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Seasonal dynamics and diversity of hydrophytic vegetation in the wetlands of Khedbrahma Taluka, Sabarkantha, North Gujarat, India

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Abstract
This study assesses the floristic composition and seasonal dynamics of wetland vegetation in Khedbrhma Taluka, Sabarkantha district, Gujarat. Spanning a two-year period from 2023 to 2025, the research involved six extensive field surveys covering Pre-monsoon, Post-monsoon, and Winter seasons across five selected wetland sites. A total of 142 plant species were documented, including 67 wetland species and 31 hydrophytes. Analysis of seasonal data reveals a distinct temporal pattern, with species richness peaking significantly during the post-monsoon seasons, attributed to optimal water levels and nutrient availability. Among the study sites, Sitol and Vartol consistently exhibited the highest species diversity, recording up to 57 and 58 species respectively during peak seasons. Morphological classification indicates a clear dominance of Herbs across all sites and seasons, followed by trees and shrubs. The hydrophyte community showed marked seasonal fluctuation, with Emergent species being the most resilient and abundant group, while Free-floating species remained rare or absent in dry spells. The study highlights the ecological sensitivity of these wetlands to seasonal water regimes and underscores the dominance of herbaceous flora in sustaining the local aquatic ecosystem.

Keywords: Hydrophytes, khedbrhma, phytodiversity, wetland flora, seasonal survey, sabarkantha district

Introduction

Wetlands are widely recognized as some of the most productive and biologically diverse ecosystems on Earth, functioning as essential transition zones between terrestrial and aquatic environments (Mitsch & Gosselink, 2015) [5]. These unique habitats play a fundamental role in hydrological stability, nutrient cycling, and the sustenance of global biodiversity, often referred to as the "kidneys of the landscape" for their ability to filter and purify water (Ramsar Convention Secretariat, 2016) [10]. In the context of the Indian subcontinent, wetlands are critical for ecological balance, covering a significant portion of the landscape. According to the National Wetland Atlas, Gujarat holds the distinction of possessing the highest proportion of wetland area in India, accounting for approximately 21.9% of the country's total wetland extent (SAC, 2011).

While Gujarat is renowned for its vast saline deserts and major Ramsar sites like Nalsarovar and Thol Lake. The smaller, inland freshwater wetlands of semi-arid regions—such as those in the Sabarkantha district remain comparatively underexplored (Saxton, and Sedgwick, 1918; Punjani, and Chaudhary, 2014; Barot *et al*., 2017) [1, 9, 11]. These inland water bodies are often ephemeral or semi-permanent, undergoing drastic environmental changes dictated by the seasonal monsoon cycle. The structural foundation of these ecosystems is provided by hydrophytes, or aquatic macrophytes, which are plants specifically adapted to thrive in water-saturated soil or submerged conditions (Cook, 1996) [2].

The distribution and life-cycle of these hydrophytes are intrinsically linked to the hydrological regime. In regions like Khedbrahma Taluka, the alternation between the water-abundant monsoon season and the dry winter/pre-monsoon periods creates a dynamic environment where only specific life forms such as emergent, submerged, or free-floating species can survive at different times (Patel, 2025; Prajapati *et.al*., 2025) [8]. Understanding these seasonal dynamics is crucial, as the fluctuation in water levels directly influences the species richness (alpha diversity) and the structural complexity of the vegetation.

Despite the ecological importance of these habitats, there is a paucity of comprehensive, multi-year data regarding the floristic composition of wetlands in Khedbrahma. Most existing checklists are static and fail to capture the temporal shifts in vegetation that occur between the wet and dry seasons. To address this gap, this research presents an extensive floristic survey conducted from 2023 to 2025. The study aims to document the biodiversity and ecological strategies of aquatic flora through a rigorous seasonal framework.

Material and methods

Study Area

The present study was conducted in Khedbrahma Taluka, located in the Sabarkantha district of Gujarat, India. This region is characterized by a semi-arid climate and a diverse topography that supports a network of seasonal and perennial wetlands. These aquatic systems function as critical ecological reservoirs, facilitating groundwater recharge and supporting a wide variety of floristic and faunal biodiversity. The district's wetlands are essential for sustaining local livelihoods, particularly in rainfed agricultural zones where they serve as primary water sources during lean periods.

For this research, five specific wetland sites were selected based on their hydrological persistence and ecological significance: Vartol, Matoda, Radhivad, Sitol, and Bandiyana. These five wetlands are situated across various parts of Khedbrahma Taluka, spanning diverse topographic landscapes. Among these, the Vartol Wetland (24° 5' 5.34" N, 73° 3' 56.90" E) is the most prominent, spanning approximately 28.2 hectares near Vartol village. This site holds a unique dual status as both a biodiversity hotspot and a cultural landmark due to the adjacent Chamunda Mata Temple, though its northern littoral zone faces increasing pressure from local quarrying activities. The Matoda Wetland (24° 6' 38.10" N, 73° 0' 51.47" E) covers 25.4 hectares and serves as a critical hydrological asset, functioning primarily as a water retention and aquifer recharge zone that supports the surrounding agrarian ecosystem. Complementing these larger water bodies are three smaller but vital wetlands that sustain the region's biological network. The Bandiyana Wetland (24° 9' 36.32" N, 73° 0' 51.55" E), covering 19.2 hectares, remains a relatively undisturbed natural habitat, providing a crucial refuge for sensitive aquatic species. The Sitol Wetland (24° 3' 58.94" N, 73° 4' 52.63" E), encompassing 10.6 hectares, plays a specific role in groundwater recharge and acts as a sanctuary for wetland-dependent fauna. Finally, the Radhivad Wetland (24° 4' 1.77" N, 73° 0' 53.20" E), though the smallest at 9.98 hectares, functions as an essential stepping-stone habitat for avian and aquatic life in the semi-arid landscape. Together, these five wetlands form an integrated ecological complex that is essential for maintaining the hydrological balance and floristic diversity of Khedbrahma Taluka.

Methodology

Field Surveys and Qualitative Sampling Extensive floristic explorations were carried out through six periodic field visits between 2023 and 2025, covering pre-monsoon, post-monsoon, and winter seasons. A qualitative sampling approach was employed, involving thorough walk-through surveys across the littoral and limnetic zones of each wetland. This method was chosen to maximize the detection of rare or seasonally ephemeral species that might be overlooked in fixed-area sampling. Direct observations and systematic recording of all visible plant species were performed at each site to document total floristic richness and community composition.

Taxonomic identification of specimens, specimen were collected in their flowering and fruiting stages to ensure accurate taxonomic determination. Identification was carried out using standard regional floras, primarily The Flora of Gujarat State (Shah, 1978) [12] and Aquatic and Wetland Plants of India (Cook, 1996) [2]. Botanical nomenclature was subsequently validated through the Plants of the World Online (POWO) database.

Spatio-Temporal Analysis, the qualitative data obtained from all five sites was tabulated to compare species presence across different survey fields. This allowed for the assessment of Site-wise and Season-wise variation in diversity, as well as the identification of critical biodiversity refugia within the taluka.

Result

Species Richness across wetlands

The floristic assessment of Khedbrahma Taluka documented a total of 142 plant species belongs to 110 genera of 50 families. An analysis of the taxonomic distribution reveals that Dicotyledons were the dominant class, comprising 108 species belonging to 85 genera and 39 families. Monocotyledons were represented by 33 species distributed across 24 genera and 10 families, while Pteridophytes contributed a single species to the total diversity. From an ecological perspective, 67 species were identified as wetland flora, with a specific subset of 31 species classified as true hydrophytes (Table 3).

Analysis of growth forms (habit) revealed a clear dominance of herbs, which were represented by 93 species. The remaining floristic diversity comprised 13 sedges, 12 trees, and 10 climbers. Shrubs and grasses were the least represented groups, contributing 7 species each to the total flora (Fig. 1).

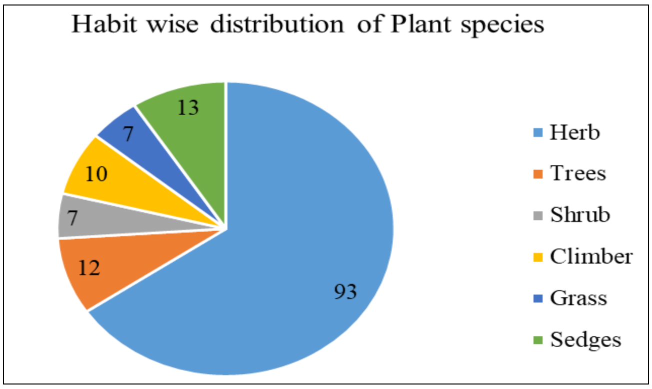

Fig 1: Graph Demonstrating Habit wise classification of total recorded species.

Analysis of the floristic composition at the family level revealed that Cyperaceae was the most dominant family, represented by 13 species. This was closely followed by Asteraceae with 12 species and Convolvulaceae with 10 species. Papilionaceae and Poaceae shared the fourth position, each contributing 7 species to the total floristic diversity. These top five families collectively represent a significant portion of the vegetation in the study area.

Taxonomic evaluation at the generic level indicated that Cyperus and Ipomoea were the most speciose genera, sharing co-dominance with 5 species each. The genus Senna occupied the second rank with 4 species, while Euphorbia, Fimbristylis, Phyllanthus, and Schoenoplectiella were represented by 3 species each. The prevalence of these genera, particularly those belonging to the sedge family (e.g., *Cyperus, Fimbristylis, Schoenoplectiella*), underscores the semi-aquatic ecological character of the Khedbrahma study area.

Morpho-Ecological Classification of Hydrophytes

The 31 identified hydrophyte species were categorized into four distinct ecological life forms based on their growth habit and relationship with the water surface. The distribution is as follows:

Emergent Hydrophytes (Dominant Group - 14 Species): This was the most diverse group, comprising species that are rooted in the substrate with vegetative parts extending above the water surface. Dominant taxa included *Typha angustata, Bolboschoenus maritimus, Limnophyton obtusifolium,* and various sedges like *Cyperus difformis* and *Fimbristylis* spp. The high representation of emergents suggests that the littoral zones of these wetlands are well-developed and that water levels fluctuate significantly, favouring amphibious plants.

Rooted with Floating Leaves (9 Species): This category included ecologically sensitive species such as *Nelumbo* *nucifera*, *Nymphaea pubescens*, *Nymphaea stellata*, and *Trapa natans.* The presence of these species, particularly in sites like Vartol and Sitol, indicates zones of stable, moderate water depth and nutrient-rich sediment.

Submerged Hydrophytes (6 Species): Species such as *Hydrilla verticillata, Vallisneria spiralis,* and *Najas minor,* and *Ottelia alismoides* were recorded. These plants are completely submerged and are excellent indicators of water clarity and oxygenation. Their presence fluctuated most drastically with seasonal water reduction.

Free Floating Hydrophytes (2 Species): The least represented group, comprising *Eichhornia crassipes* and *Spirodela polyrrhiza*. The low diversity of free-floating species may be attributed to the seasonal drying of wetlands, which prevents the permanent establishment of diverse floating communities.

Spatio-Temporal Dynamics and Seasonal Variation Quantitative

Assessment across six field seasons (2023–2025) revealed significant temporal heterogeneity in species richness and hydrophyte abundance (Table 1).

Table 1: Seasonal Variation in Hydrophyte Species Richness by Site

Seasons	Bandiyana	Matoda	Radhivad	Sitol	Vartol	Ganva	Lakhiya
Pre-Monsoon 2023	3	5	5	5	9	2	9
Post-Monsoon 2023	9	5	6	10	17	2	13
Winter 2024	7	1	5	15	14	0	11
Pre-Monsoon 2024	3	5	5	5	10	10	8
Post-Monsoon 2024	10	8	6	16	23	3	18
Winter 2025	7	3	8	19	25	3	18

Seasonal Oscillation: A marked "Boom and Bust" pattern was observed.

Peak Diversity (Post-Monsoon): The highest richness was consistently recorded during the Post-Monsoon seasons (Field 2 in 2023 and Field 5 in 2024). For instance, in the Fifth Field (Post-Monsoon 2024), the site Vartol recorded a peak of 23 hydrophyte species and 57 total wetland species. This surge is attributed to maximum water availability and optimal temperature for germination.

Lean Periods (Pre-Monsoon/Winter): Diversity declined sharply during Pre-monsoon surveys. In the First Field (Pre-Monsoon 2023), Bandiyana recorded only 3 hydrophyte species, dominated primarily by resilient emergent taxa, while submerged and free-floating species were largely absent due to desiccation.

Site-Specific Trends: High Diversity Zones: Vartol and Sitol emerged as the most floristically rich sites. In Field 6 (Winter 2025), Vartol maintained 25 hydrophyte species, suggesting superior water retention capacity and habitat heterogeneity compared to other sites.

Moderate/Low Diversity Zones: Matoda and Lakhiya showed moderate diversity but experienced sharper declines in hydrophyte counts during dry spells (e.g., Matoda dropped to just 3 hydrophytes in winter 2025), indicating these wetlands may be shallower or more prone to anthropogenic water extraction.

The investigation into the seasonal dynamics of 31 hydrophyte species across selected wetlands of Khedbrahma taluka revealed a pronounced cyclical trend in average species richness closely synchronized with the regional hydrological cycle. Initially, the baseline survey in Field 1 (Pre-Monsoon 2023) recorded a mean richness of 5.43 species, which significantly escalated to 8.86 species during the Field 2 (Post-Monsoon 2023) survey following the arrival of monsoon rains.

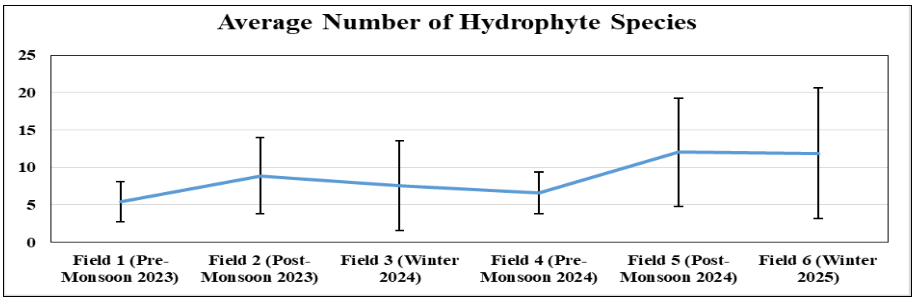

Fig 2: Demostarating Seasonal variation of Average Hydrophyte species

A characteristic decline was observed during the subsequent drier periods, with average diversity dipping to 7.57 in Field 3 (Winter 2024) and further to 6.57 in Field 4 (Pre-Monsoon 2024), reflecting the high sensitivity of aquatic flora to receding water levels and habitat desiccation. However, the most substantial surge occurred in Field 5 (Post-Monsoon 2024), where diversity peaked at an average of 12.00 species per site, followed by a slight stabilization in Field 6 (Winter 2025) with a high mean of 11.86. This spatial and temporal heterogeneity, particularly the high standard deviation noted in the final two field surveys, underscores the critical role of specific perennial refugia such as Vartol and Sitol, which maintained high hydrophyte counts (25 and 19 respectively) compared to more ephemeral sites like Matoda or Ganva that recorded as few as 3 species in the same period (Fig. 2).

Seasonal Variation of Wetland Plants by Site

The site-specific analysis of wetland floristic composition exhibited marked heterogeneity and distinct spatiotemporal fluctuations across the six seasonal surveys. Among the surveyed locations, Vartol and Sitol emerged as the most ecologically stable and floristically diverse habitats, consistently supporting the highest species richness. For instance, Vartol recorded a progressive increase from 20 species in the initial pre-monsoon survey (Field 1) to a peak of 38 species in the post-monsoon season of 2024 (Field 5), demonstrating superior habitat resilience. In contrast, ephemeral or smaller wetlands like Matoda and Ganva displayed significant seasonal sensitivity; Matoda, for example, exhibited a sharp decline from a post-monsoon high of 26 species (Field 5) to just 12 species in the subsequent winter (Field 6), indicating a rapid loss of peripheral wetland vegetation due to receding water levels and soil desiccation. Notably, Lakhiya showed a remarkable ecological recovery over the study period, expanding its floral assemblage from a mere 11 species in the first field to 36 species by the final winter survey.

Table 2: Seasonal Variation in Wetland Species Richness by Site

Seasons	Bandiyana	Matoda	Radhivad	Sitol	Vartol	Ganva	Lakhiya
Field 1 (Pre-Monsoon 2023)	14	17	15	16	20	12	11
Field 2 (Post-Monsoon 2023)	25	20	18	28	27	11	21
Field 3 (Winter 2024)	17	10	15	22	24	12	26
Field 4 (Pre-Monsoon 2024)	15	19	18	23	25	13	11
Field 5 (Post-Monsoon 2024)	27	26	20	37	38	16	32
Field 6 (Winter 2025)	19	12	18	32	37	19	36

Average Wetland Species Diversity Trends

The aggregate assessment of wetland species diversity across Khedbrahma taluka revealed a pronounced cyclical trajectory driven by the region's hydrological regime. The mean species richness followed a distinct "boom and bust" pattern, rising from a baseline average of 15.00 in the first pre-monsoon survey (Field 1) to 21.43 in the post-monsoon period (Field 2), before receding to 18.00 during the winter of 2024 (Field 3). A more robust floristic expression was observed in the second annual cycle, where favorable environmental conditions drove the average diversity to a study-period maximum of 28.00 species per site in the fifth field survey (Post-Monsoon 2024). Although a slight decline to an average of 24.71 was noted in the final winter survey (Field 6), the overall trend indicates a positive correlation between water availability and species proliferation, while the high variance observed in the later seasons suggests uneven water retention capacities among the different wetland sites (Fig. 3).

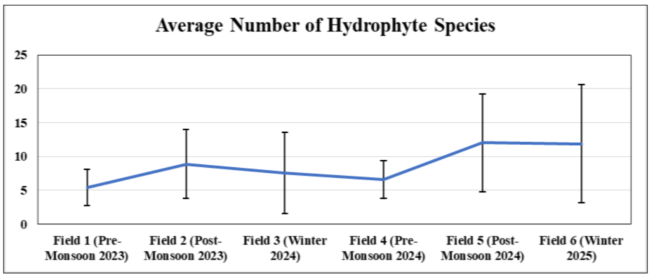

Fig 3: Representing Average Wetland Species Diversity Trend

Discussion

The present study documented a significant floristic diversity of 142 plant species across the selected wetlands of Khedbrahma Taluka, of which 67 species (47.18%) were identified as wetland-associated flora. The dominance of the family Cyperaceae (13 species) followed by Asteraceae (12 species) and Convolvulaceae (10 species) aligns with general trends observed in the aquatic flora of semi-arid Indian wetlands. The prevalence of Cyperaceae (sedges) and Poaceae (grasses) is ecologically significant; these families possess rhizomatous root systems that allow them to persist in water-logged soils and survive seasonal desiccation, a trait essential for the ephemeral wetlands of North Gujarat (Cook, 1996) [2]. The co-dominance of the genera Cyperus and Ipomoea (5 species each) further indicates a habitat transition zone where amphibious and climbing traits provide a competitive advantage in fluctuating water levels.

The classification of 31 hydrophyte species revealed a distinct dominance of Emergent forms (14 species), followed by Rooted with Free-Floating Leaves (9 species), Submerged (6 species), and Free Floating (2 species). The high proportion of emergent species (e.g., *Typha angustata, Limnophyton obtusifolium*) suggests that the study sites are characterized by extensive littoral zones and shallow water depths. This life form is most resilient to the "drawdown" effect (seasonal water recession), allowing them to thrive even when surface water disappears in winter. The low representation of free-floating species (*Eichhornia crassipes, Spirodela polyrrhiza*) can be attributed to the seasonal drying of these wetlands. Unlike emergent plants, free-floating species require permanent water columns to survive and are often flushed out during heavy monsoonal inflows or die off during summer desiccation (Gopal, 1990) [4].

The quantitative assessment across six seasons (2023–2025) demonstrates a strong correlation between hydrological regimes and species richness. The "Boom and Bust" pattern where average hydrophyte diversity peaked at 12.00 species in the Post-Monsoon of 2024 compared to a low of 5.43 in the Pre-Monsoon of 2023 confirms that water availability is the primary limiting factor in this semi-arid landscape. The sharp increase in diversity during the Post-Monsoon seasons (Fields 2 and 5) is likely triggered by the inundation of the wetland seed bank. Many aquatic annuals remain dormant in the soil during dry months and germinate rapidly following monsoon rains. The sustained high diversity in winter 2025 (Field 6) compared to winter 2024 (Field 3) suggests that the 2024 monsoon provided superior groundwater recharge, allowing wetlands to retain moisture longer into the dry season.

The study revealed significant spatial heterogeneity, with Vartol and Sitol functioning as critical biodiversity hotspots. Vartol consistently supported the highest richness (peaking at 25 hydrophytes), likely due to its larger surface area (28.2 ha) and the cultural protection afforded by the adjacent Chamunda Mata Temple, which may limit destructive anthropogenic encroachment (Dedhrotiya & Acharya, 2024) [3]. Conversely, the high variance and lower diversity in sites like Matoda and Ganva often dropping to < 3 species highlight their vulnerability to anthropogenic pressures such as agricultural water extraction and grazing. The recovery of Lakhiya from 9 species (Field 1) to 18 species (Field 5) demonstrates the resilience of these ecosystems, provided that hydrological connectivity is maintained.

Table 3: Showing Wetland Plants with Habit, Family, Class and Types of Hydrophytes

Botanical name	Habit	Family	Class	Type of Hydrophytes
Hygrophila polysperma (Roxb.) T. Anderson	Herb	Acanthaceae	D	E
Alternanthera sessilis (L.) Dc.	Herb	Amaranthaceae	D	No
Acmella paniculata (Wall. ex DC.) R. K. Jansen	Herb	Asteraceae	D	No
Ageratum conyzoides L.	Herb	Asteraceae	D	No
Caesulia axillaris Roxb.	Herb	Asteraceae	D	No
Cyanthillium cinereum (L.) H. Rob.	Herb	Asteraceae	D	No
Eclipta prostrata (L.) L.	Herb	Asteraceae	D	No
Grangea maderaspatana (L.) Poir.	Herb	Asteraceae	D	No
Coldenia procumbens L.	Herb	Boraginaceae	D	No
Heliotropium ovalifolium Forssk.	Herb	Boraginaceae	D	No
Chamaecrista pumila (Lam.) K. Larsen	Herb	Caesalpiniaceae	D	No
Evolvulus nummularius (L.) L.	Herb	Convolvulaceae	D	No
Ipomoea aquatica Forsk.	Climber	Convolvulaceae	D	RWFL
Ipomoea carnea subsp. *fistulosa* (Mart. ex Choisy) D.F.Austin	Shrub	Convolvulaceae	D	E
Merremia gangetica (L.) Cufod.	Herb	Convolvulaceae	D	No
Bergia ammanniodes Roxb.	Herb	Elatinaceae	D	No
Bergia suffruticosa (Del.) Fenzl	Herb	Elatinaceae	D	No
Euphorbia prostrata Ait.	Herb	Euphorbiaceae	D	No
Phyllanthus maderaspatensis L.	Herb	Euphorbiaceae	D	No
Nymphoides cristata (Roxb.) Kuntze	Herb	Gentianaceae	D	RWFL
Nymphoides indica (L.) Kuntze	Herb	Gentianaceae	D	RWFL
Spirodela polyrrhiza (L.) Schleid.	Herb	Lamiaceae	D	FF
Ammannia baccifera L.	Herb	Lythraceae	D	No
Glinus oppositifolius (L.) A. DC.	Herb	Molluginaceae	D	No
Nelumbo nucifera Gaertn.	Herb	Nymphaeaceae	D	RWFL
Nymphaea pubescens Willd.	Herb	Nymphaeaceae	D	RWFL
Nymphaea stellata Willd.	Herb	Nymphaeaceae	D	RWFL
Ludwigia octovalvis subsp. *sessiliflora* (Micheli) P.H.Raven	Herb	Onagraceae	D	No
Desmodium triflorum (L.) DC.	Herb	Papilionaceae	D	No
Indigofera cordifolia Heyne ex Roth	Herb	Papilionaceae	D	No
Polygonum plebeium R. Br.	Herb	Polygonaceae	D	No
Portulaca oleracea L.	Herb	Portulacaceae	D	No
Potentilla supina L.	Herb	Rosaceae	D	No
Dentella repens (L.) J. R. Forst. & G. Forst.	Herb	Rubiaceae	D	No
Oldenlandia corymbosa L.	Herb	Rubiaceae	D	No
Limnophila indica (L.) Druce	Herb	Scrophulariaceae	D	E
Lindernia crustacea (L.) f. Muell.	Herb	Scrophulariaceae	D	No
Corchorus fascicularis Lam.	Herb	Tiliaceae	D	No
Trapa natans L. var. *bispinosa* (Roxb.) Makino	Herb	Trapaceae	D	RWFL
Phyla nodiflora (L.) Greene	Herb	Verbenaceae	D	No
Limnophyton obtusifolium (L.) Miq.	Herb	Alismataceae	M	E
Murdannia nudiflora (L.) Brenan	Herb	Commelinaceae	M	No
Bolboschoenus maritimus (L.) Palla subsp. *maritimus*	Sedges	Cyperaceae	M	E
Cyperus compressus L.	Sedges	Cyperaceae	M	No
Cyperus difformis L.	Sedges	Cyperaceae	M	E
Cyperus iria L.	Sedges	Cyperaceae	M	No
Cyperus michelianus subsp. *pygmaeus* (Rottb.) Asch. & Graebn.	Sedges	Cyperaceae	M	No
Cyperus rotundus L.	Sedges	Cyperaceae	M	No
Fimbristylis argentea (Rottb.) Vahl	Sedges	Cyperaceae	M	E
Fimbristylis bisumbellata (Forssk.) Bubani	Sedges	Cyperaceae	M	E
Fimbristylis littoralis Gaudich.	Sedges	Cyperaceae	M	E
Schoenoplectiella articulata (L.) Lye	Sedges	Cyperaceae	M	E
Schoenoplectiella juncoides (Roxb.) Lye	Sedges	Cyperaceae	M	E
Schoenoplectiella lateriflora (J.F.Gmel.) Lye	Sedges	Cyperaceae	M	No
Hydrilla verticillata (L. f.) Royle	Herb	Hydrocharitaceae	M	S
Nechamandra alternifolia (Roxb. ex Wight) Thwaites	Herb	Hydrocharitaceae	M	S
Ottelia alismoides (L.) Pers.	Herb	Hydrocharitaceae	M	S
Vallisneria spiralis L.	Herb	Hydrocharitaceae	M	S
Najas minor All.	Herb	Najadaceae	M	S
Echinochloa colona (L.) Link	Grass	Poaceae	M	No
Paspalidium flavidum (Retz.) A. Camus	Grass	Poaceae	M	No

Eichhornia crassipes (Mart.) Solms	Herb	Pontederiaceae	M	FF
Potamogeton crispus L.	Herb	Potamogetonaceae	M	S
Potamogeton nodosus Poir.	Herb	Potamogetonaceae	M	RWFL
Stuckenia pectinata (L.) Börner	Herb	Potamogetonaceae	M	RWFL
Typha angustata Bory & Chaub.	Herb	Typhaceae	M	E
Marsilea crenata C. Presl	Herb	Marsileaceae	P	E

Conclusion

This study provides a comprehensive floristic assessment of seasonal wetland ecosystems, documenting a total of 142 plant species. Within this diversity, 67 species (47.18%) are ecologically classified as wetland flora, including a specific subset of 31 obligate hydrophytes. Taxonomic analysis reveals a clear dominance of the family Cyperaceae (13 species), followed by Asteraceae (12 species) and Convolvulaceae (10 species), reflecting a composition typical of semi-arid aquatic habitats.

The morpho-ecological distribution of hydrophytes is predominantly characterized by Emergent life forms (14 species), significantly outnumbering Rooted with Free-Floating Leaves (9), Submerged (6), and Free-Floating (2) taxa. This structural profile suggests a habitat dominated by shallow littoral zones that are subject to frequent water-level fluctuations.

Temporal monitoring across six field seasons identifies a distinct "boom and bust" diversity cycle driven by the hydrological regime. Average hydrophyte species richness exhibits a significant spike during post-monsoon periods (reaching a peak mean of 12.00 species) compared to a pre-monsoon baseline of 5.43 species. Furthermore, the investigation highlights the role of perennial water bodies as critical biodiversity refugia, as these sites maintain high species richness across all seasons despite regional environmental stressors. These findings underscore the vital importance of maintaining hydrological connectivity and protecting permanent wetlands to preserve regional aquatic germplasm.

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