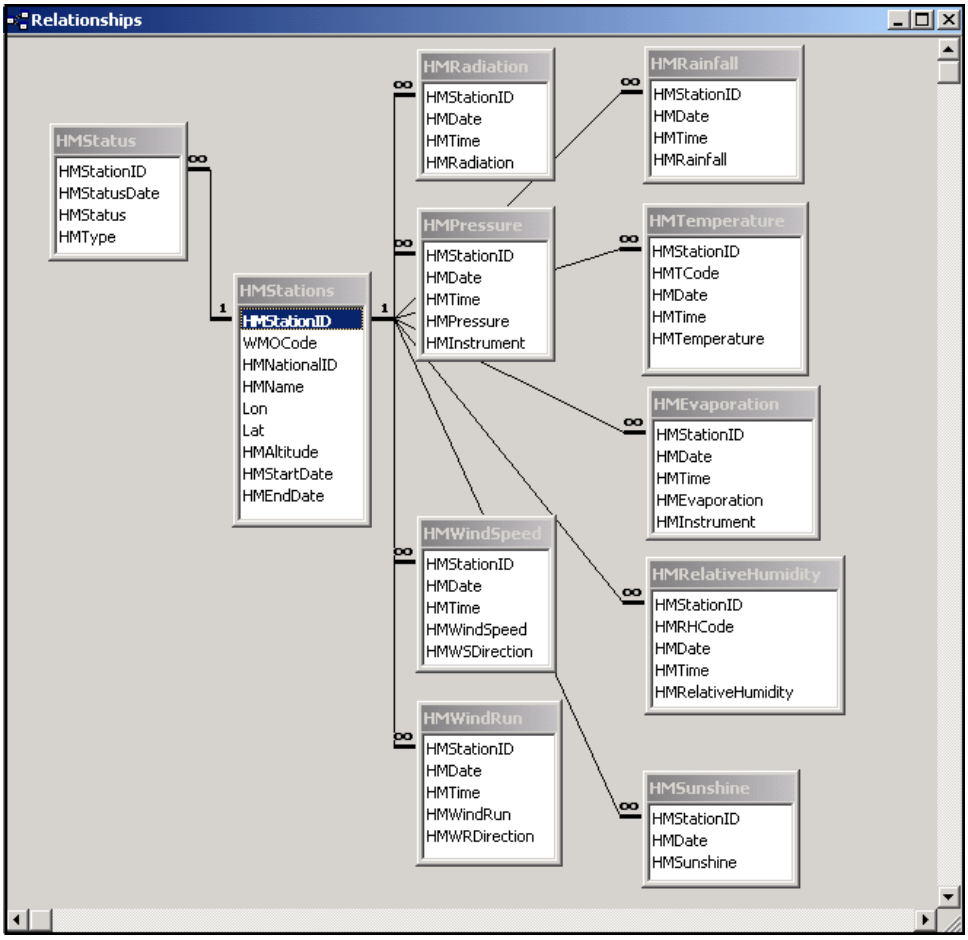


Figure 9-4 Design and structure of the meteorological database

The meteorological database shall also contain a stations table and nine other tables containing the daily and sub-daily data for the following parameters; radiation, pressure, wind speed, wind run, rainfall, temperature, evaporation, relative humidity and sunshine. The validation and quality control procedures of the responsible data generating institutions should be applied.

Data could be displayed by setting up simple queries as illustrated Fig. 9.4.

Query1 : Select Query

HFStationID	HFNationalID	HFDate	HFTime	HFGaugeHeight
100001	81201	01-Jan-48	8:00 AM	10.72
100001	81201	01-Jan-48	4:00 PM	10.72
100001	81201	02-Jan-48	8:00 AM	10.72
100001	81201	02-Jan-48	4:00 PM	10.72
100001	81201	03-Jan-48	8:00 AM	10.72
100001	81201	03-Jan-48	4:00 PM	10.72
100001	81201	04-Jan-48	8:00 AM	10.72
100001	81201	04-Jan-48	4:00 PM	10.72
100001	81201	05-Jan-48	8:00 AM	10.70
100001	81201	05-Jan-48	4:00 PM	10.73
100001	81201	06-Jan-48	8:00 AM	10.74
100001	81201	06-Jan-48	4:00 PM	10.72
100001	81201	07-Jan-48	8:00 AM	10.72

Record: 1 of 37234

Figure 9-5 Detailed lay out of entries

9.5 Review of the Nile Equatorial Lakes Fisheries Project for Lake Albert and Lake Edward

This program assumes special significance to Lake Albert Eastern Catchment Management Initiative due to the opportunity to enhance synergy. The fisheries project will focus on sustainable utilisation of the fisheries and its objective will be to establish a sustainable framework for the joint management of the fisheries in the Lakes Albert and Edward to improve the living conditions of the people and to protect the environment.. There are synergies to be exploited by the two projects in the following areas:

- Identification of issues affecting continued viability of fish biodiversity
- investments in micro-projects to construct or restore small scale community infrastructure
- Catchment pollution survey/water quality management
- Database management
- Socio-economic studies

The project office for this project is in the final stages of establishment. The Fisheries Zonal Officer (Lake Albert) shall be a key resource person in linking the activities of the districts with those of the central project management. It is therefore recommended that Lake Albert Eastern Catchment Management Initiative puts in place a collaborative framework for planning and management with the Fisheries project.

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