SUMMARIES OF RESEARCH FINDINGS UNDER BUFFERING CAPACITY OF WETLANDS SUB-COMPONENT.

1.1: RAPID ASSESSMENT OF WETLANDS AND MAPPING

The aim of the assessment was to identify location, type and size of wetlands in the Tanzanian part of Lake Victoria basin including both fringing and non-fringing wetlands.

Assessment of fringing wetlands has been completed and a report that shows wetland location/distribution, area, threats and social economic values has been produced.

Some preliminary qualitative data on major rivers were collected. Physical parameters of water were measured for the river Mara, Rubana, Mbalageti, Simiyu, Nyashishi and Mahina. Nutrients, and heavy metals were not measured due to delays in procurement of laboratory equipment and chemicals

Mara river had highest water quality compared to all other rivers sampled, probably this was contributed by buffering effect by a big wetland which is associated with Mara river system.

In Mara region, Mara River has indicated higher water quality with respect to Turbidity, Electric Conductivity, Total Hardness and Chloride content compared with Rubana and Mbalageti rivers. This might be due to the reason that, Mara River flows through extensive wetland. In Mwanza region, Simiyu River and its main tributary, Duma has indicated higher values of pH, Electric Conductivity, Total Alkalinity, Hardness and Chloride content than Nyashishi and Mahina rivers. This generally indicates that, Simiyu and Duma rivers have higher mineral content compared to Nyashishi and Mahina. Higher Permanganate Values were also indicated for Nyashishi river compared with the other rivers and this is an indication of higher organic content in the Nyashishi River.

Digital map for land use/cover has been produced. Maps for land use/cover (1:50,000?) have also been produced in collaboration with Institute of Resource Assessment (IRA), University of Dar es Salaam. IRA has produced maps of Lake basin showing current land use/cover features by analyzing satellite imagery. Arrangements to get aerial photographs for fringing wetlands from Survey and Mapping Division have been made and these will be used to trace changes in land use/cover in pilot wetlands.

Topographical maps 1:50,000 provided amongst other feature, information on type and distribution of wetlands in the basin. Although these maps were mostly based on aerial photography from the period 1961-1991, they were found to be accurate, they were therefore the main source of information for the assessment. Additional general data on wetland distribution in the basin was obtained from the 1:500,000 map produced by the then Ministry of Water, Energy and Minerals in 1991.

A 1:500,000 map depicting the four wetland classes recognized on the topographical maps has been produced by manual superimposing on the 1:500,000 base map of lake Zone.

1.1.1 Main draining lines

A total of about 28 distinct individual river systems were identified within lake Victoria basin in Tanzanian part. The main river systems draining into the lake are clockwise between the Kenyan and Ugandan border.

- Mori river originating close to the Kenyan border
- Mara river originating far inland Kenya, Masai Mara and draining into Musoma bay
- Rubana/Grumeti Rivers originating in Arusha close to Kenyan border and enter the lake through the northeastern part of Speke Bay.
- Mbalageti River originating in the eastern limit of Shinyanga Region and flowing into Speke Bay
- Simiyu River with main tributaries, originating in eastern-central Shinyanga Region and draining into the southern part of Speke Bay
- Magogo/Mwame (Maome) River, Isanga River, and the Ikuyu/Munama/Nyaruhwa rivers which enter Mwanza Gulf from the east, south and west, respectively
- Kagera River, originating in Rwanda, and draining into Lake Victoria just north of the Ugandan border; with the Mwisa River as its main tributary.

1.1.2 Distribution of main wetland types within the basin

(i) Permanent swamps

Papyrus, Typha and *Phragmites* communities or combinations of these usually dominate permanent swamps in the basin, and they include

- Mara River mouth, but extending into a widening plain, up to 30 kilometres inland
- Rubana River mouth
- Simiyu River mouth
- fringes of Mwanza Gulf
- fringes of the multi-fingered bays south of Rubondo island, in the extreme south-western limit of the Lake
- Kagera and Ngono river systems.

The total area covered by permanent swamps in the Tanzanian part of the basin is estimated at 57,000 ha. 19,600 hectares (34%) lies in the Mara River swamp, 13,600 hectares (23%) around Mwanza Gulf, and 7,600 hectares (13%) along the southern and south-western limit of the Lake. According to the topographical maps permanent swamps are absent from the western Lake shores, north of Msega Bay. Field visits carried out in the Kagera Region revealed however that several wetlands indicated as "seasonal swamp" on the topographical maps are actually permanent. This has resulted to under estimation of areas covered by permanent swamps and over estimation of seasonal ones. More accurate estimates will be derived from the database (digital maps).

(ii) Seasonal floodplains

Most wetlands in the basin are of this type. Permanent swamps are usually associated with seasonal floodplains extending into the basin, grass- and sedge communities, along with rice cultivation dominate. Common species in these areas for example the Nyashishi floodplain are *Cyperus* spp., *Cynodon* spp., *Scirpus* spp., *Setaria* spp., *Dactyloctenium aegyptium* and the small shrub *Sesbania goetzi* (Katondo, 2001).

The total area covered by this type of wetland in the Tanzanian part of the Lake Victoria basin is estimated at 308,000 hectares. The most significant of such plains are located:

- east of the Mara River swamp (15,000 ha - 4.8%);
- between and around the Rubana/Gurumeti and Mbalageti rivers, extending up to some 60 kilometres inland (about 50,000 ha - 16%).
- Surrounding Mwanza Gulf, particularly in the middle reaches of the Magogo/Mwame (Maome) rivers (25,000 ha), Isanga River (25,000 ha), and Nyaruhwa River. Total cover of this type in the Mwanza Gulf area is estimated at 72,000 hectares - 24%;
- along the Kagera River and its main tributaries (in total 96,000 ha or 31%), i.e.
    - the upper reaches of the Mwisa River draining into Kagera River;
    - the middle reaches of the Kyakakela and Ngono rivers, both draining into Kagera River;
    - Ruzinga swamp associated with lower reaches of Kagera River.

It is to be noted here that part of the seasonal swamps as defined on the topographical maps in the Kagera Region are actually permanent swamps.

(iii) Tree swamps

The estimated total coverage of the Tanzanian part of the Lake Victoria basin by tree swamps amounts to 33,000 hectares. The majority of the identified tree swamps lie in the Kagera Region (9,900 ha; 30%), and around the cluster of relatively small bays in the south-western limit of the Lake, south of Rubondo island (9,700 ha; 29%). Localities where, according to the topographical maps, these tree swamps occur include:

- along the Rubana and Mbalageti rivers in Serengeti National Park, e.g. *Acacia xanthophloea* (Yellow Fever Tree);
- along the Duma River, a tributary of Simiyu River, some 10 kilometres and 40 kilometres inland from the river mouth;
- along the Nyaruhwa River, draining from the west into Mwanza Gulf, i.e. some 10 and 20 kilometres inland;
- around and inland of bays of Luhorongoma, Chenzumla, Bugonde, Ikuga and Nungwe, all located in the extreme south-western limit of the Lake, south of Rubondo island;
- in Kabilkiliro Bay, on the western lake shore - being the only known locality within the basin where this wetland type occurs on the lake fringe;
- within the Kagera River basin:
    - near the confluence of the Kyakakela and the Ngono rivers, both main tributaries of the Kagera; this also includes areas around and in the Ngono study site;
    - in the upper reaches of Mwisa River, north-west of the large Lake Burigi;
    - along the upper reaches of the Ruiza and Kasongenye rivers, being both main tributaries of the Mwisa River; and

- along the Kagera, i.e. amidst hill tracts east of Lake Rushwa, and around Lake Ngoma.

(iv) Open water

With annual rainfall decreasing from west to east in the basin from about 2,000 mm to 700 mm respectively, open water bodies, particularly lakes, mostly occur in the western part of the basin. Significant lakes in the Kagera Region include:

- down the Kagera River subsequently: Lake Ngoma, Lake Rwakanjunju, Lake Rushwa, and Lake Katwe; similar lakes are expected to exist in the Rwandan part of the Kagera River basin;
- the large Lake Burigi in the upper reaches of the Mwisa River;
- Lake Ikimba in the middle reaches of the Kyakakela River.

The only significant open water bodies in the southern and eastern parts of the basin, apart from the Lake itself, lie within the Mara River system, i.e. particularly Lake Kubigena. Total estimated area covered by open water, excluding the Lake itself, is 23,000 hectares.

(v) Overall area covered by wetlands in the basin

Table 5.1 Area of 4 main wetland types in Tanzanian part of Lake Victoria basin

Wetland type	**Area covered (ha)**	**Percentage**
Permanent swamps, mainly reed/*Papyrus*	58,000	14
Seasonal swamps/floodplain	308,000	73
Tree swamps	33,000	8
Open water, mainly inland lakes	23,000	5
Total	422,000	100

1.1.3 Data base establishment

Wetland database development is in progress. All wetlands features on the topographical maps had been digitised in ArcView software and merged. Hard copy maps showing only the wetland features (4 classes) have been printed. After completion of wetland data base the following can be done;

- A comparison between wetland areas in 1994 (date of most map sheets used for the wetland lamp) and the wetlands mapped using the 1999/2000 satellite images.

- Refinement of the calculation of total areas of wetlands per wetland type.

1.1.4 Vegetation surveys

Vegetation surveys at Nyashishi, Ngono and Geita study sites focused on identifying visually the main vegetation communities, and species composition within these. For this, standard and widely accepted methods have been used, such as the Braun-Blanquet Cover scale for assessing species dominance, and the frequency cover of associated species in these main vegetation communities (by the Causton method).

Preliminary results of the vegetation surveys indicate 3-4 main classes that have fairly distinctively been distinguished in the field. These classes and their rating on the Braun-Blanquet Cover scale for the three study sites are given in Table 5. This basically 5-point scale indicates land cover from 1 (land coverage: low i.e. less than 5%) to 5 (land cover greater than 75%).

Table 5.2 Main vegetation communities in the three selected study sites

Study site	**Main vegetation community**	**Braun-Blanquet scale**
Nyashishi	*Cyperus-Typha*	2
	Typha	4
	Cyperus papyrus	5
	Phragmites mauritianus	3
Geita	*Cyperus papyrus*	4
	Mixed *Cyperus-Miscanthidium-Phragmites-Vossia*	2
	Mixed forest swamp-reed-papyrus	2
	Cultivated crop/paddy	3
Ngono	*Miscanthidium*	4
	Mixed *Cyperus-Hyparrhenia-Vossia*	3
	Mixed forest-papyrus swamp	2

Notes: and land coverage as noted during field surveys in March-April 2001, according to the Braun-Blanquet Cover scale: 1 = <5% land cover; 2 = 5-25%; 3 = >25-50%; 4 = >50-75%; 5 = > 75% land cover

1.1.5 BUFFERING CAPACITY PROCESSES STUDIES

Site selection

Four priority wetland sites were selected after the rapid assessment of wetlands in the Lake Victoria regions namely Nyashishi in Mwanza/Missungwi districts, Ngono and Kagondo in Bukoba and Mtakuja and Mabubi in Geita.

The major criteria for selection of the priority study wetlands were:

- Location and accessibility of the sites
- Wetland type
- Representative ness
- Size of the catchments
- Extent of human activity in the catchment areas (reflecting nutrient load entering the wetlands)
- Definable inlets and outlets

Nyashishi, Ngono and Mtakuja and Mabubi were selected as priority sites for modelling purposes. Field surveys were carried out to collect data for the model testing. Water samples were collected from wetlands and analysed for nutrients, heavy metals (Hg, Pb^3, Cu, Ni), TOC/DOC, SS, BOD^5, LOI, cyanide, chlorides EC and pH.

Nyashishi

The Nyashishi Wetland is located in Mwanza and Missungwi districts and is about 15 km south of Mwanza City. The wetland borders Nyanghomango and Mwasonge villages to the south, and located within Missungwi district. The study area of the wetland extends between the bridge on the main Mwanza Shinyanga road to the east and open waters of Mwanza Gulf. The wetland covers approximately 1200 ha of which 500 ha is a permanent swamp. The wetland has two distinct components: an extensive floodplain and a permanent swamp abutting the waters of the Mwanza Gulf. The Wetland is compact, surrounded by hills, with a relatively well-defined edge. It has one obvious seasonal river inflow, the Nyashishi River, subtending two different vegetation zones, i.e. that of the floodplain vegetation and that of the permanent swamp. The surounding communities have converted the seasonal wetland to agricultural and grazing land. The wetland is dominated with *Cyperus papyrus, Typha domingensis* with small patches of *Phragmites mauritianus.*

Ngono

The Ngono Wetland is located in Bukoba District about 20 km from Bukoba town on the western shores of Lake Victoria. It covers approximately 3000 ha. The wetland comprises mainly permanent swamp dominated by *Cyperus papyrus, Typha* with patches of *Cyperus-Typha* and *Phragmites mauritianus* and is well defined by surrounding hills, which are extensively cultivated with coffee and banana.

The study area is a part of a large wetland formed along Ngono River that originates just north of Muhutwe (on the west coast of Lake Victoria) after the Buhingo River meets the Kyebingo Stream. It meanders generally northwards till it meets the Kagera River, some 20 km before it flows into Lake Victoria. Swampy areas along its entire course flank the Ngono River, the main swamps being the Kamanywabake, Ngono, Majuinguizi, Kaigembe and Omukajunguti Swamps.

Geita

The Geita Wetland is located about 20 km northwest of Geita town; the permanent swamp extends to Nungwe Bay along Lake Victoria. The size of the swamp is about 900 ha, and is formed by two arms that join together close to Nungwe Bay. The right arm is associated with a small Mtakuja River while the left arm by the Mabubi River flowing from the adjacent hills, passing through the Geita Forest Reserve and discharging into the Nungwe Bay. The Mtakuja River forms a seasonal swamp while the area originally a seasonal swamp on the Mabubi river has been converted into paddy fields. As the two streams discharge into the Nungwe Bay they form a permanent swamp. *Cyperus papyrus* and mixed wooded grassland-paddy community dominate the wetland. There are also patches of mixed sedge-*Miscanthus-Phragmites-Typha* community and mixed *Forest swamp–reed- papyrus* community. Buffering capacity study for nutrients, heavy metals and cyanide in particular were carried on the Mtakuja and Mabubi Rivers. The Mtakuja river study area is located downstream of a modern large-scale industrial mining applying Carbon In Leach (CIL) method for gold extraction. The tailing dam is few hundred meters from the study site. Cyanide is used in this process and any possible cyanide pollution is likely to be discharged into the Mtakuja River. Mtakuja River also receives the leaching materials from the exposed overburden of both the present and the past mining activities.

The Mabubi River study area is located just downstream of the small scale mining activities at Mugusu village applying mercury amalgamation to extract the precious metal. The processing of gold by the small-scale miners is all done along the river. The mercury loses do end up into the stream, which is diverted into paddy fields for irrigation in the downstream area.

Results

General

The result of this study has given some light on the buffering functions of a natural wetland. The differences in the three selected study areas has been well reproduced in the water quality results, sediment analysis result and vegetation survey.

The flood plain in Nyashishi is an agricultural area used for farming and animal grazing. The permanent swamp is encroached by farmers who cultivate vegetables. With the fast growing Mwanza City, and being so close to the city, the need to use the swamp for agricultural activities would increase. Hunters and fishermen also practice burning of the swamp. Those who harvest papyrus for handcraft materials burn the swamp so that new good shoots may emerge.

Generally the Ngono wetland has the lowest loading of nutrients and pollutants, signifying that the current practices in its catchment do not pose a significant threat to the wetland in terms of pollution loading. Of interest is also the fact that within the Ngono study area there were almost

no disturbances caused by human activities such as farming. There was some encroachment by human activities around Kishenge village where small-scale farming is practiced in the vicinity of the wetland. There were also a small number of animals grazing in the floodplain around Kishenge. This practice is far too small to pose any threat to the wetland although regular burning to encourage grass re-growth may have some local effects. Other areas too at Ngono showed a clear demarcation between the cultivated land and the wetland. This is because Bukoba in general has enough fertile land receiving enough rain for farming. At the moment there is no immediate advantage of doing any farming in the wetland.

The Geita study wetlands are probably the worst affected by human activities. The mining activities in Geita date back to colonial times. Both industrial scale and artisanal mining has been practiced. There is a report of a tailing dam accident that occurred in the 1960s that deposited large amount of the tailing dam contents into the Mtakuja River. The remnants on this accident can be seen in Mtakuja river wetland today. Both the Mabubi and Mtakuja have always been surrounded by artisanal mining activities, which use mercury amalgamation in their process. Moreover, the Geita wetlands are threatened by farming activities, which are converting the swamps into paddy fields. During this study it was observed that there is hardly any natural vegetation at what used to be the Mabubi River swamp downstream of Mugusu village. At present Mtakuja wetland is downstream of a modern gold mining and processing plant, Geita Gold Mine (GGM) while Mabubi wetland receives water used in the processing of gold by artisanal miners at Mugusu. GGM is doing environmental monitoring of water and air in the area

Water Quality

The average water quality parameters have been compared to the Tanzanian Standards (TZS) for Receiving Waters Category 2 and World Health Organisation (WHO) standards. The average water quality parameters for Nyashishi indicated that with the exception of DO all water quality parameters do meet the Tanzanian Standards.

The water quality for Ngono also with the exception of DO meet the Tanzanian Standards for receiving water. The values of DO are however lower than the standard value used in this comparison. It should however be pointed out that the values of DO in Ngono and Nyashishi are normal for floating mat swamps.

For Geita the water quality does not meet the Tanzanian Standards for receiving waters. The mean value of pH at the inlet to Mtakuja study area is outside the TZS limit. Also some of the DO values. The mean values of Ni exceed the standards in all points except the inlet of Mabubi. The values of Hg exceed the standards in the inlet of Mtakuja and outlet of Mabubi.

Vegetation

Vegetation sampling was carried out in the Geita study areas. Reed dominated the upper part of Mtakuja while the lower part was dominated by papyrus. It was therefore decided to sample for the two vegetations predominant in the Mtakuja study area. For the Mabubi study area it was found that most of the natural swamp had been converted into paddy fields, it was therefore decided to sample paddy plants for analysis.

Results have indicated that there is a clear difference in the capacity of different vegetations to accumulate heavy metals. Papyrus accumulates substantial levels of heavy metals. Different parts of vegetation have different capacities of storing heavy metals. Reed stores more heavy metals in the part of plant below the ground surface while papyrus stores more heavy metals in the parts above the ground. On average, 75% of all heavy metals accumulated in reed is located below the ground. Paddy stores at average 50% of heavy metals in parts below ground. In average Papyrus stores 74% of heavy metals in the part above the ground. This has a significant impact especially if plant harvesting is intended to remove the heavy metals. This means papyrus is more feasible in removing heavy metals than reeds by simply cutting the part above the ground.

In this study, rice seeds were found to accumulate mercury but also the other heavy metals. During this study the seed husks were not separated from the kernel so it was not possible to exactly tell the part of seed that contains the mercury. In particular rice seeds closer to the gold processing area at Mugusu were found to contain appreciably high levels of mercury. This is a very important finding especially regarding mercury and lead that are known to cause serious health problems.

Heavy Metals in sediments, soils of Geita

The soils from the wetland have been found to contain high levels of heavy metals. The Cu, Ni and Pb have been carried to the wetland either in sediments and in water as a result of long-term mining activities that has been going on in the area well before the present GGM activities. During mining, the rock is exposed to atmospheric conditions in presence of oxygen and water. Weathering occurs and when the rocks contain pyrite, sulphuric acid is formed. Because of these acidic conditions some metals are leached from rocks and are transported by water. When metal containing water reaches areas of different conditions the metals may then be adsorbed onto sediments and/or released back into aqueous environment. Mercury, on the other hand, results from the artisanal mining activities.

This presence of high levels of heavy metals in soils/sediments can result to accumulation in food plants and other vegetations. Disturbances in the soil by farming for example may create conditions whereby heavy metals are released into the environment from soils.

The wetland along Mabubi River downstream of Mugusu village has been completely converted into paddy fields. Mercury lost during the processing of gold by amalgamation at Mugusu village finds its way to the paddy field, as mercury is transformed from the immobile metallic mercury to soluble methyl mercury. Results obtained in this study indicate a presence of mercury in the rice seeds sampled from the area.

Other areas along the Mtakuja River have also been turned into paddy fields.

It should be borne in mind that although the activities of small-scale mining are small compared to industrial mining the environmental impact that is associated with small-scale mining can be significant. It is much more difficult to exercise pollution control measures among the small-scale miners, and their incomes are so low that investment in pollution control is not possible. In short:

- The heavy metal content in the Geita soils poses a real threat to human health if the wetlands are used for agricultural activities.

- A thorough study must be conducted to assess the distribution of heavy metals in food crops grown in the high risk areas.
- Encroachment of the swamps for agricultural activities should be controlled.

Wetland modelling

A model describing the cycling of nutrients and fate of behaviour of heavy metals in wetlands. The model was developed using DUFLOW. DUFLOW modelling tools for simulation of rainfall runoff (hydrology), hydraulics and water quality. The models have been tested against field data for the three selected study areas. In general the model was able to represent the observed concentration levels reasonably well.

The model was used to analyse the key processes in the wetlands. For nitrogen nitrification, denitrification and degradation of organic matter turned out to be the controlling processes. Adsorption and accumulation in the sediment are the important processes that determine the fate of phosphorous and heavy metals.

For the Nyashishi wetland, edging Lake Victoria, the exchange between the Lake and the permanent swamp turned out to be very important. Due to seiches, large quantities of water are transported into and out of the swamp. The exchange flow brings in a significant amount of oxygen in to the swamp, which is used for mineralisation of organic matter and nitrification. Within the wetland large amount of organic matter are produced, resulting to a net export of organic matter out of the permanent swamp. The production of organic matter also leads to a net export of total nitrogen as a large pat of the nitrogen is organic. For total P there is net retention. The efficiency (based on load) is 30 for the permanent swamp and around 5 % for the seasonal wetland (Table….). Almost all the inorganic phosphorous is retained in the permanent swamp. The efficiency is over 90% . For the seasonal swamp the efficiency over the study period was 60 % for inorganic phosphorous. The efficiency for ammonium was 50 –70 %. However as the model predicts a low denitrification most of the nitrogen is exported as nitrate.

Also for the Ngono wetland there a net export of organic matter. However the export is much lower then for Nyashishi. The Ngono wetland is a low loaded fairly undisturbed system. In Ngono there is net retention of phosphorus.

Table 5.3: Retention efficiency for various wetlands **(in %)**

Wetland system	**Total P**	**Inorganic P**	**Ammonium**	**Nitrate**	**Total Nitrogen**	**Dissolved organic matter**	**Particulate organic matter**	**Suspended Solids**
Nyashishi Seasonal Swamp	5.8	59.8	52.8	-122	-166.9	-342	-202	-42
Nyashishi Permanent Swamp	28.8	92.3	68.8	-79.0	-89.9	-142	-85	+44
Ngono	45.7	63.5	22.1	-34.8	-16	-2.3	-7.6	-2

The heavy metal model was applied for the Mtakuja river in Geita. The model shows no distinct change in the levels of Hg. The levels in the sediment are in equilibrium with the overlying water column. There is a slight decrease of Ni from the sediment. Ni concentration in the sediment are extremely high. For Cu all measurements were below the detection limit so as was also predicted by the model.

Kagondo

The wetland is approximately 3 ha and is about 3 km from Bukoba town on the west of Rwamishenye township along the Bukoba-Kyaka road.

The wetland is characterized with mixed vegetation, the dominant ones being *Miscanthus violacens, Phragmites mauritianus, Vossia cuspidata, Panicum hymenocahnus, Cyperus* spp. and other mixed vegetation. A small stand of *Cyperus papyrus* is found few meters towards the outlet of wetland 2

Kagondo wetland is drained by natural water that has low nutrient. But generally, wetlands in Bukoba are characterised by very low nutrient levels possibly because they not yet significantly affected by human activities. There some activities, which are coming up at Kagondo wetland such as farming, brick making and baking and grazing.

It was observed that the water that flows into the wetlands has low mineral content as reflected from low electrical conductivity, which ranged between 9.7 – 64.6 μS/cm.

The wetland was able to reduce (buffer) significant levels of nutrients from water. Wetland 1 reduced nitrate nitrogen (NO_3-N) levels by 90.7%, TP by 74.3% and SRP increased by 9.3%. I wetland 2 NO_3-N levels were reduced by 64.1%, SRP by 68.7% while TP increased by 25.9%. Trace metals were significantly reduced in wetland 1 but increased from wetland 2. The increase of phosphorus and metals could be due to leaching of wetland soils and from dying plants.

Cyperus papyrus accumulated high levels of nutrients trace metals compared to *Vossia cuspidata*, but both *Cyperus papyrus* and *Vossia cuspidata* accumulated high levels of nutrients in the above ground organs, in *Papyrus* total nitrogen 62.4%, total phosphorus 65.6% and in *Vossia* total nitrogen 60.9%, total phosphorus 74.8%. The above ground of *C. papyrus* also accumulated high levels of manganese (80.4%), lead (61.5%), and zinc (52.2%) while *Vossia cuspidata* accumulated high levels of lead (69%) and zinc (64.7%). High levels of iron were accumulated in roots and rhizomes (91.4% in *Papyrus* and 84.2% in *Vossia*). Selective harvesting can permanently remove nutrients and metals from the system.

The sediments accumulated low levels of both nutrients and trace metals with exception of iron, (total nitrogen ranged from 1.02-2.16 mg/g dry wt. and total phosphorus 0.31-1.28 mg/g dry wt.).

Action Planning

Main objectives, as specified in the Study's Term of Reference, for the Consultancy on buffering capacity of wetlands were to:

i. study the buffering processes and capacity (that is their ability to absorb sediments, nutrients and pollutants) of individual wetlands within the Lake Victoria basin and

ii. recommend wetland management policy in order to reduce the inflow of these nutrients into Lake Victoria. The policy must be maximise wetland buffering capacity while at the same time protect the wetland environment.

Specific duties were;

a. Carry out a rapid qualitative assessment that leads to prioritization (i.e. ranking by size and importance) of individual Lake Victoria basin wetlands which will then allow the consultant to concentrate on the most important areas. The consultants will then have to develop a simulation methodology that could be field tested on several of the priority wetlands as ranked in the first step above.

b. The consultant in conjunction with the LVEMP implementing agency for the component, will identify 2 or 3 wetland areas that would serve as Pilot areas for development of a basic model that estimates the impact of input loads on water quality and quantity, sedimentation rates in the wetland area and the Lake, and on the biological communities of the wetland and the Lake. The simulation model would be another physical deliverable of the consultancy.

c. With background information obtained above, the consultant is expected to make recommendations on how to carry out the following:

    i. An intensive field based program of monitoring of loads into priority wetlands to validate loads and seasonality of water quantity, quality parameters, sediment and biological processes. The consultant will also be required to collect field data through sampling to fulfil the requirement to develop a basic simulation model mentioned in (b) above.

    ii. Identification of the principal individual processes (and their rates) within the priority wetland systems which together constitute the overall buffering function (evaporation, nutrient uptake and sediment retention, pollutant transformation) and the dependency of individual processes on the vegetation/soil/water complex.

    iii. Field-based investigation of the fate of assimilated minerals and nutrients within wetlands, with estimates of the volume of stored Lake-threatening pollutants.

    iv. Estimation of the overall buffering capacity within individual wetlands based on the nature and the extent of the vegetation/soil/water complex.

    v. Categorisation of individual wetlands according to their provision of buffering services to Lake Victoria.

    vi. Simulation of magnitude of change in buffering function associated with the threats to wetland resources.

    vii. Economic evaluation of buffering services provided to Lake Victoria by wetlands.

viii. Production of guidelines and investment proposals for introducing waste water into wetlands.

ix. Production of guidelines and investment proposals for wetland rehabilitation and artificial wetland construction to maximize the buffering capacity of the Lake basin wetlands.

The consultant has carried the duty (a) and (b) including (c) in which the Action plan has been developed for further activities that are to be carried after termination of the study.

SUMMARIES OF RESEARCH FINDINGS UNDER SUSTAINABLE UTILIZATION AND MANAGEMENT OF WETLANDS PRODUCTS SUB-COMPONENT

1. Status of agriculture at Nyashishi, Simiyu, and Mara wetlands (Hongo H.)

Studies showed that:

- crop yields from upland crops are very low
- Farmers tend to use wetlands during the off-season
- The use of wetlands during off-season (dry season) is not sustainable due to poor agronomic practices and lack of extension services.
- Many wetlands are subjected to soil erosion during rainy seasons. This results in siltation and eutrophication to the lake.

Recommendations for wise use:

- Farmers be trained on sustainable utilization of wetlands, includes demonstration projects
- introduction of buffer zones such that at least 50-100m should be left between the fields and the lake.

2. Impact of immigrant livestock grazing in Lamadi and Mbalageti wetlands (Hongo, H., Masikini M, Kisoza L.J. and Kalema V.)

Studies showed that:

- High influx of immigrant pastoral herds from Bariadi district (Shinyanga region) since 1990s.
- The impacts noticeable on flood plains, river estuaries, riverbanks, vegetation cover
- Damages include overgrazing, rill and gull soil erosion, animal trails, soil compaction, deforestation and loss of herbaceous vegetation cover.

Recommendations for wise use

- Peoples' awareness be raised on the conservation of environmental resources
- Mobilisation of the local communities to take increased responsibility on management of the environmental resources

3. Status of wetland soils and their suitability for crop cultivation at Mara, Simiyu, and Nyashishi wetland (Baruti J. and Hongo H.)

The study showed that:

- Wetland soils are loamy and clayey, are imperfectly drained and differ largely from those of uplands. These soils have very low to moderate fertility, nitrogen and phosphorus being the major limiting nutrients.

- Some soils at Mara wetland have rather high levels of exchangeable sodium adversely affecting the growth of many crops. Water from the sub soil bring and accumulate salts on the surface soil, making crop cultivation difficult.
- Wetland soils have a good potential for lowland rice cultivation. Crops such as maize could be grown in seasonal flood plains under improved drainage and water control.

Recommendations for wise use:

- Improvement of the current crop husbandry,
- Maintenance of the wetland along River Mara for ecological functions
- Field demonstration plots be initiated.

4. Vegetation community studies at Rubana and Simiyu (Katondo, J.)

- Wetlands vegetation influenced by flooding regimes that results in seasonal and permanent wetlands
- Seasonal wetlands at Rubana dominated by Acacia seyal and grasses (Themeda, Penissetum mezianum). Scattered shrubs (e.g. A. drepanolobium, Balanites) common. Impact of local people on tree density is highly pronounced.
- Seasonal wetland at Simiyu dominated by reeds and a mosaic of shrubs
- Permanent wetlands at Rubana and Simiyu wetlands dominated by *Cyperus papyrus*. Associated with other sedges, ferns, cattails, reeds, climbers, and grasses. Floodplain with grasses, shrubs, trees.
- Over 250 species of plants occur at Smyu wetland
- Impact of fires is widely spread and affects succession and ecological balance of flora and fauna

5. Status of Cyperus papyrus at Rubana and Simiyu wetlands (Katondo, J.)

- Used commercially for mat making, packaging materials, brooms. Non-commercial uses: fuelwood, construction, cookery. Harvesting sustainable.
- Mats are used as for various purposes: vending carpets, pubs, home seats, beds, ceiling, etc. Some weavers produce mats of low quality.
- High production and marketing of mats: May - September. However low – lack of eqpt (tools, transport)
- Simiyu weekly production during peak: 500 - 1200 mats, price Tshs 130-200: sold mainly to middlemen who retail them in Mwanza City, Bariadi, Shinyanga, etc.
- Rubana weekly production btn 200 – 400, max. Tshs 100,000 (100USD). Sold to Bunda, Guta, Bariadi, etc.
- Mainly family job; training by friends and mothers. Women lead.

- Problems include threats from snakes, mosquitoes, hippos, crocodiles, drowning, leeches, bees, and scarcity of harvestable papyrus materials. Also conflicts with other users.
- Threats: burning, conversion, bad harvesting. Decline in abundance/coverage of papyrus.

Recommendations*:*

- Habitat management – control burning, conversion, overgrazing.
- Establish rotational harvesting - in blocks
- Awareness on wise use and conservation – farmers, fishers, livestock
- Increase and sustain production & sells of high quality mats and other crafts: equipment, training, selling centres.

6. Marketing of majamvi-mats and other handicraft goods in Musoma, Bunda, Magu and Mwanza districts (Katondo, J.)

- Over 10 types of handicraft goods are sold, e.g. mats (majamvi, mikeka, virago), hats, baskets, ungo, packaging materials etc. Majamvi mats dominate.
- Sold at weekly open markets and personal home markets.
- The main source of mats in Musoma - Mara; Bunda - Rubana, Mwanza - Simiyu. High sells May – September.
- Problems middlemen: cumbersome to collect mats from homes; supply of mats is generally low, uncertain.

Recommendations

- Permanent village buying/selling centres be established
- High quality products should be made

7. Utilization and conservation status of Wild date palm (Phoenix reclinata) at Kagera-Minziro wetland (Katondo, J.)

- Production of mats is high during dry seasons; 1 mat – 2weeks, mainly women job.
- Mats sold to customers from within Kagera region Mwanza, Dar es Salaam, Uganda and Burundi. ELCT major customers.
- Problems – harvesting: wildlife conflicts (crocs, snakes, buffalo), thorns, conflicts with Forest staff
- Threats: bush fires set by Waralo pastoralists from Uganda and hunters; conversion, bad harvesting practices and felling for pit latrines and charcoal. Continued decline in abunace.

Recommendations*:*

- Habitat conservation – control threats, dialogue with forest staff.
- Restoration of palms – planting in selected areas
- Promotion and sustainability of marketing of palm-mats

. Impact of artisanal fisheries on wetland biodiversity at Simiyu and Rubana wetlands (Katondo, J.)

- Fishers well knowledgeable of wetland fauna (birds, mammals, reptiles
- Ten species are important to artisanal fishers (e.g. *Schilbe*, *Labeo*, *Alestes*, *Synodontis*, Cichlids, etc). Gears used are mainly gillnets with mesh size 1-3 inches and weirs.
- Fishing depth is usually 3 to 5 cubits. Fishing is also done in the main rivers and floodplains during heavy rains. Fishing methods are not sustainable.
- Snakes, monitor lizards, and waterbirds (cormorants, pelicans, etc) are frequently caught in gillnets.
- Problems: conflicts with crocs, hippos; gear theft, water hyacinth
- Proposed many species for conservation – hippos, birds, fish

Recommendations

- Establishing protected or nature reserve in the wetland,
- Protect wetland fishes: breeding grounds, avicides, illegal fishing
- Training, awareness, and seminars on improved fishing

9. Perception of livestock keepers on values and conservation status of wetland biodiversity at Rubana and Simiyu wetlands (Katondo, J.)

- Herdsmen knowledgeable of wetland biota: grasses/pastures, animals, birds, and snakes. Many species identified using vernaculars.
- Grazing mainly during dry seasons (July – October)
- Noted decline in abundance of suitable pastures. Grazing is not sustainable.
- Problems: attacks by crocodiles, snakes, and hyenas especially at Rubana.

Recommendations

- Establish grazing areas/rangelands
- Regulatory mechanism: by-laws, procedure for immigrants

10. Wetland birds at Kitaji, Rubana, Simiyu and Mwanza (Katondo, J.)

- Over 90 species of birds identified. Many occur at Rubana and Simiyu wetlands, where habitat diversity is high.
- Kitaji and Mwanza wetlands - wintering sites for some palearctic birds.
- Mwanza city – major breeding/roosting sites for cormorants. Highest population of Marabous in the world.
- Rubana and Simiyu support rare, endemic and threatened species. These habitats are threatened by burning, aerial spraying of avicides.
- Water hyacinth – favour some species e.g. Little egrets, jacana
- Some species are crop pests, e.g. weaverbirds, doves.
- Tourists from Serengeti showed interest in touring Rubana wetland.

Recommendations

- Protect breeding habitats
- Promote ecotourism, especially in Mwanza city, Rubana, and Kitaji wetlands.

11. Environmental problems and community-based strategies at Rubana and Simiyu wetlands (Katondo, J.)

Studies involved questionnaires with village government leaders from all nine villages bordering Rubana and Simiyu wetlands. The study showed that:

- The main environmental problems: wild fires, deforestation, illegal fishing, erosion, wetland degradation.
- Land tenure – many families own plots in wetland
- Many villages have by-laws and committees for environmental conservation.
- Achievements n each village variable.

Leaders provided the following recommendations on wise use and management of wetland resources:

(a) Recommendations for sound environmental management:

- Environmental Committees should be trained on environmental management issues;
- Environmental Committees should be provided with facilities and incentives;
- Seminars on environmental issues should be conducted to local communities;
- Environmental committees should be established in villages where they do not exist;
- Micro-projects should be initiated to improve income of local communities.

(b) Recommendations for sustainable agriculture in wetlands:

- Promote agro-forestry
- Farmer Groups should be formed
- Irrigated agriculture should be promoted and inputs provided
- Maintain land allocated for agriculture

(c) Recommendations for sustainable grazing in wetlands

- Every village should allocate grazing land (rangeland);
- Livestock keepers should be educated on wise grazing;
- Livestock keepers should reduce excess cattle. Introduce dairy farming.
- Immigrants should be controlled.

(d) Recommendations for sustainable harvesting of macrophytes in wetlands

- Seminars should be conducted to sensitise local communities to stop wild fires;
- Harvesting of macrophytes should be done systematically using modern facilities;
- Modern traditional conservation areas i.e. *'ngitiris'* should be established;
- Special areas should be allocated for harvesting of macrophytes (reeds and papyrus);

(e) Recommendations for sustainable fishing and conservation of fauna in wetlands

- Hippopotamuses and crocodiles should be controlled to prevent conflicts with communities
- Sustainable cultivation that ensures protection of wildlife.
- Wetland conservation areas should be established

3. **WAY FORWAD**

3.1: IMPLEMENTATION OF MANAGEMENT PLANS:

(i) Buffering Capacity:

Interventions will be carried out at four pilot wetlands (Nyashishi, Geita, Ngono, and Kagondo) once Mitigation measures have been developed.

(a) Nyashishi wetland

The communities living around have converted the seasonal wetland to agricultural and grazing land. In this case its contribution to buffering function is very low (5% for total P). Rehabilitation of the above is necessary to improve its buffering function.

Therefore modification of the upstream river flow by:

- Developing wetland management strategy
- establishing embankments, which will allow water to spread to a wider area and
- planting useful vegetation/macrophytes for animal feeding and other uses between the embankments. By so doing will check the water flows (speed), reduce pollutants fluxes and provide high retention time for the buffering processes to take place.

Concurrent with the above activity awareness seminars have to be conducted to the surrounding communities on sustainable utilisation of wetlands.

(b) Geita wetland

The Geita Wetlands are facing the following environmental problems that need attention in terms of monitoring:

- Floodplains being converted into paddy fields
- Large scale mining in an area with pyrite rocks thus generating Acid Mine Drainage (AMD)
- Small scale mining releasing Hg into the environment.

It is recommended that more studies should be conducted to evaluate the accumulation of heavy metals in food plants and their ultimate effect so that appropriate measures may be taken.

Some of the measures that can be taken after getting all the facts:

- Preventing further conversion of wetlands into agricultural land.
- Rehabilitation of the land contaminated with mercury
- Controlling the use of mercury among small-scale miners.

The Mabubi river system to be rehabilitated. Areas downstream artisanal miners to be planted with machophytes such as *papyrus/reeds* and trees, which can be harvested for building purposes or others.

Conduct awareness seminars to communities who use the flood plain for agriculture on the dangers of mercury and other metals that have accumulated in the soil and some being

accumulated in food plants and convince them to stop cultivating that area. The area need to be replanted with vegetation and given time to regenerate to a wetland as was before its conversion.

(c) Ngono

Ngono wetland is not yet impacted by human activities, therefore continuation of the monitoring exercise for Ngono is important and will provide information on important processes happening in the Ngono type wetlands.

Conduct awareness raising workshops to the surrounding communities on the sustainable use of wetlands and develop management strategy for the wetland

(d) Kagondo

The wetland still receives less polluted water from its catchment meaning that there are fewer disturbances in the area. Small farmers especially in dry seasons and brick makers have invaded the wetland. It is proposed to conduct awareness raising workshops to communities of Bukoba district on the sustainable uses of wetland, and then develop management strategy to prevent further destruction of the same.

(ii) SUSTAINABLE UTILIZATION

Most of interventions will be based on Management Plans to be adopted by the local communities at Rubana and Simiyu wetlands. The plans/strategies clearly stipulates measures to undertaken so as to improve income and conservation of wetland biodiversity.

(a) Socio-economic (poverty alleviation, employment and income)

- Support to various groups of crop and vegetable growers in the fringing wetlands to improve yields per unit area and increase seasonality of production (say producing crops twice a year instead of once ie use small scale irrigation scheme to irrigate either crops or vegetables).
- Help farmers to organize reliable market as market of farm produce was identified as one of the major problems. This will be achieved by advising farmers to plant particular vegetable or crop at the same time so that they are harvested at the same time in large quantities to attract buyers.
- Support to livestock keepers (provision of advises especially on reduction of the size of herds so that herds size can match with pasture in a given area (carrying capacity) and help construct deeps or provision of education especially on animal health to improve animal husbandry).
- Support ecotourism projects for organised Groups at Rubana and Kitaji wetlands by providing boats, engines, binoculars, building hides, etc. Tourists have already shown interest in visiting these areas that have abundant wildlife.
- Support local artisans who are involved with utilization of papyrus for craftwork. Assistance is need in training on making high quality handicraft goods, securing reliable markets, establishing permanent selling centres, and harvesting equipments.

- Introduce fish culture in seasonal and permanent wetlands.

(b) Environment:

Environmental conservation will be improved through adoption and implementation of strategies for sustainable use and management of wetlands resources, i.e. fish, wildlife, forest, agriculture, etc. The following measures will be implemented in collaboration with local stakeholders and district personnel:

(i) Wetland fisheries resources

The current fishing practice that involves use of illegal methods (e.g. weirs, under-mesh gillnets, beach seines) threatened biodiversity in wetlands. The component will work in synergy with the Fisheries staff to:

- Prevent illegal fishing practices.
- Protect fish breeding areas
- Prevent burning of swampy wetlands
- Support Conservation Groups (e.g. BMUs)

(ii) Wetland wildlife resources

Wetlands support many species of wildlife, including birds, hippos, crocodiles, sitatunga, snakes, monkeys, bushpigs, monitor lizards, and otters. These are threatened by human activities such as habitat destruction (burning, agricultural encroachment, etc.) and poaching. Measures are needed to protect wildlife by:

- Preventing burning and other habitat destructive activities
- Rehabilitating and restore wetland habitats
- Preventing poaching and illegal hunting
- Establishing conservation areas

(iii) Wetland forest and macrophytes resources

Macrophytes include higher plants such as trees, shrubs, papyrus, reeds, cattails and grasses. These plants are widely used by local communities for various purposes including construction, fishing, fuel, and craftwork. Therefore in order to sustain these resources, efforts will be geared towards:

- Preventing burning/bush fires
- Planting trees at homes, farmlands, and degraded floodplains
- Allow natural regenerations in degraded floodplains
- Follow rotational harvesting of papyrus, reeds, and other trees

(iv) Agriculture (crop cultivation)

- establishing buffer zones of at least 50-100m from the lakeshore or 10-20m from river banks to their fields and plant either elephant grasses which can be used as pasture for livestock or sugar cane and even trees for various use in this band.
- good agronomic practices to avoid destruction of wetlands. When wetlands are converted to cropland most of the indirect benefits of wetlands are lost, especially if wetland is drained. The impact of cultivation can be reduced if practices characteristic of low input and traditional cultivation are followed or adopted. Traditional cultivation includes: planting crops which are tolerant of water logging hence minimizing the need to drain, tillage and harvesting by hands, no use of pesticide and artificial fertilizers and; not planting extensive areas but leaving indigenous vegetation between cultivated patches.
- The component should open more demonstration plots at least one in each pilot village to demonstrate sustainable and wise use of wetlands. This will include supply of small water pumps at least two in each village. Tamau, Nyatwali and Bubinza are shown to be very much interested. These villages should get priority if possible
- Conduct seminars and advise farmers to:
    - Stop cultivating in permanent swamps.
    - Reduce the amount of soil disturbance by adoption of minimum tillage
    - Stop drainage of wetlands for crop cultivation
    - Adopt ley–cropping (practice of planting a plant cover to protect soil from erosion).
    - Stop the practice cultivating same area every season (leave cultivated fallow but vegetated periodically).
    - Adopt planting of perennial pastures where possible.
    - Add organic matter on to the soil in the form of mulch.
    - Reduce use of artificial fertilizers and pesticides.

(v) Grazing in wetlands

Grazing capacity in wetlands is 1.5 times higher than in a non wetland area and grazing in wetlands encourages biodiversity, hence its useful but the communities will be advised to;

- Stop grazing in wetlands when soils are wet or water logged,
- Avoid grazing in stream source wetlands on steep slope settings, as they are prone to erosion,
- Avoid grazing in erodable banks, slopes and dam walls,
- Fix a rotation of 14 days in and 24 days out of wetland,
- Allow a full growing season to rest every 4 years,

- Graze 0.75 of wetland excluding one quarter (0.25) from stock on an annual rotation basis.

(c) Research

(i) Nyashishi and Geita: implement activities as indicated in the action plan prepared by the international consultant:

- A field-based programme of monitoring in wetlands;
- Investigation of assimilated minerals and nutrients in wetlands;
- Guidelines and investment proposal for discharge of wastewater into wetlands;
- Guideline and investment proposals for wetland rehabilitation and artificial wetland construction;
- Proposals for needed policy change.
- Identification of principal buffering processes;
- Wetland categorisation and estimation of overall buffering capacity of wetlands;
- Economic evaluation of buffering services of wetlands.

(ii) Rubana and Simiyu wetlands

- Monitor crop yield in demonstration projects
- Monitor marketing of mats in Mwanza city and Musoma.
- Monitor species diversity of plants and birds
- Monitor production levels of mats made from papyrus
- Monitor survival and growth rate of date palms (*Phoenix reclinata*)

(iii) Other wetlands

- Select at least one pilot wetland in other 10 districts (Tarime, Musoma, Misungwi, Geita, Muleba, Ukerewe, and Bukoba and undertake Participatory Wetland Appraisals to collect baseline data.
- Develop management strategies/plans for specific wetlands
- Develop strategy for sustainable utilization and management of wetlands in Lake Victoria basin.

(d) Capacity building

Capacity building will be done through seminars, study tours, workshops, and short courses. Target groups include

- local stakeholders,
- district personnel
- implementing institutions