Preliminary Assessment of the Social, Economic and Environmental Impacts of Water Hyacinth in the Lake Victoria Basin and the Status of Control

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Abstract

The paper presents preliminary data collected in an assessment of the social, economic and environmental impacts of water hyacinth in the Lake Victoria Basin. A summary of the status of control and strategies for the future is given. The report draws on field observations made, studies through interviews of affected communities and organisations, personal communications and published reports by scientists in the region.

Lake Victoria, the world's second largest freshwater body, supports an estimated 25 million people living in the Basin, with an estimated gross economic product of US$3–4 billion annually, mainly from subsistence agriculture and fishing in Kenya, Uganda, Tanzania, and parts of Rwanda and Burundi.

The multiple activities in the Lake Victoria Basin have increasingly come into conflict, thus making the lake environmentally unstable and increasingly inviting environmental threats, including infestation by water hyacinth, which has brought social, economic and environmental problems to the communities living in the Lake Basin since its first appearance in the Lake in the late 1980s and early 1990s.

The maximum water hyacinth cover in Lake Victoria was reached between 1994 and 1995 when 80% of the shoreline in Uganda was covered with about 4000 ha of water hyacinth, there was about 6000 ha coverage in Kenya and about 2000 ha in Tanzania. In Rwanda and Burundi, tributaries feeding into River Kagera currently continue to discharge mats of water hyacinth into the lake at about 3.5 ha per day. The status as at June 2000 was slightly different, with scant water hyacinth in the Uganda side of the lake and much disintegrated and stunted water hyacinth in Kenya and Tanzania sides of the lake and the scene is now dominated by hippo grass.

Impact assessments of water hyacinth have generally been subjective, with few quantitative outputs. However, over the last nine years or so, water hyacinth has had a negative impact on the organisations and communities in the Basin. Surveys have revealed negative social impacts including lack of clean water, increase in vector-borne diseases, migration of communities, social conflict and difficulty in accessing water points. Important economic impacts readily perceived by Basin communities have included reduced fish catches, increase in transportation costs, difficulties in electricity generation and water extraction, fewer tourists, blockage of irrigation canals and environmental impacts such as decline in water quality, water loss through evapotranspiration, siltation, increased potential for flooding and a decline in the diversity of aquatic life.

Although water hyacinth has posed serious economic, social and environmental consequences, there is hope that the control strategies already adopted will continue to reduce deleterious impacts and allow sustained development in the Lake Victoria Basin. There is, however, a great need to undertake research to quantify the levels of damage, and the costs of control, loss of livelihood, disease, and disruption of normal operations caused by water hyacinth.

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LAKE Victoria, with a surface area of 68,800 km^2 and an adjoining catchment of 184,000 km^2, is the world's second largest body of fresh water, second only to Lake Superior. Lake Victoria touches the equator in its northern reaches, and is relatively shallow. Its maximum depth is about 80 m and the average about 40 m. The lake's shoreline is long (about 3500 km) and convoluted, enclosing innumerable small, shallow bays and inlets, many of which include swamps and wetlands which differ a great deal from one another and from the off-shore environment of the lake.

Kenya, Tanzania and Uganda control 6, 49, 45%, respectively, of the lake surface. The gross annual economic product from the lake catchment is in the order of US$3–4 billion, and it supports an estimated population of 25 million at per capita annual incomes in the range US$90–270. The lake catchment thus provides for the livelihood of about one third of the combined populations of the three countries, and about the same proportion of the combined gross domestic product. The lake catchment economy is principally an agricultural one, with a number of crops (including exports of fish) and a high level of subsistence fishing and agriculture. In Kenya and Uganda, the areas of coffee and tea in the catchment are a significant part of those nations' major agricultural exports. The quality of the physical environment is therefore a fundamental factor in maintaining and increasing the living standards of the growing populations in Kenya, Uganda, Tanzania, Rwanda and Burundi (Labrada 1996).

Major Threats to Lake Victoria

The lake is used as a source of food, energy, drinking and irrigation water, transport, and as a repository for human, agricultural and industrial waste. With the populations of the riparian communities growing at rates among the highest in the world, the multiple activities in the Lake Victoria Basin have increasingly come into conflict. This has contributed to rendering the lake environmentally unstable. The lake ecosystem has undergone substantial, to some observers alarming, changes, which have accelerated and are increasingly dominated by the potentially toxic blue–green algae (Twongo and Balirwa 1995). The frequency of water-borne diseases has increased. Water hyacinth, absent until as recently as 1989, has choked important waterways and landings. Overfishing and oxygen depletion in the deeper waters of the lake threaten the artisanal fisheries and biodiversity (over 200 indigenous species are said to be facing possible extinction). Scientists advance two main hypothesis for these extensive changes. First, the introduction of Nile Perch as an exotic species some 30 years ago has altered the food web structure. The second hypothesis is that nutrient inputs from its catchment are causing eutrophication. Thus, although the lake and its fishery have shown evidence of dramatic changes in the past three decades, the problems have arisen mainly as a result of human activities in the lake basin (Bugaari et al. 1998; Freilink 1991; Goodland 1995).

Aquatic Weeds in East Africa

The role of plants as a vital component of the aquatic environment is recognised as that of provision of suitable shelter and food for other plants and animals. Some plants, especially when transported to non-endemic areas, will undergo rapid growth and reproduction to out-compete native plants, becoming troublesome. They may thus become weeds that cause environmental and socioeconomic problems. Three plants, namely water hyacinth, salvinia which is also known as Kariba weed or water fern (*Salvinia molesta* (Salviniaceae)) and water lettuce (*Pistia stratiotes* (Araceae)) cause the most serious problems in subtropical regions. They are also the main freshwater aquatic weeds in the Lake Victoria Basin. Other weeds that are of minimal importance are azolla (*Azolla filliculoides*), parrot's feather (*Myriophyllum aquatica*) and pennywort (*Hydrocotyle ranunculoides*).

Aquatic weeds, including water hyacinth, grow best in tropical and subtropical climates where temperatures in the range 25–30°C favour their growth almost all year round. The Lake Victoria Basin is one such area where sufficient nutrients are available and have thus added to the rapid growth of the weed (Mailu 1998a).

Water Hyacinth in East Africa

Although water hyacinth is known to have been kept in Nairobi and Mombasa as an ornamental plant since early 1957, it appeared in the natural water systems of East Africa in Tanzania (River Sigi) in 1956 and later in the Pangani River. In Uganda and Kenya, reports indicate that the weed appeared in Lake Kyoga (Uganda) and Lake Naivasha (Kenya) and later in Lake Victoria in the late 1980s (Twongo 1993, 1996; Twongo and Balirwa, 1995; Taylor 1993). It was, however, between 1990 and 1992 that the negative impacts of the weed started becoming evident along the shores of the three riparian states. The weed has continued to impact negatively on the lives of the lakeside communities living in the Lake Victoria Basin, especially those closest to the lakeside.

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Magnitude and Distribution

Weed distribution and cover in Uganda

Preliminary monitoring of the stationary fringe of water hyacinth in Lake Kyoga demonstrated that the maximum cover was reached in 1994, when about 570 ha of water hyacinth was distributed along close to 60% of the shore. Maximum cover of stationary mats along the banks of River Nile was also estimated in 1994 to fringe about 80% of shoreline length, with total water hyacinth cover estimated at about 500 ha. In Lake Albert in Uganda, the weed remained confined to the northern and southern extremities of the lake, probably because of the turbulence of the lake and the absence of extensive sheltered, shallow banks along other shores, where water hyacinth could anchor. In the Uganda portion of Lake Victoria, the stationary fringe of the water weed stabilised in 1995 when its stretched along about 80% per cent of the shoreline and covered an estimated 2200 ha. Maximum cover of the mobile components of the weed in this lake came to about 1800 ha in 1998 (Twongo et al. 1995). Hence, the maximum cover estimate for water hyacinth in the Uganda portion of Lake Victoria was 4000 ha. Estimates made in April 1999 and in August 1999 indicated that the input of water hyacinth into Lake Victoria through the River Kagera was 3.5 ha per week. However, it was noted that a significant quantity of this influx of water hyacinth into Lake Victoria by the river was fragmented in the vicinity of the river mouth by wave action. Similarly, considerable quantities of the mobile mats of the water weed were also destroyed during its annual long distance movement around the Lake Victoria, including by rainstorms and prevailing winds. Currently only small remnants of water hyacinth plants are to be found in Ugandan waters of Lake Victoria, except in the region where Kagera River enters the lake.

Weed distribution and cover in Kenya

In the Kenyan part of Lake Victoria, the infestation of water hyacinth oscillates during the year amongst the following bays: Kisumu, Kendu, Nyakach, Homa and Asembo. Some water weeds occur also in Wichlum and Uharia in Siaya; and Rukapa and Mabinyu in the Nzoia River Delta in Busia District. Infestations are insignificant in Migori and Suba districts. In April 1998, estimated cover of water hyacinth was 1000 ha in Kisumu Bay, 3200 ha in Nyakach Bay, 600 ha in the Sondu Miriu Delta and 1200 ha in Osodo Bay. Total cover in the Kenyan waters of Lake Victoria is estimated at 6000 ha. However, a survey conducted in mid August 1999 indicated a decrease in the cover in Kisumu, Kendu and Homa bays. The indications are of increasing disintegration of the weed masses, to a point where, in certain areas, ecological succession replaces the original weed mats. A major contribution to the control of stationary mats of water hyacinth along lake shores and river banks in East Africa has been the result of ecological succession, the progressive displacement of one or more species of plants (and animals) by another. Pure mats of the waterweed were invaded initially by aquatic ferns and/or sedges, often to be followed progressively by hippograss (*Vossia cuspidator*) which invariably eventually dominated and shaded out the water hyacinth. Ecological succession has made a major contribution to the control of fringing water hyacinth in Lake Kyoga and in the Ugandan portion of Lake Victoria. As at April and August 1999, stunted water hyacinth in disintegrated mats and weed succession were clearly evident in most parts in Kenyan side of infested parts of the Lake (Mailu 1998b).

Weed distribution and cover in Tanzania

Surveys conducted in April and mid August 1999 indicated that water hyacinth infestations in the portion of Lake Victoria in Tanzania were located in Mara Bay, Bauman Gulf, Speke Gulf, Mwanza Gulf, Emin Pasha Gulf and Rubafu Bay. Currently, water hyacinth occurs also in the Kagera, Sigi and Pangani rivers, as well as in streams and water ponds around Dar-es-Salaam and close to Lake Victoria. The total cover estimate of water hyacinth in the Tanzanian waters of Lake Victoria was 2000 ha. As in Kenya, increased weed stunting and disintegration of original mats indicated that water hyacinth had experienced severe environmental stress, including that occasioned by the weevils already released into the lake.

Weed distribution and cover in Rwanda and Burundi

Currently, verbal reports indicate that water hyacinth infestations are located in the major rivers that feed into the River Kagera from both Rwanda and Burundi. Surveys in April and August 1999 demonstrated that fairly large mats of the weed were floating and moving into the Kagera River and onward into Lake Victoria at the rate of approximately 3.5 ha per

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day. The status of water hyacinth infestation in the inland waters of Rwanda and Burundi is not clearly documented (Lowe-McConnel et al. 1992).

Impact of Water Hyacinth in the Lake Victoria Basin

The concern over water hyacinth

Water hyacinth infestation has resulted in serious socioeconomic and environmental problems for millions of people in riparian communities. Normally, the weed proliferates to form extensive floating mats that cause disruption in electricity generation, irrigation canals, navigation and fishing activities, and cause an increase in water loss through evapotranspiration. The weed also reportedly provides breeding grounds for schistosome (bilharzia)-carrying snails and malaria-carrying mosquitoes. The cost of water hyacinth infestation for countries in the region is estimated to be of the order of billions of dollars. For example, in Lake Victoria, the infestation currently covers 12,000 ha and is affecting the livelihoods of more than 40 million people in Kenya, Tanzania and Uganda. By the end of 1997, media agencies reported a 70% decline in economic activities at the Kenyan port of Kisumu as a result of the water hyacinth choking the port and fish landing grounds. The rapid proliferation of water hyacinth in the region is a result of the absence of natural enemies, and the widespread availability of nutrients in freshwater bodies. The nutrient-enrichment of freshwater bodies in the region is a result of pollution and other factors arising from the rapid increase of human population and corresponding activities in urban and rural areas. Large urban sewers and other effluent discharges are well known sources of point water pollution, while extensive use of improper agricultural methods, and land uses that often result in soil erosion, are a major source of non-point water pollution. Soil erosion, especially when caused by water, carries soil nutrients into the water bodies down hill.

Water hyacinth impacts on lakeside communities

Social and economic impacts

The impacts of water hyacinth may be categorised into social, economic and environmental. Scientists in the region have attempted to gather secondary data on the impact of the weed on the lakeside communities on the Kenyan, Tanzanian and Ugandan sides of the lake. This information was collected through interviews with officers-in-charge of district hospitals, fisheries, water supplies in municipalities, cargo and human transportation. Organisations and communities affected by water hyacinth infestation were thus identified in the various countries. They are listed in Table 1.

An indication relating to the perceptions of a cross-section of the communities and agencies in East Africa on impacts, as well as on control strategies of water hyacinth, was obtained through a survey, the results of which are recorded in Table 2. Lakeside communities deemed socioeconomic impacts more important than environmental impacts. The real costs and quantified impact levels were, however, not clear to the communities. Most of those interviewed identified decrease in fish catches, increase in certain diseases, increased transportation costs, and difficulties associated with clean water availability as major negative impacts.

Fish production

Information from the Fisheries Department, Kenya indicated that there was a 28% increase in total annual fish catches between 1986–1991 and 1991–1997, from 133,097 tonnes to 169,890 tonnes. There was an increase in all species of fish caught except *Oreochromis, Clarias* and *Mormyrus,* which showed declines of 14, 37 and 59%, respectively, over the same period. These declines may have been associated with the inability of fishermen to access the fishing grounds for those species because of water hyacinth infestation.

Generally therefore, as a result of water hyacinth infestation, accessibility to land and water has been hindered, resulting in reduced fish catches, especially of tilapia and mudfish which are found mainly along the shores. Fisherfolk, however, reported increased fish catches from suitable breeding grounds provided by water hyacinth e.g. tilapia, synodontis, protopterus and labeo. There is, however, need to clarify this conflicting information; in many more areas around the lake. A reduced fish catch would have an adverse effect on the quality of life of the communities around the lake and consequently affect sustainable development in the region.

Marine cargo and human transportation

In Kenya, water hyacinth hampered the movement of smaller vessels, especially canoes, used for both cargo and human transportation. The activities of the Kenya Railways have been closed since 1997 at all the piers in Asembo, Homa Bay, Kendu Bay, Kowor, Mbita and Mfangano, except for Kisumu port, which is operational for only larger vessels, though they also

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Table 1. Organisations and communities affected by water hyacinth

Country	Affected organizations/institutions/communities
Uganda	Fishing (fishermen, fishmongers, fish processors, consumers Riparian communities Lake transport (Uganda Railway Corporation) National Water and Sewerage Corporation National Agricultural Research Organization National Environmental Management Authority Department of Fisheries
Kenya	Fishing community Kenya Railways Local councils Local and provincial administration Kenya Agricultural Research Institute (KARI) Fisheries Department Kenya Marine Fisheries Research Institute (KEMFRI)
Tanzania	Fisheries from fishermen, through traders to scientists Agricultural irrigation Electricity generating Navigation Health Water supply
Rwanda	Agriculture; irrigation Community development Various non-governmental organisations
Burundi	Agriculture; irrigation

experience some difficulties. Such vessels (weighing over 700 tonnes) have their propellers deep, avoiding entanglement with water hyacinth. Boats with capacities less than 700 tonnes cannot operate where there is heavy water hyacinth infestation. The Kenya Railways keeps 10 people permanently employed to remove water hyacinth from the bridge at the Kisumu pier. Data made available by the Port Officer, Kenya Railways, Kisumu, covering the period 1996–1998, showed an increase in incoming cargo volume (from about 43,000 tonnes to 130,000 tonnes), while the reverse was the case for outgoing volume (from about 93,000 tonnes to 37,000 tonnes). There were no records for human transportation and cargo for the smaller vessels, as the beaches maintained no proper records. The frequent closure of the Kisumu port affects the communities in several ways including loss of income and a general decline in sustainable development in the affected regions.

In Uganda, where observations had been made between 1994 and 1997, large vessels were, as in Kenya, able to force their way through the weed mats, but physical removal was also necessary in Port Bell. Vessels required extra time to dock, thus resulting in the use of more fuel.

Some initial estimates were made for these costs, but additional data and observations were required to validate the initial observations. It should be noted that these figures represent 1995 estimates. At that time the water hyacinth infestation was increasing at a rapid rate and it was recognised that unless controlled, it would spread and become more of a problem (Twongo and Balwira 1995). In the absence of a successful control program, the following were the estimated costs for the five years after 1995 in Uganda.

1. Maintaining a clear passage for ships to dock at Port Bell in Uganda: US$3–5 million per annum;
2. Cleaning intake screens at the Owen Falls hydroelectric power plant at Jinja in Uganda: US$1 million per annum;
3. Losses in local fisheries from accumulation of water hyacinth at fishing beaches and landing sites around the lake, making it difficult or impossible for fishing boats to be launched or

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Table 2. Problems associated with water hyacinth in the Lake Victoria Basin

Category	Nature of problems	Number of respondents	% Respondents
Social	Lack of clean water (debris-free)	1	5.3
	Less access to water points (domestic and livestock use)	3	15.8
	Societal conflict	1	5.3
	Increase in incidence of snake bite	1	5.3
	Disappearance of the aesthetic value of water bodies	3	15.8
	Increase in disease outbreaks (schistosomiasis, cholera etc.)	5	26.3
	Reduction of riparian-based trade	2	10.5
	Migration of communities	3	15.8
	Percentage of overall responses	*19*	*34.5*
Economic	Reduced fish catches	8	32.0
	Increase in transportation costs	5	20.0
	Difficulties in electricity generation	4	12.0
	Difficulties in water extraction and purification	5	20.0
	Interference with irrigation (blockage of canals)	1	4.0
	Effects on tourism	2	8.0
	Effects of control on government budget	1	4.0
	Percentage of overall responses	*25*	*45.5*
Environmental	Decline in diversity and abundance of aquatic life	4	36.4
	Decline in water quality	2	18.2
	Increased water loss	2	18.2
	Increased siltation	2	18.2
	Increased potential for flooding	1	9.1
	Percentage of overall response	*11*	*20.0*

recovered: US$0.2 million per annum, but with a very serious local impact.

4. Loss of the beaches, water supply for domestic, stock and agricultural purposes: US$0.35 million per annum.

Water supply

Water supply to both villages and municipalities is affected by water hyacinth. In municipalities, water hyacinth interferes with the water intake points through blockage, which lowers the quantity of water pumped. In Kisumu, the municipality reports that the quantity of water supplied has dropped from 20,000 m^3 to 10,000 m^3 per day. Homa Bay reported a capacity of 1400 m^3 per day (Table 3) against a demand of 4000 m^3 for 50,000 residents. Kisumu municipality has an alternative water source of 1000 m^3 per day from the River Kibos; while Homa Bay municipality has none. This situation thus causes constant water shortage in Homa Bay and at certain times in Kisumu.

Water hyacinth infestations have been reported to lower the water quality in Kenya and Uganda (in terms of colour, pH, turbidity (suspended solids) of water), and hence increase the treatment costs. Increased costs are associated with keeping the water intake points free of water hyacinth. For example, Kisumu Municipality employs 12 casuals per day, 6 drivers and 6 boat operators, while Homa Bay municipality engages 2 divers at a cost of 1000 Kenya shillings (Ksh) per day. In Homa Bay municipality, water hyacinth builds up 3 to 4 times in a week and it takes 3–4 hours to remove it.

Table 3 indicates that water supply capacity in Homa Bay municipality has increased over the study period from 1300 m^3 (1986) to 1400 m^3 (1998), while the price of water has risen greatly from Ksh2 (1986) to Ksh120 (1998) per m^3. There were no data for the supply of water for Kisumu municipality.

The villages bordering the lake have no access to the lake to draw water at times when the beach is heavily infested with water hyacinth. Even if they get access to the water, it is dirty and often smelly because of the rotting mats of the weed. This is true for all the 143 gazetted beaches along the Kenyan side of Lake Victoria which may be infested. The same has been noted in areas around Mwanza and Musoma in Tanzania.

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Table 3. Water supply in Homa Bay municipality since 1986

Year	Quantity (m^3)	Price (Ksh/m^3)	No. of consumers (water meters)
1986	1300	2.00	500
1987	1300	2.00	520
1988	1300	2.00	550
1989	1300	18.00	600
1990	1300	18.00	650
1991	1300	18.00	700
1992	1400	30.00	770
1993	1400	30.00	800
1994	1400	60.00	950
1995	1400	60.00	1000
1996	1400	90.00	1200
1997	1400	120.00	1500
1998	1400	120.00	1700

Source: Water Engineer, Homa Bay District
Note: 78Ksh ≈1 US$

Health

The hyacinth mats provide breeding grounds for mosquitos and other vectors of disease. However, data from Kisumu District (Table 4) indicate declines in the incidences of malaria (35%) and typhoid (64%) over the study period. The trend in Homa Bay District could not be determined because of sub-division of the old South Nyanza District into five districts since 1991. There were no comparative data given for Migori District. In both Kisumu and Homa Bay Districts, there were no reported cases of snakebites. Statistics for Homa Bay for the period 1986–1991 and 1992–1998 indicated increased incidence of malaria, whereas there was a decrease in malaria cases in Kisumu over the same period. There were more cases of cholera but numbers of typhoid cases fell over the same periods; and there a slight decrease in amoebiosis. The statistics on health should be interpreted with great care as these apply only to incidences reported to the hospitals or health centres in the district. There may have been many more cases of disease that were not reported to hospitals.

Other socioeconomic impacts

Other socioeconomic impacts reported were loss of earning opportunities when fishermen could not access fishing and fish landing sites, as well as interference with fishing gear and clogging of pumps. Recreational activities were also affected. Frequent motor breakdowns and long distance travel in search of uninfested areas added to costs, likely spoilage or extra expenditures on preservation. In Uganda, interference with electricity generation was reported at the Owen Falls. Extra generation costs, and reduced efficiency were apparent until the water hyacinth was successfully controlled.

Environmental impacts

The impacts on the environment were not apparent and thus not well perceived by most of those interviewed among the communities. However, those that affected the communities directly and posed health risks were water quality (foul smell, debris) degradation, increased siltation and potential for flooding. However, other less obvious impacts included interference with diversity, distribution and abundance of life in aquatic environments. The death and decay of water hyacinth vegetation in large masses may create anaerobic conditions and production of lethal gases.

Infestations of water hyacinth affect biodiversity. Dense mats of the weed covering the water surface lead to deoxygenation of the water, thus affecting all aquatic organisms. It is known that a dense cover of water hyacinth enhances evapotranspiration.

Death of water hyacinth mats may influence changes in the composition, distribution and diversity of aquatic organisms as follows.

- Displacement of hydrophytes and depressed algal biomass (Twongo et al. 1995; Twongo and Balirwa 1995).
- Increase in diversity and abundance of some taxa of macrofauna, especially at the borders of the weed mats (Wanda 1997).
- Increase in the distribution and abundance of schistosome (bilharzia) snail vectors e.g. *Biomphalaria* spp. and *Bulinus* spp.
- Willoughby et al. (1993) reported that, based on studies on the Ugandan shoreline of Lake Victoria, mats significantly depressed the diversity of fish species and fish biomass. It was subsequently demonstrated that fish diversity, particularly small taxa, increased along the edge of water hyacinth mats (Twongo and Balirwa 1995).

It is evident that quantitative data for many of the perceived impacts are not available and that if any are available they are difficult to analyse, because of the many interrelated parameters that may influence the socioeconomic status of the riparian communities.

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Table 4. Statistics on disease infection for the Kisumu and Homa Bay districts since 1986

Type of diseases								
	Malaria		Cholera		Typhoid		Amoebiasis	
Year	Kisumu	Homa Bay	Kisumu	Homa Bay	Kisumu	Homa Bay	Kisumu	Homa Bay
1986	342633	362448	–	40	–	23	–	58716
1987	328021	325370	–	91	–	19	–	63158
1988	259839	276841	–	0	–	–	–	46012
1989	227756	377128	–	0	–	–	–	60914
1990	315570	372683	–	0	759	22	–	54641
1991	321942	469242	–	22	312	0	–	64903
Mean	299320	362952	–	26	536	16	–	58064
1992	252363	72775	5	43	252	71	–	7023
1993	19006	68553	–	19	205	152	–	5562
1994	178574	63229	–	38	191	76	–	6518
1995	148467	56692	–	0	107	88	–	4990
1996	177008	55718	–	0	287	114	–	3341
1997	278526	66861	2766	1087	217	113	–	6597
1998	128334	58694	3376	1392	76	76	–	5253
Mean	193454	63227	2049	368	191	99	–	5612

Source: Medical Officer of Health – Kisumu and Homa Bay District.

It may also be argued that, although water hyacinth poses a serious economic cost to the riparian states, the same can be said to have presented an opportunity for income earning to many labourers and manual workers in the region.

Control Strategies and Status of Control

Although water hyacinth has posed serious economic, social and environmental consequences, there is reason to hope that the control strategies adopted will eventually permit effective management of the weed.

Biological control

Since December 1996, KARI has been introducing *Neochetina* weevils from Australia, South Africa and Uganda as part of a biological control program for water hyacinth. Community-based lakeside rearing facilities have produced over 142,000 mostly adult weevils, which were released into the lake at 30 sites in 8 districts bordering Lake Victoria. Visual observations and pre and post-release sampling protocols have been used to monitor and evaluate the establishment, spread and impact of the *Neochetina* weevils on water hyacinth. Weevils are now firmly established in all affected areas and have spread as far as 50 km from points of release.

Natural enemies on the weed have been observed to have a significant impact and localised complete suppression of resident water hyacinth mats has been recorded at all sites including the Police Pier, Yacht club (Kisumu) and Bukoma Pond (Busia) some 24–36 months after release. Ecological succession by other plant species, including hippograss (*Vossia cuspidator*), papyrus (*Cyperus papyrus*) and morning glory (*Ipomea aquatica*), is now evident in most parts of the lake.

Importation and mass rearing of additional biological control agents, the moth *Niphograpta albiguttalis* (previously called *Sameodes albiguttalis*) and mite *Orthogalumna terebrantis,* was attempted, but these did not establish. Nevertheless, it is recommended that these be released in the Lake to augment control by *Neochetina* weevils.

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Recent sampling of weevil populations indicates densities of between 5.4 and 6.1 weevils per plant. Other observations include:

- disintegration of original water hyacinth mats into smaller mats;
- stress on the remaining water plants to reduce them to seriously stunted weeds;
- a general decline in water hyacinth biomass incapable of flowering and also incapable of producing ramets (daughter plants); and
- rotting water hyacinth biomass floating in smaller islands.

Ecological succession

Ecological succession—the progressive displacement of one or more species of plants by other species—has made a major contribution to the control of stationary mats of water hyacinth along the shores and banks of rivers. In Lake Victoria, pure mats of water hyacinth were invaded initially by aquatic ferns/sedges (*Cyperus papyrus* and *Ipomea aquatica*) often to be followed by hippograss (*Vossia cuspidator*) which invariably eventually dominated and shaded out the remaining stressed and dying/rotting water hyacinth. By April 1999, stunted and disintegrated mats of water hyacinth and invading weed succession were clearly evident.

Although water hyacinth will be a permanent feature in Lake Victoria, currently hippograss and not water hyacinth forms the dominant weed. The hippograss is expected to die once the nutrients from dying water hyacinth are depleted.

Myco-herbicide development

Fungal pathogens have been known to attack water hyacinth and so far 32 isolates of fungi have been identified and are maintained in the laboratory. Initial pathogenicity tests indicate that some of the isolates (such as *Alternaria eichhorniae* and *Curvularia lunata*) may cause over 50% damage to water hyacinth plants under glasshouse conditions. Fungal pathogens have thus helped to also stress the water hyacinth after initial attacks are made by the weevils. Additional fungal isolations are still being carried out to increase the level of attack by obtaining even more virulent isolates. Pathogenicity tests under ambient environmental conditions will be carried out at Kibos, while additional isolations, identifications, host-specificity, glasshouse pathogenicity tests and product formulation work continues at Muguga.

Physical control

Manual removal

The fisherfolk communities around Lake Victoria have identified key sites for manual removal. These include fish-landing beaches, ports and piers, irrigation canals and water supply points and sources. Fish-landing beaches in most of the affected districts are the prime targets for manual removal operations. From over 100 gazetted beaches, some 25–30% had been severely infested by water hyacinth at specific periods during the year. In 1997, hand tools were distributed.

Mechanical control

Mechanical control operations have so far consisted solely of chopping and dumping of the chopped pieces of water hyacinth and other weeds into the lake. Regrowth of the chopped weed is likely to take place, especially if most of the natural enemies are destroyed during chopping. In addition, shallow areas of the lake are likely to fill up with vegetation, especially along the shoreline, leading to drying up and subsequent reduction in the size of the lake. The use of machines to destroy or remove water hyacinth has limitations, including their inability to move around a large lake. The future of mechanical control options should be reassessed.

Conclusion

The survey and consultations on the impacts of water hyacinth in the Lake Victoria Basin indicate that, currently, water hyacinth biomass is declining, but slowly. Despite this trend in Lake Victoria, indications are that other freshwater bodies continue to be infested. The precise areas of coverage by the weed cannot be accurately known because of a lack of appropriate tools and systems for monitoring and of proper coordination of activities throughout the region. The range of social, economic and environmental problems caused by the weed are generally well perceived by communities living in the Lake Victoria Basin. However, quantitative data are not usually available to give an idea of the real implications and impacts on the communities. This presents a challenge to socioeconomists to quantify impacts and thus define the real problems caused by water hyacinth. A comprehensive strategy needs to be crafted to address the socioeconomic and environmental concerns associated with water hyacinth. Further, a coordinating mechanism needs to be put in place to ensure that a common approach is adopted in the East Africa and

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Great Lakes regions to manage water hyacinth and other invasive weeds. For the future, it is recommended that a common approach needs to be implemented to the management of water hyacinth in order to enhance understanding and alleviate some of the impacts associated with infestation by this weed.

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