CHAPTER TWELVE

Impacts of water quality change on beneficial uses of Lake Victoria, Uganda

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ABSTRACT. *The nuisance macrophyte, water hyacinth, is an alien aquatic weed that was first reported on the Ugandan portion of Lake Victoria in 1989. Since that time, water hyacinth spread rapidly and by 1995, it had colonised much of the lake's shoreline. Lake wide surveys were conducted with the objective of collecting data on environmental factors influencing hyacinth proliferation, in addition to impacts of its infestation on the ecological, social and economic aspects of the environment. The data was collected before, during and after the peak infestation.*

The nutrient-rich environment contributed significantly to the weed's rapid proliferation, and was enhanced by shelter from offshore winds. Additionally, waves and water currents dispersed viable propagates to several destinations and got established across the lake. Both the stationary and mobile mats imposed varying magnitudes of impacts on the ecological, social and economic aspects of the lake environment. Water hyacinth infestation impaired fishing, breeding and nursery grounds, impaired fishing and transport activities, in addition to negatively impairing various business enterprises at the lakeshores.

The overwhelming negative impacts led to declaration of water hyacinth as an environmental pest hence all efforts were aimed at controlling it. Biological control was applied on a large scale, while manual and mechanical extraction of the weeds was effected at strategic locations. By 1999, water hyacinth had been brought under control (by more than 80 %) in most bays of the lake, but infestations in riverine environments remain untackled despite the concerted efforts. The well-established biological control agents continue to suppress any resurgence of the weed hence proliferation is unlikely to attain the magnitude recorded in 1998.

The problem of other potential aquatic weeds (e.g. Naja horrida and Trappa natans) however, pose challenges to management especially of the littoral water quality and fisheries in Uganda's aquatic systems and need redress before they attain alarming magnitudes. Additionally, management of nutrient loading into aquatic systems ought to be an integral part of every effort to manage aquatic weeds since nutrients are critical environmental factors in influencing proliferation.

INTRODUCTION

Beneficial uses of Lake Victoria are increasingly becoming unsustainable due to changes in trophic status with the lake water becoming more eutrophic and contaminated by pollutants, toxic cyanobacteria and water hyacinth, and energy transformation limited by the number of trophic groups in the lake. The authors recognise the scarcity of historical monitoring data, but by using high resolution palaeolimnological data, they show that eutrophication-induced loss of deep water oxygen started in the early 1960's (Talling 1961). By eliminating the deep water habitats, the displacement and reduction of deep water haplochromine stocks could have further been fuelled by the simultaneous explosive increase in the stocks of the introduced predatory Nile perch.

Parallel to changes in trophic status, the last two decades have been characterised by a dramatic decline in fish species and trophic diversity rendering the lake ecosystem functioning less efficient and prove to unpredictable short term fluctuations. The decline in stocks of native fishes by the 1960's and the emergency of a commercial fishery based on the stocked predatory Nile perch, Nile tilapia and the small pelagic native 'mukene' (*Rastrineobola argentea*) have not stemmed the unsustainable/effort fishing that is characterised by illegal, unregulated and unreported (IUU) fishing malpractices including the catching of immature fish, and the use of poisons.

Stakeholder Issues and Environment Management Approaches

There now exists general understanding by stakeholders that environmental factors such as temperature, pH, oxygen, nutrients, the type and density of wetland vegetation at the shore, and aquatic weeds especially water hyacinth, all influence water quality, and play a role in fish production. There is also basic knowledge of food webs involving fishes, fish habitats and biodiversity. There is thus consensus that the Lake Victoria environment, its wetlands and fisheries need to be sustainably managed. There are also laws/regulations that are relevant to the sustainability of the aquatic resources. These laws govern the use of Lake Victoria resources but the laws covered in NEMA wetland statutes are not always strictly followed. Human population hot spots contribute to sources of human waste, urban runoff and discharge from a wide range of industries of various scales.

Some of the more direct causes of water quality changes are:

- Inflows of residues from use of chemicals herbicides and pesticides such as DDT, and, to a limited extent, heavy metals resulting from gold mining operations and some industries e.g. leather tanning.
- Raw waste settlements, market centres, and towns around the lake contributing significantly to pollution of the lake waters.
- Unsustainable use of major wetlands due to livestock rearing and other agricultural activities which have compromised the buffering capacity of the wetlands.
- Alteration of the species composition of the lake and loss of locally favoured fish species known for their medical and cultural values due to introduction of Nile perch and Nile tilapia species, and use of inappropriate fishing practices and methods.
- Inflow of nutrients (phosphorus and nitrogen) has given rise to a five-fold increase in algal growth since 1960s causing de-oxygenation of the water threatening survival of some species. Nutrient enrichment has also enhanced proliferation of aquatic weeds especially water hyacinth.

Impacts of Water Quality Changes on the Lake Victoria Basin Fisheries

For the fisheries, the impacts are associated with:

i. Loss of biodiversity
ii. Loss of fish habitats
iii. Ineffective food webs
iv. Food web contamination, and
v. Nuisance macrophyte growth

MATERIALS AND METHODS

Information and data on issues relating to causes of water quality change on the beneficial uses of Lake Victoria basin resources was collected from literature materials, consultations with various experts and experience of the authors. The reported information in this chapter is not limited to

LVEMP contribution, but from various sources including data accumulated by projects prior to LVEMP. During pre-LVEMP surveys, scientific data was collected from various locations on Lake Victoria and its satellite lakes. Scientific data was collected from various bays, while socio-economics information was collected from various fishing villages

RESULTS

Invasion, Proliferation and Infestation of Water Hyacinth

Water hyacinth infestation was characterised by stationary mats along sheltered shorelines, and the mobile masses that were propelled around the lake by winds and waves. Stationary water hyacinth became a common feature along much of the lake shoreline and riverbanks. On the Uganda portion of Lake Victoria, water hyacinth attained its peak biomass cover (≅ 2,200 ha) by 1995, with an average lateral width of 10 to 15 m. The trends in the distribution and cover of mobile water hyacinth in the Uganda portion of Lake Victoria are illustrated in Table 1. Figure 1 presents changes in biomass cover of water hyacinth in the main production bay and three storage bays.

TABLE 1. Trends in cover abundance (ha) of water hyacinth in some bays of Lake Victoria, Uganda between 1994 and 2005.

Location (Bays)	**1994**	**1997**	**1998)**	**1998**	**1999**	**2001**	**2002**	**2003**	**2004**	**2005**
Murchison⊕	877	490	100		2.0	10.0	9.0	10.0	12.0	15.0
Waiya*	3	80	140	20.0	1.0	0.5	1.0	0.5	0.3	0.5
Thruston*	108	790	800	30.0	1.0	1.0	1.0	1.0	1.0	0.8
Hannington*	96	304	750	300.0	1.0	1.0	1.0	0.8	1.0	1.5
Macdonald	13	4	2.0	2.0	1.0	1.0	1.0	2.0	3.0	5.0
Pringle	15	5	1.0	1.0	1.0	1.0	1.5	1.0	0.5	0.3
Napoleon Gulf	--	--	--	--	1.0	2.0	2.0	3.0	2.5	4.0
Bunjako	--	--	--	--	--	2.0	8.0	8.0	9.0	9.0
Total	1,112	1673	1, 793	353	8	18	25	26.3	29.0	36.1

⊕ Major production centre; * Major storage bays

The Nakivubo Channel of Inner Murchison Bay, which drains Kampala area and empties into the lake, had the most luxurious water hyacinth plants with the highest reproductive index of 3 to 4 daughter plants per mother plant. A biomass cover of 8 ha was estimated in the inner portion of the bay in 2001. Water hyacinth periodically drifted out to Wazimenya and Gobero sub-bays where about 2 ha were estimated in 2001. By the early part of 2002, weed cover in each of the major infestation bays such as Macdonald, Hannington and Thruston was estimated at less than one hectare. Most of the mats were small, consisting of the less prolific non-bulbous growth form. Some weed proliferation was noted in Pringle and parts of Fielding Bay, which had about 2 ha of water hyacinth, each. It was only the centres along the western shores of the lake namely inner Murchison, Bunjako and Lwera bays that had considerable quantities of water hyacinth. Water hyacinth in the Wazimenya and Gobero sub-bays was mostly non-bulbous, of poor physical condition, and heavily infested with biological control weevils.

Impacts of Water Hyacinth Infestation

Impacts on Fish and the Water Environment

The impact of water hyacinth infestation on fish catches was determined by comparing pre-infestation trawl data from 1983, and data collected during weed infestation. Data was from Thruston Bay where the hyacinth was permanently resident as compared to Itome Bay that had no permanently resident hyacinth. In both bays, the fish species composition was high in 1982 before the invasion by hyacinth and comprised about 10 species in each. After the collapse of water hyacinth, only three fish taxa were recorded in trawl catches annually in Thruston Bay. Whereas the trawl catch rates in Thruston bay were higher (711kg h^{-1}) than Itome Bay (419 kg h^{-1}) before the weed collapsed in 1998, the catch rates of Thruston Bay were much lower 20 to 50 kg h^{-1} compared to those of Itome Bay (200 to 221 kg h^{-1}), after water hyacinth sunk (Table 2). In terms of weight, less than eight species in each bay contributed to at least 90% of the fish biomass during the sampling period (Table 3). Native fish species especially haplochromines and *Brycinus sp.* together contributed at least 30% of the total fish density. Less than eight fish species in each bay contributed to all the fish caught (Table 4).

TABLE 2. Bottom trawl fish catch composition from Thruston and Itome Bays between 1993 and 2000.

Period	Number of samples	Kg hr^{-1}	Standard Error	Percentage catch composition (by weight)							
				Lates niloticus	*Oreochromis niloticus*	*Haplochlomines.*	*Protopterus*	*Clarias*	*T. zillii*	*Synodontis afro.*	*Synodontis victoriae*
(a) Thruston Bay											
1993	14	198.20	10.20	98.10	1.50	0.40					
1994	3	125.34	22.50	98.10	1.50	0.40					
1995	3	62.94	6.00	95.36	4.63	0.01					
1996	--	--	--	--	--	--					
1997	--	--	--	--	--	--					
1998	5	20.20	4.92	96.70	3.10	0.20					
1999	5	50.22	25.10	96.40	0.03	3.53			0.04		
2000											
(b) Itome Bay											
1993	2	25.18	20.10	95.99	3.97	0.04					
1994	5	77.76	14.20	42.54	5.79	0.44	1.03	0.41		28.31	21.48
1995	6	35.93	25.10	97.51	2.48	0.01					
1996	2	67.90	44.70	67.38	32.47	0.15					
1997	6	148.29	28.80	90.63	8.69	0.61			0.03	0.04	
1998	23	157.88	21.50	87.10	12.83	0.07					
1999	15	199.50	24.20	80.09	17.19	2.19			0.52	0.01	
2000	21	221.90	25.30	84.92	10.07	0.22	4.53		0.25	0.01	

TABLE 3. Relative abundance (% by weight) of fish species in Thruston, Waiya and Fielding Bays between 1998 and 2001.

Species	**Thruston**		**Waiya**		**Fielding**	
	1998/99	2000/2001	1998/99	2000/2001	1998/99	2000/2001
Lates niloticus	39.4	19.9	40.7	45.1	28.9	39.9
Oreochromis niloticus	17.8	18.9	23.0	10.3	50.2	28.7
Haplochromines	27.6	18.4	3.4	4.1	2.8	3.6
Brycinus	0.8	7.0	2.5	6.2	2.1	3.2
Astatoreochromis	2.0	3.1	1.3	1.3	0.7	1.6
Protopterus aethiopicus	7.1	26.2	24.9	26.6	13.6	16.4
No. of Fishing events	6	5	2	3	4	3

TABLE 4. Relative abundance (percentage by numbers) of fish species in Thruston, Waiya and Fielding bays between 1998 and 2001.

	Thruston Bay		**Waiya Bay**		**Fielding Bay**	
Keystone Species	1998/99	2000/2001	1998/99	2000/2001	1998/99	2000/2001
Lates niloticus	21.0	18.0	41.0	34.0	37.1	44.0
Oreochromis niloticus	7.7	6.6	9.9	3.6	25.5	11.7
Haplochromines	58.4	40.8	14.0	15.0	16.1	17.4
Brycinus Spp	4.0	22.2	26.0	37.0	12.9	17.6
Astatoreochromis alluaudi	2.7	3.3	2.3	2.4	2.3	3.0
Protopterus aethiopicus	0.8	2.3	2.5	2.9	2.5	2.4
%Contribution to total Numbers	94.5	93.2	95.7	94.9	96.4	96.1
No. of Fishing events	6	5	5	3	4	3

Socio-economic Impacts

A socio-economic assessment of impacts of the sunken water hyacinth on fish production, water transport, beach environment, water quality and health of fishing communities was carried out in March 2002. Questionnaires were administered to 190 respondents at randomly selected but stratified landing sites and institutions around the lake. Most respondents (76%) had encountered debris of water hyacinth. Most of those who associated the weed with impacts (55%) said it influenced the fishery by affecting breeding (50%) and fishing grounds (41%). Most respondents (86%) indicated that tilapia was the most affected fish species since the debris occupied their natural habitats close to the shoreline.

Most respondents (88%) reported that the debris affected gillnets most by sticking on them. Gillnets became dirty, easily seen by fish, heavier and sometimes got torn. Most respondents (52%) reported that long lines and hand lines were not affected; in some cases that they were affected, the debris sometimes covered the long lines leading to their disappearance and loss while the debris got stuck on hooks of hand lines.

Most respondents (78%) said that the weed debris did not affect water transport. The few (22%) who said that it affected this mode of transport indicated that sometimes debris of sunken water hyacinth choked outboard engines. Most respondents (85%) revealed that the debris affected beaches whenever winds concentrated weeds at the shoreline. This made beaches muddy (83%), blocked boats from landing (11%) and made it difficult to draw water (6%). Costs had to be incurred in that passengers, their property and fish had to be carried in order to avoid the muddy water.

Some respondents (47%) revealed that they depended on the lake and river as the main source of water for drinking and other domestic uses. Most respondents (95%) however, reported that the sunken weed affected water quality by making it muddy (41), contaminating it with debris (38%), giving it unpleasant odour (14%) and changing its colour (8%). Most respondents (63%) reported that the debris of sunken water hyacinth was associated with vectors and diseases especially snails (52%), worms (46%) and mosquito larvae (2%). The most prevalent diseases were bilharzia (52%), diarrhoea (23%), skin rush (20%), malaria (3%) and abdominal pain (2%) were the most prevalent diseases, and could be associated with deterioration in the water environment due to increased debris. Management at Entebbe Water Works explained that they had not faced any problems caused by the debris of sunken water hyacinth.

Water was harvested offshore to avoid any debris at the shoreline. However, at Lido beach, when the winds blew the debris to the shoreline, the beach became muddy limiting swimming and other beach games. Management of Uganda Railways Ferry Terminal at Port Bell, and Nalubaale and Kiira Dams in Jinja also reported that the debris of sunken water hyacinth did not have any impacts on their docking and power generation activities, respectively.

DISCUSSION

The various issues that are associated with water quality change on beneficial utilisation of the Lake Victoria basin resources have been highlighted and need to be addressed in order to reverse the observed deteriorating health of the lake.

Loss of Biodiversity and Fish Habitats

The expansion of the gill net fishery, catching of fishes during breeding seasons and the use of small mesh illegal nets greatly reduce the spawning stock of the large-bodied fishes and results into changes in the trophic structure that links primary producers and consumers and secondary to tertiary consumers. Additionally, the use of beach seines (drag gear) apart from destroying fish breeding areas, catch fish indiscriminately. The impact of predation by the Nile perch especially on the small haplochromine cichlids, and competition between the Nile perch and native predatory fishes has greatly reduced the efficiency of energy transfer through food chain truncation. These factors have led, in part, to loss of fish diversity. The general aquatic biodiversity, however, has been adversely affected by such issues as sedimentation, increased turbidity, eutrophication, algal blooms, deoxygenation, reduced density and spread of submerged macrophytes, reduction in lakeshore wetlands vegetation cover, increased atmospheric deposition, aquatic weeds proliferation, and water level changes.

Inefficient Food Webs and Food Web Contamination

Predation by Nile perch has altered the efficiency of the original food webs. This has resulted into, for example, elimination of some key trophic group elements in the food chains/webs and has created serious gaps related to energy flow. For example, the originally known high diversity of the haplochromine cichlid flock has been reduced significantly that the efficiency of the ecosystem in energy flow has been drastically reduced. In addition, some elements of the ecosystem such as the microbial loop and the biogeochemical cycles are not well understood. Understanding the various elements of the ecosystem and how these relate to each other is key to rational management of natural resources.

There is potential food web contamination but data on this subject is either scanty or non existent. The presence of some industries (e.g. leather tanneries) and businesses (e.g. car washing), in addition to such phenomenon as methylation pose a threat to the quality of the aquatic environment and the resources therein. Other contaminants include presence of coliform bacteria that have been found in waters of turbidity between 4 and 84 NTU, free chlorine residuals between 0.1 and 0.5 mg L^{-1}, and a minimum contact time of 30 min. In turbid water, *Escherichia coli* has been shown to be protected in the presence of chlorine levels of 0.35 mg l^{-1} or greater. The adsorptive capacity of some suspended particulates can lead to the presence of undesirable inorganic and organic compounds in drinking water. Most important in this respect is the organic or humic component of turbidity. For example, herbicides such as 2,4-D, paraquat, and diquat can be adsorbed on to clay–humic particulates, the adsorption being greatly influenced by metal cations present in the humic material. In addition, the strength of the bonds in some metal–humate complexes in the turbidity fraction may complicate the measurement of trace metals in natural waters, resulting in an underestimation of the metal concentrations. The consumption of highly turbid water may constitute a health risk, because, as mentioned above, excessive turbidity can protect pathogenic microorganisms from the effects of disinfectants, stimulate the growth of bacteria in distribution systems, and increase the chlorine demand. In addition, the adsorptive capacity of some particulates may lead to the presence of harmful inorganic and organic compounds in drinking-water. High levels of turbidity in water supplies also cause wear on equipment and water reticulation systems and can block them.

Nuisance Macrophyte Growth

Proliferation of nuisance aquatic macrophytes negatively Impacts on fish breeding, spawning, nursery and feeding habitats. Extensive macrophyte cover also impairs water quality for both fisheries production and human consumption, in addition to impairing navigation, businesses at beaches, and human health

Coupled with the above issues, it is to be appreciated that agricultural developments around the Lake Victoria basin have resulted in deforestation, bush burning and drainage of swamps, leading to accelerated soil erosion (Hecky *et al*. 1996) and associated siltation of the littoral zone of the lake (Ogutu-Ohwayo *et al.* 1997). Siltation fouls breeding, nesting and nursery grounds for inshore fishes, particularly the Nile Tilapia, *Oreochromis niloticus*

(Balirwa 1998), and contributes to nutrient loading of the lake through fertilizers applied on farmlands (Bugenyi and Magumba 1996; Ogutu-Ohwayo and Hecky 1991). Urban and industrial expansion along the lakeshore has increased sewage and other effluents discharged to the lake (Bugenyi and Magumba 1996; Ogutu-Ohwayo *et al*. 1997), thus increasing nutrient loading and water pollution. Increased nutrient inputs through wet and dry deposition (Hecky *et al.* 1996), from industrial and domestic sewage and agricultural runoff have doubled the biological productivity (Oskam and Genderen 1996) of Lake Victoria during the last three decades (Mugidde 1993; Hecky and Bugenyi 1992).

Given the extensive catchment area of Lake Victoria (184,000 km^2) and a flushing time of 140 years (Hecky and Bugenyi 1992), the retention capacity of nutrients and other pollutants is so high that eutrophication, pollution and anoxia may become long-term phenomena in the lake. Advanced stages of these phenomena may be difficult to reverse (Jorgensen and Vollenweider 1988). The Great Lakes of North America provide an example of reviving a fishery and its associated water quality. In the Lake Victoria basin, management measures have not fully internalised and addressed the cause-effects phenomenon of the issues that affect the health of aquatic systems within the basin. It is further to be borne in mind that tropical freshwater systems can suffer from serious alien species invasions, can have high biological turnover and productivity, and are susceptible to rapid ecosystem changes (Denny 1998).

Though water hyacinth was first reported on the Uganda portion of Lake Victoria in 1989, it could have occurred in the lake at an earlier date. This aquatic weed is thought to have entered Lake Victoria through the Kagera River probably around 1987. This nuisance aquatic plant exhibited high proliferation rate and by 1990, it had become a common feature in many parts of Lake Victoria. Water hyacinth occurred in form of stationary mats in quiescent sheltered bays and along much of the lakeshore, in addition to the mobile mats that were propelled around the lake by winds, waves and water currents. At the Kagera River mouth and in other offshore parts of Lake Victoria, turbulence due to strong winds fragmented water hyacinth, but viable fragments were thought to have contributed to further proliferation.

The sheltered bays and riverbanks were the initial habitat for widespread establishment of water hyacinth. Lakeshores and riverbanks most suitable for weed establishment were characterized by shallow water (<5 m deep) and soft muddy bottoms. Establishment along the shores of the Nile and Kagera Rivers occurred along deposition sides of the river bends and inlets where young water hyacinth plants were sheltered from river currents thus allowing stationary weed mats to establish. Such areas were relatively shallow due to heavy deposits of silt that was presumably rich in nutrients. Papyrus *(Cyperus papyrus)* was the dominant vegetation along much of the lakeshore and riverbanks where water hyacinth was initially established. Papyrus was therefore recognized to be an indicator macrophyte of sites suitable for establishment of water hyacinth along the shores of lakes and rivers.

During the second half of the year 2000, water hyacinth resurgence occurred in several zones of Lake Victoria, and was characterized by a wave of plant re-growth especially in sheltered bays (e.g. Thruston, Bunjako and Waiya), and in the nutrient-rich Murchison Bay. This resurgence did not produce large plant mats but regressed before formation of extensive mats. Their influence on spatial weed distribution was therefore minimal. Suppression of rapid growth was mainly attributed to presence of biological control weevils as was noted from the clustered feeding marks on especially bulbous plants. It was however, noted that resurgence during the later part of 2000 was sustained in most of the bays and lakeshores that were previously characterized by luxurious weed growth.

The presence and subsequent collapse of hyacinth had a negative impact on the fish stocks. There was localized deterioration in environmental quality, and a decline in species richness in biotic communities. This was partly attributed to the sinking and decomposition of water hyacinth where decomposition products (e.g. depressed dissolved oxygen conditions) resulted into a deteriorated water environment. However, these changes returned to normal suggesting that the collapse of hyacinth did not have long-term effects on the environment. Experiments to monitor long-term trends in nutrient dynamics are recommended in order to clarify the dynamics of nutrients in sediments containing sunken water hyacinth debris.

The debris that resulted from sunken water hyacinth was said to reduce the efficiency of fishing gears and increased maintenance costs in that the debris had to be removed, nets cleaned, frequently repaired and replaced. Contamination by the water hyacinth debris on fishing gears, and on breeding and fishing grounds resulted into reduced fish catches hence income. Due to deterioration in water quality as a result of sunken and decomposing water hyacinth, it became difficult to draw water at the shores and a cost was incurred to hire somebody to draw water offshore using a boat. Local people sometimes were compelled to go to alternative sources (e.g., wells, taps, boreholes and springs) for water that, in some cases, were located far away. In the long run, business establishments (e.g., recreation centres) at various beaches were negatively affected as customers were discouraged from going to such places due to bad odour from the lake, decomposing weed biomass and attendant bad smells.

Conclusions

Most of the problems facing Lake Victoria have escalated as a result of weak enforcement institutional mechanisms. Additionally, the aspect of "Common Property" implies the sense of ownership hence property right has negatively affected implementing management measures.

i. Loss of biodiversity has been attributed in part, to over exploitation of natural resources, alien species introductions, and deterioration in environmental quality.
ii. Loss of fish habitats is attributed to anthropogenic activities that have resulted into sedimentation, turbidity, eutrophication, deoxygenation, and proliferation of aquatic weeds.
iii. Inefficiency in food webs are due to predation by the introduced Nile perch that has altered the food web structure by preying especially on haplochromines of various trophic levels, thus creating energy flow gaps.
iv. Contamination of the food web was attributed to discharge of pollutants from some industries (e.g. leather tanneries), faecal contamination, in addition to methylation.
v. Proliferation of aquatic weeds especially water hyacinth was partly due to the rich nutrient base that fosters plant growth.

Recommendations

The main objective of management intervention should be to regulate human activity impacts on the beneficial uses of the Lake Victoria basin resources in order to ensure their stability in a healthy environment. The approach should involve measures including:

1. For lake shores, there is a law that protects 100 to 200 m buffer zones between the shore line and towards dry land. This law should be enforced.
2. A similar distance (200m) from the shoreline towards open water should be gazetted as a “no fishing zone” and enforced by BMUs.
3. Sandy and rocky shores should be regarded as part of critical habitats and protected under appropriate legislation.
4. Beach Management Units (BMUs) and conservation management units (CMUs) should include diverse stake holders to avoid sectoral approaches.
5. Interventions by policy makers and managers should place emphasis on closed areas, closed seasons, and bans to fishing in critical habitats.
6. Selected habitats with high fish diversity should designated as “Marine Parks” or Reservoirs and protected as provided for in existing legislation.
7. The established conservation management units on some satellite lakes should be reinforced and extended to other lakes.
8. Reclamation of swamps and clearing of macrophytes surrounding the lakes for agriculture should be avoided to stop the spread of Nile perch and other human impacts.

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