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# Assessing Aquatic Plant Diversity and Management Potential in Wetlands in Northwestern and Southwestern Bangladesh

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## ABSTRACT

Aquatic plants are essential organisms for assessing ecological health and for managing and conserving aquatic biodiversity. The present study investigated the diversity of aquatic flora, in addition to their applications and management, in northwestern (Gajner Beel) and southwestern (Padma Beel) Bangladesh. This research utilized a mixed-methods approach, incorporating observation of the study area for collecting samples, qualitative interviews, and quantitative surveys. A total of 38 aquatic plant species of 4 types belonging to 16 orders and 23 families were recorded from the two wetlands. Asterales was the predominant order in both wetlands, with Araceae and Asteraceae being the largest families. Almost half (44%) of the aquatic plants in both ecosystems bloomed during the rainy season. In Gajner Beel and Padma Beel, 41% and 48% of aquatic plants, respectively, rarely occurred, while 31% and 41% of aquatic weeds were frequent, respectively. Approximately a quarter of the plants have an unevaluated IUCN conservation status, with about 13% of plants in Gajner Beel and 15% in Padma Beel being exotic. Farmers only employ manual or mechanical techniques to control common aquatic weeds, without any preventive measures. About 74% of the aquatic plants in both regions are used for various purposes by local people, including traditional medicine, human food, animal feed, raw materials for handicrafts, and fertilizers. The study examined management approaches for the aquatic flora in both regions, emphasizing their potential utilization.

## HIGHLIGHTS

This study recorded 38 aquatic plants (16 orders, 23 families) in two wetlands. Asterales was the dominant order; Araceae and Asteraceae were the richest families. 44% of species bloomed in the rainy season, while 13-15% were exotic. Management and control relied only on manual/mechanical methods. 74% of the species were used by locals for diverse applications.

## 1. INTRODUCTION

Wetlands are vital ecosystems that link people, life, and climate through mutual interactions (Maltby, 2009). They provide key environmental and ecological services (Schuyt, 2005), supported by their functionality. Aquatic and riparian vegetation are especially important for wetland structure, function, and service provision (Chambers et al., 2008). The symbiotic relationships between wetlands and aquatic flora yield substantial benefits for both the environment and human communities. Wetlands provide habitat for aquatic plants, which sustain ecosystem health by offering food, shelter, and breeding grounds for aquatic species (Kevin and Lancar, 2002). They also engage with a varied spectrum of other organisms, from microbes to vertebrates, by providing shelter and sustenance (Engelhardt and Ritchie, 2001; Wood et al., 2017). Furthermore, they facilitate the transport of nutrients into sediments and influence the hydrological,

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geomorphological, and physicochemical environments (Paul, 2022). In a different context, certain aquatic plants are classified as aquatic weeds, which are hazardous or unattractive species proliferating in aquatic environments where they are undesirable (Aloo et al., 2013). These aquatic weeds affect water bodies, leading to serious ecological and economic losses by affecting fisheries, impairing water quality and degrading floodplain farmland. Nonetheless, the extensive adaptability to diverse water levels and the inability to differentiate their natural habitat between aquatic and terrestrial contexts complicates the precise definition of an aquatic weed (Aloo et al., 2013). However, various major factors have compromised the diversity of aquatic plant populations, including the overexploitation of resources, water pollution, siltation, alterations in water flow such as abstraction, habitat destruction or degradation, and the invasion of alien species (Dudgeon et al., 2006; Schuyt, 2005; Sonal et al., 2010).

Gajner Beel (GB) and Padma Beel (PB) are two of the most significant wetlands found in the northwest and southwest regions of Bangladesh, respectively. These waterbodies are locally known as Beels, which are characterized by high biological diversity. Beels can be defined as a large surface water system that holds water from surface runoff through an internal drainage channel, usually starting with topographic lows produced by erosion (Banglapedia, 2012). The GB functions as a spawning and feeding ground for a number of fish species (Rahman et al., 2024). PB is popularly known as Bhutia Padma Beel, which is renowned for its fish and tourism attractions. This study selected these two ecosystems due to their geographical and topological distinctions.

The aquatic plants act as a useful bioindicator of ecological health owing to their high level of sensitivity to pollution (Lacoul and Freedman, 2006). They also serve as model organisms of the ecological cycle and play a significant role in alleviating eutrophication and carbon sequestration to mitigate climate change (Bao et al., 2022). To develop effective management plans, a proper listing of aquatic plants for a specific region is essential. These lists are also mandatory to prepare an environmental impact assessment and fulfill permit requirements (McKinley et al., 2017). In addition, management of aquatic weeds is one of the most important aspects of managing ponds (Giri, 2020). Thus, understanding aquatic plants and their roles in ecosystems helps effectively manage these, ensure the maximum yield, and maintain sustainability (Wilk-Woźniak et al., 2019). The application of modern control methods can effectively utilize aquatic weeds. However, research on aquatic plants focusing on their sustainable utilization is notably limited in Bangladesh. This study aimed to evaluate the species diversity in aquatic plants, compare compositional variations between two wetlands in Bangladesh, and suggest sustainable management strategies for aquatic plants.

## 2. METHODOLOGY

### 2.1 Study area

The study examined two wetlands in distinct agroecological zones of Bangladesh: Gajner Beel (northwestern region) at the Ganges floodplain confluence with silt loam to clay soils, and Padma Beel (southwestern region) with acidic, peat-underlain grey clays (Figure 1). The study area had three identified seasons: hot pre-monsoon/summer (March-May), wet monsoon (June-October), and cold, dry winter (November-February). Temperature in Pabna (8.4-34.3°C) and Khulna (12.0-34.8°C) peaked in April and was lowest in January. Monthly rainfall ranged from 8.1-335.6 mm in Pabna and 13.3-344.4 mm in Khulna, with July being the wettest month and January the driest (BMD, 2012). GB covers 5.54 ha with a mean depth of 135±36.34 cm and transparency of 102±21.52 cm, while PB spans 26.46 ha, with a mean depth of 172±34.65 cm and transparency of 78±13.65 cm.

### 2.2 Aquatic plant sampling and analysis

The survey was conducted from March 2022 to February 2023 across 24 sites (12 per wetland), each covering 5,000 m². Using a randomized design, the study applied a semi-quantitative method, assessing preselected locations via presence/absence appraoch to determine species frequency (Madsen and Wersal, 2017). Subjective evaluations of submerged plants were conducted by observers using plant rakes. The semiquantitative method was selected due to its lower effort and cost compared to other plant sampling methods and, its ability to regulate variability (Madsen and Wersal, 2017).

### 2.3 Identification of species and analysis

Visual inspection was used to identify aquatic weed samples, referencing studies by Journey et al. (1993), Pasha and Uddin (2013), Basar and Rahman (2023), and Kevin and Lancar (2002). The

Encyclopedia of Flora and Fauna of Bangladesh (Ahmed et al., 2008) was investigated, and recent nomenclature was cross-checked using Pasha and Uddin (2013). Origin and conservation status were assigned in accordance with the IUCN (2024) Red List categories.

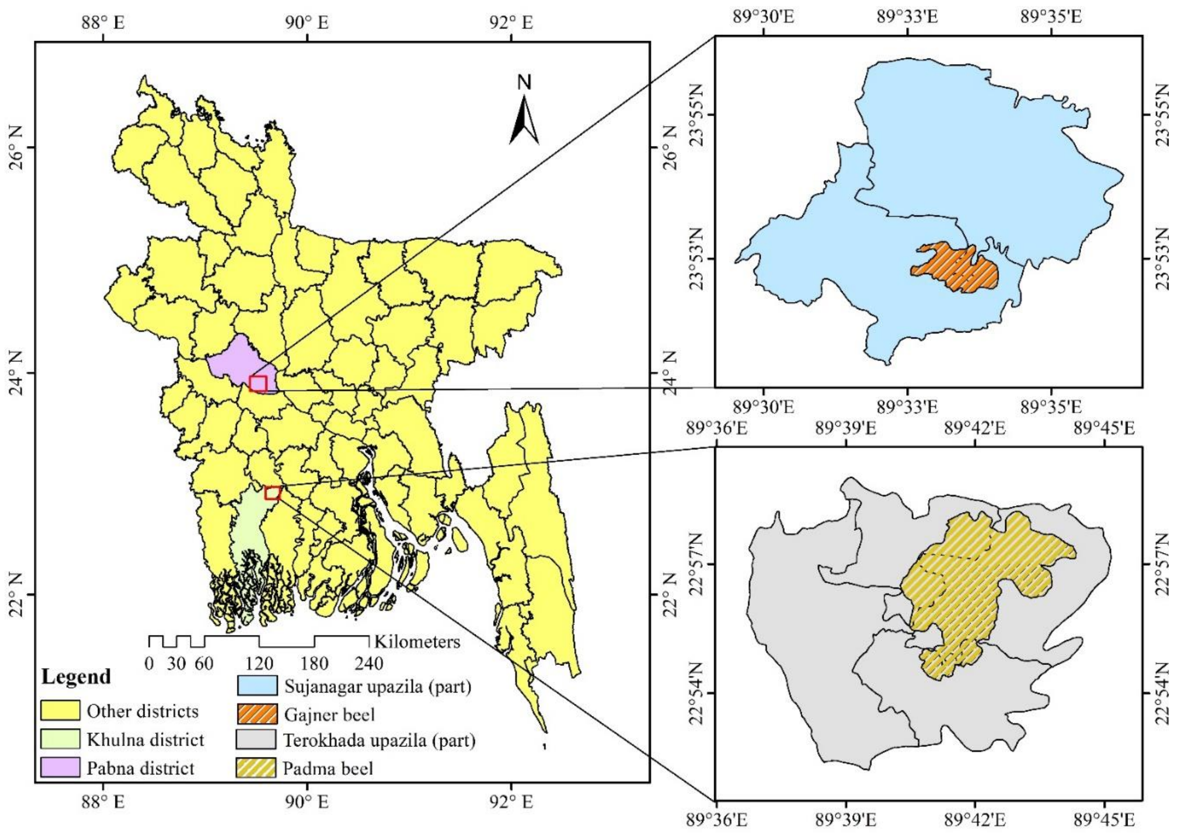


**Figure 1.** Map indicating the location of Gajner Beel and Padma Beel

The relative frequency of the aquatic plants was determined as follows:

$$F(\%) = [n/N] \times 100$$

Here; F(%)=frequency of aquatic plants; n=frequency of aquatic plants and N=total number of sites.

The frequency of occurrence was categorized as, Frequent=>50%; Moderate=25-50%; Rare=<25%. The Jaccard's similarity index (JSI) (Jaccard, 1912) and Sorensen's similarity index (SSI) (Sorensen, 1948) were determined as follows.

$$\text{Jaccard's similarity index (JSI): } S_j = \frac{a}{a+b+c}$$

$$\text{Sorensen's similarity index (SSI): } S_s = \frac{2a}{2a+b+c}$$

Here; a=number of common aquatic plants in GB and PB; c=number of aquatic plants in GB (site A); b=number of aquatic plants in PB (site B).

### 2.4 Data obtained from PRA tools

This study employed a mixed-methods approach, combining observation, interviews, and surveys. Data on aquatic macrophytes (local names, uses, seasonal availability, and management) were collected through interviews with 20 locals (15 men, 5 women) from diverse backgrounds (fishermen, farmers, ayurvedic practitioners, vegetable salesmen, and homemakers). A focus group discussion (FGD) with 10 people (experts and community leaders) was held in each region, along with 5 key informant interviews for data validation.

### 2.5 Statistical analysis

All qualitative and quantitative data were carefully collected and organized using MS Word and MS Excel 2019. Data were further analyzed using R and RStudio software. The map of the study area was generated using ArcGIS software (Version 10.8).

## 3. RESULTS

The study recorded 38 aquatic plant species (16 orders, 23 families) across both wetlands (GB and PB), with 21 species common between them (Table 1). Among the plants, Alismatales was documented as the most dominant order in both beels, followed by Poales (Figure 2), while Araceae and Asteraceae were the most abundant families (Figure 3).

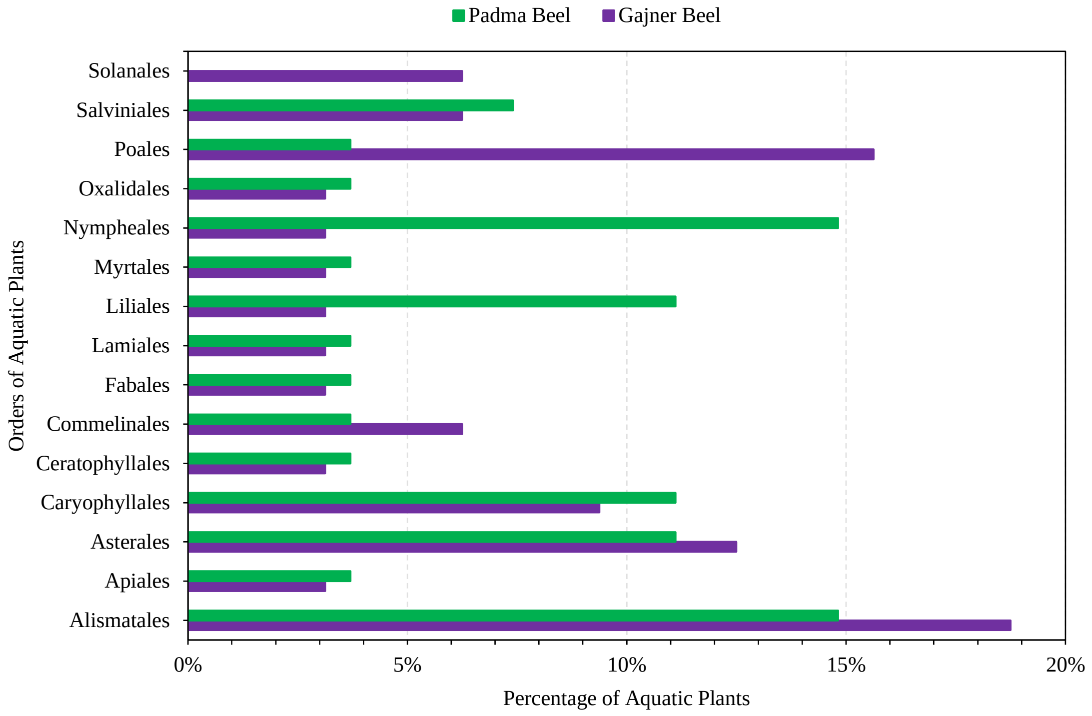


**Figure 2.** Orders of aquatic plants (%) recorded in northwestern (GB) and southwestern (PB) Bangladesh

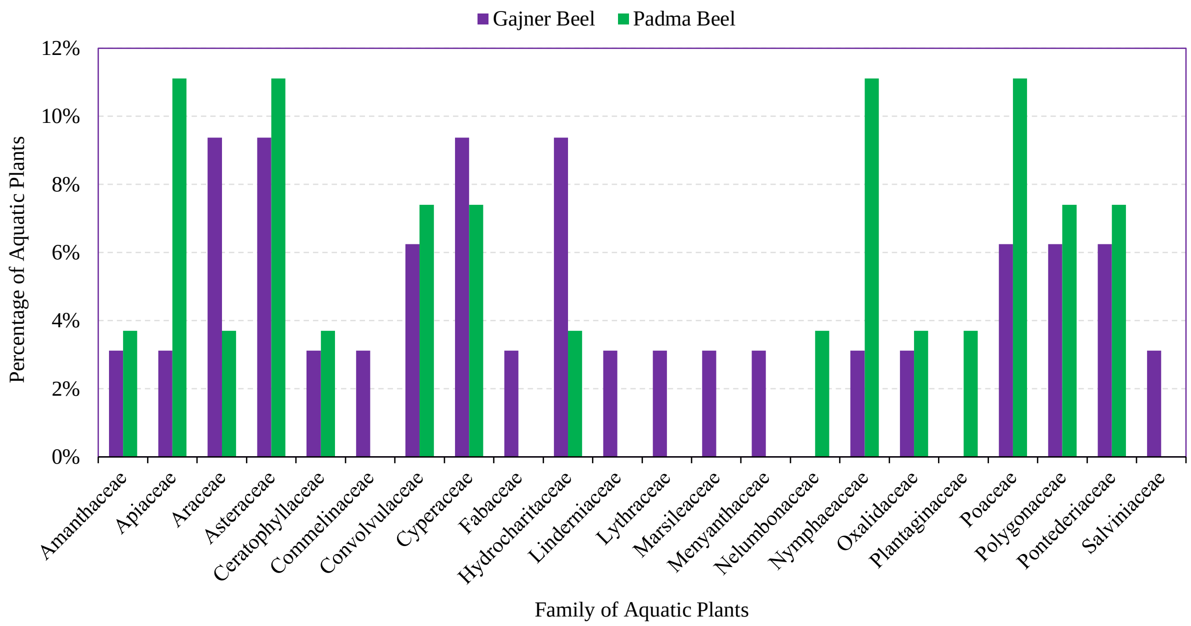


**Figure 3.** Families of aquatic plants (%) recorded in northwestern (GB) and southwestern (PB) Bangladesh

**Table 1.** List of aquatic macrophytes of northwestern and southwestern Bangladesh (GB and PB)

| Order | Family | Local name | Common name | Scientific name | Types | Frequency | | Availability | Origin | Con. Stat. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | GB | PB | | | |
| Aquatic weeds recorded both in GB and PB: | | | | | | | | | | |
| Alismatales | Araceae | Topapana | Water lettuce | *Pistia stratiotes* | FF | F | F | AS | N | LC |
| | | Kachu | Chinese Potato | *Colocasia esculenta* | EM | F | F | AS | N | LC |
| | | Sonapana | Common duckweed | *Spirodela polyrhiza* | FF | R | R | AS | N | LC |
| | Hydrocharitaceae | Pata jhanji | Eel-grass | *Vallisneria spiralis* | SU | R | R | SS | N | LC |
| Asterales | Asteraceae | Helencha | Water cress | *Enhydra fluctuans* | EM | F | F | RS | N(1) | NE |
| | | Kesuti | False daisy | *Eclipta prostrata* | EM | R | R | AS | N | LC |
| | | Nak ful | Indian lilac | *Acmella paniculata* | EM | M | R | RS | N | LC |
| Commelinales | Pontederiaceae | Kachuripana | Water hyacinth | *Pontederia crassipes* | FF | F | F | AS | E(2) | NE |
| Caryophyllales | Amanthaceae | Malancha | Alligator weed | *Alternanthera philoxeroides* | EM | F | F | SS | E(3) | NE |
| | Polygonaceae | Redshank | Knotgrass | *Polygonum barbatum* | EM | M | R | SS | N | LC |
| | | Bishkatali | Polygonum | *Polygonum glabrum* | EM | F | F | WS | N | LC |
| Ceratophyllales | Ceratophyllaceae | Kata jhanji/ Sheola | Con's tail | *Ceratophyllum demersum* | SU | M | R | RS | N | LC |
| Liliales | Pontederiaceae | Baranukha | Leaf pondweed | *Monochoria hastata* | FF | R | R | SS | N | LC |
| Nymphaeales | Nymphaeaceae | Shada shapla | Blue lotus | *Nymphaea nouchali* | RF | F | F | RS | N | LC |
| Oxalidales | Oxalidaceae | Amrool shak | Indian sord | *Oxalis corniculata* | EM | F | F | RS | U(4) | NE |
| Poales | Cyperaceae | Chechra | Bog bulrush | *Schoenoplectiella mucronata* | EM | M | M | RS | N | LC |
| | | Mutha | Nut grass/Coco-grass | *Cyperus rotundus* | EM | M | M | WS | N | LC |
| | Poaceae | Dol | Asian | *Hygroryza aristata* | EM | R | R | RS | N(5) | NE |
| Solanales | Convolvulaceae | Kolmi | Water spinach | *Ipomoea aquatica* | EM | F | F | AS | N | LC |
| | | Dhol kolmi | Bush morning glory | *Ipomoea fistulosa* | EM | M | M | RS | E(6) | NE |
| Salviniales | Salviniaceae | Kutipana | Mosquito fern | *Azolla pinnata* | FF | F | F | AS | N | LC |

NB.: FF-Free floating, RF-Rooted floating, EM-Emergent, SU-Submerged, M-Moderate, R-Rare, F-Frequent, AS-All Season, RS-Rainy Season-SS-Summer Season, WS-Winter Season, E-Exotic, N=Native, U-Unknown, LC =Least concern, NE-Not Evaluated, VU-Vulnerable, Con. Stat.- Conservation Status, [1](Ali et al., 2013); [2](Cherwoo et al., 2024); [3](Sosa et al., 2008); [4](Groom et al., 2019); [5](Ahmed et al., 2008); [6](Acevedo-Rodríguez and Strong, 2012); [7](Acharya et al., 2009); [8](ITIS, 2011)

**Table 1.** List of aquatic macrophytes of northwestern and southwestern Bangladesh (GB and PB) (cont.)

| Order | Family | Local name | Common name | Scientific name | Types | Frequency | | Availability | Origin | Con. Stat. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | GB | PB | | | |
| Aquatic weeds recorded only in GB: | | | | | | | | | | |
| Alismatales | Hydrocharitaceae | Najas | Brittle naiad | *Najas minor* | SU | | R | RS | N | LC |
| | | Hydrilla | Waterthyme | *Hydrilla verticillata* | SU | | R | RS | N | LC |
| Apiales | Apiaceae | Thankuni | Gotu kola | *Centella asiatica* | EM | | R | AS | N | LC |
| Asterales | Menyanthaceae | Chandmata | Crested floating heart | *Nymphoides cristata* | EM | | R | RS | N | LC |
| Commelinales | Commelinaceae | Kanaidoga | Asiatic dayflower | *Commelina appendiculata* | EM | | R | RS | N(7) | NE |
| Fabales | Fabaceae | Shola | Indian jointvetch | *Aeschynomene indica* | EM | | M | RS | N | LC |
| Lamiales | Linderniaceae | Chhoto helencha | Spamow false pimpernel | *Lindernia antipoda* | EM | | M | RS | N | LC |
| Myrtales | Lythraceae | Haincha | Yellow ammannia | *Ammannia pedicellata* | EM | | R | WS | E | VU |
| Poales | Cyperaceae | Kesur | Giant bulrush | *Scripus grossus* | EM | | R | WS | U | NE |
| | Poaceae | Arail | Swamp rice grass | *Leersia hexandra* | EM | | R | AS | N | LC |
| Salviniales | Marsileaceae | Shusnishak | Pepperwort | *Marsilea quadrifolia* | EM | | M | WS | N | LC |
| Aquatic weeds recorded only in PB: | | | | | | | | | | |
| Apiales | Araliaceae | Poicha lily | Lawn Marshpennywort | *Hydrocotyle sibthorpioides* | EM | R | | AS | N | LC |
| Lamiales | Plantaginaceae | Ambulla | Asian marsh weed | *Limnophila indica* | SU | R | | RS | N | LC |
| Nymphaeales | Nymphaeaceae | Lalshapla | Red water lily | *Nymphaea rubra* | RF | R | | RS | N | LC |
| | | Golapi Shapla | pink water lily | *Nymphaea pubescens* | RF | R | | RS | N | LC |
| Poales | Poaceae | Nolkhagra | Tall reed | *Phragmites karka* | EM | R | | AS | N | LC |
| Proteales | Nelumbonaceae | Poddo | Pink lotus | *Nelumbo nucifera* | RF | F | | RS | E(8) | NE |

NB.: FF-Free floating, RF-Rooted floating, EM-Emergent, SU-Submerged, M-Moderate, R-Rare, F-Frequent, AS-All Season, RS-Rainy Season-SS-Summer Season, WS-Winter Season, E-Exotic, N=Native, U-Unknown, LC =Least concern, NE-Not Evaluated, VU-Vulnerable, Con. Stat.- Conservation Status, [1](Ali et al., 2013); [2](Cherwoo et al., 2024); [3](Sosa et al., 2008); [4](Groom et al., 2019); [5](Ahmed et al., 2008); [6](Acevedo-Rodríguez and Strong, 2012); [7](Acharya et al., 2009); [8](ITIS, 2011)

Based on habitats, four types of aquatic plants have been found, and their percentage distributions are presented in Figure 4.

Most of the species were emergent aquatic plants, comprising 69% and 56%, respectively. In the present study, most aquatic plants (44%) grew during the rainy season in both ecosystems, followed by year-round (all seasons), summer, and winter seasons (Figure 5).

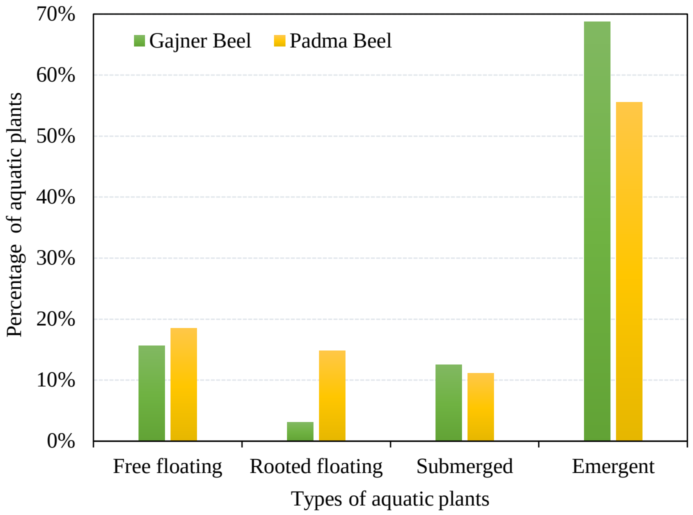


**Figure 4.** Types of aquatic plants (%) recorded in northwestern (GB) and southwestern (PB) Bangladesh

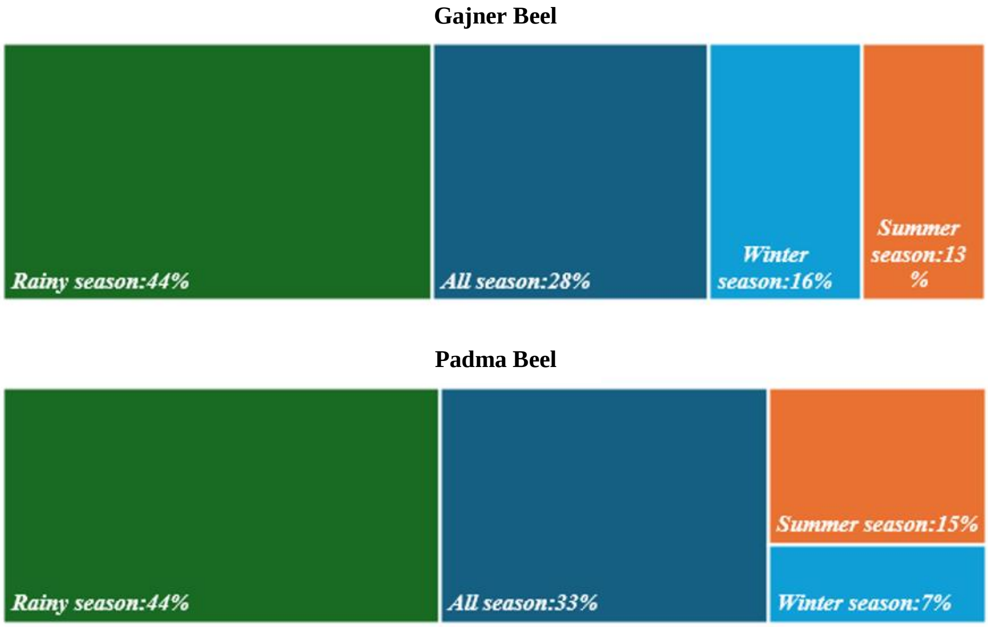


**Figure 5.** Seasonal availability of aquatic plants in northwestern (GB) and southwestern (PB) Bangladesh

In both ecosystems, most aquatic plants were rare, with 41% and 48% in GB and PB, respectively. 28% and 11% of aquatic macrophytes were classified as moderate, while 31% and 41% of aquatic weeds were frequently observed in GB and PB, respectively (Figure 6).

Figure 7 shows that native aquatic plants dominated (81%), followed by exotic species (13% in GB, 15% in PB). However, the origin of 6% and 4% of plants in GB and PB, respectively, was unknown. The conservation status, documented from the IUCN Red List, shows most aquatic plants represented as Least Concern (LC), accounting for 72% in GB and 74% in PB, respectively. In contrast, about a quarter of aquatic plants were classified as Not Evaluated (NE) in both wetlands. Only 3% of aquatic plants recorded in GB were vulnerable (Figure 8). The Jaccard's similarity value between the two ecosystems was 0.5526, and Sorensen's similarity index (SSI) was 0.71186.

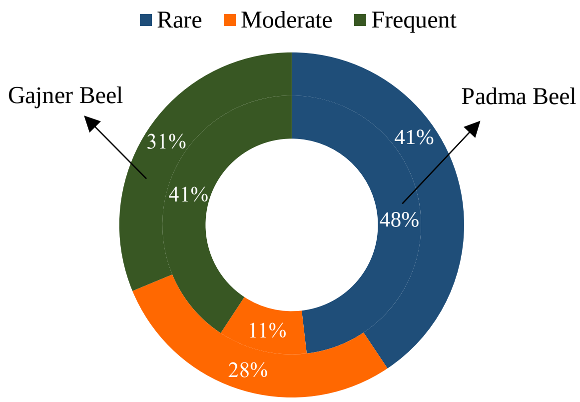


**Figure 6.** Frequency of occurrence of aquatic plants in northwestern (GB) and southwestern (PB) Bangladesh

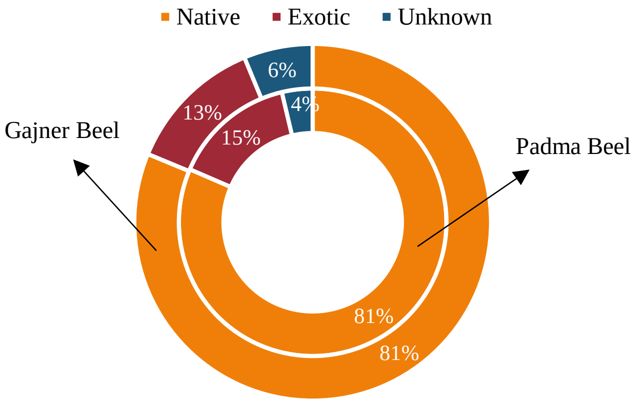


**Figure 7.** Origin of aquatic plants in northwestern (GB) and southwestern (PB) Bangladesh

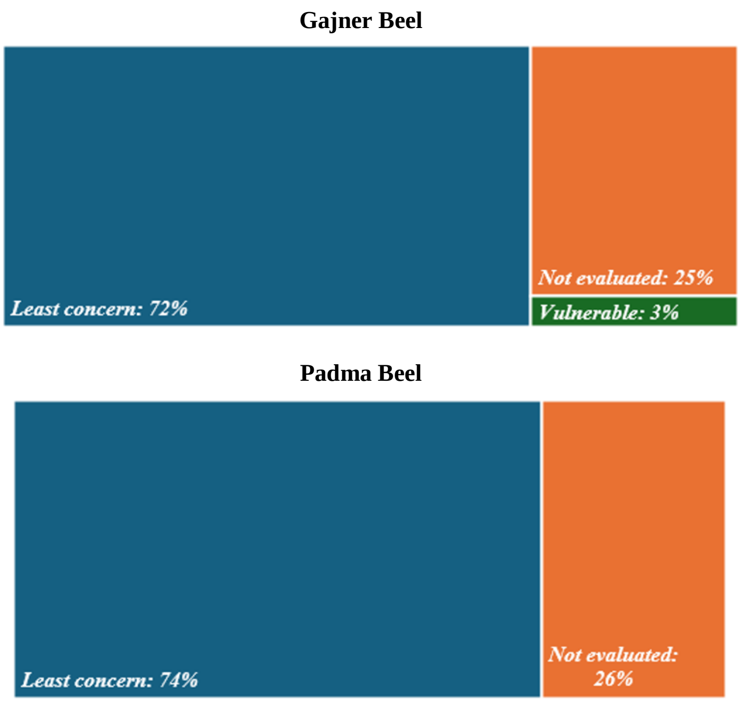


**Figure 8.** Conservation status of aquatic plants in northwestern (GB) and southwestern (PB) Bangladesh

No preventive measures were documented for the invasive aquatic plants in both regions. As a control measure for frequently available aquatic weeds, 94%, 3%, and 3% of the farmers followed manual/ mechanical, chemical and biological methods in GB. In contrast, only manual/mechanical (97%) and biological (3%) methods were used in PB. Eco-physiological approaches were not employed in any location. However, aquatic weeds found in both areas have several potential uses that have financial and environmental values (Figure 9). Figure 9 illustrates general methods of management of aquatic plants, prioritizing potential uses documented by the literature.

Twenty-eight aquatic plant species were documented as being used by communities, with similar utilization patterns observed across the study areas. Specifically, 21 species are used as traditional medicine (55%), while six are consumed as food (16%), four are provided as animal feed (11%), two are utilized as materials for handicrafts and fertilizers (5%), and five are used for other purposes (13%). In addition, 10 species (26%) in these regions remain untapped for any purpose (Table 2).

**Table 2.** Different uses of recorded aquatic plants in the northwestern (GB) and southwestern (PB) Bangladesh

| Upcycling potential | Species number | Percentage (%) |
|---|---|---|
| Medicine | 21 | 55 |
| Human food | 6 | 16 |
| Fodder | 4 | 11 |
| Handcraft materials | 2 | 5 |
| Fertilizers | 2 | 5 |
| Others | 5 | 13 |
| No use | 10 | 26 |

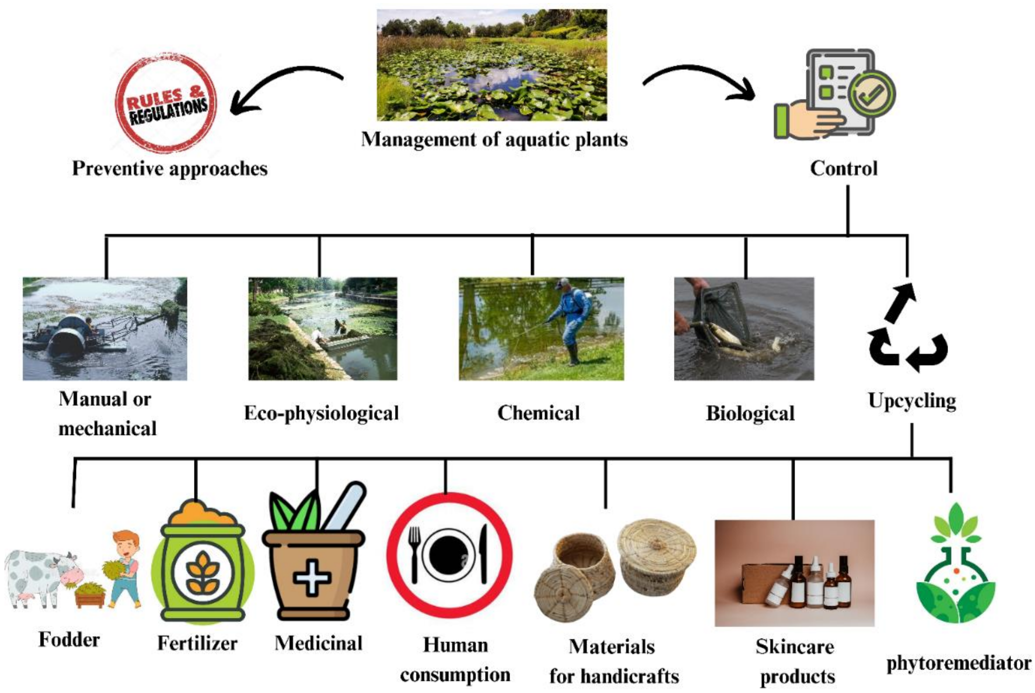


**Figure 9.** Schematic diagram of management of aquatic plants focusing on potential uses

Traditionally, 21 aquatic macrophyte species serve medicinal purposes for treating fever, jaundice, cough, wounds, snake bites, and food poisoning, administered raw, cooked, mashed, or liquefied. *Nymphaea nouchali* and *N. rubra* (Shapla) are consumed cooked or fried, while *A. philoxiroides* and *Centella asiatica* are prepared as vegetables. *Colocasia esculenta* is consumed fried/mashed, and *Nelumbo nucifera* seeds provide dietary protein. Several species (*Pistia stratiotes*, *Azolla pinnata*, *Spirodela polyrhiza*, *Hygroryza aristata*) serve as animal/fish feed, whereas *Pontederia crassipes* and *Schoenoplectiella mucronata* are crafted into mats, bags, boxes, and ropes. Agricultural applications include organic fertilizers (*P. stratiotes*, *Hydrilla verticillata*), floating beds (*A. pinnata*, *P. stratiotes*), and ornamental uses (*N. rubra*, *N. nucifera*).

## 4. DISCUSSION

This study documented 27 aquatic plant species in PB, fewer than the 32 recorded in GB. Other studies in Bangladesh, Rashid et al. (2014) documented 77 species (23 families) in the northwestern region, while Hossain et al. (2024) recorded 47 species (25 families) in the southeastern region, which supports the findings. However, Hasan et al. (2021) reported 23 species (15 families) in southwestern Bangladesh. There is not much data regarding the diversity and variation of aquatic plants in Bangladesh to compare. The observed variations are likely due to geographical differences, including soil composition, flood elevation, and hydrology (Rahaman et al., 2019; Wantzen and Junk, 2000).

Alismatales and Poales were the dominant orders in both wetlands, which is similar to the findings in southeastern Bangladesh (Hossain et al., 2024). Sultana et al. (2021) mentioned 50% emergent plant occurrence which is lower than our findings. The study highlighted the peak abundance during the rainy season. The observation is consistent with the result reported by Chowdhury and Ahmed (2012). Many plants were in the rare category, which is supported by the findings of Ame et al. (2022). Additionally, 72% of plants in GB and 74% in PB are classified as LC. A similar result has been recorded by Ashrafuzzaman et al. (2023), where 67.14% of plants were LC. In both ecosystems, about 25% plants are in the NE category, underscoring the necessity of studying the diversity and conservation status, focusing on the management of aquatic plants in Bangladesh. This study is the first of its kind and will form the baseline of future studies.

Effective invasive plant management requires either prevention, which demands comprehensive knowledge, or control, which often involves resource-intensive methods such as mechanical, chemical, or biological measures that lack scalability. Although eco-physiological approaches like habitat manipulation or allelopathy are promising (Gross, 2003; Inderjit and Duke, 2003), their implementation remains complex. As a result, current practices are predominantly manual. Upcycling could provide a sustainable alternative, generating both economic and ecological benefits. Upcycling aquatic plants means transforming undesired plant biomass into products like human food, fertilizer, therapeutics, cosmetics, handicraft materials, and phytoremediators, and thus contributes to renewable energy, sustainable agriculture, and water management (Ezzariai et al., 2021; Ansari et al., 2020; Mustafa and Hayder, 2021). Furthermore, the integration of these approaches into community-based management shifts invasive control towards proactive strategies, enhancing ecosystem health and local economic growth (Newaz and Rahman, 2019).

Among 38 aquatic plants studied, five are edible for humans with edible seeds, rhizomes, leaves, and petals. These are *Nymphaea nouchali*, *Nymphaea rubra*, *Colocasia esculenta*, *Alternanthera philoxeroides*, and *Nelumbo nucifera*, (Conard, 1905; Nahar et al., 2022; Jane et al., 1992; Temesgen and Retta, 2015). *Azolla pinnata*, *Colocasia esculenta*, *Hygroryza aristata*, *Pistia stratiotes*, and *Spirodela polyrhiza* demonstrate suitability as cost-effective feed alternatives for livestock and aquaculture, maintaining production efficiency (Babu et al., 2022; Mathur et al., 2013; Sudaryono, 2006; Fasakin et al., 1999; Ravindran et al., 1996).

The study recorded a total of 24 aquatic plant species that possess significant therapeutic potential. For example, *Pistia stratiotes* and *Enhydra fluctuans* exhibit diuretic and antimicrobial activities, respectively (Ali et al., 2013; Gupta and Prakash, 2014). Anti-cancer, antioxidant, antibacterial, and skin nourishing properties are evident in aquatic plants like *Eclipta prostrata* (Feng et al., 2019; Zhu, 2016), *Spirodela polyrhiza* (Lee et al., 2016), and *Marsilea quadrifolia* (Ripa et al., 2009). Several species displayed anti-diabetic (*Nymphaea rubra*, *Nymphaea pulescens*, *Nelumbo nucifera*) and anti-inflammatory (*Colocasia esculenta*, *Lindernia antipoda*) effects (Angadi et al., 2013; Ishrat et al., 2024; Phulera et al., 2014; Kaur et al., 2019; Sahare et al., 2023; Prajapati et al., 2011). Furthermore, hepatoprotection by *Centella asiatica* (Roy et al., 2013), antiparasitic action by *Cyperus rotundus* and *Polygonum glabrum* (Peerzada et al., 2015; Muddathir et al., 1987), and neuroprotection by *Ipomoea fistulosa* (Phulera et al., 2014) were evident. *Hydrocotyle sibthorpioides* exhibits anti-hepatitis-B activities (Huang et al., 2013).

Aquatic plants demonstrate other applications across multiple sectors. *Pontederia crassipes* offers sustainable alternatives for plastic-reducing handicrafts (Sierra-Carmona et al., 2022), while *Nymphaea rubra* and *Centella asiatica* hold cosmetic potential (Kamma et al., 2019; Hoque et al., 2023). Several species, including *Azolla pinnata*, *Hydrilla verticillata*, *Spirodela polyrhiza*, *Marsilea quadrifolia*, *Phragmites karka*, and *Ceratophyllum demersum*, effectively remove heavy metals (Jangwattana and Iwai, 2010; Ahmed et al., 2018;

Rahman et al., 2007; Rai, 2021; Singh et al., 2022; Qadri et al., 2022), with *Vallisneria spiralis* and *Leersia hexandra* aiding broader environmental remediation (Chen et al., 2022; Han et al., 2020). Beyond these uses, *Azolla pinnata* functions as a bioinsecticide (Ravi et al., 2020), *Hydrilla verticillata* enhances biogas production (Jain and Kalamdhad, 2018), *Colocasia esculenta* provides plastic alternatives (Briones et al., 2020), and *Scirpus grossus* mitigates noise pollution (Suhaeri et al., 2024).

Local communities of both Beels play a vital role in utilizing and managing aquatic plants, similar to global practices where wetlands provide essential resources for livelihood (FAO, 2019; Campos-Silva and Peres, 2016, Khan et al., 2022). The multiple uses of these plants, covering food security, traditional medicine and income generation, pave the way for achieving sustainability (Prasad et al., 2008; Wiart, 2017; World Bank, 2016) but are hindered by a lack of awareness, market access, and management (Gettys et al., 2014; King et al., 2021). Addressing the challenges, aligning with conservation strategies and collaboration among stakeholders will be key to ensuring sustainability in both ecological and economic aspects in the long run (FAO, 2019; King et al., 2021).

The study perfectly aligns with international conservation frameworks and strongly supports the Ramsar Convention (1971) and the Sustainable Development Goals (SDGs) 6, 13, 14, and 15 (UN, 2015), thus escalating the integrity of the ecosystem and sustainable use of the resources in changing climates. However, the lack of preventative measures against invasive species highlights the critical need for the enhancement of control mechanisms in Bangladesh, which will also support the aims of the Global Invasive Species Programme (GISP) (Meyerson et al., 2022). These findings promote eco-physiological approaches, upcycling invasive biomass, and community-based management for long-term wetland sustainability and resource management.

## 5. CONCLUSION

Despite their label as "aquatic weeds," it is essential to recognize the significance of native and beneficial aquatic flora. Although Bangladesh is rich in aquatic plants, regional data on these species remains limited. The diversity, origin, and conservation status of aquatic plants in northwest and southwest Bangladesh have been stated in this study. The study emphasized upcycling aquatic plants over eradication. Shifts in these plant communities indicate ecological changes and pollution impacts, making accurate species identification key for management. Despite moderate biodiversity, invasive species remain a major threat due to weak prevention. Future strategies should combine invasive species control with upcycling to boost ecosystem resilience and human benefits. Effective conservation depends on community involvement, policies aligned with global standards, and focused research on wetland and aquatic plant management.


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## AUTHOR CONTRIBUTIONS

Conceptualization and Methodology, Md. Foysul Hossain; Formal Analysis, Md. Foysul Hossain, Koushik Chakroborty; Data Curation, Md. Foysul Hossain, Sumiya Bhuyain, Abrar Hossain, Mst. Mosfeka Khatun Ritu; Writing-Original Draft Preparation, Md. Foysul Hossain, Koushik Chakroborty, Gazlima Chowdhury, Writing-Review and Editing, Md. Foysul Hossain, Koushik Chakroborty, Gazlima Chowdhury, Roksana Jahan.

## DECLARATION OF CONFLICT OF INTEREST

The authors declare no conflict of interest.

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