1 Introduction

Lake Victoria is the second largest freshwater lake in the world and holds the world’s largest freshwater fishery largely based on the introduction of Nile Perch, which supports an economically and socially important export fishery for the riparian countries around the lake. The lake hosts 500+ cichlids species, the lake basin supports about 30 million people, and it is the source of River Nile. The threats facing the lake are eutrophication, overexploitation of fisheries, introduced exotic species, toxic contamination, and climate change. The population in the catchment is growing rapidly and the lake itself attracts people because of the economic opportunities it offers. The residence time of the lake is 23 years while the flushing time is 123 years. Because of the long retention time of the lake, pollutants entering the lake remain in the lake for a long time.

Domestic and industrial wastewater, solid waste, sediments due to soil erosion from the catchment area, agricultural wastes and atmospheric deposition are the major sources of pollution to the lake. Parts of Lake Victoria, especially deeper areas, now are considered dead zones, unable to sustain life due to oxygen deficiency. The threats facing the lake have caused considerable hardship for the populations dependent on the lake for their livelihoods and have also reduced the biodiversity of the lake’s fauna, most notably the phytoplankton and fish.

As is often the case with ecological problems, the challenges facing the lake do not recognize jurisdictional boundaries. Addressing these issues effectively and in a sustainable manner calls for an ecosystem-oriented approach that includes cooperation among all countries in the lake basin. Key to this approach is the availability of useful and timely data and information on the physical and biological state of the lake and the socio-economic factors in the basin. Such data and information have been gathered through several projects that have been undertaken on the lake.

One of the major initiatives undertaken by the three riparian countries to reverse the deterioration of the lake is the Lake Victoria Environmental Management Project (LVEMP) Phase I whose major objective is to restore a healthy, varied lake ecosystem which is inherently stable and which can support, in a sustainable way, the many varied human activities. LVEMP Phase I was funded by International Development Association (IDA) and Global Environment Facility (GEF) and became operational in 1997. It was completed in 2004 and Phase II is currently under preparation. The total funding for Phase I was USD 75,
636,000, of which the three riparian states contributed 10% (LVEMP, 2003). The project components included management and control of water hyacinth, improvement in the fisheries management and fisheries research, water quality monitoring, management of industrial and municipal wastes, conservation of biodiversity, catchment forests and wetlands, sustainable land use practices, and capacity building.

The riparian governments have started to coordinate their responses to the management of the fisheries sector, but have yet to develop a coordinated plan of action for managing the lake and its catchment across all sectors. However, the recent formation of the East African Community (EAC) and the development of its Protocol for Sustainable Development of the Lake Victoria Basin are the beginning of such a response. In spite of these recent, positive developments, there remains a tension between managing the lake to benefit the riparian communities and managing the lake to benefit the downstream countries of the Nile. This issue is currently being addressed by Nile Basin Initiative (NBI), a forum that brings together all the ten countries in the Nile Basin.

2 Background

Lake Victoria is the world's second largest freshwater lake by surface area, second only to Lake Superior. It is bordered by Tanzania, Kenya and Uganda. It stretches 412 km from north to south between latitudes 0°30'N and 3°12'S, and 355 km from west to east between longitudes 31°37' and 34°53'E. The lake is situated at an altitude of 1,134 m above sea level. It has a volume of 2,760 km³ and an average depth of 40 m. The maximum depth is 80 m. Lake Victoria is the largest lake in Africa, with a surface area of 68,800 km² and a catchment area of 193,000 km². Table 1 shows the morphometric data for the lake. Burundi and Rwanda, although not riparian, lie within the catchment of the lake. The lake contains numerous islands and has a highly indented shoreline estimated to be about 3460 km long. Figure 1 shows the catchment area of the lake. The flushing time (volume/average outflow) is 138 years and the residence time is 21 years.

Table 1. Morphometric data for Lake Victoria (Andelic[VM1] 1999)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface area</td>
<td>68,800 km²</td>
</tr>
<tr>
<td>Catchment area</td>
<td>193,000 km²</td>
</tr>
<tr>
<td>Volume</td>
<td>2,760 km³</td>
</tr>
<tr>
<td>Average depth</td>
<td>40 m</td>
</tr>
<tr>
<td>Maximum depth</td>
<td>80 m</td>
</tr>
<tr>
<td>Altitude above sea level</td>
<td>1,134 m</td>
</tr>
</tbody>
</table>

Figure 1. Lake Victoria and its Catchment area

2.1 Drainage Basins

The main rivers flowing into the lake from the Tanzanian catchment are Mara, Kagera, Mirongo, Grumeti, Mbalageti, Simiyu and Mori (LVEMP 2001). From the Kenyan catchment, the main rivers are Nzoia, Sio, Yala, Nyando, Kibos, Sondu-miriu, Kuja, Migori, Riaria and Mawa, while from the Ugandan catchment the main rivers are Kagera, Bukora, Katonga and Sio (LVEMP 2003). The Kagera, which drains Burundi and Rwanda and part of Uganda, is the single largest river flowing into the lake. However, rivers entering the lake from Kenya, which contains the smallest portion of the lake, contribute over 37.6% of the surface water inflows (Table 2). About 86% of total water input falls as rain and evaporative losses account for 80% of the water leaving the lake (Okanga 2001; COWI 2002). The mean annual rainfall based on rainfall data from year 1950 to 2000 ranges between 886 mm to 2609 mm. The mean evaporation rate over the lake ranges between 1108 to 2045 mm per year (COWI 2002).
The Nile is the only surface outlet from the lake, with an outflow of 23.4 km³/y (Mott MacDonald 2001). The long term average discharges from the river basins in the catchment based on data from year 1950 to year 2000 are as shown in Table 2.

**Table 2. Long term average discharge from river basins in Lake Victoria catchment area (COWI 2002)**

The mass balance of water in the lake based on the inflow and outflow is as shown in Table 3. The outflow in the White Nile is correspondingly larger than the inflow from the catchment. The sum of the flows gives a small positive inflow of 33 m³/s which accounts for the observed rise in the lake water level of about 1.0 m between January 1950 and December 2000 (COWI 2002). However, the annual fluctuations in levels range between 0.4-1.5 m (Balirwa 1998).

**Table 3. Average inflows and outflows from Lake Victoria (COWI 2002)**

The topography around the lake is flat allowing satellite lakes and wetlands to predominate. The catchment area of Lake Victoria is slowly being degraded due to deforestation. Deforestation, coupled with bad agricultural practices, has degraded the soil leading to siltation in the lake. Agro-chemicals and industrial effluents are polluting the lake, while deforestation, soil erosion, and increasing human and livestock populations have all contributed to increased nutrient loading to the lake.

### 2.2. Socio-Economic Setting

The population of the lake basin is about 30 million, which constitutes about one third of the population of Kenya, Tanzania and Uganda that is estimated to be 90 million. The lake basin provides resources for the livelihoods of the population living in the basin. The lake is used as source of food, energy, drinking and irrigation water, shelter, for transport, and as a repository for human, agricultural and industrial waste. The lake basin resources also provide amenities for cultural activities as well as leisure for the people. Over 70% of the population within the catchment area of the three riparian countries is engaged in agricultural production mostly as small scale farmers for crops such as sugar, tea, coffee, maize, cotton, horticultural products, and livestock keeping. Lake Victoria supports the most productive freshwater fishery in the world with annual fish yields in excess of 500,000 tons worth USD 600 million annually. The fisheries of the lake are dominated by two introduced species, Nile perch *Lates niloticus* and Nile tilapia *Oreochromis niloticus*, and one native cyprinid *Rastrineobola argentea*. Nile perch is the basis of a lucrative export industry supporting about 30 fish processing factories in the three countries. The rate of population growth of the riparian municipalities of the three countries stands at above 6% per annum and is among the highest in the world.

The lake is the source of the White Nile and thus, is an important asset for all countries within the Nile Basin. The waters originating from the lake provide hydropower through its only outlet, the Nile River, at Owen Falls in Uganda and other power plants lower down the river. The power from the two plants at Owen Falls provide 260 MW, part of which is exported to Kenya. These waters also support extensive irrigated agriculture schemes in Egypt, ecological values in the Sudan and other wetlands, an important tourism industry on the Nile River, and navigation and transport over large distances in the lower river.
3 Biophysical Environment

3.1 Water Quality

The lake ecosystem has undergone substantial, and to some observers alarming changes, that have accelerated over the last three decades. Massive blooms of algae have developed, and have come to be increasingly dominated by the potentially toxic blue-green variety. The transparency has declined from 5 meters in the early 1930s to 1 meter or less for most of the year in the early 1990s. Waterborne diseases have increased in frequency. Water hyacinth, absent in the lake as late as 1989, has begun to choke important waterways and landings, especially in bay areas in Kenya and Uganda. Over-fishing and oxygen depletion at lower depths of the lake threaten the artisanal fisheries and biodiversity (over 200 indigenous species are said to be facing possible extinction). These extensive changes have been attributed to the introduction of Nile perch that has altered the food web structure, and also to increased input of nutrients to the lake that results in eutrophication.

Land use has intensified and human and livestock population increased, especially along the lakeshores and on the islands in the lake. Increased pollution from municipal and industrial discharges is visible in some of the rivers feeding the lake and in urban areas along the shoreline such as Kisumu, Mwanza and Kampala. Among the sources of pollution are a number of basic industries such as breweries, tanning, fish processing, agro-processing and abattoirs. Small-scale gold mining is increasing in parts of the Tanzanian catchment, leading to mercury contamination. Increased nutrient flows result from sediments eroded from the catchment, burning of wood-fuels, and human and animal waste from the areas surrounding the lake.

One of the major challenges facing the management of Lake Victoria is the proper quantification of nutrient loading to the lake. This section of the report gives the quantification of the pollution loading to the lake undertaken under LVEMP.

3.1.1 Pollution loading due to urban wastewater and runoff

The LVEMP study on pollution loads (COWI 2002) indicates that there are 87 large towns in the Lake Victoria basin with respective numbers in Kenya, Tanzania and Uganda being 51, 30 and 6. The pollution loading to the lake originating from the urban areas is shown in Table 4.

Table 4. Pollution loading to Lake Victoria due to urban wastewater and runoff

The data in Table 4 considered a reduction of loading through other methods of treatment by 50%. The reduction of pollution loading through the river system before reaching the Lake was not included. Figures 2-4 show the distribution of point sources of pollution resulting from urban development (COWI, 2002). A different study by LVEMP indicated that the pollution loading to the lake from the urban areas was 6,955 t-BOD/y, 3028 t-Total-N/y and 2,686 t-Total P/y (Wastewater Report 2001). These figures represents the pollution loading from the urban areas close to the lake shore without consideration of the pollution loading originating from towns located far away from the lake shore and which drain in lake Victoria via streams and rivers.

Figure 2. Distribution of point sources of pollution, BOD (kg/day) (COWI 2002).
3.1.2 Pollution loading due to industrial activities

The pollution loading to the lake due to the industrial activities in the catchment area is as shown in Table 5. The total number of industries in the catchment area is 68, of which 16 are in Kenya, 34 in Tanzania and 18 in Uganda (COWI 2002). The pollution loading to the lake originating from industries was estimated based on the production rate or amount of water used.

Table 5. Industrial loading to Lake Victoria (COWI 2002)

3.1.3 Pollution loading due to rivers

Rivers carry soil eroded from the catchment area to the lake and hence at their outlets the water is more turbid and shallow than other parts of the lake. For example, Winam Gulf is comparatively shallow, having a maximum depth of 35 m and a mean depth of 6 m. Generally the gulf is more turbid than the main body of the lake and its waters less productive. The input of nutrient loads from the rivers located in the catchment area is 49,509 t Total-N/y and 5,693 t Total-P/y as shown in Table 6.

Table 6. Annual loads of nitrogen and phosphorous to Lake Victoria from River Basins

3.1.4. Pollution loading due to atmospheric deposition of nutrients

Atmospheric deposition can be divided into wet deposition, i.e. the deposition of nutrients washed out by rain, and dry deposition which is deposition onto the water surface from the air during dry weather periods. Due to lack of special sampling equipment for dry deposition, a simple method involving analysing the increase of nutrients in distilled water exposed in a bucket for a certain time was applied (COWI 2002). For the estimation of atmospheric deposition the lake was divided into 17 rain boxes for which the annual average rainfall could be calculated individually (Figure 5).

Figure 5. Location of rain boxes and load points

Table 7 shows the average results of estimates of atmospheric deposition of pollutants to the lake. The estimated total loads from are 102,000 t/y of Total-N and 24,000 t/y of Total-P. These values are close to what was initially estimated by a model study (COWI 2002), and indicate that the atmospheric deposition is far the most significant contribution to the overall nutrient budget of the lake.

Table 7. Estimated annual atmospheric deposition of N and P to Lake Victoria

Table 8 summaries the sources of pollution loading to Lake Victoria and the relative contribution of each source. As shown in Table 8, atmospheric deposition has been shown to be the major source of pollution to the lake. The results indicate that total atmospheric
deposition (wet and dry deposition) contribute about 45% and 64% total nitrogen and total phosphorus loading, respectively. Thus, changes in farming, land utilization, industrial activities and forest management will give significant impact on reduction of pollution loading to the lake due to atmospheric deposition. It should be noted that some local scientists have disputed the high nutrient loadings attributed to atmospheric deposition.

Table 8. Annual external nutrient loading to Lake Victoria (Modified from LVEMP, 2003)

3.1.5. Nutrient mass balance

The load of nutrients buried in the sediments was calculated using a mass balance approach. This gave an amount of 20,100 t/y of phosphorus being buried in the sediments (Figure 6) and 502,900 t/y being released by the sediments into the water column. The same calculation based on the present study’s load estimates for nitrogen gives a net deposition of 73,400 t of nitrogen in the sediments (Figure 7). However, this may be a low estimate given that the N:P ratio is known to be about 10:1.

Clearly, the nutrient mass balance still needs to be refined – the terms with the greatest uncertainty are estimates of atmospheric deposition and the nitrogen fixation and denitrification rates. Moreover, sediment flux experiments would strongly support the understanding of exchange of nutrients between the sediments and the water column. However, the preliminary mass balance gives a sufficiently realistic estimate of the relative importance of the different sources of nutrients to act as a guide to management action. The data show clearly that the areas which are highly affected by eutrophication are those near the lake shore such as Winam Gulf, Murchison Bay, Napoleon Gulf, and Mwanza Gulf. The present study has measured 170 µg/L of chlorophyll-a in Mwanza Gulf and a study on Murchison Bay in 1997 measured up to 300 µg/L chlorophyll-a. For comparison, Talling (1965, 1966) reported maximum values of chlorophyll-a of 70 µg/L in near shore areas of the lake. A low N:P ratio in the near shore waters of the lake indicates that nitrogen may occasionally be limiting and promoting the occurrence of the potentially toxic blue-gree algae.

3.1.6. Heavy metals and organics

The pollution from heavy metals and organics appears to be localized. Thus, Cu, Hg, Pb, Cd, Cr and Zn were found in the sediments of Mwanza Gulf but not in dangerous concentrations (Kishe & Machiwa 2001). The concentrations were greatest near towns, supporting their urban industrial origins (apart from the Hg which may originate from gold mining activities). There was no evidence of serious bioaccumulation of Hg in fish tested near cities in the lake and this does not appear to pose a human health problem (Campbell et al. 2003). The mean concentration of heavy metals in Winam Gulf was found to be 0.12 - 0.45 mg/L Pb, 0.01 mg/L Cd, and 0.16-1.82 mg/L Ar in water (Tole and Shitsama 2001). The same study reported 21.2-76.2 mg/L Pb, 0.4-2.8 mg/L Cd, and 37.6-394 mg/L Ar in the sediment.

Although agro-chemicals and their residues have been detected in the lake waters their concentrations at the moment are not high enough to be of threat to human health, export products, or ecosystem integrity. However, because of the tendency of organics to
bioconcentrate and bioaccumulate in the food chain, their long term impact to ecosystem integrity cannot be ignored. In general, the riparian countries have adequate legislation and regulations to control the use of these chemicals. Existing regulations forbidding the use of DDT for agricultural production reasons and regulating the use of other agro-chemicals need to be enforced by the riparian governments. Very low concentrations (0.01-0.03 mg/L) of endosulfan, B-endosulfan and endosulphan were detected in fish (Henry & Kishimba 2002).

A recent inventory on oil spillage to the lake indicated that there are high possibilities of oil spillage due to transportation (LVEMP 2003). The inventory further noted that the capacities of the oil separators/interceptors of nearly all visited factories/industries are too small hence resulting on inefficient separation, the separators were contaminated and therefore having limited functions, and that many drainage systems from filling stations drain oil directly to sewerage systems or to rivers. It has also been noted that bilge oil is regularly discharged into Lake Victoria (LVEMP 2001).

3.2 Impact of land use on pollution loading to the lake

While perennial horticultural areas are generally well managed with perennial cover and runoff control, many other areas under annual crops such as maize do not maintain ground cover. Thus, Majaliwa et al. (2001) reported that soil erosion losses are highest for annual crops and lowest for coffee and bananas. In addition, cropping areas often continue down to streams and lake edges, eliminating riparian buffering vegetation (wetlands). Forested areas surrounding the lake have been cleared for settlement and agricultural activities. The result of this poor land management is that large areas of land are subject to severe soil erosion. Scheren et al. (2001) indicated that land utilization has high impact on nutrient loading to the lake and hence eutrophication of water. The annual increase of the cultivated land is 2.2%, and overgrazing by 1.5 million cattle and 1.0 million goats exceeds sustainable grazing rate by a factor of 5. The resulting influence on eutrophication reveals itself in two main aspects, namely, increasing soil erosion and nutrient runoff and leakage to surface waters, and increasing release to the atmosphere of nutrients from animal and bio-mass burning and consequent deposition to surface water (Scheren et al. 2001). One consequence of eutrophication is that Lake Victoria has become turbid to the point that brightly colored fish species cannot see each other clearly enough and therefore they have begun to interbreed. This silt not only causes the turbidity observed in Winam Gulf (and possibly other semi-enclosed areas) but also transports nutrients such as phosphorus and contaminants such as agricultural chemicals. Some rivers are also the probable source of Hg from mining activities that has been observed near shore in Mwanza Gulf.

The current annual sedimentation rates in Lake Victoria are of the same order of magnitude as modeled for 1978 and the comparison with calculated net deposition rates shows that 4% of the sedimented phosphorus, 8% of nitrogen and 10% of silicon is permanently buried (COWI 2002). The burial rates represent an annual accretion of 1 mm/y, so the lake is in no danger of being filled with sediment in the immediate future. However Swallow et al. (2001) showed that the settling rate at the outlet of the rivers in the catchment area was 1.0 cm/y. This indicates high accumulation of sediments at the lakeshore.

3.3 Wetlands and pollution loading to the lake

The freshwater wetlands in Lake Victoria Basin constitute an important natural resource base upon which communities in the riparian districts depend for their livelihood. In Kenya and
Uganda, the wetlands of Lake Victoria constitute, respectively, about 37% and 13% of the total surface area of wetlands in the two countries. The wetlands are important in terms of food production, hydrological stability and ecological productivity. The wetlands are a source of goods and services for the riparian communities including: sources of raw materials, handicrafts, fuel; support for fisheries, grazing and agriculture; outdoor recreation and education for human society; provision of habitat for wildlife, especially water fowl; contribution to climatic stability, and a source of water and food production during the dry season. Wetlands act as filters of nutrient and silt loaded water. Most of the nutrients are retained by absorption by wetland plants. Throughout the region, these wetlands are disappearing or being degraded at an alarming rate (Balirwa 2002).

Wetlands particularly the shallow ones have been put under intensive cultivation for crops such as sugar cane, sweet potatoes, yams and eucalyptus. Others are excavated for obtaining sand and clay for brick making. The pits left have attracted water hyacinth and water borne disease vectors such as mosquitoes and snails (e.g. in Kyetinda wetlands in Kampala). Other wetlands are used for dumping of wastewater and garbage such as those close to Luzira prison, Masese swamp, and Walugogo valley in Iganga town in Uganda. Others are deforested to obtain woodfuel and other craft products such as at Mukona, Mpigi and Amsha districts and Sango Bay in Rakai district in Uganda. Although Uganda's wetlands are protected, most of them are still being reclaimed and degraded. These wetlands support up to 12 million people who extract freshwater, fish, medicinal plants and building material. It is estimated that about 75% of the wetland area has been significantly affected by human activity and about 13% is severely degraded. Many of the wetlands have received too much pollution to the extent that they cannot perform their filtration function efficiently. Therefore, pollutants normally retained by wetlands enter the lake unchecked, thus further contributing to the deterioration of lake water.

3.4 Water quality monitoring and concentration of pollutants in Lake Victoria

This section discusses the results of water quality monitoring undertaken in Lake Victoria under the Lake Victoria Environmental Management Project (LVEMP) Phase I. A total of 56 monitoring stations (9 stations in Kenya, 19 in Uganda and 28 in Tanzania) were established within the lake as shown in Figure 8. About 18 monitoring stations were established on rivers draining to the lake. The data obtained from the monitoring stations were used for computation of water balance, nutrient loading to the lake (see Section 3.1).

Figure 8. Lake Victoria Monitoring Stations

The findings indicate that the measured temperature profiles show that thermal stratification seems to exist most of the time in Mwanza Gulf. Hence the spreading of the pollutants from the lakeshore to the centre of the lake is caused by dispersion rather than advection for most of the year. The dispersion is caused by local turbulence generated by wind. The wind blowing over the lake is gentle to moderate with maximum wind speed during storm rarely exceeding 15 m/s (COWI 2003). The waves generated by wind are correspondingly low, with maximum (1 in 100 years) significant wave height of 2.5 m. The daily waves generated by the onshore-offshore breezes will normally not exceed 1.0 m. The waves cause mixing of the lake water to a depth of 5-15 m.
Due to the combination of a large surface area and relatively shallow depth, the lake does not react homogeneously. Thus mixing occurs at different times and different degrees in different parts of the lake.

Figures 9-11 show the distribution of the nutrients in the lake. The concentration of nutrients is high near the shore areas than offshore.

**Figure 9. Nitrate concentrations in the photic zone, November 2000 - August 2001.**
**Figure 10. Ammonium concentrations in the photic zone, November 2000 - August 2001.**
**Figure 11. Phosphate concentrations in the photic zone, November 2000 - August 2001.**

The data indicated that lakeshore areas are highly affected by eutrophication, especially the hot spot areas such as Winham Gulf, Murchison Bay, Napoleon Gulf, and Mwanza Gulf. Figure 12 which gives the secchi depths (transparency) in the lake shows that the most eutrophic areas are along the shore. The chlorophyll-concentrations in the lake are shown in Figure 13. The increased inflow of nutrients into the Lake is resulting in eutrophication. Phosphorus and nitrogen concentrations have risen and algal growth has increased five-fold since the 1960s. Chlorophyll levels are typically 2-3 times greater in the Gulf than in the main lake (Njuru 2001). The primary productivity of the lake has increased by a factor of 2, but chlorophyll (i.e. phytoplankton) concentrations have increased by 8-10 times (Mugidde 1993). The lake is suffering from increasing eutrophication that is caused by excessive nutrients entering the water.

**Figure 12. Secchi depths, November 2000 - August 2001.**

**Figure 13. Chlorophyll-a concentrations, November 2000 - August 2001:**

Lake Victoria has experienced a steady increase in nutrient and phytoplankton concentrations for many decades. The diatom, *Aulacosiera*, which was the dominant phytoplankton up until the 1960s was last recorded in the lake in 1990. Nitrogen fixing cyanobacteria, particularly *Cylindropermopsis sp.* and to a lesser extent *Anabaena*, now dominate the phytoplankton. Over 70% of the nitrogen input to the lake is from fixation (Muggide 2001). Thus, the phytoplankton community is not limited by access to nitrogen. Instead there is evidence that they are limited by the availability of light (Muggide et al. 2003) as a result of self-shading by algal biomass within Lake Victoria proper (Mugidde 1993) or higher mineral turbidities in Winam Gulf (Njuru 2001) and possibly other enclosed areas receiving riverine input. The dominant cyanobacteria species in the lake are known to produce toxins that are toxic to mammals, including humans. However, there is little information on this potential hazard. A shift of algal flora composition towards blue-green algae is causing deoxygenation of water. Dioxygenation of the deep water is another undesirable change which has precluded a stable demersal fishery (Hecky et al. 2002). Deepwater species have sharply declined and periodic upwelling of hypoxic water has caused massive fish kills. Figures 14-16 show the profile of DO in the lake.

**Figure 14. Oxygen concentration at the bed of Lake Victoria - minimum values.**
**Figure 15. Oxygen concentration at bed of Lake Victoria - lower quartile.**
**Figure 16. Oxygen concentration at bed of Lake Victoria - median.**

Whereas Talling (1965, 1966) saw anoxia only in the deepest parts of the lake in 1960-1, Hecky (???[VMB]) reported widespread and long lasting (October-March) anoxia below 45 m in
1990-1, and Njuru (2001) reported deoxygenation to within 30 m of the surface. Given that the mean depth is 40 m, this implies that a significant volume of the lake is now denied as habitat for commercial and non-commercial fish species for part of the year. These conditions have probably contributed to the loss of endemic benthic fish species and cause fish kills when these anoxic bottom waters reach the surface through upwelling. The increase of nutrients in the lake has resulted in high eutrophication of the lake, high growth of the water hyacinth and loss of biodiversity of the lake as discussed below.

3.5 Aquatic Weeds

Water hyacinth, *Eichhonia crassipes*, is an invasive aquatic macrophyte which invaded Lake Victoria in 1989 and has had significant socio-economic and environmental impacts, which remain largely unquantified (Ochiel & Wawire 2001; Raytheon *et al.* 2002). The water hyacinth has a high growth rate, resulting in physical obstruction of waterways, hydropower generation plants, water abstraction units, among others (Masifwa *et al.* 2001). It produces large quantities of long-lived seeds that can survive up to 30 years. Weed populations can double up in every 5-15 days at temperatures of between 25 °C and 27.5 °C and growth ceases at temperatures of below 10 °C and above 40 °C. The weed forms a permanent floating fringe often replacing the obligate acropleustophyte, *Pistia stratiotes* at the highly productive wetland/openwater interphase (Denny 1991), alters the food web (Balirwa 1995, 1998) and affects biological diversity (Masifwa *et al.* 2001).

The total water hyacinth cover in Lake Victoria in 1998 was estimated at about 12,000 hectares, with 6,000 hectares in Kenyan waters, 2,000 hectares in Tanzania and 4,000 hectares in Uganda. The water hyacinth covers the lake surface especially along shorelines with serious impacts on the health and livelihoods of the local fishermen and farming communities. About 80% of the Ugandan shoreline has been affected by this problem. Although no authoritative estimates have been made on the adverse economic impacts of the water hyacinth invasion, they include a rapidly declining fish catch for small-scale fisherfolk and the disruption of commercial transportation on the lake, which is now much slower as well as more costly and risky.

The impacts of unmanaged water hyacinth population include: impeding transport of irrigation and drainage water in canals and ditches, hindering navigation, interfering with hydropower schemes, increasing sedimentation by trapping silt particles, decreasing human food production in aquatic habitat (fisheries and crops); decreasing the possibilities for washing and bathing, and adversely affecting recreation (swimming) (Pieterse 1990). Additional impacts include hindering the processing and delivery of municipal and industrial water supplies, harboring venomous snakes; transforming aquatic habitats into wetlands or terrestrial habitats through succession by other plant species; and disappearance of native flora and fauna not able to compete or survive in infested environments; and increased water loss through excessive evapotranspiration hence reduction in lake levels. In addition water hyacinth provides a favorable habitat for vectors of diseases such as malaria, encephalitis, and filariasis (Mitchell 1990; Denny 1991; Maillu *et al.* 1998; Raytheon *et al.* 2002). Figure 17 shows the water hyacinth covering the entrance to the port of Homa Bay.

**Figure 17. Closure of Homa Bay port by hyacinth (September 2003)**

On the other hand water hyacinth has some positive impacts on Lake Victoria fisheries. These include the abatement of pollution since the plant has the capacity to accumulate heavy
metals and phenols including cadmium, lead, magnesium and nickel. The other notable impact in the Kenyan waters of Lake Victoria involves increase in fish diversity with the establishment of water hyacinth. To date some of the species that had disappeared like *Protopterus aethiopicus*, and *Clarias gariepinus*, among others, have reappeared in the catches (Ogari 2001).

Efforts made under LVEMP have reduced the infestation of this noxious weed to about 78% lake wide (Aloyce *et al.* 2001; Ndunguru *et al.* 2001). A combination of physical and biological methods have been used to combat the proliferation of the weed.

### 3.6 Biodiversity

Lake Victoria originally had a multi-species fishery in which two tilapiine species (*Oreochromis Esculentus* and *O. Variabilis*) were the most important (Ogutu-Ohwayo 2003). In the mid 1950s, the lake had adverse fish fauna comprising 28 genera and about 350 species (Greenwood 1974). Out of these, more than 300 species were haplochromine cichlids (Greenwood 1974; Witte *et al.* 2000). Starting from the 1950s, Nile perch *Lates niloticus* and non-indigenous tilapiines, Nile tilapia *Oreochromis niloticus*, *O. leucostictus*, *Tilapia zilli* and *T. Rendalli* were introduced into the lake (Lowe McConnell, 1997). The introduction of tilapiines was aimed at improving the declining indigenous stocks of *O. esculentus* and *O. variabilis* and to remove the so-called “trash fish” - the haplochromines with little value. During the 1970s, haplochromines were the most abundant fish species in the lake, constituting up to 80% of the demersal fish stocks (Kudhongania & Cardone 1974). Stocks of Nile perch increased rapidly during 1970s which was followed by the decline and in some areas total disappearance of some of the indigenous species (Witte *et al.* 1992). Within the last 50 years, as many as 200 species of fish in Lake Victoria have disappeared, due in part to the introduction of the Nile perch, which has eaten many of the smaller fish species.

In 1905, the pressure of the fisheries increased due to introduction of more efficient gill nets and extension of railways. In 1931, the gill net size was restricted due to over-fishing of *Oreochromis Esculentus*, following a survey made in 1928. Lake Victoria Fisheries Service (LVFS) was set to manage fisheries for the three riparian countries in 1928. This was followed by the formation of a fisheries research organization, the East African Freshwater Fisheries Organization (EAFFRO). The LVFS was disbanded in 1960, and its role was transferred to the individual national fisheries departments of Kenya, Tanzania and Uganda. Thus, there were no longer regional mechanisms to manage or coordinate management of these shared resources. Due to over-fishing *Oreochromis Esculentus* and *O. Victotianus* became endangered species in the Lake Victoria Basin.

Other factors that have caused a series of changes emanate from excessive and uncoordinated exploitation, human interventions in the lake basin and global environmental changes affecting the lake ecosystem (Katunzi *et al.* 2001). Excessive fishery exploitation, introduction of alien fishes (Nile perch and tilapias) and plants (water hyacinth) are factors which raise concern for fishery sustainability. Other changes to the lake environment have been caused by drainage of wetland buffers and streams, deforestation, lakeshore developments and increasing use of the lake as a depository of nutrient-rich wastewater. With increasing demands on the ecosystem, it is clear that further biodiversity change is eminent (Balirwa *et al.* 2001).
It seems that the reduction in water clarity in Lake Victoria in 1970s created a cover of duskiness which enhanced depletion of cichlids by Nile perch predation. Protection of littoral vegetation and improvement in water clarity would be beneficial to conservation of biodiversity (Chandler & Ogutu-Ohwayo 2002). The threat to biodiversity of Lake Victoria Region continues to grow despite our increasing knowledge about the system (Fuerst & Mwanja 2001). However, studies by Mwanja et al. (2001) for nearly ten years in the Lake Victoria Region aquatic system have revealed that a significant portion of the cichlid fauna that was considered lost from the main lakes of the Lake Victoria region (Lakes Victoria and Kyoga) is still extant both in very marginal habitats in the periphery of the main lakes and in the satellite small water bodies around the main lakes. Reintroduction and restoration, if well planned and managed, will be the only tool for conservation of cichlid biodiversity in the face of the many threats they face.

Changes in zooplankton have been muted and they exert a minor grazing pressure on the algal biomass. Kenyanya (2002) observed that in areas with high cover of water hyacinths, the DO concentration was 0.84-1.50 mg/L and Nile perch catch declined and was substituted with *O. Niloticus*, *Protopterus* and other species that are tolerant to low levels of DO.

There was a decreasing trend in Nile perch standing stocks in Lake Victoria from 790,000 mt in August 1999 to 530,000 mt in September 2001 while the small *pelagics* increased from 350,000 mt to 1,200,000 mt in same period. The causes of decline are over-exploitation, use of illegal gears and environmental degradation from the catchment areas. Different areas of the lake have different productions. This is due to different nutrient levels. Proliferation of water hyacinth led to an increase in catches of *C. gariepinus*, *P. aethiopicus*, Tilapia and *haplochromines*. The weed provided refugia, breeding and feeding areas and reduced fishing activities. However, about 200 of these species have now become extinct due to the introduction of Nile Perch and Nile Tilapia, the increase in eutrophication which has denied benthic waters to fish and changed the base of the food web, and possibly the increase in unsustainable commercial fishing practices.

The Nile Perch and Nile Tilapia are the two exotic fish species which have contributed both negatively and positively in the Lake Victoria fisheries. Their positive impacts in the lake fishery development include increased export earnings, recreational opportunities, increased supply of desirable protein food, increased fish production, increased employment and increased earnings for fishermen among others (Ogari, 2001). Given the importance of the Nile perch fishery to the economy of the region as well as to the riparian nations, it is difficult to see that the pressure exerted by these predators on the endemic species will lessen.

### 3.7 Summary of major threats

Based on the above analysis, the current major threats to Lake Victoria may be summarized as follows:

- Population pressure contributing to the existence of “hot spots”, caused by human waste, urban runoff, effluent discharges from such industries as breweries, tanning, paper and fish processing, sugar, coffee washing stations and abattoirs.
- Atmospheric deposition of nutrients.
- Raw waste from settlements, market centers and towns around the lake contributing significantly to pollution of the lake waters.
• Nutrients (phosphorus and nitrogen) inflow has given rise to a five-fold increase in algae growth since 1960s causing de-oxygenation of the water that threatens the survival of deep water-fish species.
• Inflow of residues from use of chemical herbicides and pesticides, and to a limited extent heavy metals resulting from gold mining operations.
• Proliferation of water hyacinth in the lake causing biodiversity and economic losses in the catchment areas of the lake.
• Unsustainable utilization of the major wetlands through agricultural activities and livestock keeping, which has greatly compromised the buffering capacity of the wetlands.
• Introduction of two exotic species, the Nile perch and the Nile tilapia, and the use of unsustainable fishing practices and gears have altered the species composition of the fauna and flora of the lake. Before this introduction, haplochromines constituted over 80% of the fish stocks. Now the Nile Perch constitutes 80% of the fish stocks, which has led to the loss of locally favored fish species, known for their medicinal and cultural values.
4 Lake Management Environment

4.1 Institutional Roles and Management Strategies

Currently, the three riparian countries do not have an agreed upon policy for the overall management of Lake Victoria. The national water resources, agriculture and livestock, and forestry policies of all three riparian countries do not pay particular attention to the issues of lake management or transboundary water resources management. Instead, that function has been assigned to the recently revived East African Community (EAC) organization representing Kenya, Tanzania and Uganda. Management is sectorally based with little coordination among sectors. Of the sectors, fisheries management is probably the most coordinated, partly because of its importance to the economy of the riparian countries and partly because of the assistance from the fisheries management projects on the lake. Activity in this sector was galvanized following the denial of Nile perch imports into the European Union (EU) because of poor hygienic conditions in the industry. Improvements in lake-wide fisheries management occurred because of the shock that all riparian countries felt when earnings from a major export commodity were threatened.

Other aspects of lake management are nationally based and uncoordinated. There are no agreed baseline against which management actions can be judged, no common lake management protocol, and no common water quality or discharge standards. The lack of transboundary water quality standards makes it impossible to ensure that remedial actions undertaken by one government will be effective and sustainable. Even a uniform set of data to describe the state of water quality in the lake has not been assembled from the separate national data collection efforts. Thus, there is no baseline from which to measure changes in the status of the lake’s environment or from which coordinated management activities can be based.

In spite of this lack of formal cooperative water quality mechanisms, when water hyacinth spread rapidly in the mid-1990s to threaten much of the lake shore, the riparian countries communicated well to contain the outbreak, even though different control mechanisms were trailed in each country. The Lake Victoria Environmental Management Programme (LVEMP), which had an aquatic weed component, contributed to this effort. The hyacinth is believed to have entered the lake via the Kagera River from Rwanda. Thus, unless efforts to manage the weed within Rwanda are made, the lake will remain vulnerable to further infestations. That is, water hyacinth control is an example where management efforts need to extend beyond the three riparian countries.

Catchment management activities are also nationally based with little harmonization between countries and, in some instances, between Ministries within the same country. Thus, while Kenya and Uganda have comprehensive legislation covering environmental management, Tanzanian environmental and resource legislation remains fragmented between the various sectors. On the other hand Kenya has introduced extensive water resources reforms, starting with the 1999 water policy, the 2002 Water Act and the draft water resources management strategy. Tanzania is also introducing reforms with a new water policy that includes specific reference to management of transboundary water resources such as Lake Victoria. In many cases the policies and strategies of Ministries that affect water resources within each country are not coordinated. Thus, in Kenya forest clearing activities have been undertaken in many of the critical headwater areas with little regard for the impacts on other sectors such as downstream agriculture and fisheries.
The EAC is the main regional forum for discussing management issues of Lake Victoria by the three riparian countries. Other transboundary institutions and projects dealing with the management of the lake include, among others, LVEMP, Lake Victoria Fisheries Research Project (LVFRP), Lake Victoria Fisheries Organization (LVFO) and Nile Basin Initiative (NBI). The effective performance of these transboundary institutions and projects has been based on the financial assistance from the international institutions such as World Bank, SIDA, DANIDA, UNDP, GEF and others. The next section summarizes the role played by the above mentioned institutions and projects.

4.1.1 Lake Victoria Environment Management Programme (LVEMP)

Lake Victoria Environment Management Programme (LVEMP) is a Global Environmental Facility (GEF) funded project. Phase I of LVEMP was completed in 2004 and Phase II is under preparation. The total funding for Phase I was USD 75,636,000, of which the three riparian states contributed 10% (LVEMP 2003). Specific objectives of LVEMP Phase I were to maximize the sustainable benefits to the riparian communities from using resources within the basin to generate food, employment and income; to supply safe water and sustain a disease free environment; to conserve biodiversity and genetic resources for the benefit of the riparian communities; to harmonize national and regional management programs in order to achieve to the maximum extent possible the reversal of environmental degradation; and to promote regional co-operation. Details of the project are provided in Box 1.
Box 1. Lake Victoria Environment Management Programme (LVEMP) Phase I

In response to the seriousness and the magnitude of the problems facing Lake Victoria, the three riparian countries sought funding from the Global Environmental Facility (GEF) to address Lake Victoria’s ecosystem health. LVEMP Phase I was completed in 2004 and Phase II is currently in preparation. The fundamental objective of the project is to restore the ecological health of the lake basin so that it can sustainably support the anthropogenic activities in the catchment and in the lake itself in a holistic regional approach to the management of an ecosystem.

Objectives of LVEMP Phase I were:

- To maximize the sustainable benefits to the riparian communities from using resources within the basin to generate food, employment and income,
- To supply safe water and sustain a disease free environment,
- To conserve biodiversity and genetic resources for the benefit of the riparian communities,
- Harmonize national and regional management programs in order to achieve to the maximum extent possible the reversal of environmental degradation, and
- To promote regional co-operation

The project had the following eleven components:

I. Catchment Afforestation Component aimed at increasing forest cover through tree planting and preventing soil erosion as well as conservation of natural forests.
II. Land use Management Component emphasized soil and water conservation and appropriate use of agrochemicals to reduce pollution loading and improve agricultural production.
III. Wetlands Management Component emphasized sustainable use of wetlands in order to conserve them as well as improve their buffering capacity.
IV. Industrial and Municipal Waste Management Component emphasized wastewater management by industries as well as use of artificial or natural waste water treatment.
V. Water Quality Monitoring Component focused on the establishment of water quality monitoring system in order to provide qualitative and quantitative information on nutrient, eutrophication and pollution, phytoplankton communities and their composition; algal blooms and their dynamics; lake zooplankton, microbes etc.
VI. Water Hyacinth Control and Management Component focused on the control of the weed by reducing the weed to manageable levels using a combination of biological and mechanical/manual removal methods.
VII. Fisheries Management Component focused on the establishment of a sustainable collaborative management of the fisheries through stakeholder involvement. The component also puts emphasis on extension services, law enforcement, data collection, fish quality control, post harvest improvement and establishment of Fish Levy Trust to ensure sustainability. It also finances community demand driven micro-projects to enhance the welfare of the community.
VIII. Fisheries Research Component focused on information on fish biology and ecology, stock sizes, qualitative and quantitative information on aquatic biodiversity, socio-economic characteristics of the fishery and restoration of scarce or depleted species.
IX. Micro-projects are small community demand-driven investments, which addressed concerns directly related to communities in the sectors of health, water supply, education, sanitation, access roads, afforestation and fisheries.
X. Support to Riparian Universities Component aimed at building capacity and strengthening facilities for environmental analysis and graduate teaching at the riparian Universities of Dar es Salaam, Moi and Makerere.
XI. Establishment of the Lake Victoria Fisheries Organisation (LVFO) Secretariat – aimed at establishing the Lake Victoria Fisheries Organization (LVFO) Secretariat in Jinja, Uganda. It was treated as a component under LVEMP in Uganda.
4.1.2 Lake Victoria Fisheries Organization (LVFO)

This is an institution of the East African Community (EAC) that is specifically responsible for promoting proper management and optimum utilization of the fishery resources of the Lake Victoria. The Lake Victoria Fisheries Organization (LVFO) is mandated to forge partnership and collaboration with institutions and stakeholders, and consolidate the relationships with mutual arrangements, through joint delivery of complementary programmes focused on the health of Lake Victoria’s ecosystem for sustainable fisheries resource utilisation and socio-economic development of the riparian communities. The establishment of LVFO was facilitated by the concerted efforts of the three riparian countries, the Food and Agriculture Organisation of the United Nations (FAO), the European Union (EU) through the Lake Victoria Fisheries Research Project (LVFRP), and the World Bank and the Global Environment Facility (World Bank/GEF) through funding of the Lake Victoria Environment Management Project (LVEMP). The Strategic Vision document prepared describes the focus, intent and direction of the Lake Victoria Fisheries Organization programmes through the year 2015. Embracing a holistic management view, a healthy ecosystem approach has been adopted as the fundamental concept for Lake Victoria. Therefore, the Strategic Vision document will be the guiding force for the Organization in the new Millennium.

4.1.3 The Lake Victoria Fisheries Research Project (LVFRP)

During the 1990’s, the Governments of Kenya, Tanzania and Uganda requested the European Union’s assistance for a new fisheries project. Thus the Lake Victoria Fisheries Research Project (LVFRP) was established in 1997. The principal aim of the Project was to assist the Lake Victoria Fisheries Organization in establishing a framework for the rational management of Lake Victoria’s fisheries. The specific objectives of the project were to carry out stock assessment, to train fisheries researchers, to rehabilitate and construct research vessels, to equip the research institutes and to investigate socio-economic issues related to the Lake and its fisheries. The LVFRP has provided the research institutes with the support needed to carry out lake wide research, covering both stock assessment and socio-economic studies. This includes operational expenses and workshops for data analysis; seven Ph.D. and 12 M.Sc. scholarships; a wide range of research equipment, books, computers and vehicles; and technical assistance. The successful formula has been the fruitful collaboration achieved between the East African Fisheries Research institutes and a consortium from Europe, led by UNECIA Ltd., consisting of the Hull International Fisheries Institute in the UK and the Institute of Marine Biology of Crete in Greece. The LVFRP maintained a fleet of research vessels, which conducted surveys of the fish stocks in the lake. Traditionally, the government has always regulated the fishery industry. One of the areas that LVFRP has addressed is involvement of fishing communities in managing the fisheries of the lake. Through the project fish stocks, fish speciation, market surveys and species abundance studies have been undertaken.

4.1.4 The East African Community (EAC)

The East African Community (EAC) is a regional forum that represents Kenya, Tanzania and Uganda. The EAC is the main regional forum for discussing management issues in Lake Victoria. Through the EAC, the three partner states have designated the Lake Victoria Basin as an economic growth zone that has to be exploited in a sustainable manner. The EAC and the Governments of Sweden, France and Norway, the World Bank and the East African Development Bank (EADB) have joined into a long term Partnership on the promotion of
sustainable development of the Lake Victoria Basin. This arrangement was formalized in 2001 through the signing of a Partnership Agreement between the EAC and the development partners. Included in this agreement are the need to take a multi-sectoral, regional approach to the lake’s management, the need for a long-term commitment, the need for a common understanding and vision that transcends sectoral and national approaches, and the need for subsidiary in management. The partnership is guided by visions and strategies developed as part of ongoing programs. The partnership was entered into on the recognition that: the Lake Victoria Basin, with its abundance of natural resources, has the potential of becoming a prosperous region; a majority of the people in the basin live in abject poverty; environmental degradation in the Basin is escalating; and that the potential of the basin cannot be sustainably developed unless problems related to environmental degradation, deepening poverty and poor health standards are addressed in a broad and coordinated manner. This project, to be completed in 2015 will lay the foundation for more coordinated approach to lake management. It is anticipated that the EAC will approve a Protocol for Sustainable Development of the Lake Victoria Basin and establish a Lake Victoria Basin Commission as part of that Protocol.

Box 2. East African Community–Donor Partnership for Development of the Lake Victoria Basin

Recognizing the vast potential for economic development that exists within the Lake Victoria Basin, the three countries that share Lake Victoria (Kenya, Tanzania and Uganda), through the East African Community (EAC), have declared the area as a Economic Growth Zone. Strategies and a shared vision for the lake basin have been developed to foster economic growth in the basin. This initiative is supported by development partners through a Partnership Agreement between EAC and the development partners signed in 2001. The initiative lays an important foundation for more coordinated approach to lake management. It is anticipated that the EAC will approve a Protocol for Sustainable Development of the Lake Victoria Basin and establish a Lake Victoria Basin Commission as part of that Protocol.

The objectives of the EAC – Lake Victoria Basin Partnership are:

- To exploit the opportunities for development in the Lake Victoria Basin in a sustainable manner and address the present problems relating to economic and social development, poverty and environment.
- To identify and investigate specific aspects of threats and obstacles to sustainable, economic, social and environmental development, and their underlying causes and propose relevant interventions.
- To assist in the formulation of policies to guide the various actors involved with activities relevant to sustainable development in the region.
- To build capacity through the development and strengthening of local institutions and organizations concerned with these issues.
- To promote co-ordination of the development efforts undertaken by various authorities, institutions and bodies established within EAC with an interest in supporting the developments in the Lake Victoria Basin.
- To provide consultative forum and focal points for various actors with an interest in the developments in the Basin.
- To broaden the co-operation between EAC, the EAC member states and donor agencies; To identify investment opportunities and work to create a climate conducive to investments; and to mobilize resources for the implementation of identified Programs.

4.1.5 The Nile Basin Initiative (NBI)

There are ten countries which make up the Nile River Basin, namely, Burundi, Democratic Republic of Congo, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, Sudan, Tanzania and Uganda. Some of the countries have only a small part of their area within the basin, whilst others are virtually entirely within the basin. The Nile Basin Initiative (NBI) is an initiative by the ten Nile Basin countries whose aim is to promote the exploitation of the development potential of...
the Nile River in a way that focuses on gaining mutual benefits from developments rather than on defending rights. The initiative is funded by a number of donors including the World Bank, Norway and Sweden. The Nile Council of Ministers (Nile-COM) serves as the highest decision-making body of the NBI. The Nile-COM is made up by Ministers of water affairs of the Nile Basin Riparian Countries. Technical support to the Nile-COM is provided by the Nile Basin Initiative Technical Advisory Committee (Nile-TAC) and the execution of its decisions is by the Nile Basin Initiative Secretariat (Nile-SEC).

The Nile Equatorial Lakes Subsidiary Action Plan (NELSAP), is a component of the NBI, concerned with transboundary development in the Nile Equatorial Lakes countries – Burundi, Democratic Republic of Congo, Egypt, Kenya, Rwanda, Sudan, Tanzania and Uganda. Eight projects have been identified for investment in the NELSAP region, including three basin management projects for managing river basins that flow into Lake Victoria, water hyacinth control in the Kagera River, and a regional agricultural project all of which have direct implications for management of the lake. At present, the NELSAP is executed by a small management unit located in Entebbe, Uganda that has links with other regional projects but is independent from them.

4.2 Technical Capacities

There are good technical/scientific capabilities in fisheries management in all three countries, partly as a result of the support provided from the LVEMP and LVFRP projects. All three riparian countries have fisheries research institutions that have good analytic capabilities, refurbished boats, and well-trained staff. Although these institutions are focused on fisheries research, they also undertake relevant water quality research in the lake.

Apart from this research and development (R&D) capacity, the three countries have invested in laboratories for quality control of fish exports as part of their continued entry to the EU market. In addition, a strong informal network has been established between the fisheries researchers that will provide a basis for future cooperation on technical issues. These technical capabilities remain one of the strengths for management in Lake Victoria. However, the infrastructure for fisheries and water quality research is expensive and the continuation of these capabilities remains dependent on further external investments.

The technical/scientific capacity available for catchment management is less coordinated than is the fisheries research. Universities in each of the countries provide the main technical capacity in this area although the analytical capabilities are also available in the various government ministries concerned with land and agricultural management. However, these capabilities are not coordinated towards management of catchment activities that impact on the lake.

The various projects on Lake Victoria have resulted in much new knowledge about the functioning of the lake. Important issues that remain to be resolved include the full taxonomy of lake fishes, the sources of the atmospheric nutrient loads and the extent of internal nutrient loading. However, there is now a sufficient knowledge base available for properly informed lake management to occur. To a considerable extent this has occurred in the fisheries sector. However, the mass of information from the projects has yet to be assembled into management-friendly and community-friendly packages that clearly convey the options available for other aspects of lake management. Until that is done, the benefits from these major investment programs will not be realized.
4.3 Community involvement

Community-level involvement in management is most advanced in the fisheries sector. As a result of the LVFRP and LVEMP, beach management units have been established in each country to provide local ownership for enforcing fisheries rules to avoid over-exploitation of the fish stock. Legislation is being prepared to support their activities in each country. Also fishing communities have been successfully engaged in raising and releasing the beetles for water hyacinth control. Both activities show the power of community-level initiatives when the outcomes clearly directly affect the livelihoods of those communities. However, this level of involvement has not been achieved with catchment communities to reduce the loads of sediment and nutrients reaching the lake from surface sources.

The East African Communities Organisation for the Management of Lake Victoria (ECOVIC) is one of the most prominent non-governmental organization (NGO) in the Lake Victoria region. It is primarily focused on poverty and environmental issues. There are a very large number of Community Service Organizations (CSOs) and NGOs active in the region although not necessarily involved directly in-lake management issues. It is estimated that about 40 NGOs in the lake region are concerned with environmental issues. There has been a high level of community involvement in the design of donor funded activities, such as the LVEMP, LVFO and EAC Visioning exercises. However, it is less clear whether these local groups are involved in the on-going management of these projects or other national investments and there appears to be no development of a long-term mechanism for community level involvement in lake basin management, after these transient donor supported investments are completed. The proposed Lake Victoria Basin Commission would provide an important vehicle for this input.
Lesson Learned

Based on the above review of the management situation of Lake Victoria and its basin, the following lessons can be drawn. These lessons should provide a useful guide for the current and future management of the lake and its basin.

A. **An agreed vision is essential.** At present the management of the lake is fragmented between sectors and nations. Thus, critical choices - whether to manage for biodiversity or commercial fish catch; how to allocate fish catches between countries – are made by default or not at all. Deliberate management to achieve development of the lake for the benefit of all will not happen until there is an agreed vision, common goals, and accepted objectives, policies and national and transboundary action plans. The first steps of this process are now underway.

B. **Lake management policies and action plans need to be consistent with national activities.** Most of the actions to emerge from a lake-wide management policy will need to be implemented by the riparian and catchment governments. Thus, the national water resources, agricultural, forestry, poverty alleviation policies of all riparian and catchment governments will need to include specific components that will lead to the required actions called for in the lake management policy. In turn, the establishment of the lake management policy will have to include consideration of the existing policies and strategies of the riparian and catchment countries.

C. **Where the problem is catchment-wide, it is essential that all countries in the catchment are involved in management.** Some of the management issues are essentially in-lake (such as loss of biodiversity) and so can be managed by the three riparian nations that currently constitute the East African Community (EAC). Other issues, such as management of water hyacinth and sediment control, are unlikely to be properly managed without the active involvement of all nations in the watershed. Consequently, it is important that Rwanda (and to a lesser extent Burundi) work actively with the EAC in managing the lake and its watershed, whether or not they actually join the EAC.

D. **In the absence of strong external motivations, it is important to build strong logical case for government action.** The advances in lake-wide fisheries management occurred because of the shock that all riparian countries felt when earnings from a major export commodity were threatened. However, the riparian countries have not felt the same level of pressure to resolve the other major problems facing the Lake – loss of biodiversity, infestation by aquatic weeds, and eutrophication – and so have been slower to act. Nevertheless, the inclusion of joint lake management in the program of the EAC, and the subsequent development of a common vision for the lake, are very positive steps. Given that the other issues are not likely to catch the governments’ attention because of the threat of economic losses, it is important that a credible scientific and social case be developed to ensure that the EAC initiatives are properly mandated, funded and supported from the highest political levels.

E. **Communities have to be involved in all aspects of management.** There are heartening success stories where communities have been involved in on-ground activities that affect their livelihoods. However, there are issues – such as nutrient reduction – where the problem originates from diffuse sources that are impossible to tackle other than through community engagement. So far there has not been the same level of success with community involvement in these areas. As part of this action, community-level representation will be needed on the ongoing management body for the lake.

F. **R&D should be designed around management objectives.** There is now a good knowledge base for Lake Victoria. However, the programs to gather this information have
not been carefully focused on the management objectives, largely because these have not been properly established (see above). Consequently, some of the R&D activities have not been of direct relevance and, more importantly, some management-critical knowledge has yet to be acquired. A related issue is the packaging of the knowledge gained in a management and community friendly way. Unless the R&D findings are simplified and carefully related to the management objectives, their relevance will escape senior decision-makers without scientific training.

Phase II of the LVEMP project is now under preparation. The second phase of the LVFRP is in place. The latter program will continue to support efforts to manage the fisheries resources of the lake while the LVEMP Phase II will coordinate with these activities and tackle other management issues. Given the above analysis, LVEMP Phase II can now cease to be primarily a knowledge acquisition project and move towards supporting management of biodiversity, water weeds and eutrophication. Thus, LVEMP Phase II could be directed towards such activities as protecting endangered fish species in satellite lakes, supporting the EAC management initiatives by building capacity in transboundary environmental management, supporting joint Rwandan-EAC activities to control aquatic weeds in the Kagera River, and reducing eutrophication by tackling the sources of nutrients once these have been identified. However, it should also include a focused, priority research and development (R&D) component aimed at resolving some of the major management questions such as the sources of the atmospheric phosphorus entering the lake, the potential for sediment nutrients to continue to contribute to eutrophication even after external sources are controlled, the presence of cyanobacterial toxins in the lake, and opportunities to protect fish biodiversity in surrounding lakes and wetlands.

The EAC, identified by the riparian countries to manage the lake, is the obvious organization to oversee further transboundary lake management programs. The Lake Victoria Fisheries Organization (LVFO) has already been transferred to the EAC. It would be reasonable for the LVEMP Phase II to also be executed by the EAC to ensure coordination and focus. The Nile Basin Initiative (NBI) spans a much larger area than just the catchment of Lake Victoria. Nevertheless, the implementation of the Nile Equatorial Lakes Subsidiary Action Plan (NELSAP) program should also be closely coordinated with EAC to ensure that its activities contribute effectively towards the agreed vision for managing the lake.

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7 References


