American Journal of Renewable and Sustainable Energy
Vol. 1, No. 3, 2015, pp. 128-132
http://www.aiscience.org/journal/ajrse

The Contribution of the Multiple Usage of Water Hyacinth on the Economic Development of Reparian Communities in Dunga and Kichinjio of Kisumu Central Sub County, Kenya

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Abstract

A native of South American ornamental plants, water hyacinth has clogged water ways in many parts of the world, causing immense losses to fishermen, water way users like lake transport and sports, and ecotourism activities. Control measures that have been put in place like chemical control, biological control, and mechanical control have not been fruitful, and some have proved lethal to water life. Harvesting of water hyacinth for the purpose of usage in producing goods for domestic use, farming, and agriculture has gained mileage due to economic development that communities derive from harvesting the weed. This study sought to establish the contribution of multiple usage of water hyacinth on the economic development of riparian communities in Kisumu County. Specific objectives were to assess the impact of organic manure from water hyacinth on economic development; the impact of bio-fuel from water hyacinth on economic development; the impact of art work from water hyacinth on economic development, and the effect of animal feeds from water hyacinth on economic development of the riparian communities in Kisumu County. Descriptive research design was adopted on a population of 600 beach unit management members with a sample size of 120 respondents selected using simple random sampling. Questionnaires and interview schedules were used for data collection and analysed through descriptive statistics using percentages and frequency counts. The study found that the community members use water hyacinth for making green manure, art work, and animal feeds. Biogas and related products are seldom produced from water hyacinth. The researchers concluded that biogas production required advanced technology, which the community members lack, and recommended training on relatively cheaper technology in the production of biogas.

Keywords

Water Hyacinth, Water Ways, Bio-Fuel, Animal Feeds

Received: July 7, 2015 / Accepted: July 25, 2015 / Published online: August 4, 2015

1. Introduction

Water Hyacinth (*Eichhornia crassipes* Martius) is a monocotyledonous freshwater aquatic plant, belonging to the family *Pontederiaceae*, related to the lily family (*Liliaceae*) and is a native of Brazil and Equador region. It is also a well known ornamental plants found in water gardens and aquariums, bears beautiful blue to lilac colored flowers along with their round to oblong curved leaves and waxy coated petioles. It grows from a few inches to about a meter in height. The stem and leaves contain air filled sacs, which help them to stay afloat in water (Bhattacharya and Kumar (2010).

The beautiful, large purple and violet flowers of the South American water hyacinth (Eichhornia crassipes) make it a very popular ornamental plant for ponds. However water

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hyacinth has also been labelled as the world's worst water weed and has garnered increasing international attention as an invasive species (Zhang *et al.* 2010).

Water hyacinth has been identified by the International Union for Conservation of Nature (IUCN) as one of the 100 most aggressive invasive species (Téllez *et al.* 2008) and recognized as one of the top 10 worst weeds in the world (Shanab *et al.* 2010, Gichuki *et al.* 2012, Patel 2012). It is characterised by rapid growth rates, extensive dispersal capabilities, large and rapid reproductive output and broad environmental tolerance (Zhang *et al.* 2010). In Africa, for example, where water hyacinth is listed by law as a noxious weed in several countries, it is the most widespread and damaging aquatic plant species. The economic impacts of the weed in seven African countries have been estimated at between US$20-50 million every year. Across Africa costs may be as much as US$100 million annually (UNEP 2008).

Africa has particularly been affected by the introduction and spread of water hyacinth, facilitated in part due to a lack of naturally occurring enemies. In a review of water hyacinth infestation in Eastern, Southern and Central Africa, Mujingni (2012) reports that the weed was first recorded in Zimbabwe in 1937. It colonized important water bodies, such as the Incomati River in Mozambique in 1946, the Zambezi River and some important rivers in Ethiopia in 1956. Rivers in Rwanda and Burundi were colonised in the late 1950s while the rivers Sigi and Pangani in Tanzania were infested in 1955 and 1959. The plant colonised Kafue river in Zambia in the 1960s, the Shire River in Malawi in 1968 and Lake Naivasha in Kenya in 1986 (Mironga *et al.* 2012). The plant was recorded from Lakes Kyoga in Uganda in 1988-89, Victoria in 1989–1990, Malawi/Nyasa in 1996 and Tanganyika in 1997. Lake Victoria in Africa is the second largest freshwater lake in the world and currently supports approximately 30 million people. Infestation of water hyacinth in the lake has been a serious nuisance, generating public outcry (World Agro Forestry Centre, 2006, Kateregga and Sterner 2007, Gichuki *et al.* 2012). At its peak, it was estimated that the weed was growing at 3 hectares (12 acres) per day on the lake (Ayodo and Jagero 2012). The plant has also spread fast throughout Uganda's lakes and rivers in just 10 years.

1.1. Statement of the Problem

Water hyacinth is challenging the ecological stability of freshwater water bodies by out-competing all other species growing in the vicinity, posing a threat to aquatic biodiversity. Besides suppressing the growth of native plants and negatively affecting microbes, water hyacinth prevents the growth and abundance of phytoplankton under large mats, ultimately affecting fisheries. The weed often clogs waterways due to its rapid reproduction and propagation rate, disrupting socioeconomic and subsistence activities like ship and boat navigation, restricting access to water for recreation, fisheries, and tourism when waterways are blocked or water pipes clogged. The floating mats may limit access to breeding, nursery and feeding grounds for some economically important fish species. In Lake Victoria, fish catch rates on the Kenyan section decreased by 45% because water hyacinth mats blocked access to fishing grounds, delayed access to markets and increased costs in terms of effort and materials of fishing. Floating mats of water hyacinth support organisms that are detrimental to human health. The ability of its mass of fibrous, free-floating roots and semi-submerged leaves and stems to decrease water currents increases breeding habitat for the malaria causing anopheles mosquito as evidenced in Lake Victoria basin.

Control of water hyacinth has been a big challenge to many states all over the world. The use of chemical agents to control the weed, like 4-D and other herbicides including glyphosate and diquat is common has been tried; however, the use of chemicals is largely discouraged as its long term effect of human health, and the ecosystem is unknown. In the future, plants may become more tolerant to such chemicals and slowly these chemicals may become ineffective, thus requiring higher dosage, which may increase costs associated with application. Further, the treated area may become uninhabitable for other plant species. Physical eradication is largely used, although this is not entirely effective, limited by a certain area which can be covered in a day, besides costs and human resources involved, which may become a bottleneck in various locations. However, when water hyacinth is used for bio-fuel and art work production, this is perhaps the best method to both control and harvests them. This study sought to establish the contribution of multiple usage of water hyacinth on the economic development of riparian communities in Kisumu County.

1.2. Purpose of the Study

The purpose of the study was to establish the contribution of multiple usage of water hyacinth on the economic development of riparian communities in Kisumu County. The specific objectives were to assess the impact of organic manure from water hyacinth on economic development; the impact of biofuel from water hyacinth on economic development; the impact of art work from water hyacinth on economic development, and the effect of animal feeds from water hyacinth on economic development of the riparian communities in Kisumu County.

2. Literature Review

Research into the utilization and related technologies for the

control of water hyacinth have been tested over the last few decades (Ndimele *et al.* 2011). It is being speculated that the biomass can be used in waste water treatment, heavy metal and dye remediation, as substrate for bioethanol and biogas production, electricity generation, industrial uses, medicines, animal feed, agriculture and sustainable development (Patel 2012). However, seldom does utilization provide a sustained solution to the spread and impact of water hyacinth, and in fact could provide a perverse incentive to maintain the invasive plant to the detriment of the environment and production systems at high economic and social costs. There is not one example from anywhere in the world where utilization alone has contributed to the management of any invasive plant (EEA 2012).

Water hyacinth fulfills all the criteria deemed necessary for bioenergy production – it is perennial, abundantly available, non-crop plant, biodegradable and has high cellulose content; however its strong disadvantage is that it has over 90% water content which complicates harvesting and processing. The biomass can be subjected to biogas production to generate energy for household uses in rural areas (Chuang *et al.* 2011). Experiments in China show that mixing biomass of water hyacinth with pig manure leads to a much higher biogas production than by using pig manure alone (Lu *et al.* 2010). It can also be used for producing ethanol, but technical and logistical challenges need to be overcome before the commercial scale ethanol production becomes a reality because of the high tissue water content (Ndimele *et al.* 2011).

As a readily available resource, water hyacinth has been used in several small cottage industries in the Philippines, Indonesia and India for paper, rope, basket, mats, shoes, sandals, bags, wallets, vases, etc (Ndimele *et al.* 2011, Patel 2012). Yet these are rarely successful to reduce infestations and the market for these products is far too small to have any impact on water hyacinth populations. In addition, income generation may facilitate its spread to new, uninvaded, water bodies

When sun-dried, water hyacinth has been found to be rich in protein, vitamins and minerals and serves as a high quality feedstock for some non-ruminant animals, poultry and fishery in Indonesia, China, the Philippines and Thailand (Lu *et al.* 2010, Saha and Ray 2011). But it is not recommended for use if primarily used for removal of heavy metals and toxic substances from wastewater (Chunkao *et al.* 2012). Decomposed water hyacinth can also be used as green manure or as compost that improves poor quality soils (Ndimele *et al.* 2011). However, its high alkalinity (pH>9) and potentially toxic heavy metals contents would restrict its use to flowering-plants, with no allowable application to horticulture for edible vegetables (Chunkao *et al.* 2012, Zhang 2012).

3. Study Methodology

3.1. Research Design

Descriptive survey research design was used for this study. The study population consisted of 600 Beach Management Unit members (BMU members) from Dunga and Kichinjio, one National Environmental Management Authority (NEMA) officer, and one officer from Lake Victoria Environmental Management Program (LAVEMP). Simple random sampling technique was used to select a study sample of 120 respondents. Saturated sampling technique was used to select one officer each from NEMA, LAVEMP, and Kisumu Innovations Centre of Kenya (KICK). In-depth interview schedule, questionnaires, and observation guide were used for data collection.

3.2. Data Collection and Analysis

The data collected from the close-ended items in the questionnaire were analyzed using descriptive statistics in form of percentages and frequency counts. Qualitative data were collected from open-ended items in the questionnaire and in-depth interviews were analyzed and organized into themes and sub-themes as they emerged. The return rate of the study questionnaire was 100%, and all the NEMA, LAVEMP, and KICK officials allowed the researcher ample time for interviews.

4. Results and Discussions

4.1. Research Objective 1

The study sought to: assess the impact of organic manure from water hyacinth on economic development.

The researchers asked the respondents to state the level of their usage of organic or manure made from water hyacinth in their farms and gardens. The responses obtained by the researchers were tabulated as shown in Table 1.

Table 1. The usage of green manure from water hyacinth for home gardening.

Uses of water hyacinth green manure	Highly used	Least used
Green manure for tree planting	38	12
Green manure for vegetable farming	27	10
Compost manure for soil conservation	13	20
TOTAL	78	42

The findings show that 78 out of 120 respondents have indicated that green manure obtained from water hyacinth is highly used (65%), and only 35% of the residents indicated that green manure is least used for gardening and tree

planting. This proved to be beneficial to tree nursery farmers due to affordable inputs.

4.2. Research Objective 2

In the second objective, the study sought to: establish the impact of bio-fuel production from water hyacinth on economic development.

The respondents were asked by the researchers to state the level of their usage of bio-fuel and its bye-products from water hyacinth in their (respondents) homes, and the responses obtained are shown in Table 2.

Table 2. The use bio-fuel from water hyacinth and bye-products by households.

Biogas produced from water hyacinth	Highly used	Least used
Slurry from biogas is used as manure	13	29
Biogas is commonly used by households as fuel	11	25
Dried slurry cakes are used as fuel for cooking	10	32
TOTAL	34	86

Water hyacinth has been used to produce cooking gas and ethanol, and the main bye-product (slurry) used as organic manure in the gardens. When the researchers asked the respondents whether they have gained from the production of bio-fuel using water hyacinth, majority (86 or 71.7%) stated that they have used bio-fuel from water hyacinth and its products the least, and only 21.3% of the respondents indicated that they have used bio-fuel from water hyacinth and its bye-products highly. This low usage may be attributed to technological expertise required in the digestion of bio-fuel from water hyacinth.

4.3. Research Objective 3

The third research objective sought to: establish the impact of art work from water hyacinth on economic development.

To gather information relating to art work from materials made out of water hyacinth, the researchers asked the respondents to state the level of their agreement with 4 statements relating to 4 types of art works used by households and tourists. The respondents stated their agreements as shown in Table 3.

Table 3. Art works made from water hyacinth.

Art work uses of water hyacinth	Strongly agreed	Strongly disagreed
Mart making has increased	32	10
Rope making has increased	26	7
Furniture making has boosted	19	6
Sandals and ornamentals has increased	15	5
TOTAL	92	28

From the table above, majority (92 or 76.7%) of the respondents strongly agreed that mart making, rope making, furniture making, and sandals/ornamentals making has increased from materials made from water hyacinth. Only 23.3% strongly disagreed that these art works production has thrived due to the availability of materials made from water hyacinth.

4.4. Research Objective 4

The last objective of the study was to evaluate the impact of animal feeds from water hyacinth on the economic development.

The researchers asked the respondents to state the level of their agreement in relation to various types of feedstock (animal feeds) made from water hyacinth. The responses obtained were tabulated as indicated in Table 4.

Table 4. Feedstock made from water hyacinth.

Animal feedstock from water hyacinth	Strongly agreed	Strongly disagreed
Price of fish feeds has reduced because of cheap feeds from water hyacinth	23	13
Price of poultry feeds has reduced due to cheap feeds from water hyacinth	31	18
Price of pigs feeds has reduced because of cheap feeds from water hyacinth	28	7
TOTAL	82	38

As shown in Table 4, majority (82 or 68.3%) of the respondents strongly agreed that the price of feedstock for fish, poultry, and pigs have reduced, thus reducing the cost of input. Only 38 (31.7%) of the respondents strongly disagreed that feedstock made from water hyacinth have been cheap.

4.5. Discussions

The study results indicated that the residents of the two communities (Dunga and Kichinjio) rely on water hyacinth for making organic (or green) manure, art works, and feedstock (animal feeds). The residents seldom use water hyacinth for the production of bio-fuel. The plant can be composted and used as fertilizer for farming activities. It retains most of the nutrients (Gunnarsson and Petersen, 2007) when dried thus decreasing the usage chemical fertilizer. The time taken in composting is estimated at only 30 days (Polprasert et al., 1980) compared to other crop plants, which can take between 2-3 months. Water Hyacinth can be converted into ash (40%) according to Gunnarson and Petersen (2007) which is rich in micronutrients and thus can be used for soil enrichment. Therefore, compost from water hyacinth improves physical, chemical and biological properties of the soil. Water hyacinth can also be used as feeds for livestock to provide roughage component (Gunnarsson and Petersen, 2007). The weed can further be

used for manufacturing furniture and other ornamental items, which are in high demand and available through online stores (typical examples, http://www.balifurnish.com and http://www.whup.20m.com). They are also used to manufacture building board. Finally, water hyacinth can be used in both normal and grease - proof paper production (De Groote et al., 2003).

5. Recommendations and Conclusions

5.1. Bio-Fuel Technology Training

It is evident that the menace created by water hyacinth could be transformed to benefit the communities who previously relied on fishing and tourism activities in Lake Victoria. The researchers therefore recommend that the community members should be trained on bio-fuel production from water hyacinth to increase their usage of bio-fuel from water hyacinth.

5.2. Bio-Digesters

Adequate bio-digesters should therefore be installed at various strategic locations within the area after trainings and the biogas piped to respective households for cooking and lighting. The result would be a double gain from environmental conservation point and economic growth and development among the community members.

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