RESEARCH ARTICLE

Phytosociological Study of Bakhira Lake, a Ramsar Wetland of Uttar Pradesh, India

Vinay Kumar Tiwari[1*], Sunita Verma[2]

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Abstract

The phytosociological study of Bakhira Lake, a Ramsar wetland in Uttar Pradesh, India, focuses on understanding the diversity, composition, and distribution of macrophytes within the ecosystem. Wetlands, often described as "biological supermarkets," provide essential ecosystem services, including water purification, flood control, and habitat for diverse flora and fauna. The study area, Bakhira Bird Sanctuary, covers 29 square kilometers and is prone to seasonal flooding, which influences the local vegetation and biodiversity. Field surveys conducted from June 2023 to May 2024 involved 180 quadrats, with data collected on the density, frequency, and abundance of macrophyte species following established ecological methods. A total of 127 angiospermic species across 83 genera and 43 families were identified, with Cyperaceae, Poaceae, and Asteraceae being the most dominant families. The ecological classification revealed a higher prevalence of free-floating hydrophytes. Data analysis showed that species like *Eichhornia crassipes*, *Phragmitis karka*, and *Lemna minor* had the highest Importance Value Index (IVI), indicating their dominance and adaptability in the wetland. The study also identified 10 invasive species, such as *Alternanthera philoxeroides* and *E. crassipes*, which threaten native biodiversity through rapid spread and competition for resources. This research underlines the need for conservation strategies to protect the wetland from anthropogenic pressures, including agricultural encroachment. The findings provide valuable insights for policymakers, emphasizing the importance of managing invasive species and conserving native biodiversity to maintain the ecological balance of Bakhira Lake.

Highlights:

- The study of Bakhira Lake, a Ramsar wetland in Uttar Pradesh, focuses on the diversity, composition, and distribution of macrophytes across its ecosystem.
- Field surveys conducted from June 2023 to May 2024 identified 127 angiosperm species from 83 genera and 43 families, with Cyperaceae, Poaceae, and Asteraceae as the dominant families.
- Species like *Eichhornia crassipes*, *Phragmites karka*, and *Lemna minor* had the highest importance value index (IVI), reflecting their ecological dominance in the wetland.
- The study identified 10 invasive species, including *Alternanthera philoxeroides* and *E. crassipes*, which threaten native biodiversity by rapidly spreading and competing for resources.
- The findings emphasize the need for conservation measures to manage invasive species and protect Bakhira Lake's biodiversity and ecological balance from anthropogenic pressures, such as agricultural encroachment.

Keywords: Floristic, Phytosociological, Bakhira, Wetland, Frequency, Density, Abundance

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Introduction

Wetlands are often referred to as the "Kidneys of the Landscape" or "biological supermarkets" due to their vital role in aquatic ecosystems (Allen-Diaz *et al.,* 2004). These natural assets support millions of people by providing goods and services, such as water purification, flood control, and habitat for biodiversity (Barbier, 2011). Aquatic macrophytes play a vital role as the primary biotic constituents of wetland environments, contributing significantly to nutrient cycling, depth regulation, biodiversity, and the pollution levels of wetlands (Reshi *et al.,* 2021; Chaudhary & Devkota, 2021). These hydrophytes, including aquatic angiosperms and pteridophytes, grow in or near water and spend at least part of their life cycle submerged or floating (Mandal & Mukherjee, 2024). In addition, they serve as bioindicators of ecosystem health and provide shelter for a wide variety of invertebrates, fish, and birds (Mishra & Singh, 2021). Biodiversity, particularly the variety and variability of life forms, is a key parameter for assessing ecosystem health. Floristic analysis, which encompasses the total vegetation composition within a specific geographical area, is crucial for evaluating ecosystem dynamics (Sen, 2021; Roka *et al.,* 2022). Phytosociology, the science of studying the composition, structure, and development of plant communities, is essential for understanding the relationships between species within these ecosystems (Pott, 2011). Understanding the floral diversity, ecological parameters, and conservation needs of wetland

[1]Research Scholar, Department of Botany, Christ Church College Kanpur, Uttar Pradesh 208001.

[2]Professor, Department of Botany, Christ Church College Kanpur, Uttar Pradesh 208001.

***Corresponding author:** Vinay Kumar Tiwari, Research Scholar, Department of Botany, Christ Church College Kanpur, Uttar Pradesh 208001, Email: vkt1686@gmail.com

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ecosystems is essential for their protection and restoration (Zaparina *et al.,* 2024). Several floristic studies have been conducted across India, including notable research at the Bakhira Bird Sanctuary of Uttar Pradesh (Mishra & Narain, 2010; Kumar & Dwivedi, 2022). Despite these efforts, the Bakhira wetland has not been explored in terms of its phytosociological parameters. Recognizing the significance of assessing macrophyte diversity and evaluating the health of wetland ecosystems, this research aims to examine the species composition and phytosociological characteristics of macrophytes in the Bakhira wetland. The study offers valuable insights into the frequency, diversity, and abundance of macrophytes, highlighting their role within aquatic ecosystems.

Material and Methods

Study Area

Bakhira Bird Sanctuary, also known as Bakhira Tal (N 26°54′, E 83°06′), is India's largest natural floodplain wetland, situated west of the Rapti River's bank in Sant Kabir Nagar district of Uttar Pradesh (Fig. 1). It is a shallow, river-connected wetland that was designated as a bird sanctuary in 1990 by the Forest and Wildlife Department of Uttar Pradesh, India. Covering an area of 29 km^2, Bakhira Tal is part of the natural floodplain of the Rapti river, characterized by its mostly flat terrain and an average elevation of 100 meters above sea level, representing a typical Terai landscape (Fig 2). The region is prone to severe flooding, especially during the monsoon season, which causes significant damage to both property and lives. The flat topography of the Sant Kabir Nagar district, combined with heavy rainfall, often leads to prolonged flooding and waterlogging issues. Mishra *et al.* (2021) have focused on wetland conservation, highlighting the challenges posed by anthropogenic pressures like agriculture and urbanization. The sanctuary receives an average annual rainfall of approximately 1,000 mm, most of which occurs during the monsoon season from June to September (Singh & Mishra, 2019). The temperature at Bakhira Bird Sanctuary fluctuates significantly throughout the year, with summer temperatures ranging from 30 to 42°C, causing high evaporation and water loss. In winter, temperatures drop between 8 and 22°C, creating ideal conditions for migratory birds from regions like Siberia and Central Asia (Singh & Yadav, 2020). Humidity at Bakhira Bird Sanctuary is highest during the monsoon season, often exceeding 85%, while in the winter and summer, it drops to 40 to 60% (Pandey & Singh, 2018).

Data collection

A Field survey was carried out from June 2023 to May 2024, covering the three seasons (summer, monsoon and winter) to collect the data. Collected macrophytes were dried properly by changing the paper and work out of the specimen was done in the laboratory for identification. Phytosociological attributes of plant species were studied by laying 180 quadrats of 10 x 10 m^2 size at intervals of 100 m (Braun-Blanquet, 1932). The collected specimens were identified with the help of regional floras, taxonomic revisions and monographs by using identification keys (Hooker, 1872-1897; Subramanyam,1962; Cook, 1996, Srivastava,1976 and Saini *et al.*, 2010). Besides that, Plants of the World Online (POWO 2024) and World Flora Online (WFO 2024) were used to check the accepted names of the flora. Collected specimens were cross-checked at the herbarium of the National Botanical Research Institute (NBRI), Lucknow.

Data analysis

The vegetation data recorded was quantitatively analyzed for density, frequency and abundance (Curtis and McIntosh 1950). The relative values of these indices were determined (Phillips, 1959) and summed up to get the Importance Value Index (IVI) of individual species (Curtis, 1959).

$$Density = \frac{Total\ number\ of\ individuals\ of\ a\ species\ in\ all\ quadrats}{Total\ number\ of\ quadrates\ studied}$$

$$Frequency\ (\%) = \frac{Number\ of\ quadrats\ in\ which\ the\ species\ occurs}{Total\ number\ of\ quadrate\ studied} \times 100$$

$$Abundance = \frac{Total\ number\ of\ individuals\ of\ a\ species}{Number\ of\ quadrates\ in\ which\ species\ occurs}$$

$$Relative\ Density\ (RD) = \frac{Density\ of\ a\ species}{Total\ density\ of\ all\ the\ species} \times 100$$

$$Relative\ Frequency(RF) = \frac{Frequency\ of\ a\ species}{Total\ frequency\ of\ all\ the\ species} \times 100$$

$$Relative\ Abundance\ (RA) = \frac{Abundance\ of\ a\ species}{Total\ abundance\ of\ all\ the\ species} \times 100$$

Importance Value Index (IVI) = RA+RD+RF

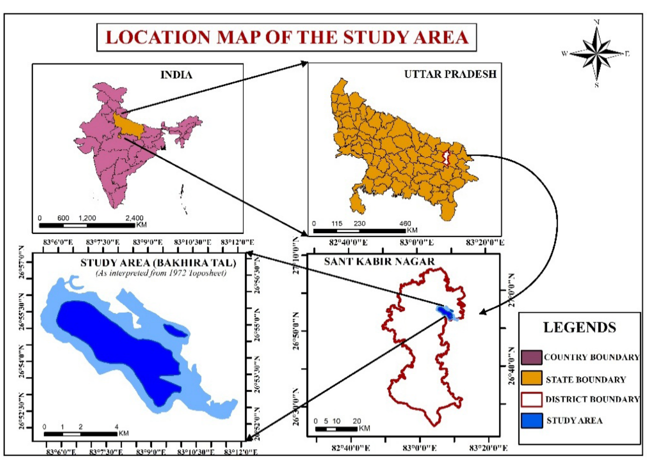

Fig. 1: Location map of Bakhira Bird Sanctuary

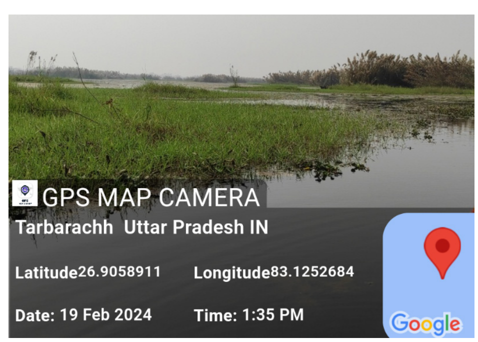

Fig. 2: A view of Bakhira wetland

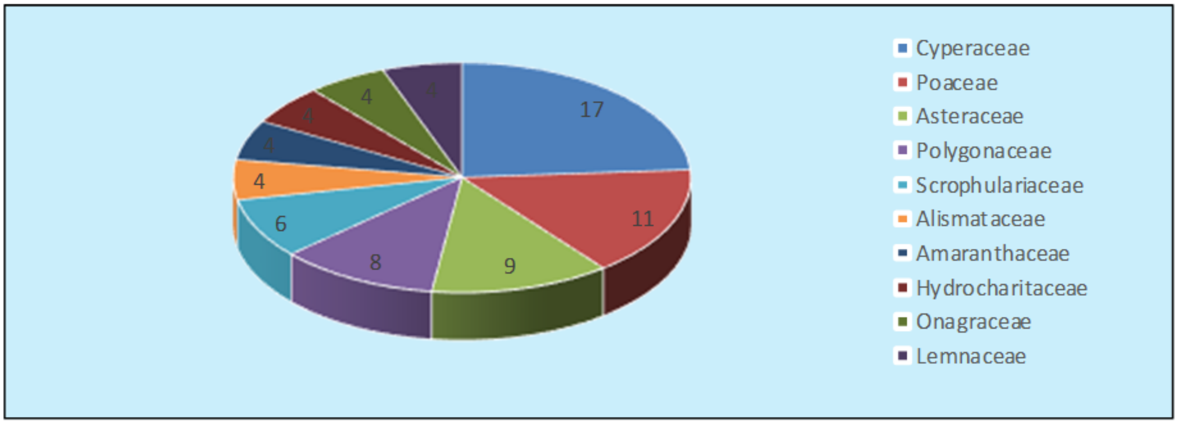

Fig. 3: Most represent plant families in Bakhira wetland

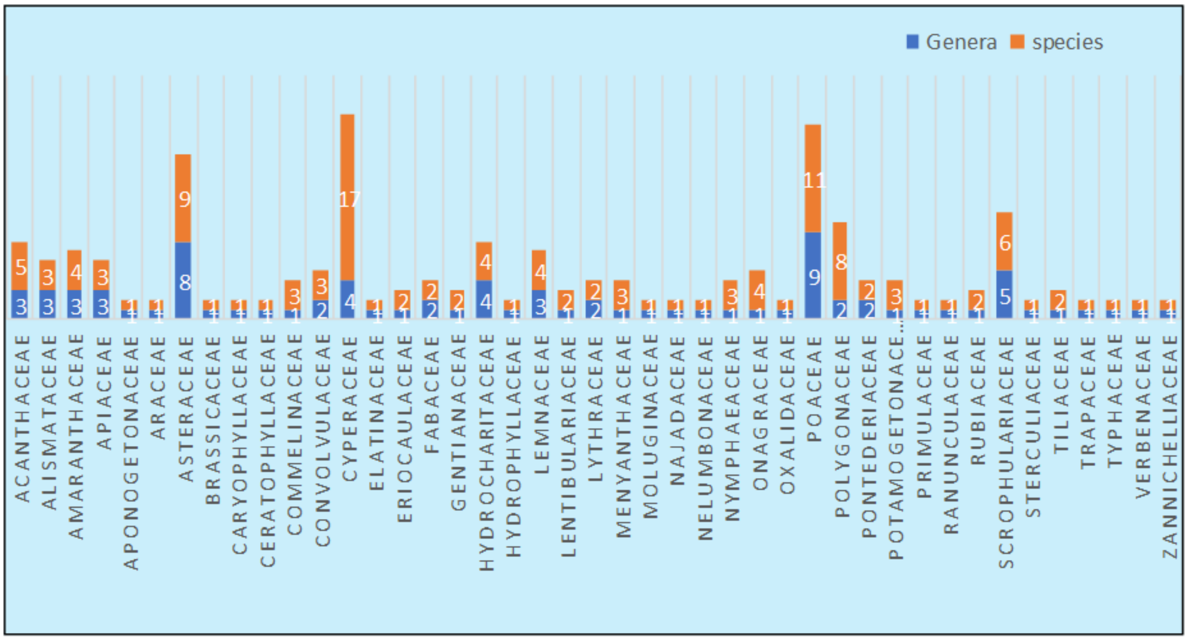

Fig. 4: Composition of angiospermic macrophytes in Bakhira wetland

Result and Discussion

A total of 127 angiospermic plant species of 83 genera belonging to 43 families were recorded (Table 1) during the study period. 20 species belonging to 14 angiosperms families. Among which, cypresses are the most dominant family with 17 species, followed by Poaceae (11 Species) Asteraceae (9 species), Polygonaceae (8 species), Scrophulariaceae (6 species), Alismataceae (4 species), Amaranthaceae (4 species) Hydrocharitaceae (4 species) Onagraceae (4 species) Lemnaceae (4 species) (Fig. 3). A similar observation was recorded by Mishra & Narain (2010) in their study on Bakhira wetland. In terms of genus composition, Poaceae has the highest (9 genera), followed by Asteraceae (8 genera), Scrophulariaceae (5 genera), and Cyperaceae (4 genera) (Fig. 4).

On the basis of ecological category, the composition of macrophytes was found as amphibious hydrophytes (15%), emergent hydrophytes (20%) submerged hydrophytes (20%), Free-floating hydrophytes (30%) and rooted floating hydrophytes (15%) (Fig. 5).

67.44% of the families were dicots and 32.56% of monocot plants (Fig 6), indicating that dicots predominate over monocots concerning species, genera and families. Such a dominance of dicots over the monocots in aquatic habitats has been emphasized by several workers (Burlakoti and Karmacharya, 2004; Manhas *et al*., 2009; Saini *et al*., 2010; Niroula and Singh, 2010).

Various phytosociological parameters, such as density frequency abundance, relative density, relative frequency and relative abundance and their respective IVI values have been measured in this investigation (Table 1**)**. The dominance of species based on IVI value is presented (Fig 7**)**. The maximum IVI value 5.87 was recorded in *Eichhornia crassipes* followed by *Phragmitis karka* (5.72), *Lemna minor* (5.72), *Hydrilla verticillata* (5.66), *Potamogeton pectinatus* (5.50), *Typha angustifolia* (5.44), *Vallisnaria spiralis* (5.34), *Wolffia arrhiza* (4.22), *Vetiveria zizanioides* (3.97), *Saccharum spontaneum* (3.94). Dwivedi *et al*., (2013) conducted a similar phytosociological study of Turanala,

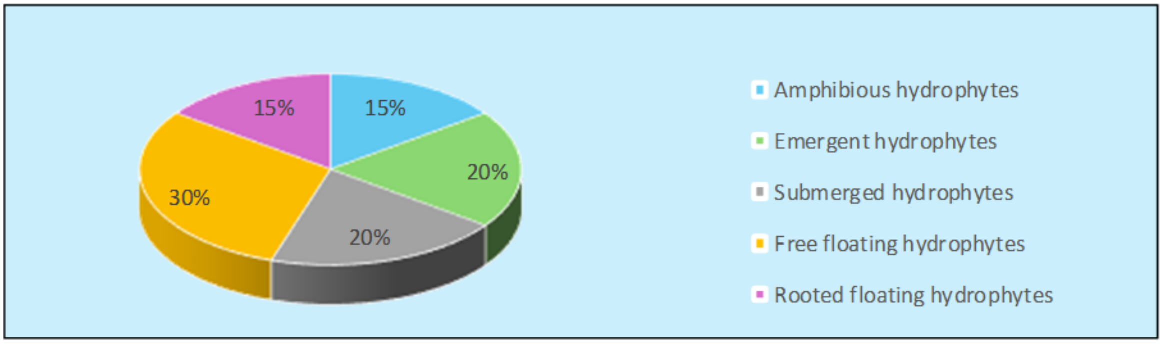

Fig. 5: Composition of ecological categories in Bakhira wetland

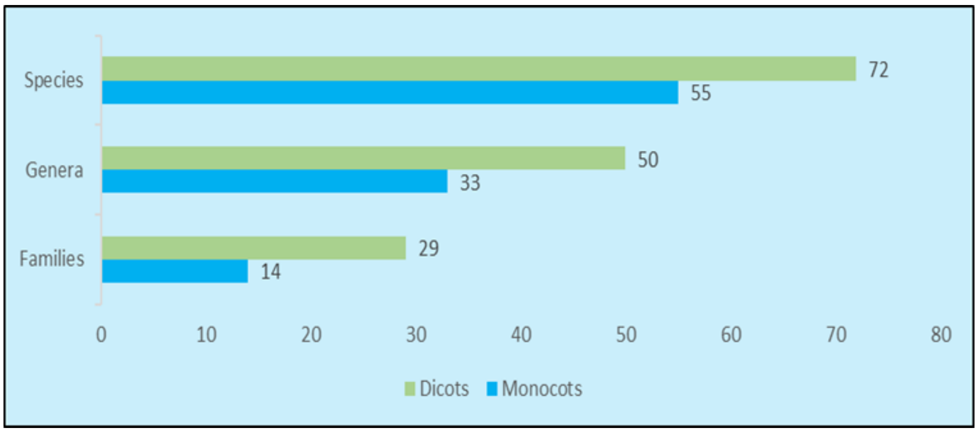

Fig. 6: Number of families, genera and species within dicots and monocots in Bakhira wetland

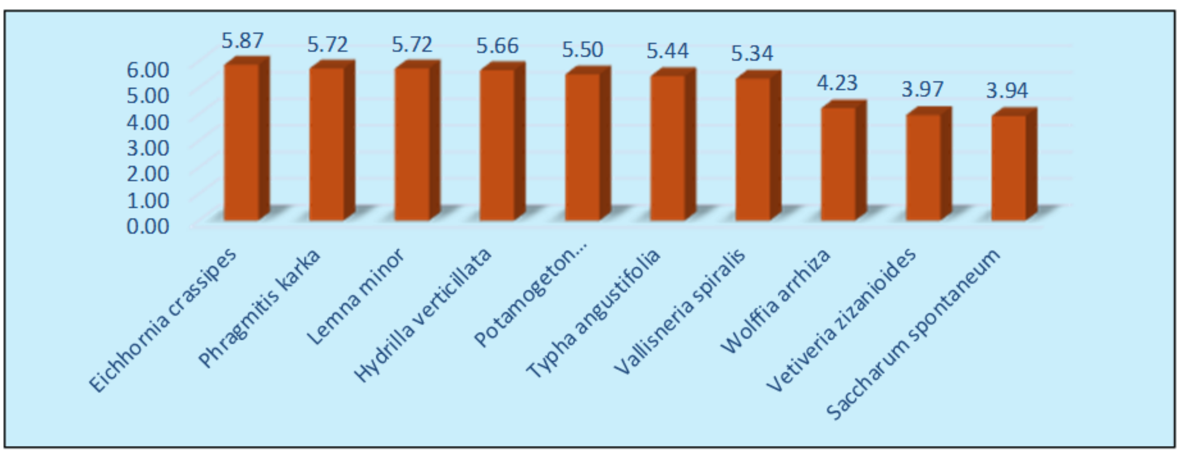

Fig. 7: Dominating species with IVI in Bakhira wetland

a riverine wetland of Gorakhpur, India. Importance value Index (IVI) is the measurement of the ecological amplitude of species (Ludwig and Reynolds, 1988) which indicates one of the abilities of a species to establish over an array of habitats. It gives composite information by taking into account the relative density, relative frequency and relative basal area. The frequency, abundance and density values are suitable for herbs and shrubs (Airi *et al.*, 2000). IVI is important information for all species. The vegetation characteristics of the area should be looked into through upper-story, middle- story and under-story vegetation for the purpose of a holistic assessment. The high importance value index of the species states its dominance and ecological success, its better power of regeneration and ecological amplitude in the area (Bhandari *et al.*, 1999).

Table 1: The phytosociological parameters of Bakhira wetland (D=Density, F=Frequency, A=Abundance, R=Relative, IVI=Importance Value Index)

Sl.No.	*Name of the plant species*	*D*	*F*	*A*	*RD*	*RF*	*RA*	*IVI*
1	*Adenostemma lavenia*	16.5	21.5	125	0.49	0.8	0.65	1.946
2	*Aeschynomene aspera*	22.25	17.75	100	0.66	0.66	0.52	1.846
3	*Alternanthera philoxeroides*	16	22.5	145.45	0.48	0.84	0.76	2.075
4	*Alternanthera sessilis*	24.5	12	127.5	0.73	0.45	0.67	1.842
5	*Amaranthus tenuifolius*	31.5	21.75	100	0.94	0.81	0.52	2.271
6	*Ammannia baccifera*	16.75	22	145.78	0.5	0.82	0.76	2.08
7	*Anagallis arvensis*	11	24.5	133.5	0.33	0.91	0.7	1.938
8	*Aponogeton crispus*	17.5	25	160	0.52	0.93	0.84	2.289
9	*Bacopa monnieri*	22.5	11.75	100	0.67	0.44	0.52	1.63
10	*Bergia ammannioides*	34	32	169.76	1.01	1.19	0.89	3.092
11	*Brachiaria reptans*	36.75	27.75	151.76	1.09	1.03	0.79	2.921
12	Bulbostylis barbata	32	28	165.65	0.95	1.04	0.87	2.861
13	*Caesulia axillaris*	27.25	32.5	144.56	0.81	1.21	0.76	2.778
14	*Caldesia parnassifolia*	37	20.5	170	1.1	0.76	0.89	2.753
15	*Canscora decurrens*	7	12.25	114.66	0.21	0.46	0.6	1.264
16	*Canscora diffusa*	11.5	31	119	0.34	1.16	0.62	2.12
17	*Celosia argentea*	10.5	24	142.89	0.31	0.89	0.75	1.954
18	*Centella asiatica*	16	31.25	100.34	0.48	1.17	0.52	2.165
19	*Centipeda minima*	19.5	7.5	114.67	0.58	0.28	0.6	1.459
20	*Ceratophyllum demersum*	37.35	10	166.79	1.11	0.37	0.87	2.356
21	*Coix lacryma-jobi*	23	19.75	143.7	0.68	0.74	0.75	2.171
22	*Commelina benghalensis*	18.5	32.5	100	0.55	1.21	0.52	2.285
23	*Commelina hasskarlii*	22.5	21	100	0.67	0.78	0.52	1.975
24	*Commelina longifolia*	12.75	8	112.43	0.38	0.3	0.59	1.265
25	*Corchorus capsularis*	13.25	11	134.57	0.39	0.41	0.7	1.507
26	*Corchorus olitorius*	16.5	12.5	141.59	0.49	0.47	0.74	1.697
27	*Cyperus brevifoliu*s	41.25	17.5	189.47	1.23	0.65	0.99	2.87
28	*Cyperus compactus*	19	31.75	123.47	0.57	1.18	0.64	2.394
29	*Cyperus difformis*	25.5	9.5	145	0.76	0.35	0.76	1.87
30	*Cyperus iria*	14	11	120.53	0.42	0.41	0.63	1.456
31	*Cyperus laevigatus*	23.5	27.25	159.75	0.7	1.02	0.83	2.55
32	Cyperus niveus	34	8.5	181.75	1.01	0.32	0.95	2.278
33	*Cyperus pilosus*	30.5	13	160	0.91	0.48	0.84	2.228
34	*Cyperus procerus*	23.25	15.5	150.87	0.69	0.58	0.79	2.058
35	*Cyperus pumilus*	17.5	12.75	167.97	0.52	0.48	0.88	1.873
36	*Cyperus rotundus*	11.5	7	165.96	0.34	0.26	0.87	1.47
37	*Cyperus tenuispica*	17.25	16.75	114	0.51	0.62	0.6	1.733
38	*Echinochloa colonum*	34.5	11.5	174	1.03	0.43	0.91	2.364
39	*Echinochloa crus-galli*	23	33.25	135.79	0.68	1.24	0.71	2.633
40	*Echinochloa stagnina*	11.5	32.6	122.45	0.34	1.22	0.64	2.197
41	*Eclipta prostrata*	42	9	184	1.25	0.34	0.96	2.547
42	*Eichhornia crassipes*	73.25	66.5	231.29	2.18	2.48	1.21	5.867
43	*Eleocharis acutangula*	24	32.5	126.76	0.71	1.21	0.66	2.588

44	*Eleocharis atropurpurea*	6	11	156.48	0.18	0.41	0.82	1.406
45	*Eleocharis dulcis*	14	27.5	144	0.42	1.03	0.75	2.194
46	*Enhydra fluctuans*	31.5	17.5	156.85	0.94	0.65	0.82	2.409
47	*Eriocaulon cinereum*	7	6.75	141.59	0.21	0.25	0.74	1.2
48	*Eriocaulon quinquangulare*	42.5	14.5	191.44	1.26	0.54	1	2.805
49	*Evolvulus nummularius*	8.25	5.75	154.58	0.25	0.21	0.81	1.267
50	*Glinus lotoides*	9	11	114.59	0.27	0.41	0.6	1.276
51	*Grangea maderaspatana*	23.5	16	145	0.7	0.6	0.76	2.053
52	Hydrilla verticillata	72	63.5	219.5	2.14	2.37	1.15	5.657
53	*Hydrolea zeylanica*	26	19.75	112	0.77	0.74	0.58	2.095
54	*Hygrophila auriculata*	34.75	11.5	167.86	1.03	0.43	0.88	2.34
55	*Hygrophila polysperma*	23	29.25	116.99	0.68	1.09	0.61	2.386
56	*Hygroryza aristata*	20.25	23	156.35	0.6	0.86	0.82	2.277
57	*Ipomoea aquatic*a	23	12.5	130	0.68	0.47	0.68	1.83
58	*Ipomoea carnea*	11	17.75	143.57	0.33	0.66	0.75	1.739
59	*Justicia quinqueangularis*	19.5	9.5	147.58	0.58	0.35	0.77	1.705
60	*Lemna minor*	71.25	65	225.5	2.12	2.42	1.18	5.722
61	*Lemna perpusilla*	50.5	29.25	199.35	1.5	1.09	1.04	3.635
62	*Limnophila indica*	45.25	24	189.75	1.35	0.89	0.99	3.232
63	*Limnophyton obtusifolium*	21	17.5	123.89	0.62	0.65	0.65	1.924
64	*Lindernia anagallis*	22.25	20.75	145.58	0.66	0.77	0.76	2.196
65	*Lindernia crustacea*	24	10.5	185.99	0.71	0.39	0.97	2.077
66	*Ludwigia adscenden*s	21.5	32	135.88	0.64	1.19	0.71	2.543
67	*Ludwigia octovalvis*	11	10.5	113.99	0.33	0.39	0.6	1.314
68	*Ludwigia perennis*	9.75	7	100	0.29	0.26	0.52	1.073
69	*Ludwigia prostrata*	21	17	146.44	0.62	0.63	0.76	2.024
70	*Mazus pumilus*	19	11.75	123	0.57	0.44	0.64	1.646
71	*Melochia corchorifolia*	12.5	9	143.67	0.37	0.34	0.75	1.458
72	Monochoria vaginalis	14.75	12	145	0.44	0.45	0.76	1.644
73	*Najas graminea*	27.75	30.5	167	0.83	1.14	0.87	2.835
74	*Najas minor*	12	14	146.75	0.36	0.52	0.77	1.646
75	*Nechamandra alternifolia*	9.5	11.5	117.56	0.28	0.43	0.61	1.325
76	*Nelumbo nucifera*	47	31	190.67	1.4	1.16	1	3.55
77	*Nymphaea nouchali*	49.5	20.5	187	1.47	0.76	0.98	3.214
78	*Nymphaea pubescens*	37	17.75	156.68	1.1	0.66	0.82	2.581
79	*Nymphaea rubra*	17.75	21.5	114.9	0.53	0.8	0.6	1.93
80	*Nymphoides cristata*	23.5	11	167.97	0.7	0.41	0.88	1.987
81	*Nymphoides hydrophyllum*	46	29.6	168.67	1.37	1.1	0.88	3.353
82	*Nymphoides indica*	37.5	25.25	150	1.12	0.94	0.78	2.841
83	*Oenanthe javanica*	13	19	120.56	0.39	0.71	0.63	1.725
84	*Oldenlandia corymbose*	34.5	21.5	169	1.03	0.8	0.88	2.711
85	*Oldenlandia pumila*	11.5	7	134.87	0.34	0.26	0.7	1.308
86	*Oplismenus burmannii*	14.75	11.75	134.85	0.44	0.44	0.7	1.581
87	*Oryza rufipogon*	31.5	27.25	116	0.94	1.02	0.61	2.559
88	*Ottelia alismoides*	17	8	156.98	0.51	0.3	0.82	1.624
89	*Oxalis corniculata*	21.75	17.25	144	0.65	0.64	0.75	2.043

90	*Phragmitis karka*	72.5	64.5	222	2.16	2.4	1.16	5.722
91	*Phyla nodiflora*	6.75	11	167.86	0.2	0.41	0.88	1.488
92	Pistia stratiotes	45.5	31	189	1.35	1.16	0.99	3.497
93	*Pluchea lanceolata*	17.9	16.25	124.9	0.53	0.61	0.65	1.791
94	*Polygonum barbatum*	11.25	13	145	0.33	0.48	0.76	1.577
95	*Polygonum glabrum*	23.5	14.75	156.89	0.7	0.55	0.82	2.069
96	*Polygonum lapathifolium*	21.5	15.25	147.96	0.64	0.57	0.77	1.981
97	*Polygonum minu*s	13	11.25	137.89	0.39	0.42	0.72	1.527
98	*Polygonum plebeia*n	44.75	37	158.68	1.33	1.38	0.83	3.54
99	*Polygonum limbatum*	31.5	21.75	184.47	0.94	0.81	0.96	2.712
100	*Potamogeton crispus*	16.5	9	145.88	0.49	0.34	0.76	1.589
101	*Potamogeton pectinatus*	69.5	62	215	2.07	2.31	1.12	5.503
102	*Potamogeton nodosus*	43.75	27.25	167.7	1.3	1.02	0.88	3.194
103	*Ranunculus sceleratus*	37	19	148.99	1.1	0.71	0.78	2.588
104	*Rorippa indica*	41.5	14	146.87	1.24	0.52	0.77	2.524
105	*Rotala indica*	13.5	11.75	138.48	0.4	0.44	0.72	1.563
106	*Rumex dentatus*	21.25	14	174	0.63	0.52	0.91	2.063
107	*Rungia pectinata*	7.5	10.25	115.69	0.22	0.38	0.6	1.21
108	*Rungia repens*	19	12.75	145.78	0.57	0.48	0.76	1.802
109	*Saccharum spontaneum*	63.25	30	179	1.88	1.12	0.93	3.936
110	*Sagittaria guayanensis*	16.75	11.5	144.89	0.5	0.43	0.76	1.684
111	*Scirpus articulatus*	22	8	167.64	0.65	0.3	0.88	1.829
112	Scirpus juncoides	49	31.75	189.66	1.46	1.18	0.99	3.633
113	*Sesbania bispinosa*	7.5	11	145.88	0.22	0.41	0.76	1.395
114	*Seseli diffusum*	13	9.75	137.58	0.39	0.36	0.72	1.469
115	*Spilanthes ciliata*	41	27.5	198.26	1.22	1.03	1.04	3.281
116	*Spilanthes radicans*	33.75	27	114.48	1	1.01	0.6	2.609
117	*Spirodela polyrhiza*	12	11.5	136.67	0.36	0.43	0.71	1.5
118	*Stellaria media*	17.5	13.5	174.37	0.52	0.5	0.91	1.935
119	*Trapa natans*	37.75	31.25	176.35	1.12	1.17	0.92	3.21
120	*Typha angustifolia*	68.25	61.5	213.5	2.03	2.29	1.12	5.439
121	*Utricularia aurea*	11.25	8.75	174.57	0.33	0.33	0.91	1.573
122	*Utricularia stellaris*	9.75	14	134	0.29	0.52	0.7	1.512
123	*Vallisneria spiralis*	67.5	59.75	212	2.01	2.23	1.11	5.344
124	*Veronica anagallis-aquatica*	30	27	148.54	0.89	1.01	0.78	2.675
125	*Vetiveria zizanioides*	51.5	40.25	180	1.53	1.5	0.94	3.973
126	*Wolffia arrhizal*	56.75	47.5	146.99	1.69	1.77	0.77	4.228
127	*Zannichellia palustris*	8.25	11.5	135.78	0.25	0.43	0.71	1.383

Species with a high importance value index (IVI) are Best adapted to the environmental conditions of their habitat, reflecting their dominance and ecological success. A high IVI not only points to strong regeneration abilities and broad ecological adaptability but also indicates that the species makes efficient use of available resources compared to others in the ecosystem. Species often grow together in specific environments due to similar needs for factors like light, temperature, water, soil nutrients, and drainage. They may also share resilience to human and animal activities such as grazing, burning, cutting, or trampling (Wood *et al*., 1994). It is generally suggested that each species relies on interactions with others for its survival, co-evolving within its ecosystem (Paine, 1966). Additionally, Abdullahi *et al*., (2009) noted that climatic conditions play a crucial role in determining species distribution across habitats. Out of 127 plant species of Bakhira wetland, 10 (7.87%) species were found exotic and invasive in the Bakhira wetland. These species are introduced in India from different countries are continents i.e. *Alternanthera* *philoxeroides* (South America), *Anagallis arvensis* (Southwest Asia and Europe), *Celosia argentea* (Tropical Africa), *Eclipta prostrata* (South America), *E. crassipes* (South America), *Ipomoea carnea* (Americas), *Lemna perpusilla* (North America), *Polygonum minus* (Southeast Asia), *Spilanthes ciliata* (South America) and *Spilanthes radicans* (South America). These invasive species are notorious for their rapid growth, forming dense mats on the water's surface that obstruct sunlight and deplete oxygen levels, ultimately harming aquatic fauna (India Water Portal, 2023), forming extensive colonies in wetlands, reducing local biodiversity and altering hydrological flows (Singh & Sundaramoorthy, 2021; Padma, 2022).

Conclusion

This study sheds light on the floristic composition and various types of macrophytes in the Bakhira wetland, detailing the overall dominance based on density, frequency, abundance, and IVI. While the Bakhira wetland hosts a considerable amount of biodiversity, it faces significant anthropogenic pressure from surrounding agricultural activities, leading to habitat degradation and loss. Parts of the wetland have been drained, converted into rice fields, and utilized for other crops. To protect this delicate ecosystem, it is essential to regulate the overuse of its biotic resources. The findings from this study provide a crucial basis for conservation initiatives aimed at preserving both the biodiversity and ecological functions of the wetland community. Conservation strategies are urgently needed to prevent further degradation and biodiversity loss in the region. This study serves as a valuable tool for conservationists, policymakers, and decision-makers, empowering them to make informed decisions and take the necessary actions to protect the Bakhira wetland. These efforts are vital for the long-term preservation and sustainable management of the ecosystem, safeguarding its ecological balance and benefits for future generations.

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Author's Contribution

Author-1 conducted the field work, calculated the statistical data and prepared the full manuscript. Author-2 gave the idea and designed the manuscript. All the authors revised the manuscript carefully and then approved.

Conflict of Interest

There is no conflict of interest.

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