



WETLANDS IN BIHAR: A COMPREHENSIVE ANALYSIS OF EXTENT SOCIO-ECONOMIC SIGNIFICANCE, ECOLOGICAL BENEFITS, AND ASSOCIATED RISKS

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Abstract: Bihar, situated in the eastern part of India, possesses a repository of 21,998 wetlands, covering an extensive area of 403,209 hectares. These wetlands, known for their ecological richness, have a crucial role in offering a wide range of ecological services. Their diverse functions, which include hydrological processes like recharging and discharging groundwater, controlling floods, and regulating water flow, highlight their importance. However, there has been a lack of comprehensive research on wetlands of Bihar, State. This paper provides a thorough analysis of Bihar's wetlands. It also explores the social and environmental benefits that they provide, highlighting their pivotal role in maintaining the ecological equilibrium and local economies of the region. Furthermore, this paper dissects the various threats faced by these wetlands, stemming from human activities and environmental changes. In addition to the ecological perspective, this study investigates the socio-economic conditions of communities living near these invaluable wetlands. It critically assesses their reliance on wetland resources and the consequences of wetland degradation on their well-being. This research also offers policy recommendations to promote the sustainability of wetlands.

Keywords: Bihar, Wetland, Extent, Socioeconomic and Ecological Benefits.

Introduction

Wetlands, often referred to as the Earth's kidneys, are vital ecosystems with global significance, providing ecological, economic, and social benefits (Mitsch et al., 2015; Verma et al. 2001). They serve as biodiversity hubs, freshwater sources, and regulators of floods and carbon sequestration³. The hydrological structure, including water supply

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³ The Ramsar Convention defines wetlands, highlighting their diverse nature.

dynamics, is fundamental to wetland nature. Prolonged water presence is pivotal for their development. Despite their crucial role, wetlands face serious concerns due to extensive degradation and diminishing size, prompting questions about their preservation. The comprehensive classification system categorizes wetlands based on various characteristics (Cowardin et al. in 1979; Bassi et al., 2014) and this multifaceted analysis underscores the importance of wetlands and emphasizes the urgent need for effective conservation strategies to preserve these ecosystems (Alikhani et al., 2021). Several countries, including India, have also taken steps to protect wetlands. But, the Supreme Court of India has played a pivotal role in shaping policies for wetland conservation, leading to the enactment of The Wetlands (Conservation and Management) Rules in 2017 in India. However, concrete policies for wetlands have not been uniformly implemented across Indian states, with states like Bihar lacking attention.

Situated in the Gangetic plains, Bihar is home to diverse wetland ecosystems, including rivers, lakes, ponds, marshes, and floodplains. These wetlands hold economic significance, supporting traditional livelihoods such as fishing, agriculture, and the collection of non-timber forest products (Das et al., 2015; Rai & Kumar, 2018; Jha et al., 1991). Despite having a substantial number of wetlands, Bihar has only one designated Ramsar site, indicating a gap in recognizing and preserving these valuable ecosystems. On the other hand, in Bihar, wetlands are rapidly diminishing and facing contamination due to concurrent issues of reduction and pollution. The transformation of wetlands into agricultural, urban, and various other land uses has significant ecological consequences, particularly on a local scale (Mishra, 2020; Srinivasan, 2010). Major threats include changes in water inflow and outflow, pollution, encroachment, and the spread of invasive species. Given this background, the objective of this paper is to review the status of wetlands in Bihar, considering their geographic distribution, ecosystem services, stressors, socio-economic conditions, and legal and policy approaches for conservation and management. This comprehensive review underscores the importance of wetlands in Bihar and emphasizes the urgent need for effective conservation strategies. The multifaceted analysis provides valuable insights for policymakers, researchers, and practitioners to develop sustainable management practices and policies for the preservation of wetlands in Bihar.

Distribution and Extent of Wetlands in Bihar

The National Wetlands Atlas: Bihar (2010) provides a comprehensive overview of the state's wetlands, revealing that Bihar is home to 21,998 wetlands spanning 403,209 hectares (see Table 1). Notably, 92% of these wetlands are natural, while 3.5% are man-made (see Figure 1). Wetlands smaller than 2.5 hectares constitute 4.36% of the total wetland area. Analysing the distribution of wetland types (see Figure 2), it's intriguing to observe the dominance of the "River/Stream" category, constituting only 1.08% of wetlands but covering a substantial 74.01% of the total wetland area. This is attributed to the linear nature of rivers and streams, influencing large areas along their course, including floodplains and riparian zones. "Wetlands (<2.25ha)" constitute a larger percentage of wetlands (79.93%), covering a relatively smaller area (4.36%) (Figure 1). Lakes/Ponds (Natural), with a low number (2.34%), cover a moderate area (5.03%). Ox-

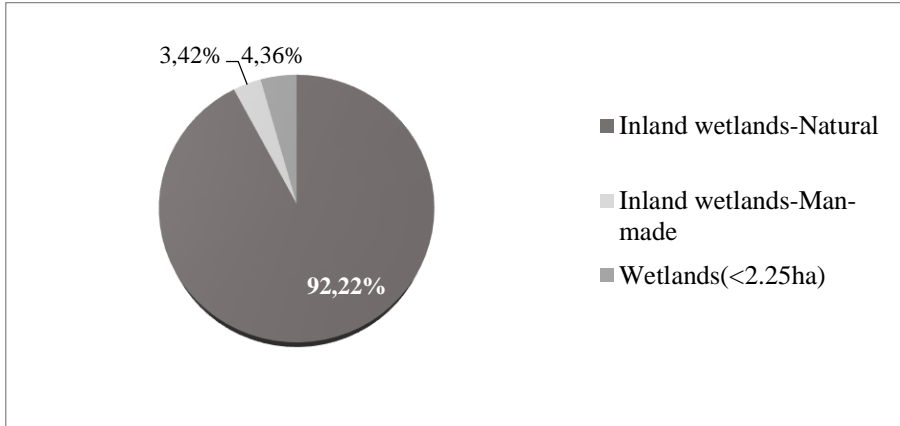
bow lakes, resulting from river changes, show a relatively higher number, possibly due to river meandering. Riverine wetlands, associated with river systems, have both a low number (0.91%) and low area coverage (0.53%) due to limited space along riverbanks. Comparison between "waterlogged (Natural)" and "waterlogged (Man-made)" reveals their low percentages in both numbers and coverage. However, "waterlogged (Natural)" covers a significantly larger area (8.65%) compared to "waterlogged (Man-made)" (0.08%) (see Figure 4). Natural waterlogged areas may occur in low-lying regions with water accumulation, explaining their larger coverage. Reservoirs/barrages and tanks/ponds, human-made structures, cover larger areas due to their construction. Tanks/ponds, created for various purposes, show a relatively higher number, reflecting their widespread usage. The atlas reports the post-monsoon water-covered area of inland wetlands at 2,24,655 hectares and 1,48,382 hectares during the pre-monsoon period. Across all wetland types, water-covered areas notably decrease from post-monsoon to pre-monsoon seasons, indicating shifts in use and changes. "Natural" wetlands generally exhibit larger water-covered areas compared to "Man-Made" wetlands in both periods. The reduction in water-covered area from post-monsoon to pre-monsoon is more significant for "Natural" wetlands (34%) compared to "Man-Made" wetlands (28.5%), suggesting greater responsiveness to seasonal changes. Understanding these variations is crucial for managing and conserving wetlands, ensuring their ecological health and the diverse services they provide to the environment and society.

Table 1: Wetland Landscape: A Comprehensive Overview of Area Estimates in Bihar (in hectare)

Wetland category	Number of wetlands	Total wetland area	% of wetland area	Open water	
				Post-monsoon area	Pre-monsoon area
Inland wetland-Natural					
Lake /Pond	514	20281	5.03	11506	6345
Ox-bow lakes/Cut-off meanders	989	16172	4.01	10130	5264
Riverine wetlands	200	2118	0.53	1664	777
Waterlogged	1300	34878	8.65	21185	9507
River/stream	238	298408	74.01	168984	118481
Inland wetlands-Man-made					
Reservoirs/Barrages	90	8612	2.14	7587	6005
Tanks/Ponds	1067	4822	1.2	3363	1870
Waterlogged	18	336	0.08	236	133
Sub -Total	4416	385627	95.64	224655	148382
Wetlands(<2.25ha)	17582	17582	4.36		
Total	21998	403209	100	224655	148382

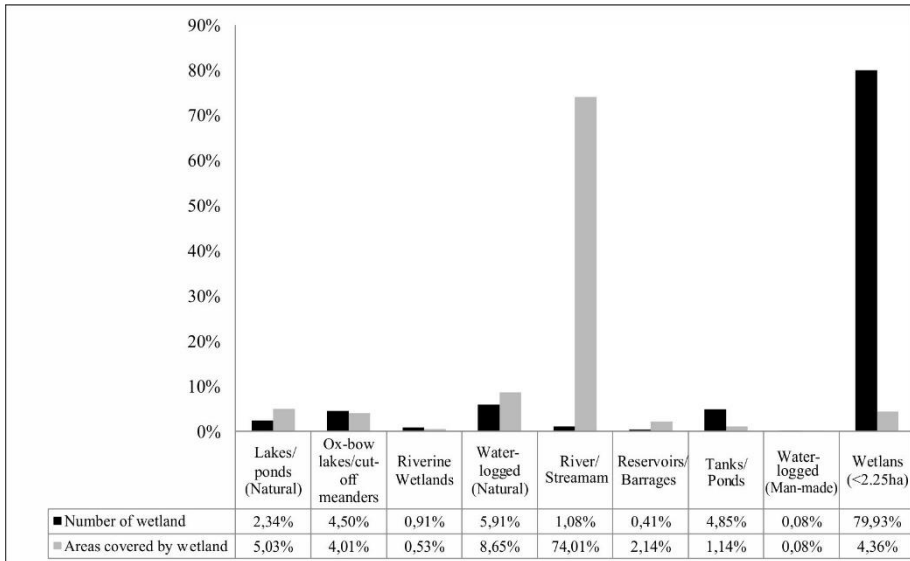
Source: National Wetlands Atlas: Bihar 2010

**Figure 1: Bihar's Wetland Landscape:
A Comprehensive Distribution Analysis**



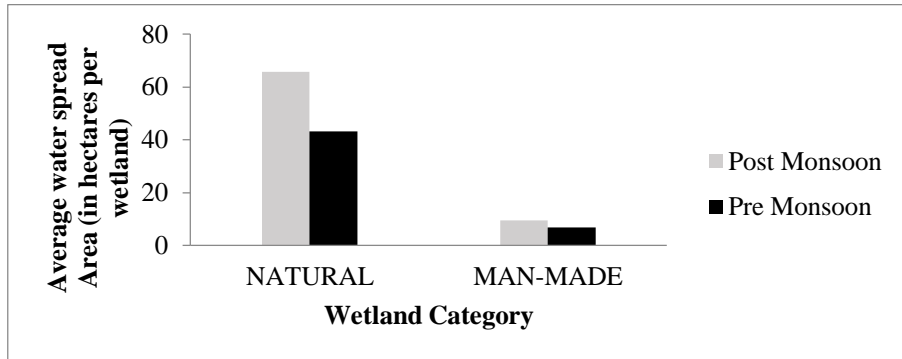
Source: National Wetlands Atlas:Bihar, 2010

**Figure 2: Wetland Diversity in Bihar:
Analysing the Proportion of Various Types**



Source: National Wetlands Atlas:Bihar, 2010

Figure 3: Analysing Average Water Spread Area in Various Wetland Types across Bihar



Source: Author's analysis using data from NATIONAL WETLAND ATLAS: Bihar (2010).

Regional and District-wise variations in Extent and Type of Wetlands

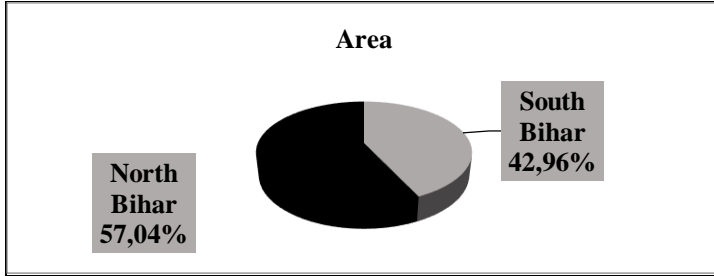
Bihar, with its expansive 94,163 square kilometres, unfolds a diverse canvas divided into two major regions. South Bihar, constituting 43% of the total state area, stands distinct in its topography and cultural heritage. On the flip side, North Bihar, occupying 57.04%, weaves an intricate tapestry of geography and history (Figure 4). The state's wetlands cover a significant 403,209 hectares, playing a vital role in sustaining diverse species and ecosystems. South Bihar contributes 36% of this total wetland area, emphasizing its crucial role in conserving aquatic habitats and biodiversity (Figure 5 & Figure 6). In contrast, North Bihar dominates with a 64% share, underlining its significance in preserving the state's wetland ecosystems and ecological balance. When assessing wetland proportions relative to the geographical area, Begusarai leads with 17.5%, showcasing its commitment to wetland conservation. In contrast, Kaimur and Sheikhpura allocate a mere 0.43% of their land to wetlands. Katihar emerges as the leader among districts, dedicating 22.8% of its area to wetlands, while Sheikhpura contributes minimally to the state's wetland expanse. The water-spread area of wetlands undergoes seasonal fluctuations. During the post-monsoon period, water covers about 55% of the total wetland area, revealing a substantial inundation. In the pre-monsoon period, this coverage decreases to 36%, indicating a seasonal ebb. Regions like East (Purba) Champaran, Muzaffarpur, Gopalganj, Siwan, Vaishali, Samastipur, Bhagalpur, and Buxar witness water spread constituting over 60% of the total wetland area during the post-monsoon period, emphasizing the dynamic nature of these ecosystems (Table 2 and Figure 7). This intricate interplay of geography, wetland distribution, and seasonal variations underscores Bihar's commitment to preserving its natural heritage. The disparities among districts highlight the need for tailored conservation strategies to ensure the sustained health of wetland ecosystems across the state.

Table 2: District – Wise Wetland Areas in Bihar

District	District geographical area (sq.km)	Wetland area (ha)	% of total wetland area	%of district geographical area	Open water (ha)	
					Post-monsoon	Pre-monsoon
West (Pashchim) Champaran	4250	21697	5.38	5.11	11924	10118
East Champaran	4155	12477	3.09	3	8915	5119
Sheohar	443	1476	0.37	3.33	845	782
Sitamarhi	2628	2601	0.65	0.99	906	588
Madhubani	3478	8958	2.22	2.58	2411	2280
Supaul	2985	19285	4.78	6.46	9004	9021
Araria	2797	4157	1.03	1.49	2245	1930
Kishanganj	1939	10954	2.72	5.65	5542	4886
Purnia	3203	12401	3.08	3.87	5279	3365
Katihar	3010	31011	7.69	10.3	17135	14574
Madhepura	1797	3539	0.88	1.97	1589	967
Saharsa	1196	12086	3	10.11	7202	4125
Darbhanga	2502	8709	2.16	3.48	5171	2467
Muzaffarpur	3123	10490	2.6	3.36	6984	4048
Gopalganj	2003	7122	1.77	3.56	5128	3783
Siwan	2213	7105	1.76	3.21	4295	2117
Saran	2624	21170	5.25	8.07	12118	7950
Vaishali	1995	17148	4.25	8.6	11405	5970
Samatipur	2579	15022	3.73	5.82	10867	7133
Begusarai	1889	20365	5.05	10.78	10628	7703
Khagaria	1486	11645	2.89	7.84	9060	5807
Bhagalpur	2502	24171	5.99	9.66	16237	10273
Banka	3020	9895	2.45	3.28	5151	3847
Munger	1419	11979	2.97	8.44	7001	5498
Lakhisarai	1229	4177	1.04	3.4	1759	1447
Sheikhpura	689	296	0.07	0.43	163	73
Nalanda	2362	1589	0.39	0.67	756	283
Patna	3130	20678	5.13	6.61	11943	7570
Bhojpur	2337	11154	2.77	4.77	5700	2435
Buxar	1634	3717	0.92	2.27	2449	1408
Kaimur (Bhabua)	1840	796	0.2	0.43	296	174
Rohtas	3838	18641	4.62	4.86	9259	4040
Jehanabad	1569	4345	1.08	2.77	1843	564
Aurangabad	3389	8116	2.01	2.39	3428	1436
Gaya	4941	11422	2.83	2.31	3979	626
Nawada	2498	5464	1.36	2.19	2445	1241
Jamui	2997	7351	1.82	2.45	3593	2734
Total	91689	403209	100	4.4	224655	148382

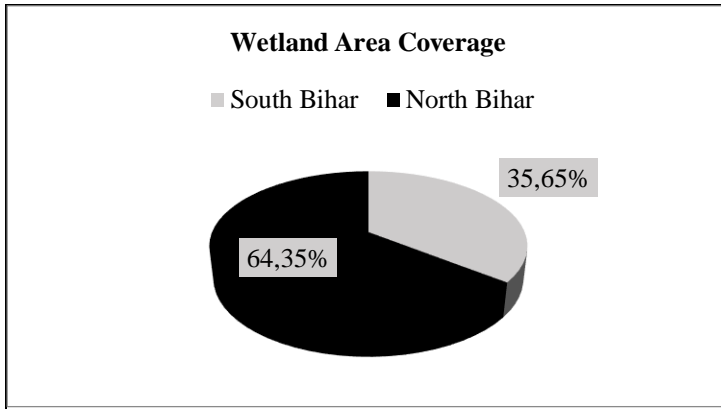
Source: National Wetlands Atlas: Bihar, 2010

Figure 4: Distribution of Bihar's Geographical Area



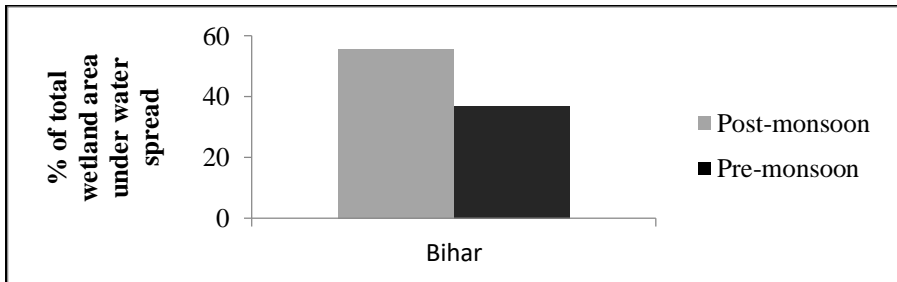
Source: Author's analysis using data from NATIONAL WETLAND ATLAS: Bihar (2010)

Figure 5: Regional Distribution of Wetland in Bihar



Source: Author's analysis using data from NATIONAL WETLAND ATLAS: Bihar (2010)

Figure 6: Proportion of Total Wetland¹ Area Under Water Spread in Different Seasons in Bihar



Source: Authors' analysis using data from National Wetlands Atlas: Bihar, 2010

¹ Wetlands exceeding a size of 2.5 hectares are the only ones included in this analysis.

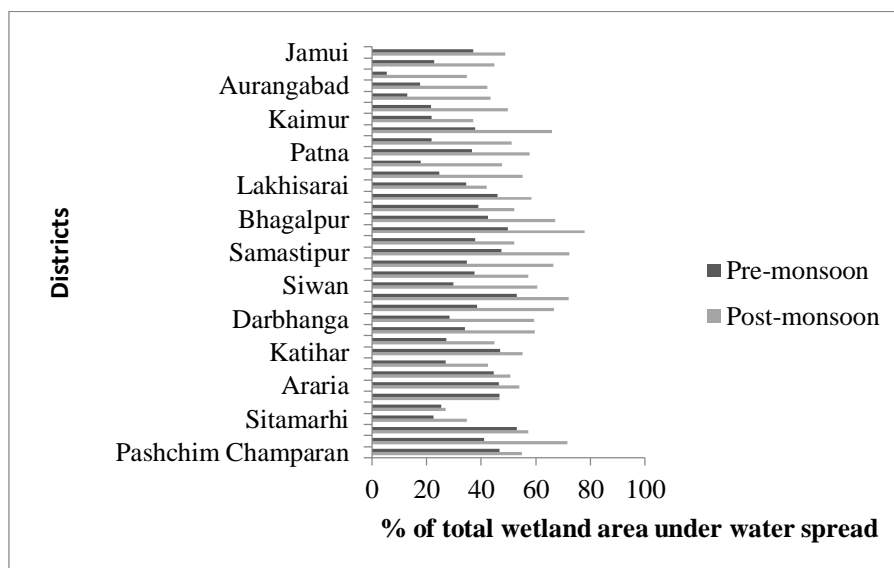
Ecosystem services Provided by Wetlands in Bihar

Based on the health status report of 28 wetlands of Bihar collected from Government’s Website and literature review, we have categorized the socio-economic and ecological services of wetlands in Bihar under seven main categories: domestic uses of water, income-generating activities, ecotourism, serving as biodiversity hotspots, holding environmental importance, aiding in flood control, and holding cultural and religious significance (Table 3).

Domestic Purpose

The assessment of ecosystem services from the 28 wetlands in Bihar reveals the diverse utility of wetland water for various domestic purposes. This includes its use for drinking water, bathing, and wallowing of domestic animals, highlighting the multifaceted importance of wetlands. The economic value of these services is underscored by a few studies in case of Bihar. For instance, in the case of Kabartal Wetland, a study (Ambastha and Badola, 2007) indicates that among the sampled population, a significant percentage (65.8%) owned livestock. Notably, 67% of these individuals relied on Kabartal as a vital source of fodder for their livestock. This showcases the wetland’s contribution to supporting local livelihoods through providing essential resources for agriculture and livestock maintenance.

Figure 5: Proportion of Total Wetland’ Area Under Water Spread In Districts of Bihar



Source: Authors’ analysis using data from National Wetlands Atlas: Bihar, 2010

¹ Wetlands exceeding a size of 2.5 hectares are the only ones included in this analysis.

Income generating activities.

Wetlands, encompassing tanks, ponds, lakes, and reservoirs, have been historically integral to various income-generating activities in Bihar, contributing to the economic sustenance of the region. Kabar Lake (Kabartal Wetland) stands out as a crucial economic asset, yielding approximately two tonnes of fish daily and serving as a vital water source for irrigation (Shah & Laha, 2022). The economic benefits of using wetlands for irrigation extend to cost savings, notably in terms of reduced fertilizer expenses (Mukherjee, 2008). Traditional tank systems in Bihar, as well as in states like Orissa, Uttar Pradesh, and West Bengal, play a significant role, contributing nearly 25% to the net tank-irrigated area (Pant & Verma, 2010). Beyond irrigation, these tanks play a pivotal role in fisheries, providing substantial value in terms of household income, nutrition, and health, particularly benefiting economically disadvantaged populations (Kumar et al., 2012). The fisheries sector, critical for food security, employment, and state revenue, supports a significant portion of the population's livelihoods.

The 2011 data reports a total fisher population of 2,658,163 in Bihar, with 68 percent of the income of wetland fishers derived from the fishery profession (Chandra & Das, 2019). Communities like the Mallahs and Godhis, economically disadvantaged and residing along wetlands like Kabartal, rely entirely on these ecosystems for their livelihoods, engaging in fishing and boatmen activities (Shah & Laha, 2022). Bihar's wetlands are rich repositories of various aquatic plants, including Water Chestnut (Singhara), Amaranth (Ramdana), Fox Nut (Makhana), and Water Lily (Kamal Kakri). The aquatic flora in these wetlands play a multifaceted role, meeting sustenance, medical, and financial needs of the local populations (Raut et al., 2020). For example, *Trapa natans* fruits and *Nelumbo nucifera* leaves are collected, with the latter specifically used in crafting plates made of leaves. Beyond Singhara, other notable edible plants include Ramdana, Makhana, and Kamal kakri, providing economic benefits to the local community and serving as a significant source of income. Additionally, individuals living near Kabartal wetland engage in the cultivation of deepwater rice locally known as Barobar (Ambastha et al., 2007). Bihar's contribution to more than 85 percent of the total makhana production in the country highlights the economic, cultural, and religious significance of this crop, particularly for communities like the Mallah fishing community in Darbhanga (Verma, 2019). Moreover, Makhana is recognized for its role in effective cardiac ailment treatment (Das et al., 2006). The intricate interplay between wetlands, economic activities, and community livelihoods underscores the profound importance of these ecosystems in Bihar's socio-economic fabric.

Ecotourism

Bihar holds considerable ecotourism potential within its wetlands, driven by diverse ecosystems, rich biodiversity, and unique cultural heritage. Notable sites like Kanwar Lake Bird Sanctuary (Kabartal/Kanwar Taal), Bhimbandh Wildlife Sanctuary, and Kusheshwar Asthan Bird Sanctuary attract birdwatchers and ornithologists, establishing them as birding tourism hotspots. These wetlands support various flora and fauna, providing opportunities for wildlife enthusiasts to observe species in their natural

habitats. Destinations like Kanwar Lake and Gandhi Ghat offer water-based activities, such as boating and fishing, contributing to the ecotourism experience. These areas provide serene environments for relaxation, with activities like picnicking, meditation, and nature walks. Wetlands also serve as outdoor classrooms for environmental education and research. The government and environmental agencies can boost wetland ecotourism through supportive policies, infrastructure development, and marketing campaigns, potentially increasing visitation and revenue.

Biodiversity

The wetlands of Bihar not only support a variety of noteworthy plant and animal species but also serve as significant congregation sites for migratory birds. Additionally, they play a crucial role in sustaining the life cycles of various fish and amphibian species. The endangered Greater Adjutant storks are found in Jagatpur Lake. Other vulnerable species of birds, such as Lesser Adjutant stork, Woolly-necked stork, and Black-necked storks, are also recorded in Jagatpur Lake. In a study conducted on Jagatpur wetland from August 2003 to July 2005, it was found that the wetland hosted a total of 34 bird species, and approximately 79% of these species were dependent on wetland ecosystems (Kumar & Choudhary, 2006). In a study conducted on Kanwar Tal, it was observed that there were a total of 61 tree species, which included two species of bamboo (Kumar & Pandey, 2021).

Flood Control

In 2010, floods in Bihar affected 0.72 million people, submerged 3.24 million hectares of cropland across 8 out of 32 districts, and damaged around four thousand houses (Bassi et al., 2014). The repetitive floods placed a fiscal burden on both the State and Central governments, with approximately INR 759.80 lakhs being allocated during 2021-22 solely for flood management initiatives in the Ganga River basin (ANNUAL REPORT 2021-22). But, wetlands serve as natural floodwater drainage points, effectively mitigating the impact of flood situations in the surrounding catchment areas. The area of influence of these wetlands extends into the Gangetic plain, which is frequently susceptible to flooding during the monsoon season. The presence of these wetlands, as significant water bodies, plays a crucial role in flood control.

Cultural and Religious Significance

Wetlands in Bihar carry cultural and religious significance deeply intertwined with the local way of life. One notable example is Kanwar Lake in Begusarai district, believed to be the spot where Lord Shiva consumed poison during the churning of the ocean in Hindu mythology. Consequently, the lake is considered sacred, attracting devotees during religious festivals. The region possesses historical and religious significance dating back to the post-Sunga period (185–73 BC), with a small temple island named Jaimanglagarh

in the southeastern corner of the wetland, officially designated as of state importance under the Bihar Ancient Monuments and Archaeological Sites, Remains and Art Treasure Act, 1976 (Ambastha et al., 2007).

Table 3: Socio-Economic Benefits of Wetlands in Bihar

Purpose	Use	Details
Domestic Purpose	Drinking Water, Households Demand, Livestock	Water is withdrawn for drinking purposes.
		Cattle wallowing and bathing is done by village residents.
Income Generating Activities	Irrigation	The people in the neighbouring villages extract water from the wetlands and utilize it for irrigation on their agricultural lands. In several areas, this serves as the sole source of water for the surrounding region.
	Fisheries	
	aquatic food plants	A number of aquatic food is cultivated in the wetlands of Bihar.
	Medical Plants	
Ecotourism	Tourism	The wetlands of Bihar hold great potential for recreation and tourism. Proposals have been submitted to initiate eco-tourism ventures in the future.
	Boating	Boats are popular means of travel from one village to another .
Biodiversity	Support noteworthy plant species	
	Support noteworthy animal species	The endangered Greater Adjutant storks are found in Jagatpur Lake. Other vulnerable species of birds like Lesser Adjutant stork, Wolly necked stork, and Black necked storks are also recorded in Jagatpur lake.
	Site of high congregation of migratory water birds	During the migratory season, hundreds of migratory birds can be observed. Vikramshila Gangetic Dolphin Sanctuary is one of the largest congregation site of migratory birds in Bihar
	Support life cycle of fish or amphibians	The wetlands and adjoining marshes in this region are home to a diverse range of aquatic life, including numerous fish, amphibians, and insects.
Environmental Importance	Ground Water Recharge	The wetland of Bihar stores water all the year around and helps in recharging the surrounding water table
	Water Purification	
	Act as a sink of sediments	Wetland acts as sink for silt received during flood pulses from river.
Flood control	Flood Control	The wetlands act as natural floodwater drainage points, effectively reducing the impact of flood situations in the catchment area.
Cultural and Religious significance	Cultural and Religious Use	The local community utilizes this water body for religious purposes, particularly during the annual Chhat Puja festival.
Others	Grazing	Grazing is done by cattle owned by local residents.

Source: Authors' Compilation.

Similarly, Gandhi Ghat in Patna, situated along the Ganges River, serves as a prominent religious site where people take holy dips and perform rituals, emphasizing the purifying

qualities of the river. The Chhath Puja festival, celebrated with great fervor in Bihar, further underscores the connection between wetlands and religious practices. This festival involves various rituals conducted in and around water bodies to express gratitude to the Sun God for its life-giving energy. Local myths and legends often link wetlands to gods, goddesses, and ancient heroes, contributing to their cultural significance. Traditional livelihoods such as fishing, agriculture, and plant collection from wetlands are also deeply rooted in local culture. The 'Kojagara' festival on Ashwin Poornima is marked by the tradition of gifting Makhana, and in weddings, it's customary for the bride's parents to present Makhana to the groom's family during the first year of marriage (Verma, 2019). Furthermore, the sacred nature of these wetlands can inspire conservation efforts, as communities and religious leaders actively engage in their protection and preservation, highlighting the unique blend of tradition and environmental awareness associated with Bihar's wetlands.

Table 4: Ecosystem Services Provided by Wetlands in Bihar

Wetland	Ecosystem services	Wetland	Ecosystem services
Jagatpur	B, C, D, G, H, J, K, L, N, O, P, S	Berai Chaur	
Baraila Chaur (Siwan)	B, C, H, I, J, L, M, N, O, P, Q, R, S	Boaria Chaur	B, C, D, E, F, G, H, I, J, M, N, P, Q, R, S
Gamhoria Chaur (Saran)	G, H, P, Q, R	Dhane Chaur	B, C, D, E, FG, H, I, J, K, L
Bhatkesri Chaur	B, C, E, G, H, P, Q, R, S	Loma Chaur	
Mangolapur Chaur	B, C, G, H, J, P, Q, R,	Tal Berai	B, C, D, E, F, G, H, I, J, K, L, N, O, Q, S
Dhurde Tal / Chaur	B, C, E, G, H, I, J, N, P, Q, R, S	Sonbarsa Man (Motihari)	B, C, E, G, H, I, J, K, P, R, S
Prenaina Talab	A, B, C, G, H, J, N, O, P, Q, R.	Sohag Man	B, C, E, G, H, I, J, K, N, O, P, R, S
Samika Chaur	B, C, E, G, H, P, R, S	Sarotar Chaur	B, C, E, F, H, I, J, N, P, Q, R, S
Maken Wetland	B, C, D, H, I, J, M, N, O, P, Q, R, S	Matwalee Man	B, C, E, G, H, I, J, P, R, S
Batis Khumba (Vaishali)	B, C, D, E, F, G, H, I, J, K, M, N, P, Q, R, S	Dariyapur Lake	C, E, G, H, I, J, P, R,
Pahetia Chaur	B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q, R, S	Chorma Siraha Jalkar	B, C, D, E, G, H, I, J, K, L, M, O, P, R, S
Manorai Chaur	A, B, C, D, E, F, G, H, I, J, K, L, M, N, P, Q, R, S	Bhutaha Chaur	B, C, E, G, H, I, J, O, P, Q, R,
Lochan Chaur	B, C, D, E, F, G, H, I, J, K, M, N, P, Q, R, S	Bawlee Lake	A, B, C, E, G, H, I, J, P, Q, R,
Powra	B, C, E, F, G, H, I, J, K, M, N, P, Q, R, S	Balwa Man	B, C, E, G, H, I, J, O, P, R

Source: Authors' Compilation using Health Cards of Wetland Downloaded from Government's Website.

In this context, A represents the source of drinking water for people living in and around the area, B signifies the source of water for agriculture, and C denotes its importance for fisheries. D stands for the cultivation of aquatic food plants, while E highlights its use

for buffalo wallowing and domesticated animals. F signifies the growth of medical plants, and G emphasizes its role in buffering communities from extreme events like floods and storms. H denotes its contribution to groundwater recharge, and I signify its role in water purification. J represents its function as a sink for sediments, and K underscores its significant cultural and religious values. L designates it as a site for recreation and tourism, and M indicates its support for noteworthy plant species. N represents its support for noteworthy animal species, and O highlights its role as a site of high congregation for migratory water birds. P emphasizes its contribution to the life cycle of fish or amphibians, and Q represents its role in agriculture or horticulture within the wetland. R signifies its use for grazing, while S indicates its suitability for playing boat.

Overall Ecosystem Services Provided by Wetlands in Bihar

Wetlands in Bihar serve as indispensable ecosystems with a myriad of functions crucial for both nature and human societies. They are a primary source of drinking water for local communities and provide essential water resources for agriculture, supporting the growth of crops. Wetlands foster fisheries, contributing to the livelihoods of many, and cultivate aquatic food plants, enriching local diets. These areas are utilized for diverse purposes, including buffalo wallowing, the care of domesticated animals, and the cultivation of medicinal plants. Acting as natural buffers, wetlands protect communities from extreme events like floods and storms. They play a pivotal role in groundwater recharge and water purification, ensuring environmental sustainability. Wetlands act as sinks for sediments, maintaining ecological balance. With significant cultural and religious values, wetlands are sites for recreation and tourism, supporting noteworthy plant and animal species. They attract high congregations of migratory water birds and contribute to the life cycles of fish and amphibians. Furthermore, wetlands facilitate agriculture, horticulture, grazing activities, and even serve as locations for recreational boating, highlighting their diverse and vital contributions to both ecosystems and human well-being.

Threats to Wetlands in Bihar

Table 5 provides a comprehensive assessment of both current and potential threats to various wetlands in Bihar. Each wetland is assigned specific threat codes represented by letters: T for changes in water inflow and outflow, U for pollution, V for unsustainable harvest of biological resources, W for mining, X for siltation, Y for encroachment, and Z for the spread of invasive species. As of now, wetlands like Lochan Chaur, Tal Berai, and Sarotar Chaur are actively experiencing multiple threats in Bihar. Looking ahead, future concerns may escalate for wetlands such as Manorai Chaur, Pahetia Chaur, and Powra. This information acts as a crucial reference for the assessment of environmental challenges faced by each wetland in Bihar. It plays a pivotal role in devising effective conservation and management strategies to mitigate these threats and ensure the sustainability of these vital ecosystems.

Table 5: Present and Potential Threats to wetland in Bihar

Wetland	Threats		Wetland	Threats	
	Present	Potential		Present	Potential
Jagatpur	T, U, V, X, Z	W, Y	Powra		T, U, V, W, X, Y, Z
Baraila Chaur (Siwan)	T, U, V, W, X, Z		Berai Chaur		
Gamhoria Chaur (Saran)	T, W,	U, V,	Boaria Chaur	T, U, V, W, X	Y, Z
Bhatkesri Chaur	T, X, Z	U, V, Y	Dhane Chaur		
Mangolapur Chaur	T, U, X,	V, Z	Loma Chaur		
Dhurde Tal / Chaur	T, U, V, Z	X, Y,	Tal Berai	T, U, V, W, X, Y, Z	
Prenaina Talab	T, V, W, X,	U, Y, Z	Sonbarsa Man (Motihari)	U, X, Y, Z	T
Samika Chaur	T, U, X	V, Y, Z,	Sohag Man	T, U, X, Z,	
Maken Wetland	T, V, X, Z	U,	Sarotar Chaur	T, U, V, X, Y, Z	
Batis Khumba (Vaishali)		T, U, V, W, X, Y, Z	Matwalee Man	U, X, Y, Z	T
Pahetia Chaur		T, U, V, W, X, Y, Z	Dariyapur Lake	U, X, Z	T
Manorai Chaur		T, U, V, W, X, Y, Z	Chorma Siraha Jalkar	U, X, Y, Z	T
Lochan Chaur	T, U, V, W, X, Y	Z	Bhutaha Chaur	T, U, X, Y, Z	
Bawlee Lake	T, U, X, Y, Z		Balwa Man	T, U, X, Y, Z	

Note: In this context, T represents changes in water inflow and outflow, U signifies pollution, V denotes unsustainable harvest of biological resources, W represents mining, X stands for siltation, Y indicates encroachment, and Z highlights the spread of invasive species.

Source: Authors' Compilation using Health Cards of Wetland Downloaded from Government's Website.

Conclusion and Policy Suggestion

In conclusion, Bihar's wetlands stand as vital ecosystems, providing ecological, economic, and social benefits. Despite their global significance, these wetlands face severe degradation and reduction, raising concerns about their preservation. The comprehensive review presented in this paper highlights the urgent need for effective conservation strategies in Bihar. The distribution and extent of wetlands in Bihar, as outlined in Section I, illustrate the rich diversity of these ecosystems, with rivers and streams dominating the landscape. However, the state faces challenges, with only one Ramsar site and a gap in recognizing and preserving these valuable ecosystems. Regional and district-wise variations in wetland extent, discussed in Section II, underscore the importance of tailored conservation strategies. While South Bihar contributes significantly to the total wetland area, disparities among districts highlight the need for a nuanced approach to ensure the sustained health of wetland ecosystems. Section III delves into the socio-economic benefits of wetlands, showcasing their contribution to domestic uses, income-generating activities, ecotourism, biodiversity, flood control, and cultural and religious

practices. Wetlands in Bihar serve as essential sources of water for various purposes, support income-generating activities like fishing and agriculture, and hold immense potential for ecotourism. However, these valuable ecosystems face threats, as outlined in Section V, including changes in water inflow and outflow, pollution, encroachment, and the spread of invasive species. These threats pose significant ecological consequences, urging the implementation of robust conservation measures. In essence, the multifaceted analysis provided in this article emphasizes the critical importance of wetlands in Bihar. The state needs comprehensive conservation strategies that consider geographic distribution, ecosystem services, socio-economic conditions, and legal and policy approaches. The disparities among districts highlight the need for tailored conservation strategies, recognizing the unique challenges faced by each region. This review serves as a valuable resource for policymakers, researchers, and practitioners, offering insights to develop sustainable management practices and policies for the preservation of wetlands in Bihar. The urgent need for effective conservation strategies cannot be overstated, considering the vital role wetlands play in sustaining biodiversity, supporting livelihoods, and providing a range of ecosystem services. The preservation of Bihar's wetlands is not just an environmental imperative but also a commitment to safeguarding the cultural, economic, and ecological heritage of the region.

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Declaration of conflicting interests

The authors declare no conflicting interests.

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