A Cost-Effectiveness Evaluation of Water Hyacinth Control Methods

The Case of Lakes Kyoga and Victoria Ecosystems in Uganda

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LIST OF ACRONYMS

APC	Agricultural Policy Committee
GDP	Gross Domestic Product
GTZ	German Technical Cooperation
FAO	Food and Agriculture Organisation of the United Nations
FGDs	Focus Group Discussions
MAAIF	Ministry of Agriculture, Animal Industry and Fisheries
MFEP	Ministry of Finance and Economic Planning
MNR	Ministry of Natural Resources
NAARI	Namulonge Agriculture and Animal Research Institute
NARO	National Agricultural Research Organisation
NTCWH	National Technical Committee on the Control of the Water Hyacinth
NWSC	National Water and Sewerage Cooperation
URC	Uganda Railways Cooperation
UEB	Uganda Electricity Board
WHO	World Health Organisation

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A COST-EFFECTIVENESS EVALUATION OF WATER HYACINTH CONTROL METHODS: THE CASE OF LAKES KYOGA AND VICTORIA ECOSYSTEMS IN UGANDA

Abstract: The water hyacinth was first reported on Lake Kyoga in 1988. Given its high proliferation rate it has spread to cover about 70,000 and 20,000 hectares on Lakes Victoria and Kyoga, respectively. It has inflicted enormous negative effects that include: increased evapotranspiration that has reduced the water table; physical obstruction of water transport means loss in quality of fish and other products leading to reduced incomes; increased operational costs attached to fishing activities resulting from loss of nets and boat engine breakdowns; reduced fish reproduction; and being a breeding ground for many disease-causing organisms. These effects have in turn affected the national economy; the environment and the health status of lakeshore residents and have resulted in its condemnation.

Four control methods, namely, biological, chemical, manual and mechanical have been tried in Uganda at different sites. Comprehensive economic data on costs and effectiveness of the four methods are lacking. Given the limited resources at our disposal it is unjustifiable to undertake control of the weed without evaluation of the most cost-effective strategy.

This study was undertaken: to conduct environmental economic analyses and make comparisons among the four control methods, to make simulations of potential combination of the four methods and undertake sensitivity analysis and to develop an analytical procedure that can guide policy makers on deciding the best control strategy.

Findings indicate that mechanical control method is the most cost-effective with a cost-effectiveness (C:E) ratio of 0.016. This is followed by the manual, biological and chemical control methods with cost-effectiveness ratios of 0.116, 0.208, and 0.299, respectively. These ratios suggest the amount of money (in US dollars) required to clear a square metre area per hour.

The mechanical method is, therefore, recommended for use in combination with manual method in a ratio as close to 4: 1 as possible. This is in the interest of effective control and creation of some employment opportunities. This scenario would require about US $32 millions to undertake full-blown achievement. This is equivalent to US $108,000 per month.

Finally, more pragmatic policy intervention and further research are necessary to evaluate use of the weed in animal feed formulations, biogas digesters, mulching and paper industries. More research in

chemical and biological control methods and increasing public awareness and cooperation between the East African countries are also necessary to deal with the problem satisfactorily.

1. INTRODUCTION

1.1 Background

Water hyacinth (*Eichhornia crassipes*), also known as the water weed, arguably the most noxious aquatic weed in the world, is native to South America where it occurs basically harmlessly in streams and seasonally flooded environments. The plant is, however, one of the most widely distributed aquatic weeds, having been translocated almost all over the tropical and sub-tropical world mainly by collectors of ornamental plants.

The weed was first reported in Uganda on Lake Kyoga in May 1988 and on Lake Victoria in December 1989, having entered the latter lake from Kagera River. It is estimated that Kagera River empties into Lake Victoria 1 to 3.5 ha of the weed weekly. This is equivalent to between 350 and 1,225 tonnes.

The weed spread rapidly over the years to fringe over 50% of the shores of Lake Kyoga, about 80% of the banks of Nile River and most of the northern tip of Lake Albert. According to estimates made in July 1995, Lake Victoria had about 2000 ha while Lake Kyoga had 600 ha of the weed. Rough estimates based on the fact that the weed population doubles twice a month showed that by the end of 1996, Lakes Victoria and Kyoga, whose surface areas are 28,655 km^2 and 2,047 km^2 according to the Ministry of Natural Resources (1994), were covered up to 70,000 and 20,000 hectares, respectively.

The water hyacinth is widely distributed in Uganda's aquatic environment. As far as lakes are concerned, Victoria, Kyoga and Albert are all infested. The rivers Victoria Nile and Albert Nile, along with numerous wetlands surrounding many smaller lakes and rivers, are also infested.

Uganda was not the first country to be infested with *E. crassipes*. In 1952, for example, it was introduced into Congo River at Kisanghani and has since then been a problem in development of water transport. It was introduced into Egypt in the early part of this century and it has since remained a problem in irrigation systems. It appeared in central Sudan's upper Nile swamps in 1958 and it remains a problem at the Jebel Aulia Dam.

In Nigeria and Benin, infestation dates back to 1985 and currently it is seriously affecting fish catches. Ghana's water bodies were infested in 1980 and Malawi's in 1968. Available information indicates that about 15 African countries have experienced this problem. Elsewhere in the world, water

bodies, such as those in Australia, Indonesia, India, Sri-Lanka and the USA, have been infested.

1.2 Statement of the Problem

The water hyacinth has inflicted enormous negative effects not only on the country's environment but also on the health status and well-being of many people who seek livelihood from the infested waters and the country's economy in general. Therefore, eradication of the weed is highly advocated the world over. However, its fast growth rate, the large water bodies in Uganda that facilitate its growth, and seeds that remain viable for over 30 years are manifestations of the difficulty associated with its complete eradication.

Experiences of other countries indicate that all the control methods tried are very costly and not as effective as they seem to be. For instance, in Sudan manual control takes 500 men to clear a hectare a day. Only 20 sq. metres can be cleared a day (equivalent to 350 kg on a wet basis) to maintain access to a fish landing site. Further, the costs of labour to attract workers are quite high.

The mechanical control methods are not perfect either. A hybaler machine used in Sudan, apart from its high procurement and maintenance costs, lasts from 3.5 to 4 years. A mechanical harvester recently procured by URC from Britain at US $250,000 never worked satisfactorily. On top of this, the chopped weed has to be removed from the water immediately; otherwise, it rots and removes the oxygen or grows into new plants very quickly by vegetative means. This necessitates employing manual labour to supplement the mechanical methods, with further financial implications. Therefore, manual or mechanical control alone is not adequate. From Nigeria's experience in the 1980s, an annual total of US $750,000 was required for mechanical control.

The chemical control method using either glyphosate, diquat or 2,4-D herbicide is being contemplated in Uganda and has been used in Zimbabwe. The grave limitation of this method remains its negative impact on the environment.

As for biological control, the weed has no effective predators in Uganda or Africa because it is not indigenous to Africa and as such has no natural biological enemies. The weevils *Neochetina bruchi* and *Neochetina eichhornia* have been identified as absolutely specific to the hyacinth and they have been tried in Sudan and on Lake Kyoga. Research on these weevils is being carried out at Namulonge Agriculture and Animal Research Institute (NARA) of Uganda's National Agricultural Research Organization (NARO).

There is lack of satisfactory empirical research results to guide policy makers on an economical control method. It is, therefore, imperative that

the costs and defectiveness of individual control methods be analysed to identify the least costly and most effective method before full-blown investment in what could turn out to be an inefficient and /or environmentally catastrophic control measure.

1.3 Purpose of the Study

This study aims at comparing and evaluating the water hyacinth control methods in terms of costs, effectiveness and environmental sustainability at sites where the methods have been tried. Further, sensitivity analysis of potential combinations of these methods will be theoretically simulated and evaluated. Results of both approaches are expected to yield an economical and environmentally sustainable scenario worth adopting.

1.4 Objectives

1. To conduct environmental and economic analyses and make comparisons among the weed control methods at sites where each method has been tried.
2. To make theoretical simulations of the potential combinations of four control methods, namely, mechanical, chemical, manual, and biological and evaluate their costs and effectiveness.
3. To develop analytical procedures that will guide policy makers and technocrats on the best control strategies to adopt.

1.5 Significance of the Problem

If the weed is not checked, it will choke out all water life, bring to a halt any economic activity on Uganda's water bodies and drastically affect the environment and its contribution to development. It is because of this that the weed is condemned the world over, and should be eradicated at any cost.

Considering Uganda's many economic constraints that include, *inter-alia*, balance of payment and deficit problems, funds must be spent rationally. Policy makers need to be advised to adopt the most cost-effective strategies to attain the desired results.

The theoretical simulations of the potential combinations of the control methods are expected to give an insight into the possible policy strategies to be considered in weed control. If the weed is brought under control, the water resources will resume their significant contribution to the economy, and people's health status and livelihoods will improve. The research findings will also contribute to existing knowledge and stimulate further research on the weed and use of the analytical technique used herein.

1.6 Hypotheses

1. The mechanical control method is the most costly of the four contemplated methods, viz., biological, chemical or manual method.

2. The chemical controls method, though the most effective of the contemplated control methods, is not environmentally friendly.

2. REVIEW OF LITERATURE

2.1 The Weed: What It Is, Its Effects and Implications

The water hyacinth is a member of the plant family *Pontederiaceae*. Although several species of the genus *Eichhornia* exist, only *E. crassippes* has become a problem. It is believed to have been introduced into Uganda's aquatic environment at Lake Mubanzi, in Rakai District where the Kagera River joins Lake Victoria, intentionally because of its beautiful purple flowers. This may be the reason why it was named the "noxious beauty".

There are basically three ways in which the weed may be dispersed from one location to another: (i) water-borne dispersal which demands connection between water bodies; (ii) diving eater-birds could swallow the weed's seeds as they sift mud for food, and then pass them through the gut, but no concrete evidence for bird-mediated dispersal exists; (iii) people - the reason being its exceedingly attractive purple flower with great demand for aquarium and ornamental ponds. This is how it was introduced into the Congo River, Egypt and Uganda.

Many researchers have contemplated positive utilization of the weed. Whereas it has great potential in theory, in practice, it is poor in terms of nutrient make up. It is 95% water, and after burning off the carbon, you end up with 50% silica and 30% potassium and less than 0.5% of the plant is nitrogen. This makes it unpalatable to livestock. Its fibre length is very short and so cannot make good quality paper and its C: N ratio is too high to make good fertilizer since the decomposing bacteria would use all the available nitrogen without leaving any for the crops. It is usable in water treatment, but the papyrus is environmentally compatible and has better potential according to research

2.1.1 Ecological Niche

The weed grows readily on any open or sheltered water surface due to its high buoyancy. This has far-reaching implications for Uganda. Uganda's wetlands cover an estimated area of 29, 580 km^2, about 18% of the country's surface area (Ministry of Natural Resources 1994). This indicates the weed's high potential.

2.1.2 Growth Rate

Water hyacinth proliferation shows variable rates. It is extremely rapid in nutrient enriched environments such as Murchison Bay and in the deltas of major rivers such as the Kagera and Katonga. However, the proliferation appears to be poor in bays such as Buka and McDonald, which have no major inflow.