Review of the impact of water hyacinth on Lake Victoria: the case of Winam Gulf, Kenya.

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Abstract

Water hyacinth, *Eichhornia crassipes*, invaded Lake Victoria in 1989 and has had significant social, economic and environmental impacts, which remain largely unquantified. The biological control administered by Kenya Agricultural Research Institute (KARI) coupled with other control measures have reduced water hyacinth levels from 6000 ha to a current estimate of 400 ha., on the Kenyan Side of the lake. The objective of this study was to document the impact of water hyacinth. Data was derived from personal interviews with key respondents, Annual Reports and other publications from the relevant departments in the Ministries. The analysis involved comparing data between two periods, without water hyacinth (1986-91) and the period with water hyacinth (1992-99). The results indicated that there was an increase of total fish production from 140597 to 168019 tons signalling an increase of 20% over the two periods. However, significant increases were reported in Nile Perch and *Prototerus,* while significant decreases were realized with *Mormyrus* and other mixed fish species. The results also showed that there was an increase in the incoming cargo and a decline in the outgoing marine cargo handled at the Kisumu pier as shown by the available data covering the period 1996-1998. Water supply to Kisumu municipality decreased by 25% in the year 1999, although time series data was not available. The increases or decreases in fish production and water supply points to the fact that water hyacinth may have had an effect. On the contrary, there were mixed and unclear trends on the incidence of water hyacinth related diseases (malaria, bilharzia, cholera and gastro-intenstinal disorders) which could not be directly associated with water hyacinth when the two periods are compared. This was due to inadequate data resulting from recent subdivision in the various districts and the fact that it was not easy to apportion the disease incidence resulting from water hyacinth and other related causes. The study suggested the need to obtain reliable time series data on water hyacinth infestation and initiate specialized studies to establish the impact of water hyacinth on bio-diversity, water quality and supply, ecological succession and health and nutrition (343).

Key words: Water hyacinth, impact, fishery, transport, water supply, health, bio-diversity, aquatic weeds, succession, Winam Gulf, Kenya

Introduction

In 1989, Lake Victoria was invaded by the water hyacinth *Eichhornia crassipes* (Ponteridiaceae). The tropical aquatic weed of South American origin, presented an enormous challenge for its control in East Africa. The weed has disrupted commercial and artisanal fishing and boat transport. It has affected infrastructural facilities including water supply intake points, port facilities and the hydroelectricity power generation plant at Owen Falls, Uganda (Harley *et al*., 1996). The weed is also associated with increased incidence of water-borne diseases. In Lake Victoria, ideal environmental conditions caused by anthropocentric environmental degradation and the lack of biological control agents such as phytophagous insects, mites and microbial pathogens were responsible for rapid growth and spread of the water hyacinth during the last decade. The effort of water hyacinth control through biological control and mechanical harvesting have reduced the infestation levels to

about 400 hectares, most of which has been due to the resurgence emanating mainly from the river mouths on the Kenyan side of Lake Victoria.

The Kenyan portion of the Lake stretches for 600 km from Berkeley Bay (Busia district) in the north to Muhuru Bay (Migori District) in the south. Most of the fishing activities and transport operations are concentrated in the Gulf, an important economic lifeline to the riparian communities. This paper attempts to review the social, economic and environmental impacts of water hyacinth, with specific reference to the Winam Gulf of Lake Victoria.

Methodology

The main aim of this exercise was to document the impact of water hyacinth by comparing the period before (1986-1991) and after (1992-2000) the invasion of water hyacinth on the Kenyan side of Lake Victoria, on socio-economic and environmental effects, viz: fish production, marine cargo and human transportation in the affected piers, water supply mainly in the affected municipalities; disease infection and snake bites in the districts (for Kisumu/Nyando and Homa Bay districts) and biodiversity. Data used in this report on fish catch is for lake wide but only on the Kenyan side.

The information/data used in this paper was collected through interviews with the officers in charge of the district hospitals, fisheries offices, and water supply in municipalities, cargo and human transportation. Annual reports and other publications from the respective departments provided additional information required. Efforts at managing the water hyacinth have paid dividends as the water hyacinth has been effectively controlled bringing back life to the various beaches that were infested. The water hyacinth currently noticed on the lake is due to the resurgence, which emanated from major riverine systems flowing into the lake including Kuja-Migori, Sondu, Miriu, Nzoia, Nyando and Sio.

Most of the districts bordering Lake Victoria have been infested by water hyacinth but at different intensities. The districts with highest intensity include Kisumu, Rachuonyo and Homa Bay while moderate intensity is reported in Migori district. Districts with low intensity include Siaya, Suba and Busia. Low infestation refers to the state where the beaches and passage ways are clear of floating hyacinth mats with free access to water by fishermen and transport boats, while moderate infestation is the situation where there are a few and sometimes resident mats of water hyacinth with partial access to the lake. High intensity is where the beaches, piers, and ports are completely clogged most of the time with no access to water by boats, animals and humans.

There has been no proper record of water hyacinth cover on the lake since 1992, when water hyacinth became visible, on the Kenyan side of the lake. However, available records (Radarsat International, 1998 and 2000) indicate that the total area covered by water hyacinth was estimated to be 6000 ha on the Kenyan side of Lake Victoria (April 1998) and was reduced to 900 ha. February 2000 and is currently estimated at 400 ha. (2001).

In 1998, the highest concentration was reported in Nyakach bay with 3200 hectares while the distribution was as follows in other bays: Osodo bay (1200 hectares), Kisumu (1000 hectares) and Sondu Miriu Delta (600 ha) (Anon. 1998). The resurgence has notably been sited in Nyakach, Kendu and Homa bays. There is need to assemble data from satellite imagery in order to obtain time series data on water hyacinth cover. This will be able to give an estimate of the amount of water hyacinth in the lake over the time to give an indication of the extent of control by the various control methods being engaged.

Fish production

Commercial and artisanal fishing in the Winam Gulf contribute significantly to the national economy**.** Fish exports were valued at KShs. 5.8 billion in 1998 while the total value of fish was estimated to be Kshs. 7.0 billion. The main commercial species are the *Lates niloticus* (Nile Perch), *Oreochromis* spp. (Tilapia) and *Rastrineobola argentea* (Omena) This important industry has been affected by the invasion of water hyacinth, although fish catches have not declined significantly after water hyacinth invasion (Wawire, unpublished report). Table 1 indicates that there has been an increase of total annual fish caught from 140,597 tons (1986-91) to 168,019 tons (1992-1999) signaling an increase of 20% when the two periods are compared. There were significant differences in fish catch between the two periods in *Lates niloticus* (Nile perch) (P value of 0.001, *Propterus* (P value 0.045), *Mormyrus* (P value 0.034) and other species (P value 0.0940) (Table 1).

There was an increase in the fish caught in all the species reported except, *Oreochromis*, *Clarias*, *Mormyrus*, and other species, which indicated a decline in production when the two periods are compared (Table 1). The reduction in the quantities for these species might be associated with

The fact that fishermen were not able to access the fishing grounds that harbour these species along the shoreline. These breeding areas were rendered inaccessible by water hyacinth mats.

Table 1:T-test on fish production (metric tons) by species between water hyacinth-free and water hyacinth infestation periods.

Fish species	Without Water Hyacinth (1986-1991)		With Water hyacinth (1992-1999)		P-Value
	Mean	St. dev	Mean	Sd. Dev.	
Lates	61048	7702	93072	15385	0.0010
Rastrineobola	43137	9182	47053	11088	0.4960
Oreochromis	18672	11915	14587	4125	0.3810
Other tilapines	4667	7411	9825	6615	0.1950
Haplochromis	1650	2060	3127	1326	0.1280
Clarias	719	547	567	524	0.6350
Mormyrus	298	225	101	58	0.0340
Propterus	71	47	715	697	0.0450
Other species	10335	10678	2759	4562	0.0940
Total catch	140597	-	168019	-	-
No of observations	6		8		

On the other hand, increases in fish catch for various fish species may be attributed to the fact water hyacinth mats in the breeding grounds provides conducive breeding conditions, leading to increased stocks. The prices for all the fish species considered were significantly different in the two periods (Table 2). This is expected in view of the rising inflation hence increasing prices over the period. It may be difficult to isolate the impact of the change in the supply of fish associated with water hyacinth and the general increase in prices due to inflation over the time.

Table 2: T-test on fish prices (Ksh/kg) by species between water hyacinth-free and water hyacinth infestation periods.

Fish species	Without Water hyacinth (1986-1991)		With Water hyacinth (1992-1999)		P-Value
	Mean	St. dev	Mean	Sd. Dev.	
Lates	6.05	4.74	31.43	14.32	0.002
Rastrineobela	2.96	1.65	10.04	5.60	0.013
Oreochromis	9.39	1.66	29.27	5.56	0.000
Other Tilapines	8.66	1.96	26.27	3.31	0.000
Haplochromis	4.27	3.09	18.57	1.49	0.000
Clarias	4.70	1.53	30.18	4.46	0.000
Mormyrus	7.98	3.79	29.06	4.93	0.000
Propterus	7.06	2.45	48.68	12.93	0.000
Other species	5.21	1.83	24.36	4.33	0.000
No of observations	6		8		

Marine cargo and human transportation

Before the infestation of water hyacinth, 1991, Lake Victoria used to be an important means of transport connecting Port Bell, Kisumu and other lake towns. Passenger and freight traffic used to ply the lake ports unhindered and even 1000 tonnes vessels could dock at the

Kisumu Railway Marine Pier. Since 1992, lake transport in the Winam Gulf has been adversely affected and only vessels weighing over 700 tonnes were able to dock at the Kisumu Pier. The bigger vessels are able to sail through the water hyacinth because their deep propellers are not entangled in the hyacinth, as compared to small vessels. The drydock facilities and the linkspan at the Kisumu Pier were rendered un-operational by water hyacinth. The Kenya Railways discontinued their ferry service between Kisumu, Kendu Bay, K'Owuor, Homa Bay, Mbita and Mfangano in 1997.

A preliminary survey of the impact of water hyacinth on lake transport (Wawire, unpublished report) did not get adequate statistics in order to estimate the economic cost. Table 3 shows that during peak water hyacinth infestation, 1996 to 1998, incoming cargo volume increased from 43,500 tonnes to 137,900 tonnes while the outgoing cargo volume decreased from 97,000 tonnes to 35,000 tonnes. There is no indication about how much revenue was lost and whether the reduction in outgoing cargo volume was a direct result of water hyacinth. No data was available for human traffic for the same period. Local and foreign private transporters have also been affected. The economic cost of water hyacinth infestation is enormous, in terms of delays and extra fuel expenses, yet it has not been possible to estimate the cost in quantitative terms. Alternative road transport is expensive and the poor state of the roads compounds the problem.

Table 3: Statistics on Marine Cargo and Human Transportation at the Kisumu port since 1986

Year	**Cargo Volume**	
	Incoming	*Outgoing*
	Tons	**Tons**
1996	43,576	97,053
1997	52,814	87,335
1998	131,908	33,488
Mean	**76,099**	**72,625**

Source: Port Officer, Kenya Railways-Kisumu

At the peak of water hyacinth infestation, the Kenya Railways used a permanent gang of 10 people per day to remove the water hyacinth from the bridge at the Kisumu pier. This amounted to a total cost of Ksh. 1500 per day for the ten people engaged to keep the port bridge free of water hyacinth.

Table 4: Statistics on Water Supply in Homa Bay Municipality since 1986

Year	Quantity (m^3/day)	Ksh/m^3	No. of Consumers (Water Metres)
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
Mean	**1300**	**10**	**587**
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
Mean	**1400**	**73.00**	**1131**

Source: Water Engineer, Homa Bay District.

Water supply

Within Winam Gulf, the Kisumu and Homa Bay Municipality water supply intake points have been threatened by water hyacinth infestation and attempts have been made to remove the weed manually from the intake points. Water supply to Kisumu Municipality in 1999 was reduced by 25% from 18 000 m^3 to 14 000m^3 per day and Kshs. 0.5 million spent to keep the intake clear of water hyacinth (Mailu *et al*., 1999). In the rural areas, particularly in Nyakach, Osodo, Kendu and Homa Bays, the weed has reduced the availability and lowered the quality of water for humans and livestock at specific periods in the year. Wawire (unpublished report) notes that the local communities spend more time and money to obtain clean water when the physical presence of thick mats of water hyacinth denies them access to water.

Although analysis of water from hyacinth infested areas has not been done, this weed has been reported to lower the water quality (in terms of colour, pH, turbidity (suspended solids) of water hence increases the treatment cost. Increased costs are associated with

keeping the Water intake points free of water hyacinth. For example, Kisumu Municipality engaged 12 casuals per day (about Ksh. 1800 per day), six divers and six boat operators, while Homa Bay municipality engages two divers at a cost of Kshs. 1000 per day. In Homa Bay municipality, water hyacinth builds up three to four times in a week and takes three to four hours to remove it during the peak period.

Table 4 indicates that water supply capacity in Homa Bay municipality has increased over the study period from 1300m^3 (1986) to 1400m^3 (1998), while the price of water has risen greatly from Ksh 2 (1986) to Ksh.120 (1998) per m^3. There was no data for the supply of water in Kisumu municipality.

Health

Water hyacinth provides ideal breeding ground for vectors of human and animal diseases such as schistosomiasis (bilharzia), malaria, encephalitis and onchocerciasis (river blindness). The water hyacinth may also harbour organisms causing cholera and other gastrointestinal disorders. Wawire (unpublished report) noted a decrease in malaria cases in the riparian districts in Winam Gulf. This could be as a result of improved management of malaria in the affected areas. Vital epidemiological data before and after water hyacinth invasion are lacking. Therefore, it is not possible to correlate the presence of water hyacinth and disease incidence in quantitative terms.

Data from Kisumu district (Table 5) indicates a decline of the malaria incidence (35%) and typhoid (64%) over the study period. The trend in Homa Bay district could not be determined due to sub-division of the old South Nyanza District into five districts since 1991. There was no comparative data given for Migori District. In both Kisumu and Homa Bay districts there was no single reported case of snakebite.

The statistics on health should be interpreted with a lot of care as these only apply to incidences reported to the hospitals or health centres in the district only.

However, a comparison of water hyacinth related diseases before and during water hyacinth infestation shows that there were significant differences in the incidences of malaria in Kisumu and Homa Bay districts but no significant differences in the incidence of cholera in Homa Bay district (Table 5). There were significant differences in typhoid and amoeba in Homa Bay district. Water hyacinth infestation interferes with self-clearance of water system thus giving rise to increased levels of bacteria disease (e.g., cholera, typhoid, etc.). In fresh water it takes eight days for the bacteria to die while in saline water it takes 21 days to die, thus increasing the risk for infection. The hyacinth mats provide suitable breeding grounds for mosquitoes and other disease vectors.

Impact on biodiversity

The impact of water hyacinth on biodiversity is controversial. It is speculated that, in the Winam Gulf, there was an increase in catches of traditional fish species, such as *Bagrus* (Ningu), *Clarias* (Mumi) and *Protopterus* (Kamongo), and a corresponding reduction in catches of commercial fish species, *Lates* (Nile Perch), *Oreochromis* (Tilapia) and *Rastrineobola* (Omena), after the invasion by water hyacinth. There are several theories to support these claims (i) that the water hyacinth interferes with the breeding grounds of commercial species (ii) that water hyacinth protects the fish species from predation by Nile Perch and (iii) that the traditional species thrive under the low oxygen levels below water hyacinth. Research is needed to substantiate these claims. Impact of water hyacinth on phytoplankton, macro and micro invertebrates, insects, amphibians, reptiles and mammals also needs to be investigated.

Table 5: T-test on the incidence of diseases comparing water hyacinth-free and water hyacinth infestation periods

Types of diseases	**Without W/Hyacinth (1986-1991)**		**With W/Hyacinth(1992-1997)**		**P-Value**
	Mean	St. dev	Mean	Sd. Dev.	
Malaria(Kisumu)	299293(6)	45068	175657(6)	91383	0.014
Malaria (Homa Bay)	363952(6)	63898	63983(6)	6759	0.000
Cholera (Homa Bay)	26(6)	36	198(6)	436	0.357
Typhoid (Kisumu)	536(2)	316	210(6)	61	0.030
Typhoid (Homa Bay)	16(4)	11	102(6)	30	0.001
Amoeba (Homa Bay)	58064(6)	6899	5672(6)	1364	0.000

The number in parentheses shows the number of years used in the computation

Impact of biological control of water hyacinth

Ecological succession of water hyacinth by emergent plant species, including papyrus, C. *papyrus*, hippo grass, *V. cuspidata*, morning glory, *Ipomoea aquatica,* water primrose, *Ludwigia* sp., cattail, *Typha* sp. and several Graminaceous species, was observed in late 1999 and early 2000 in the Winam Gulf (Ochiel, personal communication). This phenomenon was observed in Lake Kyoga, Uganda, following the successful biological control of water hyacinth by *Neochetina* weevils. It is believed that the emergent plant species contribute to the control of water hyacinth by out competing it, particularly in the littoral zones. These plants, which were not free-floating, used the water hyacinth as a substrate to grow upon. It is possible that they utilized the decaying water hyacinth and the silt and mud concentrated in the roots of water hyacinth as nutrient sources. The dominant plant species, hippo grass, created problems in lake transport, fishing and water supply. Papyrus is a wetland product traditionally harvested by the riparian communities to make mats and for thatching roofs. Hippo grass could be used as animal fodder, particularly during the dry season.

When the water hyacinth decayed and eventually sunk, the substrate and nutrient source for the emergent plant species diminished and the plants gradually disappeared. Mechanical control was suggested for clearing the water hyacinth and successional vegetation,

particularly at strategic sites like piers, water supply intake points and major fish landing beaches.

Conclusions and recommendations

Water hyacinth infestation gradually increased to a maximum of 6000 hectares (1998) and declined to current levels of an estimated 400 hectares (2001). The efforts in the control of this weed have been mainly through KARI using biological control agents (weevils). Other methods used in combating this weed include Aquatic Vegetation Cutters (AVCs) by an American company Aquarius Systems, meant to shred 1500 hectares and use of manual removal using hand tools/implements.

Although water hyacinth may have positive effects, many activities such as fishing, marine cargo and human transport, water supply and health were disrupted at its peak infestation. The beneficial effects of water hyacinth includes provision of suitable breeding grounds for fish and use of this weed for making handicrafts, as fertilizers and as mulch, but with heavy infestation these benefits are surpassed by the negative effects.

The available data indicates that there were significant increases in fish catch during the time of water hyacinth infestation for Nile perch and P*ropterus*, while significant reduction were reported in *Mormyrus* and other species. There was a reduction in the outgoing marine cargo handled at the Kisumu pier, while the incoming marine cargo increased during the water hyacinth period, coupled with increased expenses in clearing of the pier bridge using manual removal. Water supply to Kisumu Municipality reduced by 25% in 1999, although added expenditures were met while keeping the water supply intake points free. The trends in disease incidence were variable with malaria declining in Kisumu and increasing in Homa Bay districts. There was a notable increase in cholera in Homa Bay although the incidence was not great (from 26 to 198).

Recommendations

- There is need to come up with time series data on water hyacinth cover on the lake in order to keep track of the level of infestation, the extent of the control measures and the impact of water hyacinth. The use of satellite images will be handy in obtaining the required data.
- Specialized studies should be encouraged to document realistic impacts of water hyacinth on fish species diversity, water quality, ecological succession and health and nutrition.

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