CONTROL OF

WATER HYACINTH AND OTHER INVASIVE WEEDS

IN LAKE VICTORIA

(A Regional Project Proposal)

PREPARED FOR THE LAKE VICTORIA ENVIRONMENTAL

MANAGEMENT PROGRAMME

BY

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Corrigendum

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ACRONYMS

FAO	-	Food and Agriculture Organization
IIBC	-	International Institute of Biological Council
CSIRO	-	Commonwealth Science and Industrial Research Organization
NGO	-	Non-Governmental Organization
NARC	-	National Agricultural Research Centre
KARI	-	Kenya Agricultural Research Institute
KEMFRI	-	Kenya Marine Fisheries Research Institute
LBDA	-	Lake Basin Development Authority
NARS	-	National Agricultural Research System
IUCN	-	International Union for Conservation Nature
IITA	-	International Institute of Tropical Agriculture
KSTCIE	-	Kenya Standing Technical Committee on Imports and Exports
GTZ	-	German Technical Cooperation
MAAIF	-	Ministry of Agriculture, Animal Industry and Fisheries (Uganda)
NARO	-	National Agricultural Research Organization
RCs	-	Resistance Councils
MLG	-	Ministry of Local Government
MNR	-	Ministry of Natural Resources
DEP	-	Directorate for Environment Protection
WDD	-	Water Development Department
MH	-	Ministry of Health
MI	-	Ministry of Information
UEB	-	Uganda Electricity Board
NW & SC	-	National Water and Sewerage Corporation
MWT	-	Ministry of Works and Transport
URC	-	Uganda Railways Corporation
MF & EP	-	Ministry of Finance and Economic Planning
MTNRE	-	Ministry of Tourism, Natural Resources and Environment
TAFIRI	-	Tanzania Fisheries Research Institute
IMCE	-	Inter-Ministerial Committee on Environment
MoA	-	Ministry of Agriculture
ASARECA	-	Association for Strengthening Agricultural Research in Eastern and Central Africa
TECCONILE	-	Technical Cooperation for the Promotion of the Development and Environmental Protection of the Nile Basin
FIRI	-	Fisheries Research Institute
LVEMP	-	Lake Victoria Environmental Management Programme

SUMMARY

This proposal requests the World Bank, through the FAO and the Governments of Kenya, Uganda and Tanzania to fund a "Regional Project for the Control of Water Hyacinth, with Particular Reference to manual harvesting and the Introduction of natural enemies for the weed Suppression." The project cost is estimated at US$ 8,350,200 from the donor for equipment and operational expenses, and funds from the three Governments for staff salaries and other overheads for a period of five years. This regional project is a component of a larger regional programme "Lake Victoria Environmental Management Programme".

The project would provide support for the establishment and strengthening of national biological control facilities in a number of sites around Lake Victoria. The project would include support for on-the-job training of Government staff of the three countries in biological control at technical level, the rehabilitation or construction of rearing facilities in the field and at the coordinating units, community mobilization activities (including contractual arrangements for manual removal of the weed), importation of natural enemies, provision of vehicles, laboratory and field equipment (including funds for operation and maintenance), support to research work undertaken by any specialized groups on behalf of the project and possible technical assistance by other country programmes and specialized groups. It is proposed that provision for a project manager in each country be made to ensure a good quality scientist is recruited to oversee programme coordination and implementation.

In addition to the evaluation of physical/manual removal of water hyacinth, possible alternative use of harvested water hyacinth and monitoring programme of the abundance of the weed and impact of natural enemies on the water hyacinth abundance will be investigated.

A Coordination Unit would, through field rearing units, facilitate project implementation in each country, while National Steering Committee and a Regional Policy and Steerin Committee would review progress of project implementation and the programme of work at national and regional levels respectively. Annual workshops would bring together national and regional scientists and other technicians to review progress and constraints during project implementation and plan for the year ahead.

The project's prime concern would be the introduction of environmentally sound control strategy of water hyacinth, in which the use of chemicals would have a limited role. The establishment of successful biological control of the weed would therefore significantly reduce the risks to which human and animal populations would otherwise be subjected to. However, the three Governments will need to be convinced that biological control is effective, beneficial and safe. The three Governments should thus adopt a policy of biological control (which should be integrated with other control measures) for reduction of the problem and economical and sustainable control; and commit to implement the programme for a minimum of five years. Policy instruments to support major features of a properly planned, adequately funded programme should be in place before project implementation.

This project is conceived as a regional programme implemented at national levels, with the consensus of the region. Information exchange within the region becomes a critical issue.

It is proposed that the ASARECA could have a role in facilitating information exchange and ring of resources both human and physical to ensure project activities implementation.

Experience demonstrates that three water weeds, namely water hyacinth, water fern and water lettuce/Nile cabbage usually occur but currently water hyacinth causes major problems.

This project document details current status of water hyacinth, and known control strategies and proposes the way forward. In Uganda, where water hyacinth infestation is heaviest, the first line of attack should be both manual and mechanical removal, especially so at Port Bell, the Owen Falls Dam at Jinja, and at water supply points. At these sites biocontrol will follow once the water hyacinth mass is reduced. At all other sites in Uganda biocontrol strategy is proposed. The effects of herbicide use in the water environment should be investigated in isolated dams and sites. Data collected locally should then be the basis for use or non-use of herbicides in the lake. Elsewhere at the shores of the lake in Kenya and Tanzania it is recommended that biocontrol strategy be implemented without further delay. Manual removal of the weed should be implemented where necessary in Kenya and Tanzania.

Through community awareness campaingns reduction of nutient infiltration to the lake should be incoporated in the long term control of the weed. This should be done through the prevention of soil erosion around the lake and prevention of runoff into the lake, from cultivated fields.

To ensure the water hyacinth control is successful surveys, monitoring and control activities should include sites of infestation at source. Cooperation of the LVEMP with the Kagera Basin Organization and Technical Cooperation for the Promotion of the Development and Environmental Protection of the Nile Basin (TECCONILE) becomes extremely necessary. It is proposed that Rwanda and Burundi be included in the programme, through provisions of the (TE CCONILE) and the ASARECA, especially in the manual removal of the weed from Kagera river, and the release of natural biocontrol agents, as well as in monitoring activities.

PART I: CONTROL OF WATER HYACINTH: REGIONAL STRATEGIES

1.0 BACKGROUND

1.1 Lake Victoria Environmental Management Programme (LVEMP)

It is to be appreciated that under FAO effort, starting in 1991 and after identification missions in the Lake Victoria countries, a workshop held in Harare on the control of floating weeds made recommendations calling on the survey, biological control and promotion of collaborative activities by Lake Victoria countries. Subsequently, surveys were carried out in Uganda. After surveys on the situation in Uganda side of Lake Victoria, it was further recommended to undertake control measures at national levels, while a focus would be made on a regional approach to the problem and on the role of biological control agents, as well as the role of short-term control measures on the eradication or suppression of water weeds on the lake.

As a response to the commitment shown by FAO, the Riparian countries of Kenya, Uganda and Tanzania have undertaken to facilitate the implementation of Lake Victoria Environmental Management Programme. The culmination of these efforts and initiatives in part is the current proposal on the "Control of Water Hyacinth and Other Invasive Weeds in Lake Victoria". Under the FAO/TCP (RAF 2371) and the World Bank funding, this comprehension project document was prepared. This is a follow-up of meetings held in the region by the Regional Policy and Steering Committee, approval of the preparation of this project document as a contribution of Task No.10 on "Control of Water Hyacinth and other Invasive Weeds"; and as part of Regional Task Force I on "The Management of Fisheries and Control of Water Hyacinth and Other Invasive Weeds".

2.0 INTRODUCTION

2.1 The Problem: Historical Perspective

Water hyacinth *Eichhornia crassipes* Martius Solms-Laubach is a flowering plant, in the family Pontederiaceae. During the last 90 to 100 years, water hyacinth has spread to many tropical and subtropical regions of the world from what is thought to be its centre of origin, the Amazonia in Brazil. In Africa, water hyacinth is alarmingly increasing, since its appearance in Egypt between 1879 and 1892, South Africa 1910, Congo River in 1952 and Nigeria 1987.

In the Riparian countries of Kenya, Uganda and Tanzania, records indicate that water hyacinth was grown as ornamental since 1957. The weed appeared in Lake Naivasha between 1982 and 1983 where it seemed to be out-competed by *Salvinia molesta*. It was confirmed to be in the Kenyan side of Lake Victoria in 1992, but scanty reports on its existence in Lake Victoria had been received in 1990. In Uganda, reports indicated the presence of the weed east of Lake Kyoga in 1988. In Tanzania the weed was reported in 1990 (Barret et al 1982).

Eco-climatic requirements for water hyacinth favour its persistence and growth in Lake Victoria and clearly in natural water-ways, wetlands, lakes, dams, irrigation developments and hydro-schemes throughout the riparian republics of Kenya, Uganda and Tanzania. The weed hampers the landing of boats, deoxygenates the shallow water habitats of fish, causes overheating of engines of ferries and outboard motors. Further, hydroelectric power, the domestic and industrial water supply are threatened. Other features that are threatened are reduction to biodiversity and scenic beauty.

2.2 Characteristics and Factors Aggravating the Problem

Climatic factors that cause an increase in the growth and reproduction of the weed

aggravate the problem in East Africa. Population increase of the weed is principally through production of stolons, bearing daughter plants, but in addition, large quantities of long-lived seeds are produced. The weed populations have been known to double in every 5 to 15 days under optimum temperatures of between 25 to 27.5°C. It is also noted that the plant ceases to grow when water temperature is below 10°C or above 40°C (Mitchell 1978). Additionally, increase in growth and reproduction are usually the result of availability of nutrients, especially nitrogen and phosphorus in the water. Both flowing and still water may be nutritionally enriched by drainage from agricultural land, discharge into the water from factories or urban waste and inadequately treated sewage effluent. The identification and reduction of sources of nutrient enrichment becomes a critical issue. The above factors will be found to exist in Lake Victoria hence favouring the observed prolific growth of the weed.

3.0 CURRENT STATUS OF WATER HYACINTH DISTRIBUTION IN EAST AFRICA

Water hyacinth was first reported in Lake Victoria in 1988 in the Uganda side (Twong 1991). It has since spread to all corners of the lake, including Tanzania and Kenya shorelines. The weed has also infested other water ways of Lake Victoria Basin area, including the inland lakes and rivers in Rwanda, Burundi, Uganda, Tanzania and Kenya. A clear understanding of the weed distribution and abundance is a prerequisite to successful implementation of specific control strategies in specific sites. As at August 1995 floating mats of water hyacinth occurred either singly or in big mats in the following sites:

3.1 KENYA

3.1.1 Lake Naivasha

In the past, GTZ, the International Institute Tropical Agriculture (IITA), IIBC and KARI have worked on the control of *Salvinia molesta* in Lake Naivasha. Although salvinia weed has been largely controlled, water hyacinth has taken over and has become a problem in the lake. Activities towards the control of the weed on Lake Victoria will be influenced by experiences at Naivasha.

Lake Naivasha, a fresh water lake situated about 100km North West of Nairobi at an altitude of 1830m above sea level at the floor of the Rift Valley is 150 square kilometres. Reports from the lake Naivasha indicate that water hyacinth was increasing at a significant rate, with some mats covering 100m x 50m or more, which was a substantial increase over the 50m x 20m

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3.1.2 Lake Victoria

Although the weed originally occurred in sheltered bays, it has now extended to the open lake. This infestation is suspected to have been introduced in Lake Victoria from the Kagera River in Uganda.

Visits were made to Karungu, Usenge and Asembo Bays, Yala swamp, Mageta, Sirijombe and Magare Islands. Other field visits were made in Sori, Kadem, Kanyango, Nyira and Aringo forest beaches in Karungu bay, Bukoma beach, Marenga beach, Sio Port, Nzoia and Yala deltas, Kendu Bay, Mbita Point, Homa Bay and again at Karungu Bay in July and early August 1995.

3.1.2.1 Karungu Bay Area

Water hyacinth infestation was monitored in the interior of Lake Victoria.

The width of weed mats at the Nyira beach varied in length from 5 to 50m. One mat lying 250m from the shoreline at Aringo beach was estimated to cover 800m^2. In a subsequent survey, floating mats of the weed were found over a wide area, especially along the lake shores.

3.1.2.2 Usenge Bay Islands in Usenge Bay and the Yala Swamp

Other areas with high densities of water hyacinth in Lake Victoria include Karungu (Sori) Bay, Luanda, Kanyahngo, Muhuru Bay, Usenge South. The weed has invaded the Yala Swamp but is yet to reach the Yala River at this point.

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Survey at Usenge Bay showed that the weed had drifted into the open waters, and was at the Mageta Islands, Magare, Uhanya and along the shores of the Yala Swamp. At Asembo Bay, water lettuce was also observed, while the shores of Uhanya, Magare Island, Mageta Island and Sirijombe had floating Islands of water hyacinth of up to 5 metres in length and $10m^2$. Water hyacinth was also seen at the Nyambo beach, Oseko and Yala swamps. According to fishermen in the area the weed was first noted at the Yala swamp in 1990.

It would appear that natural water-ways, wetlands, lakes, dams and irrigation schemes are threatened, not only by water hyacinth, but also by water fern, (*Salvinia molesta*), all of which tend to occupy similar habitats. This points to the desirability of controlling water hyacinth, water fern and water lettuce concurrently. The three aquatic weeds are a cause for concern, have enormous potential for their spread in Kenya, and still have a potential for their control.

3.1.2.3 Bukoma Beach

Heavy infestations were found occasionally but reportedly are blown away into the lake. It was reported by residents also that heavy infestations would be found at Bulwani and Osieko in Siaya.

3.1.2.4 Marenga Beach

It was reported that at times water hyacinth was blown into this area,

but eventually clears off to the open lake. Water hyacinth was also reportedly found in Nzoia and Yala rivers, and that the channels emptying into the lake were choked.

3.1.2.5 Sio Port

Small mats of water hyacinth were located at the lakeshores. It was reported that occasionally the weed completely blocks the Port, thus affecting all beach activities.

3.1.2.6 Nzoia and Yala Deltas

It was noted during a recent survey that most of the channels in the Yala and Nzoia rivers were blocked by water hyacinth. The banks of the rivers had growths of water hyacinth as well as papyrus. Rusinga beach on river Yala was not accessible due to blockage by the weed. The worst hit was Bulwani area with mats ranging from 50 x 100m to 5km from the lakeshore.

3.1.2.7 Kendu Bay

Only traces of weed mats were seen, indicating that the area was relatively free from heavy infestation

3.1.2.8 Homa Bay

Water hyacinth was not seen in the beaches in this area, during July 1995. However, residents explained that during the rainy season, the bay was usually full of the weed.

3.1.2.9 Mbita Point

Water hyacinth was found in the area. Residents reported that it was five years now since the infestation was noticed.

3.2 UGANDA

Recent surveys indicated that water hyacinth was constantly increasing. The area between Entebbe and the Uganda/Kenya border was characterized by widespread mats of floating weeds, and the average area covered by water hyacinth was estimated at 1000 ha. The pier at Port Bell was completely covered by the weed while at Murchison Bay, drifting patches of weed mats were observed. At Port Kibanga large field of water hyacinth was seen in July 1995. The bay west of Entebbe Airport was characterized by scanty mats of the weed.

It was further noted in a similar survey in the area between Entebbe and Kagera River, including Ssese Islands that infestations were common in Bukasa Island, islands between Bukasa. Bukasa islands, coastline from Ssese Islands to Kagera River, and the coastline bays North of Ssese Islands up to Entebbe.

It was thus concluded that as at August 1995 water hyacinth infestations in Uganda could be summarized as follows:

3.2.1 Bays:

The bays of the North coast of Lake Victoria are heavily infested with water hyacinth probably due to the dominant Southerly winds and the presence of nutrient rich water.

3.2.2 Fish Landings:

Parts of the fish-landing shores were enclosed by narrow bands of water hyacinth, but some landing-sites were free of the weed. Drifting large wats were however noticed at Gabba, whereas at Mulungu and Kansesero isolated plants were common. At Masese, a narrow band of the weed which was reportedly temporary was observed.

3.2.3 Railway-Ferries:

Port Bell was most affected by large amounts of water hyacinth, hampering the docking and alignment of the railway ferries to the pier. The pier at Jinja was free of infestation.

3.2.4 Hydroelectric Power

It was noted in August that the "Owen Falls Dam" was under the threat a permanent and extended mat of water hyacinth that face the dam just above the turbine screens and is a threat to electricity production.

3.2.5 Islands:

The coast of the northern islands, east of Entebbe were only lightly infested with water hyacinth, however some shores and bays had narrow bands of permanent weed. The Ssese Islands were more affected, especially Bugala.

3.2.6 Lake Victoria:

The Lake shore, south of the Islands was completely free from water hyacinth.

3.2.7 Coast South of Ssese Islands

No aquatic weed was reported as at July, 1995.

3.2.8 Kagera River:

The river was highly infested with water hyacinth and brings a lot of plants into Lake Victoria

3.2.9 Natural Control of Water hyacinth:

It is believed that the rafts of water hyacinth that are blown out into Lake Victoria would be fragmented by strong winds and high waves, since the old plants may not withstand the dynamic action of the rolling waves.

The coastlines with landing shores of the islands are lightly infested with water hyacinth while the bays and the North-East part of Lake Victoria, from Bukakata to Kibanga were highly affected, with about 75% of all water

hyacinth observed in the Uganda part of lake Victoria.

3.3. TANZANIA

In Tanzania, the weed infestation was heaviest in cotton growing areas of Mara and Mwanza Regions, particularly in the sheltered and quiet bays. It is now believed that the rapid growth of the weed in the cotton growing areas was a result of the presence of high quantities of phosphates and nitrates which had been washed from the farms into the lake as these areas use a lot of fertilizers in growing cotton. In 1994, the most heavily infested cotton growing areas included, Majita areas (Suguti and, Majita Bays and Bowmanns Gulf), Kisorya, Bunda District (entrance to River Rubana), Magu area (entrance of River Simiyu), Mwanza area (almost the whole of Mwanza Gulf) Sengerema, Geita (especially Emin Pasha Gulf) and Biharamulo District. Infestation in the Kagera region had been quite low. This was believed to be due to the configuration of the shoreline (straight with very few bays) and the rough waves which pound the need to the rocky shoreline and move it towards the north.

Distribution of water hyacinth around the shores of Lake Victoria is shown in Appendices I-III. Generally it was observed that water hyacinth infestation in the Uganda side of the lake is a tragedy which requires immediate emergency measures. The Kenya and Tanzania sides of the lake are relatively lightly infested, and may require long term control measures as first lines of attack.

4.0 IMPACT OF WATER HYACINTH INFESTATION ON SOCIETY

The rapid expansion of the water hyacinth in Lake Victoria is already reported to be showing serious economic, social, health and environmental impacts in the riparian states. Important activities within the fisheries, transport, water and electricity supply as well as water quality are affected by the spread of the weed.

4.1 The Fisheries Sub-Sector:

Concern has been raised over the threat to the fisheries of Lake Victoria. Lake Victoria supports a thriving fishing industry, which supplies both the domestic and export markets. The supply of affordable protein, income and employment opportunities offered to the local communities are important social aspects of the fisheries sub-sector.

The infestation of water hyacinth is perceived to affect the fisheries through reduced level of production, a reduction in species composition of the catch, poor quality of fish, rising costs of operation resulting in lower incomes to the fishermen and/or higher prices to fish consumers. Some of the effects of the water hyacinth infestation are outlined below, based on the interviews carried out during the preparation of this document, and interviews during earlier missions to the region by other groups.

(i) Production decline is said to result from reduction in phytoplankton growth which takes place as a result of reduction in nutrient levels caused by the water hyacinth growth.

(ii) Reduction of oxygen levels in the water by the water hyacinth creates an environment unsuitable for fish survival. Fishermen have reported catch declines down to 10% of the pre-weed situation.

(iii) Water hyacinth has infested sheltered bays more than other areas. Bays are breeding and nursery grounds for fish, particularly the tilapia, the species most preferred in the region. There has been a reduction of tilapia in the catch composition of the fish species. Tilapia, until recently, the second largest commercial species on the lake, is now moving to the third position after *Rastrimobela argentina* a small pelagic locally known as "mukene" in Uganda and "omena" in Kenya. Thus fish-fauna and diversity of birds is reportedly affected.

(iv) As a result of the water hyacinth colonization of the bays, the subsistence fishermen operating with hooks, traps and baskets have been forced out of operation and their source of livelihood and protein interfered with.

(v) In the open waters, mats of water hyacinth have swept away and entangled fleets of nets. This reduction in fishing capacity has contributed further to the declining fish catches.

(vi) Large mats of water hyacinth have posed major obstruction to fisheries operations. Catch delivery times have been increased on average by 2 - 3 hours daily and sometimes by as much as 3 days. These delays have at times resulted in deterioration of fish quality and at most in complete spoilage of the catch rendering it unsuitable for consumption. To avoid spoilage operators have had to carry additional ice, resulting in higher costs.

(vii) Water hyacinth mats have caused higher costs to operators. In cutting their way through the mats, boats need more time and have to use more fuel (average 30%), sometimes 3 times as much as the normal amount, depending on infestation.

Maintenance costs of engines have risen due to the weed getting sucked into the cooling system. "Engine Knock" is now a common occurrence as a result of the water weed. This causes reduction in fishing and delivery capacity for the fisheries sub-sector, requiring additional expenses in capacity restoration.

(viii) Industrial fish processors have had to wait longer for delivery of the catch, incurring higher costs in ice. Furthermore, when the main fish landing sites are completely blocked, the

processors have had to hire additional labour to carry the catch from side landings often inaccessible by truck.

Rising costs of operators, together with lower quality of fish have resulted in lower earnings for fishery operators. Declining fish supplies, coupled with rising costs of production, have resulted in higher fish prices on the market.

4.2 Water Supply:

Water hyacinth infestation has affected both urban and rural water supply to the lake basin communities, due to the following:

(i) Clogging at water supply intake has already been experienced and other urban supply points are threatened in the same way.

(ii) On a more continuous basis, suspensions of decaying organic matter from the weed, as well as the change in water colour, pose additional problems in the processing of the water. The problem is worsened by the unpredictability of the weed invasion, making it difficult to prepare for it. Plans to set up flexible screening mechanism at the intakes will result in additional costs to the national water supply units and higher water prices to the consumers.

(iii) Lake Victoria is also the main source of water supply to the rural communities found all along the shoreline and the islands. Blockades imposed by the water hyacinth hinder access to water supply. Mats of the weed are often difficult to penetrate even by canoes and the communities often have no alternative source of water supply.

(iv) Reduced water flow will cause flooding especially in water ways and irrigation canals, where water flow is reportedly reduced 40-90 per cent.

(v) When mats of the weed are blown away, they leave behind mud and extremely dirty water filled with suspended decaying organic matter of unpleasant odour and that makes the water unsuitable for any domestic use.

4.3 Transport Sector:

Water hyacinth infestations have resulted in disruptions, delays and rising operating costs in the transport sector. The effects of these are already being felt widely within other sectors of the economy served by this important trade route, through rising costs and product prices. The water transport is of social importance to the lake side communities because it is the only means of communication and a source of livelihood. A variety of transport activities on Lake Victoria, summarized below, have been affected by the water hyacinth infestation:

(i) The recently expanding fisheries sector on the lake requires quick and reliable delivery transport services preserve fish quality. As already discussed, water hyacinth invasions have resulted in delayed fish deliveries and quality loss; lower prices to fisher persons who are unable to deliver their supplies to the market on time; higher operating costs for the motorized boat transporters and shorter lifetime for the transport equipment, particularly the outboard motors and boats.

(ii) Other transport activities related to fishing have also been expanding on the lake. There have been increasing movement of goods and people between the islands and the mainland and also within the islands using water transport. Mats of water hyacinth infestation have disrupted and often cut off these movements, much of which is operated manually using boat and paddle.

Although this category of transportation does not probably involve the movement of goods worth millions of dollars, it is important from the social point of view because it represents supply and livelihood lines of poor people who depend on this transport for their survival.

(iii) Lake Victoria is also an important route for the regions' export-import trade. In addition to the wagon and passenger ships operating on the lake, several motor boats carry such Ugandan exports as beans, maize, bananas to Kenya and beer to Tanzania and in return bring in assortments of such consumer goods as cooking fats, toilet soap and perfumes, mattresses, etc. in what is known as cross border trade.

The ships as well as the motor boats often take longer travel

times as they try to avoid large mats of the weed that may have moved into their navigation routes, resulting in higher operating costs.

During docking, both categories of vessels have often to push through thick mats, consuming more fuel and running the risk of damage to the engines. Often, they have to incur costs in hiring labour to cut their way for docking. In all these cases, docking time is increased from the usual 20 minutes to 2 hours and at worst up to 3 days. (Twong 1991)

4.4 Environment and Health:

Concerns have been raised about the environmental impact of water hyacinth infestation mainly through water loss and eutrophication. The plant is known to have a high rate of transpiration (Benton et al 1978). Consequently, large cover mats of the weed are said to result in high rate of evaporation in a water body, which could affect the water balance in the region. Drying parts of the plant cause sedimentation and silting of the water body. Decomposition of the plants in the water leads to eutrophication and pollution of the water environment.

Water hyacinth is reported to impact negatively on the health of lake side communities. It provides habitat for agents of malaria and bilharzia and harbours snakes. It is said to transmit amoeba, dysentery and typhoid and to cause severe skin rashes when in contact (Fishermen - personal communication). It turns water green and dirty, making the supply unsuitable for drinking and for other domestic uses. This impact poses additional burden on the limited health services and facilities available to the poor rural communities.

4.5 Power Generation:

The supply of electricity, an important utility input into the various production processes in the economy has also been interfered with. The Owen Falls Power Station receives water hyacinth infestation from the lake on a continuous basis and is frequently blocked by large mats of the weed.

The weed has to be removed immediately to avoid particles getting into the filters and coolers. Despite this removal effort, water hyacinth materials do reach the generator filters and coolers. Although there are no additional costs involved in cleaning the filters and coolers, any of the generators may have to be switched off if its filter/cooler gets blocked and has to be cleaned. Switching the generator off means not only a loss of revenue but also inconveniences to the consumers. Disruptions and rising costs of production of these utilities lead to higher operating costs and inconvenience to producers elsewhere in the economy.

5.0 STRATEGIES FOR WATER HYACINTH CONTROL

Four main options of water hyacinth control have been tried, in countries in Africa, and almost all of them have been tried in East Africa. It is proposed that these are adopted, where appropriate.

5.1 Physical Control

This includes the removal of the weeds by manual labour, or even by mechanical harvesters, use of barriers and where possible by use of draining the water body.

The riparian governments have attempted to control water weeds through manual removal. Individual fishermen and fishermen groups have also attempted manual removal to make way for their boats. The weed is removed and placed by the shore to dry, or is pushed back into the lake to be blown away by wind to other locations. This technique is useful and sometimes essential in the short term. The main constraint here is high expenditure involved. Physical control would have to be a permanent operation, if it is the only means of control used.

5.2 Chemical Control

In 1964 aerial application of Gramaxone-S (Paraquat) was undertaken on Lake Naivasha to control *Salvinia molesta* and other aquatic weeds (Njuguna 1991). Hand operated sprayers were also used to supplement the aerial applications. Hand operated sprays were especially useful for killing *Salvinia molesta* in densely populated papyrus areas (Waithaka 1981). Generally, this method of control is effective against the smaller growths of weeds but has proved expensive and ineffective against large infestations. Other constraints associated with this strategy are as follows:

(i) It has been noted that where conditions are favourable, water hyacinth and salvinia can grow faster than the chemical can kill them. Resurgence of the problem is possible (through seeds), many years after the problem has apparently been solved. In Uganda the use of herbicides has never been recommended. However, it is now reported that limited use of appropriate chemicals is being considered for application in certain infested areas.

(ii) The effects of chemicals on human health (real or imagined) on other

plants and animals and their damaging effects on the environment are other causes for concern. Chemicals may however be a valuable means of control in the short term, and in specific situations.

5.3 Biological Control

Biological control of exotic water weeds is a technology pioneered over recent years by the International Institute of Biological Control, IIBC (formerly CIBC), the Commonwealth Science and Industrial Research Organization, CSIRO of Australia and the US Department of Agriculture. In 1961 attempts by IIBC for biological control of water hyacinth was initiated. Exploration was undertaken in South America, and West Indies. More detailed studies were carried out in Guyana, Surinam and Brazil. A list of insect and mite species associated with water hyacinth was produced. Among these, the weevils *Neochetina bruchi* Hustache and *N. eichhorniae* (Warner) and Lepidopteran *Sameodes albiguttalis* (Warren) were shown to cause considerable damage to water hyacinth, and all are host specific.

Through the use of this technology the spread of water hyacinth has been combated in many countries. In Bangalore, India between 1983-86, the two weevils resulted in 90 percent reduction of the infestation. A drastic reduction in the growth rate of water hyacinth was achieved in Sudan (1979-81) after the introduction and release of the weevil (N. bruchi) and the pyralid moth (*S. albiguttalis*). Classical biological control on water hyacinth has also been employed in Cuba (1993), with success Benin (1990-93) and plans are made to do the same in Malawi (Harley, 1990; Thielen et al, 1994).

In Kenya biocontrol agents have been released for the control of Salvinia

molesta and water hyacinth in Lake Naivasha (Mailu, 1990). These attempts will need to be extended to L. Victoria. In Uganda the two weevils have been released in 20 sites in Lake Kyoga. The rate of production of these weevils may hinder successful colonization. The technology will in the long term be cheaper than other options, and will, if successful be a permanent feature, which will require little recurrent costs.

5.4 Integrated Control

This employs physical, chemical and biological methods of control as components in an overall management strategy. The emphasis of each of the control components will vary from country to country according to circumstances and over time. Physical , Mechanical and chemical control will be phased out as soon as practicable, as total reliance on biological control is the long-term objective.

6.0 MANAGEMENT AND CONTROL PROGRAMME

6.1 Scope:

It is now apparent that the water hyacinth problem is real and spreading rapidly in major Kenyan, Tanzania and Uganda water bodies. In lake Victoria, the problem has had a serious impact on the socio-economic fabric of the communities around it, and especially so in Uganda.

Lakes Naivasha, Kyoga and Victoria have severe water hyacinth problems. However, there are also large hydroelectric dam impoundments on the Nile, Sagana, Tana and Turkwell rivers, which are particularly vulnerable to water weeds infestations. In the coastal Tana Delta region and along the entire Coast Province of Kenya, irrigation schemes and seasonally flooded grassland areas offer suitable aquatic weed habitat. Elsewhere, in the riparian states, any slow moving water or static pool offers opportunities for water weeds growth.

Control measurers employed in three countries have been reviewed. These approaches, (Mechanical/Manual removal, chemical, biological control and integrated pest management) have been tried to a certain extent in the three countries.
Mechanical and chemical control strategies may have some value in some specific cases. However, these are constrained, not only by labour requirements, but also by the high capital expenditure that may go with their application. Environmental considerations also limit the usefulness of chemical control of water weeds generally. The spread of water hyacinth is now too wide for effective application of chemical or mechanical means in the circumstances. However, in certain cases

manual/mechanical removal may be tested.

6.2 Control Strategies

Preference should be given to integration of biological, physical, chemical and other methods of control with the hope that all other components, except biological control would be quickly phased out. It is proposed that the following strategies would be employed, as a general approach to the control programme.

(i) Biological control should be implemented as soon as infestation and pest identity are confirmed. It is the only cost-effective, permanent and environmentally friendly option.

(ii) Where a measure of control is urgently required e.g. in Port Bell and Owen Dam, in the short-term, appropriate physical/mechanical methods will be implemented.

(iii) When physical and/or chemical methods are used, their appropriateness and compatibility with biological control methods will first be evaluated in isolated pockets of water hyacinth infestation.

(iv) Where mechanical clearance is undertaken as a temporary measure, utilization of the resultant biomass may be investigated. The local community and NGOs may be used in this venture.

(v) Every action must be taken to prevent infestation spread to other uninfested areas. Community awareness, including awareness by policy makers will be needful for effective mobilization. Legislation may need to be enforced where necessary.

6.3 Programme Objectives

The overall goal of the programme is to ensure control of water hyacinth and other invasive weeds in the Lake Victoria Basin area, through the implementation of intensified publicity, legislation and integrated pest management strategy with particular emphasis on the use of biocontrol agents. Specific Objectives are:

(i) To assess the potential of biocontrol agents for the control of water hyacinth in Lake Victoria, with participation of local communities.

(ii) To investigate the possibilities for integrating different control strategies (mechanical, chemical and biocontrol) in certain specific situations for control of water hyacinth.

(iii) To evaluate the potential for alternative uses of water hyacinth that has been mechanically/manually harvested, in a participatory approach involving the local communities.

(iv) To design a model for community mobilization that ensures awareness and training programme on the effects of water weeds and the potential for control through the use of naturally occurring organisms.

(v) To build a national capacity and increase effectiveness for control of water weeds, through on-job training, and provision of infrastructure to facilitate control.

(vi) To investigate the possibility of reducing the quantities of water hyacinth through mechanical/manual removal and putting the harvested weed in an income generating use.

(vii) To evaluate the end products for suitability as animal feed, farmyard manure (silage) and briquettes for fuel.

6.4 Justification

The possible impacts of the infestation with water hyacinth in Lake Victoria have been reviewed. Wide proliferation of the weed disrupts nutrient dynamics, fish feed, breeding, nursery activity and biodiversity. The weed is currently interfering with fish activities, blocks beaches, damages nets and interferes with irrigation as well as other water supplies. In view of the large contribution of Lake Victoria in terms of transport, water supply, fisheries, power generation, environment and health, the need to ensure it is relatively free from water hyacinth infestation is real and hence its control is essential. Biological control, through introduction of natural enemies has the highest potential for successful control of the weed in the long-term. This

strategy has been used in other areas where water hyacinth had been a problem, with spectacular results. In specific areas however, manual, mechanical efforts will be required to clear the weed in the short-term.

6.5 General Methodologies/Perceived Activities

6.5.1 Biological Control

Insect agents for control of water weeds were released first in 1971 in Lake Naivasha (Mailu 1990). Typically, heavy infestations of *Salvinia molesta* covering 60% or more of the water's surface have been reduced to 20 and 25% cover, within 3 to 5 years of release of the agents. Weevils already established in East Africa attack well established crowded, tall water hyacinth plants that are likely to cause most problems. It is usually desirable to establish first one then the other species of weevil and then the moth as third option (Harley, 1994).

The following characteristics favour this approach:

- Biological control agents have been discovered in the native range of water hyacinth;
- Research has shown that these agents cannot survive on any other plant except water hyacinth; and
- These biological agents have successfully controlled the weed in several countries and are currently reared and have successfully established in some Kenyan and Ugandan water bodies.

In each of the countries the following activities are proposed:

6.5.1 Surveys to establish and reconfirm the extent and source of problem

Although ground surveys have been carried out on the extent of water hyacinth

problem, there will be need to first reconfirm the extent of the problem. Surveys would be mounted, through the use of a boat to map out areas in the lake that have infestations. Lake maps showing the initial water hyacinth status will need to be drawn, as points of future reference. One appropriate methodology would perhaps be the use of remote sensing technology as a tool for monitoring water hyacinth infestations. The Regional Centre for Surveying, Mapping and Remote Sensing in Nairobi in collaboration with IIBC could be requested to complement the local scientists ground surveys with information from remote sensing.

6.5.2 Assessment of compatibility and appropriateness of different control measures

Adoption of a policy of biological control for reduction of the problem and sustainable economical control is advocated. Biological control may however, be integrated with other control measures, where it is necessary to reduce water hyacinth immediately. It will thus be desirable to first ensure that the control measures employed

are compatible with biological control. The following activities are envisaged:

- Laboratory experiments will be conducted to ensure that herbicides used are not harmful to the natural enemies;
- timing of sprays will be conducted to coincide with the stage of the natural enemies that is least susceptible to herbicide effects; and
- mechanical/manual removal will be timed such that breeding of natural enemies is not disrupted. Weed removal by means of barriers, rakes, nets or mechanized harvesters may be evaluated. A physical barrier may be erected across lagoons to trap water hyacinth that may drift to open waters.

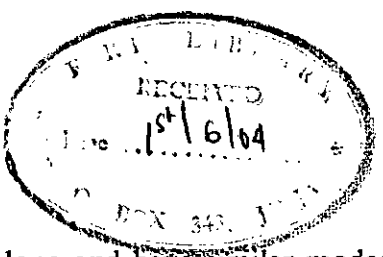
In all cases, about 5 kg wet mass of water hyacinth would be collected each month and weighed. The insects extracted when counted would determine their densities. The percentage of damaged buds would also be noted.

6.5.3 Importation of Biocontrol Agents

The two weevil species that have, to-date been most widely used and found effective world-wide and are host specific have already been imported, reared and released in Kenya and Uganda.

- The chevroned water hyacinth weevil *Neochetina bruchi* Hystache;
- the water hyacinth weevil *N. eichhorniae* Warner;

The water hyacinth moth *Sameodes albiguttalis* (Warren) should be imported to augment the weevils.



Mode of Attack

The two *Neochetina* spp are 3.5 to 5.0 mm long and have similar modes of attack on the plant. Minor differences in biology ensure that they are not competitive. Adults are nocturnal and feed preferentially on the upper surface of leaf lamina and upper 1/3 of petioles, making characteristic sub-circular pits Heavy feeding causes desiccation of leaves. Oviposition is in petioles and ligules. Larvae tunnel towards the base of petioles and into the crown, where they excavate small pockets which often become contiguous. Pupation occurs under water in a cocoon, made from root hairs. The generation time for *N. bruchi* is 96 days and for *N. eichhorniae* is 120 days. Heavy attack causes the plants to float lower in water and can lead to waterlogging

rotting and plant death. These relatively long life cycles mean that high population densities are slow to develop.

S. albiguttalis discriminates between different growth forms of water hyacinth, causing patchy distribution. Young larvae are unable to penetrate leaves with a hard cuticle and the attack is predominantly on young plants with bulbous petioles found in areas of low plant density, but may occur on lush larger plant. Generation time is 34 days. *S. albiguttalis* complements the damage to water hyacinth caused by the *Neochetina* spp. Thus when implementing a project on biological control of water hyacinth, it is usual to establish first one, then the other species of *Neochetina* and later *S. albiguttalis* (Center, 1984).

Newly imported biocontrol agents would normally be reared in quarantine through one generation before the same are released to field rearing units. Field rearing units, using plastic, concrete or corrugated iron pans are recommended to be erected at identified sites.

6.5.4 Organization of Field Rearing Units

It is proposed to locate rearing units as follows:

- **KENYA**

  (i) **NARC-Muguga/ Coordination, Quarantine and Rearing Unit.**

  Activities

  - Importing biocontrol agents in consultation with -KSTCIE;

- processing the imported materials through quarantine;
- conducting specificity tests where necessary;
- distributing materials to field rearing units for further mass rearing;
- releasing biocontrol materials in consultation with other rearing units;
- monitoring the establishment and eventually evaluate impact of biocontrol agents, in liaison with other rearing units; and
- convening meetings of Coordinating Committee, whose membership includes all stakeholders.

(ii) **Kibos, Fibre Research Centre, Kisumu**

This will be the main rearing unit in Lake Victoria Basin area.

- receiving materials from KARI-Muguga (NARC-Muguga) and mass rearing the same for release involving the local communities;
- releasing biocontrol agents in Lake Victoria;
- liaising with Lake Basin Development Authority, The Fisheries Department, KEMFRI to monitor the establishment of biocontrol agents effects of water hyacinth and its distribution;
- evaluating the impact of biocontrol agents in Lake Victoria;
- training of fisheries extension staff/scouts and selected persons at community level; and
- Sensitizing communities on pertinent infestations.

(iii) **Bukoma Beach, Busia District and Karungu Bay, Migori District rearing units at the Lake Victoria Shore**

- Mass rearing of biocontrol agents;
- supply biocontrol agents to fishermen for distribution to affected areas; and
- training in mass rearing techniques to fisheries assistants, scouts and selected persons at community level.

Bukoma beach rearing units will supply biocontrol agents to Busia and Siaya Districts. The site at Karungu bay will supply sites in Homa Bay, Migori District. Coordination of supply of biocontrol agents will be through KARI, fisheries extension, and beach leaders.

- **UGANDA**

i) Namulonge Agricultural and Animal Production Research Institute (NAARI)

It is proposed that since facilities are already available, this becomes the major rearing centre.

- Importing of biocontrol agents;
- processing the imported biocontrol agents through quarantine;
- conducting specificity tests when necessary;
- distributing biocontrol materials to other field rearing units;
- releasing materials in consultation with other rearing units;
- monitoring establishment and evaluate impact of biocontrol agents in liaison with other units; and
- Convening National Coordinating Committee meetings of all stakeholders.

ii) Entebbe, Port Bell Rearing Units

- Receiving materials from Namulonge Coordinating Centre, and mass rear the same;
- releasing at all infested sites in the lake nearest them;
- evaluating the impact of biocontrol agents in the lake; and
- training of fisheries extension staff/scouts and selected persons at community level; and

- these will be under Namulonge supervision.

iii) Jinja (Fisheries Research Institute - FIRI) Rearing Unit

This will be set at Masese fish landing site to:

- mass rear biocontrol agents;
- liaise with fishermen on physical removal of water hyacinth from Own Dam;
- investigate the impact of the weed on the water environment; and
- monitor the effect of biocontrol and other control strategies on the lake ecosystem.

- TANZANIA

i) TAFIRI, Mwanza Rearing Units

- Importing of biocontrol agents;
- processing the imported materials through quarantine,
- conducting specificity tests where necessary;
- distributing biocontrol agents to field rearing units for further mass rearing;
- releasing biocontrol agents in consultation with other rearing units;
- monitoring establishment and evaluate impact of biocontrol agents in liaison with other rearing units; and
- convening Coordinating Committee meetings of all stakeholders.

ii) Musoma, Sota, Mori Bay, Mwanza Gulf, Basisi 'ferry', Bukoba Port Field Rearing Units

- receive materials from Kibaha Rearing Unit and mass rear the same for field release;
- releasing at all infested areas;

- evaluating the impact of biocontrol agents; and
- training fisheries extension and selected persons at community level; and
- conducting community awareness campaigns through distribution of rearing materials on water weeds.

Biocontrol Agents Release Protocol

- Biocontrol agents will be collected from the rearing pans in the different rearing units in Uganda, Kenya and Tanzania;
- barriers will be erected to demarcate water hyacinth plants in infested areas and to ensure that same plants can be visited for a recheck of the status of establishment;
- releases of batches of biocontrol agents will be made into the above mats that are stable, sedentary and not likely to be blown away by changes in wind direction; and
- infested plants (containing adults, pupae larvae and eggs) will be placed into the mats of water hyacinth.

6.5.1.5 **Immediate Activities**

- Further training in parent-stock maintenance and mass rearing of the biological control agents;
- procurement of more inputs for the field rearing units and coordinating centres;
- train and deploy the required personnel (laboratory technicians, field assistants and other support staff);
- locate, construct and equip lakeside field rearing units for mass rearing of biological control agents (rearing tanks, basins, buckets, outboard engines, canoes, etc) and material (fertilizer, initial supply of biological control agents, etc);
- mass rear biological control agents; determine field release strategy with respect to the movement of water hyacinth in the Lake; select and "seed" locate experimental weevil release centers to test reproductive viability in the field; undertake extensive field release of the biological control agents;
- sensitize local communities and involve them in the distribution of biological agents;

- identify and train required manpower in monitoring and evaluation techniques;
- establish a strategy to monitor and evaluate the development of weevil populations in the field and their impact on the distribution and magnitude of the weed.

6.6.1.6 Expected outputs

- Improved parent-stock maintenance standards and adequate mass rearing capacity for the biological control agents *Neochetina bruchi* and *Neochetina eichhorniae* to supply all the fields Rearing Units around the shores of Lake Victoria over a limited period of time.
- sufficient mass rearing capacity at the lakeside for the biological control agents in time for a coordinated field release program.
- formulated field release strategy involving local community participation.
- data and information compiled on the performance of biological control agents in the field and on their impact in the distribution and magnitude of water hyacinth.
- improved skills in parent-stock maintenance and mass rearing other biocontrol agents;
- improved rearing standards and capacity building at the major coordinating Units;
- improvement in quality and quantity of the biological control agents from Units
- field mass rearing units fully equipped with the necessary facilities;
- release of biological control weevils throughout areas of weed infestation;
- community participation in weed management;
- trained personnel in monitoring and evaluation;
- a monitoring and evaluation protocol for water hyacinth;

- data on the development of biological control agents on water hyacinth;
- data on the impact of Neochetina weevils on the distribution of water hyacinth in Lake Victoria.

6.5.2 Mechanical/Manual Removal

6.5.2.1 Community Mobilization

In certain cases eg. canals, and irrigation installations, manual water hyacinth removal will be organized through community mobilization groups. The following scenario is proposed.

(i) Under directions of the National Steering Committee The Ministries of Culture and Social Services in each country will be called upon to undertake to get groups together. The District/Social Development Officers (or their equivalent) will be involved; and together with ground workers, Farmer Cooperatives, Fishermens' groups, community awareness of the weed will be created.

(ii) It is proposed that the Fisheries officers convene meetings, in liaison with the Ministry of Culture and Social Services personnel in each country to chart out action plans for the control of water hyacinth from those areas where immediate control would be desired, for example in canals, irrigation sites, and pumping stations. It is proposed that this activity takes place at the field rearing units. The same meetings would discuss measures to be taken to avoid further spread of the weed. Through these organized community mobilization groups, the adverse effects of the weed would be highlighted. Legislation governing the movement of the weeds would also be made known to the communities around the water bodies.

- In Uganda, where the weed has reached serious proportions, it is proposed to use mechanical means through utilization of "harvesters". This should urgently be employed in Port Bell, Owen Dam and Gabba areas; in effort to decrease the large weed mats before other measures are taken.

- In Tanzania manual removal is recommended in Bukoba, Buwmanns Gulf, and Mwanza Gulf.

- In Kenya, manual remvoal is proposed in areas where it may cause concern.

6.5.2.2 Perceived Activities

- Develop a mechanical control strategy for water hyacinth;
- Procure approved mechanical control machinery and support systems (harvester, engines, trucks, boats, cars, shore facilities, etc);
- Train personnel to operate and maintain the mechanical control devices.
- Deploy mechanical control devices to critical sites.
- Mobilize the local fishing communities to backstop control efforts.

6.5.2.3. Expected Outputs

- Water hyacinth burden relieved from selected critical economic targets such as the Wagon Ferry Terminal at Port Bell, the Owen Falls Hydro-electric generation plant at Jinja, Kagera River mouth and major water transport routes/fish landing sites using mechanical devices.
- Mechanical control strategy in place;
- Trained personnel to operate and maintain the mechanical control machinery;
- Suitable equipment and machines for mechanical control identified
- Effective control of water hyacinth at critical economic targets.
- Small and medium sized landing points on Lake Victoria freed from closure due to invasion with water hyacinth mats.
- Community participation in water hyacinth management;
- Road transport (lorries and pick-ups) purchases;
- Strong canoes hand tools and protective gears to assist in physical removal of water hyacinth;
- Accessible landing sites.

6.5.2.4 Budget

Provision is made under the budget under items Hired labour and field equipment.

6.5.3 Chemical Control

The final decision on the use of herbicides in the lake will be made by each country's National Steering Committee, in consultantion with the Regional Policy and Steering Committee.

A strategy which relies on herbicidal control of plants will require a high and continuing commitment of funds and other resources. On infrequent occasions when dealing with small easily accessible infestations, herbicides will be used. Careful consideration must however be given on the consequences of any contamination of the water as a result of applying herbicides. It is proposed that evaluation of herbicides be carried out in isolated pockets dams and bays to ascertain the effects on the water environment, and possible use in selected sites.

The will be need to establish if , in addition to biological and manual water hyacinth control, the use of herbicides can modify characteristics of the weeds, thereby rendering them more prone to attack by insect control agents to be employed. The long term objective should however be effective biological control of all infestations without use of herbicides or other control methods.

6.5.3.1 Perceived Activities

- Train personnel to undertake study of application of chemical to control water hyacinth; and train operators in the safe handling and application of chemicals,
- Identify and evaluate suitable chemicals for application; evaluate tests based on candidate chemicals; select criteria for applying the herbicides; and estimate costs.
- Assessment of laws concerning herbicide use, registration and regulation in each country.
- Carry our tests of herbicide efficacy; and apply herbicides on selected and isolated weed locations after a positive environmental impact assessment.
- Undertake field appraisals of environmental impacts, cost efficiency, and water use priorities in relation to herbicide use;
- Undertake public awareness education and awareness programmes (newspapers, radio, television, etc) on the use of the chemical control option.
- Elaborate the laws concerning herbicide use in water hyacinth control and guidelines for the local communities.

6.5.3.2 Expected Outputs

- Researched strategy on chemical control of water hyacinth in Lake Victoria.
- Contacts established and discussion initiated with countries in the Lake Victoria basin on the need for selectic chemical control of water hyacinth and other potential herbicides.
- Trained personnel on chemical control in the aquatic environment.
- Regional consensus on the chemical option; agreement on the introduction of chemical control of water hyacinth in Lake Victoria;
- Public awareness and participation, education programmes (newspapers, radio, television), etc on the use of the chemical control option in Lake Victoria.

6.5.3.3 Budget:

Chemical control has been found to be a very expensive undertaking

in theose countries where it has been employed. During evaluation of herbicides, as suggested estimates of costs will be determined. For purposes of evaluation, of herbicides in isolated pockets, a provision is made in the budget tables under "Laboratory equipment".

6.5.4. Identification and reduction of sources of Nutrient Enrichment

As a long term control measure the following activities are proposed:

- Construction of semi-circular banks to reduce runoff from cultivated fields into the lake. Community runoff from cultivated fields into the lake. Community mobilisation is necessary for this activity.
- Enhancement of agroforestry activities and the lake to reduce soil erosion from surrounding fields.
- A major campaign to sensitise communities living around tributaries leading into the lake to reduce soil erosion would reduce siltation into the lake and hence reduce nutirient enrichment in the lake in the long-term.

6.6 Alternative Uses of Water Hyacinth

Manually removed water hyacinth will be subjected to a number of processes.

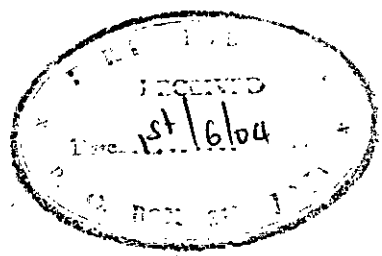
Simple alternative use options of water hyacinth will be investigated, and demonstrated to community groups for acceptance and/or verification.

6.6.1 Objectives

(a) To investigate the possibility of reducing the quantity of water hyacinth through mechanical/manual removal and putting the harvested weed in an income generating use e.g. briquettes for fuel

(b) To evaluate the end products for suitability and economic viability as:

- animal feed;
- Farmyard manure (silage)



6.6.2 Methodology/Activities

(i) Through available skills and with interested NGO's, hand operated machinery will be fabricated or adapted from other regions. A number of small machines could be tested.

(ii) Excess water will be removed with a screw press mincer of intermediate press or other devices that can squeeze out most of the water in the water hyacinth.

(iii) Solids produced from (ii) will be processed into dry pellet cakes or briquettes to some low water content. Simple equipment e.g. rollers or compressors could be used.

(iv) Through community mobilization groups, local residents will test the products to find the best use. An economic/financial viability appraisal will be done when product has been tested and acceptability ascertained.

6.6.3 Organization

The project will enter into contractual arrangements with an NGO and fabricators who could be utilized to operationalize the scheme at national level.

It is proposed that FIRI undertakes to spearhead this project in behalf of the

region.

6.6.4 Perceived Activities

- Feasibility studies of the potential for water hyacinth utilization especially for small scale production by riparian communities to offset massive quantities of fuelwood used for fish smoking;
- Construct demonstration local adaptable technologies and usage for riparian communities in selected landing sites.

6.6.5 Expected Outputs

- Recommendations on economic and acceptable utilization of water hyacinth biomass accumulated from mechanical and manual control activities;
- Data base packages on socio-economic feasibility an acceptability of opportunistic water hyacinth utilization; and
- Design and investment on locally appropriate systems focusing on water hyacinth utilization.

6.7 Capacity Building and Public Awareness

To ensure sustainability of control strategies, it is critical that the communities around the lake perceive this as their project and responsibility. The project will need to carry the communities with it right from the start. It is proposed that the following be implemented during the term of the programme.

6.7.1 Training

Training needs will be assessed and then training will be given at appropriate levels to develop the skills of national staff. To meet the goals of the project and to implement strategies recommended, training is recommended at the following levels.

(i) In-country MSc and Ph.D level research on water hyacinth and other

waterweeds can be undertaken by officers working on the project, or others sponsored by different organizations. Two officers to be sponsored from each country.

(ii) Short-term orientation specialist courses, seminars and workshops should be held at national and regional levels. The project will make a provision for these short term courses to be conducted for local communities, researchers and specialized groups.

Groups requiring these courses are: Lake Victoria riparian farmers, fishermen, researchers and extension staff. It will be desirable for administrative cadres to be put through courses to ensure they can identify noxious water weeds, biocontrol agents and other insect pests that may be confused with biocontrol agents. This is required in view of a requirement that enforcement of legislation to avoid unnecessary movement of water noxious weeds to other regions would be necessary.

6.7.2 Public Awareness

Recent surveys indicated that there was lack of awareness at high political and bureaucratic levels of the potential dangers and the speed of spread of these weeds. This is a factor that may effect the control of water weeds in general in the region. This lack of awareness would also lead to the assumption that there should be no budget for continued surveillance of the problem, and no monitoring activities would be in place.

The project should therefore make provision for public awareness campaigns to be made at high bureaucratic and local village levels through bulletins and newsletters on water hyacinth and other noxious weeds. Public meetings should also

highlight the problems caused by these weeds, their identification and methods of control.

6.7.3 Community Mobilization

(i) Local administrative machinery and the Ministries in charge of Culture and Social Services and Fisheries will be used to mobilize the population to workshops, meetings and barazas in which water hyacinth and other water weeds would be discussed.

(ii) Field extension staff and fisheries staff to appraise local fishermen regarding the seriousness of the weeds, and control measures in which the participation is crucial for success of the efforts.

(iii) Development and enforcement of regulations by Fisheries officers to prevent the introduction and spread of floating water weeds.

6.7.4 Perceived Activities

- Conduct community sensitization and mobilization;
- Procurement of transport for distribution of physical removal inputs;
- Assist in handling natural enemies in the field rearing units;
- Procurement and distribution of suitable hand tools, and protective gears; and
- Demonstration of physical removal techniques.

6.7.5 Expected Outputs

- Well informed communities around the lake;
- Organized groups undertaking to cooperate in the removal of water hyacinth from the lake;
- Communities undertaking to work on other control measures e.g. rearing units.

7.0 MONITORING PROGRAMME

7.1 Introduction

The distribution of water hyacinth in Lake Victoria needs to be known and monitored to facilitate its control. A monitoring programme needs to be implemented to go along with the control programme. These activities will be implmented by the Coordination Unit in each country under the direction of the National Steering Committee.

7.2 Justification

Factors controlling observed movement/patterns of weed mats, and the quantities of weeds involved need to be investigated. The impact of the weed on the biology and ecology of fisheries/resources and the water environment in general, on the quality and availability of water for domestic use, and its impact on other users of water (e.g. fish industries, hydroelectric) will need to be investigated and monitored.

7.3 Objectives

7.3.1 General Objective

To evolve a method for monitoring the distribution of water hyacinth, its effects on the water environment and its impact on users of the Lake Victoria water.

7.3.2 Specific Objectives

(i) To monitor the distribution and abundance of water hyacinth in Lake Victoria.

(ii) To investigate and verify factors that control the movement of water hyacinth across the lake.

(iii) To monitor the effects of control strategies employed on the lake.

7.4 Methodologies

7.4.1 Monitoring Distribution and Movement

7.4.1.1 Ground Surveys

Motorized boats moving along and close to shore would be used to identify areas on maps which are impacted and to what extent the water hyacinth covers the shoreline (visual estimation). It may not be possible to monitor mobile hyacinth or mats which occur in the open waters. Moreover, the accuracy of the method may be limited by weather conditions i.e. mats being dislodged the wind or flush floods and being missed out on routine monitoring. Ground surveys are however the most reliable by other methods and, they are the technique on which ground truthing and quantification are based.

7.4.1.2 Aerial Surveys

Conducted from the air, aerial surveys are used in combination with photography. This method would be quick and would give an overall impression of the pattern of distribution especially with regard to mats entangled with other vegetation. Aerial surveys are also subjected to error terms due to overlapping flight paths. Moreover, some vegetation types such as *Pistia* may also appear and be regarded as water hyacinth in the aerial photographs.

7.4.1.3 Satellite imagery

The use of satellite data to specifically discriminate water hyacinth from other shoreline vegetation is an aspect which is probably still only in experimental stages. Landsat and Spot images have been tried and it seems there is scope to finally be able to estimate water hyacinth cover using additional GIS software. FIRI in conjunction with The Regional Centre for Services in Surveying, Mapping and Remote Sensing and The International Institute of Biological Control in Nairobi have investigated the possibilities of using remote sensing in locating and quantifying water hyacinth infestations in Lake Kyoga. This needs to be enhanced.

The following Scheme of Activities is proposed to monitor the distribution, and assess the quantities of water hyacinth:

(i) Aerial Reconnaissance Surveys and interpretation of aerial photographs: It is essential that the entire shoreline of the lake is surveyed within a relatively short time. It will be necessary to award a contract for this activity because it will require special skills in aerial surveying, photography and map reading of aerial photos.

(ii) Following aerial surveys, photographs will be interpreted and distribution will be mapped according to the impressions obtained.

After the mapping process, ground truthing of some of the definitive sites will be done to cross-check the information obtained from aerial photography. It is important to undertake this activity as soon as the mapping exercise is completed.

(iii) Ground truthing will be based on well known sites which can be correlated with stable features on normal topographic maps. Ground truthing will also be planned to take into account the various forms of water hyacinth infestation.

(iv) A separate activity will involve quantification of the biomass in representative spots. This is to be based on sampling techniques which also consider the diverse forms of weed and

distribution patterns.

(v) It is important that as soon as is feasible, satellite data will be made available as the most efficient method of monitoring the distribution of hyacinth. This will require capacity building for the relevant institutions in the field of satellite imagery.

There are thus two components to this activity: Evaluation and Uses of satellite data and related tools and training in the use of the techniques. Once established as a verifiable method, remote sensing for hyacinth and other invasive weeds will become part of the control and monitoring process.

(vi) Some information exists in archives relating to initial surveys of hyacinth. This information will be consolidated to provide some impression of the magnitude of the weed infestation at an earlier period with a view to projecting the burden in the future. As a follow up to this information, data bases will be created to periodically generate hyacinth maps.

7.4.2 Effects of Water hyacinth on the Water Environment

The effects of water hyacinth will be monitored with time through a number of ways, most of which will monitor the character and ecology of the water environment.

(i) Levels of oxygen in water with various densities of water-hyacinth

(ii) Phytoplankton life and their densities

(iii) Fish life and availability relative to the amounts of water hyacinth present

7.4.3 Monitoring the establishment biocontrol agents

Evaluation of biological control programmes requires the monitoring

of changes in population of an agent. A method of indirectly estimating weevil populations was developed by A.D. Wright and T.D. Centre in 1990. A direct relationship between the number of feeding scars per leaf and adult density was revealed through earlier works. The empirical formula $I=0.0366^{R775}$ where I=weevils per plant and S=feeding scars per lamina effectively predicted I. This technique is recommended for estimating adult weevil populations in regions where monitoring of biological control of water hyacinth is undertaken; and would be employed in monitoring the establishment of the national enemies. The same technique will be used to monitor impact of natural control on the weed.

7.4.4 Monitoring the impact of biological control agents

Various techniques for measuring the effects of biological control agents on water hyacinth, have been investigated by a number of researchers. Factual information will need to be gathered on:

- Whether or not an agent has been established after release in a particular area;
- its natural spread within that area;
- how long it took to develop a population which was clearly damaging the weed;
- the progressive reduction in weed infestation; and
- The eventual level of control.

Specific experiments will be mounted on each of the above parameters, to provide a measure of the success, the biological control process and the time frame within which results would be achieved in these biocontrol

attempts. Specifically a few methodologies will be employed to elucidate the impact of biocontrol agents:

(i) Measuring the reduction in average plant biomass per unit area (plant minus roots) This is done by randomly sampling and weighing plants into and without roots in a standard way. A method developed derives a relationship between a standing crop and leaf length. Another relationship uses life tables to assess the impact of weed on leaf longevity.

(ii) The population dynamics of the biocontrol agents and their associated damage will serve to monitor impact on the weed. Weed damage and weevil numbers have been known to fit into a mathematical relationship.

(iii) Monitoring changes in the area covered by the weed at selected areas at some intervals of time (photography). Photographing a particular area from a fixed ground-station from the air at predetermined intervals assists to gather information on spread and severity of damage and on levels of control.

(iv) Use of remote sensing technique will be exploited. The technique has been used elsewhere to monitor changes in infestation levels of water weeds on a large scale.

7.4.5 Perceived Activities

- Training both informal (seminars, tours) and formal in aerial, ground surveillance and remote sensing techniques, GIS methodologies, aquatic ecology, botany limnology of required equipment.
- Procurement of required equipment.
- Develop application of remote sensing methods to discriminate water hyacinth from adjacent aquatic vegetation and periodically determine changes in weed distribution and cover.
- Monitor the influx of water hyacinth from River Kagera, distribution, movement and biomass of water hyacinth, map weed distribution and document movements.
- Regular fishing surveys to determine the impact of the weed on fish biodiversity, feeding, breeding and shelter.
- Quantify water hyacinth impacts on composition, biomass and productivity of aquatic life.

- Field surveys at selected sites to determine socio-economic effects on local communities relative to water quality and availability, fishing activities, transportation, etc.

- Socio-economic surveys to assess community perception of weed impact and control measures undertaken.

- Conduct public education, mobilization and awareness campaigns.

- Conduct surveys and interviews on public health issues related to water hyacinth infestations.

7.4.6 Outputs

- Information/data on distribution, movement and impacts of water hyacinth in Lake Victoria.

- Maps, satellite images on weeds distribution and magnitude.

- Information on factors that influence distribution and growth of the weed.

- Trained manpower.

- Stimulation of community awareness in control efforts and in the importance they should attach on to the lake.

- Data on effectiveness of control strategies.

- Public education through the news media.

- Strengthened National Systems to undertake the programme in a sustainable manner.

- Data on environmental quality, biodiversity and fisheries of comparable hyacinth infested and weed free habitats.

- Data on recovery of various environmental features.

- Information on general health of lakeside communities and on incidence of water vector borne diseases.

8.0 POLICY AND INSTITUTIONAL ARRANGEMENTS

8.1 Policy

8.1.1 The Concept of Biological Control

The idea of deliberately introducing insects is often quite alien because teaching has emphasized the problems of pest species in these groups and neglected the fact that many insect species are beneficial. Most insects and many fungi interact to help maintain order and diversity. It is a significant challenge to explain the concept of biological control and that it is safe to introduce properly screened biocontrol agents to policy makers and administrators. The opportunity to undertake biological control of water hyacinth comes at a time when the weed is causing considerable concern in Africa. Biological control has been well researched by a number of government organizations to protect and preserve the water ways and wetlands.

The three governments should adopt a policy of biological control of water hyacinth for reduction of the problem and sustainable, economical control. Biological control may be integrated with other measures, if necessary to reduce aquatic weed infestations immediately.

8.1.2 Planning the Project and Provision of Resources

Having adopted biological control as the preferred long term control strategy, the next steps are to plan and provide resources, staff and management. A number of projects in the countries and elsewhere have not been well planned, are under-resourced and lack experienced leadership. Worldwide experience has demonstrated

that properly planned, well supported projects are more likely to succeed than those which are poorly planned and do not have adequate support. The challenge is to ensure that the programme is properly designed, adequately supported by national institutions, has well trained staff and is managed by scientists experienced in biological control and aquatic weeds.

Major features which touch on policy and institutional features that should be observed in this project are included here below:

(i) Design should be based on a survey of existing situation, identification of the weed species and determination of major constraints. This step has largely been passed, but a last check would be recommended before project implementation, since situations change rapidly.

(ii) identification of national institution(s) which will be involved and the resources and staff that they can contribute. Enough expertise exists within the NARS. The project should thus be implemented with little outside borrowing of expertise, if any; and all stakeholders should be involved in implementation;

- Documentation and cost of all other resources, staff and training required to effectively run the project for 5 years. Commitment is required, not only from funding sources, but also from the three governments to adequately support project implementation;

- There are abundant opportunities to implement projects on biological control especially in situations where weeds have increased at a phenomenal rate during the last 5 to 10 years. Training programmes on biological control of weeds are available. National scientists with extensive experience in biological control are available and should be utilized.

Policy instruments to support the major features of a properly designed, adequately funded project should be in place before project

implementation.

8.2 Organizational Structures for Project Implementation

National institutions that will be involved, and the resources that they can contribute need to be identified. Each country may have its own features to characterize its organizational situation.

8.2.1 KENYA

(i) Coordination Unit

Effective coordination is essential to the success of the project and the prime duty of this element would be to ensure smooth running of the project, collaboration within and between the several elements of the project. Effective coordination at national level is prerequisite to project success at regional level.

The National Biological Control Programme at NARC-Muguga is proposed to be a Coordination Unit in Kenya. A provision should therefore be made for the following:

- Effective liaison with coordinating units in Uganda and Tanzania;
- coordinating functions and meetings and follow-up actions;
- making meeting arrangements and specific proposals;
- training at all levels, as necessary of effective project implementation;

- receiving feedback and analysis of responses;
- production of newsletters and brochures for awareness creation and community mobilization; and
- circulation of information on training and other technical matters.

(ii) **National Steering Committee**

It is proposed that to oversee the implementation of the project, the coordinating unit would consult with all relevant institutions and constitute a Technical National Steering Committee, whose function would be:

- to review planned activities;
- monitor progress of all project activities; and
- discuss budgets for the various planned activities.

It is proposed that the following elements of Kenya's National Agricultural Research System (NARS) be represented in the committee

- Ministry of Natural Resources, through National Environmental Secretariat (NES) (Convener);
- Department of Fisheries;
- Kenya Agricultural Research Institute (KARI);
- Kenya Marine Fisheries Research Institute (KEMFRI);
- International Union for the Conservation Nature (IUCN);
- Kenya Standing Technical Committee on Imports and Exports (KSTCIE) Ministry of Agriculture, Livestock Development and Marketing; and

- Lake Basin Development Authority (LBDA)

The above committee may coopt other members on specific issues as may be required. Of particular interest would be IIBC and CSIRO. The team may also wish to coopt members of communities working around Lakes Victoria and Naivasha.

(iii) **Rearing Units**

It is expected that the field sites will be employed in mass rearing of biocontrol agents, and these will be part of the organizational structure for the project. These are:

NARC-Muguga Biocontrol Unit, Kibos Fibre Research Centre, Kisumu, Bukoma Beach and Karungu Bay Rearing Units

NARC-Muguga rearing unit will do the initial importation while the other units will be involved in further mass rearing and field releases.

8.2.2 UGANDA

8.2.2.1 Existing Institutions

Because of the diverse impacts of water hyacinth, different categories of institutions have been involved in efforts to control the weed. They include

Government ministries/departments, parastatals, donor agencies, private sector firms and Non-Governmental Organizations (NGOs).

Coordination of Water Hyacinth Control Activities:

In view of the diverse nature of the water hyacinth problem and the wide range of institutions involved, the need for a coordinating body and mechanism was realized. Two structures are in place to that effect.

(i) **The National Task Force for Water Hyacinth: Coordinating Unit**

The National Task Force for Water Hyacinth was set up under the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) to coordinate the efforts of controlling the weed. Under the chairmanship of the Director General of NARO, the task force is multi-sectoral, but drawing its membership from Government departments and parastatals.

The main outcome of the task force has been its recommendation upon which two species of weevils - *Neochetina bruchi* and *Neochetina eichhorniae* have been imported to control the weed, and even released in Lake Kyoga.

(ii) **Regional Task Force 1: Fisheries Management and Control of Water Hyacinth and Other Invasive Weeds:**

Under the Agreement on the Preparation of a Tripartite Environmental Management Programme for Lake Victoria, the above

task force was established on 5th August, 1994. This could be equivalent to the National Technical Steering Committee in Kenya and with similar functions.

The secretariat of this task force is located in MNR (convener) which has also provided a coordinator for the Environmental Management Programme for Lake Victoria work in Uganda.

8.2.2.2 Proposed Institutional Framework for Emergency Control

It is proposed that the most suitable organizational arrangements and operational mechanisms for the implementation of an emergency plan for the control of water hyacinth on Lake Victoria, including assignment of institutional responsibilities for implementation of the plan should be as follows:

(i) **Coordination Unit:**

Coordination of control is presently under the National Task Force for Water Hyacinth, situated in NARO of MAAIF. The Water hyacinth problem in Uganda was very serious and cuts across the interests and activities of different institutions operating in such wide ranging fields as fisheries, water supply, transport, electricity generation and the environment. This required coordination by a body completely dedicated to tracking the problem in an emergency fashion.

In view of the considerations above, it is proposed that a national Emergency Water Hyacinth Management and Control Committee be established to coordinate the implementation of the plan.

(ii) **The Emergency Water Hyacinth Management Control Steering Committee:**

The National Task Force for Water Hyacinth and Members of the Regional Task Force I in Uganda would merge into a single committee.

It is proposed that a strong emergency water hyacinth management control committee be established. This committee on emergency water hyacinth control, would oversee the main activities including surveillance of the infestation, public awareness, community involvement in control management, tests and demonstrations of control options, site identification, control applications, monitoring and evaluation, training, etc. The committee would oversee all activities under the Environmental Management Programme for Lake Victoria for a coordinated programme of action on Lake Victoria and the nation's other water bodies. The composition of the committee should include all stakeholders. This would be equivalent to the Programme Steering Committee in Kenya.

8.2.2.3 Institutional Responsibilities

In Uganda, where there is need for a strong Emergency Water Hyacinth Control Committee (Steering Committee) to coordinate control activities in the country, the role of each institution in the implementation of the emergency plan must be well defined.

(a) **Ministry of Agriculture, Animal Industry and Fisheries:**

(i) MAAIF-NARO will identify or recruit heads for biological, chemical and manual control for the Directorate.

(ii) MAAIF, through the Fisheries Department and NARO will be responsible for all aspects of biological and chemical control, including testing of biological agents, conducting demonstrations studies with the chemicals and applying them at identified sites.

(iii) The Ministry will be responsible for implementing manual removal, utilizing its field stations along the lake side and working jointly with the Resistance Councils (RCs) under MLG.

(iv) MAAIF will identify fish landing sites and bays for the various types of control action and will, in conjunction with relevant institutions, be responsible for administering control measures at all fish landings and bays.

(v) Using its unified extension system, MAAIF will also work jointly with MLG and MI to undertake the necessary public sensitization and mobilization for community participation.

(b) **Ministry of Natural Resources:**

(i) MNR and in particular the Directorate for Environment Protection (DEP) will take charge of assessing the environmental impact of the weed infestation. DEP will also advise on the environmental impact of application of the various types of control methods to be applied under the plan.

(ii) Under MNR is also the Water Development Department (WDD) which is the Government institution responsible for the development of water supply in the country. WDD will work in conjunction with MLG, MH and MAAIF to ensure that

waterways are kept open, particularly for rural communities who depend on direct intake of lake water for domestic consumption.

(iii) National Water and Sewerage Corporation (NW & SC), a parastatal under MNR responsible for urban water supply will be involved with implementation of control at the three water intake points, namely Entebbe, Kampala and Jinja.

(iv) In cases of large water hyacinth mat invasions, mechanical application will be deployed. In addition, NW & SC will advise on the construction of appropriate screening mechanisms against decomposing carbon materials from the weed that might go into the water system.

(v) The Uganda Electricity Board (UEB) is responsible for generation and distribution of electricity in the country. UEB will undertake surveillance of the weed in the vicinity of the existing and new sites for power generation and take part in maintenance control in these areas, applying a combination of manual and mechanical measures.

(vi) UEB will oversee the erection of any booms at the power station to stop any floating weeds that may have escaped the control activities higher on and the construction of suitable screens to shield the filters and coolers against decomposing particles from the water hyacinth.

(c) **Ministry of Works and Transport (MWT):**

(i) MWT will identify or recruit the head for mechanical control for the Directorate.

(ii) MWT will be responsible for the technical aspects of mechanical control. Although these machines are "harvesters" and would more appropriately of MAAIF, the level of technical capacity required, in terms of engineering skills and workshop facilities, are to be found more in MWT than in MAAIF. Secondly, MWT is responsible for providing support to the transport sector in the country. MWT would therefore, identify important waterways to be kept clear and work with the necessary parties to implement control action at these sites.

(iii) One aspect of the water hyacinth control problem is disposal. MWT has fleets of tippers for road maintenance which could be deployed in disposing of the weed material away from the lake side after removal.

(iv) The Uganda Railways Corporation (URC) ferry services are badly affected not only by the infestation at its peer at Port Bell but often by large mats of the weed all along its navigation routes to Kenya and Tanzania. Secondly, URC is a carrier which could prove important in the disposal of the bulky harvested weed material, utilizing the vast ferrying capacity of its railway wagons. Under the plan, URC will be responsible for the various aspects of mechanical control at the pier at Port Bell as well as the safe disposal of the weed material.

(v) Utilizing its movements across the lake, URC will also take part in monitoring the movement of large mats of the weed for any offshore control measures.

(d) Ministry of Health (MH):

In view of the health impact of the weed infestation, MH will take part in public awareness campaigns on the health risks associated with the weed. Furthermore, MH will work closely with the other institutions, advising on the safe application of the different weed control methods.

(e) Ministry of Finance and Economic Planning (MF & EP)

Ensure that budgets proposed to the Government are considered and approved funds released to the plan on time. MF & EP will also solicit funds from the donors and generally ensure that the plan receives adequate funding.

(f) Ministry of Local Government (MLG):

The primary role of MLG in the plan will be public awareness and mobilization. Utilizing its local authority system of RCs, MLG

will work together with the other institutions involved to sensitize the public about the problem and mobilize the people for their participation.

(g) **Ministry of Information (MI):**

As part of the public awareness exercise and in support of the community mobilization drive, MI will put the media at the disposal of the plan.

8.2.3 TANZANIA

It is proposed that the following institutional structure will implement the programme:

1. The Ministry of Tourism, Natural Resources and Environment (MTNRE) will be responsible for project implementation.
2. National Steering Committee.

The following public institutions will form a steering committee that will oversee the project implementation.

(i) Ministry of Local Government will in addition be responsible for public mobilization and training of local groups in water weeds control.

(ii) Ministry of Regional Administration will also assist in enforcement and public awareness through Regional Development Directors and Regional Commissioner.

(iii) Five divisions of the MTNRE (Fisheries, Forestry, Bee-keeping, wildlife, Tourism and Environment) - coordinating Ministry.

(iv) Regional Fisheries Officers and District Fisheries Officers.

(v) Tanzania Fisheries Research Institute (TAFIRI).

(vi) Ministry of Agriculture (Research).

8.3 Linkages and Collaboration

Apart from collaboration with institutions forming the proposed Steering Committees in each country, it is further proposed that close collaboration be maintained with:

- Other International Institutions eg. CSIRO of Australia who may give technical backstopping to the project;
- IIBC, Kenya Station and
- Kenya, Uganda and Tanzanian institutions which will implement the project.

8.4 Legislative Arrangements

Legislation exists in the three countries to recognize water hyacinth as a noxious plant, and the law prohibits its spread by individuals. However, it would seem that there is lack of awareness on the part of the population to recognize these facts. There is thus need for intensified educational campaign and law enforcement to ensure that the weed does not spread to other delicate installations.

It is proposed that under this project, the proposed Steering Committees will liaise with the relevant government machinery, through public mobilization and awareness units to sensitize the public on the need to

ensure non-spread of these weeds. Plant Protection Acts in the three countries need to be studied and factors that have hindered enforcement of legislation pertaining to these noxious weeds be identified and corrective measures be taken.

The Inter-ministerial Committee on Environment (IMCE) and a technical Committee in wetland have had the mandate to coordinate wetland issues. These committees could use the current project to raise policy issues and other matters that require legislation.

8.5 Perceived Activities

- Institutionalize and unify water hyacinth control and management under a multi-sectoral agency with various levels of coordination include specialist organs/committees.
- Design an integrated strategy for water hyacinth management comprising environmental monitoring, biological control, manual/mechanical removal and chemical application.
- Identify relevant institutes and related institutions to undertake various activities.
- Pass such legislation and provide/seek budgetary support as required to support the Action Plan for the control and management of water hyacinth and other potential aquatic weeds.
- Establish contact and initiate discussion with countries in the Lake Victoria basin and multinational agencies on regional coordination and funding of the Joint Action Plan for the control and management of water hyacinth.

8.6 Expected Outputs

- Institutional Framework set for facilitating the control of water hyacinth.

- Integrated control strategy for water hyacinth adopted at decision making levels.
- Commitment by governments to make provision to sustain programme activities.
- All countries under the Kagera River basin join in the water hyacinth control activities.

9.0 SOCIO-ECONOMIC CONSEQUENCES

The impact of water hyacinth infestation on fisheries sub-sector, water supply, transport, environment and health and power generator was covered in section 4.0 of this document. Conversely, strategies employed for the control of the weed will have socio-economic consequences, which need to be born in mind.

Related to water hyacinth are environmental and economic costs, many of which would be difficult to estimate.

(i) Herbicides have been successful in controlling small infestations accessible by land or boat. Control using herbicides requires a high input of manpower and mechanical equipment and is expensive. The long term commitment required for control is often difficult to maintain and is an ongoing cost. Institutions involved (KARI, NARO, TAFIRI, NES, Fisheries Department, etc.) will have to bear this in mind. There is an environmental cost in using herbicides. Residues of herbicides in the water and sediments may affect the aquatic environment and kill fish directly or by reduced levels of oxygen caused by decaying weed. Water may be unsuitable for irrigation/human consumptions.

(ii) Physical removal and drainage is "environmentally safe", and useful in reducing small infestations and for maintaining canals. Commitment of resources is never ending. Permanent drainage may deprive water to livestock and inconvenience villagers.

(iii) Biological Control

This could be the most cost effective means of control, where successful establishment occurs. However, patience must prevail, as it is likely that it will take quite sometime for effective control to be realized. The initial investment is likely to be substantial. Thus, biocontrol will be a long-term, adequately funded project.

10.0 EXPECTED OUTPUTS OF EVENTUAL CONTROL

(i) Water hyacinth is an exotic invader, which has increased to pest proportions and causes detrimental changes to the character and ecology of the ecosystem. Successful control will reduce the pest population to proportions that will not be able to have detrimental effects to the ecology of the ecosystem.

(ii) Changes caused by water hyacinth affect the hydrological regime and biodiversity, jeopardize utilization by man of natural resources (eg fisheries). Control of these weeds will reverse the condition and increase productivity of the water bodies (biodiversity) and fish catches.

(iii) Floating mats of water hyacinth disrupt or stop activities fundamental to village society such as transportation and communication. It is hoped that where this disruption has occurred, transport and communication will be facilitated.

(iv) Biological control will not introduce pesticide into the environment. The prime benefit will thus be reduction in the surface area of water covered by the target weed; and the reversal of the undesirable effects.

(vi) A most cost-effective method of control, that is self sustaining will be in place. This will keep pest populations suppressed to levels that can be tolerated, hence avoid the use of other labour, and cost intensive methods of control.

11.0 ISSUES AND RECOMMENDATIONS

11.1 The Scourge

Floating aquatic weeds have become a scourge in many tropical and subtropical regions of the world, outside their native range. Research has shown that these weeds are amenable to classical biological control. Safe effective, and host-specific control agents for major aquatic weeds are known.

It is recommended that where water hyacinth has invaded, water hyacinth weevils and water hyacinth moth should be introduced as soon as possible.

11.2 Challenge

The challenge for the future is not only to ensure that biological control of weeds is viewed favourably, but that it is considered the preferred technique because of its safety, excellent benefit to cost ratio and positive environmental impacts. The challenge of obtaining adequate resources and training to undertake the work is also real. There is need for: **Convincing the three governments and regulatory bodies that biological control is effective, beneficial and safe.**

11.3 Biological Control Concept

The concept of biological control may be misunderstood. It is a significant challenge to explain the concept to policy makers and administrations. It is recommended that **Governments should adopt a policy of biological control of aquatic weeds for reduction of the problem and sustainable economical control. Biological control may be integrated with other control measures where it is very**

necessary to reduce weeds immediately.

11.4 Funding

Short-term and under funded projects will fail. It is recommended that commitment of funds for a minimum period of 5 years is critical. Worldwide experience has demonstrated that properly planned, well supported projects are more likely to succeed than poorly planned under-resourced, short - term projects. The three Governments will need to commit resources from their own Treasuries to sustain project implementation activities, and complement donor efforts.

Opportunities to implement effective, properly supported biological control of water weeds have remained largely neglected; largely due to unavailability of funds necessary to start an effective project. It is now critical to ensure that the current project is adequately resourced and that it is funded for adequate period of time (5 or more years) to ensure enough time for - natural enemies evaluation, importation, rearing, mass release, and monitoring of pest and natural enemies population dynamics.

Permanent rearing units, preferably at the sites of infestation will offer the best opportunity for natural enemies mass rearing and release.

11.5 Leadership

Lack of experienced leadership in some projects in Africa has led to project failure. It is recommended that identification of a scientist experienced in biological

control of aquatic weeds who is available for the position of the project manager is critical. The position would need to be advertized and filled after interviews.

11.6 Institutional Collaboration

(i) The challenge is to ensure that a project is properly designed, adequately supported by funding bodies and national institutions. National Institutions which will be involved and the resources and staff that they can contribute should be identified. Staff with experience and skill and resources for rearing, distribution and monitoring are required for all projects in biological control. Although each country may have adequate resources for rearing and releasing biocontrol agents in large numbers, reduction in infestation of water hyacinth is unlikely to occur under three years and more likely five years. This long-term commitment is necessary.

(ii) The Association for strengthening Agricultural Research in Eastern and Central Africa (ASARECA) aims to set up National Information Focal Points in each of the member countries (Kenya, Uganda, Tanzania, Burundi, Rwanda, Zaire, Sudan, Ethiopia, Eritrea and Madagascar). Each National Information Focal point will make available all agricultural research and other information and this will be shared among all countries. Under this arrangement, information pertaining to water hyacinth and control attempts will be shared amongst these countries that share the problem. It is therefore proposed that ASARECA can be involved through:

- Production of specific Newsletters in Water hyacinth that can be exchanged;
- a task force to ensure coordination of the efforts at regional level may need to be formed; and
- regional workshops that will facilitate information exchange relating to the weed control.

(iii) Although local expertise exists for project implementation, there is everything to be gained through collaboration. The professional staff of IIBC and CSIRO could be requested to work closely with national scientists and environmental conservation programmes to provide technical assistance service in the project implementation.

11.7 Cooperation with the Kagera Basin Organization and Tecconile

The suppression of water hyacinth in Lake Victoria will be constrained by the

influx of water weed mats and single plants from River Kagera. The need to control water hyacinth at source becomes a critical issue. River Kagera is reportedly infested with water hyacinth along the entire river course. The countries that prescribe to the Kagera Basin Organization therefore need to be brought into the LVEMP, especially in the water hyacinth management and control component.

Provisions of TECCONILE

Ministers responsible for water affairs in the Nile Basin countries signed an agreement in December 1992 on the future cooperation on water resource matters. Signatories to this Agreement are Egypt, Rwanda, Sudan, Tanzania, Uganda and Zaire. Matters on this water resource would be pursued through "Technical Cooperation for the Promotion of the Development and Environmental Protection of the Nile Basin (TECCONILE)". Representatives from Burundi, Eritrea, Ethiopia and Kenya have attended as observers; and associate with the activities of TECCONILE.

Activities

The Nile Basin Action Plan, which was indorsed by all the countries include project on Environmental degradation causes, trends and impacts. Included under this general programme are specific projects one of which is the control of aquatic weeds.

Objectives

The relevant project, "Water and Land Environment Protection and Enhancement" has the following objectives which are relevant to LVEMP.

(i) Control of water weeds, especially water hyacinth and pollution in the equatorial lakes and the White Nile.

(ii) Training of national professionals and technicians in watershed management and integrated development planning.

Linkage

The TECCONILE provisions allow the activities under LVEMP to be undertaken under the larger TECCONILE umbrella. Thus, Rwanda, Burundi and Zaire will be taken on board the current LVEMP activities on the control of water hyacinth in river Kagera. The following activities are proposed to be undertaken by these countries, and especially by Rwanda under the spirit of ASARECA and TECCONILE.

(i) **Release of Weevils**

It is proposed that initially Namulonge Research Station Biocontrol rearing unit mass rear the two species of weevils for release in Rwanda and Burundi. Contacts will be made with ISAR (Rwanda) and ISABU (Burundi) for weevil release and endorsement of the activities.

(ii) Surveys for distribution and abundance of water hyacinth in the Kagera and its tributaries.

(iii) Information exchange relating to the management and control of water weevils in the water bodies of the Kagera Basin countries.

12.0 PERSONNEL REQUIREMENTS

Projected Manpower Requirements (Coreteams)

Discipline/Cadre	Total Requirements		
	Kenya	Uganda	Tanzania
Project Manager	1	1	1
Entomologists	3	3	3
Weed Scientists	1	1	1
Fisheries Specialists	2	2	2
Socio-Economists	1	1	1
Aquatic Ecologist	1	1	1
Technical Officers	3	5	3
Technical Assistants	6	10	6
Drivers	2	2	2
Typists	3	3	3
Subordinate Staff	9	12	9
	32	41	32

Scientists collaborating in the project to be drawn from:

- KARI, NARO, Ministry of Agriculture, Tanzania
- Ministries of Natural Resources - Kenya, Uganda, Tanzania
- Fisheries Departments (to assist in monitoring of natural enemy establishment and status of water hyacinth
- KEMFRI, TAFIRI and FIRI
  to assist in studies on the effect of water hyacinth on the water environment and on fish distribution and diversity.

13.0 FINANCIAL REQUIREMENTS

(a) Government Contribution

It is proposed that collaborating institutions (KARI, Fisheries Department, KEMFRI, Ministry of Natural Resources (Kenya) MAAIF, NARO, MI, MNR, DEP, MLG, MH, MWT (Uganda) TAFIRI, MoA (Tanzania) and other public Institution bear personnel costs of their staff identified for deployment to the project.

Each country's Coordinating Unit will support overheads with relation to the coordination unit that will be housed at national institutions with facilities for importation, quarantine and release of natural enemies. This will be Government contribution.

Financial requirements for capital and recurrent expenditures are shown in Table 1a and 1b (Kenya); 2a and 2b (Uganda) 3a and 3b (Tanzania) respectively to cover project period of 5 years.

Table 1a: Capital Equipments Budget Summary: US$ '000's (Kenya)

Title/Item	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
Rearing Rooms refurbishment	10.0			5.0	-	15.0
Vehicle((s) (3)	52.0			30.0		82.0
Computer, printer software	5.0					5.0
Photocopier	3.0					3.0
Camera + Zoomlens	1.0					1.0
Balances (2)	4.0					4.0
Drying oven	2.0					2.0
Binoculars (2 pairs)	0.5					0.5
Lifejackets (6)	0.6			0.6		1.2
Wetsuits (4)	1.0		1.0			2.0
(1) Boats x 3	6.0					6.0
Outboard (355HP) x 3	22.5					22.5
(2) Boat Accessories	0.5					0.5
Boat trailer	3.0					3.0
Binocular microscope	1.0					1.0
Freight costs	15.0					15.0
Total Investment costs	127.6	-	1.0	35.6	-	163.7

Table 1(b): Recurrent Costs Budget Summary: US$'000's (Kenya)

Item(s)	Yr1	Yr2	Yr3	Yr4	Yr5	Total
Laboratory[3] Equipment	60.0	20.0	20.0	20.0	20.0	140.0
Operating and Maintenance	50.5	50.0	50.0	50.0	50.0	255
Travelling and[4] Accommodation	62.0	68.0	74.0	82.0	86.0	372
Contractual Arrangements	40.0	42.0	44.0	46.0	48.0	220
Field Equipment[5]	40.0	20.0	20.0	20.0	20.0	120.0
Transport Operating[6]	10.0	10.5	10.6	10.7	10.8	52.6
Casual/Hired Labour	50.0	50.0	20.0	20.0	10.0	150.0
Community[7] Mobilization	80.0	50.0	50.0	50.0	50.0	280
Staff Meetings/Travel & Honoraria	10.0	10.0	10.0	10.0	10.0	50.0
Regional[8] Meetings	25.0	25.0	25.0	25.0	25.0	125.0
Training/ Workshops	60.0	60.0	60.0	60.0	60.0	300.0
Consultancies[9] TCO/Project Manager	36.0	36.0	36.0	36.0	36.0	180.0
Sub-Total	**578.0**	**491.5**	**419.6**	**429.7**	**425.8**	**2365.1**
Grand Total	**705.1**	**491.5**	**420.6**	**465.3**	**425.8**	**2508.3**

Table 2a: Capital Equipment: US$'000's (Uganda)

Title/Item	Yr1	Yr2	Yr3	Yr4	Yr5	Total
Rearing Room Refurbishment	10.0			5.0		15.0
Vehicles (3)	52.0			30.0		82.0
Computer, Printer	5.0					5.0
Photocopier	3.0					3.0
Camera + Lens	1.0					1.0
Balances (2)	4.0					4.0
Drying Oven	2.0					2.0
Binoculars (2)	0.5		1.0			0.5
Life Jackets (13)	1.5		1.5			3.0
Wet Suits (6)	0.6					0.6
Boats x 3	6.0					6.0
Outboard (35 HP) x 3	22.5					22.5
Boat Accessories	0.5					0.5
Boat Trailer	3.0					3.0
Binocular microscope	1.0					1.0
Freighting costs	15.0					15.0
Total Investment Costs	127.6		1.5	35.0		144.1

Table 2b: Recurrent Costs: US$'000' (Uganda)

Items	Yr1	Yr2	Yr3	Yr4	Yr5	Total
Laboratory Equipment	100.0	100.0	20.0	20.0	20.0	260.0
Operating and Maintenance	60.0	60.0	60.0	60.0	60.0	300.0
Travelling and Accommodation	82.0	90.0	99.0	108.0	109.0	488.0
Field Equipment	40.0	40.0	20.0	20.0	20.0	140.0
Transport Operating	12.0	13.0	15.0	12.0	10.0	62.0
Community Mobilization and Publication	90.0	50.0	50.0	50.0	50.0	290.0
Hired Labour	200.0	200.0	100.0	50.0	50.0	600.0
Staff Meeting/Travel and Honoraria	10.0	10.1	10.2	10.3	10.4	51.0
Contractual Arrangement	40.0	42.0	44.0	46.0	48.0	220.0
Training	60.0	60.0	60.0	60.0	60.0	300.0
Consultancies, TCO/Manager	36.0	36.0	36.0	36.0	36.0	180.0
Regional Meeting	25.0	25.0	25.0	25.0	25.0	125.0
Sub-Total	**755.0**	**726.1**	**539.2**	**497.3**	**498.4**	**3016.**
Grand-Total	**882.6**	**726.1**	**540.7**	**532.3**	**498.4**	**3180.1**

Total
260.0
300.0
488.0
140.0
62.0
290.0
600.0
51.0
220.0
300.0
180.0
125.0
3016.
3180.1

Table 3a: Capital Equipment Budget Summary: US$'000's (Tanzania)

Title/Item	Yr1	Yr2	Yr3	Yr4	Yr5	Total
Rearing Room Refurbishment	10.0			5.0		15.0
Vehicles (3)	52.0			30.0		82.0
Computer, Printer	5.0					5.0
Photocopier	3.0					3.0
Camera + Lens	1.0					1.0
Balances (2)	4.0					4.0
Drying Oven	2.0					2.0
Binoculars (2)	0.5					0.5
Life Jackets (8)	1.0		1.0			2.0
Wet Suits (6)	1.5					1.5
Boats x 3	6.0					6.0
Outboard (35 HP) x 3	22.5					22.5
Boat Accessories	3.2					3.2
Boat Trailer	3.0					3.0
Binocular microscope	1.0					1.0
Freighting costs	15.0					15.0
Total Investment Costs	**130.7**		**1.0**	**35.0**		**166.7**

Table 3b: Recurrent Costs: US$'000' (Tanzania)

Item(s)	Yr1	Yr2	Yr3	Yr4	Yr5	Total
Laboratory Equipment	60.0	20.0	20.0	20.0	20.0	140.0
Operating and Maintenance	55.0	50.0	50.0	50.0	50.0	255.0
Travelling and Accommodation	62.0	68.0	74.0	82.0	86.0	3720
Field Equipment	40.0	20.0	20.0	20.0	20.0	120.0
Contractual Arrangements	40.0	42.0	44.0	46.0	48.0	220.0
Transport Operating	10.0	10.5	10.6	10.7	10.8	52.6
Community Mobilization and Publications	80.0	50.0	50.0	50.0	50.0	280.0
Hired Labour	150.0	150.0	30.0	30.0	20.0	380.0
Staff Meeting/ Travel & Honoraria	10.0	10.0	10.0	1003	10.0	51.0
Training	60.0	60.0	60.0	60.0	60.0	30.0
Consultancies/TCO Manager	36.0	36.0	36.0	36.0	36.0	180.0
Regional Meeting	25.0	25.0	25.0	25.0	25.0	125.0
Sub-Total	**628.0**	**541.5**	**429.6**	**429.6**	**435.8**	**2495.1**
Grand Total	**758.7**	**541.5**	**430.6**	**474.7**	**435.8**	**2661.8**

Budget notes

(1) 5 metre, double-skin fibreglass dinghy

(2) ropes, auctions, toolkit, safety equipment, first aid etc

(3) rearing cages, plastic bowls/buckets, dissecting instruments etc, importation of natural enemies, chemicals, (herbicides).

(4) 4 days travelling per month - 4 persons (a) US$ 16.0

(5) Quadrants, booms, ropes, field basins/pans,

(6) for a 4WD vehicle + other maintenance costs boat fuel and maintenance

(7) Local meetings, posters, leaflets, protective clothing

(8) regional meetings

(9) Workshops to share experiences/results; training sessions for support staff.

(10) To discuss results of research activities.

Hired labour for physical/manual removal of the weed.

Contractual Arrangements

It is envisaged that arrangements will be made with local fabricators and NGOs and other private persons to work on suitable devices for conversion of harvested water hyacinth with some useful products. The leading institution for making the contractual arrangements would be FIRI. However, other national units would also be involved in testing these materials with community participation in their own regions.

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National Working Groups Papers from:

- Kenya
- Tanzania
- Uganda

Appendix 1: TERMS OF REFERENCE

Task 10: Controlling Water Hyacinth

(1) Preparing a detailed program for continuous monitoring of the distribution and effects of water hyacinths and the environmental impact of control measures being applied.

(2) Prepare a program for biological control and suggest implementation modalities, involving establishment of units for weevils; and in distribution of weevils to the local communities; and in participation with the community, a program for mechanical control of weeds including the testing of the economic and technical feasibility of the alternative uses of water hyacinth.

(3) Preparing a program to build capacity at community and Government levels for effective water hyacinth control involving awareness creating and participation of local communities;

(4) Determining through consultations with the Governments of Rwanda, Zaire and Burundi the scope for cooperation with the Kagera Basin Organization for water hyacinth control, and incorporating conclusions from such consultation in the design and implementation of proposals for a lake wide control program.