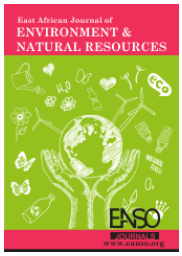

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Original Article

Local Communities' Perceptions about the Impacts of Water Hyacinth Infestation in Lake Victoria on Economic Activities in Nyalenda B Ward, Kisumu County, Kenya

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ABSTRACT

Water hyacinth (Eichhornia crassipes) is ranked as one of the most invasive weeds causing negative effects on aquatic ecosystems around the world. In the last decades, there has been increased interest in the impacts of water hyacinth and how it can be utilised in various applications such as animal feeds and fertiliser production, wastewater treatment, biofuel production and as raw material for handicraft products. The objectives of this study are: (i) to determine the impacts of water hyacinth infestation in Lake Victoria on the economic activities of the local community living in Nyalenda B Ward, Kisumu County, Kenya, and (ii) to assess the methods which can be used to control water hyacinth in the lake. The study used a descriptive research design. The study involved the collection of data through observation, questionnaires, and interviews. The study found that water hyacinth infestation in the lake mainly impacted economic activities such as fishing, tourism, weaving and biogas production. Fewer respondents (<20 %) utilised water hyacinths to make animal feeds and to produce fertiliser. The most preferred methods for controlling water hyacinth were manual and mechanical methods. The utilisation of water hyacinth in various industrial applications such as pulp and paper production, wastewater treatment and agriculture needs to be explored and scaled up by the relevant government agencies to contribute towards the economic wellbeing of local communities and environmental conservation of Lake Victoria.

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INTRODUCTION

Water hyacinth (*Eichhornia crassipes*) is a free-floating aquatic plant and is a native plant species from South America (Dechassa, 2020). It is considered one of the aquatic plants with the most negative effects on the aquatic environment because of its fast growth rate and its adaptation to a wide variety of physico-chemical conditions (Kriticos & Brunel, 2016; Lahon et al., 2023). According to the International Union for Conservation of Nature (IUCN), water hyacinth is among the worst invasive species affecting aquatic ecosystems in the world (Lowe et al., 2020). The plant is used as an ornamental plant, but this has enabled the weed to spread to different regions of the world (Lahon et al., 2023). Other explanations for the spread of water hyacinth include its capacity to quickly multiply when away from its natural habitats in South America. The plants have infested aquatic ecosystems in other regions of the world, such as Africa, Asia, Europe, and North America (Kriticos & Brunel, 2016).

Water hyacinth replaces native aquatic plants due to its rapid growth rate. The plant has a very high growth rate and can double its biomass within a period of two weeks (Lahon et al., 2023). Additionally, water hyacinth has high tolerance to a wide range of environmental conditions, high dispersal capacity, undergoes flowering throughout the year and has the capability to survive at various water depths due to its ability to float freely on the water surface (Kriticos & Brunel, 2016; Garcia-de-Lomas et al., 2022).

Water hyacinth plants are established rapidly in water bodies with relatively high-water temperatures, nitrogen and phosphorous concentrations (Kriticos & Brunel, 2016). However, high salinity levels inhibit the growth of water hyacinth and can cause mortality (Kriticos & Brunel, 2016; Bick et al., 2020). Thus, water hyacinth plants are typically found in freshwater environments such as lakes, ponds, rivers, and wetlands (Lubembe et al., 2023).

The primary means of reproduction and growth for water hyacinth is through stolons - also called runners, which ultimately form new plants (Gupta & Yadav, 2020). The plant also produces seeds that can remain viable for up to twenty years (Degaga, 2019). These reproductive characteristics make it difficult to manage and control water hyacinths in water bodies. Water hyacinth is controlled using manual, mechanical, chemical, and biological methods (Harun et al., 2021; Karouach et al., 2022).

In Africa, water hyacinth was introduced as an ornamental plant but was subsequently accidentally introduced into aquatic ecosystems (Lubembe et al., 2023). After the introduction, the hyacinth plants established rapidly due to a lack of competitors and predators in the environment, which has caused negative effects on biodiversity and environmental quality (Ovarr, 2019; Musinguzi et al., 2022; Lubembe et al., 2023). The rapid spread of water hyacinth is exacerbated by increased input of nutrients emanating from non-point sources such as agriculture and point sources such as sewage effluents. Currently, water hyacinth plants have infested African lakes such as Victoria, Naivasha, Tanganyika and Tana (Lubembe et al., 2023).

Water hyacinth has affected water quality and biodiversity in the African countries where it has been introduced (Wawire, 2000; Kiyemba et al., 2023). The hyacinth plants have economic impacts such as decrease in the abundance and diversity of fish harvested, blockage of water irrigation channels and electricity generation

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turbines, interference with transport and tourism activities, obstruction of rivers leading to flooding and property destruction, destruction of fishing gears such as nets, blockage of fish landing sites and fishing grounds (Villamagna &Murphy, 2010; Segbefia et al., 2019; Voukeng et al., 2019; Damtie et al., 2022). Additionally, the dense mats of the weed can act as ideal areas for the breeding of mosquitoes, increasing the cases of malaria. Water hyacinth curtails business activities and subjects families to economic hardships. Despite the negative economic effects, water hyacinth has positive economic effects, such as utilisation in weaving and production of biogas, animal feeds and fertiliser production (Kamau et al., 2015; Ilo et al., 2020; Harun et al., 2021).

Lake Victoria is the world's second-largest freshwater lake and is a hotspot for biological diversity (Okechi et al., 2022). The lake is crucial for the economic development of the East African region and supports the livelihoods of millions of people. However, the introduction of water hyacinth into Lake Victoria in the late 1980s has led to a change in the economy and ecological condition of the area (Güerena et al., 2015). The objectives of the current study are to (i) determine the impacts of water hyacinth infestation in Lake Victoria on the economic activities of the local community living in Nyalenda B Ward, Kisumu County, Kenya, and (ii) assess the methods that can be used to control water hyacinth in the lake.

METHODOLOGY

Study Area

The study was conducted in Nyalenda B Ward, Kisumu Central Constituency, Kisumu County. Nyalenda is one of the largest informal settlements in Kisumu and is located on the Southern side of Kisumu City. Nyalenda lies along a latitude of -0°7'36.012''S and longitude of 34°45'27.02''E. The Nyalenda settlement consists of Nyalenda A and Nyalenda B wards. Nyalenda B is subdivided into smaller administrative units (i.e., Western, Kilo, Nanga and Dunga). The ward has a human population of approximately 32,430, comprising 16,189 males and 16,241 females (KNBS, 2009). The area is accessible from the Ring Road and Kisumu-Busia Road. The area is close to Lake Victoria, and fishing is one of the key economic activities providing livelihood to the riparian communities. Just like in other fast-growing urban centres in Kenya, the area faces various challenges, such as overcrowding and lack of adequate water and sanitation services.

Study Research Design

According to Jilcha (2020), the aim of research design is to provide a plan of study that allows accurate evaluation of relationships between variables. This study adopted a descriptive research design. Residents of Nyalenda B ward answered open and close-ended questions that were issued through questionnaires. Key stakeholders involved in economic activities impacted by water hyacinth answered questions administered during key informant interviews and focus group discussions. Focus groups and key informants are used to gather perspectives from respondents on a certain topic and can help to discuss complex ideas in depth, generate new ideas and obtain information from individual experts (Mckenna & Main, 2013; Sim & Waterfield, 2019; Akhter, 2022).

Study Population and Sample Size

According to Banerjee and Chaudhury (2010), a study population refers to a group of individuals or objects known to have similar characteristics. The study evaluated the opinions of the residents of Nyalenda B Ward about the impacts of water hyacinth infestation in Lake Victoria on their economic activities and livelihood. The population of Nyalenda B is 32,430 (KNBS, 2009).

A sample refers to a subset of individuals or objects containing the characteristics of a larger population (Singh & Masuku, 2014). For conclusions of research to be reliable, samples should be representative of the study populations. The sample size was calculated according to Yamane (1967), as shown below:

$$n = \frac{N}{1+Ne^2}$$

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In the above formula (1): n = sample size, N = population size, and e = margin of error, e = 0.1.

Hence,

$$n = \frac{32{,}430}{1+32{,}430(0.1^2)} = 100$$

Methods of Data Collection

The study utilised both quantitative and qualitative methods during data collection. The study used questionnaires, interviews, discussions, observation, and document analysis as the main methods of data collection. The study utilised a survey method to administer 100 questionnaires to residents of Nyalenda B ward. The questionnaires had both open and close-ended questions to enable the respondents to fully express themselves on the matter under investigation. Both qualitative and quantitative data were collected from the questionnaires. The data collected included personal information about the respondents (e.g., age, gender, household size), economic activities undertaken by respondents, infestation of lake with water hyacinth and impacts of infestation of lake with water hyacinth on economic activities. For more in-depth information on the data collected, focus group discussions were undertaken and involved bringing together different groups of people to give their opinions on the impacts of water hyacinth infestation on economic activities in the area. The groups of people involved in focus group discussions were purposively selected while taking into account heterogeneity in terms of age, sex and prior involvement in issues related to water hyacinth infestation in the lake. The groups were composed of ten members, and discussion guides were used to obtain the necessary information. Four focus group discussions comprising of the youth, women, men, and elderly residents were organised in different areas within the ward so that members could share their perspectives regarding the economic impacts of water hyacinth.

The County fisheries and environmental officers, local administrator (i.e., chief), social development officer and representatives of a local community-based organisation were purposely selected to give their views on the impacts of water hyacinth infestation on economic activities and local community livelihoods in the area. They also helped in highlighting the challenges involved in the control of water hyacinths and potential solutions. All the issues were captured during the key informant interviews.

The study also used direct observation by investigating the various enterprises utilising water hyacinth to make products as well as impacts such as hindrance with navigation and blockage of fish landing sites. Secondary data was collected from published sources such as journal publications, reports, and magazines.

Validity and Reliability of Data Collection Method

Reliability and validity are concepts that are used to assess the quality of data collected by research projects. Validity refers to how well a research method measures what it is intended to measure. On the other hand, reliability focuses on the accuracy and consistency of results produced by a data collection method over a given period of time and area (Brink, 1993; Kimberlin & Winterstein, 2008; Heale & Twycross, 2015). In this study, the questionnaires were pre-tested to determine their validity and reliability as a data collection method. After pre-testing, corrections were made, and questions were adjusted accordingly to enable the attainment of reliable and consistent results.

Ethical Considerations

The researcher informed the respondents about the objectives of the study and gave them the liberty to take part in the study or not. Confidentiality was achieved by asking the respondents not to write their names on the questionnaires. Respondents were identified using serial numbers rather than names. Confidentiality was also guaranteed by grouping data rather than presenting responses from individual respondents. The study respondents were informed that the information obtained would be used purely for scholarly work.

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Data Analysis

The questionnaires were segregated into those that were partially filled and those that were fully filled. Out of the 100 questionnaires that were administered, 90 questionnaires met the expectations of the research in terms of completeness and accuracy of information. Quantitative data was keyed into Microsoft Excel, analysed and presented using figures and tables.

RESULTS

Rate of Response to Questionnaires

The study collected data from a total of 90 households, although the initially targeted number of households was 100. Therefore, the rate of response to the questionnaires is 90% (*Table 1*).

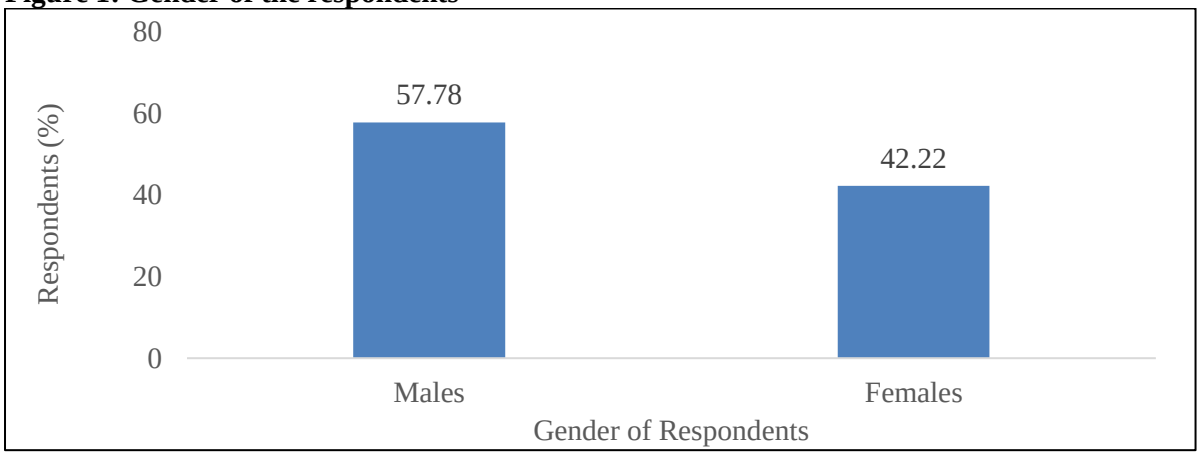
Table 1: Rate of response to the questionnaires

	Original sample size	Sample achieved	Response rate
Number of households	100	90	90%

Personal Information of the Respondents

The respondents were mainly males (57.8%), while the percentage of females (42.2%) interviewed was comparatively lower (*Figure 1*).

Figure 1: Gender of the respondents



Most of the respondents who were interviewed were between 25 and 40 years (41.1%) and 40 and 50 years (26.6%), whereas fewer respondents were aged above 50 years (10%) (Table 2). Most of the households had between 5 to 8 family members (46.6%) and 3 to 5 family members (25.5%). However, fewer households had 1 to 3 family members (7.8%) (*Table 3*).

Table 2: Age and household size of respondents

		Frequency	Percentage (%)
Age	0-25	20	22.2
	25-40	37	41.1
	40-50	24	26.6
	>50	9	10
	Total	90	100
Household size	1-3	7	7.8
	3-5	23	25.5
	5-8	42	46.6
	>8	18	20
	Total	90	100

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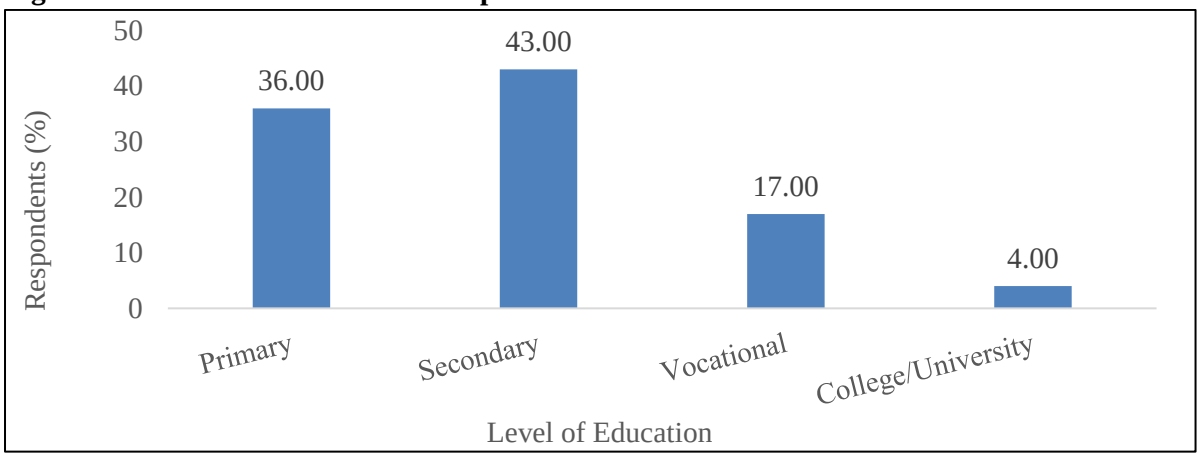
Most of the respondents had reached primary (36%) and secondary school (43%) in terms of educational attainment, whereas fewer respondents had attained vocational (17%) and college/university (4%) education (*Figure 2*).

Figure 2: Level of education of the respondents



The respondents were asked to provide information about economic activities impacted by water hyacinth infestation in which they engaged. The most common economic activity affected by water hyacinth infestation among the respondents was fishing (40%), tourism (27%) and weaving (20%). On the other hand, relatively fewer respondents engaged in biogas production (6%), animal feed production (4%) and fertiliser production (3%) (Figure 3). With regard to income, most of the respondents earned between Ksh. 5,000 and 10,000 (33.3%) and below Ksh. 5,000 (22.2%). However, fewer respondents earned above Ksh. 30,000 (5.6%) (Figure 4).

Figure 3: Economic activities undertaken by the respondents

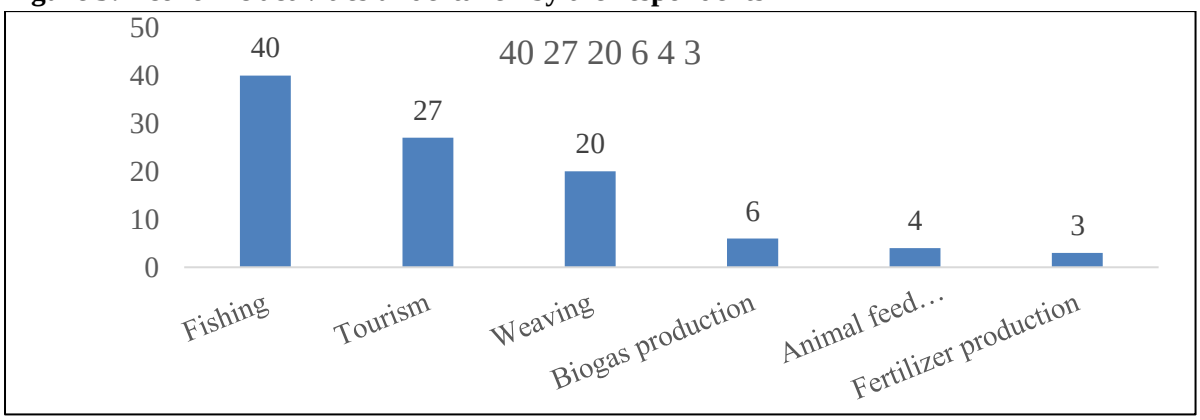
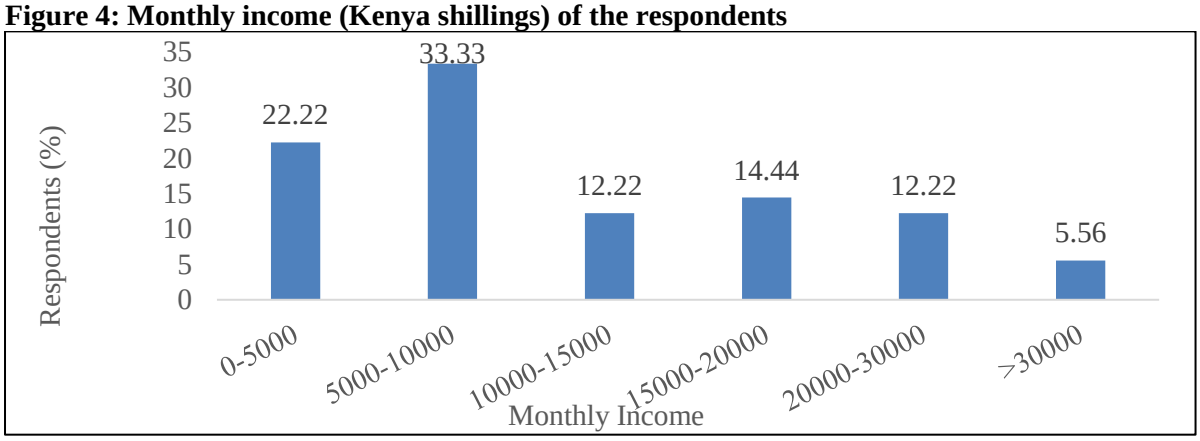


Figure 4: Monthly income (Kenya shillings) of the respondents



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The respondents were asked to provide information about how long they had engaged in economic activities impacted by water hyacinth infestation. Most of the respondents indicated that they had engaged in economic activities for 2 to 4 years (30%) and for more than ten years (23.3%). On the other hand, fewer respondents had engaged in economic activities for less than 2 years (11.1%) (*Table 3*).

Table 3: Experience of respondents with economic activities

Experience	Frequency	Percentage (%)
Less than 2 years	10	11.1
2-4 years	27	30
5-7 years	18	20
8-10 years	14	15.6
More than 10 years	21	23.3
Total	90	100

Infestation of Lake with Water Hyacinth

Most of the interviewed respondents (92.2%) indicated that they were aware of the presence of water hyacinths in Lake Victoria. The respondents were asked to indicate the period of the year during which the lake was highly covered by water hyacinth and the period during which the lake was less covered by water hyacinth. Most of the respondents indicated that the lake was highly covered by water hyacinth between November and December (25.6%) and between March and June (32.3%). On the other hand, most respondents indicated that the lake was less covered by water hyacinth between July and October (54.4%) and between January and February (23.3%) (*Table 4*).

Table 4: Proportion of lake covered by water hyacinth

Period of the year	Lake highly covered		Lake less covered	
	Frequency	Percentage (%)	Frequency	Percentage (%)
January-February	16	17.7	21	23.3
March-April	20	22.3	5	5.7
May-June	9	10	7	7.7
July-August	7	7.7	40	44.4
September-October	15	16.7	9	10
November-December	23	25.6	8	8.9

Impacts of Water Hyacinth Infestation on Economic Activities

Impact on Fishing Industry and Tourism

Most of the respondents mainly associated water hyacinth with negative effects on the fishing industry through interference with navigation (37.8%), blockage of fish landing sites (25.6%), destruction of fishing gears (13.3%) and water pollution (11.1%) (*Figure 5*).

With regard to tourism, most of the respondents (92.2%) associated the presence of water hyacinth with reduced visitation by tourists, whereas fewer respondents (7.8%) indicated that water hyacinth had no effect on visitation of the lake by tourists (*Table 5*). The respondents also indicated that tourists mostly visited the lake between September and October (41.1%) and between July and August (25.5%) (*Table 6*).

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Figure 5: Impact of water hyacinth on the fishing industry

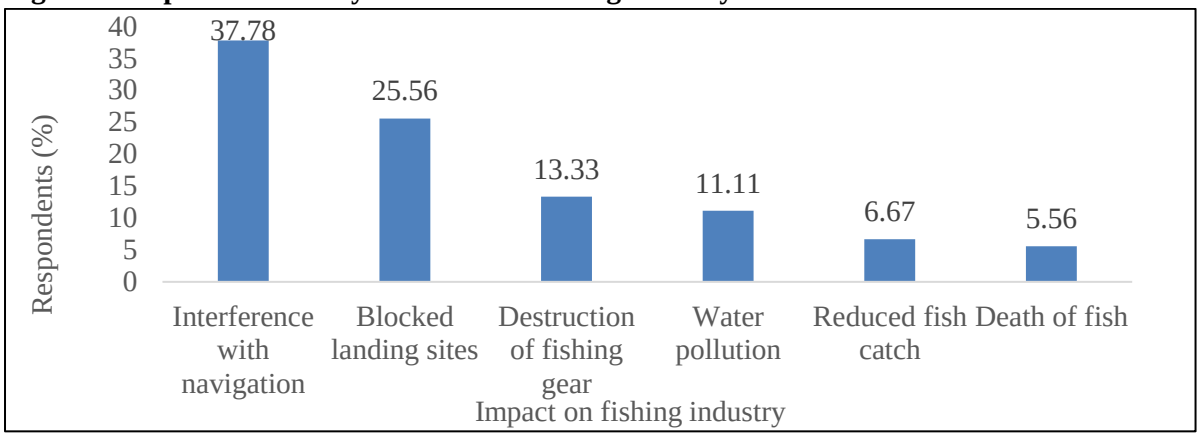

Table 5: Impact of water hyacinth on tourism

Impact on tourist visitation	Frequency	Percentage (%)
Yes	83	92.2
No	7	7.8
Total	90	100

Table 6: Annual frequency of visitation to the lake by tourists

Period of the year	Frequency	Percentage (%)
January-February	5	5.6
March-April	6	6.7
May-June	7	7.8
July-August	23	25.5
September-October	37	41.1
November-December	12	13.3

Impact on the Weaving Industry and Biogas Production

The respondents were asked to indicate whether water hyacinth was used as a raw material for the weaving industry. Most of the respondents (94.4%, *Table 7*) indicated that water hyacinth was used as a raw material in the weaving industry to make various items. When the respondents were asked which items were made from water hyacinth, they indicated the following items: baskets, cupboards, table mats, seats, handbags, earrings, bangles, necklaces, trays, chairs, and coffins. However, the majority of the respondents (>80%) indicated that water hyacinth was primarily used in making seats, which fetched a higher price. The respondents were asked whether water hyacinth can be used to make other items. Most respondents (91.1%) indicated that water hyacinth can be used to make other items, while 8.9% indicated that water hyacinth cannot be used to make other items (*Table 7*). The respondents gave examples of other items that can be made using water hyacinths, such as papers, key holders, caps, and fertilisers.

Table 7: Usage of water hyacinth as a weaving raw material

Hyacinth as weaving raw material	Frequency	Percentage (%)
Yes	85	94.4
No	5	5.6
Total	90	100
Hyacinth for making other items		
Yes	82	91.1
No	8	8.9
Total	90	100

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With regard to biogas production, the respondents indicated that water hyacinth was mainly harvested between May and June (27.7%), March and April (22.2 %) and November and December (21.1%) (*Table 8*).

Table 8: The month water hyacinth is harvested for biogas production

Period of the year	Frequency	Percentage (%)
Jan-Feb	8	8.9
Mar-April	20	22.2
May-June	25	27.7
July-Aug	10	11.2
Sep-oct	8	8.9
Nov-Dec	19	21.1

Most respondents (80%) indicated that biogas sales volume was highest during periods of the year when the lake was highly covered by water hyacinth. However, most respondents (35.6-41.1%) indicated that biogas sales volume ranged from low to average during periods of the year when the lake was less covered by water hyacinth (*Table 9*).

Table 9: Biogas sales volumes during different periods of the year

Biogas sales volume	Lake less covered		Lake highly covered	
	Frequency	Percentage (%)	Frequency	Percentage (%)
High	21	23.3	72	80
Average	37	41.1	15	16.7
Low	32	35.6	3	3.3
Total	90	100	90	100

Impact on Animal Feed and Fertilizer Production

Most of the respondents (82.2%) indicated that they did not use water hyacinths to make animal feeds (*Table 10*). Similarly, most respondents (85.6%) did not use water hyacinth to produce fertiliser (*Table 10*).

Table 10: Usage of water hyacinth to make animal feeds and fertiliser

Hyacinth for animal feeds	Frequency	Percentage (%)
Yes	16	17.8
No	74	82.2
Total	90	100
Hyacinth for fertiliser production		
Yes	13	14.4
No	77	85.6
Total	90	100

Methods of Controlling Water Hyacinth

The respondents were asked which was the most appropriate method for controlling water hyacinth in the lake. Most respondents indicated that the manual (37.8%) and mechanical (25.6%) methods were the most appropriate for controlling water hyacinth. However, relatively few (14.4%) respondents indicated that the chemical method was the most appropriate method for controlling water hyacinth (*Figure 6*).

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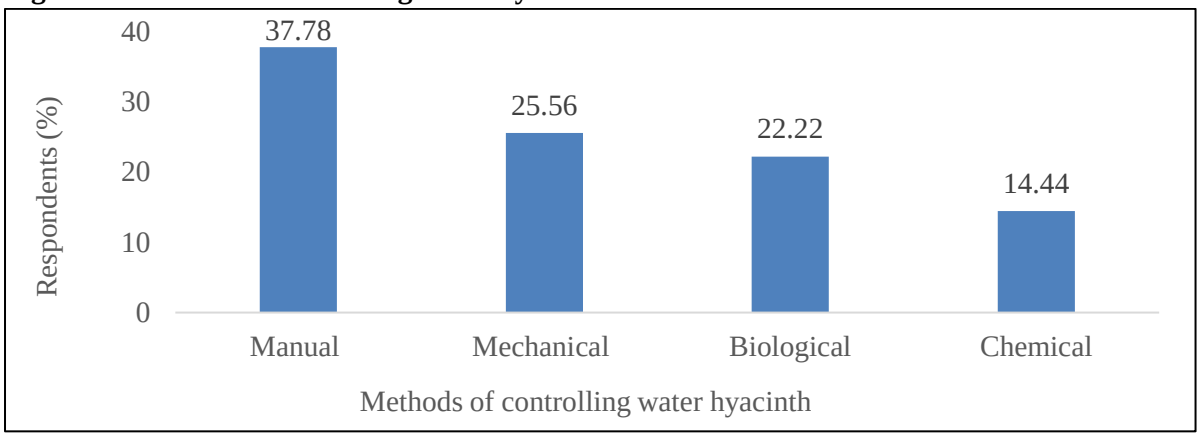
Figure 6: Methods of controlling water hyacinth



DISCUSSION

The response rate to questionnaires in this study was 90% and is considered to be high enough to represent the study sample size. A response rate refers to the number of individuals who respond to a survey divided by the number of eligible individuals in the sample (Sitzia & Wood, 1998; Fowler, 2013). There is no standard criterion for defining a high response rate, but a rate that is 80% or higher is generally taken to be excellent (Booker et al., 2021). High response rates are an important characteristic of research in terms of the generation of valid and generalisable results for survey investigations (Nair et al., 2008; Wu et al., 2022).

Most of the respondents (57.8%) in this study were males. This could possibly be due to the fact that the most common economic activities (e.g., fishing, tourism) affected by water hyacinth infestation in the lake are mainly undertaken by men (Namisi, 2005). Additionally, males are typically the household heads and are more likely to be respondents in surveys. The response rate in survey studies may sometimes be influenced by factors such as the gender of the interviewer and respondents, the type of survey (e.g., face-to-face) and the interest of the respondents in the questions asked (Flores-Macias & Lawson 2008; Slauson-Blevins and Johnson, 2016; Mulder & Bruijne, 2019).

Most of the respondents were aged between 25-50 years, whereas fewer respondents were aged above 50 years or below 25 years. This indicates that most of the respondents are middle-aged and probably have more experience and knowledge about the economic activities impacted by water hyacinth. The ability of respondents to understand and interpret questions may be enhanced if they have prior knowledge about the contents of a survey, and this may have an impact on the quality of data collected (Knäuper et al., 1997).

Most of the households had between 3-8 family members. This is within the average national household size of 4 persons per household (UN, DESA, 2019). Over the last century, the size of households has been declining in both developed and developing countries (OECD, 2011). However, developing countries with low levels of development activities, limited modernisation and mainly based on subsistence economy still present relatively large household sizes (Meyer & Nishimwe-Niyimbanira, 2016). Household size is related to levels of poverty in an area (Bhattacharjee, 2019; Tripathi, 2020).

With regard to educational qualification, most respondents had not proceeded beyond the secondary school level. This finding can be due to the fact that the Nyalenda settlement is an informal settlement where access to basic services such as housing and educational facilities may be limited (Simiyu et al., 2018). Such areas are also characterised by poverty, and lack of funds may hinder the achievement of higher education qualifications. Participation by school pupils in economic activities such as fishing can lead to poor academic performance and an increased

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school dropout rate (Nyonje & Kachieng, 2014; Ligeve et al., 2012).

The most common economic activity impacted by water hyacinth infestation in Lake Victoria was fishing. This could be due to the fact that the fishing industry is a key economic activity in the area. The fishing industry plays a crucial role in the Kenyan economy and provides employment to over 500,000 Kenyans who are engaged in fishing-related enterprises (Rasowo et al., 2020; Njiru et al., 2021). Despite the importance of the fishing industry to the economy, factors such as environmental pollution and invasive weeds such as water hyacinth hinder the achievement of their full potential (Wawire, 2000; Segbefia et al., 2019; Harun et al., 2021).

Water hyacinth impacts the accessibility of fishing grounds through interference with navigation and causes a reduction in the abundance of fish (Vincent et al., 2010; Waithaka, 2013; Enyew et al., 2020; Lubembe et al., 2023). Water hyacinth also affects the fishing industry through blockage of landing sites, destruction of fishing gear, water pollution and death of fish (Villamagna & Murphy, 2010; Damtie et al., 2022; Kiyemba et al., 2023). For example, Waithaka (2013) assessed the impact of water hyacinth on the fishing communities of Lake Naivasha, Kenya, and found that water hyacinth led to the death of fish due to factors such as oxygen depletion and displacement from nursery and feeding habitats. Water hyacinth affected the economic activities of the fishing communities through blockage of fish landing sites, lowering of the abundance of fish caught, hindering boat navigation and pollution of water. In Ghana, Segbefia et al. (2019) assessed the impacts of water hyacinth infestation on fishery activities along the River Tano and Abby-Tano Lagoon and found that most (80%) fishermen reported having had their fishing activities negatively impacted by water hyacinth. The fishermen reported that water hyacinth affected their economic activities by reducing their ability to access the fishing grounds, entanglement and destruction of fishing nets, increasing the cost of repairing fishing gear, reducing the quantity of fish caught, longer working hours and reducing income. With regard to the quantity of fish caught, water hyacinth can have varied effects. For example, Wawire (2003) investigated the effect of water hyacinth on fish productivity and species composition in Lake Victoria and found that the weed caused an increase in Tilapiines and *Protopterus* sp whereas there was a decrease in abundance of *Rastrineobola argentea* and *Mormyrus* sp. The increase in the abundance of some fish species with water hyacinth infestation could probably be due to their ability to utilise the new habitat and food resources (e.g., invertebrates) found in areas with dense water hyacinth mats (Toft et al., 2003).

Most of the respondents in this study indicated that water hyacinth had an impact on tourism, and visits by tourists were greatly reduced between January and June and between November and December. The reduction in visits by tourists between January and June could be due to the high proportion of lakes covered by water hyacinth during this period of the year (Table 5). On the other hand, an increase in the frequency of visitation of lakes by tourists between July and October could be due to a reduced proportion of water hyacinth covering the lake. Given that water hyacinth is buoyant and is not anchored on the substratum, it is moved by wind from one place to another. Other studies conducted elsewhere have also recorded similar findings. For example, Ovarr (2019) assessed the impact of water hyacinth infestation in Nigerian inland waters and found that water hyacinth hindered navigation and had a negative impact on economic activities such as tourism. In other areas of the world, such as China, infestation of water bodies with water hyacinth also caused negative impacts on ecosystem services such as recreation and tourism (Yan and Guo, 2017).

In this study, most respondents stated that water hyacinth was used as a raw material in the weaving industry. Weaving is an important economic activity for communities with indigenous knowledge and skills to weave various products for sale, and studies conducted in other

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countries also found water hyacinth to be a useful source of fibre for making various handicraft products. In Indonesia, Agustin et al. (2023) demonstrated that water hyacinth was useful for making products such as mats, carpets, tissue boxes and trays. A different study conducted in Madagascar found that water hyacinth was used for making handicrafts such as hats, sandals, shopping bags, mats and handbags. The study also found that assembling handicrafts using water hyacinth was easy and fast and led to the production of robust products that were rated as of very good quality (Rakotoarisoa et al., 2016).

In the current study, most respondents (>80%) indicated that they did not utilise water hyacinth to produce animal feed or fertiliser. Despite this finding, studies conducted in other regions, such as Nigeria and Ethiopia, demonstrated that including water hyacinth in the diet of animals such as sheep and goats resulted in rapid weight gain and lower feeding costs compared to other diets (Sunday, 2010; Mekuriaw et al., 2018). Other studies conducted in countries such as Egypt and Sri Lanka found that water hyacinth can be used as a substitute food source for fish and rabbits (Hassan et al., 2015; Fouzi and Deepani, 2018). Therefore, there exists an opportunity for increased utilisation of water hyacinth as a source of food for domestic animals in Kenyan areas such as Nyalenda B Ward. Additionally, there is also an opportunity for the utilisation of water hyacinth in the production of fertiliser, as demonstrated in other regions of the world (Gosal et al., 2022).

Most respondents indicated that manual and mechanical methods were the most appropriate methods for controlling water hyacinths in the lake. However, other approaches, such as the application of herbicides and biological control methods, are also utilised in the control of water hyacinths (Gupta & Yadav, 2020). For example, Souza et al. (2020) evaluated the utility of a herbicide (i.e., glyphosate) in the control of water hyacinth in Brazil and found that the herbicide was effective but had a negative effect on water quality. A different study conducted in South Africa indicated that chemical and mechanical methods were not effective in the control of water hyacinths and that biological control was considered the best long-term solution to the water hyacinth infestation problem (Cilliers, 1991). Other studies have advocated the integration of different approaches in the biocontrol of water hyacinth. For example, the integration of grass carp and weevils has been found to be more effective in the control of water hyacinths in India (Gopalakrishnan et al., 2011). Another study conducted in the USA advocated for the integration of biological control agents and herbicides in the control of water hyacinths (Center et al., 1999).

CONCLUSIONS AND RECOMMENDATIONS

Water hyacinth infestation in Lake Victoria has an impact on economic activities undertaken by local communities living in Nyalenda B Ward, Kisumu County. Economic activities affected by water hyacinth infestation include fishing, tourism, weaving and biogas production. Most respondents indicated that they did not use water hyacinth as raw material for animal feeds and fertiliser production. Most respondents indicated that manual and mechanical methods are most appropriate for controlling water hyacinths in the lake. It is recommended that there is a need for relevant government agencies to explore how water hyacinth utilisation can be scaled up in industrial applications such as pulp and paper production, wastewater treatment, handicraft, agriculture and renewable energy. The local communities should be provided with the necessary inputs and expertise to utilise water hyacinth in additional economic enterprises and to contribute towards the environmental conservation of the lake.

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