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Utilization Pattern of Macrophytes in Rudrasagar Lake, a Ramsar Site in India

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Abstract This study was undertaken to explore the diversity of macrophytes and their utilization pattern in Rudrasagar Lake of Tripura, which is a Ramsar site in India. We identified 31 species of macrophytes from the study site. Important Value Index (IVI) and Total value Index (TVI) of these plants were estimated to know their diversity and utilization pattern. Some of the dominant species included *Nymphoides indica* (L.) Kuntze, *Eichhornia crassipes* (Mart.) Solms, and *Vallisneria spiralis* L. The majority of local households using the macrophytes for domestic purposes. Macrophytes most preferred by the local people were *Euryale ferox* Salisb., *Trapa natans* var. Bispinosa and *Ehnydra fluctuans* Lour. We found that the dominant species of the lake were not always preferred by the community. Thus awareness and cultivation of the preferred species can reduce pressure on the availability of the highly preferred species and also improve the livelihoods of the wetland-dependent people of the area.

Keywords: *dominant species, utilization pattern, macrophytes, Important Value Index*

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1. Introduction

Wetlands, the most productive ecosystems on Earth [1], house the majority of floral and faunal groups and act as a base of our environment [2]. These ecosystems are saturated with water, either permanently or seasonally, as well as at low tides less than 6 m deep [3]. Ponds, lakes, marshy places, and shady moist areas are ideal for the growth of macrophytes. Macrophytes are submerged, free floating and emergent in nature and sometimes grow on moist or even semi-dry soils. Macrophytes are an important part of wetland ecosystems. Plants are an essential factor in fixing energy that powers all other components of the system. Macrophytes play an important role in the structure of freshwater wetlands and have been targeted for wetland restoration and conservation [4]. Macrophytes have significant effects in terms of the physical and chemical environment of wetlands [5].

India has more than 757,000 wetlands, 26 of which have been designated as Ramsar sites or wetlands of international importance [6]. Rudrasagar Lake is a Ramsar site situated in Tripura state of northeastern India. This lake was declared a Ramsar site in 2005 and is considered a wetland of international importance. This wetland has a maximum area of about 8.16 km^2. The total catchment area is 13,336 ha, which includes 716 ha of small hillocks with human habitation, 4,942 ha of crop land, 175 ha marshy land, 178 ha shifting cultivation area, 466 ha of government orchard land, 215 ha of pasture land, 1,340 ha of reserve forest area, and 4,534 ha of scrub/bamboo/degraded forest [7].

Studies on macrophytes have been conducted by many researchers [8-17], but no work has been carried out to understand the diversity of macrophytes or their seasonal patterns of utilization in this region. Rudrasagar Lake is a great source of biodiversity, providing many services to the local human population [18]. However, this wetland ecosystem is degrading day by day due to various anthropogenic stresses, necessitating urgent measures for wetland conservation and restoration. This study focused on the diversity of macrophytes in Rudrasagar Lake and the pattern of their utilization by local communities, information that will be helpful for developing management strategies and a restoration plan for the ecosystem. IVI is an ecological index which helps to understand the diversity of plants in an area and TVI help to understand the utilization pattern of plants by local people. So IVI and TVI is use in this research to understand the diversity and utilization pattern of macrophytes.

2. Materials and Methods

2.1. Study Area

Tripura is a landlocked state in northeastern India that experiences a monsoonal climate with the main seasons being winter (Dec-Feb), pre-monsoon or summer (Mar-Apr), and monsoon (May-Nov). Rudrasagar Lake is located at Melaghar in the Sepahijala district of Tripura. The wetland is at 23°29′N, 90°01′E (Fig ure 1). The lake has a total area of 240 ha; Neermahal (Water Palace) is

situated in the middle of the lake. In the area surrounding the lake, a mostly Bengali community resides. The main occupation of the community people is fishing, supplemented by earnings from ecotourism and agriculture.

2.2. Sample Collection for Diversity Estimation

The study was carried out during three seasons (winter, summer, and monsoon) from January 2017 to March 2018. The initial survey was done visually by boat covering the whole lake to study various species and distribution of macrophytes. A total of 112 quadrats (1 × 1 m) were laid out at 12 sampling stations during the study period. Macrophyte specimens were collected, photographed, and taken to the laboratory for further identification. Macrophytes were identified to the species level using standard literature [19,20].

2.3. Ecological Indices

Ecological indices measuring composition, abundance, richness, evenness, and diversity provide a quantitative approach to patterns among macrophyte distribution. However, 6 metrics (density, frequency, abundance, relative density, relative frequency, and relative abundance) were selected to ensure comparability with existing literature and low redundancy. An Importance Value Index (IVI) was calculated by following the methodology described by Misra [21] and Curtis [22] as follows:

$$IVI = Relative\ density + Relative\ frequency + Relative\ abundance.$$

For measuring diversity, the Shannon-Weaver index [23] as follows were used

$$H = \sum \frac{ni}{N} \log_n \frac{ni}{N}$$

Where, ni is the total density value for species, i, and N is the sum of the density values of all the species in that site.

For estimating dominance species, Simpson index [24] were calculated.

$$D = \frac{\sum n(n-1)}{\sum N(N-1)}$$

Where, N = total number of species and n = number of species in a given community.

2.4. Data Collection

In order to identify the pattern of macrophyte utilization by the local community, free listing [25] was done, which is the listing of macrophytes that a research participant can cite at a given time. For this free listing 64% of total households were covered in the study area. A total of 146 household heads (male = 49.6%, female = 50.4%) agreed to participate in the free listing. These plant species lists were used for the determination of ethno-cultural importance of macrophytes.

2.5. Ethno-cultural Survey of Aquatic Plants

An ethno-cultural survey was made to understand the cultural behavior of local people regarding the utilization of macrophytes. The cultural value (CV_e) of a species was determined by using the methodology of Reyes-Garcia et al. [26]:

$$CV_e = Uc_e \times Ic \times IUc$$

where CV_e is the cultural value of species *e*, Uc_e is the total number of uses reported for species *e* divided by the total number of potential uses (e.g., food, fodder, construction), Ic is the number of participants who listed species *e* as useful divided by the total number of people participating in free listing, and IUc is the number of participants who mentioned each use of species *e* divided by the total number of participants. To calculate the practical value of a species, a similar formula was used, following Reyes-Garcia et al. [26]:

$$PV_e = UP_e \times P_e \times DUp_e$$

where PV_e is the practical value of species *e*, UP_e is the number of different uses observed for species *e* divided by the potential uses of a species considered in the study, P_e is the number of times species *e* was brought to a household divided by the total number of informants participating in observation, and DUp_e is the duration of use for each item brought to the household. Economic value (EV_e) of a species was calculated by the local market price of a species and the number of times it was brought to any household using the formula of Benz et al. [27]. Total value index (TVI) of a species was enumerated by summing of cultural value (CV_e), practical value (PV_e), and economic value (EV_e) as described by Byg and Balslev [28]:

$$TVI = CV_e + PV_e + EV_e.$$

3. Results

The survey revealed the occurrence of 31 plant species belonging to 20 taxonomic families (Table 1). The different parts of macrophytes (Figure 2) were used for various purposes (Table 1).

3.1. Assessment of Dominant Macrophytes

The most dominant species of the lake were *Nymphoides indica* (L.) Kuntze (IVI=41.14), *Eichhornia crassipes* (Mart.) Solms (IVI=38.60), *Vallisneria spiralis* L. (IVI=36.69), *Amischophacelus axillaris* (L.) R.S.Rao & Kammathy (IVI=31.11), and *Trapa natans* var. Bispinosa (Roxb.) Makino (IVI=28.27) (Table 1). The least dominant species were *Ipomoea fistulosa* Mart. ex Choisy (IVI=6.80), *Pennisetum polystachyon* (L.) Schult (IVI=8.02), *Azolla pinnata* R.Br. (IVI=8.76), *Salvinia cucullata* Roxb. (IVI=9.69), and *Polygonum hydropiper* L. (IVI=10.60). The most dominant species during summer was *Eichhornia crassipes*, whereas *Pennisetum polystachyon* was the least dominant. *Nymphoides indica* and *Ipomoea fistulosa* were the most dominant and least

dominant species, respectively, during monsoon season. However, in winter *Eichhornia crassipes* was the most dominant and *Ipomoea fistulosa* was the least dominant (Figure 3).

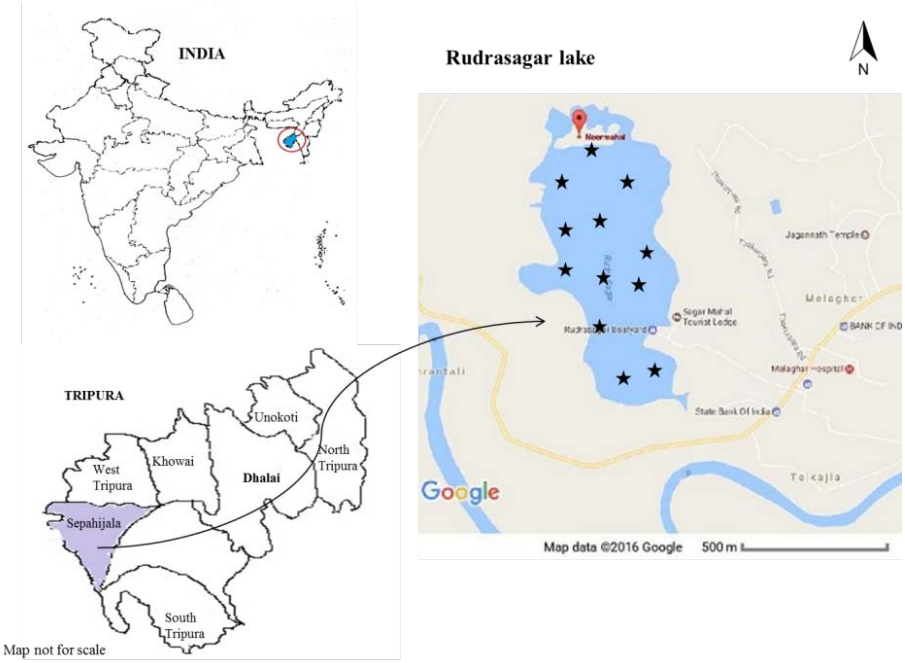

Figure 1. Map of Rudrasagar Lake, Tripura, India. Stars indicate sampling stations.

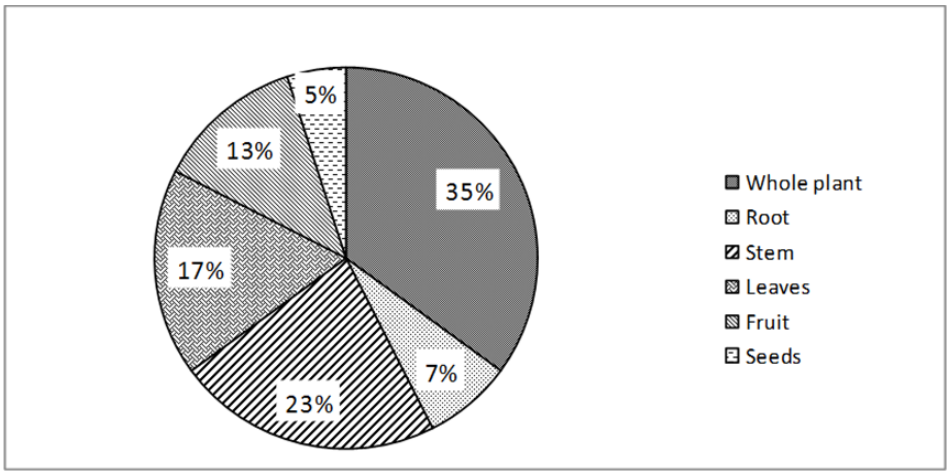

Figure 2. Plant part usage, by category, of macrophytes present in Rudrasagar Lake, Tripura, India

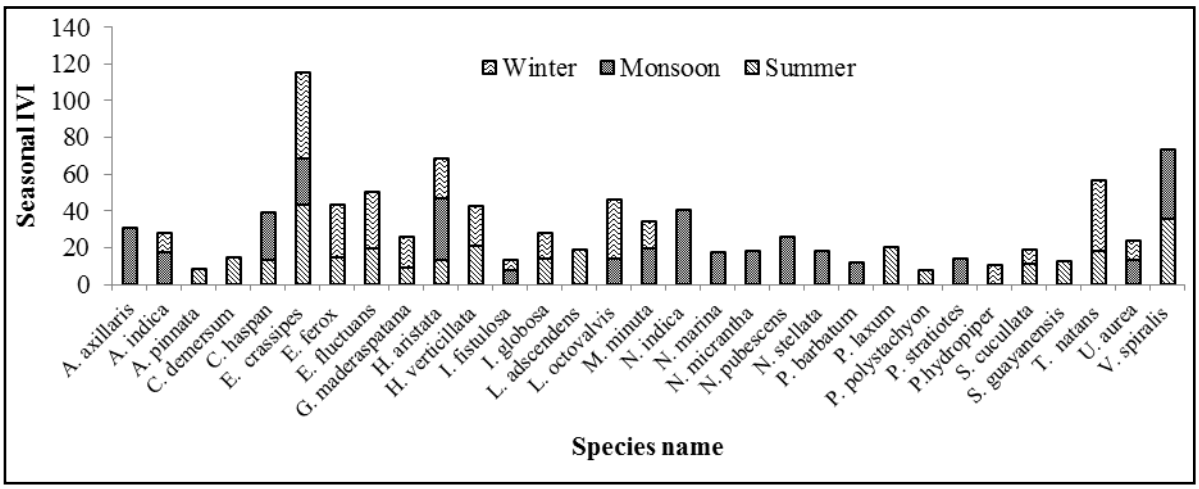

Figure 3. Importance Value Index of different aquatic plants during summer, monsoon, and winter seasons

Table 1. Importance Value Index and Total Value Index of macrophytes in Rudrasagar Lake, Tripura, India

Species	Family	Common name	IVI	TVI	Uses
Alocasia indica Schott	Araceae	Kachu	14.19	62.46	Roots are edible
Amischophacelus axillaris (L.) R.S.Rao & Kammathy	Commelinaceae	Ghash	31.11	81.43	Used as fodder
Azolla pinnata R.Br.	Azollaceae	Pana	8.76	1.13	Used to treat urinary problems
Ceratophyllum demersum J.G.Klein ex Cham.	Ceratophyllaceae	Jhaji	15.09	0.90	Use to reduce pain from insect bites; fruit used as food for domestic ducks
Cyperus haspan L.	Cyperaceae	Unknown	19.71	1.22	Used as fodder
Eichhornia crassipes (Mart.) Solms	Pontederiaceae	Kochuripana	38.60	3.85	Used as fertilizer; reduces oil in lake water
Enhydra fluctuans Lour.	Asteraceae	Halancha	25.40	92.47	Leaves are eaten as a salad or vegetable
Euryale ferox Salisb.	Nymphaeaceae	Makna	21.97	202.93	Used as a vegetable; medicinal
Grangea maderaspatana (L.) Poir.	Asteraceae	Namuti	12.96	0.76	Used as fodder
Hydrilla verticillata C.Presl	Hydrocharitaceae	Jhaji	21.47	1.29	Used as fish food, aquarium plant, fertilizer
Hygroryza aristata Nees	Poaceae	Dondo	22.83	0.78	Used to treat urinary diseases, fodder
Ipomoea fistulosa Mart. ex Choisy	Convolvulaceae	Baralott	6.80	9.39	Stems used for fencing
Isachne globosa Kuntze	Poaceae	Unknown	14.15	1.76	Used as fodder
Ludwigia adscendens (L.) H.Hara	Onagraceae	Kasordham	19.27	73.44	Aerial parts are used to make poultices for treating skin problems; new shoots used as a vegetable
Ludwigia octovalvis (Jacq.) P.H.Raven	Onagraceae	Malcha	23.11	26.42	A decoction of the aerial parts is used as a treatment for dysentery, fever, cough, ophthalmia
Marsilea minuta L.	Marsileaceae	Shusni	18.38	33.83	Used as food and to treat sleeping problems
Najas marina L.	Hydrocharitaceae	Naja	17.27	63.41	Used as fish food
Nymphaea micrantha Guill. & Perr.	Nymphaeaceae	Shapla	17.70	63.41	Used as medicine for fever
Nymphaea pubescens Willd.	Nymphaeaceae	Sada shapla	25.85	63.06	Young stem and unopened flower buds can be boiled and served as a vegetable
Nymphaea stellata F.Muell.	Nymphaeaceae	Sankha shapla	18.25	62.46	Young stem and unopened flower buds can be boiled and served as a vegetable
Nymphoides indica (L.) Kuntze	Menyanthaceae	Penchuli	41.14	2.02	Used to reduce fever
Panicum laxum Sw.	Poaceae	Unknown	20.33	1.64	Used as fodder
Pennisetum polystachyon (L.) Schult.	Poaceae	Unknown	8.02	1.03	Used as fodder
Pistia stratiotes L.	Araceae	Toka pana	14.27	0.78	Root used as pain killer for hemorrhoids
Polygonum barbatum Comm. ex Meisn.	Polygonaceae	Panmorich	12.21	1.18	Root used for tanning; root and seeds are medicinal
Polygonum hydropiper L.	Polygonaceae	Bish katali	10.60	1.52	Medicinal
Sagittaria guayanensis Kunth	Alismataceae	Tir mukhi	12.88	11.58	Used in composting fertilizer
Salvinia cucullata Roxb.	Salviniaceae	Kani pana	9.69	0.74	Used as fodder
Trapa natans var. Bispinosa (Roxb.)Makino	Trapaceae	Singara phal	28.27	163.13	Used as edible fruit
Utricularia aurea L.	Lentibulariaceae	Unknown	11.88	1.03	Edible (high in nutrients) and is used to treat urinary diseases
Vallisneria spiralis L.	Hydrocharitaceae	Unknown	36.69	2.27	Used as fish food; helps to clean water

3.2. Assessment of Preferred Macrophytes

The macrophytes most preferred by the local people were *Euryole ferox* Salisb. (TVI=202.93), *T. natans* (TVI=163.13), *Enhydra fluctuans* Lour. (TVI=92.47), *A. axillaris* (TVI=81.43), and *Ludwigia adscendens* (L.) H.Hara (TVI=73.44). TVI value was high for these plants due to their preferred utilization by the community. The local people get huge profits by selling these macrophytes, which increases their TVI value. The least preferred macrophytes were *Salvinia cucullata* (TVI=0.74), *Grangea maderaspatana* (L.) Poir. (TVI=0.76), *Hygroryza aristata* Nees (TVI=0.78), *Pistia stratiotes* L. (TVI=0.78), and *Ceratophyllum demersum* J.G.Klein ex Cham. (TVI=0.90) due to their lower levels of utilization (Table 1).

3.3 Management of Macrophytes

The management and conservation of the lake has been taken care by the *Rudrasagar Udbastu Fisherman Samabaya Samity* (local community body) for several years. It is on record that after every five years period the community creates a new group consist of nine people with the mechanism of voting, and hands over the responsibilities of the lake to them for the purpose of management and conservation. One of the astonishing fact

about the entire process has been that male and female members of the community are entrusted to work with shoulder to shoulders in the management and conservation of wetlands. Another fact remains that people belonging to the local community who doesn't have any stakes are not allowed to take participate in any kind of management activities of the lake. The community generates revenues through issuing licenses for fishing in the lake, cultivation of crops in surrounding areas, and boating. Paddy (*Oryza sativa*) is usually cultivated in the adjacent areas of the wetland during winter. Farmers wield fertilizers and pesticides during the period of cultivation and especially during rainy season. It is believed that runoff from agricultural land to water body causes degradation of water quality in Rudrasagar Lake. The community allows the growing of several aquatic plants to provide shelter to fingerlings and for the nesting of aquatic birds. Plants such as *Eichhornia crassipes* renders shield to small fishes from predators. Every year during monsoon season, *Euryale ferox* is auctioned by the cooperative society. As a result of the auction, the highest bidder is given the privilege to harvest all the plants and in addition garners fruits to sell in the local market. During summer, *Trapa natans* is harvested. The fruit is known for its nutritional value and for its thirst-quenching properties. It has been widely recognized as one of the favorite fruits of local people and moreover the fruit has been known for a good chunk of revenue return for the community. During winter, aquatic plants are harvested and the lake turns out to be a carnival for boat racing festival. The selling of these harvested edible macrophytes has become a source of additional income for the local people. Some of the major hurdles of Rudrasagar lake are siltation from three inlets (Noachora, Kamtalichora and Durlav narayanchora), weed infestation (uncontrolled growth of *Eichhornia crassipes)*, encroachment for agricultural land and households, pollution from open swage, illegal fishing by poisoning water and hunting of migratory birds in winter season. Runoff of fertilizers and pesticides from agricultural land during rainy season, mixing poison for fishing, oil and grease from boat, open swage are the main cause of water pollution in Rudrasagar lake.

4. Discussion

4.1. Assessment of Plant Diversity

Among the 31 macrophytes, Nymphaeaceae and Poaceae were represented by 4 species and Araceae, Asteraceae, Hydrocharitaceae, Onagraceae, and Polygonaceae were represented by 2 species each. One species each was recorded from Alismataceae, Azollaceae, Ceratophyllaceae, Commelinaceae, Convolvulaceae, Cyperaceae, Lentibulariaceae, Marsileaceae, Menynthaceae, Najadaceae, Pontederiaceae, Salviniaceae, and Trapaceae (Table 1). Bhowmik et al. [29] reported 65 hydrophytes from wetlands in West Tripura, India. Some of the species have already been reported by him, but 16 species are newly reported in our study.

Eichhornia crassipes was the dominant macrophyte of Rudrasagar Lake during summer (IVI=43.36) and winter (IVI=47.23); *Nymphoides indica* (IVI=41.14) was dominant during monsoon season. The dominant macrophytes throughout the year were *Nymphoides indica* (IVI=41.13), *Eichhornia crassipes* (IVI=38.60), and *Vallisneria spiralis* (IVI=36.69) (IVI=31.10) (Figure 3). Saluja and Garg [4] also reported IVI of 28 macrophyte species from Bhindawas Lake, Haryana, in which the dominant species was *Salvinia natans* (L.) All. (IVI=64.11). A few plants, such as *Nymphaea micrantha* Guill. & Perr., *Nymphaea pubescens* Willd., and *Nymphaea stellata* F.Mueller, were only found in the monsoon season. These species are highly utilized by local people, so in summer and winter when the water level is low, these plants are rarely available in the lake. *Eichhornia crassipes* is hardly visible in the monsoon season, but during summer and winter its vigorous growth reduces the surface area of open water and creates problems for boating. However, according to local people, this plant is able to absorb oil from motor boats, which helps to maintain water quality.

Shannon's index had maximum values in the monsoon season (3.15) and summer (2.72), whereas a minimum value during winter (2.60) due to low atmospheric temperature effect plant growth. The mean diversity of macrophytes was much higher in monsoon season than during summer and winter. Simpson's value was high during the monsoon season (0.10) and winter (0.09) and lowest in summer (0.07). Overall, macrophyte diversity of Rudrasagar Lake was at its maximum during monsoon season and minimum in winter. According to Suluja and Garg [4], the maximum value of Shannon and Simpson indexes was 2.28 and 0.86, respectively, in Bhindawas wetland, India. This indicates that Bhindawas wetland ecosystem has lower diversity but higher dominance than the present study, which might be due to water-related variables (dissolved oxygen, pH, and phosphorus levels) or soil nutrient factors (soil carbon and phosphorus levels).

4.2. Identification of Plant Use Category

Macrophytes were found to be used for various purposes such as food, fodder, medicine, and fencing. It was also observed that whole plant or different parts of plants such as roots, stems, leaves, fruit, and seeds were used for various purposes (Figure 2). We found that 35% of macrophytes were used as a whole plant for medicine, food, and fodder, whereas in the case of 5% of the macrophytes only the seeds were used.

Total value index of these 31 species was calculated on the basis of cultural value, practical value, and economic value. The cultural values range from 0.51 to 2.4; the practical and economic values range from 0.23 to 2.23 and 0 to 200, respectively. High TVI indicates macrophytes that were highly preferred by the community and low TVI indicates less preferred. According to TVI, *Euryale ferox* (202.93), *Trapa natans* (163.13), *Enhydra fluctuans* (92.47), *Amischophacelus axillaris* (81.43), and *Ludwigia adscendens* (73.44) were the most preferred macrophyte species (Table 1). This might be due to easy availability, easy harvesting method, and high utilization value of those macrophytes. The economic values of these macrophytes were also much higher than the values of the other macrophytes we found.

4.3. Comparison of IVI and TVI

After determining the IVI and TVI ranks of the macrophyte species, the data were compared. For most of the macrophyte species the rank by IVI differed from the TVI ranking (Table 2). *Nymphoides indica*, *Eichhornia crassipes*, and *Vallisneria spiralis* were the most dominant species as per IVI, whereas *Euryale ferox*, *Trapa natans*, and *Enhydra fluctuans* were considered the most useful macrophytes based on TVI. Macrophytes with high IVI are dominant in nature due to their high relative abundance but the TVI value depends on the utilization pattern. High TVI values indicate high practical and economical values. In the community, one macrophyte was highly utilized but the people are not concerned about its relative abundance. This is why plants with high TVI value but low IVI value are facing threats. Plants with high IVI increase after harvesting as disturbance sometimes increases the vegetation. So in both cases TVI is directly or indirectly controlling the IVI, especially by relative abundance. Note that *Nymphoides indica*, which was ranked first by IVI value, was 17th in the TVI ranking as its economic value was less than that of other species. *Trapa natans* was the second most preferred macrophyte species according to TVI and ranked 5th as per IVI because it was easily available. *Salvinia cucullata* is only used as fodder and least preferred macrophyte species as per TVI. It was reported by other worker that wetland conservation should be based on traditional knowledge and resource priority by the community that will eventually aid in fostering biodiversity and preserving key ecosystem services in cost effective and sustainable way [30].

4.4. Correlation between IVI and Other Useful Properties of Macrophytes

Correlation between the IVI and different parameters of TVI was calculated (Table 3). Positive correlations were found between TVI and cultural value ($r = 0.603$; $P < 0.01$) and between TVI and economic value ($r = 0.975$; $P < 0.01$). Cultural value also showed a positive correlation with practical value ($r = 0.434$; $P < 0.05$). The high correlation between the cultural value and practical value was also reported by Reyes-Garcia et al. [26]. IVI values had a positive correlation with cultural value ($r = 0.357$; $P < 0.05$), which indicates that easily available macrophytes are culturally important for the local people. But practical value of the macrophytes does not show any relation with the availability of those macrophytes in the lake. Therefore if a macrophyte has high practical value it means it is highly used by the community.

Table 2. List of aquatic plant species in Rudrasagar Lake, Tripura, India, ranked by Importance Value Index (IVI) and Total Value Index (TVI)

Importance Value Index	Corresponding rank	Total Value Index
Nymphoides indica (L.) Kuntze	1	*Euryale ferox* Salisb.
Eichhornia crassipes (Mart.) Solms	2	*Trapa natans* var. Bispinosa (Roxb.)Makino
Vallisneria spiralis L.	3	*Enhydra fluctuans* Lour.
Amischophacelus axillaris (L.) R.S.Rao & Kammathy	4	*Amischophacelus axillaris* (L.) R.S.Rao & Kammathy
Trapa natans var. Bispinosa (Roxb.)Makino	5	*Ludwigia adscendens* (L.) H.Hara
Nymphaea pubescens Willd.	6	*Nymphaea micrantha* Guill. & Perr.
Enhydra fluctuans Lour.	7	*Najas marina* L.
Ludwigia octovalvis (Jacq.) P.H.Raven	8	*Nymphaea pubescens* Willd.
Hygroryza aristata Nees	9	*Alocasia indica* Schott
Euryale ferox Salisb.	10	*Nymphaea stellata* F.Muell.
Hydrilla verticillata C.Presl	11	*Marsilea minuta* L.
Polygonum hydropiper L.	12	*Ludwigia octovalvis* (Jacq.) P.H.Raven
Cyperus haspan L.	13	*Sagittaria guayanensis* Kunth
Ludwigia adscendens (L.) H.Hara	14	*Ipomoea fistulosa* Mart. ex Choisy
Nymphaea micrantha Guill. & Perr.	15	*Eichhornia crassipes* (Mart.) Solms
Nymphaea stellata F.Muell.	16	*Vallisneria spiralis* L.
Najas marina L.	17	*Nymphoides indica* (L.) Kuntze
Marsilea minuta L.	18	*Isachne globosa* Kuntze
Ceratophyllum demersum J.G.Klein ex Cham.	19	*Panicum laxum* Sw.
Pistia stratiotes L.	20	*Polygonum hydropiper* L.
Alocasia indica Schott	21	*H. verticillata*
Isachne globosa Kuntze	22	*Cyperus haspan* L.
Grangea maderaspatana (L.) Poir.	23	*Polygonum barbatum* Comm. ex Meisn.
Sagittaria guayanensis Kunth	24	*Azolla pinnata* R.Br.
Polygonum barbatum Comm. ex Meisn.	25	*Pennisetum polystachyon* (L.) Schult.
Utricularia aurea L.	26	*Utricularia aurea* L.
Polygonum hydropiper L.	27	*Ceratophyllum demersum* J.G.Klein ex Cham.
Salvinia cucullata Roxb.	28	*Pistia stratiotes* L.
Azolla pinnata R.Br.	29	*Hygroryza aristata* Nees
Pennisetum polystachyon (L.) Schult.	30	*Grangea maderaspatana* (L.) Poir.
Ipomoea fistulosa Mart. ex Choisy	31	*Salvinia cucullata* Roxb.

Table 3. Pearson correlation coefficients of different parameters

Parameters	Importance Value Index	Cultural value	Practical value	Economic value	Total Value Index
Importance Value Index	1	0.357*	0.217	0.255	0.252
Cultural value		1	0.434*	0.648**	0.603**
Practical value			1	0.141	0.123
Economic value				1	0.975**
Total Value Index					1

*Correlation is significant at the 0.05 level (2-tailed).
**Correlation is significant at the 0.01 level (2-tailed).
(n = 31).

5. Conclusion

This study determined the influence of macrophyte species on utilization pattern in wetland ecosystems of India. We showed that the cultural value of a macrophyte depends on its dominance, but the practical value of the macrophyte depends on its easy availability. Since practical value is not dependent on dominance it creates a threat for overutilized macrophytes. Overutilization of dominant macrophytes reduces the relative abundance of those macrophytes in nature, which ultimately reduces their dominance. A few macrophytes, such as *Euryale ferox*, *Trapa natans*, and *Enhydra fluctuans*, may be cultivated in water bodies to reduce stress on selected species.

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References

[1] Ghermandi, A, Van den Bergh, J.C.J.M., Brander, L.M., de Groot, H.L.F., Nunes, P.A.L.D. The economic value of wetland conservation and creation: a meta-analysis. FEEM. http://ageconsearch.umn.edu/bitstream/44229/2/79-08.pdf 2008 [Online].

[2] Garg, J.K. "Wetland assessment, monitoring and management in India using geospatial techniques." *J Environ Manage.* 148: 112-123. 2015.

[3] Chen, F. and Yao, Q. "Review of wetland ecosystem services valuation in China." *Adv. J Food. Sci .Techn.* 6(1). 1277-1281. 2014.

[4] Saluja, R., Garg, J.K. "Macrophyte species composition and structure along littoral region in relation to limnological variables of a tropical wetland ecosystem." *Chem Ecol*. 33. 499-515. 2017.

[5] Cronk, J.K., Fennessy, M.S. *Wetland plants: biology and ecology.* Boca Raton (FL): CRC Press. 2001.

[6] [SAC] Space Applications Centre. *National wetland atlas*. Ahmedabad, India: Indian Space Research Organisation. 2011.

[7] Kar, D. *Wetlands and lakes of the world*. London: Springer. 2013.

[8] Chavan, A.R., Sabnis, S.D. "A study of the hydrophytes of Baroda and environs." *J Indian Bot Soc.* 40. 121-130. 1961.

[9] Majumdar, N.C. "Aquatic and semi aquatic flora of Calcutta and adjacent localities." *Bull Bot Soc Bengal.* 9: 10-17. 1965.

[10] Canfield, D.E.J., Jones, J.R. "Assessing the trophic status of lakes with aquatic macrophytes." *Lake Reserv Manage*. 1. 446-451. 1984.

[11] Banerjee, A. and Matai, S. "Composition of Indian aquatic plants in relation to utilization as animal forage." *J. Aquat. Plant. Manage. Soc*., 28. 69-73. 1990.

[12] Asplund, T.R. and Cook, C.M. "Effects of motor boats on submerged aquatic macrophytes,". *Lake Reserv. Manage.*, 13. 1-12. 1997.

[13] Venu, P. "A review of floristic diversity inventory and monitoring methodology in India." PINSA. 64(5). 281-292. 1998.

[14] Jain, A., Roshnibala, S., Kanjilal, P.B., Singh, R.S., Singh, H.B. "Aquatic/semi-aquatic plants used in herbal remedies in the wetlands of Manipur, Northeastern India." *Indian J Tradit Know.* 6(2):346-351. 2007.

[15] Misra, M.K., Panda, A., Sahu, D. "Survey of useful wetland plants of South Odisha, India." *Indian J Tradit Know.* 11(4). 658-666. 2012.

[16] Pandey, A., Verma, R.K., Mohan, J., Mohan, N. "Utilization of *Azolla* aquatic plant as phytoremediation for treatment of effluent." *Int J Appl Res*., 1. 28-30. 2015.

[17] Stahr K.J., Kaemingk, M.A. An evaluation of emergent macrophytes and use among groups of aquatic taxa. *Lake Reserv Manage*. 33: 314-323. 2017.

[18] Taran, M. and Deb, S. "Valuation of provisional and cultural services of a Ramsar site: a preliminary study on Rudrasagar lake, Tripura, Northeast India." *Journal of Wetlands Environmental Management.* 5.37-43. 2017.

[19] Deb, D.B. *The flora of Tripura State.* Vol. I. New Delhi, India: Today & Tomorrow Printers & Publishers. 1981.

[20] Deb, D.B. *The flora of Tripura State.* Vol. II. New Delhi, India: Today & Tomorrow Printers & Publishers. 1983.

[21] Misra, R. *Ecology work book.* Calcutta: Oxford and IBH Publishing Company. 1968.

[22] Curtis, J.T. *The vegetation of Wisconsin: an ordination of plant communities.* Madison (WI): University of Wisconsin Press. 1959.

[23] Shannon, C.E., Weaver, W. *The mathematical theory of communication*. Urbana (IL): University of Illinois. 1963.

[24] Simpson, E.H. "Measurement of diversity." *Nature* 163. 688. 1949.

[25] Quinlan, M.B., Quinlan, R.J., Nolan, J.M. "Ethnophysiology and herbal treatments of intestinal worms in Dominica, West Indies." *J Ethnopharmacol*., 80. 75-83. 2002.

[26] Reyes-Garcia, V., Huanca, T., Vadez, V., Leonard, W., Wilkie, D. "Cultural, practical, and economic value of wild plants: a quantitative study in the Bolivian Amazon." *Econ Bot.* 60: 62-74. 2006.

[27] Benz, B.F., Cevallos, J., Santana, F., Rosales, J., Graf, S. "Losing knowledge about plant use in the Sierra de Manantlan Biosphere Reserve, Mexico." *Econ. Bot*., 54. 183-191. 2000.

[28] Byg, A., Balslev, H. "Diversity and use of palms in Zahamena, eastern Madagascar." *Biodivers Conserv*. 10. 951-970. 2001.

[29] Bhowmik, S., Saha, R., Datta, B.K. "Aquatic and marshland plants in West Tripura, India." *Pleione*. 2(1). 3-11. 2008.

[30] Kumari, R., Shukla S. K., Parmar K., Bordoloi N., Saikia, P. "Wetlands Conservation and Restoration for Ecosystem Services

and Halt Biodiversity Loss: An Indian Perspective" Upadhyay A. K. et al. (eds.), *Restoration of Wetland Ecosystem: A Trajectory Towards a Sustainable Environment* pp 75-85.