



Water Hyacinth: Potential Applications for Environmental Sustainability and Socio-economic Development

Afsana Akter¹, Md. Kawsar Alam Nadim², Mariom Mitu³, Md. Selim Reza⁴, S.M. Abdul Alim⁵ and Md. Mohimenul Islam^{6*}

¹Department of Agroforestry and Environmental Science, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. Email: aalithi07@gmail.com

²Biotechnology Division, Bangladesh Institute of Nuclear Agriculture, Mymensingh, Bangladesh. Email: nadim.kawsaralam@gmail.com

³Department of Biochemistry, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. Email: mitumariom@gmail.com

⁴Planning and Development Wing, Bangladesh Institute of Nuclear Agriculture, Mymensingh, Bangladesh. Email: selim.bsmrau48@gmail.com

⁵Plant Breeding Division, Bangladesh Institute of Nuclear Agriculture, Mymensingh, Bangladesh. Email: smaalim100@gmail.com

⁶Adaptive Research and Extension Division, Bangladesh Institute of Nuclear Agriculture, Mymensingh, Bangladesh. Email: mohimenul008ag@gmail.com

*Correspondence: mohimenul008ag@gmail.com, Phone: +8801790394077

Received: 09/01/2023

Accepted: 13/03/2023

Available online: 17/03/2023



Copyright: ©2023 by the author(s).

This work is licensed under a Creative Commons Attribution 4.0 License.

<https://creativecommons.org/licenses/by/4.0/>

Abstract: Despite the fact that people are more familiar with its drawbacks, water hyacinth has a variety of uses. This study aims to assess local inhabitants' opinions of water hyacinth and its sustainable, environmentally beneficial uses. In order to perform the study properly, we moved on to the study areas that are closer to Roa beel and a questionnaire with seven components and seven parameters was used. The Roa Beel is situated in the Chandpur Union neighborhood of the Kishoregonj district's Katiadi Upazila, Kishoregonj, Bangladesh. During the rainy season, excessive water hyacinth was found in the study region, and people of the villages of Sheker Para, Purbo Para, and Modinas Para in the Kishoregonj district were surveyed. The study assesses the locals' perceptions of their knowledge and understanding of water hyacinth, their management techniques, the benefits and drawbacks of water hyacinth, and their actual use of it in their daily lives as well as in various sectional activities like fishing, livestock rearing, agricultural farming, particularly in floating agricultural practices, and for industrial purposes. A surplus of water hyacinth in the beel can be utilized to create a promising industry for the region, especially if it is converted into affordable, environmentally acceptable animal feed, bio-fertilizer, and biogas. Undoubtedly, this will improve local environmental management efforts and provide more opportunity for local unemployed people to find employment.

Keywords: Water hyacinth; Environment; Sustainability; Bio-fertilizer; Biogas; Animal feed.

INTRODUCTION

One of the deadliest aquatic weeds in the world, water hyacinth is indeed a harmful alien invasive plant that originates in South America's Amazon region (Simberloff, D. and Rejmánek, M. 2011). Due to its nocturnal behavior, it was chosen as one of the 100 terrible invasive alien species in the world by the worldwide exotic species database (Lowe et al. 2000). The family Pontederiaceae's

free-floating monocotyledonous aqueous microphyte weed known as water hyacinth boasts lovely clusters of yellow and lavender flowers as well as bulbous green leaves. The major reason this weed was brought to Australia was to be used as decorative plants for botanical gardens and to garnish ornamental plants. Up to that point, it has reached more than 50 nations across five continents. In Southeast Asia, which includes Bangladesh, the Southeastern United States, Central and Western Africa, and Central America,

water hyacinth predominates (Brendonck et al. 2003; Bartodziej and Weymouth, 1995; Jimenez and Balandra, 2007; Lu et al. 2007).

It quickly colonizes new places as a single plant and reproduces (Williams et al. 2007; Zhang et al. 2010). This aquatic weed has spread over many tropical and subtropical regions, seriously affecting both native species and human life (Patel 2012; FAO, 2002; Villamagna, 2009; Tellez et al. 2008). Due to the intricate root system and increased evapotranspiration from the leaves, the water quality is severely impacted. When particularly in comparison to open water, even by a factor of 10, this scenario results in water scarcity in many regions (Gopal, 1987).

In addition to these drawbacks, water hyacinth has a wide range of possible applications. As an illustration, water hyacinth is frequently used as livestock feed (feed for cows, turkeys, and chickens), fish feed, and another significant usage is as fuel for cooking in rural areas. By filtering out heavy metals, it aids in both the mitigation of arsenic and the decrease of water pollution. It is used to make organic manure that may be applied to fields and homesteads for crop production. Additionally, water hyacinth is employed as a mulching substance that keeps crops moist during cultivation. In submerged locations, water hyacinth is also utilized for creating floating beds where various vegetables and crop plants are grown under challenging circumstances, like a flood.

All wastes are being recycled and reused as resources on a worldwide scale in an effort to preserve and maintain the environment. Water hyacinth is an exotic alien species

in Bangladesh that is mostly known as a waste product that can be used to create resources. Making this invasive weed environmentally friendly will allow it to be controlled and applied in many fields.

The main objectives of this study were to identify advantages and disadvantages of water hyacinth in rural areas and their management system; and to find out potential applications of water hyacinth that has impact on maintaining the sustainability of environment and on socio-economic development of rural people.

MATERIALS AND METHODS

Location of the study area

This research was carried out in three villages in Bangladesh's Kishoregonj district's Chandpur Union of Katiadi Upazila. Positioned between 24°10' and 24°22' north latitudes and between 90°43' and 90°55' east longitude, Katiadi Upazila has a total area of 219.22 sq km (Figure 1). Sheker Para, Purbo Para, and Modinas Para are the names of the three villages that make up the study area, which is located in the Chandpur union. (Ministry of Bangladesh, 2022).

Massive quantities of water hyacinth may be visible in the local water body during the rainy season, which has a negative impact on the adjacent residents' ability to support themselves through agriculture, fish farming, navigation, and other activities. On the contrary side, the indigenous inhabitants of the area used water hyacinth in a range of ways.

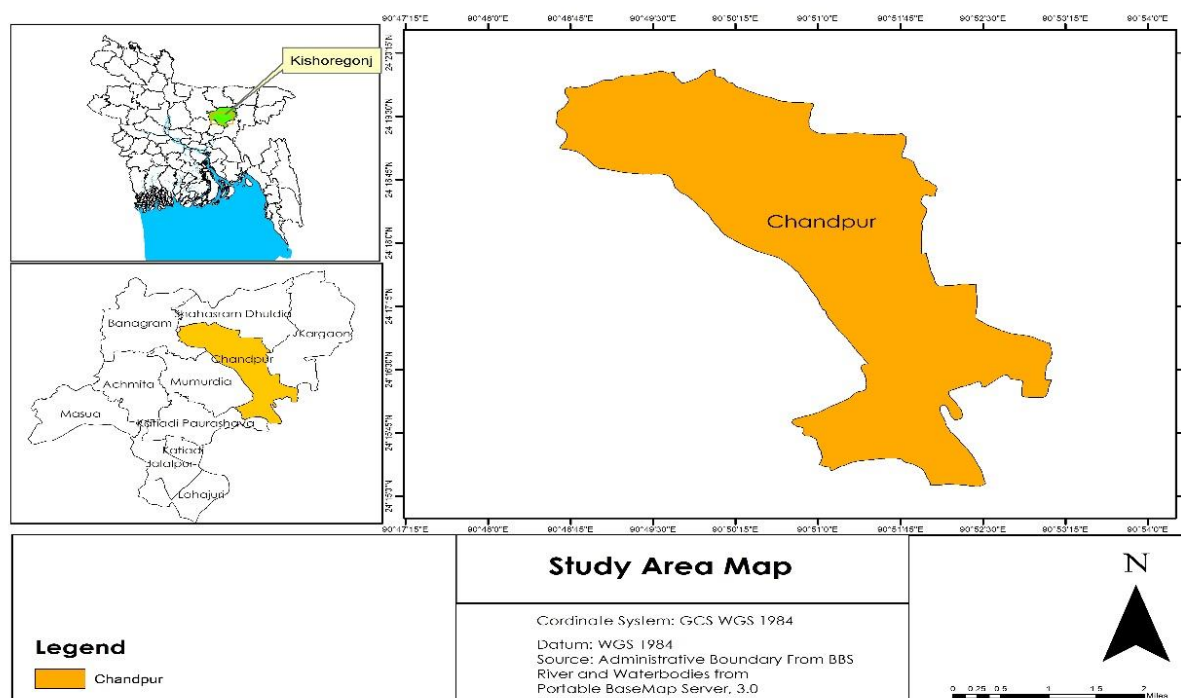


Figure 1. Study area map

Target population

All of the houses in the three villages—Sheker Para, Modinas Para, and Purbo Para—located in the Chandpur Union of the Katiadi Upazilla made up the study's target population. According to District Batayan (last updated January 25, 2016), Sheker Para has 280 males and 314 females, totaling 594 people; Purbo Para has 1723 males and 1805 females, totaling 3528 people; and Modinas Para has 598 males and 644 females, totaling 1242 people. (*People's republic of Bangladesh, 2023*). All of the households in three villages, totalling about 943 households, were included in the study's target population. The Chandpur Union Parishad offers a list of these residences. These might be viewed as the sampling frame from which the study's representative sample was drawn.

Sampling procedure

Starting from the beginning, cluster sampling was used, and the study region was divided into three sites based on the three localities of Sheker Para, Purbo Para, and Modinas Para. All three sites were near the Roa beel, where an abundance of water hyacinth was discovered during the monsoon season. When aiming to explore qualities in their natural environments or ensuring that intact groups with distinguishing traits are geographically covered in research, cluster sampling is most suited. The second phase involved choosing research participants by a simple random sampling procedure to guarantee that every member of the population had an equal and unbiased chance of being chosen. The number of homes represented at each place was taken as a random set of numbers. Then, a random home was chosen from each list to participate.

Data collection

For this study, both primary and secondary information were gathered and utilised. The primary data were gathered through survey questions, key informants from the field, and direct field data. The basic understanding of the community regarding water hyacinths, their origin, nature, and consequences for the environment, socio-economic situation, demographic distribution, etc. was included in this section. It also contained details on how excessive water hyacinth was handled locally and whether or not any newly introduced modern approaches were used. The secondary data were gathered via reviews of prior research on a matter pertaining to water hyacinths and their economic sustainability, other publications by the government and non-governmental organizations, various periodicals, the internet, etc.

A survey was created to learn more about the applications of excessive water hyacinth in regular living, the issues it causes for the environment, how to alleviate problems through sustainable, environmentally friendly use, etc. To prevent influencing the participant's responses to future questions, the sequence in which questions were presented was also carefully studied. The questionnaire's completion duration was kept as brief as possible to prevent participant tiredness, which could produce inaccurate and unreliable data. There were a number of open-ended

questions that participants might respond to. To allow respondents to respond in their own tongue, the questionnaire was written in English and translated into Bangla.

Data analysis

After gathering information from every person interviewed, questionnaires were reviewed for accuracy and completeness. In the field, both qualitative and quantitative information were gathered. The researcher coded the questionnaires, and a Microsoft Excel Worksheet was used to examine the data collected from the questionnaire. Through the use of this application, both open-ended and close-ended data were assessed. The respondent's general information, such as name, birthdate, gender, educational background, marital status, number of children, and so forth, served as the basis for the collection of these data. In addition, information was collected based on the respondent's understanding of water hyacinth, fishing activities, domestic chores, farming endeavors, and water hyacinth-related commercial ventures. These motifs or points were collected, and the computer was used to analyze them.

RESULTS AND DISCUSSIONS

Demographic and Socio-economic Information

People having different habitats have been living in the study area for years. Among them, almost 70% of people in that area are associated with agricultural activities coupled with livestock keeping. There are also other professionals like labors, rickshaw pullers, fishermen, businessmen, Govt. and private job holders, doctors, teachers, etc. About 8-10% of people deal with fishing seasonally mainly during the rainy season. Water hyacinth proliferation causes problems like a blockage in the case of navigation and fish collection in the daily activities of that fisherman. The idea of using these water hyacinths in processed nutritious fish feed creates interest among the people of that area. If it is possible, then excessive water hyacinth can be used and controlled without causing any negative impact on the environment and the peoples of that area will be benefited also.

Occupation of the respondents

Different types of people have different professions or occupations living in those three villages nearer the Roa beel. From upper class to lower class people lived here for example doctors, engineers, teachers, rickshaw-pullers, laborers, fishermen, farmers, businessmen, and so on. To know about the occupation of the respondents, it was divided into five categories for example farmer, fisherman, businessman, laborer, and others. After sorting out the information in the questionnaire it is found that there was an equal number of fishermen in each village. Most of the respondents were farmers where the highest number was found in Purbo Para and the lowest was in Modinas Para. In the case of the business profession, there were highest in Modinas Para and lowest in both Sheker Para and Purbo Para. Again, in the labor profession, there were the highest in Sheker Para and the lowest was in both Purbo and

Modinas Para. There were a little number of other professional people out there. (Figure 2).

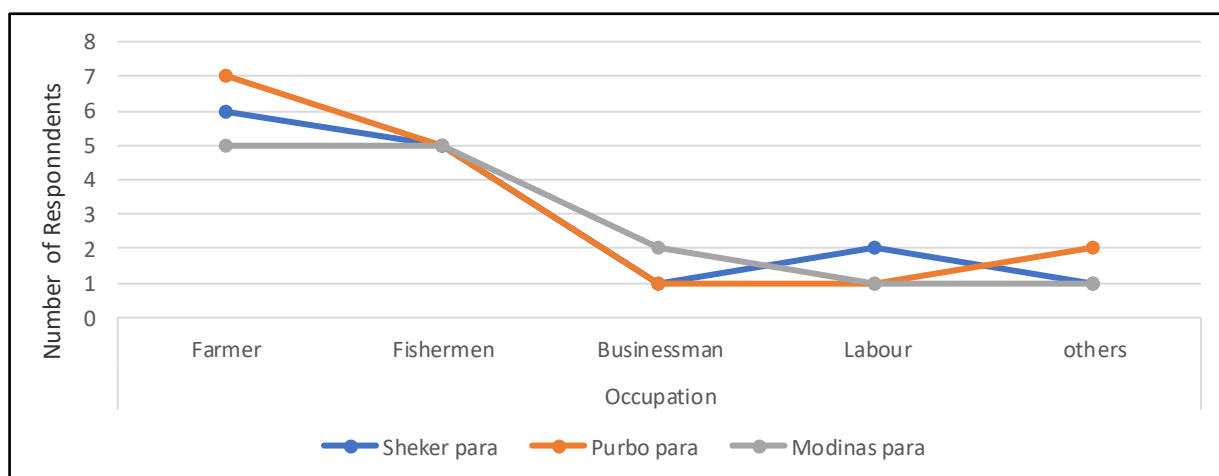


Figure 2. Occupation of the respondents (Source- Field data).

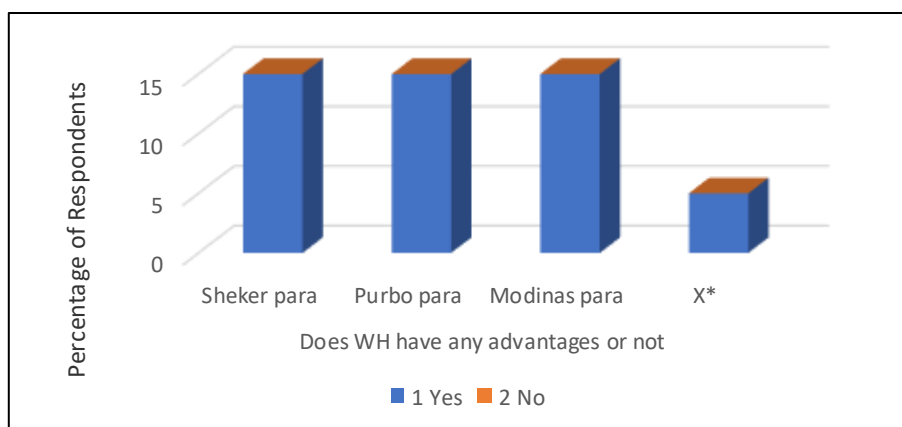


Figure 3. Whether there is any advantage of water hyacinth or not (Source- Field data) X*→ Extra 5 male interviewer.

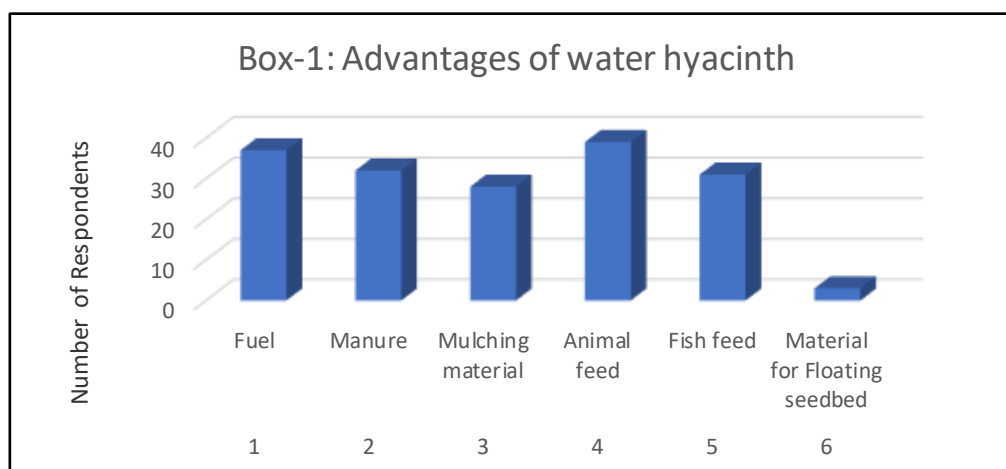


Figure 4. Advantages of Water Hyacinth (Source- Field Data).

Advantage of Water Hyacinth

Respondents were asked if they believed that water hyacinth had any advantages. The material was sorted into two categories: yes or no answers. Every respondent, including the additional five interviews, selected the "yes" response, indicating that water hyacinths offer benefits (Figure 3).

Additionally, respondents were prompted to share their opinions on any potential local applications for water hyacinth. All of them expressed their individual perspectives, but after grouping them, it was discovered that the majority of respondents claimed that water hyacinth



is primarily used as animal feed and fuel in their areas. Additionally, they included several other significant uses, such as manure, mulching materials, and fish feed. Again, only a small number of responders mentioned using water hyacinth to prepare floating seedbeds (Figure 4).

In the studied locations, water hyacinth is frequently used as mulch and fuel. People in those regions gather water hyacinth, dry it up in the sun, then pile it up and use it as fuel. Additionally, they use these dried water hyacinths as mulch for other crops, such as potato and tomato. (Figure 5).



Figure 5. Use of water hyacinth as mulching material and fuel.

Disadvantage of Water Hyacinth

Respondents perceived water hyacinth as a problematic plant with invasive characteristics. The majority of them perceived it as an obstacle to their different socio-economic activities such as create problems in crop and fish production. They also added water transport or navigation problems, difficulties in catching fish and a few said about water pollution because of water hyacinth consequently (Figure 6).

Management System of Water Hyacinth

All the respondents including extra 5 interviewees selected the option of indigenous method while none of the respondent had any idea about advance technologies like the technology to control/eliminate water hyacinth is physical, biological, and chemical or a combination of the three (Nastiti *et al.*, 2020). They also added that water hyacinth mostly managed in their villages by using bamboo sticks and ropes, even some of them indicated about the use of small hand net for the management of water hyacinth in their areas (Table 1).

Use of water hyacinth as nutritious fish feed

All the respondents came up with positive option, there was none with negative option. They had shown their highest interest about use of nutritious fish feed made by water hyacinth (Table 2).

Respondents Involvement in Livestock and Poultry Rearing

To know the respondent's involvement in livestock and poultry rearing there were four categories as cattle, poultry, both and none. Majority of the respondents having poultry like duck, chicken, pigeon etc. in their house where maximum number found in Sheker Para and minimum in Modinas Para. After that, maximum respondent having cattle as cow, goat, sheep etc. in their house where highest number found in Sheker Para and lowest in Modinas Para. Many respondents have both cattle and poultry while some of them have none of these two. Maximum number of respondents having both cattle and poultry found in Purbo Para and minimum found in Sheker Para. Again, maximum respondents having none of them found in Modinas Para and minimum in both Sheker Para and Purbo Para (Figure 7).

Use of Water Hyacinth as Animal Feed and Main Problem related to Animal Feed

In many places, water hyacinth is used as a popular animal feed. We wanted to know the use of water hyacinth as animal fodder in specific research regions. The majority of respondents provided positive responses, where Purbo Para having the most and Modinas Para having the lowest number of responders. There were also some respondents who provided unfavorable responses, with the biggest negative responses appearing in Modinas Para and the smallest in Purbo Para.

To know about the main problems related to water hyacinth as animal in those areas, we have divided it was divided into four categories as high price, low price, available and not available. Most of the respondents indicated in high price where highest respondent number found in Modinas Para and lowest in Sheker Para and a little found in not available problem where maximum respondents found in Sheker Para and minimum in Modinas Para but there were none found indicating low price or available options. That means in those study areas, price of animal feed is very high and also not so available (Figure 8).

Use of water hyacinth as cattle feed

Water hyacinth can also be used to make inexpensive, highly nutritious poultry feed. Additionally, water hyacinth can be served to animals raw, ensiled, or wilted. Both the livestock and poultry industries can use whole, chopped, or ground plants as feeds. Again, the respondents were provided two choices of yes or no to gauge their reaction to the question of whether they would utilize inexpensive livestock and poultry feed made from water hyacinth for their animals or poultry. In this instance, the majority had responded favorably; the Purbo Para contained the entire

response, and the Sheker Para contained the minimal response. And only a small percentage of respondents provided a negative response because they had no interest in these issues and better financial standing than others. The Sheker Para received the most negative responses, while the Modinas Para received the fewest, but the Purbo Para received none at all (Figure 9).

Use of Water Hyacinth in Household Activities

All of the respondents provided their own views and opinions when questioned about the potential applications of water hyacinth in domestic tasks. By categorizing their responses and points of view, it was found that the majority of them claimed that water hyacinth was mostly used as fuel for their domestic chores. They also mentioned that during the off-season, they collected water hyacinth, dried them in the sun, piled them up, and eventually used them as fuel. They added that in their home, water hyacinth was utilized as animal feed for animals including cows, turkeys, and chickens. A few survey participants claimed that water hyacinths maintain plants' ability to retain water, thus they employed them as mulch in their homestead gardening grounds (Figure 10).

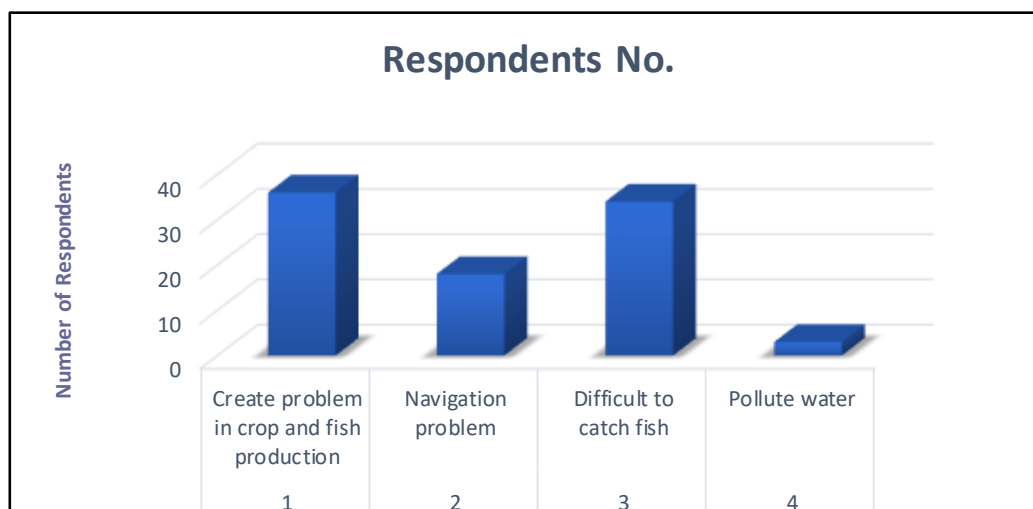


Figure 6. Disadvantages of water hyacinth (Source-Field Data)

Table 1. Management of water hyacinth in study areas.

SL	Village	Management of water hyacinth (%)	
		Indigenous system	Modern system
1	Sheker para	100	0
2	Purbo para	100	0
3	Modinas para	100	0
4	X*	100	0

Table 2. Participant's response on using water hyacinth as nutritious fish feed.

SL	Villages	People's interest in use of WH as nutritious fish feed (%)	
		Yes	No
1	Sheker para	100	0
2	Purbo para	100	0
3	Modinas para	100	0

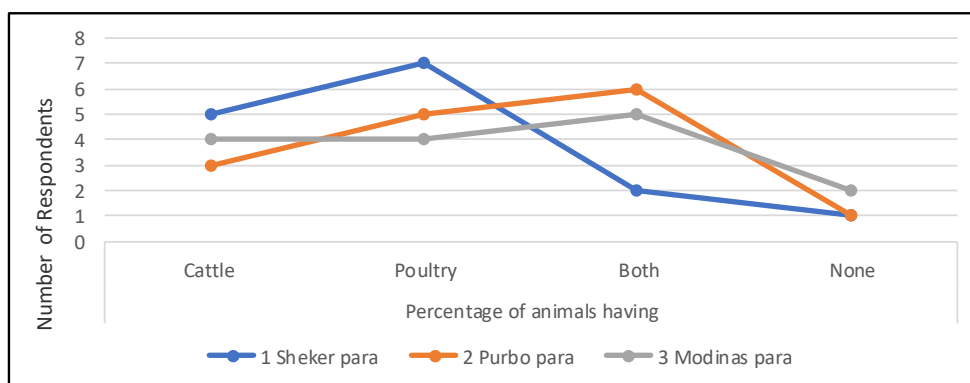


Figure 7. Respondents Involvement in Livestock and Poultry Rearing (Source- Field Data)

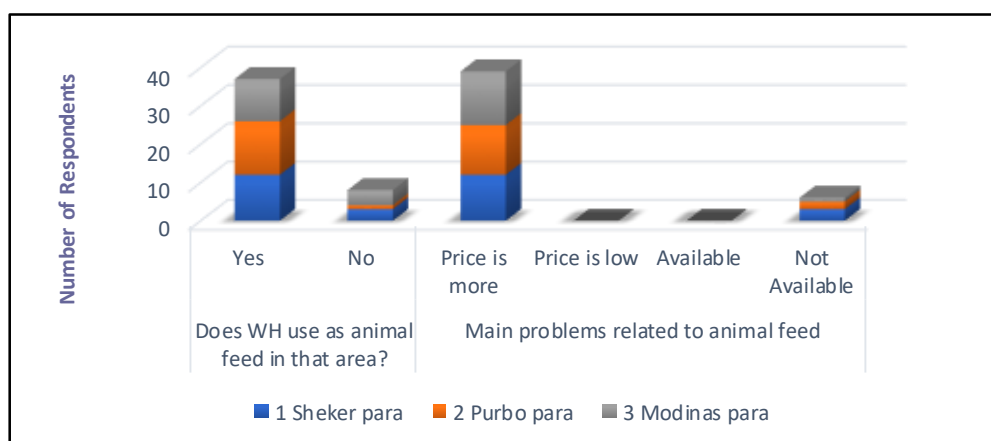


Figure 8. Use of Water Hyacinth as Animal Feed and Main Problem related to Animal Feed (Source-Field Data).

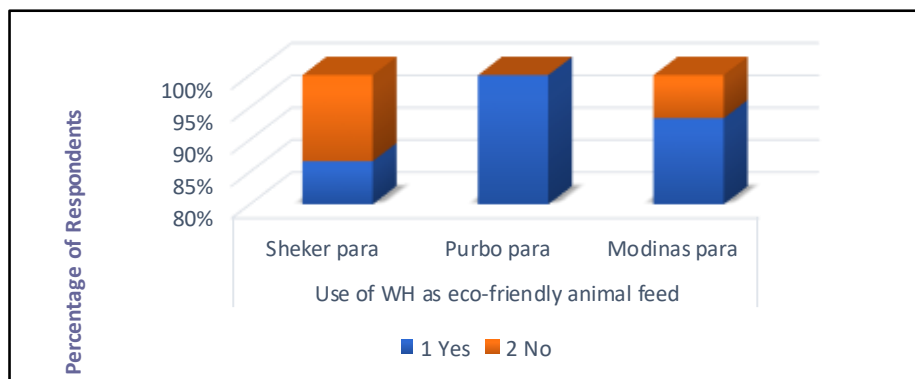


Figure 9. Interest of Respondents in Using Low-Cost Livestock and Poultry Feed Prepared by Using Water Hyacinth.

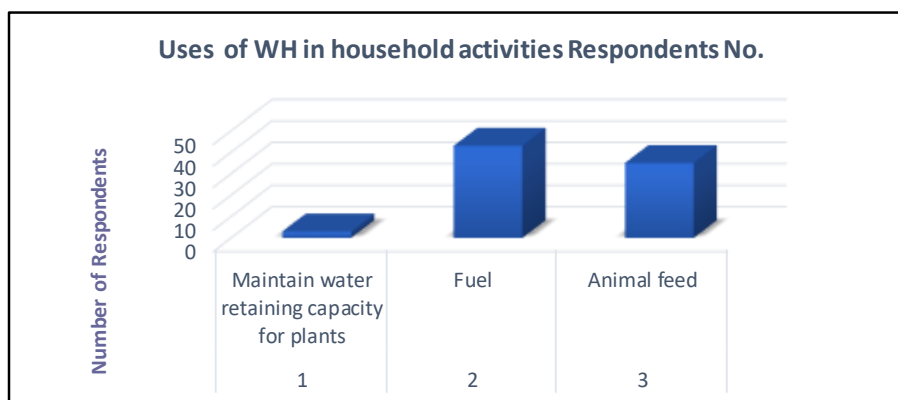


Figure 10. Uses of Water Hyacinth in household activities.

Use of Water Hyacinth as Handicraft and Biogas

Nowadays excessive water hyacinth that were considered as waste material are using as resources in many sectors. In many developing countries water hyacinth is used in making handicrafts like hand bags, baskets, mats, furniture, papers and many other things. To know whether water hyacinth is used as handicraft in the study area or not, people were asked question on it and gave them yes and no option to answer. Majority of them came up with negative reaction saying that they did not know about it. Very few respondents said that they had heard about it but it was not found in those areas.

Respondents were also asked about their perceptions if low-cost and eco-friendly biogas prepared by using water hyacinth, would they use it in their daily household fire activities or not. All most all of the respondents gave positive reaction where a very negligible number of respondents did not show their interest in using it as biogas for their household (Table 3).

Effect of Water Hyacinth on Water for Irrigation Purpose

Again, their responses were sought in whether there was any problem occurred in irrigation for water hyacinth or not and gave them three options of yes, no and not sure to answer. Majority of them agreed to this opinion by saying yes where highest respondent number found in Purbo Para and lowest was in Modinas Para. Then highest respondent found with negative reaction by saying no in Modinas Para and lowest was in Purbo Para. Other respondents were not sure about this fact because of lack of knowledge (Figure 11).

Water Hyacinth as a Prospect for Floating Agriculture

Some parts of Bangladesh are mostly affected by flood where water remains for a prolonged period of time. In those areas, farmers are using their submerged lands for crop production by adopting scientific methods which are similar to hydroponic agriculture practices, i.e., floating agriculture, whereby plants can be grown on the water in a bio-land or floating bed of water hyacinth, algae or other plant residues.

A respondent of Purbo para mentioned that, *"At rainy season, when the level of water is high, we cannot do any farming. But at this time, some of us collect water hyacinth and mix them with mud, straw etc. to make small sized bed, where we can produce rice seedlings and vegetables."*

Many people from other areas who are also affected by excessive water hyacinth at rainy season, are not using water hyacinth for floating agriculture. Because of lack of knowledge, they are not aware of this fact. Another respondent from Sheker para said that, *"We didn't practice floating agriculture before. We have seen some people to do so but we do not know how to do it. If we get any training or other facilities then we definitely will practice it."*

If it is possible to provide training and other campaigns to make them aware and let them know about the procedure of floating agriculture, then it will be possible to increase farming at the rainy or flooding season.

Water Hyacinth as Bio-fertilizer

Additionally, respondents were asked if they would utilize low-cost environmentally friendly bio-fertilizer made from water hyacinth in their farming activities. A very small percentage of respondents did not express interest in using it as bio-fertilizer, but the majority of respondents responded favorably by giving positive response (Table 6).

Water Hyacinth can be a Potential and Promising Sector in Industrial Purpose

As water hyacinth can be used as biogas, bio-fertilizer, livestock and poultry feed, it is possible to use these in a broad spectrum; contributing to the economy by creating employment opportunities for local unemployed people. A key informant from Modinas para stated that, *"We are very much interested in using water hyacinth as bio-fertilizer, livestock and poultry feed. We can do business if it is possible to process water hyacinth into these products. We expect assistance of Govt. or other organization to take initiative to process them properly and help us to start business related to these."*

As a consequence, water hyacinth can be used as a source of biogas, bio-fertilizer, livestock and poultry feed. It seems to be a potential and promising sector helping rural people's livelihood and economy.

CONCLUSION

From the study findings established that excessive amount of water hyacinth of the beel can be developed into a potential and promising sector for the locality especially by making water hyacinth into low cost and environment friendly animal feed, bio-fertilizer and biogas; that will definitely help in sustainable environment management and will also create a better income generating opportunity for the local unemployed people. This study revealed local people are interested on these uses of water hyacinth. It is possible to turn nuisance water hyacinth as useful products like bio-fertilizer, biogas, handicrafts, livestock and poultry feed without harming the environment, at the same time handling huge amount of this waste material.

Conflict of Interest

There is no conflict of interest to declare.

REFERENCES

- Bartodziej, W.I.L.L.I.A.M. and Weymouth, G., 1995. Waterbird abundance and activity on waterhyacinth and egeria in the St. Marks River, Florida. *Journal of Aquatic Plant Management*, 33, pp.19-22.
- Brendonck, L., Maes, J., Rommens, W., Dekeza, N., Nhiwatiwa, T., Barson, M., Callebaut, V., Phiri, C., Moreau, K., Gratwicke, B. and Stevens, M., 2003. The impact of water hyacinth (*Eichhornia crassipes*) in a eutrophic subtropical impoundment (Lake Chivero, Zimbabwe). II. Species diversity. *Archiv Fur Hydrobiologie*, 158(3), pp.389-405.

- Labrada, R. and Fornasari, I., 2002. Management of problematic aquatic weeds in Africa. FAO efforts and achievements during the period 1991-2001.
- Gopal, B., 1987. *Water hyacinth*. Elsevier Science Publishers.
- Jimenez, M.M. and Balandra, M.A.G., 2007. Integrated control of *Eichhornia crassipes* by using insects and plant pathogens in Mexico. *Crop Protection*, 26(8), pp.1234-1238.
- Mauremootoo, J. and Boudjelas, S., 2003. The Work of the IUCN in Invasive Species Management. *Invasive Alien Species and Terrestrial Ecosystem Rehabilitation in Western Indian Ocean Island States*, p.11.
- Ministry of Bangladesh (2022). Bangladesh National Information Window- Katiadia Upazila, (<http://katiadi.kishoreganj.gov.bd/>), accessed in 24th January, 2023.
- Nastiti, A.S., Suryandari, A. and Haryadi, J., 2020, June. *Eichhornia crassipes* aquatic plant management technology for water resources enhancement. In IOP Conference Series: Earth and Environmental Science (Vol. 521, No. 1, p. 012011). IOP Publishing.
- Lu, J., Wu, J., Fu, Z. and Zhu, L., 2007. Water hyacinth in China: a sustainability science-based management framework. *Environmental management*, 40, pp.823-830.
- Olive, M.M. and Abel, G.M., 2003. Research Methods, Quantitative and Qualitative Approaches. Nairobi. *Africa Center for Technology Studies*.
- Patel, S., 2012. Threats, management and envisaged utilizations of aquatic weed *Eichhornia crassipes*: an overview. *Reviews in Environmental Science and Bio/Technology*, 11, pp.249-259.
- Simberloff, D. and Rejmánek, M. eds., 2011. *Encyclopedia of biological invasions* (No. 3). Univ of California Press.
- Téllez, T.R., López, E.M.D.R., Granado, G.L., Pérez, E.A., López, R.M. and Guzmán, J.M.S., 2008. The water hyacinth, *Eichhornia crassipes*: an invasive plant in the Guadiana River Basin (Spain). *Aquatic Invasions*, 3(1), pp.42-53.
- Villamagna, A.M., 2009. *Ecological effects of water hyacinth (Eichhornia crassipes) on Lake Chapala, Mexico* (Doctoral dissertation, Virginia Tech).
- Williams, A.E., Hecky, R.E. and Duthie, H.C., 2007. Water hyacinth decline across Lake Victoria—Was it caused by climatic perturbation or biological control? A reply. *Aquatic Botany*, 87(1), pp.94-96.
- ZHANG, Y.Y., ZHANG, D.Y. and Barrett, S.C., 2010. Genetic uniformity characterizes the invasive spread of water hyacinth (*Eichhornia crassipes*), a clonal aquatic plant. *Molecular ecology*, 19(9), pp.1774-1786.
- বাংলাদেশ (Bangladesh) জাতীয় তথ্য বাতায়ন: গণপ্রজাতন্ত্রী বাংলাদেশ সরকার: People's republic of Bangladesh 2023. বাংলাদেশ (Bangladesh) জাতীয় তথ্য বাতায়ন | গণপ্রজাতন্ত্রী বাংলাদেশ সরকার | People's Republic of Bangladesh. Available at: <https://bangladesh.gov.bd/index.php> (Accessed: March 12, 2023).

