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Original Research Article

Macrophyte Diversity and Their Uses with Special Reference to Freshwater Wetland Ecosystem *BarbilaBeel* of Nalbari District, Assam, India

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ABSTRACT:
The present study deals with the documentation of macrophyte diversity of *Barbilabeel*, located in the district of Nalbari, Assam. We recorded total 41 species belonging to 25 families, out of which 5 species were free floating, 14 species were rooted emergent with floating leaves, 4 species were rooted submerged and 18 species were marshy marginal. The study on the use pattern of variety of macrophytes of *Barbilabeel* revealed that 4 species are used as natural fertilizer, 4 species are used as cattle feed, 2 species are used as fish feed, 14 species are used as vegetables and fruits, 17 species are used as medicines, three species are used for religious purposes and other 6 species are used for household activities. During the study period it was seen that the *Barbilabeel* is facing tremendous anthropogenic as well as natural pressures. Hence, it is essential to aware the local people for conservation of the *beel* that supports diversified macrophytic growth as well as the sustainable use of bioresources of Barbila*beel*.

Keywords: *Beel*, Macrophyte, Diversity, Uses, Conservation

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INTRODUCTION

The aquatic macrophytes are the important source of food and herbal medicine. Wetzel (1983) stated that aquatic vegetation of macroscopicsize are defined as aquatic macrophytes.

The freshwater, perennial, large, lentic water bodies in Assam are commonly known as *'beels'* which contain vitally important bio resources. A total of 11,178 wetlands have been identified in Assam which comprises 764372 hacter that is around 9.74% of the geographic area of the state (Sarma and Borah, 2014). The water qualities of the various wetlands are different in terms of physico-chemical parameters which influence the bio-resource of the specific wetland (Ghosh, 2005). The distribution of plant species in a habitat is also determined by changes in water level (Hudon, 2004), substrate composition and interaction with other plant or animal communities (Leslie *et al.*, 1983; Grenouill *et al.*, 2002). Changes in the community

composition provide valuable information on how and why an ecosystem might be changing (Scott *et al.,* 2002).

The wetlands accommodate diverse group of plant species with definite phonological cycle and they show considerable variations in different water bodies even for the same species. Macrophytes play a major role in primary productivity as well as structure and function of the aquatic ecosystem (Trisal, 1990; Dibble and Harrel, 1997 and Jeppesen *et al.,* 1998)). They use nutrient from the aquatic environment and thus influences the water quality. Denny (1985) depicted that wetland plants play a significant role in maintaining greenhouse equilibrium. Therefore, aquatic plants with floating or emergent leaves are considered as an important tool in reducing global rise in temperature (Ghosh, 2005).

The macrophytes are known as highly productive and provide food, shelter and also the breeding habitat for both aquatic and terrestrial fauna (Rejmankova, 2011). Many of the fishes as well as birds including the migratory birds consume macrophytes as food. The birds also use the aquatic macrophytes for breeding and nesting. The large floating-leafed plants are used by the many aquatic insects, molluscs and amphibians for sitting and dwelling purposes.

Macrophytes can also be nuisance to the habitat conditions, soil properties and biogeochemical functions of aquatic ecosystem when they turn out to be invasive (Douglas and O' Connor, 2003; Perna *et al.,* 2012, Amorim *et al.,* 2015), (Crooks, 2002), (Windham and Lathrop, 1999), (Ravit *et al.,* 2003). Invasive aquatic macrophytes may also disturb the re-creational activities like boating, swimming and fishing (Thus and Lennon, 2010). On the other hand, various anthropogenic activities in surrounding the wetlands lead to the Eutrophication which influence the declination of submerged vegetation (Korner, 2001).

Thus, ecological studies carried in aquatic environments must consider as an essential component to know the ecosystem functioning and aquatic bio diversity conservation. However, information on macrophyte diversity and their importance from the *beels* of Assam are very limited. Therefore, the present study has been aimed to know the present status of macrophyte diversity and their ecological services of *Babilabeel*, Nalbari, Assam, India.

MATERIALS AND METHODS

The *Barbilabeel* is situated at the intersection $26^{\circ}15'10''$ North parallel of latitude and $91^{\circ}18'30''$ East meridian of longitude of district Nalbari, Assam. The *beel* covers an area of 407.10 hectare. The *beel*is oblong in shape and has irregular shore lines. The average calculated depth of the *beel* water was ranged between 3 and 6.5 meter (Full Storage Level-FSL) during monsoon period and 1.5 and 3.5 meter (Dead Storage Level-DSL) during winter season. The *beel* gets almost dried up during winter leaving only few pockets of water. The soil type is sandy-loamy. About 6000 families comprising of Other Backward Class (OBC), scheduled caste (SC) and scheduled tribes (ST) people live in a village situated surrounding the *beel* and they depend on the fish fauna and other aquatic resources of the *beel*f or livelihood.

The macrophytes were collected by hand picking or with the help of local people during the period of January, 2017 to December, 2019. The collection was made in and around the *beel* following quadrate method. After collection the photographs were taken for each collected species and then carried in plastic bags to prepare dry herbarium or kept in 70% formalin aceto alcohol (FAA) (Haynes,1984) for identification. In the laboratory, they were kept pressed between newspapers for proper drying by changing the newspapers in every alternate day. After proper drying the dried specimens were transferred to saturated solution of mercuric chloride in absolute ethyl alcohol. The specimens were dried again and then mounted on herbarium sheets following standard laboratory techniques. The specimens were identified and categorized into different life forms and habits with the help of available literature and also by matching the species at the herbaria department of Botany, Gauhati University, Guwahati, Assam, India. For identification macrophytes ID guides were also followed (https://niwa.co.nz/freshwater-and-

estuaries/management-tools/identification-guides-and-fact-sheets/macrophyte-plant-id-guides).

Futher, Shannon-Weiner index (H') for macrophyte diversity and Simpson index (D) for dominance were calculated using the software SPSS (v.23).

To collect the data on various uses of macrophytes, the local people living in the vicinity of the *beel,* were interviewed following standard questionnaire. The questionnaire was based on the research aims and the goal of the study, targeting the respondents (fisherman, farmer, elderly people, and woman) including the questions on required information in a sequential manner. Traditional medical practitioners/healers were also visited and discussed in detail about the medicinal importance of the macrophytes.

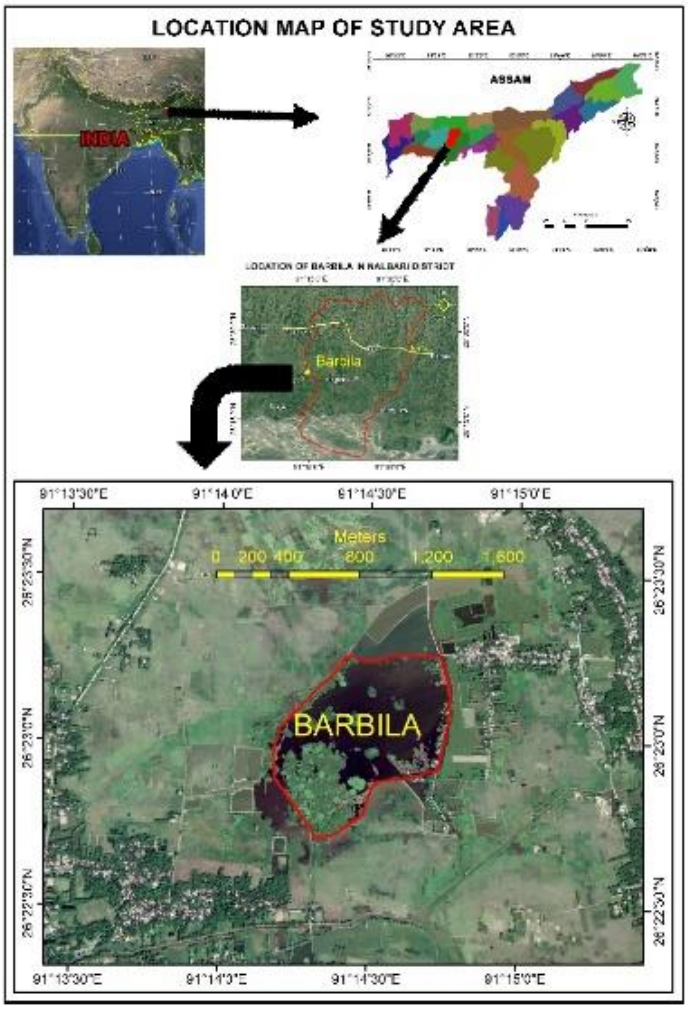

Figure 1: Location map of the study area

RESULT

In *Barbillabeel* 41 species were recorded belonging to 25 families: Poaceae 7 species, Araceae 5 species, Nymphaceae 4 species, Hydrocharitaceae 2 species, Trapaceae 2 species, Convovulaceae 2 species, Pontederiaceae, Plantaginaceae, Marseliaceae, Azzolaceae, Allismaceae, Amaranthaceae, Commelinaceae, Cannabinaceae, Menyanthaceae, Lemnaceae, Salviniaceae, Onagraceae, Potamogetonaceae, Asteraceae, Apiaceae, Alismataceae, Typhaceae, Nelumbonaceae and Salviniaceae 1 species each.

The floating plants on the water surface are known as free floating macrophytes. These macrophytes have leaves freely floating on the surface of water and their roots do not have no direct contact with soil. Therefore, the free floating macrophytes are not seen permanently in a particular place. During the study period in *Barbilabeel* 5 species were observed in this group of macrophyte. The floating macrophytes observed in the study area were *Eichornia crassipes*, *Azolla pinnata*, *Lemna purpusila*, *Pistia stratiotes and Salvina molesta* of which *Eichornia crassipes and Azolla pinnata* were the most dominant species.

Rooted Emergent with floating leave Macrophytesare the surface plants which are rooted in the bottom, but their leaves float on the water surface or above the water level. They prefer shallow parts and shores of the wetland. In *Barbilabeel*, the plants recorded from this group were *Hygrorhyza aristata, Tarpa natans, Tarpa bispinosa, Nymphea nouchali, Nymphea rubra, Numphea stellata, Nymphoides cristata, Euryale ferox, Ipomea aquatic, Ipomea carnea, Sagittaria sagittifolid, Marsilia quadrifolia, potamogeton natans and Alternanthera philoxeroides*.

Generally the submerged macrophytes are found in water logged areas and they are known as Rooted Submerged Macrophytes. The elongated stem and root help the plant for anchorage and nutrition. The leaves grow towards the light on the surface of water and float freely in water. Thus the rooted submerged macrophytes form a thick cover of leaves on water surface giving enough space for aquatic fauna for shelter and protection. They are also known to increase the dissolved oxygen content in water as well as organic matter. Four species of rooted submerged macrophytes were observed flourished throughout the study sites of *Barbilabeel*. The most common plants of this group were *Hydrila verticillata, Vallisnaria spiralis, Plantago major* and *Jussica repents*.

As the water level goes down a wide variety of marshy vegetation is formed within a few weeks. The plants germinate mostly on the edges of water and becomes a rich source of food for aquatic fauna. The different types of grasses (Poaceae) form thick mats within a short period of time. A total of eighteen varieties of species were recorded in the outer edges of the *beel*. The species of marsh/marginal plant recorded in the *beel* were *Cynodon dactyla, Eclipta prostrate, Centella asiatica, Homalumena aromaticum, Phragmitis karka, Colocasia esculanta, Vetiveria zizanoids, Commelina benghalensis, Alocasia indica, Typha elephantine, Acrorus calamus, Alisma plantago, Alpinia galena, Canabis stavia, Ipomoea fistula, Leersia hexandra, Saccharum spontalnum and Nelumbo nucifera*.

The dry fringe area of Barbila*beel* is heavily loaded with the species like *Ipomoea fistula, Typhya elephantine, Leersia hexandra, Saccharum spontaenum, and Alocasia indica.*

Table 1: Aquatic Macrophytes of *Barbilabeel* recorded during the study period (2017-2019)

S.N.	Name of Species	Local Name	Family	Life Span	Life Form	Occurence
1	*Echornia crassipes* (Mart). S.L.	*Panimeteka*	Pontederiaceae	Perennial (P)	Free floating	Severe
2	*Hygrorhyza aristata*Nees.	*Dolghah*	Poaceae	P.	Rooted emergent with floating leave	Fairley spread
3	*Tarpa natans* L.	*PaniSingori*	Trapaceae	P.	Rooted emergent with floating leave	Restricted
4	*Tarpa bispinosa* (Roxb) Makino	*Nikori*	Trapaceae	P.	Rooted emergent with floating leave	Restricted
5	*Nymphea nouchali* Burm. F.	*BogaVetful*	Nympheaceae	P.	Rooted emergent	Fairly spread

					with floating leave	
6	*Nymphea rubra*, Roxb. Ex. Salisb	*RangaVetful*	Nympheaceae	P.	Rooted emergent with floating leave	Fairly spread
7	*Nymphea stellata*. Willd		Nympheaceae	P.	Rooted emergent with floating leave	Restricted
8	*Ipomoea aquatic*. Forsk	*Kolmou*	Convovulaceae	P.	Rooted emergent with floating leave	Fairly spread
9	*Ipomoea carnea*, Jace	*Borkolmou*	Convovulaceae	P.	Rooted emergent with floating leave	Restricted
10	*Ipomoea fistula* L.	*Amarlata*	Convovulaceae	P.	Marginal	Restricted
11	*Phragmitis karka*. Trin. Ex. Stued	*Khagoribon*	Poaceae	P.	Marginal	Fairly spread
12	*Plantago major*. L.	*Panibabri*	Plantaginaceae	P.	Rooted emergent with floating leave	Fairly spread
13	*Vallisnaria spiralis*. L.	*FitaGhah*	Hydrocharitaceae	P.	Rooted emergent with floating leave	Fairly spread
14	*Marsilia quandrifolia* L.	*Panitengesi*	Marseliaceae	Annual (A)	Marginal	Restricted
15	*Hydrillaverticillat a*Royle	*Panibirina*	Hydrocharitaceae	A.	Rooted emergent with floating leave	Restricted
16	*Colocasia esculanta* L.	*Kala Kachu*	Araceae	P.	Marginal	Fairly spread
17	*Alocasia indica* (Lour)	*Man kachu*	Araceae	P.	Marginal	Restricted
18	*Azolla pinnata* R. Br.	*Puni*	Azollaceae	A.	Free floating	Fairly spread
19	*Aerorus calamus* L.	*Boch*	Araceae	P.	Marginal	Restricted
20	*Alisma plantago* L.	*Panikol*	Allismaceae	P.	Marginal	Restricted
21	*Alpinia galena* L.		Poaceae	P.	Marginal	Restricted
22	*Alternanthera philoxeroides* (Mart) Griseb.	*Panineuthani*	Amaranthaceae	A.	Rooted emergent with floating leave	Restricted
23	*Commelina benghalensis* L.	*Kona simolu*	Commelinaceae	A.	Marginal	Fairly spread
24	*Canabis stavia* L.		Cannabinaceae	P.	Marginal	Restricted
25	*Nymphoides cristata* (Roxb). Kuntze	*Panikola*	Menyanthaceae	P.	Rooted emergent with floating leave	Fairly spread
26	*Lemna purpusilla* Torrey	*Sarupuni*	Lemnaceae	A.	Free floating	Occasional &

						Restricted
27	*Pistia stratioes* L.	*Borpuni*	Araceae	A.	Free floating	Fairly spread
28	*Salvinia molesta*. Mitcheel	*Majupuni*	Salviniaceae	A.	Free floating	Occasional and Restricted
29	*Jussica repents* L.		Onagraceae	P.	Rooted submerged with floating leave	Fairly spread
30	*Potamogeton natans* L.	*Sensor bon*	Potamogetonaceae	P.	Rooted emergent with floating leave	Rare
31	*Leersia hexandra* SW.	*Arlighah*	Poaceae	P.	Rooted emergent with floating leave	Fairly spread
32	*Saccharum spontaenum* L.	*Kohuwa*	Poaceae	P.	Marginal	Fairly spread
33	*Vetiveria zizanoides* L.	*Birina*	Poaceae	P.	Marginal	Fairly spread
34	*Cynodon dactylon* (L) pers.	*Dubari*	Poaceae	P.	Marginal	Restricted
35	*Eclipta prostrate* L.	*Kehraj*	Asteraceae	P.	Marginal	Occasional and Restricted
36	*Centella asiatica* L.	*Manimuni*	Apiaceae	A.	Marginal	Fairly spread
37	*Euryale ferox* salisb	*Mokhana*	Nympheaceae	P.	Rooted emergent with floating leave	Restricted
38	*Typha elephantine* Roxb.	*Gugul Bon*	Typhaceae	P.	Marginal	Occasional & Restricted
39	*Sagittaria sagittifolid* L.		Alismataceae	P.	Rooted emergent with floating leave	Occasional & Restricted
40	*Homalumena aromaticum* L.	*Gondhsanakachu*	Araceae	P.	Marginal	Restricted
41	*Nelumbo nucifera* L.	*Podum*	Nelumbonaceae	P.	Rooted emergent	Restricted

Abbreviations: P. = Perennial, A. = Annual

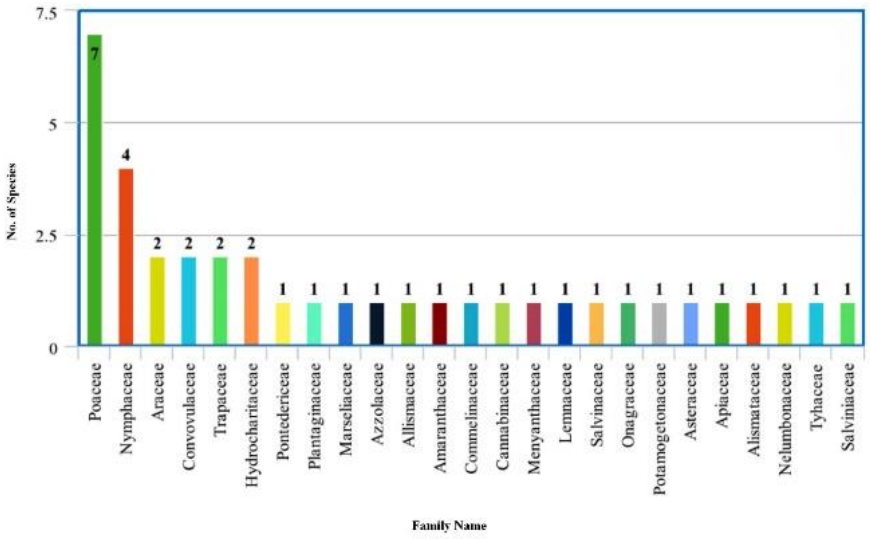

Figure 2: Family wise species of Macrophytes recorded in *Barbillabeel*

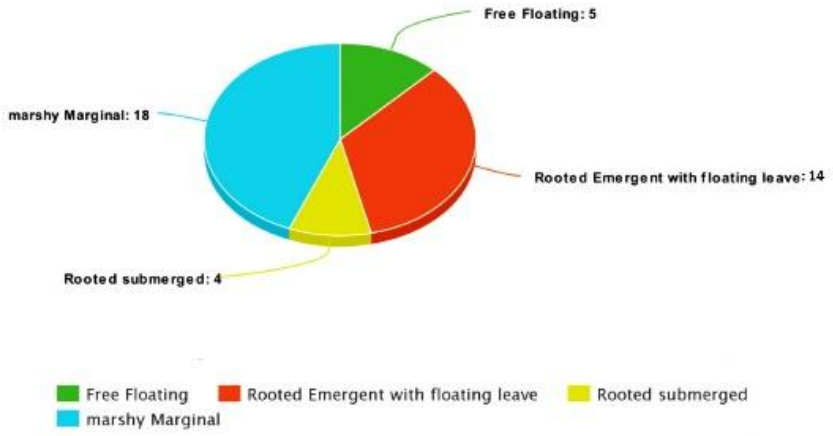

Figure 3: Life form of different macrophytes recorded from ***Barbilabeel***

The seasonal variation observed in diversity indices of the macrophytes recorded from *Barbilabeel*is represented in Table 2.

Table 2: Seasonal variation in diversity indices of aquatic macrophytes of *Barbilabeel*

Diversity indices	Index values (Summer)	Index values (Winter)
Shannon- Wiener diversity index	3.28	2.56
Simpson diversity index	0.62	0. 42
Menhinick diversity index	1.06	0.87
Concentration of dominance	0.71	0.48

During the present study, the local people living in the vicinity of the *Barbilabeel* and the traditional healers of the village revealed the various uses of macrophytes that are collected from the *beel* itself which are represented in detail in table 3 and Figure 4.

Table 3: Group wise species composition of macrophytes of *Barbilabeel* and their uses

S. N.	Name of the Species	Group	Uses
1	*Eichornia crassipes*	Free floating	Commonly used as natural fertilizer, sometimes as fodder
2	*Azolla pinnata*		Used as biofertilizer
3	*Lemna purpusila*		Water birds and some fishes feed on the plant, it destroys algae and promotes growth of the zooplankton
4	*Pistia stratiotes*		Affords excellent food for fishes, Juice of the leaves boiled in coconut oil and applied extremely in chronic diseases.
5	*Salvina molesta*		Used as biofertilizer
6	*Hygrorhyza aristata*	Rooted Emergent with floating leave	This grass is used as cattle fodder
7	*Tarpa natan*		Used as vegetable and fruits, delicious and also nutritious
8	*Tarpa bispinosa*		The stems are used as vegetable and fruits are also nutritious.
9	*Nymphea noucheli*		The rhizomes are dried, powdered and used in piles. Used to cure dental decay, seeds are edible.
10	*Nymphea rubra*		The roots are widely used for dysentery, stems and seeds are used as vegetable.
11	*Nymphea stellata*		Stem and seeds are used as vegetable.
12	*Nymphoids cristata*		Fruits are eaten
13	*Euryale ferox*		Nutritious food. Seeds eaten raw or roasted
14	*Ipomea aquatica*		Young leaves and twigs are eaten as vegetable.
15	*Ipomea carnea*		Leaves are used as vegetable
16	*Sagittaria sagittifolid*		Plant is a good oxygenator and useful for wetlands where the fishes are breed.
17	*Marsilia quadrifolia*		Whole plant is used in dysentery and urinary troubles.
18	*Potamogeton natans*		Food for cattle
19	*Alternanthera philoxeroides (Mart) Griseb*		Tender shoots are used as vegetable and medicine for abdominal pain.
20	*Hydrila verticillata*	Rooted submerged	Used in aquaria; good oxygenator, also eaten by some fishes.
21	*Vallisnaria spiralis*		Used as fertilizer. Young leaves eaten in salads.
22	*Plantago major*		Oxygenator and used as vegetable.
23	*Jussica repents*		Extract of tender leaves mixed with milk is giving orally to the patient to cure jaundice.
24	*Cynodon dactyla*	Marshy Marginal	Whole plant is used in piles treatment and as antiseptic.
25	*Exlipta prostrate*		Tonic and used in hepatic and spleen enlargements and in skin troubles
26	*Centella asiatica*		Leaves are used for indigestion, nervousness and dysentery.
27	*Homalumena*		Use in cosmetics and vegetables.

	aromaticum		
28	*Phragmitis karka*		Used in house holding material specially in some fishing nets such as *kaoilangi, goroilangi, puthilangi* etc.
29	*Colocasia esculanta*		Vegetables and used as medicine for iron deficiency.
30	*Vetiveria zizanoids*		Used in house holding material.
31	*Alocasi aindica*		Petiole juice is used for ear and toothache. Cooked Rhizome used in tonsillitis and stomach ache.
32	*Typha elephantine*		This is used as medicinal purposes.
33	*Acorus calamus*		Juice of rhizome used in treatment of caugh and asthma.
34	*Commelina benghalensis*		Leaf juice is used to stop bleeding.
35	*Alisma plantago*		Rhizome is used as food and vegetables.
36	*Alpinia galena*		Dry powder of rhizome is used in the treatment of citica, bronchitis and epilepsy.
37	*Canabis stavia*		Leaf paste used extremely in skin disease.
38	*Ipomea fistula*		Biofenching and fire wood.
39	*Leersia hexandra*		This is used for fodder purposes.
40	*Saccharum spontaenum*		Grass, on the edge of the water bodies.
41	*Nelumbo nucifera*		Seeds are eaten, paste prepared from leave is used in burning injury.

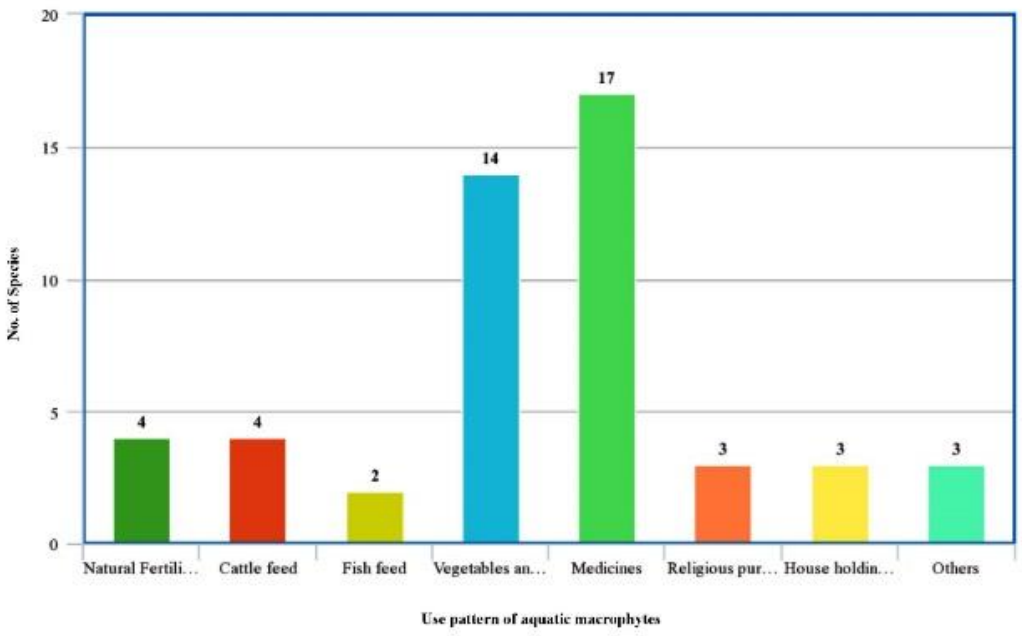

Figure 4: Use pattern of macrophytes that are collected from *Barbilabeel*

Figure 5: *Echornia crassipes*

Figure 6: *Nymphea noucheli*

Figure 7: *Ipomoea fistula*

Figure 8: *Hygrorhyza aristata*

Figure 9: *Azolla pinnata*

Figure 10: *Euryale ferox*

Figure 11: *Nelumbo nucifera*

Figure 12: *Colocasia esculanta*

Figure 13: *Alternanthera philoxeroids*

DISCUSSION

The present study clearly shows that *Barbilabeel* is rich in macrophyte diversity. The species composition is very much similar to the findings reported from other *beels* of Nalbari and nearby Barpeta district (Deka and Sarma, 2014; Dutta *et al.,* 2014) except *Alternanthera philoxeroids* which is endemic to Barbilabeel only. The close similarity in species composition may be due to the similar geographical condition and physicochemical nature of the water bodies.

The two most remarkable factors for the growth and proliferation of macrophytes in the aquatic ecosystem are amount of the nutrient laden sediments and capability of sunlight penetration. Comprehensive studies on the macrophytes in the *beels* of Assam have been reported by workers like Lahon (1983), Goswami (1985), Yadav (1987), Acharjee (1997), Bhuyan (2007) and Barthakur (2014). Besides Macrophyte growth depends on some other factors like temperature, light intensity and day-length. The variation in water level and different degree of connectivity between

main rivers and marginal aquatic habitats of the floodplains are also responsible for the high macrophytic diversity (Bornette *et al.,* 1998; Ward and Tockner, 2001; Agostinho *et al.,* 2004) as observed in the present study. On floodplains some aquatic macrophytes such as *E. crassipes, Salvania sp.* are periodically removed in dry phase, allowing the coexistence of many plant species with similar habitat requirements.

The *beels* are facing tremendous anthropogenic as well as natural pressureas observed in the present studied *Barbilabeel* (Deka and Sarma, 2014). The natural disturbance in the form of flood by the river Marapagladia badly affects the community structure of macrophytes of *Barbilabeel*. On the other hand, the aggressive growth of exotic aquatic weed like *Eichhornia crassipes*, prevent the growth of some economically important species like *Euryale ferox*, *Tarpanatans* and *Neulumbo nucifera*. During the study period the local people also revealed that ethnomedicinally important aquatic macrophyteshave been gradually disappearing from those particular areas of the *beel*. Hence, it is essential to create further awareness among the local people about the conservation of the aquatic macrophyte of the study area.

The study on species diversity is a useful parameter to assess the succession and stability in a community (Hurlbert, 1971). In the present study maximum species diversity were found during the summer season because of the availability of water along with nutrients leached from the catchment areas which has a close consortium with the findings of James *et al.,* 2005. The Maximum dominant species observed in the summer season were *Eichhornia crassipes, Azolla pinnata, Lemna purpusila and Leersia hexandra*. During the winter season the diversity of macrophytes were found to be decreased due to scarcity of water in the *beel* as well as removal of aquatic macrophytes by the fisherman communities living in the surrounding areas for fishing purposes.

Interaction with the local people revealed that most of the species of macrophytes were used for various purposes viz. food, fodder, fish feed, duck feed, biofertilizer, medicine, fuel wood, fencing material and rituals by the people of fringe area. The macrophyte species used as food are *Euryale ferox*, *Nymphoides cristate*, *Ipomoea aquatic*, *Ipomoea carnea*, *Colocasia eseulanta*, *Alisma plantago*, *Tarpa natans*, *Tarpa bispinosa*, *Nymphea noucheli*, *Nymphea rubra and Nymphaea stellata.* Some of these species viz., *Euryale ferox, Tarpanatans, Nymphea sp.* and *Ipomoea aquatic* are reported to have high nutritional value (Huang *et al.*, 2005, Mandal *et al.,* 2010, Mohan and Kalidass, 2010, Shalabh *et al.,* 2012 and Sarma *et al.,* 2014, Prasad *et al.,* 2016). The species of macrophytes used as fodder are *Eichhornia crassipes, Hygrorhyza aristata, Potamogeton natans and Leersia hexandra*. Species used fish feed are *Lemna purpusila* and *Pistia stratiotes.* The species used as biofertilizer include *Eichhorniacrassipes, Salvina molesta, Azolla pinnata and Vallisnaria spiralis*. Few species act as good oxygenator viz., *Sagittaria sagittifolid, Hydrilla verticillata* and *Plantago major*. This finding is not similar with other opinion. *Ipomea fistula* is used as fire wood and for fencing.

The macrophyte species used in religious rituals are *Nelumbo nucifera, Nymphea noucheli and Nymphea stellata*. Moreover, it was depicted in the present study that *Centella asiatica* has been for the treatment of dysentery which has a close consortium with the view of Meena and Rout (2016).However, variations were observed in the pattern of use of macrophyte resources among different communities in different regions which may be attributed to regional traditional knowledge and culture.

CONCLUSION

Thus, macrophytes may play a major role in rural economy if sustainable utilization of aquatic plants can be promoted in a systematic manner. Hence, it is essential to make the local people aware about the nutritional, medicinal and economic value of acquatic plants in *Barbilabeel*. Scientific study, transfer of information to the local people and training in the grass root may be very beneficial in the context of conservation and sustainable uses.

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CONFLICT OF INTEREST

Authors have declared that no competing interests exist.

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