Lake Victoria Environmental Management Project

Status of water hyacinth infestation and control in River Kagera

Water Hyacinth Control Components
Uganda, Tanzania and Kenya
Water hyacinth Research Sub-component, Uganda

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Status of water hyacinth infestation and control in River Kagera

A Technical report compiled by

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1. Background

During a regional workshop held in Mukono, Uganda (May 2001) by scientists and technocrats from Kenya, Tanzania and Uganda, working on water hyacinth management under the Lake Victoria Environmental Management Project (LVEMP), it was resolved that a survey of River Kagera be made to study the status of water hyacinth infestation and biological control in the river. Reports at the Mukono Workshop indicated that although Tanzania and Uganda had made serious effort to introduced biological control weevils (*Neochetina eichhorniae* and *Neochetina bruchi*) on the weed in River Kagera, the level of establishment of biological control in the river was doubtful. Large quantities of water hyacinth biomass drifted down River Kagera into Lake Victoria daily. Similar reports of apparent inability of biological control weevils to fully establish and have effect on water hyacinth in River Nile, especially the Upper Victoria Nile, were also made by Uganda, and large quantities of weed biomass continuously drifted down the Upper Victoria Nile into Lake Kyoga. This was in spite of the successful control of the weed in Lake Victoria between 1998 and 2000. The persistence of water hyacinth in riverine environments in the lake basin after it was successfully controlled in Lake Victoria was identified in Kayanja (2001).

The Mukono regional workshop, therefore, strongly recommended a rapid assessment of the status of infestation and control water hyacinth in River Kagera as a priority starting point towards understanding the factors influencing persistence of the weed in riverine environments in spite of sustained biological control effort in Lake Victoria. It was also agreed that successful control of water hyacinth in River Kagera called for the involvement of Rwanda and possibly Burundi. Efforts to involve Rwanda in the survey were, therefore, strongly recommended.

2. The survey

The survey of the status of infestation and control of water hyacinth in River Kagera was made in two stages. The first stage covered the section of River Kagera from the confluence of the Akagera and the Ruvubu Rivers at Rusumo, and the river mouth in Lake Victoria (Fig 2.1). The first stage of the survey was made between July 2nd and 12th, 2001 by scientists responsible for water hyacinth management in Kenya, Tanzania and Uganda, under the Lake Victoria Environmental Management Project (LVEMP). Counterparts from the Kagera Agricultural and Environmental Project (KAEMP) of Tanzania joined the Scientists from LVEMP. The second stage of the survey of River Kagera was made between July 29th and 3rd August 2001. It covered the section of River Kagera between the confluence of the Nyabarongo and the Akanyaru tributaries down to Rusumo (Fig 1) Scientists responsible for water hyacinth control from Institut des Sciences Agronomiques in Rwanda (ISAR) hosted their counterpart team from East Africa. The list of participants in the two surveys is attached as Annex 1

2.2. Survey objectives

The purpose of the joint survey was to gather baseline data and other information about the infestation and biological control status of the water hyacinth along river Kagera as a basis for developing a way forward towards effective control of the weed in the river. The main objectives of the survey were to:

i. Determine water hyacinth distribution, composition, and abundance along River Kagera;

ii. Relate water hyacinth distribution, composition, abundance to selected water quality parameters such as phosphorus and nitrogen levels;

iii. Evaluate impact of biological control weevils on water hyacinth along the river;

iv. Propose a way forward towards effective control of water hyacinth along River Kagera

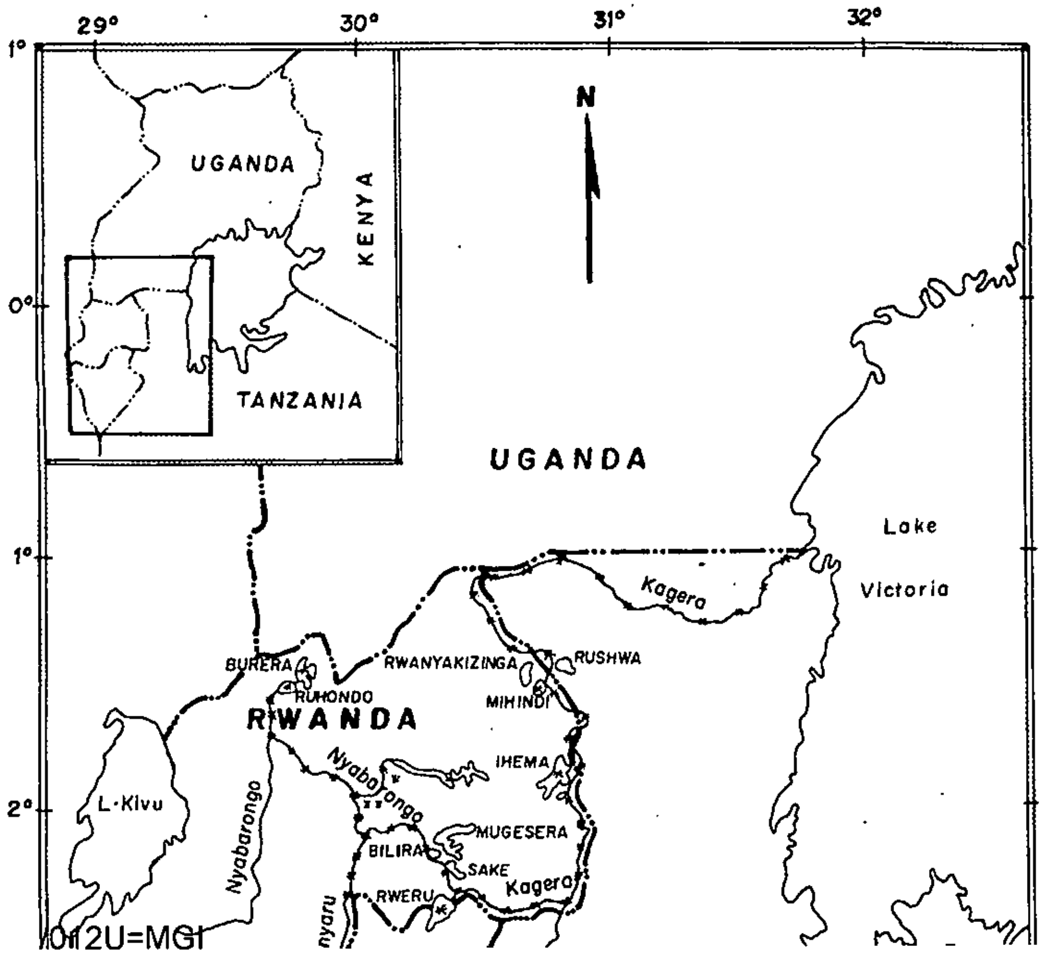

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Fig 1. Water hyacinth infestation in the Kagera river system

2.3. Survey strategy

The section of the Kagera River to be covered by the survey was long (about km) and the river traversed terrain, which was not easily accessible by road especially in Tanzania and Rwanda. In view of the rather ambitious objectives set for the survey it was decided that a rapid assessment be made in selected sections of the river. Locally available canoes were used to navigate those selected sections to collect samples and information on water hyacinth infestation and control. For the purpose of reporting, two zones namely Upper Kagera and lower Kagera are recognized. The following sections of Upper Kagera were visited (see Fig 2.1): the confluence of the Nyabarongo and Akanyaru rivers at (at Kukagoma), Gahanga Bridge and Gashora Bridge on the Akagera River system in southern Rwanda; the zone of confluence of the Akagera and the Ruvubu Rivers at Rusumo and Lakes Ihema and Mihindi, which are both associated with the Kagera River system in eastern Rwanda. The zones of the Lower Kagera visited were Kikagati/Mulongo along the borders of Tanzania and Uganda, the Kyaka zone in Tanzania, and the lower floodplain zone including the river delta, in Uganda (Fig 2.1).

The following research facilities were also visited: ISAR Kigali liaison Office, ISAR Butare (Headquarters), ISAR Karama rearing station for biological control weevils, and the Ihema rearing station for biological control weevils in Rwanda; the KAEMP Head Office and their biological control weevil rearing facility, both in Bukoba, Tanzania.

2.4. Survey procedure

The survey Team comprised scientists with a variety of specialization in water hyacinth management (Annex 1). The Team accordingly divided into several groups at every survey station to gather information and data using procedures briefly outlined below.

2.4.1. Information and data on Kagera River floodplains and water quality

Information and data on Kagera River floodplains and a nd water quality were collected opportunistically, especially in Rwanda, when time and suitable canoe facilities permitted. Sub-surface data on water temperature, dissolved oxygen (DO), conductivity and pH were collected, in situ, along transects across the river at selected sampling sites, using electronic meter probes. Data on water depth and transparency were also collected. Data were collected at both banks of the river and mid stream. Sub-surface water samples were also collected at each sampling point for analysis of soluble reactive phosphorus (SRP), total phosphorus (TP), total Nitrogen (TN), Nitrate Nitrogen (NO_3) and for Chlorophyll-a. The samples for Chlorophyll-a analysis were preserved with Lugo's iodine. In Upper Kagera, water quality data and samples were collected at the confluences of rivers Nyabarongo and Akanyaru, the Akagera and Ruvubu, and at an inshore location in lakes Ihema and Mihindi in the Akagera National Park. In Lower Kagera, data was collected in the Kikagati/Mulongo section, the Kyaka section and in the lower floodplain zone of the river, including the Delta section.

2.4.2. Collection of data on distribution, composition and abundance

A quick assessment of the production rates of water hyacinth was made by counting the number of young shoots (daughter plants) per mature plant of water hyacinth in 0.5 x 0.5 m square quadrant. Visual evaluation of plant vigour and the proportion of the actively reproducing components of the mat in a given section of the river were also made.

3.4.3. Collection of data on impact of *Neochetina* weevils.

Using a 0.5 x 0.5 m quadrant, water hyacinth plants were taken and the following parameters measured 10 plants: number of weevils, leaf length, lamina area, number of feeding scars, wet weight and root length. Averages were calculated and tabulated. Visual observations for possible fungal attack were also made.

3. Results and discussion

Results include, in that order, quick observations on features of the Kagera River floodplain, data on water quality parameters, information on distribution, composition and abundance of water hyacinth, and data on the impact of biological control on the weed.

3.1. General features of the Kagera river course

The main rivers comprising the Upper Kagera River system include the Nyabarongo, Akanyaru and the Ruvubu (Fig 2.1). River Nyabarongo probably originates from Lake Burera in the highland Ruhengeri Prefecture of northern Rwanda. River Akanyaru originates from southern Rwanda and partly runs along the Rwanda/ Burundi border. The Ruvubu River feeds River Kagera mostly from Tanzania. River Kagera is about 250 m (400 km) long. Highland valleys situated among hills, and lowland valleys with many meanders characterize the river. The Kagera river system is shared mainly by four countries namely Rwanda, Burundi, Tanzania, and Uganda and, in some sections, it forms the boundary between countries (Fig 1). In Rwanda and Tanzania, the river is associated with extensive flood plains especially in southern and eastern Rwanda. These floodplains are associated with at least 25 lakes some of which are separated from it by extensive swamp barriers mostly dominated by papyrus swamp. In the lower reaches, River Kagera flows though remnants of tropical forest before it drains into the Uganda portion of Lake Victoria.

During the survey, the upper floodplains (in southern Rwanda) from the junction of the Nyabarongo and the Akanyaru Rivers were littered with large water pools and reclamation canals associated with intense gardening (Plate 1). Various vegetables and food crops including sugarcane beans, sweet potatoes, yams and bananas were grown, possibly most of the way to the confluence with River Ruvuvu. The section of River Kagera included in the Akagera National Park down to Kikagati is generally free from intense cultivation but large herds of cattle were common on the Uganda side of the river. The lower zone of River Kagera was exposed to cultivation down to the riverbanks in many sections. All these instances of human activity in the river valley and in the extended catchment exposed the river to high silt loads. The input of silt from the highly mountainous hinterlands in the upper and middle sections was particularly high.

3.2. Water quality parameters

Data on water quality in River Kagera is presented in two sections, the upper and lower zones.

3.2.1. Upper Kagera River zone

Water quality data from the Upper River Kagera is given in Table 3.1 from the Nyabarongo and Akanyaru confluence, the Akagera and Ruvuvu confluence and from lakes Ihema and Mihindi. At their confluence, River Nyabarongo was wider, swifter and deeper (6.4 m) than River Akanyaru (2.5 m). The two rivers carried a heavy load of silt, judging from the deep brown colour of the water and the common secchi transparency of 0.15 m. The surface and off-bottom temperatures of the two rivers (Akanyaru and Nyabarongo) measured just after they joined were 21.5 and 20.9^{0}C, respectively. Much higher dissolved oxygen (8.96 mgl^{-1}) was recorded in the Nyabarongo River than in River Akanyaru (4.24 mgl^{-1}). The later value was based on a single measurement close to a swampy riverbank. The figure is suspiciously low but could have been obtained at the point of outflow from the swamp. The confluence of the two tributaries was located at the southeastern edge of an extensive floodplain wetland apparently dominated by papyrus. The following water quality parameters were, respectively, higher in the Nyabarongo than in the Akanyaru: conductivity (179 and 121 μSCm^{-1}), pH (7.61 and 6.89), soluble Reactive Phosphorus (SRP) (55 and 30μgL^{-1}). Chlorophyll-a content was, however, much lower in River Nyabarongo (9.7μg/L) than in River Akanyaru (22.2 μg/L), a difference which was not easily explainable.

The major differences in the water quality parameters of Rivers Akagera and Ruvuvu just before their confluence (Table 3.2) was in conductivity (173.3 and 49.5$\mu S cm^{-1}$, respectively); and total Nitrogen (1077.7 and 2522.3$\mu g L^{-1}$). The difference in conductivity possibly reflected the geological character of the respective river basins. No information was available to explain the observed lower temperatures (20.5^{0}C) of the Akagera before the confluence with the Ruvuvu than the lowest (20.9^{0}C) measured at the Nyabarongo –Akanyaru confluence upstream, in view of the lower elevation. The highest temperature measured along the Upper Kagera River was 24.0^{0}C at the inshore station of Lake Ihema. On the other hand, the levels of SRP were considerably lower in lakes Ihema (13$\mu g L^{-1}$) and Mihindi (11.3$\mu g L^{-1}$) than in the river where the lowest measured was 20.7$\mu g L^{-1}$ (Table 3.1).

3.2.2. Lower Kagera River zone

Water quality data from the Lower Kagera River is given in Table 3.2. The more less constant secchi disc transparence of 0.3m in this zone of the river demonstrates the heavy load of silt carried by the river to the lake. Apart from the significant decline in SRP from 51.3$\mu g L^{-1}$ at Kikagati- Mulongo to 28.5$\mu g L^{-1}$ at Kyaka and 31.3 at the river mouth (Table 3.2), most other water quality parameters including conductivity, dissolved oxygen, pH, showed little variation. Chlorophyll-a increased slightly but steadily downstream.

Table 3.1. Physico-chemical and nutrient parameters along the Upper Kagera River system and some associated lakes, July 2001

Sampling Location	TD (m)	SD (m)	DO (mg/L)	Temp (^0C)	Cond. (μSCm^{-1})	PH	TP (μg/L)	SRP (μg/L)	TN (μg/L)	NO3 (μg/L)	Chl-a (μg/L)
Akanyuru River (Kukagoma Village)*1	2.5	0.15	4.24	20.9	121	6.89	50	30	2510	470	22.2
Nyabarongo/ Akanyuru confluence)*2	6.4	0.15	8.96	21.5	179	7.61	138	55	4910	949	9.7
Akagera before confluence	4.7	0.2	0.4	20.5	173.3	6.4	119.1	20.7	1077.7	130.2	12.0
Ruvuvu before confluence	3.9	0.3	6.4	20.8	49.5	6.8	78.4	25.7	2522.3	130.2	12.0
Lake Ihema (10m offshore)	-	0.52	8.56	23.6	109	8.11	16	13	1410	18.3	44.5
Lake Ihema (150m offshore)	-	0.54	9.4	24.0	109	8.48	14	10	1435	295.2	43.1
Lake Mihindi	-	-	-	-	-	-	16	11.3	1410	6.9	20.9

Table 3.2. Physico Chemical and nutrient parameters from the Lower Kagera River (July 2001)

	TD m	Depth sampled (m)	SDm	DO mg/L	Temp C	Cond μScm^{-1}	PH	SRP µg/L	TP µg/L	NO3 µg/L	TN µg/L	Chl-a µg/L
Kikagati/Mulongo												
Mean	3.1	+	+	3.7	22.1	124.7	6.4	51.3	146.4	60.2	633.3	9.2
SE	0.4	+	+	0.7	0.4	4.2	0.1	34.5	54.2	24.6	96.1	0.5
Kyaka												
Mean	5.4	1.4	0.3	6.0	21.3	121.1	6.5	28.5	95.7	91.1	744.3	4.7
SE	0.4	0.0	0.0	0.1	0.0	0.1	0.0	1.0	5.9	2.1	111.3	1.7
Kagera Mouth 1												
Mean	6.1	2.0	0.3	4.7	21.6	114.3	6.5	29.6	87.7	83.2	1244.3	10.6
SE	1.7	0.0	0.0	0.8	0.0	0.1	0.1	0.6	13.8	2.1	111.3	1.7
Kagera Mouth 2												
Mean	4.3	2.0	0.3	4.6	21.5	114.2	6.5	31.3	91.7	72.0	1022.3	13.0
SE	0.7	0.0	0.0	0.2	0.0	0.1	0.0	1.5	6.4	10.4	55.3	2.5

Legend

1* 500m before confluence with River Ruvuvu

SRP Soluble reactive phosphorus in micro grams per Litre

\+ No measurements taken (missing data)

TP Total Phosphorus in micrograms per Litre

TD Total depth in metres

SD Secchi depth in metres

NO3 Nitrogen nitrate in micro grams per Litre

DO Dissolved Oxygen

TN Total Nitrogen in micro grams per Litre

Cond Conductivity in micro Siemens/cm pe

Chl-a Chlorophyll a in micrograms per Litre

3.3. Water hyacinth distribution, composition, and abundance

Information on distribution, composition, and abundance of water hyacinth in the Kagera River system was based on limited surveys close to the points of contact with the river, and on interviews with people from the local communities. Extensive boat surveys were, however, made in the lower floodplain zone.

3.3.1. Water hyacinth infestation in Upper Kagera River flood plains

Lake Burera in the Ruhengeri Prefecture of northwestern Rwanda (Fig 2.1) was reported as the highest location of water hyacinth in the Kagera River system (Twongo and Rolf 1999). At the confluence of rivers Nyabarongo and Akanyaru, the survey team observed a steady flow of water hyacinth from River Akanyaru and stationery mats were scattered along its banks, some among hippograss succession along predominantly papyrus fringed vegetation. Members of the local community reported presence of the weed along the Akanyaru River for long distances up stream. At the time of the visit, the flow of the water hyacinth down the Akanyaru was much more than was observed in the Nyabarongo, where fringing mats of the weed were also fewer. River Nyabarongo had a much bigger discharge and discussions with members of the local community revealed that this river carried larger loads of water hyacinth at the beginning of the rainy seasons, suggesting presence of proliferation zones upstream.

Water pools and canals visited in the Kagera River floodplains of southern Rwanda were packed with water hyacinth (**Plate 2**). However, most of the small lakes were reported to be still free from water hyacinth infestation mainly because they were physically separated from open contact with River Kagera by extensive wetlands. Lake Rweru at the Rwanda-Burundi Boarder was reported to be ifested with water hyacinth (Twongo and Winberg 1999) possibly because it established open contact with the river during flood seasons. Many water pools and irrigation canals in the floodplains were, however, reported to carry luxurious water hyacinth. Members of the survey Team from Rwanda revealed that during the rainy season, the water pools and irrigation canals were heavily flooded and most of the accumulated water hyacinth biomass was floated off and carried down-river. When the floods subsided, there was rapid re-growth of the weed. During severe draught the water pools dried up completely and so did the water hyacinth. However, recolonisation occurred, presumably from seed reserves, as soon as it rained and water filled the pools and canals. It was observed that the water pools and irrigation canals were a potential source of weed infestation for the little lakes especially if the apparently unplanned wetland reclamation continued.

3.3.2. Water hyacinth infestation in the Akagera-Ruvuvu confluence zone

Water hyacinth was not in the Ruvuvu River (**Plate 2**). The weed was, therefore, limited to less than one hundred metres above the confluence and it looked unhealthy the further away upstream. Mats of papyrus interspersed with clumps of *Vossia sp* fringed the riverbanks. Papyrus was the most dominant emergent vegetation one-kilometer from the confluence. The hinterland of the Ruvuvu in the zone surveyed was not heavily cultivated. On the other hand, the portion of Kagera River surveyed was extensively cultivated in most cases down to the riverbanks. Scattered clumps of papyrus and *Vossia sp* fringed both banks of the Kagera. Papyrus was the dominant vegetation in the river-valley (**Plate 3**). Luxurious mats of water hyacinth 2 to 5m wide **(Plate 4)** fringed most of the riverbanks including the section below the confluence. Mainly the bulbous-prolific growth form of water hyacinth, believed to reproduce most actively (Kayanja 2001), comprised fringing weed mats along the open water. There was almost continuous transport of water hyacinth down the river. Single plants, small mats and, occasionally, large mats (**Plate 5**) were transported. The weed was, however, fragmented at the Rusumo Falls (**Plates 6&7**).

3.3.4. Water hyacinth infestation in eastern Rwanda floodplain lakes

Most of the eastern floodplain lakes of River Kagera in eastern Rwanda are located in the Akagera National Park. According to the Park guide attached to the survey Team, only Lake Ihema and Lake Mihindi (Fig 1), which have open connection with River Kagera, especially during the rainy season, were infested with water hyacinth. The other lakes were said to be free from the weed. During the survey, some minor infestation was found at the shores of Lake Ihema where one of the Park's field Offices is located. Fringing mats of water hyacinth were also found along portions of the southwestern shores of Lake Mihindi (**Plate 8**). The guide reported increased infestation of the two lakes by the weed when the river was in flood. Twongo and Winberg (1999) made similar reports.

At the time of the survey, the water hyacinth in lakes Ihema and Mihindi was neither extensive nor luxurious. It was composed of bulbous stunted plants apparently transforming to become prolific and some plants were of the dwarf non-bulbous growth form (Kayanja 2001; 2002). Lack of extensive water hyacinth growth in lake Ihema and Mihindi at the time of the survey was possibly related to the low nutrients (i.e. 10 and 13 μgL^{-1} of SRP, respectively; Table 3.1) in these lakes.

3.3.5. Water hyacinth infestation in the Kikagati/Mulongo Section

The hinterland in this section of the Kagera was mainly rangeland for cattle. The riverbanks were heavily fringed by a continuous band of *Vossia* sp up to 5m wide. Occasionally, small clusters of water hyacinth lay partially hidden among the hippograss (Plate 10). Pure mats of the waterweed were not found close to the bridge and local fishermen indicated that a small concentration of water hyacinth occurred some considerable distance upstream. A continuous stream of mostly fragmented water hyacinth floated down the river (Plate 11), indicating presence of weed production centers upstream. The water was dark brown, heavily leaden with silt. There was, however, no indication of active proliferation of water hyacinth in the section of the river covered.

3.3.5. Water hyacinth infestation in the Kyaka SectionThe shores of the Kyaka section of River Kagera were extensively cultivated mostly down to the banks. Small gardens of various crops including cassava, maize, and tomatoes were grown. The water edge was fringed by patches of *Vossia sp* and widely spaced portions of papyrus. Discontinuous mats of mature water hyacinth interspersed with young actively growing sections fringed the water edge. The young waterweed was dominated by small (10cm high) and medium sized (about 20 to 30 cm long) bulbous plants. Feeding scars were not common except close to the release site below the rearing station at Kyaka. A steady stream of water hyacinth mats comprised mainly by several plants but, occasionally, by large mats floated down the river. Presence centers of active weed reproduction and continuous downriver transport of water hyacinth indicated widespread infestation and active proliferation by the weed in this zone of River Kagera.

3.3.6. Water hyacinth infestation in the lower flood plain

As it approaches Lake Victoria, River Kagera meanders considerably through papyrus dominated wetlands and portions of forest and wooded grassland. The river delta is heavily fringed by *Vossia cuspidator* most of it a product of succession with fringing water hyacinth mats. Large patches of water hyacinth covered by *Comelina bengalensis* fringed the river just above the delta and in several other locations along the lower floodplain. The rest of the river was mainly fringed by luxurious bulbous water hyacinth 2 to 4 m wide, located predominantly to the inside of the river bends where silt is often deposited. The outer bends of the river were mostly free from fringes of the weed probably because they are swept by a strong river current, which does not allow water hyacinth to establish. Some straight shores had established fringes of the waterweed 2 to 3 m wide. The fringing weed mats were often comprised by small short (10 cm) plants at the open water edge followed by medium-sized bulbous plants 10 to 30 cm long, and the large mainly non-bulbous plants >30cm long (**Plate 10**). The arrangement indicated a clear progression in water hyacinth undergoing rapid proliferation. The lower floodplain zone of River Kagera was one of the most weed-infested zones of River Kagera, and among the most prolific.

3.4. Status of biological control along River Kagera

Biological control activities were initiated in Rwanda following training in the rearing of biological control weevil in Uganda in 2000. Counterpart staff from Uganda visted Rwanda and stocked a rearing center of ISAR at Karama. This survey found the rearing center at ISAR Karama renovated and expanded. The survey team also visited a weevil-rearing center located near Lake Ihema. This center was not very active at the time. A newly constructed rearing center due for stocking by Clean Lakes, a USAID funded NGO at the time based in Uganda, was reported in Ruhengeri. Clean Lakes was said to be extending funding and technical assistance to the two weevil rearing centers at Karama and Lake Ihema.

It was reported that biological control weevils had been introduced on water hyacinth in various parts of the Upper Kagera River system. However, no feeding scars were seen on the weed in the sections visited, except at Gashora Bridge near ISAR Karama, where establishment was not extensive yet. In Tanzania, the Team visited a well-maintained weevil-rearing unit for KAEMP near Bukoba Town. Another big weevil rearing centre was located at Kyaka by the river. KAEMP and LAVEMP officials were reported to regularly release weevils in River Kagera. In Uganda, several rearing stations were located in the lower floodplain of the river. Establishment of biological control weevils throughout the Kagera River system was, however, very low (Table 3.3).

3.4.1. Water hyacinth biometric data

Water hyacinth biometric data was collected at Rusumo, Kyaka and near the Kagera River mouth. At all sites, there was virtually no weevil establishment. Plants were healthy with a low average number of feeding scars (1.2, range 0 to 25).

Average fresh weight per plant was 1.91 kg, ranging from 0.1 to 7.0 kg, near the river mouth. Average leaf area was 144.1 cm^2 and ranged from 88.0 to 198.7 cm^2, while average petiole length was 31.6 cm (10.7 to 59.3-cm). Average root length was36.3 cm with a range of 17.0 to 64.0 cm. Average fresh weights per plant was highest at the river mouth (2.09 kg) but this was not significantly different from the upstream sites with 1.57 kg and 1.81 kg at Rusumo and Kyaka, respectively. Average number of ramets was lower at upstream sites (Kyaka-2.4; Rusumo-3.5) and maximum at the river mouth (3.7). Root length was highest at the river mouth (40.22 cm) compared with Rusumo (33.0 cm) and Kyaka (30.9 cm). Leaf area was lowest at the river mouth (129.4 cm) and highest at Rusumo (198.7 cm). Results are given in **Tables 3-3 and 3-4.**

Table 3.3 Biometric data of water hyacinth plants, weevil numbers per plant and weevil damage along River Kagera in July 2001

Site	Ramets (No)	Weevils (No)		Leaf Length (cm)	Feeding Scars (No)	Leaf Area (cm)	Weight (gm)	Root Length (cm)
		N.e	N.b					
Rusumo	4.0	0.0	0.0	34.0	1.0	18.1	1963.0	33.0
Kyaka	2.0	0.0	0.0	35.0	4.0	146.0	1815.0	31.0
Kagera (mouth)	3.6	0.0	0.0	28.5	0.0	29.1	2087.5	40.4

No. plants sampled = 10

N. e = Neochetina eichhornia and N. b = Neochetina bruchi

Note: 1. Most plants were healthy with short bulborous petioles

2. Floating plants had an average of 1.35 ramets and weight of 420 gm per plant

Table 3.4. Water hyacinth growth parameters rate along River Kagera

Parameter	Mean	Minimum	Maximum
Ramets per plant*	3.28 ± 0.31	1.00	7.00
Leaf area (sq.cm)	144.5 ± 5.10	88.8	198.6
Fresh weight (Kg)	1.98 ± 0.10	0.10	7.00
Root length (cm)	36.37 ± 1.70	17.00	64.00
Petiole length (cm)	31.50 ± 1.50	10.7	59.30

** Definition of "ramet" yet to be harmonized by the survey Team.*

4. Summary

4.1 The water hyacinth problem was widespread along the entire Kagera River system surveyed and beyond. Major production and weed reserve centers were located along the riverbanks and in water pools and irrigation canals in the flood plain zones of the river. These include the upper floodplains in southern Rwanda down to the Rusumo Falls, the eastern Rwanda floodplains along the Akagera National Park, and the lower Kagera floodplains in Tanzania and Uganda.

4.2. The contribution of water hyacinth by River Nyabarongo was reported to be seasonal, being strongest during the rainy season when flood waters flushed the weed out of the upper river valleys into the main Kagera River system.

4.3. River Akanyaru was a major contributor of water hyacinth into the main Kagera River system. This contribution was apparently not well known by the LVEMP Water hyacinth Study group before the visit to Rwanda.

4.4. The seasonal flushing of water hyacinth mats from the River Kagera floodplains by the flood waters probably influences the discharge patterns and magnitude of the waterweed as far downstream as Lake Victoria.

4.5. Water quality data suggested that the nutrient content of phosphorus and nitrogen in the Kagera River system (>25μgL^{-1} of SRP) is responsible for the luxurious proliferation of water hyacinth in the Kagera River system.

4.5. The strong brown colour of the water and the low sechi disc transparency of only 0.2 to 0.3 m along the entire Kager River system is indicative of the huge load of silt carried along the entire river.

4.6. The nutrient levels (13 and 10μgL^{-1} of SRP) measured in lakes Ihema and Mihindi, respectively were significantly lower than what was measured in the main Kagera River system (>25μgL^{-1} of SRP). This low level of of SRP is considered marginal to support sustained proliferation of water hyacinth in a lake environment and probably explains the low level presense of water hyacinth in the two lakes except soon after the spate floods in the associated River Kagera. The overflow from the river possibly replenishes the nutrients in the two lakes. In this connection, it is relevant that the other lakes in the Akagera National Park were reported to carry no water hyacinth.

4.7. No feeding scars were seen on water hyacinth in the sections of the River Kagera system visited except at Gashora Bridge where the feeding scars were present but not indicative of well-established biological control agents.

4.6. Indications of presence of localized fungal attack were noted on the leaves of stationary water hyacinth at a shoreline site on Lake Mihindi. No indication of impact on the health of the waterweed was apparent.

4.7. There was no indication at the sites visited along the River Kagera system that the management strategies so far initiated were having significant control impact on the waterweed.

5. Conclusions and Recommendations

5.1. The water hyacinth problem in the Kagera River system is extensive and there is huge potential for it to increase considerably in view of the high nutrient loads in the entire river. Soil erosion is probably a major source of the nutrients into the river.

5.2. The management strategies so far initiated were not having significant control impact on the waterweed. Development of effective control strategies for water hyacinth in the Kagera River system is urgently required.

5.3. Sustainable management of water hyacinth and water hyacinth related problems in Lake Victoria is closely linked to control of the weed in the Kagera River system.

5.4. States in the Lake Victoria Basin, including Rwanda and Burundi, should develop collaborative initiatives in the management of water hyacinth in view of the huge proliferation potential of the Kagera River system.

5.5. Strategies to control water hyacinth using biological control weevils should be re-evaluated and refocused to make the option effective.

5.6. A comprehensive survey of the water hyacinth problem in the Kagera River system should follow the rapid assessment so as to make a comprehensive assessment of the problem and develop to facilitate formulation of in-depth control strategies. Detailed water quality research and socio-economic studies would be an essential component of the survey.

5.7. Cultivation down to the riverbanks (at times to the open water edge) was widespread along the Kagera River system. It is probably partly responsible for the high sediment load and nutrient content in the Kagera River system. There is urgent need to sensitize and supervise the local communities regarding soil and water conservation along the river.

5.8. Control of water hyacinth in Rwánda is likely to benefit from short term training and study visits to countries with the experience in the management of water hyacinth.

5.9. There is need to establish co-ordination among the affected institutions and collaborative strategies with neighboring countries as means to speed up strategy development for the control of water hyacinth.