

# Lake Victoria

## EXPERIENCE AND LESSONS LEARNED BRIEF

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### 1. Introduction

Lake Victoria is the second largest freshwater lake in the world by area (Figure 1), and has the world's largest freshwater fishery, largely based on the introduced Nile perch, which supports an economically and socially important export fishery for the riparian countries. The lake basin supports about 30 million people and is the source of the Nile River. The threats facing the lake include eutrophication, over-exploitation of fisheries, introduced exotic species, and climate change. The population in the catchment is growing rapidly, with the lake itself attracting people because of the economic opportunities it offers. The lake's water residence time is 23 years, while its

flushing time is 123 years. Because of its long retention time, pollutants entering the lake remain in it for a long time.

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



Figure 1. The Lake Victoria Basin.

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 a common vision shared by all countries and communities regarding the beneficial uses of the lake and how to protect them. 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 will support implementation of that vision. Such data and information have been gathered through several projects previously undertaken on the lake.

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

With assistance from the European Union-funded Lake Victoria Fisheries Research Project (LVFRP), the riparian governments have begun coordinating their responses to managing the fisheries sector, but have yet to develop a coordinated action plan 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 beginnings of such a response. In spite of these recent, positive developments, however, there remains a tension between managing the lake to benefit the riparian communities versus managing it to benefit the downstream countries of the Nile River. This issue is currently being addressed within the Nile Basin Initiative (NBI), a forum that brings together all of the ten countries in the Nile Basin.

## 2. Background

Lake Victoria is the world's second largest freshwater lake in surface area, second only to Lake Superior in North America. It is bordered by Tanzania, Kenya and Uganda, and, although not riparian, Burundi and Rwanda also lie within the lake drainage basin. Lake Victoria stretches 412 km from north to south, between latitudes 0°30' N and 3°12' S, and 355 km from west to east between longitudes 31°37' and 34° 53' E. It is situated at an altitude of 1,134 m above sea level, and has a volume of 2,760 km<sup>3</sup>, and an average and maximum depth of 40 m and 80 m, respectively. Lake Victoria is the largest lake in Africa, with a surface area of 68,800 km<sup>2</sup>, and a catchment area of 193,000 km<sup>2</sup>. The lake's morphometric data is summarized in Table 1. The lake contains numerous islands, and has a highly indented shoreline estimated to be about 3,460 km long. The catchment area of the lake is illustrated in Figure 1. The lake's flushing time (volume/average outflow) is 138 years and its residence time is 21 years. Lake Victoria surrounds several groups of large islands (e.g. Sesse or Kalangala and Buvuma in Uganda; Ukerewe in Tanzania and Rusinga in Kenya), and many smaller ones.

### 2.1 Drainage Basin

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, Sondumiri, Kuja, Migori, Riaria and Mawa. From the Ugandan catchment, the main rivers are Kagera, Bukora, Katonga and Sio (LVEMP 2003). The Kagera, draining 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 its surface water inflows (Table 2). About 86% of the total water input, however, falls as rain, with evaporative losses accounting for 80% of the water leaving the lake (Okonga 2001; COWI 2002). The mean annual rainfall, based on rainfall data from 1950 to 2000, ranges between 886-2609 mm, while the mean evaporation rate over the lake ranges between 1108-2045 mm per year (COWI 2002).

The Nile River is the only surface outlet from the lake, with an outflow of 23.4 km<sup>3</sup>/y (Mott MacDonald 2001). The long-term average discharges from the river basins in the lake catchment, based on data from 1950 to 2000 are shown in Table 2.

**Table 1. Morphometric Data for Lake Victoria.**

Item	Total	Kenya	Tanzania	Uganda	Rwanda	Burundi
Surface area (km <sup>2</sup> )	68,870	4,113 (6%)	33,756 (49%)	31,001 (45%)	0	0
Catchment area (km <sup>2</sup> )	193,000	42,460 (22%)	84,920 (44%)	30,880 (16%)	21,230 (11%)	13,510 (7%)
Shoreline (km)	3,450	550 (17%)	1,150 (33%)	1,750 (50%)	0	0

Source: Andjelic (1999).

The mass balance of water in the lake based on the inflow and outflow is 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 m<sup>3</sup>/s, which accounts for the observed lake water level rise of about 1.0 m between January 1950 and December 2000 (COWI 2002). The annual fluctuations in levels, however, range between 0.4-1.5 m (Balirwa 1998).

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 and, coupled with bad agricultural practices, has degraded the soil, leading to siltation in the lake. Industrial and domestic effluents are polluting the lake, being localized in urban areas around the lake, while deforestation, soil erosion, and increasing human and livestock populations have contributed to increased nutrient loading to the lake from rivers, in

**Table 2. Long-term Average Discharge from River Basins in Lake Victoria Catchment Area.**

Country	Basin	Discharge (m <sup>3</sup> /s)	Percentage (%)
Kenya	Sio	11.4	1.5
	Nzoia	115.3	14.8
	Yala	37.6	4.8
	Nyando	18.0	2.3
	North Awach	3.7	0.5
	South Awach	5.9	0.8
	Sondu	42.2	5.4
	Gucha-Migori	58.0	7.5
	Sub-total	292.1	37.6
	Tanzania	Mara	37.5
Grumeti		11.5	1.5
Mbalageti		4.3	0.5
E. shore stream		18.6	2.4
Simiyu		39.0	5.0
Magogo moame		8.3	1.1
Nyashishi		1.6	0.2
Issanga		30.6	3.9
S. shore stream		25.6	3.3
Biharamulo		17.8	2.3
W. shore stream		20.7	2.7
Kagera		260.9	33.5
Sub-total	476.40	61.2	
Uganda	Bukora	3.2	0.4
	Katonga	5.1	0.7
	N. shore stream	1.5	0.2
	Sub-total	9.8	1.3
Total average inflow		778.3	100.0

Source: COWI (2002).

addition to atmospheric deposition of nutrients from poor land management practices within, and possibly outside, the lake catchment.

## 2.2 Socio-economic Setting

The population of the lake basin is about 30 million, constituting about one-third of the population of Kenya, Tanzania and Uganda. The population growth rate of the riparian municipalities of the three countries stands at above 6% per annum, among the highest in the world. The lake basin nevertheless provides resources for the livelihoods of the basin population, with the lake used as source of food, energy, drinking and irrigation water, shelter, transport, and as a repository for human, agricultural and industrial wastes. The lake basin resources also provide amenities for cultural activities, as well as leisure. Over 70% of the population in 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 exceeding 300,000 tons, worth US\$600 million annually. The lake fisheries 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 lake is the source of the White Nile and is therefore an important asset for all countries within the Nile River Basin. The waters originating from the lake provide hydropower through its only outlet, the Victoria Nile River, at Owen Falls in Uganda, and other power plants further downstream. The two plants at Owen Falls provide 260 MW of power, 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.

**Table 3. Average Inflows and Outflows from Lake Victoria.**

Type of flow	Flows (m <sup>3</sup> /s)	Percentage (%)
Inflows		
Rain over lake	3,631	82
Basin discharge	778	18
Outflows		
Evaporation from lake	-3,330	76
Nile River	-1,046	24
Balance	+33	

Source: COWI (2002).

### 3. Biophysical Environment

#### 3.1 Water Quality

The Lake Victoria ecosystem has undergone substantial and, to some observers, alarming changes that have accelerated over the last three decades. Massive algal blooms have developed, becoming increasingly dominated by the potentially toxic blue-green variety. The lake water transparency has declined from 5 m in the early 1930s, to 1 m or less for most of the year by the early 1990s. Waterborne diseases also have increased in frequency. Although presently under control, water hyacinth, absent in the lake as late as 1989, choked important waterways and landings, especially in bay areas in Kenya and Uganda, in the late 1990s. Over-fishing, introduced fish species and oxygen depletion at lower lake depths threaten the artisanal fisheries and biodiversity (over 200 indigenous species are facing possible extinction). These extensive changes have been attributed both to the introduction of Nile perch that altered the food web structure, and to increased nutrient input to the lake, resulting in eutrophication.

Land use has intensified and human and livestock population increased, especially along the lakeshore 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 (e.g., Kisumu, Mwanza, Kampala). The pollution sources to the lake include a number of basic industries (e.g., breweries, tanning, fish processing, agro-processing, abattoirs). Small-scale gold mining is increasing in parts of the Tanzanian catchment and, if mining wastes are not well contained, might lead to mercury discharges into the lake water. Increased nutrient flows are entering the lake from eroded sediments in the catchment, burning of wood-fuels, and from human and animal waste from areas surrounding the lake.

Given the importance of degradation due to eutrophication, one of the major technical challenges facing the management of Lake Victoria is the accurate quantification of the nutrient load to the lake. This following sub-sections discuss the quantification of the pollutant loads to the lake undertaken under the LVEMP. A total of 56 monitoring stations (9 stations in Kenya, 19 in Uganda, 28 in Tanzania) were established within the lake to determine the in-lake pollution concentrations. About 18 monitoring stations were established on rivers draining to the lake. The data obtained from the monitoring

**Table 4. Pollution Loading to Lake Victoria Due to Urban Wastewater and Runoff.**

Country	Loading to Lake Victoria (t/y)		
	BOD	Total N	Total P
Tanzania	5,069	719	292
Kenya	10,724	2,019	848
Uganda	2,145	767	484
Total	17,938	3,505	1,624

Source: COWI (2002).

stations were used to compute the lake's water balance and nutrient loads.

##### 3.1.1 Pollution Loading Due to Urban Wastewater and Runoff

The LVEMP study on pollutant loads (COWI 2002) indicates there are 87 large towns in the Lake Victoria basin (51 in Kenya, 30 in Tanzania, 6 in Uganda). Table 4 shows the pollutant loading to the lake from urban areas.

The data in Table 4 incorporate a 50% load reduction in order to take into account load reduction through other treatment methods. However, reductions in pollutant loads through the river system before reaching the lake have not been incorporated in the data. A different LVEMP study (LVEMP 2001) indicated that the pollutant loading to the lake from urban areas was 6,955 t/y of Biochemical Oxygen Demand (BOD), 3028 t/y of Total Nitrogen (T-N), and 2,686 t/y of Total Phosphorus (T-P). These figures represent the pollutant load from urban areas close to the lakeshore, and do not consider the pollutant load from towns located far away from the lake that drain into it via streams and rivers.

##### 3.1.2 Pollution Loading Due to Industrial Activities

The pollutant load to the lake from industrial activities in the catchment area is shown in Table 5. The total number of major industries in the catchment area is 68 (16 in Kenya, 34 in Tanzania, 18 in Uganda) (COWI 2002). The pollutant load to the lake from industries was estimated on the basis of the production rate or the quantity of water used.

##### 3.1.3 Pollutant Loading Due to Rivers

Rivers carry soil eroded from the catchment area to the lake. Thus, the water is more turbid and shallow at the inlets than in 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. The input of nutrient loads from the rivers located in the catchment area is 49,509 t/y T-N and 5,693 t/y T-P (Table 6).

##### 3.1.4 Pollution Loading Due to Atmospheric Nutrient Deposition

Atmospheric deposition can be divided into wet deposition (i.e., deposition of nutrients washed out by rain) and dry deposition (i.e., deposition onto the water surface from the air during dry weather periods). Due to lack of special sampling equipment for dry deposition, COWI (2002) applied a simple

**Table 5. Industrial Loading to Lake Victoria.**

Country	Loading to Lake Victoria (t/y)		
	BOD	Total N	Total P
Tanzania	3,259	324	208
Kenya	860	57	46
Uganda	1,487	33	88
Total	5,606	414	342

Source: COWI (2002).

method involving analysis of the increased nutrient levels in distilled water in a bucket exposed to the atmosphere for a certain time. In estimating the atmospheric deposition, the

lake was divided into 17 “rain boxes” for which the annual average rainfall could be individually calculated.

**Table 6. Annual Loads of Nitrogen and Phosphorous to Lake Victoria from River Basins.**

Country	Basin	Area (km <sup>2</sup> )	Discharge (m <sup>3</sup> /s)	Total-N (t/y)	Total-P (t/y)	
Kenya	Sio	1,450	12.1	248	47	
	Nzoia	12,676	118	3,340	946	
	Yala	3,351	27.4	999	102	
	Nyando	3,652	14.7	520	175	
	North Awach	1,985	3.8	112	15	
	South Awach	3,156	6.0	322	39	
	Sondu	3,508	40.3	1,374	318	
	Gucha-Migori	6,600	62.7	2,849	283	
	Sub-total	36,378	285	9,764	1,925	
	Tanzania	Mara	13,393	38.50	1,701	304
Grumeti		13,363	12.7	561	185	
Mbalageti		3,591	4.9	216	50	
E. shore stream		6,644	20.2	892	159	
Simiyu		11,577	34.1	1,507	435	
Magogo moame		5,207	6.3	278	50	
Nyashishi		1,565	1.4	62	11	
Issanga		6,812	5.1	225	40	
S. shore stream		8,681	27.0	1,193	213	
Biharamulo		1,928	21.5	950	170	
W. shore stream		733	21.1	932	166	
Kagera		59,682	265.3	29,303	1,892	
Sub-total		253,176	458.1	37,820	3,675	
Uganda		Bukora	8,392	2.9	575	30
		Katonga	15,244	4.7	1,023	47
	N. shore stream	4,288	1.5	327	15	
	Sub-total	27,924	9.1	1,925	92	
	Total average load	197,478	752.2	49,509	5,693	

Source: COWI (2002).

**Table 7. Annual External Nutrient Loading to Lake Victoria.**

Pollution Source	Loading to Lake Victoria (t/y)		
	BOD Load	Nitrogen Load	Phosphorus Load
Domestic Waste (including urban runoff)	17,938	3,505 (1.68%)	1,624 (4.24%)
Industrial Sources	5,606	414 (0.21%)	342 (0.89%)
River Basin	25,122	49,509 (23.78%)	5,693 (14.86%)
Runoff from Cultivated Land	...	22,966 (11.03%)	2,297 (6.00%)
Runoff from Non-cultivated Land	...	29,615 (14.23%)	3,949 (10.31%)
Atmospheric Wet Deposition	...	62,601 (30.08%)	11,831 (30.89%)
Atmospheric Dry Deposition	...	39,550 (18.99%)	12,567 (32.81%)
Total	48,666	208,160 (100%)	38,303 (100%)

Source: Modified from LVEMP (2003).

The estimated total pollutant loads from atmospheric deposition were 102,148 t/y of T-N and 24,402 t/y of T-P (COWI 2002). These values are close to the initial estimates from a model study described in COWI (2002), indicating that atmospheric deposition is by far the most significant contribution to the lake's overall nutrient budget. It is noted, however, that some authorities question these data. Thus, these estimates require confirmation before initiating management actions based on them.

Table 7 summarizes the sources and relative pollutant loads to Lake Victoria. As shown in Table 7, atmospheric deposition is considered to be the major pollutant source to the lake. The results indicate that total atmospheric deposition (wet and dry deposition) contributes about 49.07% and 63.70%, respectively, of the total nitrogen and total phosphorus load. Thus, changes in farming, land utilization, industrial activities and forest management will likely significantly reduce the pollutant load to the lake from atmospheric deposition. It is reiterated, however, that some local scientists dispute the high nutrient loadings attributed to atmospheric deposition.

### 3.1.5 Nutrient Mass Balance

The load of nutrients buried in the sediments was calculated using a mass balance approach, indicating that 20,100 t/y of phosphorus were buried in the sediments, and 502,900 t/y were released by the sediments into the water column. The same calculation approach resulted in a net deposition of 73,400 t/y of nitrogen in the sediments (Figure 2). Because the N:P ratio is known to be about 10:1, however, this may be a low estimate.

It is clear that the nutrient mass balance still needs to be refined. The load estimates with the greatest uncertainty are atmospheric deposition and the nitrogen fixation and

denitrification rates. Further, sediment flux experiments would strongly support understanding of the nutrient exchange between the sediments and the water column. Nevertheless, the preliminary mass balance provides a sufficiently realistic estimate of the relative importance of the different nutrient sources to guide eutrophication management actions. The data clearly illustrate that the areas highly affected by eutrophication are those near the lakeshore (e.g., Winam Gulf, Murchison Bay, Napoleon Gulf, Mwanza Gulf). The COWI (2002) study measured 170 µg/L of chlorophyll-*a* in Mwanza Gulf, while a 1997 study on Murchison Bay measured up to 300 µg/L chlorophyll-*a*. In comparison, Talling (1965, 1966) reported maximum chlorophyll-*a* concentration of 70 µg/L in the lake's nearshore areas. A low N:P ratio in the lake's nearshore waters indicates that nitrogen may occasionally be the algal limiting nutrient, promoting the occurrence of potentially toxic blue-green algae. The data indicate that lakeshore areas are highly affected by eutrophication, especially "hotspots" such as Winam Gulf, Murchison Bay, Napoleon Gulf, and Mwanza Gulf. Phosphorus and nitrogen concentrations have increased and algal growth has increased five-fold since the 1960s. The chlorophyll concentrations are typically 2-3 times greater in the gulfs than in the main lake (Njiru et al. 2001). Further, although the lake's primary productivity has increased by a factor of 2, the chlorophyll-*a* (i.e., phytoplankton) concentrations have increased by 8-10 times (Mugidde 1993).

Whereas Talling (1965, 1966) reported anoxia only in the deepest parts of the lake in 1960-1, Hecky (1993) reported widespread, long lasting (October-March) anoxia below 45 m in 1990-1, while Njiru et al. (2001) reported deoxygenation to within 30 m of the surface. Given the lake's mean depth of 40 m, this implies a significant volume of the lake is now unsuitable 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.

### Nitrogen mass balance

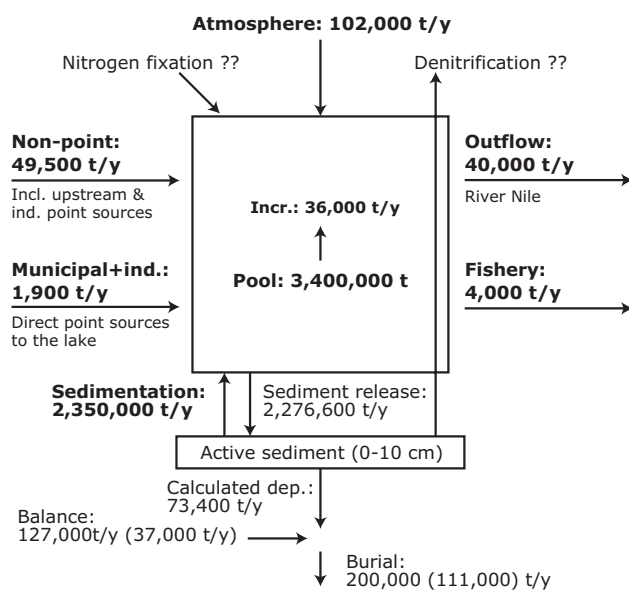


Figure 2. Nitrogen Mass Balance for Lake Victoria.

Lake Victoria has experienced a steady increase in its nutrient and phytoplankton concentrations for many decades. The diatom, *Aulacosiera*, the dominant phytoplankton up until the 1960s, was last recorded in the lake in 1990. Nitrogen-fixing cyanobacteria (particularly *Cylindrospermopsis sp.*) and, to a lesser extent, *Anabaena*, now dominate the phytoplankton. If Mugidde (2001) is correct that over 70% of the nitrogen input to the lake is from nitrogen fixation, then the phytoplankton community is not likely limited by access to nitrogen. Instead, there is evidence they are limited by the availability of light (Mugidde et al. 2003) as a result of self-shading by algal biomass within Lake Victoria proper (Mugidde 1993) or by higher mineral turbidities in Winam Gulf (Njiru 2001) and possibly other enclosed areas receiving riverine inputs. Although the dominant cyanobacteria species in the lake are known to produce toxins that are toxic to mammals, including humans, there is little information on this potential hazard. A shift of algal flora composition towards blue-green algae is causing deoxygenation of water. Deoxygenation 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 the periodic upwelling of hypoxic water has caused massive fish kills.

### 3.1.6 Heavy Metals and Organics

Pollution of Lake Victoria from heavy metals and organics appears to be localized. For example, although copper (Cu), mercury (Hg), lead (Pb), cadmium (Cd), chromium (Cr) and zinc (Zn) were found in the sediments of Mwanza Gulf, they were not present in dangerous concentrations (Kishe and Machiwa 2001). The concentrations were greatest near towns, indicating their urban industrial origins (except for mercury, which may originate from gold mining activities). There was no evidence of serious bioaccumulation of mercury in fish from sites near cities along the lakeshore and this does not appear to pose a human health problem (Campbell et al. 2003). The mean concentration of heavy metals in Winam Gulf water was found to be 0.12-0.45 mg Pb/L, 0.01 mg Cd/L, and 0.16-1.82 mg Cr/L (Tole and Shitsama 2001). The same study reported 21.2-76.2 mg Pb/L, 0.4-2.8 mg Cd/L, and 37.6-394 mg Cr/L in sediments.

Although agro-chemicals and their residues have been detected in lake waters, their present concentrations are not sufficiently high to be a 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 potential long-term impacts on ecosystem integrity cannot be ignored. Very low concentrations (0.01-0.03 mg/L) of endosulfan, B-endosulfan and endosulphan were detected in fish (Henry and Kishimba 2002). The riparian countries generally have adequate legislation and regulations to control the use of these chemicals, although the existing regulations forbidding the use of DDT for agricultural production reasons, and regulation of the use of other agro-chemicals, needs to be enforced by the riparian governments.

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

### 3.2 Impacts of Land Use on Pollutant Loading to the Lake

While perennial horticultural areas are generally well managed with perennial cover and runoff control, many other areas with annual crops (e.g., 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 extend down to streams and lake edges, eliminating riparian buffering vegetation (wetlands). Further, forested areas surrounding the lake have

been cleared for settlement and agricultural activities. These poor land management practices have resulted in large areas being subjected to severe soil erosion. Scheren et al. (2001) indicated that land utilization has a high impact on nutrient loading to the lake, thereby contributing to eutrophication. The annual increase in cultivated land is 2.2%, while overgrazing by 1.5 million cattle and 1.0 million goats exceeds the sustainable grazing rate by a factor of 5. The resulting influence of these factors on eutrophication of Lake Victoria reveals itself through two main pathways; namely, increasing soil erosion, nutrient runoff and leakage to surface waters, and increasing nutrient release to the atmosphere from animal and biomass burning and their consequent deposition to surface water (Scheren et al. 2001). Siltation not only causes the turbidity observed in Winam Gulf (and possibly other semi-enclosed areas), but also transports nutrients (e.g., phosphorus) and contaminants (e.g., agricultural chemicals). It should be noted that, whereas high turbidity in Winam Gulf is caused primarily by increased siltation from rivers, the increased turbidity in the main body of the lake is caused by high chlorophyll-*a* concentrations. This distinction has significant ecological consequences, and requires different management strategies. Some rivers also are the likely source of mercury from mining activities observed nearshore in Mwanza Gulf.

The current annual sedimentation rates for Lake Victoria are the same order of magnitude as modeled for 1978, and comparison with calculated net deposition rates shows that 4% of the phosphorus, 8% of the nitrogen and 10% of the silicon is permanently buried (COWI 2002). The burial rates represent an annual accretion of 1 mm/y. However, Swallow et al. (2001) showed that the settling rate at the river inlets in the catchment area was 1.0 cm/y, indicating a high accumulation of sediments at the lakeshore.

### 3.3 Wetlands and Pollutant Loading to the Lake

The freshwater wetlands in the Lake Victoria drainage basin constitute an important natural resource base upon which the communities in the riparian districts depend for their livelihoods. In Kenya and Uganda, the Lake Victoria wetlands constitute about 37% and 13%, respectively, of the total wetland surface area in the two countries. The wetlands are important in terms of food production, hydrological stability and ecological productivity. They also are a source of goods and services for the riparian communities, including being sources of raw materials, handicrafts, and fuel; supporting fisheries, grazing and agriculture; providing outdoor recreation and education for human society; providing habitat for wildlife (especially water fowl); contributing to climatic stability; and being a source of water and food production during the dry season. Wetlands also act as nutrient and silt filters for water entering the lake, with most of the nutrients being removed through incorporation into the tissues of wetland plants, accumulation in wetland sediments and, in the case of nitrogen, losses to the atmosphere via denitrification in the root zones of the aquatic plants.

These wetlands are disappearing throughout the region, or are being degraded at an alarming rate (Balirwa 2001). Some wetlands, particularly the shallow ones, have been put under intensive cultivation for crops (e.g., sugar cane, sweet potatoes, yams, eucalyptus). Others are excavated for sand and clay for brick making. The resulting pits have attracted water hyacinth and such waterborne disease vectors as mosquitoes and snails (e.g., Kyetinda wetlands in Kampala). Other wetlands are used for wastewater and garbage discharges (e.g., those near Luzira prison, Masese swamp, and Walugogo valley in Iganga town in Uganda). Others are deforested for wood fuel and other craft products (e.g., Mukona, Mpigi and Amsha districts, and Sango Bay in Rakai district in Uganda). Although Uganda's wetlands are protected, most are still being reclaimed and degraded. It is estimated that about 75% of the wetland area has been significantly affected by human activity, and about 13% is severely degraded.

### 3.4 Aquatic Weeds

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

The total water hyacinth cover in Lake Victoria at the peak of infestation in 1998 was estimated to be 12,000 hectares, with 6,000 hectares in Kenyan waters, 2,000 hectares in Tanzania, and 4,000 hectares in Uganda. It covers the lake surface, especially along the shoreline, 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 much slower and more costly and risky.

The water hyacinth infestation has been substantially reduced, now existing primarily at the river mouths (where it remains a nuisance), and in a few other hotspots. Generally, however, the above-noted problems have been largely overcome. Efforts made under the LVEMP have reduced the infestation of the weed to about 78% lakewide (Aloyce et al. 2001; Ndunguru et al. 2001). A combination of physical and biological methods has been used to combat the proliferation of the weed, with

biological control using two species of weevils (*Neochetina eichhornia*, *Neochetina bruchi*) being particularly successful. An important aspect of biological control was the successful involvement of local fisher communities in rearing and distributing the weevils.

The impacts of the unmanaged water hyacinth population in Lake Victoria included impeded transport of irrigation and drainage water in canals and ditches, hindered navigation, interference with hydropower schemes, increased sedimentation by trapping silt particles, decreased human food production in aquatic habitat (fisheries and crops), decreased possibilities for washing and bathing, and adversely affected recreation (swimming) (Pieterse 1990). Additional impacts included hindered processing and delivery of municipal and industrial water supplies, the harboring of venomous snakes, transformation of aquatic habitats into wetlands or terrestrial habitats through succession by other plant species, the disappearance of native flora and fauna unable to compete or survive in infested environments, and reduced lake levels because of increased water loss. Water hyacinth is also known to provide a favorable habitat for disease vectors for malaria, encephalitis and filariasis (Mitchell 1990; Denny 1991; Maillu et al. 1998; Raytheon et al. 2002).

In contrast, water hyacinth also had some positive impacts on Lake Victoria fisheries, including pollution abatement since the plant has the capacity to accumulate heavy metals (e.g., cadmium, lead, magnesium, nickel) and phenols. The other notable impact in the Kenyan waters of Lake Victoria involved increased fish diversity with the establishment of water hyacinth. Some of the species that have disappeared (e.g., *Protopterus aethiopicus*, *Clarias gariepinus*) have since reappeared in the fish catches (Ogari 2001).

### 3.5 Biodiversity

Lake Victoria originally had a multi-species fishery, in which two tilapiine species (*Oreochromis Esculentus*, *O. Variabilis*) were the most important (Ogutu-Ohwayo 2003). In the mid-1950s, the lake had a diverse fish fauna, comprising 28 genera and about 350 species (Greenwood 1974). Of these species, more than 300 were haplochromine cichlids (Greenwood 1974; Witte et al. 2000). Beginning in the 1950s, Nile perch (*Lates niloticus*) and non-indigenous tilapiines, Nile tilapia (*Oreochromis niloticus*, *O. leucostictus*, *Tilapia zilli*, *T. Rendalli*) were introduced into the lake. Introduction of tilapiines was aimed at improving the declining indigenous stocks of *O. esculentus* and *O. variabilis*, and removing the so-called "trash fish" (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 and Cardone 1974). Stocks of Nile perch increased rapidly during 1970s, followed by the decline and, in some areas, total disappearance of some indigenous species (Witte et al. 1992). Within the last 50 years, as many as 200 species of fish in Lake Victoria have disappeared, due partly to the introduction of the Nile perch, which has eaten many of



the smaller fish species. Eutrophication also may have played a role by making the benthic waters uninhabitable to fish.

The Nile perch and Nile tilapia are the two exotic fish species that have contributed both negatively and positively to the Lake Victoria fisheries. Their positive impacts include increased export earnings, recreational opportunities, increased supply of desirable protein food, increased fish production, and increased employment and earnings for fishermen (Ogari 2001). Given the importance of the Nile perch fishery to the economy of the region and the riparian nations, it is not likely that the pressure exerted by these predators on the endemic species will lessen.

The threat to the biodiversity of the Lake Victoria region continues to grow, despite our increasing knowledge of the system (Fuerst and Mwanja 2001). Studies by Mwanja et al. (2001) for nearly ten years in the Lake Victoria aquatic system, however, have revealed that a significant portion of the cichlid fauna considered lost from the main lakes of the Lake Victoria region (Lakes Victoria and Kyoga) is still extant, both in marginal habitats in the periphery of the main lakes, and in the small satellite waterbodies around the main lakes. If well planned and managed, reintroduction and restoration efforts will be the only tool for conserving cichlid biodiversity in view of the many threats facing them.

There was a decreasing trend in the Nile perch standing stocks in Lake Victoria from 790,000 metric tons in August 1999 to 530,000 metric tons in September 2001, while the small pelagics increased from 350,000 to 1,200,000 metric tons in same period. The causes of the decline in Nile perch are over-exploitation, the use of illegal fishing gear, and environmental degradation from the catchment areas. Different areas of the lake exhibit different fish production, due to different nutrient levels. The proliferation of water hyacinth led to an increased catch of *C. gariepinus*, *P. aethiopicus*, Tilapia and haplochromines. The weed provided refuge, breeding and feeding areas, and reduced fishing activities.

### 3.6 Summary of Major Threats

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

- Population pressure, contributing to the existence of “hot spots” caused by human wastes, urban runoff, and effluent discharges from such industries as breweries, tanning, paper and fish processing, sugar, coffee washing stations and abattoirs;
- Nutrient (phosphorus, nitrogen) inflows, including atmospheric deposition, causing a five-fold increase in algae growth since the 1960s, resulting in de-oxygenation of the water that threatens the survival of deep water fish species;

- Residue inflows from the use of chemical herbicides and pesticides and, to a limited extent, heavy metals resulting from gold mining operations that cause localized pollution;
- Proliferation of water hyacinth, resulting in biodiversity and economic losses in the lake’s nearshore areas;
- Unsustainable utilization of the major wetlands for agricultural activities and raising of livestock, which has greatly compromised the buffering capacity of the wetlands; and,
- Introduction of two exotic species (Nile perch, Nile tilapia), and use of unsustainable fishing practices and gears, altering the composition of the lake’s fauna and flora species (noting that while this had detrimental effects on the lake’s biodiversity, however, it also provided an important income source to some lake communities).

## 4. Management Environment

### 4.1 Institutional Roles and Management Strategies

The three riparian countries currently do not have an agreed 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 give particular attention to the issues of lake or transboundary water resource management. That function has been assigned instead to the recently-revived East African Community (EAC) organization, representing Kenya, Tanzania and Uganda. Management is sectoral, with little coordination among sectors. Of the existing 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 external assistance provided to this sector. The 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. The lake-wide fisheries management improved primarily because of the shock all riparian countries felt when their earnings from a major export commodity were threatened.

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

In spite of a lack of formal cooperative water quality mechanisms, when water hyacinth spread rapidly in the mid-1990s to threaten much of the lakeshore, the riparian countries communicated well to contain the outbreak, even though different control mechanisms were tried in each country. The Lake Victoria Environmental Management Programme (LVEMP), which had an aquatic weed component, contributed to this effort. The water 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. Thus, water hyacinth control provides an example in which management efforts must extend beyond the three riparian countries.

Many of the pollutants entering Lake Victoria originate in its catchments. However, catchment management activities are nationally-based, with little harmonization between countries and, in some instances, even between Ministries within the same country. Thus, while Kenya and Uganda have comprehensive legislation covering environmental management, Tanzanian environmental and resource legislation remains fragmented among the various sectors. On the other hand, Kenya has introduced extensive water resource reforms, starting with the 1999 water policy, the 2002 Water Act, and the draft water resource management strategy. Tanzania also is introducing reforms, with a new water policy that includes specific reference to managing 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, forest clearing activities in Kenya, for example, 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 the three riparian countries to discuss Lake Victoria management issues. The other regional institution dealing with management of the lake is the Lake Victoria Fisheries Organization (LVFO). The projects undertaken in the lake basin include the LVEMP, Lake Victoria Fisheries Research Project (LVFRP), and Nile Basin Initiative (NBI). The effective performance of these institutions and projects has been based on financial assistance from international institutions, such as the World Bank, SIDA, DANIDA, UNDP, GEF and others. The following five sub-sections summarize the roles played by the above-mentioned institutions and projects.

#### 4.1.1 East African Community (EAC)

The East African Community (EAC) is a regional forum representing 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

### **Box 1. East African Community–Donor Partnership for Development of the Lake Victoria Basin**

Recognizing the vast potential for economic development existing 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 an 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 a more coordinated approach to lake management, and it is anticipated that the EAC will approve a Protocol for Sustainable Development of the Lake Victoria Basin, establishing a Lake Victoria Basin Commission as part of that Protocol.

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

- Exploiting the opportunities for development in the Lake Victoria Basin in a sustainable manner, and addressing the present problems relating to economic and social development, poverty and environment;
- Identifying and investigating specific aspects of threats and obstacles to sustainable, economic, social and environmental development, and their underlying causes, and proposing relevant interventions;
- Assisting in the formulation of policies to guide the various actors involved with activities relevant to sustainable development in the region;
- Building capacity through the development and strengthening of local institutions and organizations concerned with these issues;
- Promoting coordination of the development efforts undertaken by various authorities, institutions and bodies established within EAC with an interest in supporting developments in the Lake Victoria Basin;
- Providing a consultative forum and focal points for various actors with an interest in developments in the basin; and,
- Broadening cooperation between EAC, its member states and donor agencies; identifying investment opportunities and working to create a climate conducive to investments; and mobilizing resources for the implementation of identified programs.

zone that must be developed in a sustainable manner. The EAC and the Governments of Sweden, France and Norway, and 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 its development partners. The agreement included 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, that a majority of the people in the basin live in abject poverty, that environmental degradation in the basin is escalating, and that the basin's economic potential cannot be sustainably developed unless the problems associated with environmental degradation, deepening poverty and poor health standards are addressed in a broad, coordinated manner. This project, to be completed in 2015, will lay the foundation for a more coordinated approach to lake management, and it is anticipated that the EAC will approve a Protocol for Sustainable Development of the Lake Victoria Basin, establishing a Lake Victoria Basin Commission as part of the Protocol (Box 1).

#### *4.1.2 Lake Victoria Fisheries Organization (LVFO)*

The Lake Victoria Fisheries Organization (LVFO) is an institution of the East African Community (EAC) specifically responsible for promoting proper management and optimum utilization of Lake Victoria's fishery resources. It is mandated to forge partnerships and collaboration with institutions and stakeholders, and consolidate the relationships with mutual arrangements, through joint delivery of complementary programs focused on the health of Lake Victoria's ecosystem for sustainable fisheries resource utilization and socio-economic development of the riparian communities. Establishment of LVFO was facilitated by the concerted efforts of the three riparian countries, the Food and Agriculture Organization 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 Programme (LVEMP). The Strategic Vision document prepared describes the focus, intent and direction of the LVFO programs through the year 2015. Embracing a holistic management view, a healthy ecosystem approach has been adopted as the fundamental concept for utilizing Lake Victoria.

#### *4.1.3 Lake Victoria Environment Management Programme (LVEMP)*

The Lake Victoria Environment Management Programme (LVEMP) is a Global Environment 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

US\$75,636,000, of which the three riparian states contributed 10% (LVEMP 2003). Specific LVEMP Phase I objectives 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 reverse environmental degradation to the maximum extent possible; and to promote regional cooperation (see Box 2).

#### *4.1.4 Lake Victoria Fisheries Research Project (LVFRP)*

During the 1990s, the Governments of Kenya, Tanzania and Uganda requested the European Union's assistance for a new fisheries project. The Lake Victoria Fisheries Research Project (LVFRP) was established in 1997, with the principal objective of assisting the Lake Victoria Fisheries Organization to develop a framework for the rational management of the lake's fisheries. Specific objectives of the project included carrying out stock assessments, training fisheries researchers, rehabilitating and constructing research vessels, equipping research institutes, and investigating socio-economic issues related to the lake and its fisheries. The LVFRP provided the research institutes with 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, 7 Ph.D. and 12 M.Sc. scholarships, a 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 United Kingdom and the Institute of Marine Biology of Crete in Greece. The LVFRP maintained a fleet of research vessels, which conducted surveys of the lake's fish stocks. Traditionally, it has been the government who has regulated the fishery industry; however, one of the areas LVFRP has addressed is involvement of fishing communities in managing the lake's fisheries. Fish stocks, fish speciation, market surveys and species abundance studies have been undertaken through the project.

#### *4.1.5 Nile Basin Initiative (NBI)*

Ten countries make up the Nile River drainage basin, namely, Burundi, the Democratic Republic of Congo, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, Sudan, Tanzania and Uganda. Some of these countries only have a small part of their area within the basin, while others are located virtually entirely within the basin. The Nile Basin Initiative (NBI) is an initiative by the ten Nile Basin countries, with the aim of promoting the development potential of the Nile River in a way that focuses on gaining mutual benefits from development, rather than on defending rights. The initiative is funded by several donors, including the World Bank, Norway and Sweden. The Nile Council of Ministers (Nile-COM) serves as the NBI's highest decision-making body. The Nile-COM is made up by ministers of water affairs of the Nile Basin Riparian Countries. Technical support is provided by the Nile Basin Initiative Technical

Advisory Committee (Nile-TAC), with the execution of its decisions 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,

### **Box 2. Lake Victoria Environment Management Programme (LVEMP), Phase I**

In response to the seriousness and 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 LVEMP 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.

The 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 reverse environmental degradation to the maximum extent possible; and,
- To promote regional co-operation.

The project had the following 11 components:

1. Catchment Afforestation Component aimed at increasing forest cover through tree planting and preventing soil erosion, as well as conservation of natural forests;
2. Land use Management Component emphasized soil and water conservation, and appropriate use of agrochemicals, to reduce pollution loading and improve agricultural production;
3. Wetlands Management Component emphasized sustainable use of wetlands in order to conserve them, as well as to improve their buffering capacity;
4. Industrial and Municipal Waste Management Component emphasized wastewater management by industries, as well as use of artificial or natural wastewater treatment;
5. Water Quality Monitoring Component focused on the establishment of a 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.;
6. Water Hyacinth Control and Management Component focused on controlling the weed by reducing it to manageable levels, using a combination of biological and mechanical/manual removal methods;
7. Fisheries Management Component focused on the establishment of a sustainable collaborative management of the fisheries through stakeholder involvement. The component also emphasizes 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 community's welfare;
8. 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;
9. 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;
10. 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; and,
11. Establishment of the Lake Victoria Fisheries Organization (LVFO) Secretariat aimed at establishing the LVFO Secretariat in Jinja, Uganda. It was treated as a component under LVEMP in Uganda.

Source: LVEMP (2003).

Democratic Republic of Congo, Egypt, Kenya, Rwanda, Sudan, Tanzania, and Uganda). Eight projects have been identified for investment in the NELSAP region, including 3 basin management projects for managing river basins flowing into Lake Victoria, water hyacinth control in the Kagera River, and a regional agricultural project, all with direct implications for Lake Victoria's management. The NELSAP presently is executed by a small management unit located in Entebbe, Uganda, that has links with other regional projects, but is independent of them.

#### 4.2 Technical Capacities

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

Apart from this research and development 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 of Lake Victoria. However, the infrastructure for fisheries and water quality research is expensive, with the continuation of these capabilities dependent on further external investments.

The technical/scientific capacity available for catchment management is less coordinated than the fisheries research. Universities in each of the countries provide the main technical capacity in this area, although analytical capabilities also are 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 the lake.

The various Lake Victoria projects have produced much new knowledge about the functioning of the lake. Important issues remaining to be resolved include the full taxonomy of the lake fish, the sources of the atmospheric nutrient loads, and the extent of internal nutrient loading. However, there is now a sufficient knowledge base for informed lake management, particularly for 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. The benefits from these major investment programs will not be realized until this is done.

#### 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 all riparian countries, 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. Fishing communities also have been successfully engaged in raising and releasing the beetles for water hyacinth control. Both activities highlight 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 sediment and nutrient loads 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 organizations (NGO) in the Lake Victoria region, primarily focusing on poverty and environmental issues. There is a very large number of Civil Society 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. It is less clear, however, whether or not 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 provides an important vehicle for this input.

### 5. Lessons Learned

Based on this review of the management situation of Lake Victoria, several lessons can be drawn, which provide a useful guide for the current and future management of the lake and its drainage basin.

**An agreed vision is essential.** The present management of the lake is fragmented between sectors and nations. Thus, critical choices—whether to manage for biodiversity or commercial fish catch, or how to allocate fish catches between countries—are made by default or not at all. Deliberate management to achieve the 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 through the EAC's Vision exercise.

**Lake management policies and action plans must be consistent with national activities.** Most of the actions emerging from a lake-wide management policy must be

implemented by the riparian and catchment governments. Thus, the national water resources, agricultural, forestry, poverty alleviation policies of all riparian and catchment governments must include specific components leading to the required actions called for in the lake management policy. In turn, establishment of the lake management policy must include consideration of the existing policies and strategies of the riparian and catchment countries.

**When a problem is catchment-wide, it is essential that all countries in the catchment are involved in its management.**

Some of the management issues are essentially in-lake (e.g., loss of biodiversity) and so can be managed by the three riparian nations currently constituting the East African Community (EAC). Other issues (e.g., management of water hyacinth, sediment control) are unlikely to be properly managed without the active involvement of all nations in the watershed. Thus, 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.

**In the absence of strong external motivations, it is important to build a strong logical case for government action.**

The advances in lake-wide fisheries management occurred because of the shock all the riparian countries felt when their earnings from a major export commodity were threatened. However, the riparian countries have not experienced 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 EAC program, 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 the EAC initiatives are properly mandated, funded and supported from the highest political levels.

**Communities must be involved in all aspects of management.**

There are heartening success stories where communities have been involved in on-ground activities affecting their livelihoods. An outstanding example is the involvement of local fisher communities in rearing and distributing weevils for the biological control of water hyacinth. 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. Thus 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 lake management body.

**Research and development (R&D) should be designed around management objectives.** A good knowledge base now exists for Lake Victoria. However, the programs to gather this information have not carefully focused on the management objectives, largely because they have not been properly

established. Thus, some of the R&D activities have not been of direct relevance and, more importantly, some management-critical knowledge is 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 evade senior decision-makers lacking scientific training.

Phase II of the LVEMP project is now under preparation and the second phase of the LVFRP is in place. The latter program will continue to support efforts to manage the lake's fishery resources, 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 toward supporting management of biodiversity, water weeds and eutrophication. Thus, Phase II can be directed toward 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 nutrient sources once they have been identified. However, it also should include a focused, priority R&D component aimed at resolving some of the major management questions (e.g., the sources of 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 already has been transferred to the EAC. It would be reasonable for the LVEMP Phase II also to be executed by the EAC to ensure coordination and focus. The Nile Basin Initiative spans a much larger area than just the Lake Victoria catchment. Nevertheless, implementation of the Nile Equatorial Lakes Subsidiary Action Plan program should be closely coordinated with EAC, to ensure its activities contribute effectively towards the agreed vision for managing the lake.

## 6. Acknowledgements

This report benefited greatly from contributions by Oyugi Aseto, Fred Bugenyi, James Richard Davis, Kisa Mfalila, Victor Muhandiki, Micheni Ntiba and Obiero Ong'ang'a.

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