नमामि गंगे

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

STATUS OF SELECT WETLANDS IN THE GANGA RIVER BASIN

A GLANCE

JULY, 2025

VOLUME I

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"Planning and Management for Aquatic Species Conservation and Maintenance of Ecosystem Services in the Ganga River Basin for a Clean Ganga"

This document is an output of the project Biodiversity Conservation and Ganga Rejuvenation sponsored by the National Mission for Clean Ganga, Ministry of Jal Shakti, Government of India, New Delhi.

Status of select wetlands in the Ganga River Basin: A glance

July, 2025

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Citation:

WII-GACMC (2025). Status of select wetlands in the Ganga River Basin: A glance. Ganga Aqualife Conservation Monitoring Centre, Wildlife Institute of India, Dehra Dun, India. Vol. 1. Pp. 124.

ACKNOWLEDGEMENTS

Ministry of Jal Shakti

C. R. Patil, *Union Minister*
Raj Bhushan Choudhary, *Minister of State*
V. Somanna, *Minister of State*
V. L. Kantha Rao, *Secretary*

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Sandeep Behera, *Biodiversity Consultant*
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Ministry of Environment, Forest and Climate Change

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Ramesh Pandey, *Additional Director General, Wildlife*
R. Raghu Prasad, *Inspector General, Wildlife*

Forest and Environment Department of Uttarkhand, Uttar Pradesh, Bihar, Jharkhand and West Bengal

Special Gratitude

Gajendra Singh Shekhawat, *Former Union Minister of Jal Shakti*
Pankaj Kumar, *Former Secretary, Ministry of Jal Shakti*
Debashree Mukherjee, *Former Secretary, Ministry of Jal Shakti*
Rajiv Ranjan Mishra, *Former Special Secretary and Director General, NMGC*
G. Asok Kumar, *Former Special Secretary and Director General, NMGC*

Wildlife Institute of India

Gobind Sagar Bhardwaj, *Director*
Ruchi Badola, *Dean*

CONTENTS

EXECUTIVE SUMMARY

Wetlands, the highly dynamic ecosystems, are ecotones between the terrestrial and aquatic systems. They are among the most productive ecosystems on Earth, and provide habitat to about 40% of the global floral and faunal species. The wetlands also provide an array of ecosystem services and goods, which contribute to human well-being. The hydrological and nutrient processes and dynamics of wetlands also act as a buffer to flood and climate change related disasters. Despite their significance for human well-being, wetlands are being lost at an alarming rate. According to an estimate, about 87% of wetlands have been lost globally in the last 300 years. The wetland loss is triggered by a combination of inter-linked factors, viz. land use changes, resource exploitation, loss of hydrological connectivity, pollution and climate change. Currently, wetlands occupy 3 to 6% of the Earth's surface, and there is a dire need to restore and conserve these wetlands, as their loss would have dire and cascading consequences for biodiversity and human well-being.

Wetlands occupy roughly 3.8% of India's landmass, a major proportion of which is in the Ganga River basin. The wetlands of the Ganga basin range from the high- altitude oligotrophic lakes in the Himalayas, marshes and swamps on the Himalayan foothills, and floodplain and riverine wetlands to coastal wetlands in the deltaic tracts, owing to their geographical extent, latitudinal and altitudinal variations. The wide-ranging role of these wetlands as sources of major rivers, biodiversity habitats, backbone of highly productive agriculture and fisheries, buffers against floods and coastal storms, and cultural heritage of populations living in and around marks their critical role in food, water, ecological, and climate security. The Ganga River basin is also an integral part of the Central Asian Flyway, and the wetlands of the basin provide refuge to several water and water-associated species, including many threatened species. Loss of wetlands in India has followed a similar pattern as in the developed world, and the Ganga basin alone lost 40% of its wetlands, over the last 300 years. In addition to a reduction in extent and number, the rise in new emerging contaminants and pollutants, including microplastics, are a looming threat to the wetlands of the Ganga River basin, and it has profound implications for the aquatic ecosystems and human health.

Wetland conservation and management are recognized as potential strategies and Nature-based Solutions (NbS) to address climate change related adaptation and resilience enhancement. While the benefits of conserving the wetland are significant, myopic landscape-level planning, associated policy incoherence, and ineffective monitoring hinder conservation of the wetlands. Addressing these barriers is crucial for maximizing the potential of wetlands as NbS in climate adaptation strategies. The Ganga River is intricately connected with a network of tributaries and the floodplain wetlands. Together, these serve as breeding grounds and refuge for aquatic species. However, these tributaries also drain pollutants into the river, severely affecting aquatic fauna and their habitat, hampering the conservation process. Monitoring the status of wetlands is thus essential for guiding conservation, management and restoration strategies and prioritizing them. Since waterbirds are considered indicator species and have been used as surrogates of ecosystem health, particularly wetlands, a study was initiated to assess the condition of wetlands in the Ganga River basin. This study addresses objective 3 of the phase II project.

A comprehensive assessment of 20 representative wetlands across five Ganga Basin states—Uttarakhand, Uttar Pradesh, Bihar, Jharkhand, and West Bengal—was undertaken. The study aimed to evaluate the status of water and water-associated bird species, identify key threats to wetland habitats, and document basic physio-chemical water parameters. The key objectives of the study were to assess - I) the status of water and water-associated bird species in the select wetland, ii) identify key threats to wetland habitats, and iii) record the basic physio-chemical parameters of the select wetlands. The survey was conducted in five Ganga Basin states during winter seasons (December 2023 and early March 2025) using standard methods to count birds and to measure basic physio-chemical parameters and human induced stressors to wetlands. A combination of field surveys, remote sensing, and GIS tools was employed, including the Modified Normalized Difference Water Index (MNDWI) for spatial wetland identification.

Altogether, 41,366 individuals of 90 water and water-associated bird species were recorded from the 20 select wetlands of the Ganga River Basin, belonging to 11 orders, and 21 families. The presence of carnivorous as the most dominant feeding guild (60%) indicates rich trophic resources in the surveyed wetlands. Charadriiformes and Anatidae were found to be the most dominant orders and families of water and water-associated species, respectively. Out of 90 recorded species, one species was endangered (EN), four species were vulnerable (VU), and seven species were in the near-threatened (NT) category of the IUCN Red List. Among the select wetlands, Haiderpur, Surajpur and Asan were recorded as one of the most abundant and diverse wetlands in the Ganga River Basin. These wetlands were also found to be high in richness. All the wetlands had salinity and pH variation within permissible limits. Unsustainable fishing, encroachment, grazing, and invasive species were some major threats identified in the select wetlands. Wetlands like Mokama, Baan Ganga, and East Kolkata were found to be shrinking rapidly, and invasive plant species are also a concern for waterbird habitats. Many of the lesser-known wetlands are prone to anthropogenic threats because they do not fall within the purview of any jurisdiction or protection regime. However, wetlands of International Importance still have a chance to be restored through active management and political will.

This assessment highlights the present status of waterbirds and wetlands during the winter season. Active participation of the government bodies and other stakeholders, perhaps, will restore or conserve these wetlands. This assessment also underscores the need for integrated wetland management, stricter enforcement of environmental regulations, localized management actions through community engagement, and scientific monitoring. Enhancing wetland monitoring, ensuring ecological flow, and restoring connectivity between rivers and wetlands are imperative to safeguarding these vital ecosystems and the biodiversity they support.

01

INTRODUCTION

Wetlands, by definition, are highly dynamic ecosystems and functionally serve as ecotones between the terrestrial and aquatic systems (Mitsch et al. 2023). They include a wide range of ecosystems, viz. rivers, swamps, lakes, marshes, rice fields, mangroves, and are highly productive. Due to high productivity, the wetlands have been supporting a diverse variety of species and contributing to human well-being (MA 2003). The terms “Kidneys of the landscape” and “nature's supermarkets” are often used to describe the functions provided by the wetlands and the importance of these functions. According to an estimate by Davison and Finlayson (2018), about 3% of the Earth's surface (15.2 million sq. km to 16.2 million sq. km) is covered by wetlands. Another study estimated about 6% of the Earth's surface to be covered with seasonal wetlands (Reis et al., 2017). Nonetheless, these wetlands provide habitat to about 40% of the floral and faunal species worldwide (The Ramsar Convention, ND). Despite their ecological, social and economic significance, the wetlands are being lost worldwide. About 87% of the wetlands have been lost in the last 300 years (IPBES 2018), and since the 1970s, about 35% of wetlands have been lost globally (Ramsar Convention on Wetlands 2018). Wetland degradation and consequent loss involve alteration or disruption of the hydrological regime,

eutrophication due to human activities (IPBES 2018). The decline in wetland area has negative consequences for the floral and faunal diversity, and one-fourth of these are already facing the risk of extinction (Ramsar Convention on Wetlands 2018). Loss of wetland is also known to increase the risk and vulnerabilities due to floods, droughts and amplify climate change related hazards. Degradation and loss of wetlands are driven by interconnected factors, which vary across spatial and temporal scales. Termed as direct drivers, these factors broadly are land use changes, resource exploitation, climate change, pollution, and invasive species (IPBES 2018; MA 2003). These direct drivers result from the underlying causes, which are the indirect drivers and encompass demography and economic growth, socio-political scenario, science and technology (MA 2003).

1.1 WETLANDS OF INDIA

The first scientific national inventory of wetlands in India was undertaken during 1992–93, using Indian Remote sensing (IRS-1) satellite data (Garg et al., 1998). This assessment provided a baseline understanding of wetland distribution. Subsequent inventories were prepared for the periods 2006–07 and 2017–18 on a 1:50,000 scale resolution (Garg & Patel, 2007; National Wetland Atlas, 2011). The National Wetland Atlas has given a three-level hierarchical system for classification of wetlands to ensure consistency in mapping and assessment, under the project National Wetland Inventory and Assessment (NWIA) Murthy et al., 2013)(National Wetland Atlas, 2011; . At Level 1 of the NWIA three-level hierarchical system, wetlands are broadly divided into two categories: inland and coastal. Level 2 expands this framework by incorporating both natural and human-made wetlands within these categories, thereby providing a more comprehensive account of wetland diversity. Level

3 further refines the classification by including site-specific ecological and hydrological attributes, enabling more detailed characterization of individual wetland types (Figure 1.1). Using the minimum mappable unit (MMU) for wetlands as polygon area > 2.25 hectares (Garg & Patel, 2007), the Space Application Centre (SAC) recorded a total of 2,01,503 wetlands in 2006-07 and 2,20,096 in 2017-18 (Gupta et al., 2021). These wetlands in India account for approximately 1,47,05,015 ha (MMU>2.25 ha), including those associated with wet paddy cultivation (National Wetland Atlas, 2011). Within this vast network, wetlands in the Ganga Basin are of particular importance, as they support rich biodiversity, providing habitats for aquatic fauna including migratory birds, and many threatened species –(WII-GACMC, 2018).

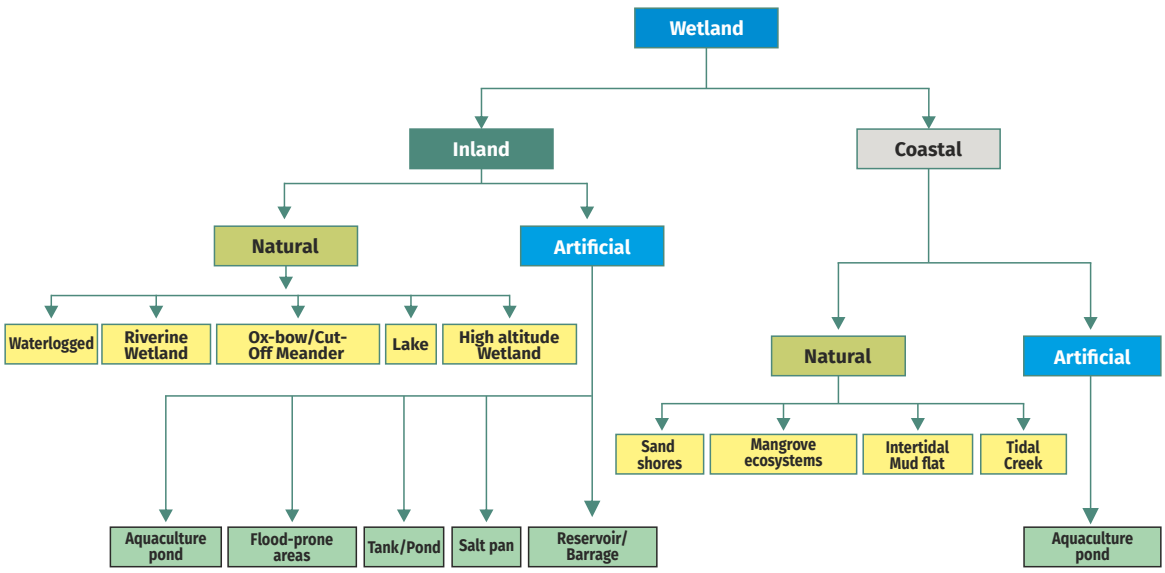


Figure 1.1. Wetland classification given in the National Wetland Atlas

1.2 WETLANDS IN THE GANGA RIVER BASIN

Among the various river basins of the country, the Ganga River basin has the highest number as well as percentage area under the wetlands. About 7,00,352 different types of waterbodies (including ponds, reservoirs, lakes, and others) are distributed across the Ganga River basin in India (MoJS 2023). Spread across a geographic area of 902,803 sq. km, the wetlands account for 4.44% of the Ganga River basin's total geographic extent (Gupta et al. 2024). As per the NWIA, about 51,024 wetlands are distributed across eleven states and 21 major rivers in the Ganga River Basin, covering a total area of 1595.96 km^2. The wetlands of the basin range from the high-altitude oligotrophic lakes in the Himalayas, marshes and swamps on the Himalayan foothills, and floodplain and riverine wetlands to coastal wetlands in the deltaic tracts, owing to their geographical extent, latitudinal and altitudinal variations (Table 1.1; Figure 1.2). State-wise distribution of these wetlands is prvided in table 1.2. Among these, the most significant are the ox-bow lakes, cut-off meanders, and riverine wetlands. About 65% of the oxbow lakes and cut-off meanders in India are found in the Ganga River basin (Gupta et al. 2024). The wide-ranging role of these wetlands as sources of major rivers, biodiversity habitats, backbone of highly productive agriculture and fisheries, buffers against floods and coastal storms, and cultural heritage of populations living in and around marks their critical role in food, water, ecological, and climate security. The Ganga River basin is also an integral part of the Central Asian Flyway, and the wetlands of the basin provide refuge to several water and water-associated species, including many threatened species (WII-NMCG 2019). Altogether, there are 111 Important Bird Areas (IBAs) and 25 designated Ramsar sites in the basin to date (Table 1.3) (Rahmani et al. 2016; Ramsar 2025). Of these, Okhla, Bharatpur, Sur Sarovar, Asan, Haiderpur, Bakhira, and Udhwa are a few significant wetlands in the basin.

Annually, more than 1,000,000 individuals of waterbird species migrate to the Indian sub-continent (Li et al. 2009). India hosts almost 300 wetland birds, of which 107 are winter migrants (Namgail et al. 2014). These 'to & fro migration' follower avian species, which cover large distances

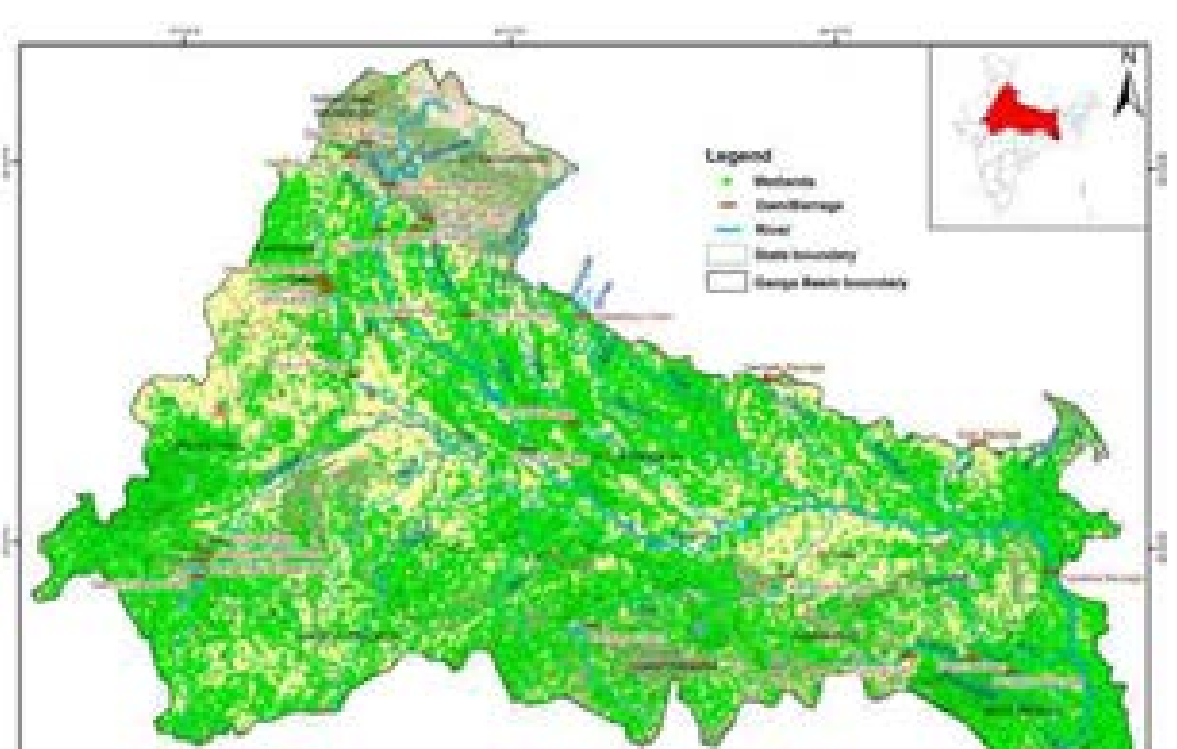


Figure 1.2. Spatial representation of the Ganga River Basin study with marked wetland locations.

Table 1.1. Wetland types and their extent across the Ganga River Basin

Geographic location	Formation	Wetland Type	Number of Wetlands	Area (in ha)
Coastal	Artificial	Aquaculture Pond	789	57365.05
	Natural	Tidal creek	314	2049.41
		Intertidal mud flat	13	264.60
		Mangrove ecosystems	666	191457.04
		Sand shores	29	1716.90
Inland	Artificial	Reservoir/Barrage	5006	592837.53
		Salt pan	40	7060.39
		Tank/Pond	25314	190918.97
		Flood-prone areas	3060	64736.05
		Aquaculture pond	579	26827.54
	Natural	High altitude Wetland	37	331.19
		Lake	4394	175975.00
		Ox-Bow /Cut-Off Meander	3242	88130.45
		Riverine Wetland	2001	73148.26
		Waterlogged	5540	123146.54
Total			**51024**	**1595964.92**

Table 1.2. Wetland distribution across the Ganga River basin states

State	Number of Wetlands	Area (in ha)
Bihar	4190	76815.92
Chhattisgarh	604	9119.83
Delhi	117	1421.89
Haryana	1256	14344.53
Himachal Pradesh	23	276.12
Jharkhand	1803	49318.83
Madhya Pradesh	7930	299299.10
Rajasthan	6753	247313.55
Uttarakhand	85	23108.60
Uttar Pradesh	17540	467887.09
West Bengal	10723	407059.46
Total	**51024**	**1595964.92**

between the Indian sub-continent and Central Asian countries, are dependent on the Ganga River basin (Gopi et al. 2014; Prins and Namgail 2017). More than 200 water and water-associated bird species utilise the wetlands of the Ganga River basin (Mahar et al. 2025). In addition to the avifaunal species, these wetlands provide habitat for the threatened mammalian species such as the swamp deer (*Rucervus duvaucelii*), otters, and the Gangetic dolphin (*Platanista gangetica*). Some of the wetlands in the floodplains of the middle Ganga River basin, Haiderpur and Jhilmil Jheel, are among the last remaining refuges and are ecologically significant for the swamp deer (Paul et al. 2020).

Loss of wetlands in India has followed a similar pattern as in the developed world (Gopal 2013; Davidson 2014; Das et al. 2022). According to an estimate, about 40% of the wetlands have been lost in the Ganga River basin, between 1700 and 2020 (Fluet-Chouinard et al. 2023). The wetlands in the lower Ganga River basin have experienced deterioration in recent times (Das et al. 2022). Urban expansion has been leading to a decline in wetland extent and number in the Ganga River basin (Modi et al. 2023; Mahapatra et al. 2024). The loss of wetland in number and extent limits the habitat for waterbirds, particularly migratory species. For example, the Okhla wetland, situated within the urban landscape of the Union Territory of Delhi, became shallow by 2009-10 due to sedimentation (Manral et al. 2012), which resulted in a population decline of the diving duck, while the population of greater flamingoes (*Phoenicopterus roseus*) increased. Additionally, poor water quality enabled the spread of invasive species such as *Typha angustifolia* and *Pontederia*

Table 1.3. Ramsar sites in the Ganga River Basin

SN	Basin State	Ramsar site	District
1	Bihar	Kabartal Wetland	Begusarai
2		Nagi Bird Sanctuary	Jamui
3		Nakti Bird Sanctuary	Jamui
4	Haryana	Bhindawas Wildlife Sanctuary	Jhajjar
5		Sultanpur National Park	Gurugram
6	Himachal Pradesh	Renuka Wetland	Sirmaur
7	Jharkhand	Udhwa Lake Bird Sanctuary	Sahibganj
8	Madhya Pradesh	Bhoj Wetland	Bhopal
9		Sakhya Sagar	Shivpuri
10		Sirpur Wetland	Indore
11		Yashwant Sagar	Indore
12	Rajasthan	Keoladeo National Park	Bharatpur
13		Sambhar Lake	Ajmer
14	Uttar Pradesh	Bakhira Wildlife Sanctuary	Santkabir Nagar
15		Haiderpur Wetland	Muzafarnagar
16		Nawabganj Bird Sanctuary	Unnao
17		Parvati Arga Bird Sanctuary	Gonda
18		Saman Bird Sanctuary	Mainpuri
19		Samaspur Bird Sanctuary	Raebareli
20		Sandi Bird Sanctuary	Hardoi
21		Sarsai Nawar Jheel	Etawah
22		Sur Sarovar	Agra
23		Upper Ganga River	Bulandshahr
24	Uttarakhand	Asan Conservation Reserve	Dehradun
25	West Bengal	East Calcutta Wetlands	Kolkata
26		Sundarban Wetland	South 24

crassipes, indicating an increase in unsuitable conditions for sustaining biodiversity. In addition to a reduction in extent and number, the rise in new emerging contaminants and pollutants, including microplastics, is a looming threat to the wetlands of the Ganga River basin, and it has profound implications for the aquatic ecosystems and human health (Chakraborty et al. 2021; Nelms et al. 2021; Sharma et al. 2025).

Wetland conservation and management have been recognized as one of the potential strategies and Nature-based Solutions (NbS) to address climate change related adaptation and resilience enhancement. Ecological processes and functions of the restored and conserved wetlands result in critical services, such as carbon sequestration, flood control, and biodiversity support, which are essential for both ecological health and human communities. While the benefits of conserving the wetland are significant, myopic landscape level planning, associated policy incoherence, and ineffective monitoring hinder conservation of the wetlands. Addressing these barriers is crucial for maximizing the potential of wetlands as NbS in climate adaptation strategies. Monitoring the status of wetlands is thus essential for guiding conservation, management and restoration strategies and prioritizing them. Since waterbirds are considered indicator species, and have been used as a surrogate of ecosystem health, particularly wetlands (Amat and Green 2010; Mansfield et al. 2024; Fox et al. 2025), a study was initiated to assess the condition of wetlands in the Ganga River basin with the following key objectives:

i) To assess the status of water and water-associated bird species in the select wetland,

ii) To identify key threats to wetland habitats, and

iii) To record the physio-chemical parameters and status of pollutants of the select wetlands.

02

METHODOLOGICAL FRAMEWORK

For this study, the Region of Interest (ROI) was defined by applying a 25 km buffer on either side of each major rivers in the Ganga Basin. Wetland layers were then spatially identified within these buffered polygons to extract sub-basin-specific wetland distribution and area statistics, preserving ecological and hydrological context. Preliminary assessments were also carried out using 10 km and 5 km buffer zones on either side of the rivers. However, these narrower extents excluded several key features, including floodplain wetlands and human-made water bodies that are ecologically significant. The 25 km extent ensures inclusion of diverse wetland types such as floodplains, oxbow lakes, and marshes that are hydrologically connected to the river systems as shown in Figure 2.1. It also accounts for human-made wetlands and land-use practices closely linked with the river, offering a comprehensive spatial framework for analysis. Therefore, the 25 km buffer was finalized as it provides a more inclusive representation of the river-wetland system and associated land-use interactions.

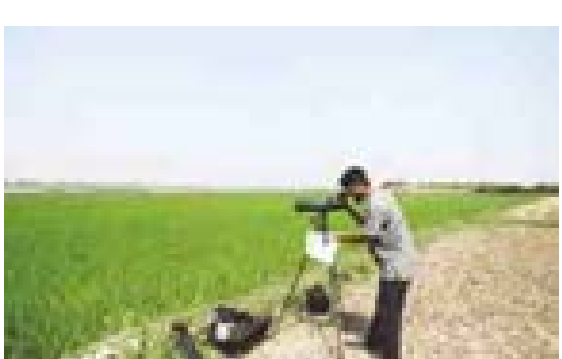
1.1. SELECTION OF STUDY SITES

Based on the 25 km buffer zone of major rivers in the Ganga River basin, 20 wetlands were selected for detailed survey and analysis (Figure 2.1; Table 2.1). These wetlands were identified through spatial overlay techniques using geodatabases from the NWIA project, complemented by field validation to ensure ecological relevance and geographical representation across various sub-basins. Selection criteria for the sites included hydrological connectivity to the river, ecological significance, wetland type diversity, and anthropogenic influence. The chosen sites encompass a variety of natural wetlands such as floodplains, oxbow lakes, and marshes, alongside human-made wetlands including reservoirs and aquaculture ponds. This integration of remote sensing data, GIS analysis, and field surveys allows for a comprehensive evaluation of wetland functions, spatial distribution patterns, and their interactions with surrounding land use within the river basin.

1.2. FIELD SAMPLING

Monitoring of the 20 select wetlands in the five Ganga River basin states (Bihar, Jharkhand, Uttar Pradesh, Uttarakhand, and West Bengal) was conducted during the winter seasons between 2023 and 2025 (Figure 2.1; Table 2.1). A total of three wetlands, including Mokama Taal, Jakhar, and Nauhatta, were monitored in the state of Bihar. Four wetlands were monitored in Jharkhand, namely Udhwa, Bramha Jamalpur, Konar Dam, and Patratu Dam. Haiderpur, Surajpur, Bakhira, and Gorakhpur Zoo wetlands were monitored in the state of Uttar Pradesh. Asan, Jhilmil Jheel, and Baan Ganga were three select wetlands monitored in the state of Uttarakhand. In addition, a total of six wetlands were identified and monitored in West Bengal, including East Kolkata (Calcutta), Nangla, Purbasthali, Dongaria, Ahiran, and Sheeal Lake.

The wetlands were surveyed using the point counts by maintaining a minimum distance of 500 m between two consecutive sampling points. The birds were counted using the total count method at each point for 15-20 mins (Bibby et al. 1998; Sutherland 2006), and all observations were made using binoculars (10X50 Zoom lens and spotting scope 60x65 mm zoom). At least one spatial or temporal replicate at each wetland was ensured by



the survey team, which was composed of two observers. Categories of waterbird feeding guilds were categorized based on the assessment of Kumar et al. (2005). In addition to avi-fauna, basic physio-chemical parameters such as pH, salinity and water temperature, dissolved oxygen (DO) were measured at the specific points of each wetland using YSI Pro DSS multi-parameter water quality meter. The wetlands' ecosystem was visually examined for features like vegetation cover, presence of litter, connectivity, disturbance factors etc. The point-specific and wetland-specific diversities (Shannon-Weiner diversity index *H'*) of avifauna were calculated in R environment software using the 'vegan' package (R Core Team 2024).

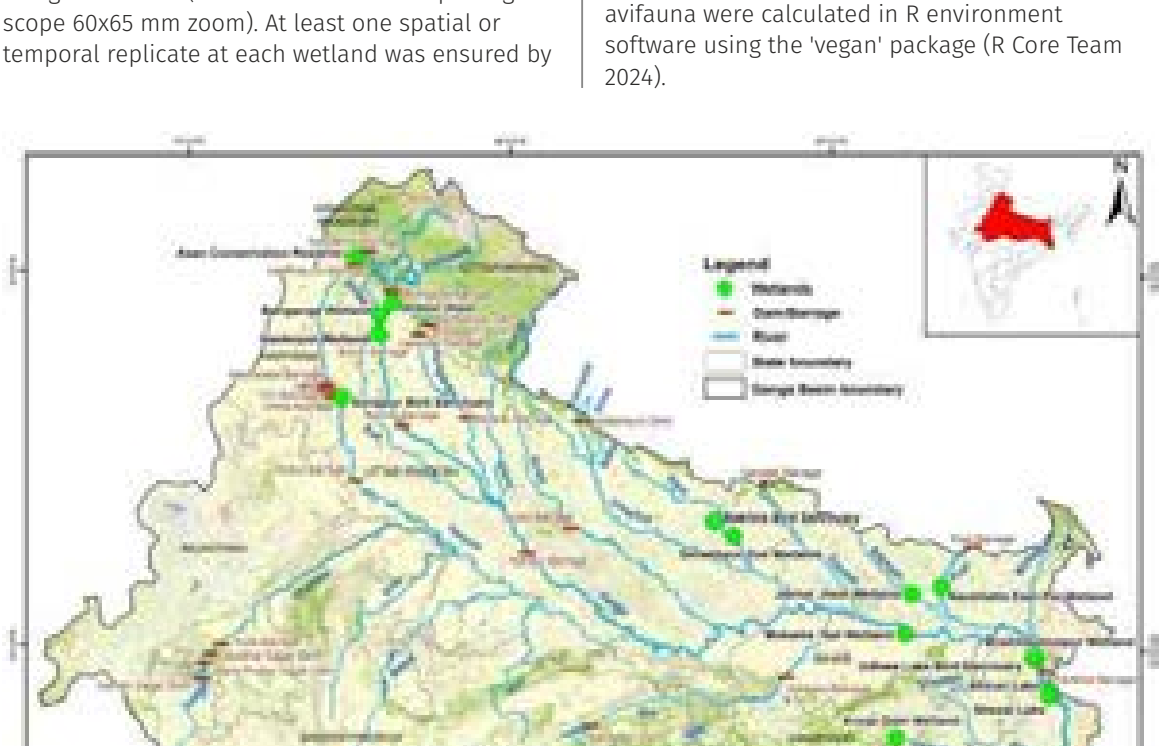


Figure 2.1. Distribution of the select wetlands in the Ganga River Basin

Table 2.1. Details of wetland profile and survey duration of the 20 select wetlands in the Ganga River Basin

State	Wetland	Survey Duration		Total Survey Effort (hours)	District	Wetland Type (Natural/ Artificial)
		Start Date	End Date			
Bihar	Mokama Taal (Barah)	20 Feb 2024	21 Feb 2024	6.3	Patna & Lakhisarai	Natural
Bihar	Jakhar	22 Feb 2024	23 Feb 2024	2.48	Samastipur	Natural
Bihar	Nauhatta	23 Feb 2024		3.98	Rohtas	Natural
Jharkhand	Konar dam	2 Feb 2024		1.99	Hazaribag	Artificial
Jharkhand	Patratu Dam	2 Feb 2024		1.99	Ramgarh	Artificial
Jharkhand	Udhwa wetland	29 Feb 2024		3.32	Sahibganj	Natural
Jharkhand	Bramha Jamalpur	1 Mar 2024		3.4	Sahibganj	Natural
Uttar Pradesh	Haiderpur	15 March 2024	18 March 2024	13.14	Muzaffarnagar, Bijnor	Artificial
Uttar Pradesh	Surajpur	Dec 2024	Jan Feb 2025	29.65	Gautam Budh Nagar	Natural
Uttar Pradesh	Bakhira	Dec 2023	Jan 2024	23.13	Sant Kabir Nagar	Natural
Uttar Pradesh	Gorakhpur Zoo wetland	Dec 2023	Feb 2024	29.65	Gorakhpur	Artificial
Uttarakhand	Baan Ganga	18 Jan 2024		1.66	Haridwar	Natural
Uttarakhand	Jhimil Jheel	12 Feb 2024	14 Feb 2024	16.14	Haridwar	Natural
Uttarakhand	Asan	15 Feb 2024	17 Feb 2024	6.81	Dehradun	Artificial
West Bengal	East Kolkata	21 Feb 2024		2.99	North 24 Parganas	Artificial
West Bengal	Nangla Wetland	22 Feb 2024		0.98	North 24 Parganas	Natural
West Bengal	Purbasthali	24 Feb 2024	25 Feb 2024	2.59	Nadia	Natural
West Bengal	Dongaria	27 Feb 2024		1.16	South 24 Parganas	Artificial
West Bengal	Ahiran	29 Feb 2024		0.83	Murshidabad	Artificial
West Bengal	Sheeal lake	1 Mar 2024		2.27	Murshidabad	Natural

GPS Location		Elevation (m)	Area (sq. km)	Conservation status (WLS/ NP/IBA/ RAMSAR/ other)	Biogeographic zone	Biogeographic province
Latitude (N)	Longitude (E)					
25.36691	85.93424	50	10	IBA	Gangetic Plain	Lower Gangetic Plain
25.88393	86.04508	64	0.04	-	Gangetic Plain	Lower Gangetic Plain
25.97976	86.48995	66	0.06	-	Gangetic Plain	Lower Gangetic Plain
23.94110	85.77500	438	16.21	-	Deccan Peninsula	Chotta Nagpur
23.60361	85.28056	422	7.31	-	Deccan Peninsula	Chotta Nagpur
24.99792	87.81335	44	9.35	Ramsar, IBA, WLS	Gangetic Plain	Lower Gangetic Plain
24.99302	87.81718	45	4.1	Part of Udhwa Lake Bird Sanctuary	Gangetic Plain	Lower Gangetic Plain
29.37510	78.03398	241	69.08	Ramsar, WLS (Under Hastinapur WLS), IBA	Gangetic Plain	Upper Gangetic Plain
28.52622	77.48812	184.7	3.08	IBA	Gangetic Plain	Upper Gangetic Plain
26.91000	83.12972	104	28.94	Ramsar, WLS	Gangetic Plain	Upper Gangetic Plain
26.72162	83.40460	96	0.05	Inside Zoological Park	Gangetic Plain	Upper Gangetic Plain
29.63361	78.04528	263	8	-	Gangetic Plain	Upper Gangetic Plain
29.79911	78.20868	275	38	IBA, Conservation Reserve	Gangetic Plain	Upper Gangetic Plain
30.43540	77.66940	422	4.44	Ramsar, Conservation Reserve	Gangetic Plain	Upper Gangetic Plain
22.54358	88.43003	19	125	Ramsar	Coasts	East Coast
22.82945	88.70832	21	0.53	-	Coasts	East Coast
23.45139	88.34306	27	3.5	-	Gangetic Plain	Lower Gangetic Plain
22.39652	88.14997	17	0.13	-	Coasts	East Coast
24.52891	88.03190	47	0.05	-	Gangetic Plain	Lower Gangetic Plain
24.77611	88.03556	39	6.5	-	Gangetic Plain	Lower Gangetic Plain

03

STATUS OF WETLANDS IN THE GANGA RIVER BASIN

3.1. STATE-WISE STATUS OF WATERBIRDS AND WETLANDS IN THE GANGA RIVER BASIN

3.1.1. UTTARAKHAND

Uttarakhand is a northern hill state of India, harboring several wetlands in its high, mid, and low altitude regions. The state is also the source of several glacial-fed rivers, including the Ganga and the Yamuna rivers. The rivers originating in the state join the Ganga River and thus the entire state is within the Ganga River basin. The state has many natural and man-made wetlands, which provide habitat to the resident and migratory waterbirds and other fauna. These wetlands are also known for their spiritual, cultural and religious significance and thus are also tourist hotspots. As per the SAC (2011) assessment, a total of 979 wetlands are present in the Himalayan region of the state, of which 42 high-altitude wetlands have been underpinned for conservation measures by the Uttarakhand forest department (UKFD-WWF 2012). Recently, 3096 different waterbodies have been identified in Uttarakhand, which are owned mainly by the village panchayats (MoJS 2023). To date, there are 18 Important Bird Areas (IBAs) and one designated Ramsar Site in the state. The natural and artificial wetlands in the Ganga floodplains and Shivalik region provide habitats to 137 waterbird species, including winter migrants (reviewed in Mahar et al. 2025), which usually arrive on annual migration from temperate wetlands of Central Asia. For the present monitoring exercise, Asan Conservation Reserve (CR), Jhlimil Jheel, and Baan Ganga wetlands were surveyed during February 2024 in the state (Figure 3.1).

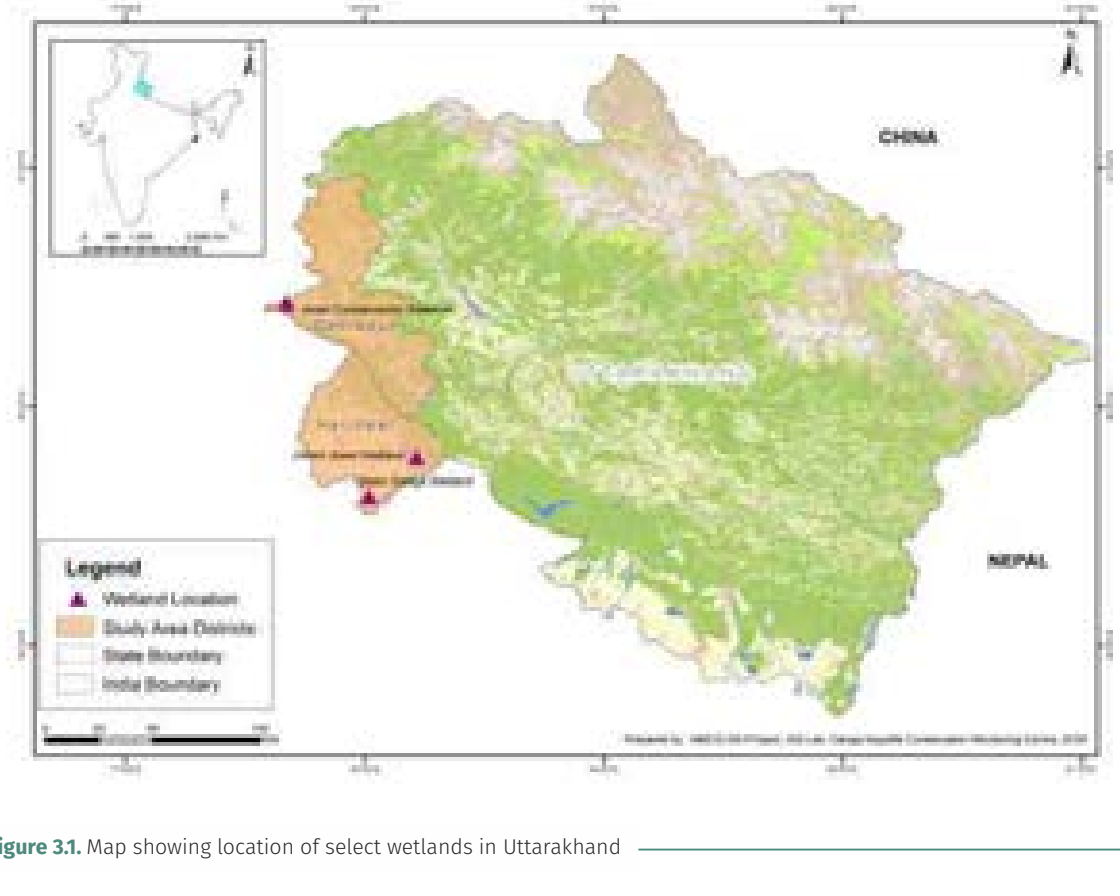


Figure 3.1. Map showing location of select wetlands in Uttarakhand

Altogether, 51 water and water-associated bird species were recorded from the three select wetlands of Uttarakhand (Annexure 1), of which 40 were waterbird and 11 were water-associated bird species. Of the 51 species, one was Endangered (EN), two species each were in the Vulnerable (VU) and Near Threatened (NT) categories as per the IUCN Red List (BirLife International 2025). Among the three surveyed wetlands of Uttarakhand, Asan CR was found to be the most diverse wetland in terms of water and water-associated birds. The average highest species Shannon diversity value was found in Asan CR (*H'*= 1.97±0.28 SD), followed by Baan Ganga (1.69±0.23) and Jhilmil Jheel (1.02±0.56) (Figure 3.2).

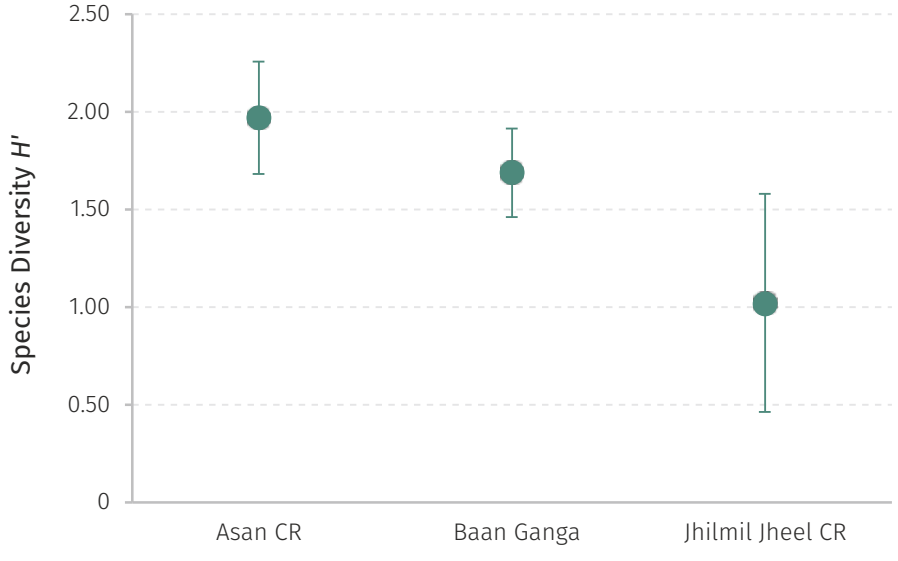


Figure 3.2. Average species diversity (*H'* mean ±SD) of water and water-associated birds in the surveyed wetlands of Uttarakhand

1. ASAN CONSERVATION RESERVE

The Asan Conservation Reserve (CR) is a man-made wetland, formed due to the construction of the barrage on the Asan River, a smaller tributary of the Yamuna River. The Asan CR between 30°26' 31.50" N, 77°40' 25.99" E and 30° 25' 54.04" N, 77° 40' 12.44" E at an average elevation of 400 m asl (Figure 3.3). The wetland has an area of 4.44 sq. km in Dehradun district of Uttarakhand. The water of the Asan barrage drains into the Yamuna River near the Ponta Sahib township of Himachal Pradesh. The irrigation department is responsible for the functioning of the barrage, while the Forest Department of Uttarakhand manages the conservation reserve. The Asan CR falls within the 7-Gangetic plains biogeographic zone and the 7A-Upper Gangetic plains biogeographic province (Rodgers et al. 2000). It is a well-known wetland with CR and IBA status, and also designated as the first Ramsar site of Uttarakhand. The Asan CR is crucial nesting site for Pallas's fish eagle (*Haliaeetus leucoryphus*) in Uttarakhand and elsewhere. It also provides refuge to large congregations of winter migrants like ruddy shelduck (*Tadorna ferruginea*), mallard (*Anas platyrhynchos*), Eurasian wigeon (*Mareca penelope*), gadwall (*Mareca strepera*), and northern shoveler (*Spatula clypeata*) (Mishra et al. 2023).

The Asan CR is surrounded by the villages of Dhalipur, Kunja, Kunja Grant, Kulhal, and Dhakrani. However, these communities do not depend primarily on the reserve. The residents of these settlements maintain significant belief regarding the reserve as a potential avenue for income generation (Ramsar 2020). According to the Census of India (2011), these five villages comprises 4,162 households with a population of 22,530. The literacy rate for the age group above six years remains fair with 69% (male 75.82%; female 61.62%) with a combined sex ratio of 931 females per 1,000 males. The individual household number in the five villages ranged between 390 and 2,327, with the highest population of 12,757 in the village Dhakrani and the lowest population of 2,042 in Kulhan Matak Majri (Census of India 2011). This wetland is a major tourist attraction on the Dehradun-Shimla highway. Seven points were selected for studying the waterbird congregation in the Asan CR.

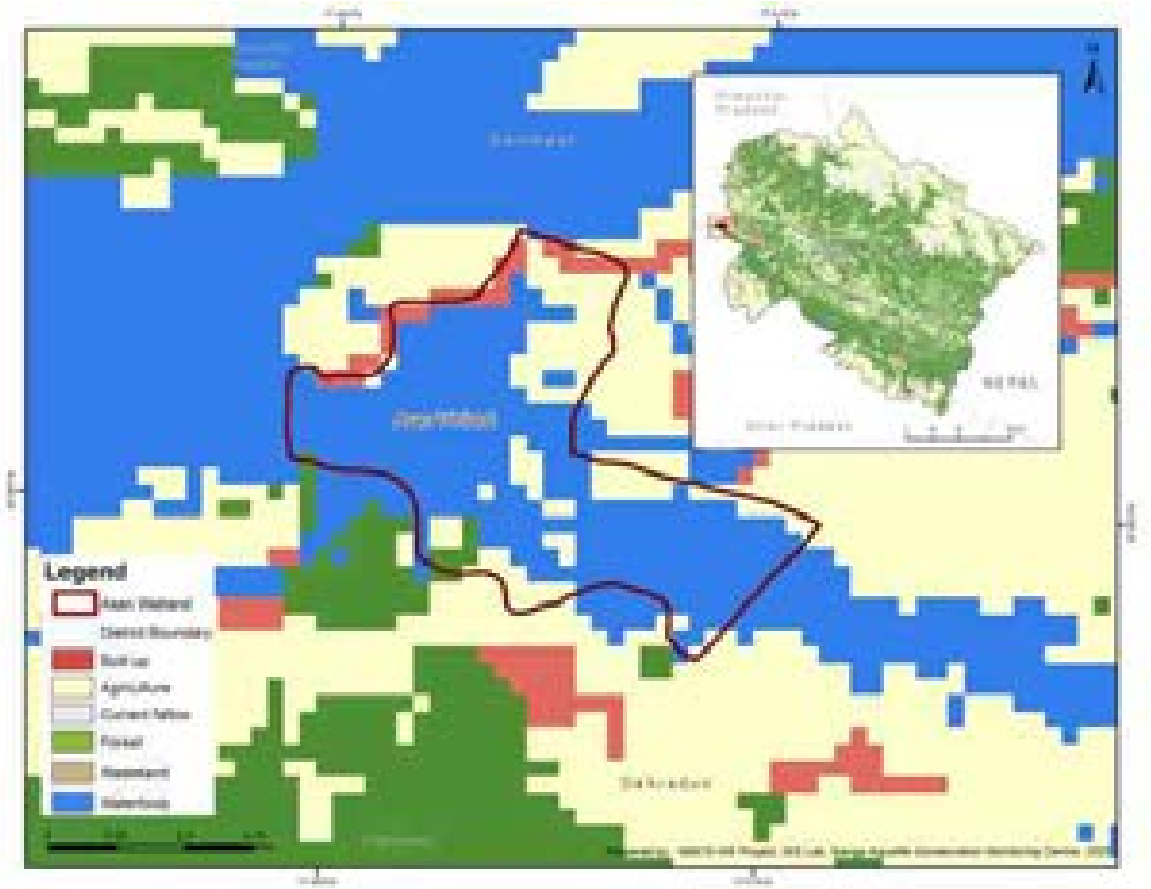


Figure 3.3. Land Use and Land Cover Map of Asan Conservation Reserve

Altogether, 8826 individuals of 47 water and water-associated bird species were recorded from the Asan CR, belonging to 10 orders, 14 families, and 31 genera in seven sampling points during three occasions (total effort= 6.81 hrs). Anseriformes (11 species) was the most dominant order, followed by Charadriiformes (9 sp.) and Pelecaniformes and Passeriformes (7 sp.) (Figure 3.4a). Anatidae (11 species) was the most dominant family, followed by Ardeidae (7 sp.) and Scolopacidae (5 sp.) (Figure 3.4b). Out of 47 recorded species, one species, the steppe eagle (*Aquila nipalensis*) was EN, one species, the common pochard (*Aythya ferina*) was VU, and one species, the river lapwing (*Vanellus duvaucelii*) was in the NT category.

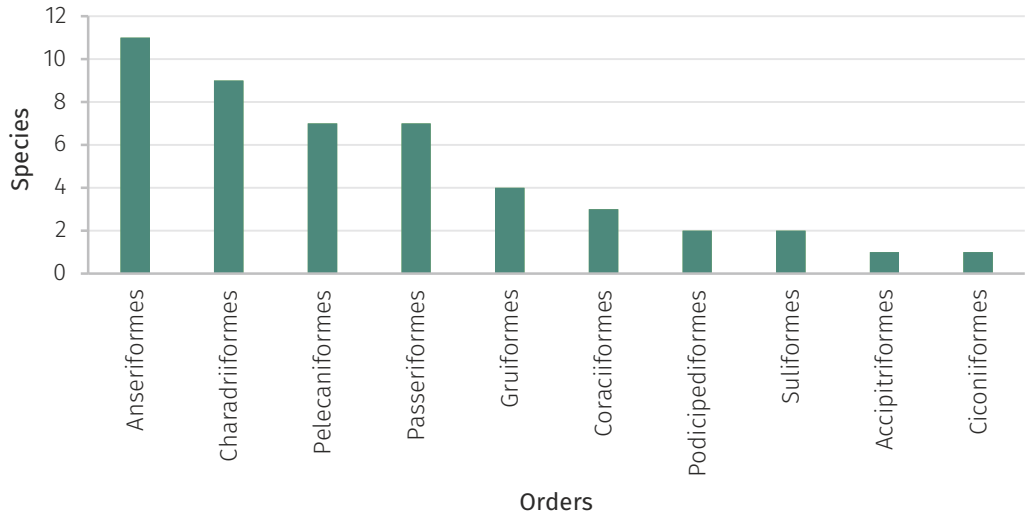


Figure 3.4a. Order-wise composition of species recorded in the Asan Conservation Reserve

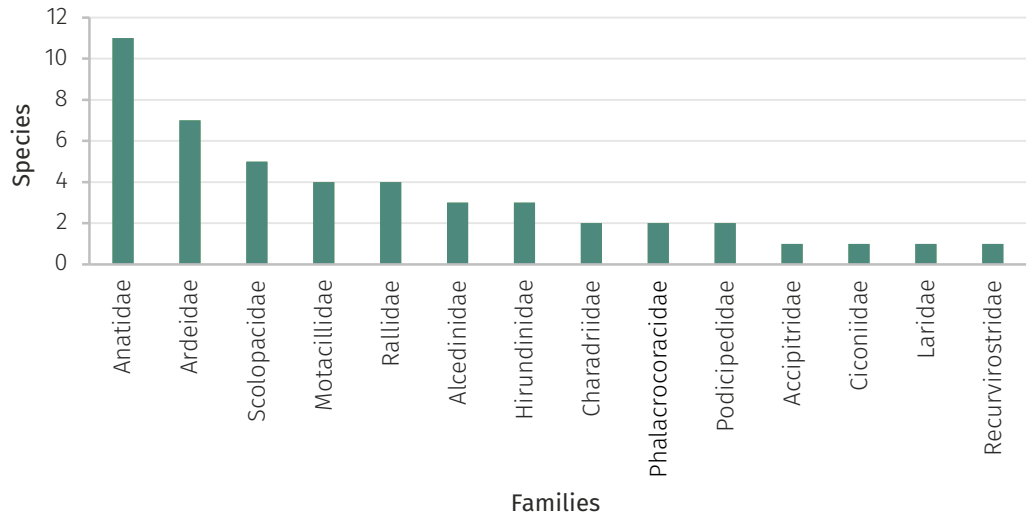


Figure 3.4b. Family-wise composition of species recorded in the Asan Conservation Reserve

Richness and Diversity

Overall species richness of water and water-associated species was found to be highest in sampling point 6 (27 species), followed by point 1 (23 sp.) and 5 (21 sp.) (Figure 3.5). Overall species diversity was found to be highest in point 7 (2.36), followed by point 6 (2.25) and 5 (2.08).

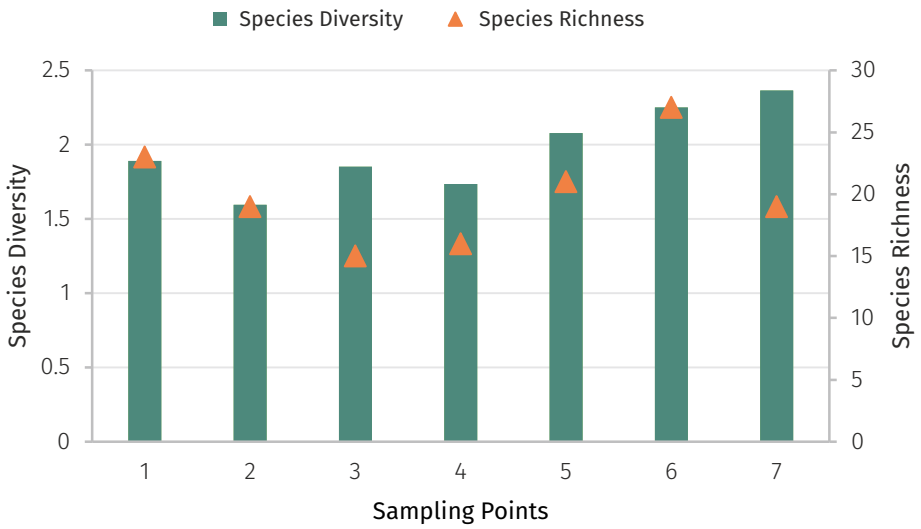


Figure 3.5. Species richness and diversity value (*H'*) of water and water-associated birds in the Asan Conservation Reserve

Waterbirds

Of the 47 species recorded during the survey, 36 species (76.60%) fell within the category of waterbirds. The highest species richness of waterbirds was recorded in point 6 (21 species), followed by point 1 and point 5 (both 19 sp.), and point 2 (18 sp.). Overall waterbird diversity value was found to be highest in point 7 (2.27), followed by point 6 (2.01) and point 5 (1.97).

Water-associated Birds

Only 11 species out of 47 species (23.40%) were identified as water-associated species with low diversity value (*H'* <1.40). The highest species richness of water-associated bird species was in points 6 and 7 (both with 6 species), followed by point 1 (4 sp.) and point 5 (2 sp.). Whereas, only one species was recorded in the remaining three points (2, 3, and 4). The highest species diversity value was recorded in point 7 (1.34), followed by point 1 (1.33) and point 6 (1.19).

Relative abundance

In terms of the combined relative abundance of water and water-associated species in Asan CR, the red-crested pochard (*Netta rufina*) (14.12%) was observed as the most abundant species, followed by gadwall (13.96%) and Eurasian coot (13.34%), while intermediate egret (*Ardea intermedia*), pied kingfisher (*Ceryle rudis*), and common kingfisher (*Alcedo atthis*) (0.01%) were found to be the least abundant species. Point 1 (21.88%) was recorded as the most abundant point, followed by point 2 (21.55%) and point 5 (14.87%), while point 7 (1.64%) was the least abundant.

Waterbirds

Out of the 36 waterbird species, the red-crested pochard (14.86%) was the most abundant species, followed by gadwall (14.69%) and Eurasian coot (14.04%), while intermediate egret (0.01%) was the least abundant species. Point 1 (22.96%) was recorded as the most abundant point, followed by point 2 (22.66%) and point 5 (14.78%), while point 7 (0.67%) was the least abundant.

Water-associated Birds

Out of the 11 water-associated species, the barn swallow (*Hirundo rustica*) (49.44%) was found to be the most abundant species, followed by the grey-throated martin (*Riparia chinensis*) (25.50%) and wire-tailed swallow (*Hirundo smithii*) (15.44%), while pied kingfisher and common kingfisher (0.22%) were the least abundant species. Point 6 (28.66%) was recorded as the most abundant sampling point, followed by point 3 (22.37%) and point 7 (19.91%).

Feeding Guild and Residential status

Overall, Carnivore (57.45%, 27 species) was the most dominant feeding guild in Asan CR, followed by Herbivore/Carnivore (17.02%, 8 sp.), and Carnivore/Herbivore (8.51%, 4 sp.), while Herbivore (4.26%, 2 sp.) was the least dominant (Figure 3.6). In terms of residential status of 48 recorded species, 15 species (31%) belonging to Resident/Local Migrants (R/LM), 13 species (27%) to Winter Migrants (WM), 10 species (21%) to Resident/Winter Migrants (R/WM), and four (8%) to Resident (R) in Asan CR.

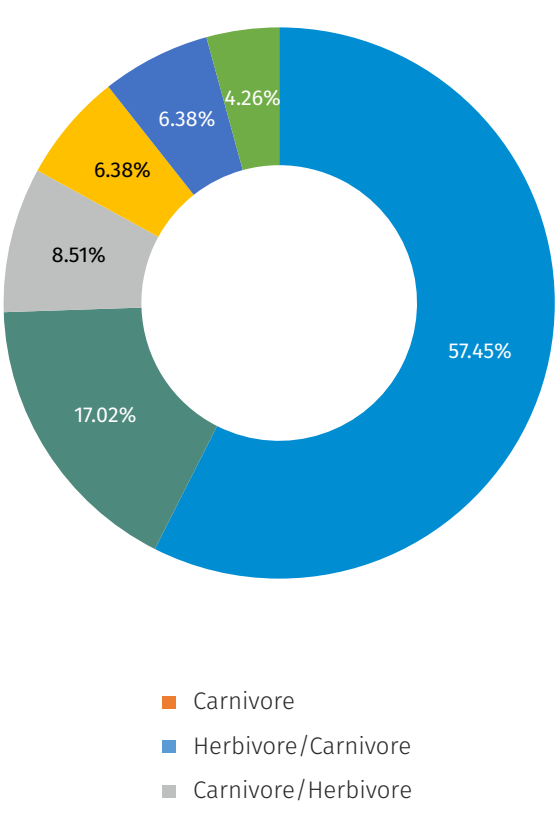


Figure 3.6. Proportion of the different Feeding Guilds of the water and water-associated birds in the Asan Conservation Reserve

Physio-chemical properties and anthropogenic stressors

During the present survey, the average pH value of water was 7.77 ±0.67 SD (range 6.5-8.31), and salinity values varied between 0.01 to 0.2 ppt (0.12± 0.09 SD) in Asan CR. The mean air temperature was recorded as 18.28 °C ± 2.56 SD, and the mean water temperature was about 17.4 °C ±1.72 SD. Out of seven monitoring points, only two (4 and 7) exhibited high litter content (polybags and thermocol), while negligible litter was observed elsewhere. Odorous water in point 7 is attributed to proximal village wastewater. Agriculture was prominent only in sampling points 6 and 7 near the village. No fishing activity was recorded from the wetland, and the irrigation department usually regulates the water level through a barrage. Half of the sampling points have the presence of small and large power lines crossing the wetland at multiple locations. Tourism activities are prominent between points 3 and 4, particularly boating, which often disturbs waterbirds. Vegetation/biomass extraction was active in only one monitoring point near the canal. Six out of seven sampling points exhibited 50% vegetation cover, mostly dominated by duckweeds. Hydrological connectivity to surface water was maintained via regulated discharge from an upstream barrage managed by the irrigation department. Grazing pressure was found to be high in all sites due to cattle from surrounding villages. *Parthenium* spp., *Lantana* spp. and *Alocasia* spp. were some of the invasive species found in the wetland, covering <30% of the wetland area. Half of the monitoring points were occupied by floating macrophytes (< 50%).

2. JHILMIL JHEEL CONSERVATION RESERVE

One of the pioneer 'Conservation Reserves' in India, Jhilmil Jheel covers about 37.83 sq. km area in Chiriyapur forest range (29° 47' 49.56" N, 78° 13' 04.77") on the left bank of the Ganga River in Haridwar district of Uttarakhand (Figure 3.7). It is a part of the Rajaji National Park with mean elevation of 260 m asl, which falls in the Gangetic plains biogeographic zone (7) and the Upper Gangetic plains biogeographic province (7A) (Rodgers et al. 2000). Apart from waterbirds, it provides excellent habitat to swamp deer. A total of 160 species of birds have been reported from the Jhilmil wetland, including both resident and migratory (Sinha et al. 2007). The wetland is also designated as one of the key IBAs in Uttarakhand.

A total of 228 households resides in Tantwala (Dudhala Dayalwala) village near Jhilmil Jheel with a population of 1,138. Overall literacy rate of the village is 63.82% (male 75.48%; female 49.53%) for the age group above 6 years. Of the total worker population (n=528) in the village, 69.31% are marginal agricultural laborer, followed by main cultivators (20.26%) (Census of India 2011). The communities viz., Punjabi, Saini, Garhwali, and Gujjar migrated to this region in the early 1950s and Gujjars were freely grazing their animals in the grasslands of the wetland. After the declaration of the region as a Conservation Reserve in 2005, Gujjars were translocated along the Rawasan River outside the reserve (Tiwari and Rawat 2013).

Eight points were identified for studying the waterbird congregation in the Jhilmil Jheel CR.

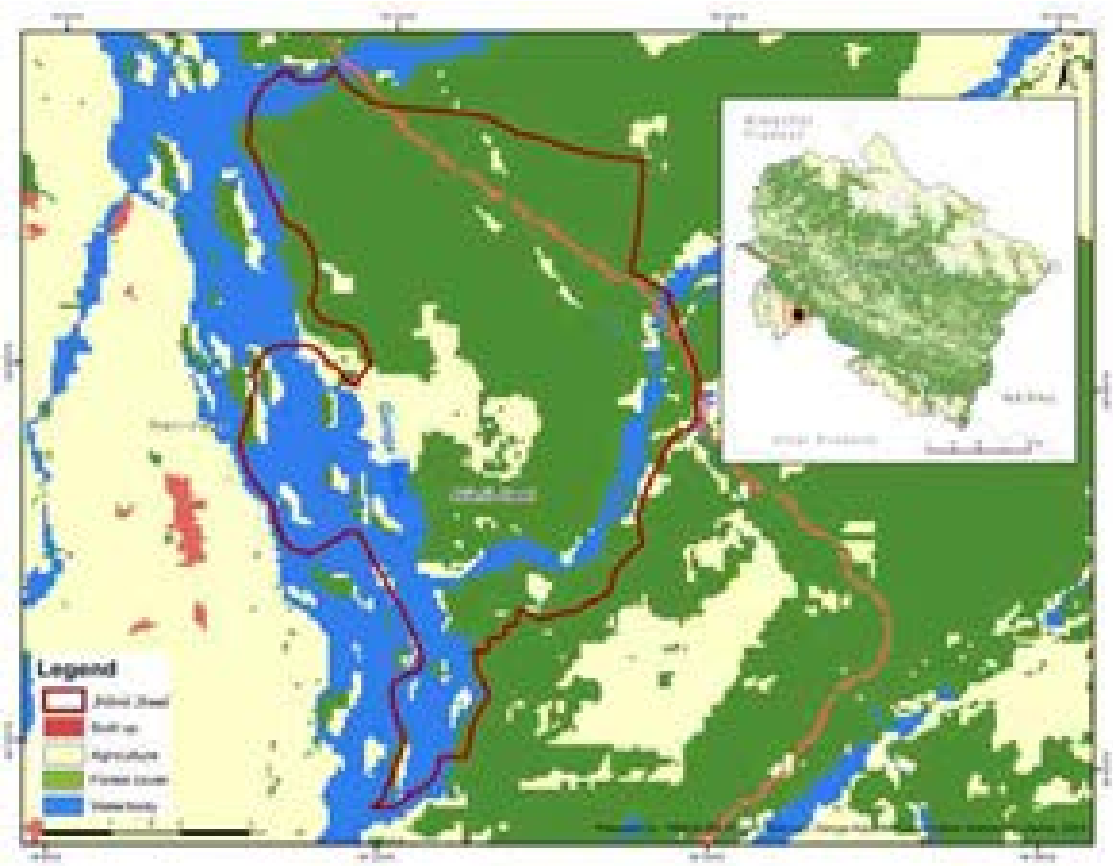


Figure 3.7. Land Use and Land Cover Map of Jhilmil Jheel Conservation Reserve

A total of 272 individuals of 10 water and water-associated bird species were recorded from the Jhilmil Jheel CR, belonging to 6 orders, 7 families, and 8 genera in eight sampling points during three occasions (total effort = 16.14 hrs). Pelecaniformes (4 species) was the most dominant order, followed by Charadriiformes (2 sp.) and Anseriformes, Ciconiiformes, Coraciiformes, and Passeriformes, with only one species (Figure 3.8a). Ardeidae (3 species) was the most dominant family, followed by Charadriidae (2 sp.) and Anatidae, Alcedinidae, Ciconiidae, Motacillidae, and Threskiornithidae, with only 1 species (Figure 3.8b). Out of 10 recorded species, one species, Asian woolly-necked stork (*Ciconia episcopus*), was listed as NT, and the rest were as least concern (LC) on the IUCN Red List.

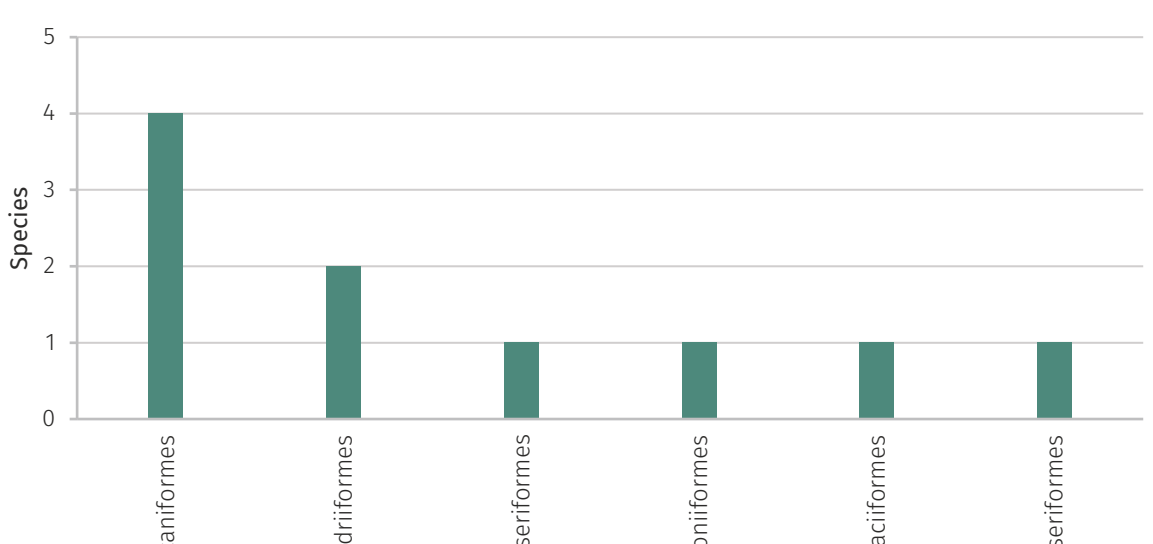


Figure 3.8a. Order-wise composition of species recorded in the Jhilmil Jheel Conservation Reserve

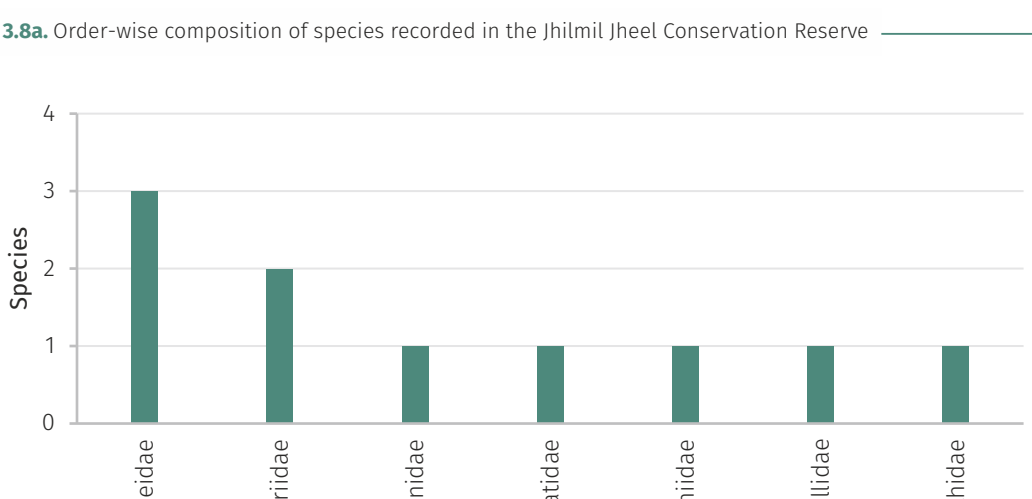


Figure 3.8b. Family-wise composition of species recorded in the Jhilmil Jheel Conservation Reserve

Richness and Diversity

Of eight sampling points, the overall species richness of water and water-associated species was found to be highest in point 5 (7 species), followed by point 7 (6 sp.) and point 6 (5 sp.) (Figure 3.9). Overall species diversity was found to be highest in point 5 (1.65), followed by point 7 (1.44) and point 6 (1.36). While point 1 had only one species (Figure 3.9).

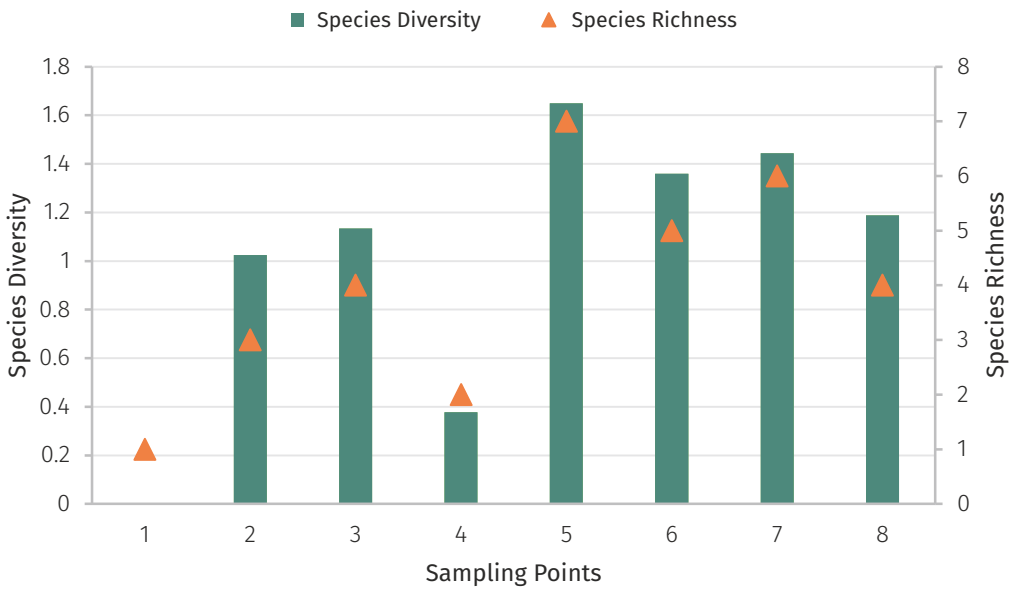


Figure 3.9. Species richness and diversity (*H'*) of water and water-associated birds in the Jhilmil Jheel Conservation Reserve

Waterbirds

Of the 10 species recorded during the survey, 8 species (80%) were waterbirds. The highest richness of waterbird species was recorded in point 5 (6 species), followed by point 7 (5 sp.), and points 2, 3, 6, and 8 (each had 3 species). Overall waterbird diversity was highest in point 5 (1.47), followed by point 7 (1.17) and point 8 (1.09). While point 1 had only 1 species.

Water-associated Birds

Only 2 species out of 10 species (20%) were identified as water-associated species with low diversity value ($H' < 1$). The highest species richness of water-associated birds was in point 6 (2 species), followed by points 3, 5, 7, and 8 (each had 1 species). Whereas, water-associated species were absent at points 1, 2, and 4. The highest species diversity value was found in point 6 (0.69).

Relative abundance

In terms of the combined relative abundance of water and water-associated species, the red-wattled lapwing (*Vanellus indicus*) (39.70%) was found as the most abundant species, followed by Asian woolly-necked stork (18.8%) and red-naped ibis (12.90%), while ruddy shelduck and yellow-wattled lapwing (*Vanellus malabaricus*) (0.74%) were the least abundant. Point 7 (27.90%) was recorded as the most abundant sampling point, followed by point 8 (24.6%) and point 5 (18.4%), while point 4 (2.94%) was the least abundant.

Waterbirds

Out of the 8 waterbird species, the red-wattled lapwing (44.63%) was the most abundant species, followed by Asian woolly-necked stork (21.07%) and red-naped Ibis (14.46%), while ruddy shelduck and yellow-wattled lapwing (0.83%) were recorded as the least abundant. Point 8 (26.86%) was recorded as the most abundant sampling point, followed by point 7 (23.97%) and point 5 (18.60%), while point 4 (3.31%) was the least abundant.

Water-associated Birds

Out of the two recorded water-associated species, the grey wagtail (*Motacilla cinerea*) (63.33%) was the most abundant species, followed by the white-throated kingfisher (*Halcyon smyrnensis*) (36.67%). Point 7 (28.66%) was recorded as the most abundant sampling point, followed by point 6 (3.33%), while points 3, 5, and 8 had only one species, and no species was found in points 1, 2, and 4.

Feeding Guild and Residential status

Overall, Carnivore (90%, 9 species) was the most dominant feeding guild, followed by Omnivore (10%, 1 sp.) (Figure 3.10). In terms of residential status, Jhilmil Jheel wetland was dominated by R/LM (50%, 5 species), followed by R (20%, 2 sp.), and one species (10%) each of Resident/Autumn Migrants (R/AM), Resident/Winter Migrant/Autumn Migrants (R/WM/AM) and Resident/Winter Migrant/Passage Migrants (R/WM/PM).

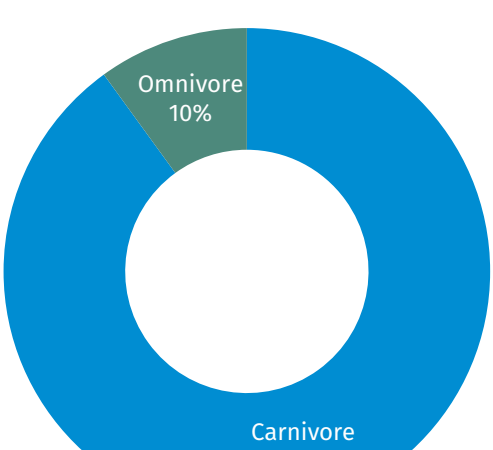
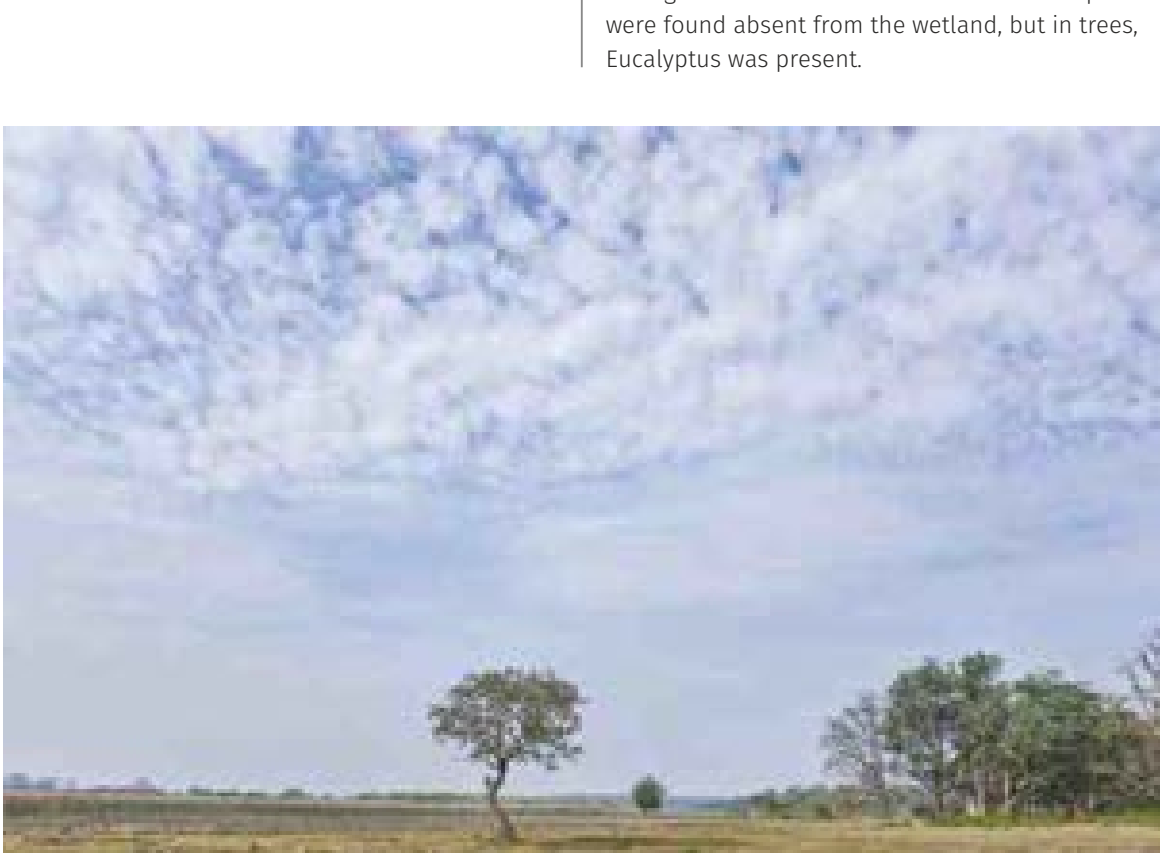


Figure 3.10. Proportion of the different Feeding Guilds of the water and water-associated birds in the Jhilmil Jheel Conservation Reserve

Physio-chemical properties and anthropogenic stressors

The Jhilmil Jheel is a marsh wetland with a mean pH value of 7.4 ±0.28 and a salinity value of 0.4 ppt, and is covered with vegetation that provides an ideal habitat to a small swamp deer population in the Upper Gangetic River system. The mean air temperature was recorded as 23.75 °C±2.18, and water temperature was about 23° C ± 4.24. The vegetation cover was mostly dominated by grassland habitat with some small water holes. Being a part of the protected area, anthropogenic pressures remained negligible or absent. The wetland exhibited no issues related to litter, agriculture, fishing, and biomass extraction during the monitoring period. Jhilmil was also devoid of any industrial outlet, powerlines, mining and washing. However, grazing was found prominent in all monitoring points. The hydrological connectivity of the wetland remains seasonal, which is usually recharged by small streams inlet in the wetland through forests. The invasive shrub or herb species were found absent from the wetland, but in trees, Eucalyptus was present.



3. BAAN GANGA WETLAND

The Baan Ganga Wetland is a small 'tropical seasonal marsh' wetland spread over an area of 8 sq. km (29° 36'10.92" N; 78° 03' 51.33" E and 29° 26 54.22" N; 77° 59'54.42" E), near Idrispur village in Khanpur block of the Haridwar district (Uttarakhand) with mean elevation of 250 m asl (Figure 3.11). The wetland falls within the Gangetic Plain biogeographic zone (7) and the Upper Gangetic Plain biogeographic province (7A) (Rodgers et al. 2000). It is also one of the last refuges of swamp deer in the Upper Gangetic Plains. A total of 178 plant species have been recorded from the wetland (Adhikari and Babu 2008). On descending to the Gangetic plains, the Ganga River anabranches and the first such anabranch resulted in a secondary river, called Baan Ganga, which flows for 40 km before confluencing with the Ganga River. The Baan Ganga wetland is located between the confluences of the Ganga and Baan Ganga rivers and the Ganga and Solani rivers (Anon 2006). The Baan Ganga River, which used to recharge the wetland, has been reduced to a great extent. Baan Ganga wetland has been a habitat for swamp deer and provided connectivity to the swamp deer habitat between the Hastinapur WLS and Jhilmil Jheel. It is now facing various conservation challenges. Over the years, encroachment, change in water regime, and other anthropogenic factors have contributed to the depletion of the stream/wetland area (Anon 2006).

A total of four villages (viz, Chandrapuri Bangar, Idrishpur, Mandavela, and Sherpur Bela) are situated along the wetland. The cultivation of sugarcane, wheat, and rice dominantly characterises human habitation. The four villages remain below the poverty line with menial jobs like manual labour and insignificant agriculture yields. Village Panchayats encourage the auction of commercial fishing and the reed harvest for manufacturing mats and thatch. Only two villages, namely Chandrapuri and Mandavela, are dependent on the Baan Ganga Wetland for fish (Badola, 2006). Idrishpur has the least population of 253, and Chandrapuri the highest, with 2210 individuals (Census of India 2011). The illiteracy rate is highest in Idrishpur (male 78.56%; female 53.92 %) and lowest in Shepur Bela (64.94 %; 46.00 %). The majority of families (85% to 97%) in the four villages own cattle. Three points were selected for studying the waterbird congregation in the Baan Ganga.

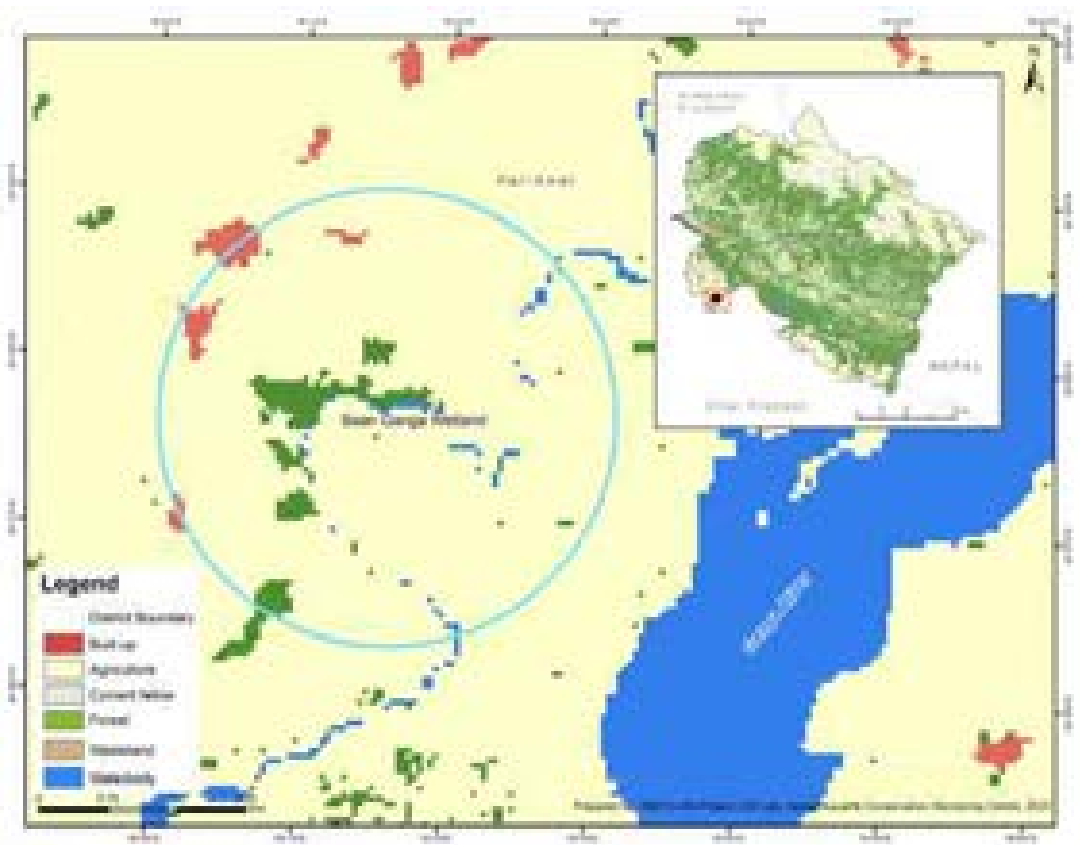


Figure 3.11. Land Use and Land Cover Map of Baan Ganga Wetland

A total of 25 individuals of 14 water and water-associated bird species were recorded from the Baan Ganga Wetland, belonging to 5 orders, 6 families, and 10 genera in three sampling points during one occasion with a total effort of 1.66 hrs. Pelecaniformes (5 species) was the most dominant order, followed by Charadriiformes (4 sp.), Coraciiformes (3 sp.), and Suliformes and Gruiformes, with only one species (Figure 3.12a).

Ardeidae (5 species) was the most dominant family, followed by Alcedinidae (3 sp.), Charadriidae, and Laridae (both 2 sp.). Rallidae and Phalacrocoracidae were the least abundant, with only one species (Figure 3.12b). Out of 14 recorded species, one species, the river tern (*Sterna aurantia*), was vulnerable (VU), and one species river lapwing, was NT on the IUCN Red List.

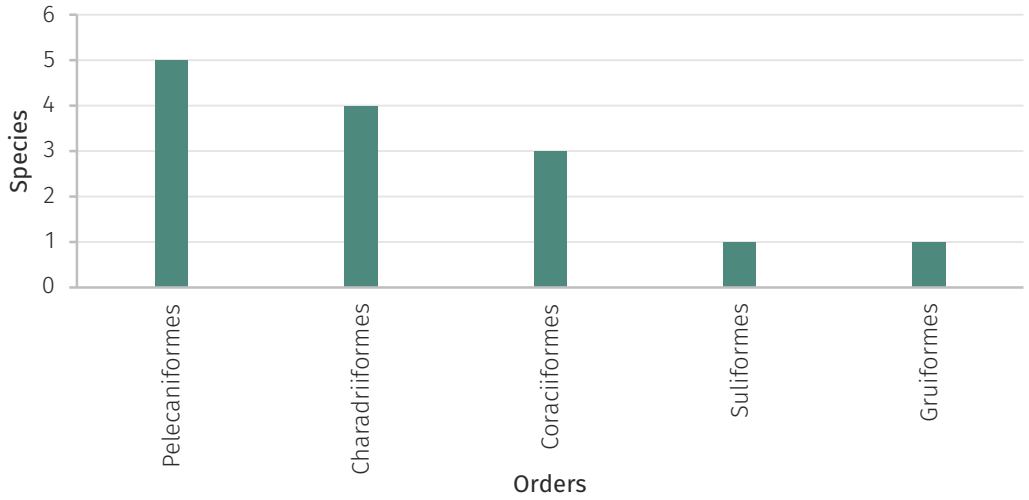


Figure 3.12a. Order-wise composition of species recorded in Baan Ganga Wetland

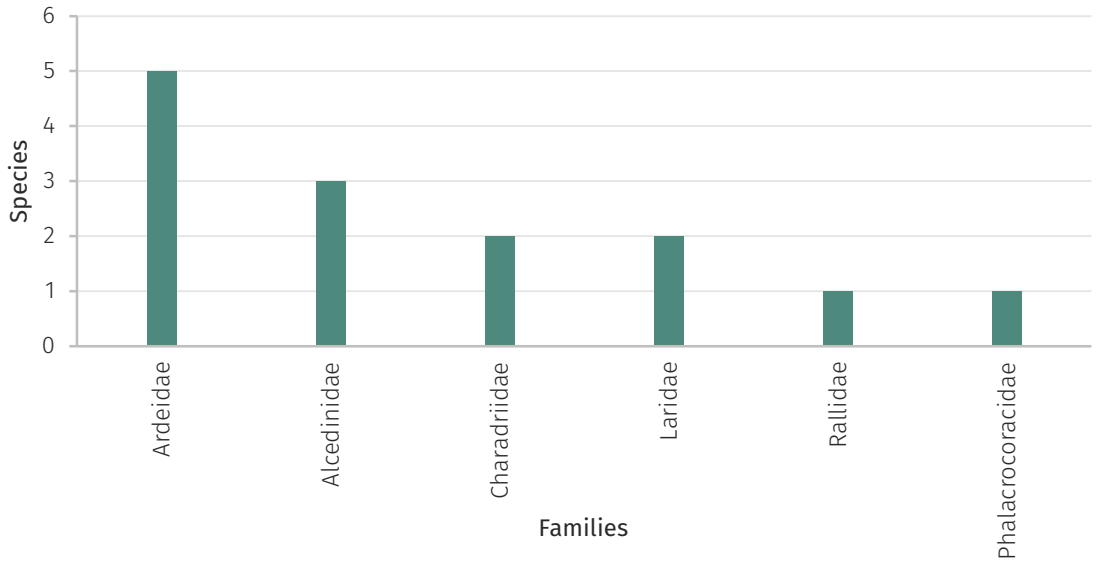


Figure 3.12b. Family-wise composition of species recorded in Baan Ganga Wetland

Richness and Diversity

Of three sampling points, the overall species richness of water and water-associated species was found to be highest in point 1 and point 2 (both 7 species), followed by point 2 (5 sp.) (Figure 3.13). Overall species diversity was highest in point 1 (1.92), followed by point 3 (1.61) and point 2 (1.52) (Figure 3.13).

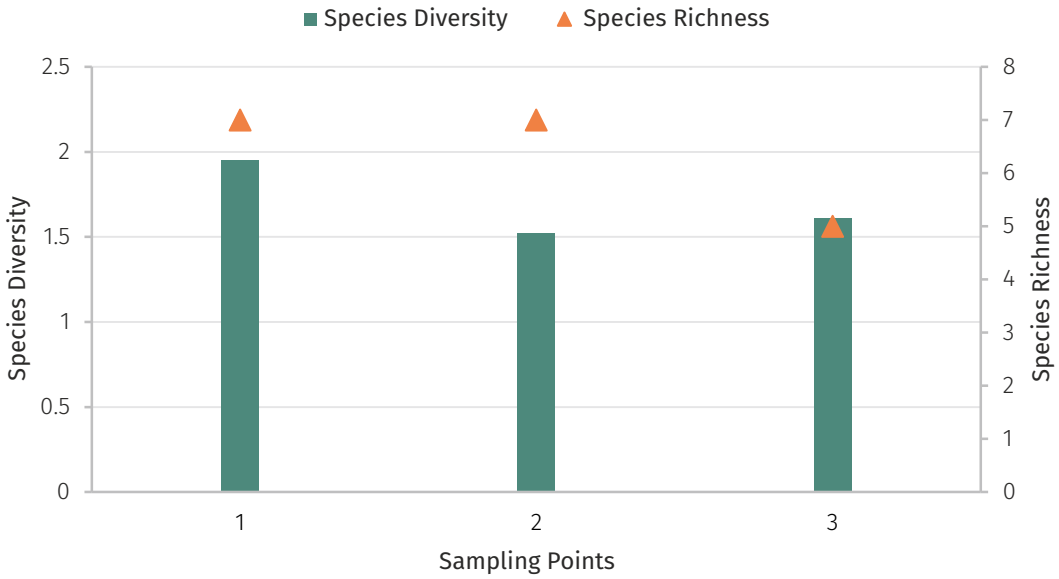


Figure 3.13. Species richness and diversity (H') of water and water-associated birds in the Baan Ganga Wetland

Waterbirds

Of the 14 species recorded during the survey, 11 species (78.57%) were waterbirds. The richness of waterbird species was the same in all three sampling points (5 species). Overall, waterbird diversity was highest in points 1 and 3 (1.61), followed by point 2 (1.16).

Water-associated Birds

Only 3 species out of 14 species (21.43%) were identified as water-associated species with low diversity value ($H' < 1$). The species richness (2 species) and diversity (0.69) were found to be similar at points 1 and 2, while point 3 had no species.

Relative abundance

In terms of the combined relative abundance of water and water-associated species, the little cormorant (*Microcarbo niger*) (32%) was recorded as the most abundant species, followed by white-throated kingfisher, Indian pond-heron (*Ardeola grayii*), intermediate egret, and little egret (*Egretta garzetta*) (8%). Point 2 (52%) was recorded as the most abundant sampling point, followed by point 1 (28%) and point 3 (20%).

Waterbirds

Of the 11 waterbird species, the little cormorant (38.1%) was found to be the most abundant species, followed by Indian pond heron, intermediate egret, and little egret (9.52%). Point 2 (52.38%) was recorded as the most abundant sampling point, followed by points 1 and 3 (23.81%).

Water-associated Birds

Of the three water-associated species, the white-throated kingfisher (50%) was the most abundant species, followed by the pied kingfisher and common kingfisher (25%). Points 1 and 2 (50%) had equal relative abundance of water-associated species, while no species were found in point 3.

Feeding Guild and Residential status

Only two feeding guilds were recorded in the Baan Ganga wetland, Carnivore (93%, 13 species) and Omnivore (7%, 1 sp.) (Figure 3.14). In terms of residential status, most of the species (57%, 8 species) belonged to R/LM, followed by R (29%, 4 sp.), and WM and R/WM (7%, 1 sp.).

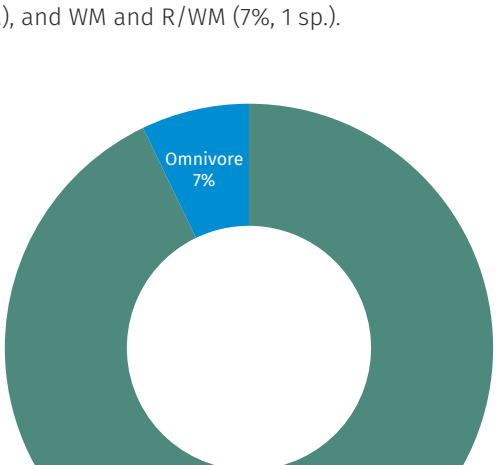


Figure 3.14. Proportion of the different Feeding Guilds of the water and water-associated birds in the Baan Ganga Wetland

Physio-chemical properties and anthropogenic stressors

The average pH value of the waterbody was measured as 7.8±0.1 and salinity as 0.3 ppt. Mean air temperature during sampling hours was 16.66 °C ±0.57, and water temperature was 15.06 °C ±0.92. The Baan Ganga wetland is surrounded by agriculture. Anthropogenic pressures in terms of fishing, agriculture were found to predominate in and around the wetland. Out of three monitoring points, fishing activity was noted at point no. 1 and was being practiced via gillnet. The wetland is devoid of any industrial outlet, powerlines, and mining activity in and around its vicinity. Washing/Bathing activities were found at point no. 2. However, no litter was found in the water, especially polythene or thermocol. Grazing pressure was high in all sampling points. No floating macrophyte was recorded in the sampled area. Points 1 and 2 were infested (<20%) with invasive species such as *Pontederia crassipes* and *Parthenium* spp., respectively. This stream necessitates earnest management heed to avoid irreversible loss of its water regime and wetland area.

3.1.2. UTTAR PRADESH

Uttar Pradesh is one of the most populous and largest states of India. Most of its wetlands are located in the floodplains of the Ganga and its tributaries. The state falls in the three biogeographic zones (4-Semi Arid, 6-Deccan Peninsula and 7-Gangetic Plain) and four biogeographic provinces (4A- Punjab Plain, 4B-Gujarat Rajputana, 6A-Central Highlands, 6B-Chota Nagpur and 7A- Upper Gangetic Plain) (Rodgers et al. 2000). The state consists of some of the key aquatic protected areas that harbor a diverse range of flora and fauna. In Uttar Pradesh, a total of 307778 wetlands collectively cover an area of approximately 9900.453 sq. km. Among these, tanks/ponds are the highest in number, accounting for 287584, followed by river/streams, which are 4312 in number and 3915 of waterlogged (inland) wetlands (Gupta et al. 2024). There are 31 IBAs and 10 Ramsar sites in the state to date (Rahmani et al. 2016; RAMSAR 2025). Many of these wetlands provide ideal habitats for winter and summer migrant waterbirds.

Studies on wetlands across the Ganga River basin highlight their multifaceted significance in maintaining ecological balance, supporting biodiversity and sustaining human livelihoods. A recent study by Joshi et al. (2024) observed a total of 126 bird species, of which 70 species were waterbirds in the Saman wetland complex in Uttar Pradesh. In the same region, Jha and Mckinley (2015) studied 12 wetlands across Uttar Pradesh and found that several managed wetlands, including Bakhira, Patna, Saman and Vijay Sagar, were experiencing agricultural pressures. In contrast, at Sarsai Nawar- a wetland categorized as unmanaged- cultivation of water chestnut was noted, which adversely affected bird habitats. When compared to Vijaysagar, the nine natural wetlands (Sandi, Samaspur, Lakh Bahosi, Patna, Nawabganj, Bakhira, Saman, Parvati Arga, and Sarsai Nawar) supported a higher diversity of bird species both overall and within aquatic bird communities. For the present study, Haiderpur, Surajpur, Bakhira and Gorakhpur Zoo wetlands were identified and were surveyed during December- February, 2024-25 (Figure 3.15).

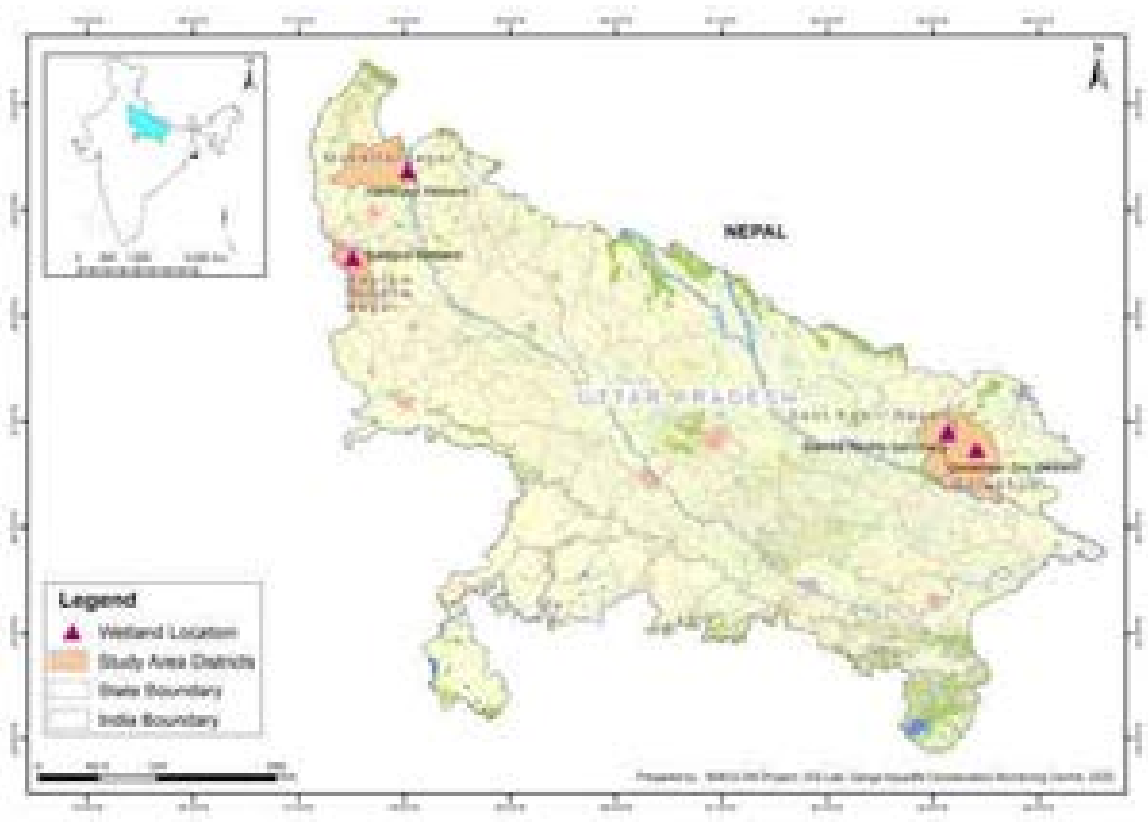


Figure 3.15. Map showing location of select wetlands of Uttar Pradesh

Altogether, 81 water and water-associated bird species were recorded from the selected wetlands of Uttar Pradesh, of which 65 represented waterbird and 16 water-associated bird species (Annexure 1). Of the 81 species, four were VU, and six species were in the NT category as per the IUCN Red List. Among the four

surveyed wetlands of Uttar Pradesh, Surajpur wetland was found to be the most diverse wetland in terms of water and water-associated bird species. The highest species diversity value was recorded in Surajpur wetland (2.23±0.40), followed by Haiderpur (2.06±0.41), Bakhira WLS (1.49±0.84) and Gorakhpur Zoo wetland (1.32±0.90) (Figure 3.16).

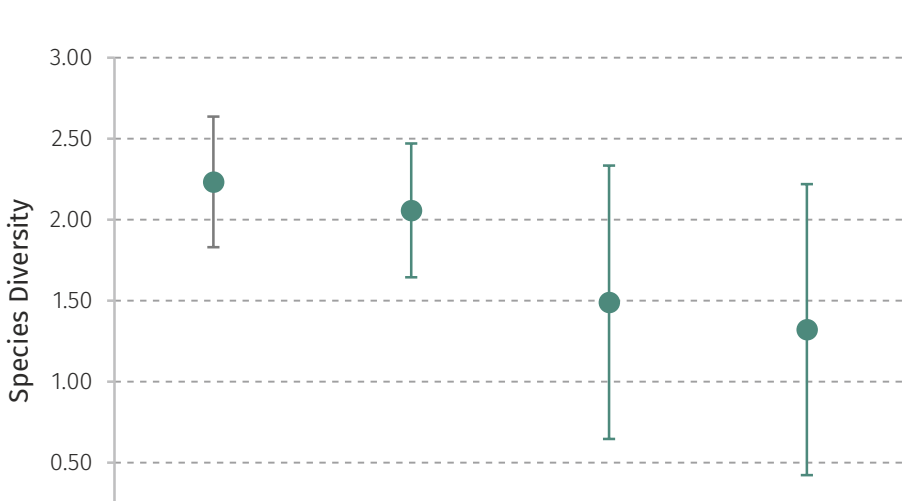


Figure 3.16. Average species diversity (*H'* mean ±SD) of water and water-associated birds in the surveyed wetlands of Uttar Pradesh

1. HAIDERPUR WETLAND

The Haiderpur wetland is part of the Hastinapur Wildlife Sanctuary with a mean elevation of 240 m asl (29°22'35"N, 78°02'02"E), also designated as one of the key Ramsar sites and IBAs in the state of Uttar Pradesh (Figure 3.17). It is a man-made wetland formed in 1984 on the Ganga River, due to the construction of the Madhya Ganga barrage. The wetland spread over the Bijnor and Muzaffarnagar districts covers an area of 69 sq. km. The wetland falls within the 7-Gangetic Plain biogeographic zone and 7A-Upper Gangetic Plain biogeographic province (Rodgers et al. 2000). Haiderpur provides habitat for ~100 waterbird species as well as some of the other endangered species like gharial and swamp deer (Barasingha). The wetland is also critical for species like black-bellied tern (*Sterna acuticauda*), Indian skimmer (*Rynchops albicollis*), steppe eagle, and several other migratory waterbird species.

About nine villages are situated in the periphery of the wetland, namely Nizampur, Katiya, Kailashpur Jasmor urf Deval, Ujaili Khurd Ahetmali- urf Jeewanpur, Jarwar, and Kashampur Khola in the Muzaffarnagar district. Nawalpur, Rafiul Nagar urf Rawali, and Amirpur Das urf Dharam Nagri, are in the Bijnor district. According to the Census of India (2011), these villages have 3,957 households with a total population of 23,026. The combined sex ratio across the nine villages is 878 females per 1,000 males, with a literacy rate of 67% for the age group above six years. The predominant occupation of these villagers is daily wage labour (63.1%), followed by agriculture (18.7%) and fishing (8.1%). Local communities use wetlands and peripheral waterbodies for water chestnut cultivation, fisheries, fuelwood and fodder extraction, and cattle grazing. Additionally, they craft rope, baskets, mats, and thatching from floodplain grasses, including kans (*Saccharum spontaneum*), munj (*Saccharum bengalense*), and typha (*Typha angustata*). Of the 82 households surveyed, 14.6% depend on wetlands for fuelwood, 18.2% for fodder, and 9.7% for fish. The highest level of fish extraction was recorded from Nawalpur, while the Nizampur and Deval villages reported the maximum fuelwood extraction (WII-GACMC 2022). Eight points were selected for studying the waterbird congregation in the Haiderpur wetland.

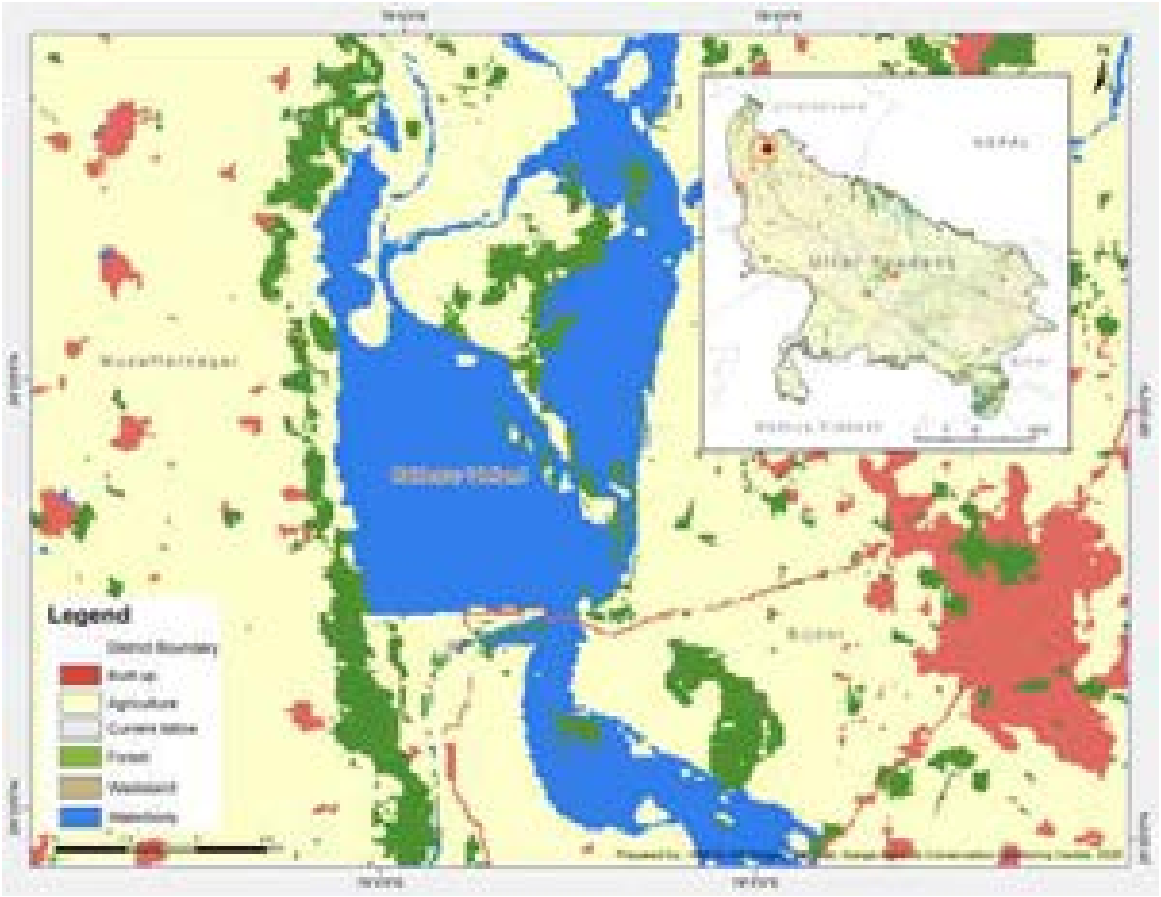


Figure 3.17. Land Use and Land Cover Map of the Haiderpur Wetland, Uttar Pradesh

During the survey, 23919 individuals of 62 water and water-associated bird species were recorded from the Haiderpur wetland, belonging to 10 orders, 20 families, and 47 genera in eight sampling points during three occasions (total effort of 13.14 hrs). Anseriformes and Charadriiformes (14 species) were the most dominant orders, followed by Pelecaniformes (12 sp.) and Gruiformes (5 sp.) (Figure 3.18a). Anatidae (14 species) was the most dominant family, followed by Ardeidae (9 sp.) and Scolopacidae (5 sp.) (Figure 3.18b). Alcedinidae, Anhingidae, Gruidae, Hirundinidae, Meropidae, Pandionidae, and Recurvirostridae were the least abundant families, with only one species. Of the 62 recorded species, four were in the VU and five species were in the NT categories of the IUCN Red List (Table 3.1.).

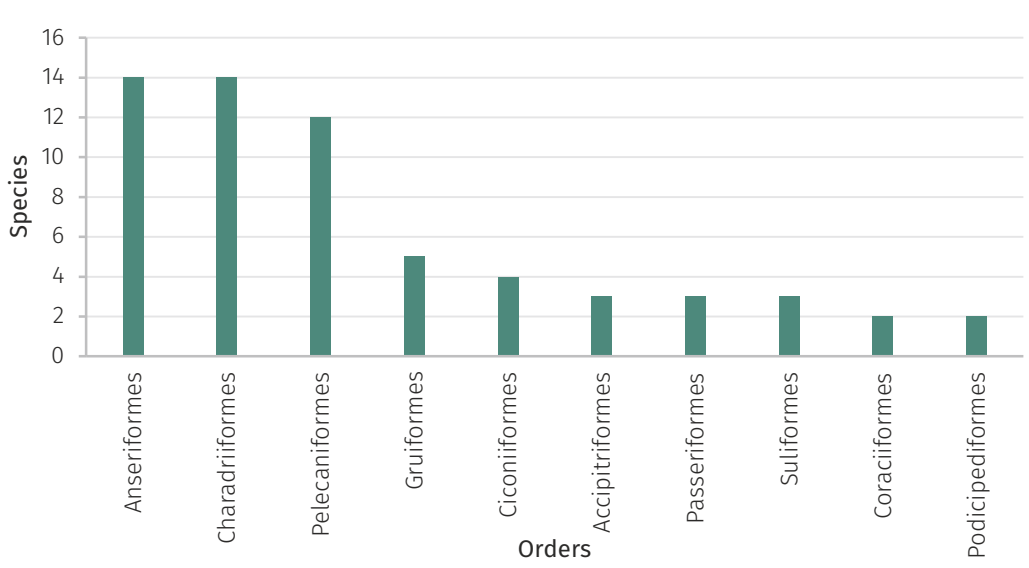


Figure 3.18a. Order-wise composition of species recorded in the Haiderpur Wetland

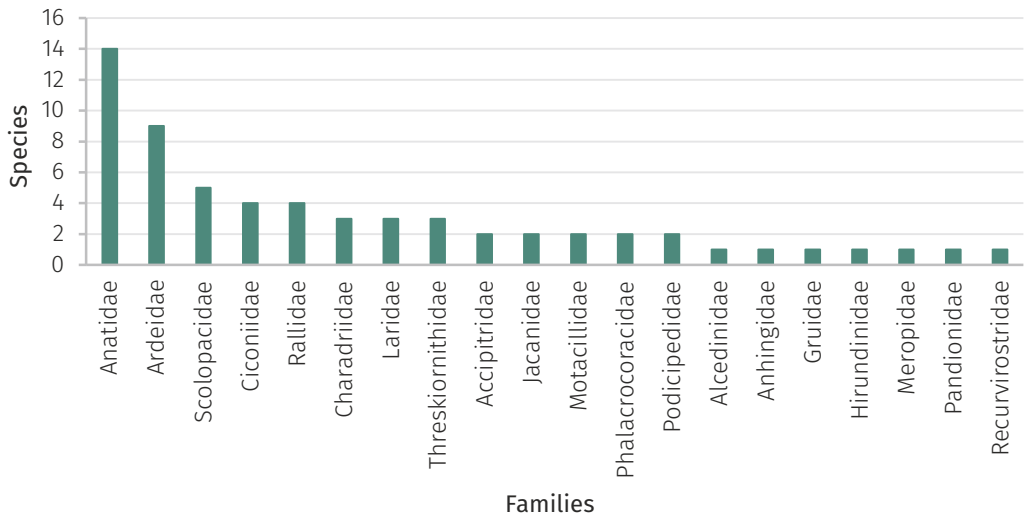


Figure 3.18b. Family-wise composition of species recorded in the Haiderpur Wetland

Table 3.1. Globally threatened species recorded from the Haiderpur Wetland

Order	Family	English Name	Scientific Name	IUCN	IWPA
Anseriformes	Anatidae	Common Pochard	*Aythya ferina* (Linnaeus, 1758)	VU	Sch.-I
Gruiformes	Gruidae	Sarus Crane	*Antigone antigone* (Linnaeus, 1758)	VU	Sch.-I
Charadriiformes	Laridae	River Tern	*Sterna aurantia* Gray, 1831	VU	Sch.-I
Accipitriformes	Accipitridae	Greater Spotted Eagle	*Clanga clanga* (Pallas, 1811)	VU	Sch.-I
Anseriformes	Anatidae	Ferruginous Duck	*Aythya nyroca* (Güldenstädt, 1770)	NT	Sch.-II
Charadriiformes	Charadriidae	River Lapwing	*Vanellus duvaucelii* (Lesson, 1826)	NT	Sch.-II
Charadriiformes	Scolopacidae	Black-tailed Godwit	*Limosa limosa* (Linnaeus, 1758)	NT	Sch.-II
Ciconiiformes	Ciconiidae	Asian Woolly-necked Stork	*Ciconia episcopus* (Boddaert, 1783)	NT	Sch.-II
Ciconiiformes	Ciconiidae	Black-necked Stork	*Ephippiorhynchus asiaticus* (Latham, 1790)	NT	Sch.-II

Richness and Diversity

Of eight sampling points, the overall species richness of water and water-associated species was highest for point 1 (44 species), followed by point 4 (31 sp.) and point 2 (30 sp.) (Figure 3.16). Overall species diversity value was highest for point 2 (2.70), followed by point 1 (2.52) and point 8 (2.31) (Figure 3.19).

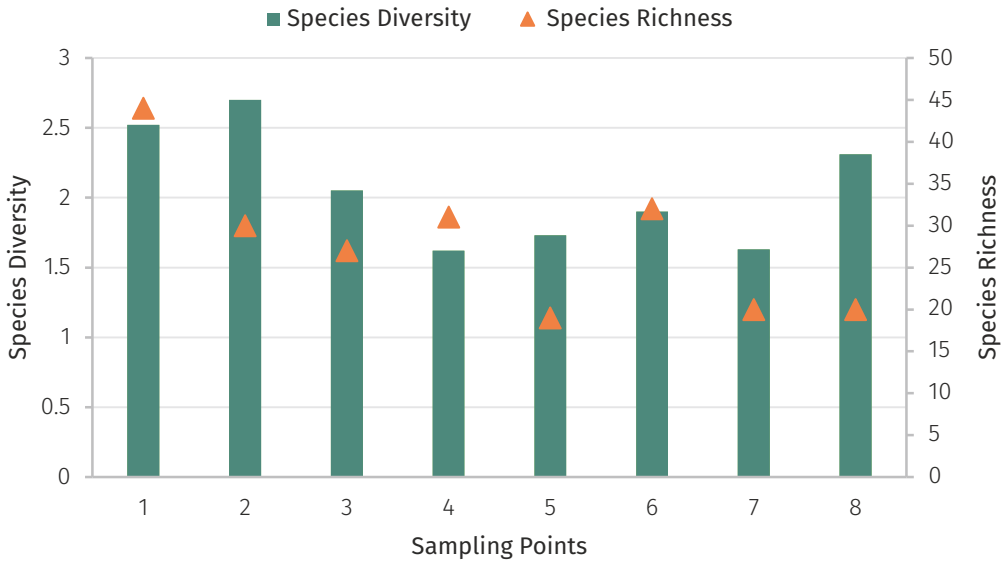


Figure 3.19 Species richness and diversity (*H'*) of water and water-associated birds in the Haiderpur Wetland

Waterbirds

Of the 62 species recorded during the survey, 54 species (87.10%) were waterbirds. The highest richness of waterbird species was recorded in point 1 (42 species), followed by point 4 and point 6 (both 29 sp.), and point 2 (28 sp.). Overall waterbird diversity was highest in point 2 (2.61), followed by point 1 (2.51) and point 8 (2.26).

Water-associated Birds

Only 8 out of 62 species (12.90%) were water-associated species. The highest species richness of water-associated birds was recorded for point 7 (4 species), followed by points 5 and 6 (3 sp.). Whereas, only one species was recorded for points 3 and 8. The highest species diversity value was found in point 5 (1.01), followed by point 6 (0.99) and point 7 (0.74).

Relative abundance

In terms of the combined relative abundance of water and water-associated species, the gadwall (18.99%) was found to be the most abundant species, followed by Eurasian coot (16.94%) and northern pintail (*Anas acuta*) (12.54%), while green sandpiper (*Tringa ochropus*), great-crested grebe (*Podiceps cristatus*), little grebe (*Tachybaptus ruficollis*), and black-necked stork (*Ephippiorhynchus asiaticus*) (0.004%) were the least abundant. Point 5 (37.20%) had the highest abundance, followed by point 1 (25.93%) and point 6 (23.15%), while point 2 (0.80%) was the least abundant.

Waterbirds

Out of the 54 waterbird species, the gadwall (19.06%) was the most abundant species, followed by Eurasian coot (17%) and northern pintail (12.59%), while green sandpiper, great-crested grebe, little grebe, and black-necked stork (0.004%) were the least abundant. Point 5 (37.31%) was recorded as the most abundant point, followed by point 1 (26%) and point 6 (23.14%), while point 2 (0.74%) was the least abundant.

Water-associated Birds

Out of the 11 water-associated species, the grey wagtail (30.10%) was the most abundant species, followed by the grey-throated martin (28.90%) and blue-tailed bee-eater (*Merops philippinus*) (14.50%). In contrast, greater spotted eagle (*Clanga clanga*) and western marsh harrier (*Circus aeruginosus*) (2.41%) were the least abundant species. Point 7 (31.33%) was the highest abundant sampling point, followed by point 6 (25.30%) and point 2 (19.28%), while point 3 (1.20%) was the least abundant.

Feeding Guild and Residential Status

Overall, Carnivore (56.45%, 35 species) was the most dominant feeding guild, followed by Herbivore/Carnivore (20.97%, 13 sp.) and Carnivore/Herbivore (9.68%, 6 sp.), while herbivore and insectivore (3.23%, 2 sp.) were the least dominant (Figure 3.20). Out of 62 species, residential status was dominated by R/LM (34%, 21 species) group, followed by WM (24%, 15 sp.), R/WM (21%, 13 sp.) and R (11%, 7 sp.). Anatidae was the major family of waterbirds that dominated WM group.

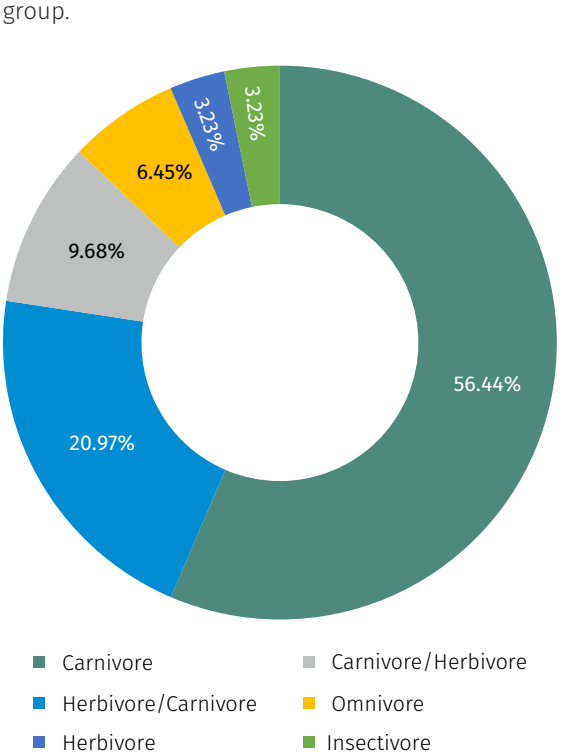


Figure 3.20 Proportion of the different Feeding Guilds of the water and water-associated birds in the Haiderpur Wetland

Physio-chemical properties and anthropogenic stressors

The average pH value of the Haiderpur wetland was measured as 6.79 ±0.91, and salinity was recorded as 0.09 ppt ±0.04. The mean air temperature during the sampling was recorded as 28.24 °C ±3.31, and water temperature was 24.03 °C ±1.83. Conductivity of water was measured as 139.29 ms/cm ±64.41, and TDS value as 83 ±38.33mg/L. No litter or solid waste was found in the sampled wetland area. In two out of eight sampling points, agriculture practice was active (7 and 8), while fishing was prominent in all sampling points. Biomass extraction was found to be an occasional practice in the wetland. Vegetation cover was found in < 20% of all sampling areas. Water connectivity and hydrology of the wetland depend on the functioning of the barrage, which is under the jurisdiction of the irrigation department. Drainage, storm outlets, extraction pumps, electric power lines, mining and washing/bathing were absent in and around the sampling points. Grazing was recorded from three sampling points (6-8), and six sampling points were infested with invasive species like *Pontederia crassipes*, covering up to 50% of the sampling areas.

2. SURAJPUR WETLAND

Surajpur wetland, located in Gautam Budh Nagar district of Uttar Pradesh (28° 31' 42'' N, 77° 29' 71'' E), is an urban wetland covering 3.08 sq. km near the Hindon River (Figure 3.21). It is designated as one of the IBAs in the state of Uttar Pradesh. The Surajpur is a freshwater swampy wetland located at an elevation of 215 m asl surrounded by urban and agricultural areas. It provides habitat to around 95 waterbird species (Ansari 2017). Northern shoveler, northern pintail (*Anas acuta*), ruddy shelduck, Eurasian wigeon and common teal Anas crecca are some of the key migrant waterbird species of this wetland.

The wetland is situated near Surajpur village in Dadri Tehsil and also falls within the Delhi–National Capital Region of India. Over the last few years, this area has witnessed rapid urban development. The Greater Noida City, the largest industrial township in Asia, is about three km away from the wetland (Ansari et al. 2016). As per the census 2011, Noida city has a total household of more than 153,474 with a population of 637,272 and a sex ratio of 824 females per 1,000 males. The literacy rate for the city is 86% (male 91%, female 81%). Five points were selected for studying the waterbird congregation in Surajpur.

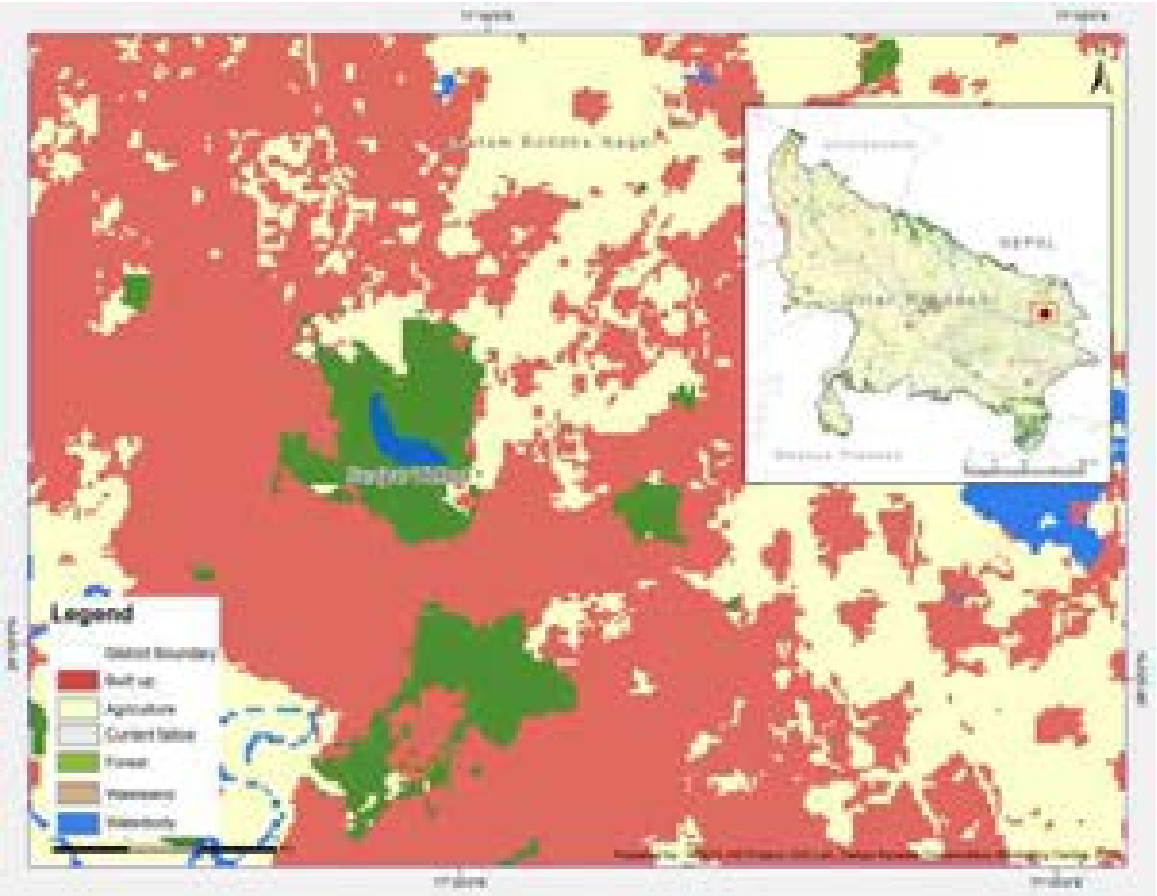


Figure 3.21 Land Use and Land Cover Map of the Surajpur Wetland, Uttar Pradesh

During the present survey, altogether 3298 individuals of 48 water and water-associated bird species were recorded from the Surajpur wetland, belonging to 10 orders, 16 families, and 35 genera in five sampling points during eight occasions (Total effort of 29.65 hrs). Anseriformes (12 species) was the most dominant order, followed by Charadriiformes (10 sp.) and Pelecaniformes (9 sp.) (Figure 3.22a). Anatidae (12 species) was the most dominant family, followed by Ardeidae (7 sp.), Motacillidae, Rallidae, and Scolopacidae (4 sp.) (Figure 3.22b). Out of 48 recorded species, one species, the common pochard, was VU, and two species, the black-tailed godwit (*Limosa limosa*) and the Asian woolly-necked stork, were in the NT categories of the IUCN Red List.

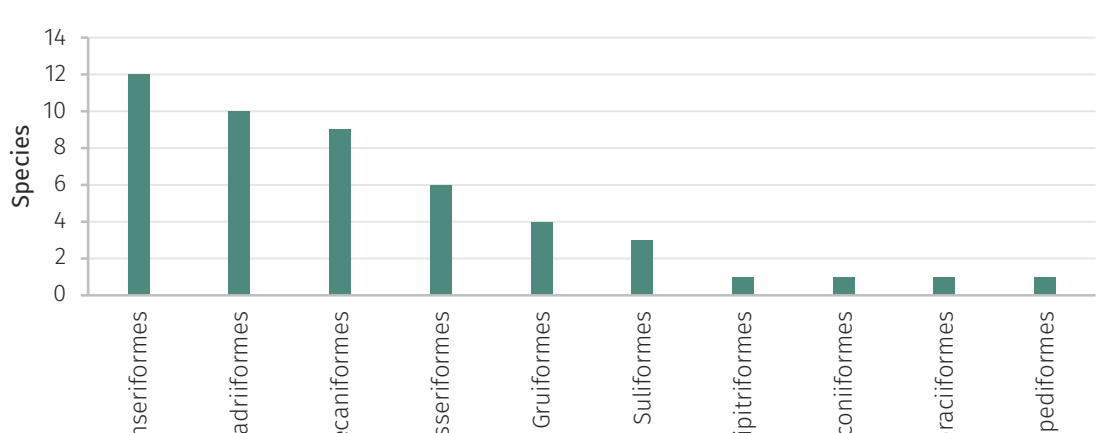


Figure 3.22a. Order-wise composition of species recorded in the Surajpur Wetland

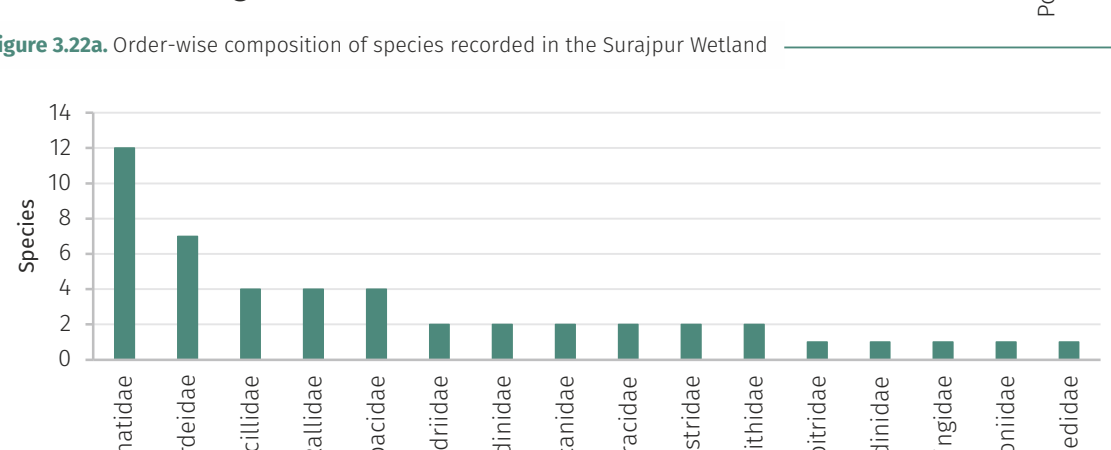


Figure 3.22b. Family-wise composition of species recorded in the Surajpur Wetland

Richness and Diversity

Of five sampling points, the overall species richness of water and water-associated species was found to be highest in point 2 (34 species), followed by point 3 (30 sp.) and point 1 (23 sp.) (Figure 3.23). Overall species diversity value was found to be highest in point 3 (2.58), followed by point 1 (2.53), and point 4 (2.27) (Figure 3.23).

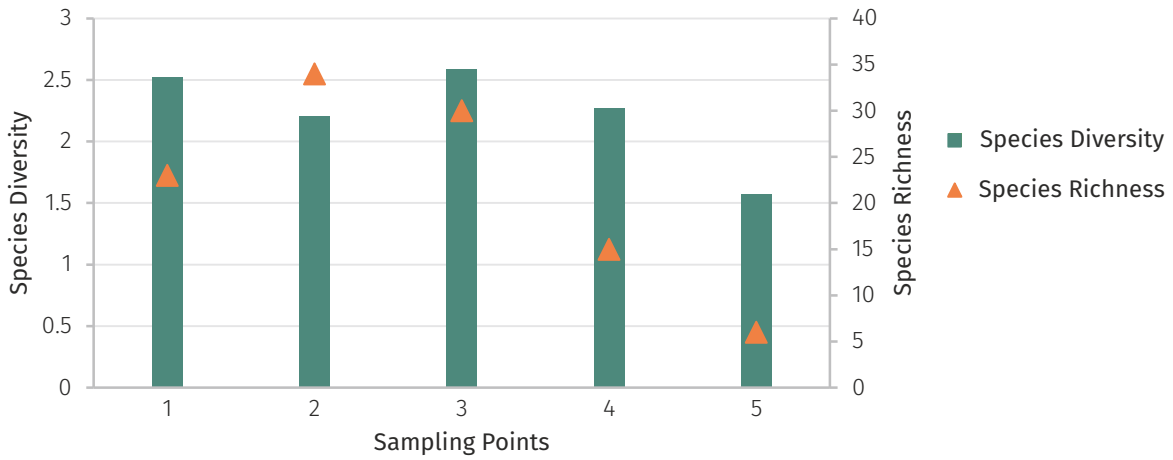


Figure 3.23 Species richness and diversity (*H'*) of water and water-associated birds in the Surajpur Wetland

Waterbirds

Of the 48 species recorded during the survey, 40 species (83.33%) were waterbirds. The highest species richness of waterbirds was recorded in point 2 (31 species), followed by point 3 (27 sp.) and point 1 (17 species). Overall waterbird diversity was highest in point 3 (2.54), followed by point 1 (2.31) and point 2 (2.20).

Water-associated Birds

Only eight out of 48 species (16.67%) were identified as water-associated species. The highest species richness of water-associated birds was at point 2 (31 species), followed by point 3 (27 sp.) and point 1 (17 sp.). The highest species diversity value was found in point 3 (2.54), followed by point 1 (2.31) and point 2 (2.20).

Relative abundance

In terms of the combined relative abundance of water and water-associated species, the greylag goose (*Anser anser*) (24.20%) was the most abundant, followed by bar-headed goose (*Anser indicus*) (17.07%) and northern shoveler (13.40%), while Asian woolly-necked stork and oriental darter (*Anhinga melanogaster*) (0.03%) were the least abundant. Point 2 (54.58%) was the most abundant, followed by point 3 (20.62%) and point 1 (19.19%), while point 5 (0.64%) was the least abundant.

Waterbirds

Among the waterbirds, the greylag goose (24.82%) was found to be the most abundant species, followed by bar-headed goose (17.51%) and northern shoveler (13.75%), while Asian woolly-necked stork and oriental darter (0.03%) were the least abundant. Point 2 (55.86%) was recorded as the most abundant, followed by point 3 (20.90%) and point 1 (18.20%), while point 5 (0.44%) was the least abundant.

Water-associated Birds

Out of the 11 water-associated species, the grey-throated martin (22.89%) was the most abundant species, followed by the barn swallow and citrine wagtail (*Motacilla citreola*) (14.46%). In contrast, the grey wagtail (2.41%) was the least abundant species. Point 1 (57.83%) was the highest abundant point, followed by point 4 (19.28%) and point 5 (8.43%).

Feeding Guild and Residential Status

Overall, Carnivore (54.17%, 26 species) was the most dominant feeding guild, followed by Herbivore/Carnivore (20.83%, 10 species) and Carnivore/Herbivore (8.33%, 4 sp.), while Insectivore (4.17%, 2 sp.) was the least dominant guild (Figure 3.24). Out of 48 species, 16 species (33%) belonged to R/LM, 12 species (25%) to WM, 9 species (19%) to R/WM, 3 species (6%) to R, two species (4%) each to R/WM/AM and R/WM/AM, and one species (2%) each to four residential groups (R/AM, R/LM/SM, R/WM/AM/PM and R/WM/LM).

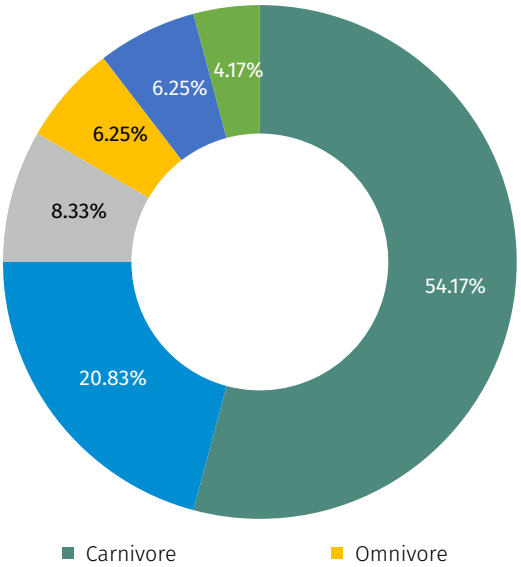


Figure 3.24 Proportion of the different Feeding Guilds of the water and water-associated birds in the Surajpur Wetland

Physio-chemical properties and anthropogenic stressors

The Surajpur wetland is an urban wetland with a mean pH value of 7.96 ± 0.26 and a salinity value of 0.16 ppt ± 0.05. The average air temperature was recorded as 19 °C ±1.41, and water temperature was slightly less (17.62 °C ±0.89). The wetland did not exhibit any signs of litter, agriculture, fishing activity, or vegetation/biomass extraction. Storm outlets, extraction pumps, electric power lines, mining, and washing/bathing were also not found in and around the wetland. Local authorities had cleared vegetation from the wetland before the sampling period. Hydrological connectivity to water sources remains intact in the wetland. The grazing activities were found active in <25% of sampling areas. Water quality remains an issue, as evidenced by a pungent smell and brownish water colour, indicating the inflow of industrial waste at sampling point 2 and other sources from the upstream. Floating vegetation represented by invasive species, *Pontederia crassipes,* covered 20 to 50% of all sampling points.

3. BAKHIRA WILDLIFE SANCTUARY

Bakhira is a natural floodplain wetland in the Sant Kabir Nagar district of Uttar Pradesh. It is a designated IBA and Ramsar site covering an area of 28.94 sq. km. The sanctuary established in 1990, lies between 26.30' N, 82.17' E and 27.30' N, 83.30' E with a mean elevation of 96 m asl (Figure 3.25). Bakhira falls within the 7-Gangetic Plain biogeographic zone and 7A-Upper Gangetic Plain biogeographic province (Rodgers et al. 2000). The wetland comprises revenue land, forest and agricultural land, and the wetland's lake forms a meandering connection to the Rapti River. The sanctuary hosts many winter migrants, including red-crested pochard, northern pintail, and northern shoveler, and also harbours 100-200 individuals of sarus crane (Rahmani et al. 2016).

There are 108 villages within a five km radius of the wetland, and 11 villages—viz., Badgo, Sanichara, Mahala, Narangpatti, Sonbarsa, Ghurapali, Govindpur, Jasawal, Nawapar, Jhumia, and Newas are found to be fully or partially dependent on the wetland (Johnson et al. 2021). Of the 320 households surveyed across 11 villages, 54% relied on fishing, while 46% dependent on agriculture as well as the collection of lotus, grass and fodder from the wetland (Johnson et al. 2021). Such high dependency imposes significant pressure on the wetland habitat. The high dependence on the Bakhira wetland for sustenance exacerbates management challenges for authorities.

Eleven points were selected for studying the waterbird congregation in the Bakhira WLS.

Figure 3.25 Land Use and Land Cover Map of Bakhira Wildlife Sanctuary, Uttar Pradesh

A total of 1300 individuals of 44 water and water-associated bird species were recorded from the Bakhira, belonging to 11 orders, 17 families, and 35 genera in eleven sampling points during 13 occasions (total effort of 23.13 hrs). Charadriiformes (11 species) was the most dominant order, followed by Pelecaniformes (10 sp.), Anseriformes, and Gruiformes (5 sp.) (Figure 3.26a). Ardeidae (7 species) was the most dominant family, followed by Anatidae (5 sp.), Rallidae, and Scolopacidae (4 sp.) (Figure 3.26b). As per the IUCN Red List, the sarus crane (*Antigone antigone*) is listed as VU, and the lesser adjutant (*Leptoptilos javanicus*) is listed as NT.

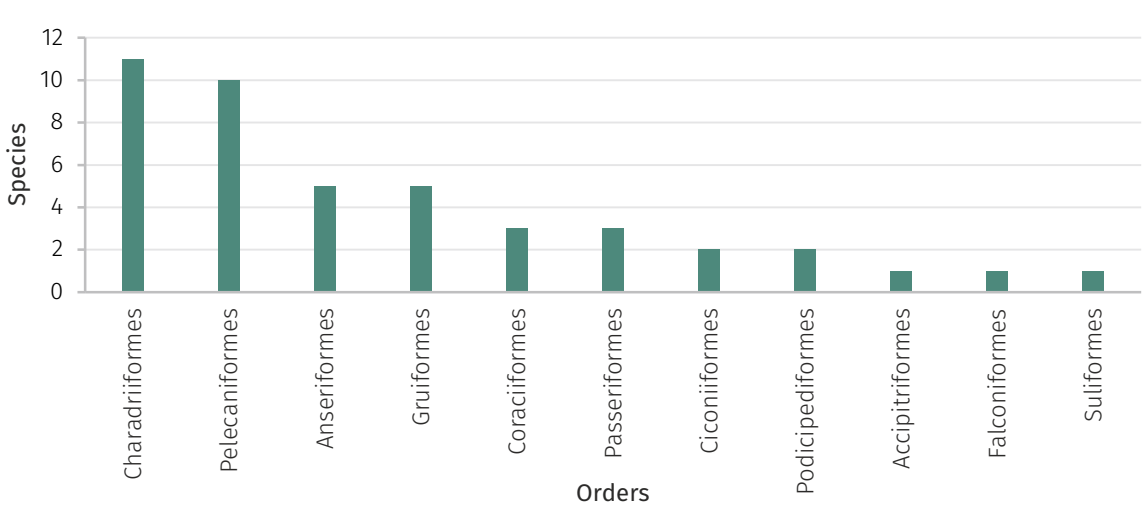


Figure 3.26a. Order-wise composition of species recorded in the Bakhira Wildlife Sanctuary

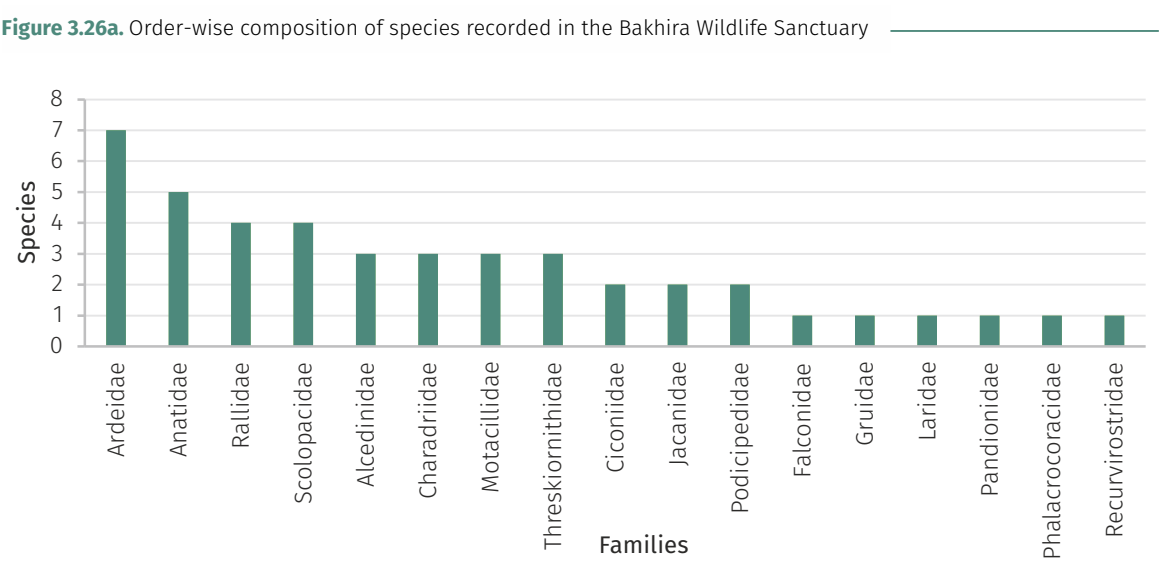


Figure 3.26b. Family-wise composition of species recorded in the Bakhira Wildlife Sanctuary

Richness and Diversity

Of 11 sampling points, the overall species richness of water and water-associated species was found to be highest in point 1 (27 species), followed by point 2 (22 sp.) and points 3 and 5 (19 sp.) (Figure 3.27). Overall species diversity was found to be highest in point 1 (2.33), followed by point 5 (2.25) and point 3 (2.15) (Figure 3.27). Whereas, points 8 and 9 had no species.

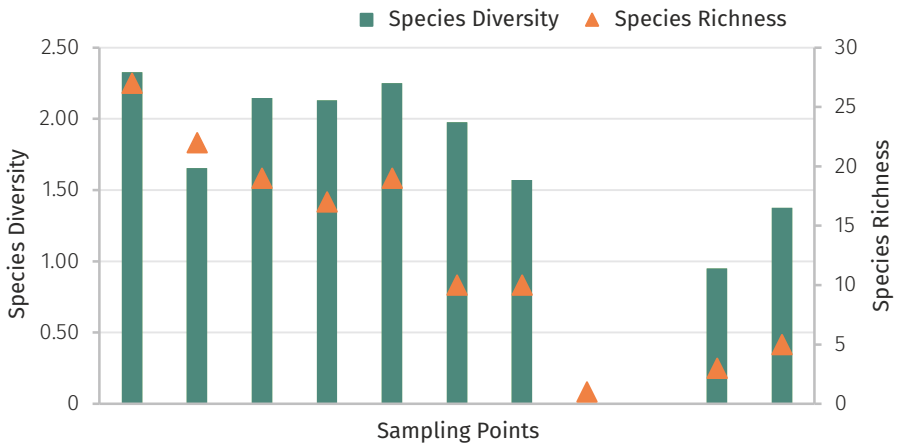


Figure 3.27. Species richness and diversity (*H'*) of water and water-associated birds in the Bakhira Wildlife Sanctuary

Waterbirds

Of the 44 species recorded during the survey, 36 species (81.82%) were waterbirds. The highest richness of waterbirds was recorded in point 1 (24 species), followed by point 2 (18 sp.) and points 3 and 5 (16 sp.). Overall waterbird diversity was highest in point 1 (2.24), followed by point 4 (2.18) and point 2 (2.07). Whereas, points 8 and 9 had no species.

Water-associated Birds

Only eight species out of 44 species (18.18%) were water-associated. The highest species richness of water-associated birds was in point 2 (4 species), followed by points 1, 3, and 5 (3 sp.). The highest species diversity value was found at point 2 (1.22), followed by point 5 (1.10) and point 1 (1.08). Whereas sampling points 7, 8, and 11 had only one species, and no species was found in points 8 and 9.

Relative abundance

In terms of the combined relative abundance (water and water-associated species), the red-crested pochard (16.69%) was recorded as the most abundant species, followed by eastern cattle egret (15.46%) and sarus crane (9.31%), while nine species (0.08%) were the least abundant. Point 1 (36%) was recorded to be the most abundant, followed by point 2 (18.31%) and point 4 (13.85%). Whereas point 9 had no species, and point 8 (0.08%) was the least abundant.

Waterbirds

Of the 36 waterbird species, the red-crested pochard (17.30%) was the most abundant, followed by eastern cattle egret (16.30%) and sarus crane (9.65%). In contrast, cotton pygmy-goose, yellow-wattled lapwing, whiskered tern, lesser adjutant, and black-headed ibis (0.08%) were least abundant. Point 2 (55.86%) was recorded as the most abundant point, followed by point 3 (20.90%) and point 1 (18.20%), while point 5 (0.44%) was the least abundant.

Water-associated Birds

Out of the 11 water-associated species, the white wagtail (*Motacilla alba*) (36.96%) was the most abundant, followed by citrine wagtail (23.91%) and white-throated kingfisher (21.74%). In contrast, osprey (*Pandion haliaetus*), common kingfisher, peregrine falcon (*Falco peregrinus*), and western yellow wagtail (*Motacilla flava*) (2.17%) were least abundant. Point 1 (26.09%) was recorded as the highest abundant sampling point, followed by point 2 (21.74%) and point 3 (15.22%).

Feeding Guild and Residential Status

Overall, Carnivore (65.91%, 29 species) was the dominant feeding guild, followed by herbivore/carnivore (20.45%, 9 sp.), while carnivore/herbivore and omnivore (6.82%, 3 sp.) were the least dominant (Figure 3.28). The Bakhira wetland was dominated by R/LM (41%, 18 species), followed by R/WM (18%, 8 species), and R and WM

(11%, 5 species). While the R/WM/PM group was represented by 3 species (7%), and five groups (R/AM, R/LM/SM, R/WM/AM, R/WM/LM, and R/WM/AM/PM) were represented by only one species (2%) each.

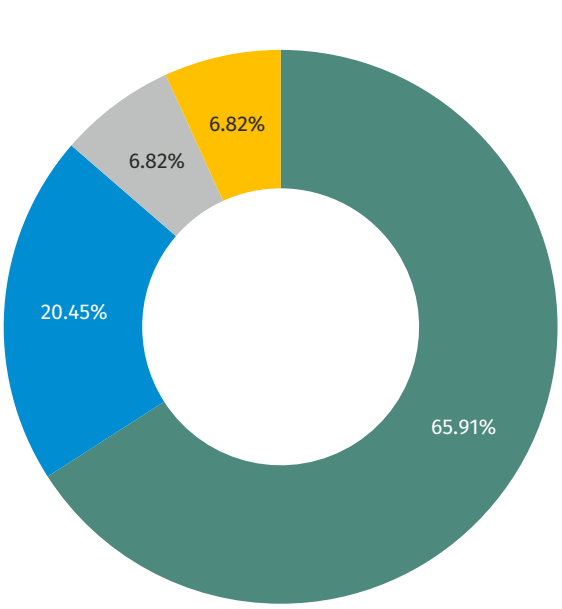
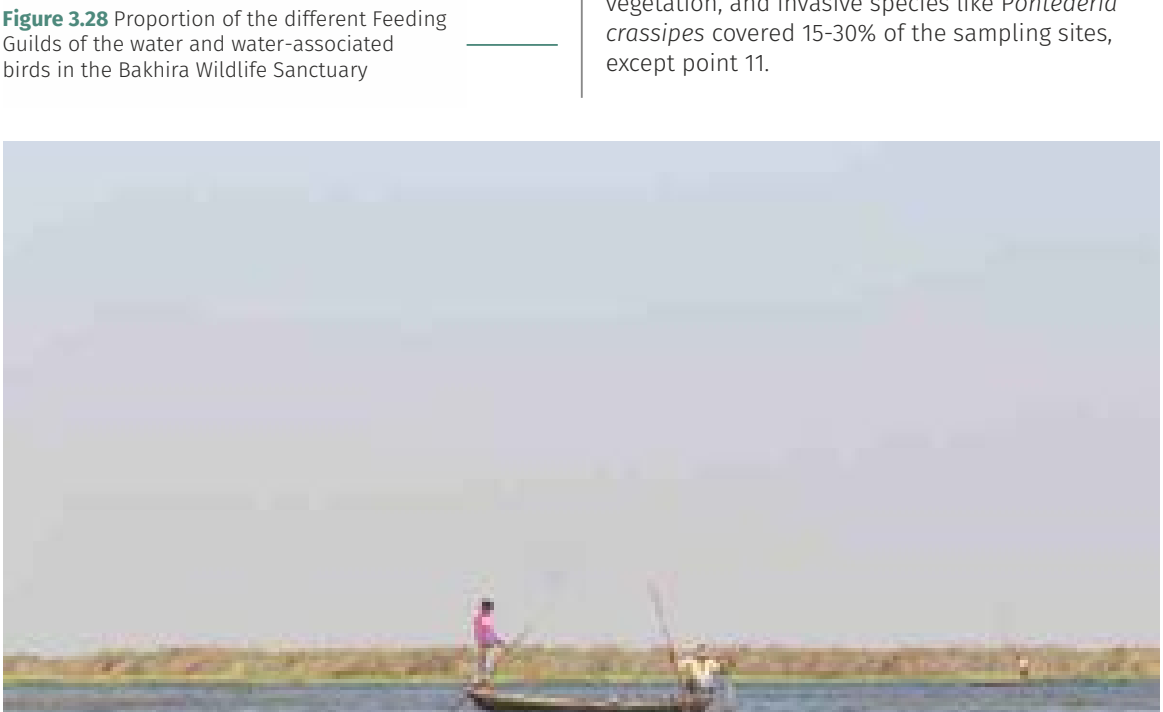


Figure 3.28 Proportion of the different Feeding Guilds of the water and water-associated birds in the Bakhira Wildlife Sanctuary

Physio-chemical properties and anthropogenic stressors

During the present survey, the average pH value of water was measured as 7.23 ±0.20 (6.86 - 7.51) and salinity as 0.14 ppt± 0.06 (0.1-0.3). The mean air temperature was recorded as 22.63 °C ± 1.80, and the mean water temperature was about 19.87 °C ±1.65. Litter was found only in and around three sampling points (2, 6, and 7). Agricultural practice was predominant in and around all 11 sampling points. Seven out of 11 sampling points (1 to 7) were prone to fishing activities using boats and gillnets for market sell and self-consumption. In addition, vegetation or biomass extraction was also found to be practised in all sampling sites of the Bakhira wetland. About half of the areas of all sampling sites were covered with vegetation (free floating and emergent). The hydrological regime and connectivity remain seasonal and are regulated by the existing barrage. Storm outlets were found in sampling point 7, and water pumps were present at most of the sampling points. There was no mining activity found in and around the Bakhira wetland. Washing/bathing activities were rare in the wetland, and the water was odourless and colourless. Grazing was prominent at all sampling points with high intensity. Most of the sampling points were covered with >50% of floating vegetation, and invasive species like P*ontederia crassipes* covered 15-30% of the sampling sites, except point 11.



4. GORAKHPUR ZOO WETLAND

Gorakhpur zoo wetland (26° 43' 17.28" N and 83° 24' 17.16" E) is a small artificial wetland (ca. 2 sq. km) inside the campus of Shaheed Ashfaq Ullah Khan Zoological Park (Figure 3.29). The wetland is located near a massive lake called Ramgarh Taal in Gorakhpur city, with a mean elevation of 95 m asl. Biogeographically, it falls under the Gangetic Plain biogeographic zone (7) and Upper Gangetic Plain biogeographic province (7A) (Rodgers et al. 2000). The wetland provides refuge to many waterbird species, particularly during the winter season. Large congregations of lesser whistling ducks are prominent in the wetland during winters, along with winter migrants. Gorakhpur is a key urban settlement of eastern Uttar Pradesh. As per the census of India (2011), the population of the city is 673,446 with a literacy rate of 84% (male 89%, female 79%) and a sex ratio of 903 females per 1,000 males. Five points were selected for studying the waterbird congregation in the Gorakhpur Zoo wetland.

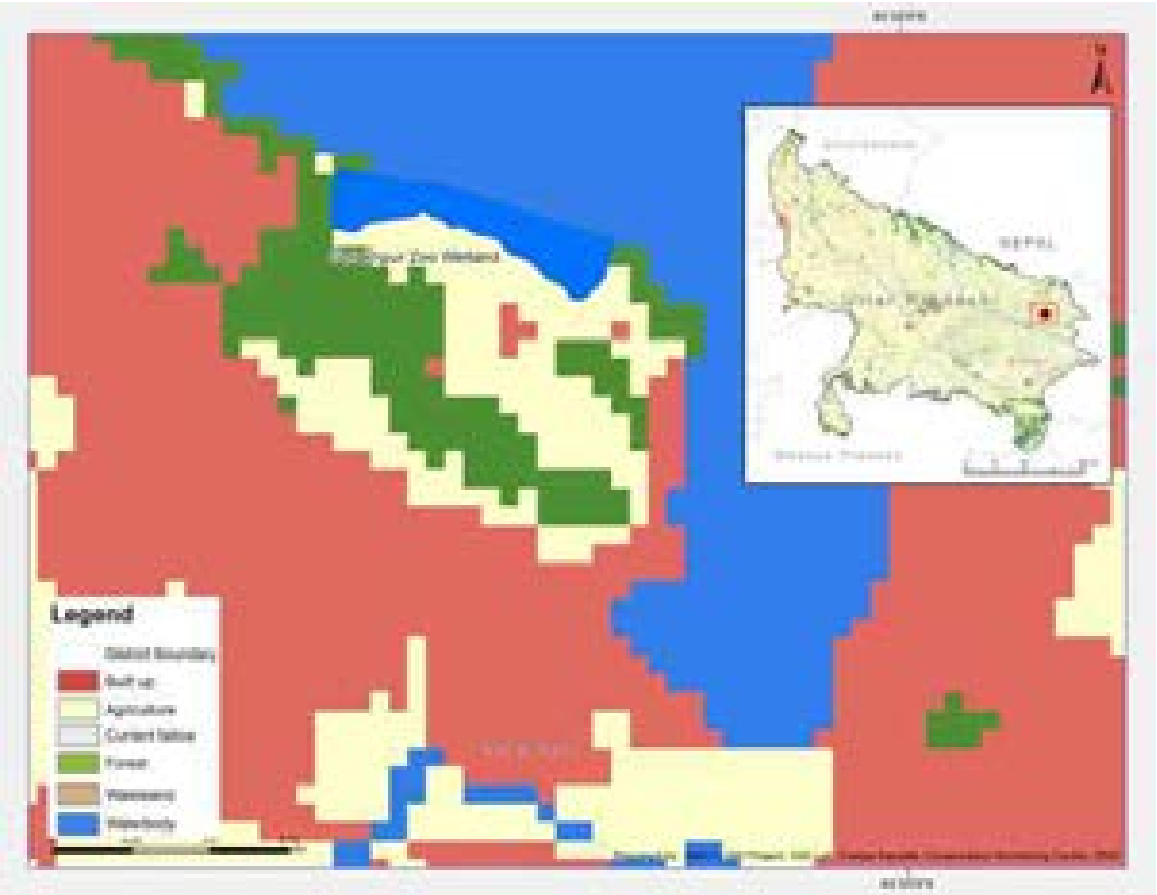
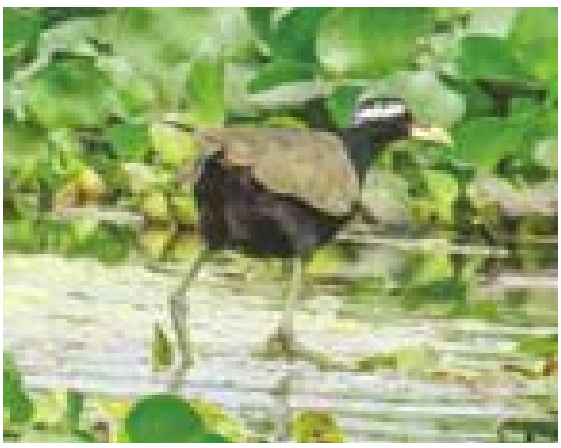


Figure 3.29. Land Use and Land Cover Map of Gorakhpur Zoo Wetland



A total of 758 individuals of 27 water and water-associated bird species were recorded from the Gorakhpur Zoo Wetland, belonging to 9 orders, 12 families, and 24 genera in five sampling points during 14 occasions with a total effort of 29.65 hrs. Anseriformes (6 species) was the most dominant order, followed by Pelecaniformes (5 sp.), Gruiformes (4 sp.), and Charadriiformes (3 sp.) (Figure 3.30a). Anatidae (6 species) was the most dominant family, followed by Ardeidae (5 sp.), Rallidae (4 sp.), and Alcedinidae (3 sp.) (Figure 3.30b). Only the ferruginous duck (*Aythya nyroca*) was in the category NT, while the rest of the recorded species were in LC on the IUCN Red List.

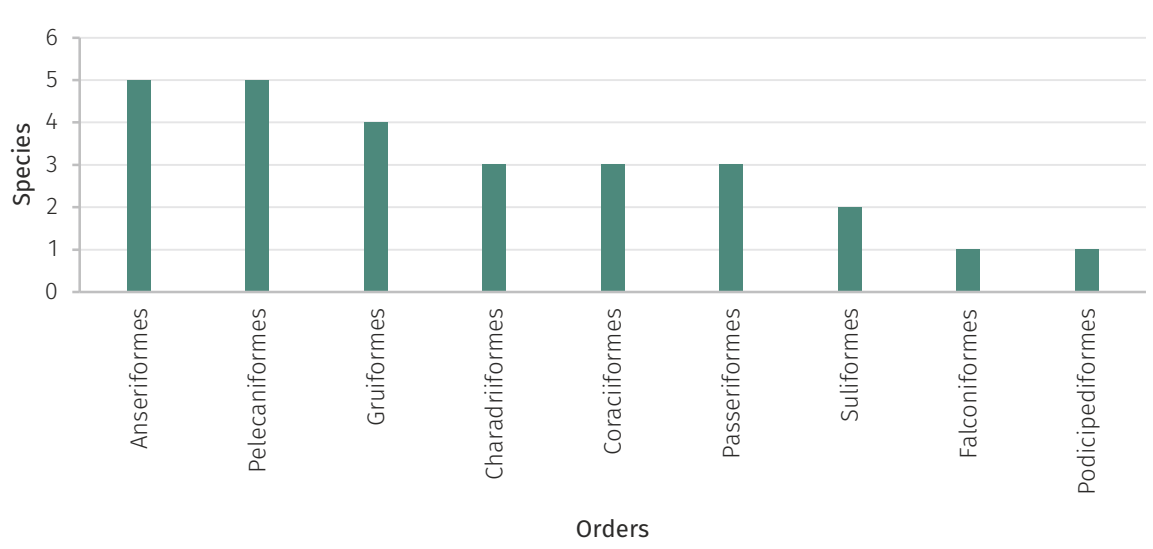


Figure 3.30a. Order-wise composition of species recorded in the Gorakhpur Zoo Wetland

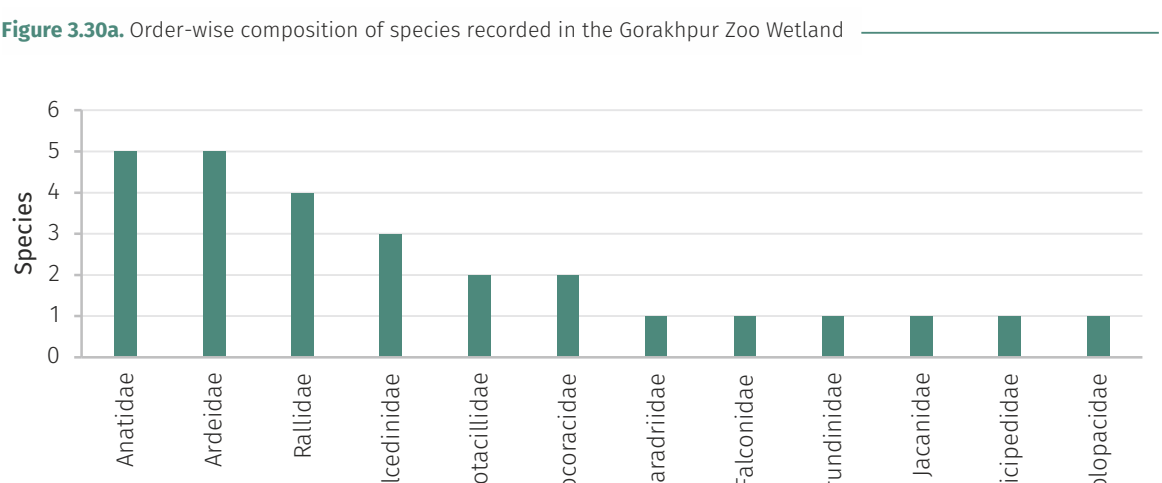


Figure 3.30b. Family-wise composition of species recorded in the Gorakhpur Zoo Wetland

Richness and Diversity

Of five sampling points, the overall species richness of water and water-associated species was found to be highest in point 4 (24 species), followed by point 3 (7 sp.) and point 2 (7 sp.) (Figure 3.31). Overall species diversity was found to be highest in point 4 (2.48), followed by point 3 (1.64) and point 2 (1.37). At the same time, no species was recorded in point 5 (Figure 3.31).

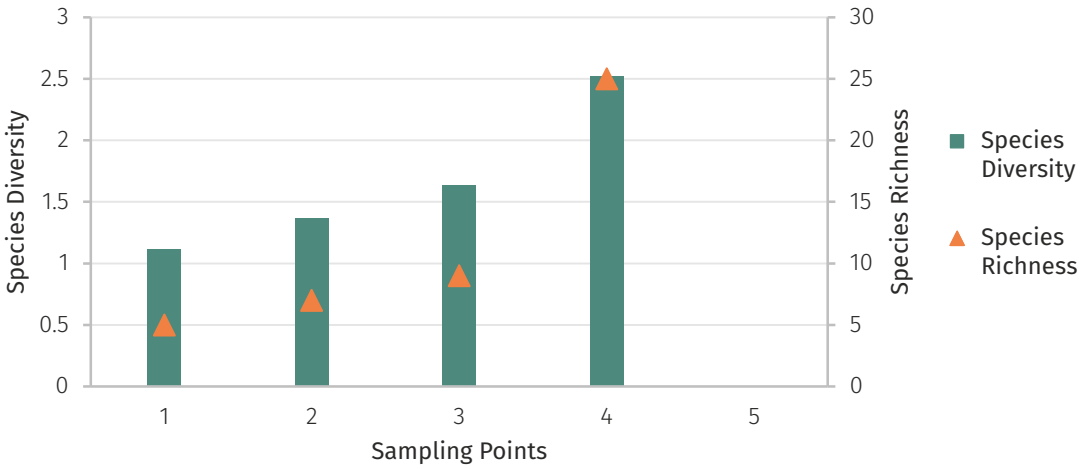


Figure 3.31 Species richness and diversity (*H'*) of water and water-associated birds in the Gorakhpur Zoo Wetland

Waterbirds

Of the 27 species recorded during the survey, 20 species (74.07%) were waterbirds. The highest richness of waterbird species was recorded in point 4 (19 species), followed by point 2 (6 sp.) and point 3 (4 sp.). Overall waterbird diversity value was highest in point 4 (2.38), followed by point 2 (1.29) and point 3 (0.80).

Water-associated Birds

Only seven species out of 27 species (25.93%) were identified as water-associated species. The highest species richness of water-associated birds was in points 3 and 4 (5 species), followed by points 1 (2 sp.). The highest species diversity value was found in point 3 (1.53), followed by point 4 (1.33) and point 1 (0.64). Whereas only one species represented point 2.

Relative abundance

In terms of the combined relative abundance of water and water-associated species, the gadwall (21.11%) was the most abundant, followed by the Eurasian coot (14.38%) and lesser whistling-duck (*Dendrocygna javanica*) (11.08%). In contrast, great cormorant, stork-billed kingfisher (*Pelargopsis capensis*), and peregrine falcon (0.13%) were least abundant. Point 4 (85.62%) was recorded as the most abundant point, followed by point 3 (6.46%) and point 2 (5.67%). At the same time, point 1 (2.24%) was the least abundant.

Waterbirds

Of the 20 waterbird species, the gadwall (22.22%) was the most abundant, followed by the Eurasian coot (15.14%) and lesser whistling-duck (11.67%), while the great cormorant (0.14%) was least abundant. Point 4 (87.50%) was recorded as the most abundant point, followed by point 2 (5.83%) and point 3 (4.72%), while point 1 (1.94%) was the least abundant.

Water-associated Birds

Out of the seven water-associated species, the white-throated kingfisher (31.58%) was the most abundant, followed by white wagtail (28.95%) and white-browed wagtail (23.68%), while stork-billed kingfisher and peregrine falcon (2.63%) were least abundant. Point 4 (50%) was the highest abundant point, followed by point 3 (39.47%) and point 1 (7.89%).

Feeding Guild and Residential Status

Overall, Carnivore (59.26%, 16 sp.) was the most dominant feeding guild, followed by Herbivore/Carnivore (22.22%, 6 sp.), and Omnivore (11.11%, 3 sp.), while Herbivore and Insectivore (3.70%, 1 sp.) were the least (Figure 3.32). Most of the species were within the category of R/LM (33%, 9 species), followed by R/WM (30%, 8 sp.), R (19%, 5 sp.), WM (11%, 3 sp.), R/AM (4%, 1 species) and R/WM/PM (4%, 1 sp.).

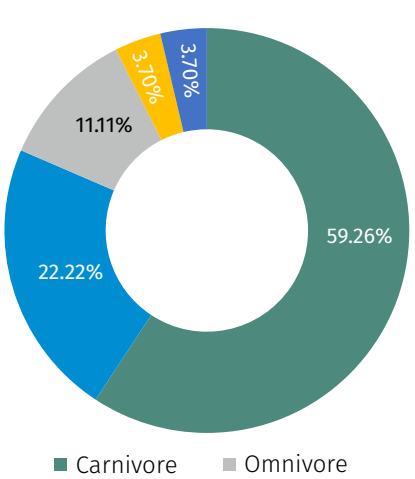
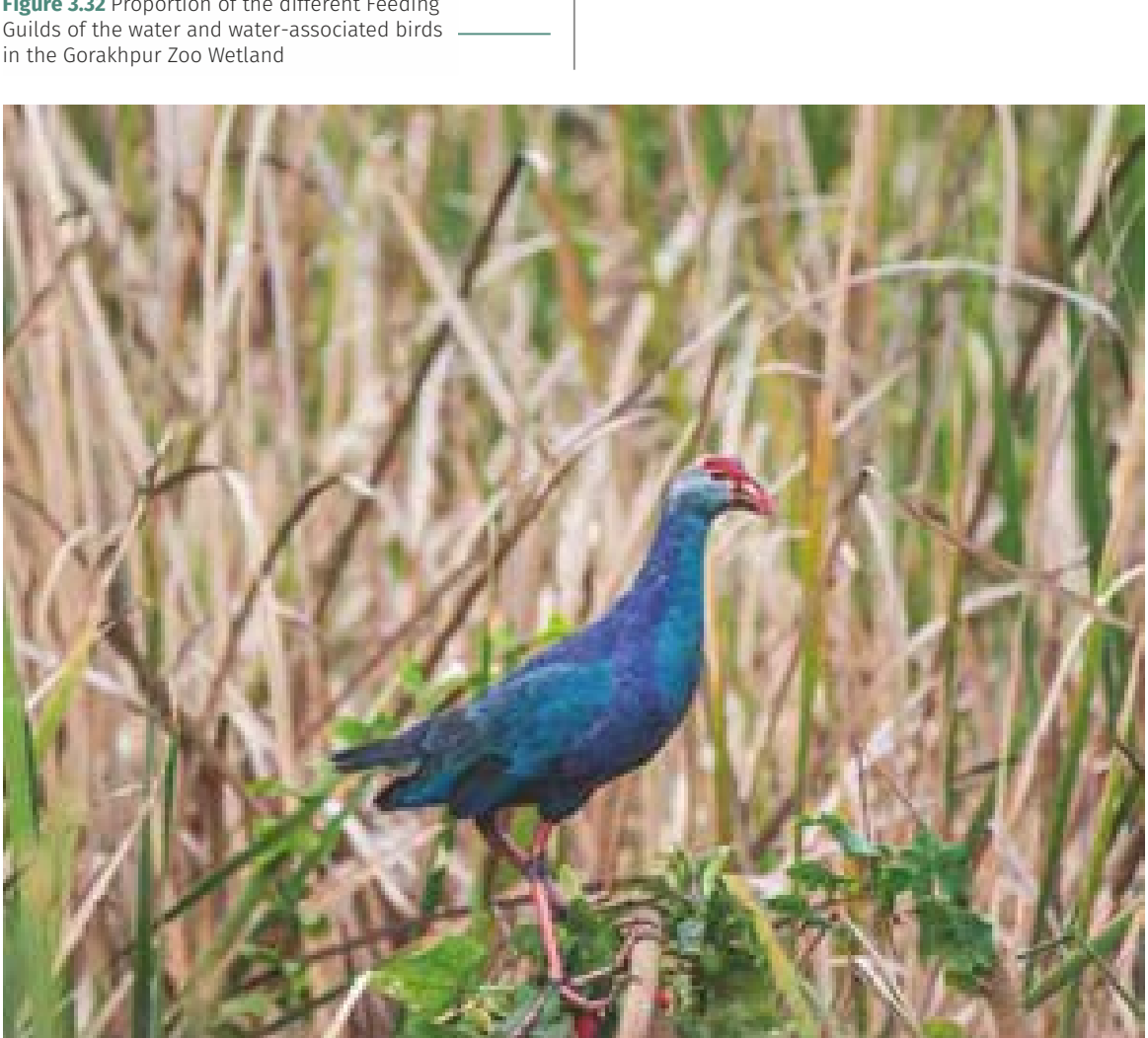


Figure 3.32 Proportion of the different Feeding Guilds of the water and water-associated birds in the Gorakhpur Zoo Wetland

Physio-chemical properties and anthropogenic stressors

The average pH of the water body was measured as 7.3, and the salinity value was 0.1 ppt. The air temperature was recorded as 21.4°C ± 1.51, and the water temperature was 20.50 °C ±1.64. Owing to being well protected inside the zoo campus, the wetland was free of most of the stressors like grazing, debris, washing, and pollution sources. Water was colourless and odourless. However, two of four sampling points were infested with invasive species (10%), such as *Pontederia crassipes*.



3.1.3. BIHAR

Bihar falls under the Gangetic Plains biogeographic zone (7) and the Lower Gangetic Plains province (7B) (Rodgers & Panwar, 1988). Apart from the Ganga River, Ghaghra, Gandak, Kosi, and Son are some other major rivers in the state, which form various ox-bow lakes in the state. About 54689 waterbodies exist in Bihar (Das et al. 2022), which covers about 6% of the state's total geographic area. A recent assessment recorded approximately 154,125 wetlands spanning over 4,715.55 sq. km in the state of Bihar. The most prominent types of wetlands in the state are the tanks, ponds, waterlogged areas, and oxbow lakes (Gupta et al. 2024). To date, the state has 14 designated IBAs and three designated Ramsar sites. Annually, several winter as well as summer migratory waterbird species visit these wetlands. For the present survey, three lesser-known wetlands were selected in Bihar, viz. (i) Mokama, (ii) Jakhar Jheel and (iii) Nauhatta wetlands. These wetlands were surveyed during February 2024 (Figure 3.33).

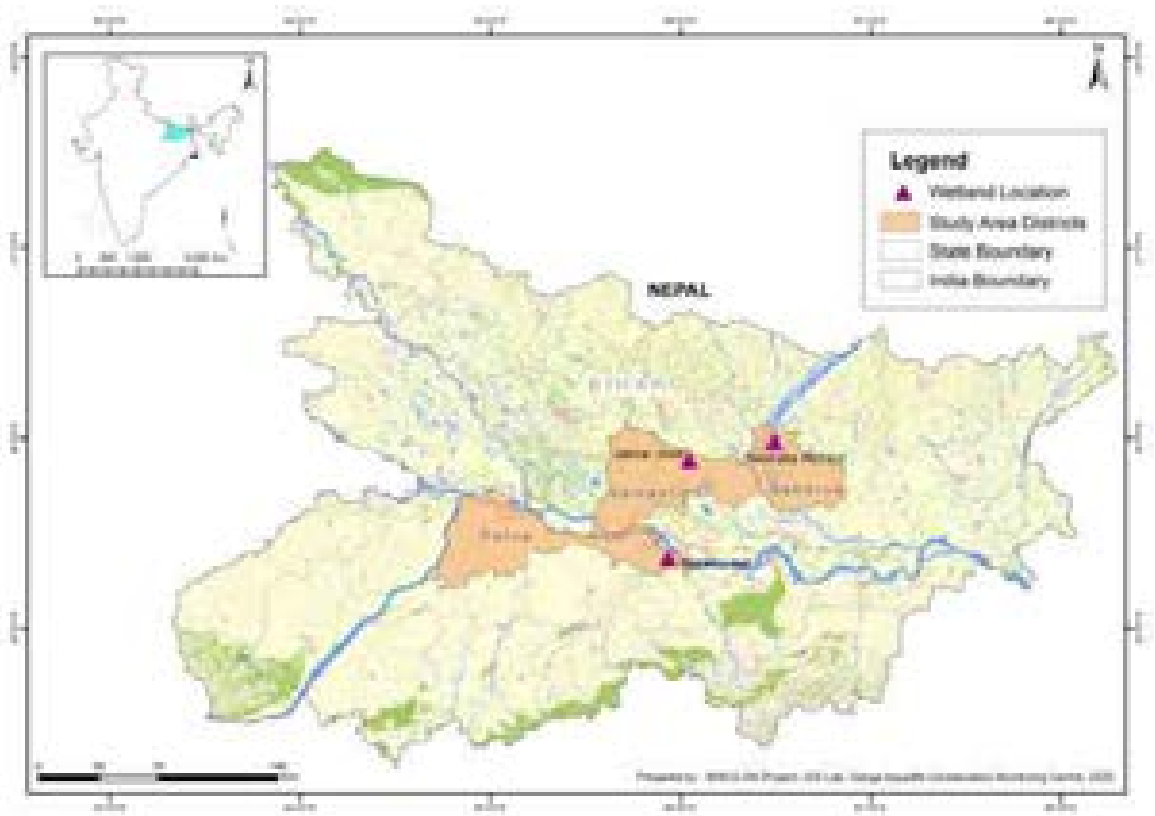
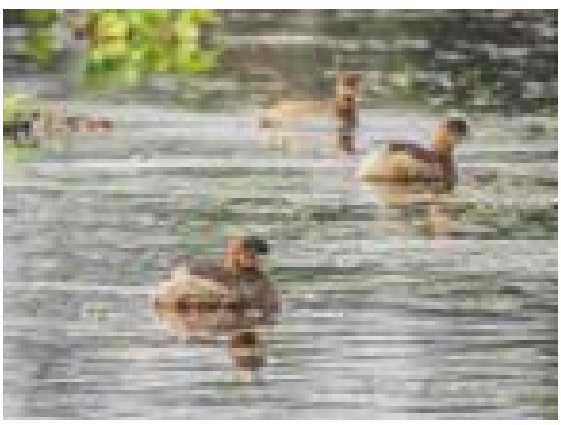


Figure 3.33 Map showing location of select wetlands in Bihar



Altogether, 43 water and water-associated bird species were recorded from the selected wetlands of Bihar, of which 32 were waterbird and 11 were water-associated bird species (Annexure 1). Of the 43 species, one was VU, and two species were in the NT category as per the IUCN Red List. Among the four surveyed wetlands in Bihar, Nauhatta wetland was found to be the most diverse wetland in terms of water and water-associated birds. The average species diversity of Nauhatta wetland was (1.72±0.59), followed by Jakhar Jheel (1.47±0.82), and Mokama Taal (0.99±1.01) (Figure 3.34).

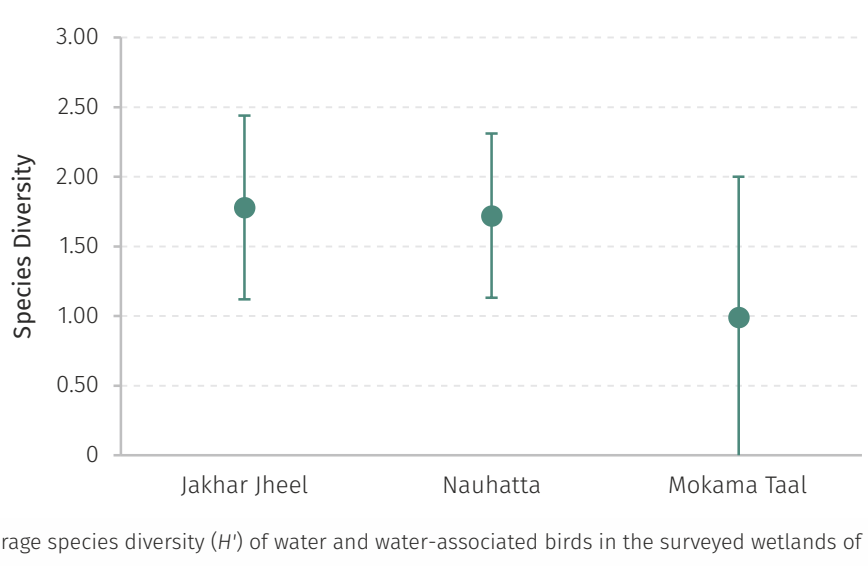


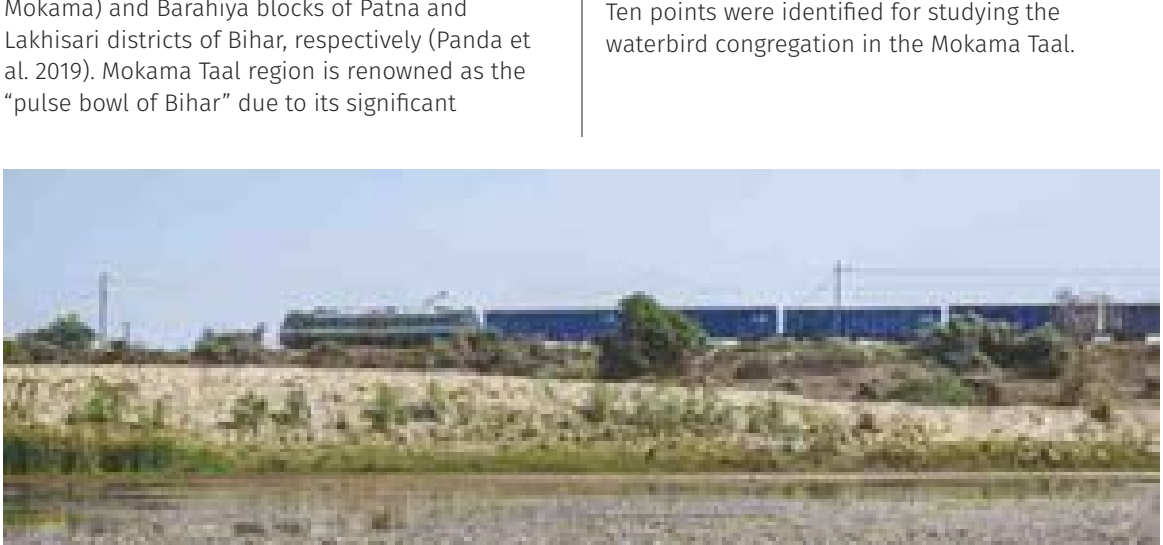
Figure 3.34 Average species diversity (*H'*) of water and water-associated birds in the surveyed wetlands of Bihar

1. MOKAMA TAAL

Mokama Taal is a shallow and perennial wetland spread over 10 sq. km (25° 20' 58.9" N and 85° 59' 11.82" E) (Figure 3.35). This wetland lies at an elevation of 50 m asl. It is designated as an IBA and Key Biodiversity Area (KBA). The black Ibis (*Pseudibis papillosa*), glossy Ibis (*Plegadis falcinellus*), Eurasian spoonbill (*Platalea leucorodia*), greylag goose and bar-headed Goose are some of the key waterbird species of the wetland (Rahmani et al. 2016).

The Mokama taal is situated in the Mokameh (or Mokama) and Barahiya blocks of Patna and Lakhisari districts of Bihar, respectively (Panda et al. 2019). Mokama Taal region is renowned as the "pulse bowl of Bihar" due to its significant contribution to pulse cultivation (Panda et al. 2019). Of the total worker population, 29.95% and 34.27% are the main agricultural labourers, while 36% and 30% are the marginal workers for the blocks Mokameh and Barahiya, respectively (Census of India 2011). The Mokama block comprises 23,675 households with a total population of 1,41,733, while Barahiya has 12,875 households with a population of 85,945. The sex ratio of both blocks is similar, 875 females per 1000 males in Mokama and 876 per 1000 in Barahiya. The literacy rates are at 62% and 65% for Mokama and Barahiya districts, respectively (Census of India 2011).

Ten points were identified for studying the waterbird congregation in the Mokama Taal.



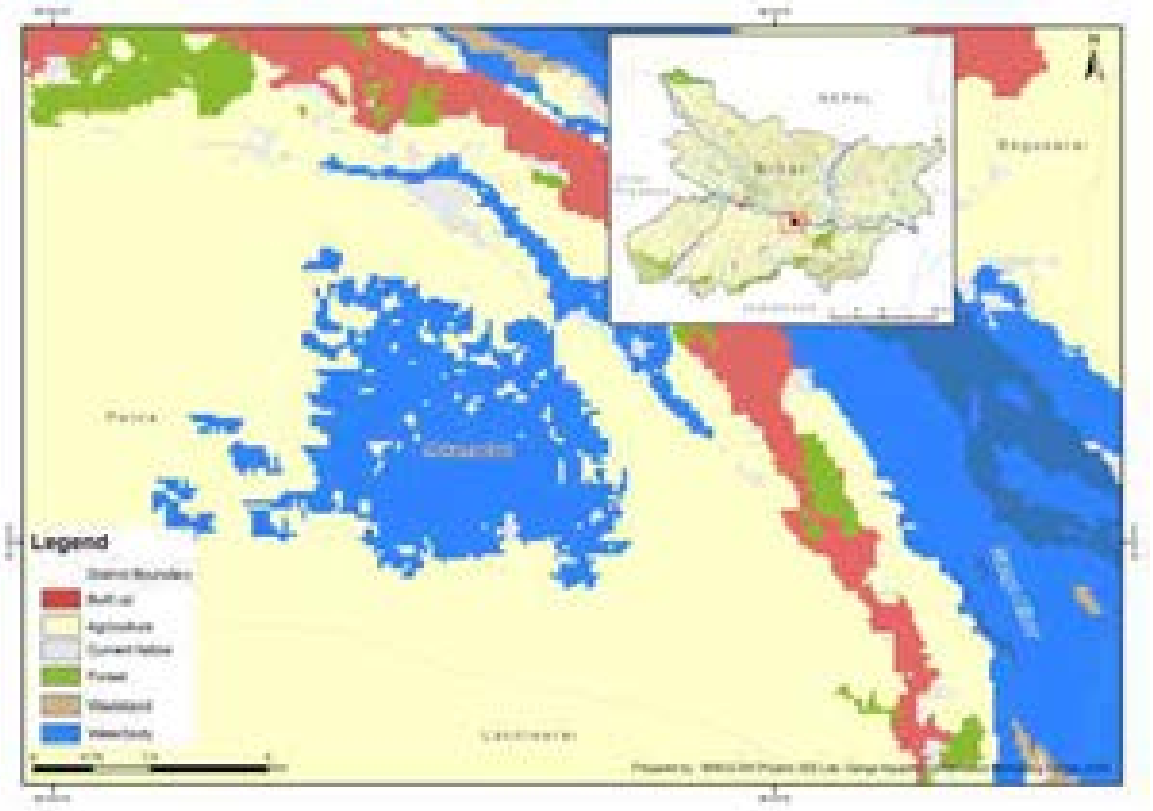


Figure 3.35 Land Use and Land Cover Map of Mokama Taal

During the present survey, a total of 295 individuals of 33 water and water-associated bird species were recorded from the Mokama Taal Wetland, belonging to 11 orders, 15 families, and 26 genera in ten sampling points during one occasion with a total survey effort of 6.3 hrs (Figure 3.36a). Pelecaniformes (9 species) was the most dominant order, followed by Charadriiformes (7 sp.), Anseriformes, Gruiformes, and Passeriformes (3 sp.). Ardeidae (7 species) was the most dominant family, followed by Anatidae, Matocillidae, Rallidae, and Scolopacidae (3 sp.) (Figure 3.36b). Out of 33 recorded species, one species, the common pochard, was listed as VU, and two species, the ferruginous duck and the lesser adjutant, were listed as NT, as per the IUCN Red List.

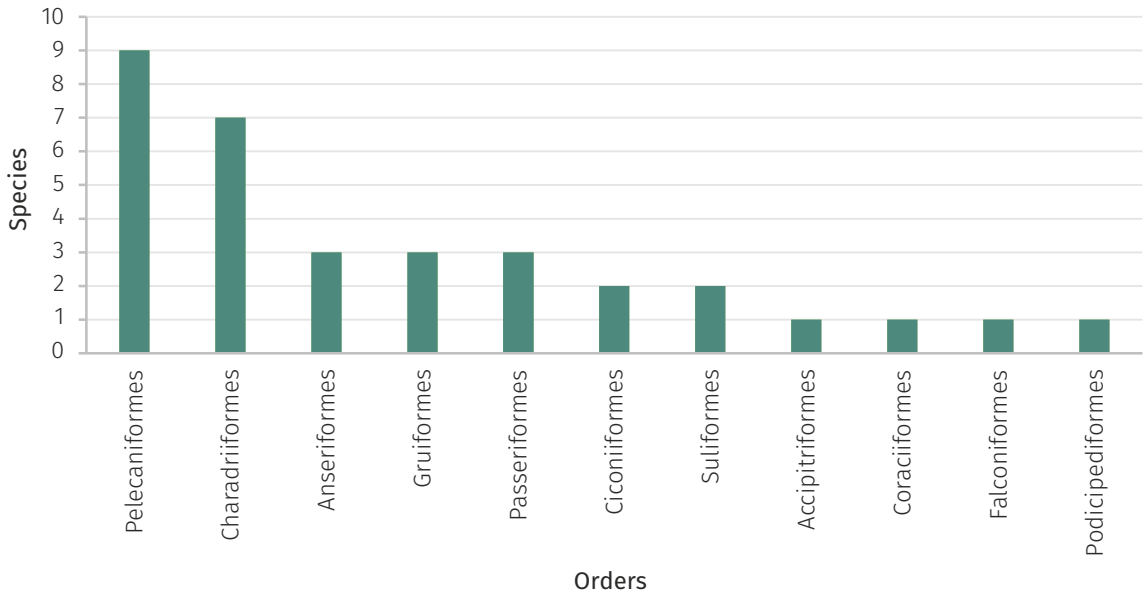


Figure 3.36a. Order-wise composition of species recorded in the Mokama Taal Wetland

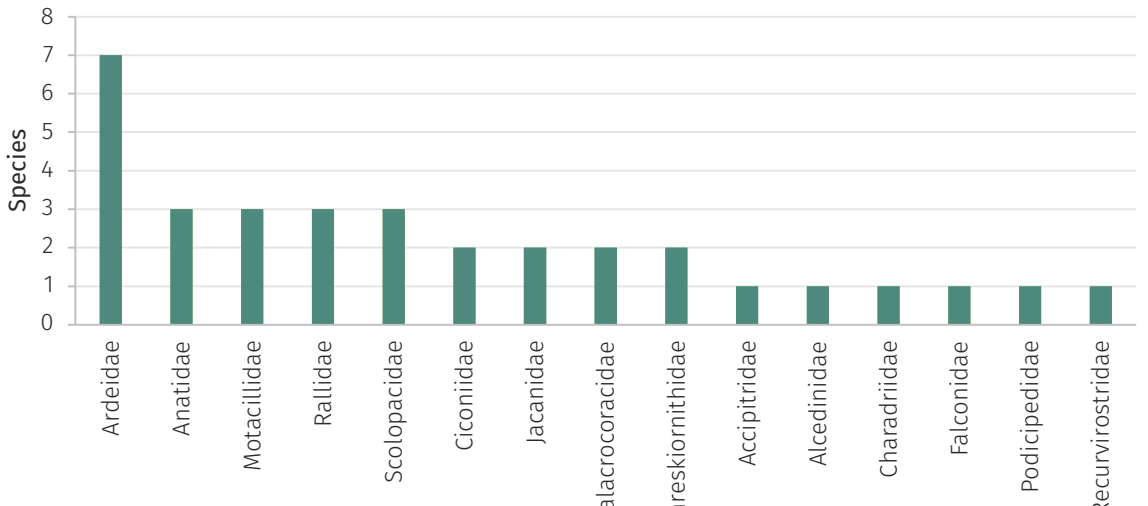


Figure 3.36b Family-wise composition of species recorded in the Mokama Taal Wetland

Richness and Diversity

Of ten sampling points, the overall species richness of water and water-associated species was found to be highest in point 8 (21 species), followed by point 9 (18 sp.) and point 6 (10 sp.) (Figure 3.37). Overall species diversity was found to be highest in point 8 (2.49), followed by point 6 (2.25) and point 9 (1.94). Whereas points 2, 4, and 5 were represented by only one species, and point 1 had no species (Figure 3.37).

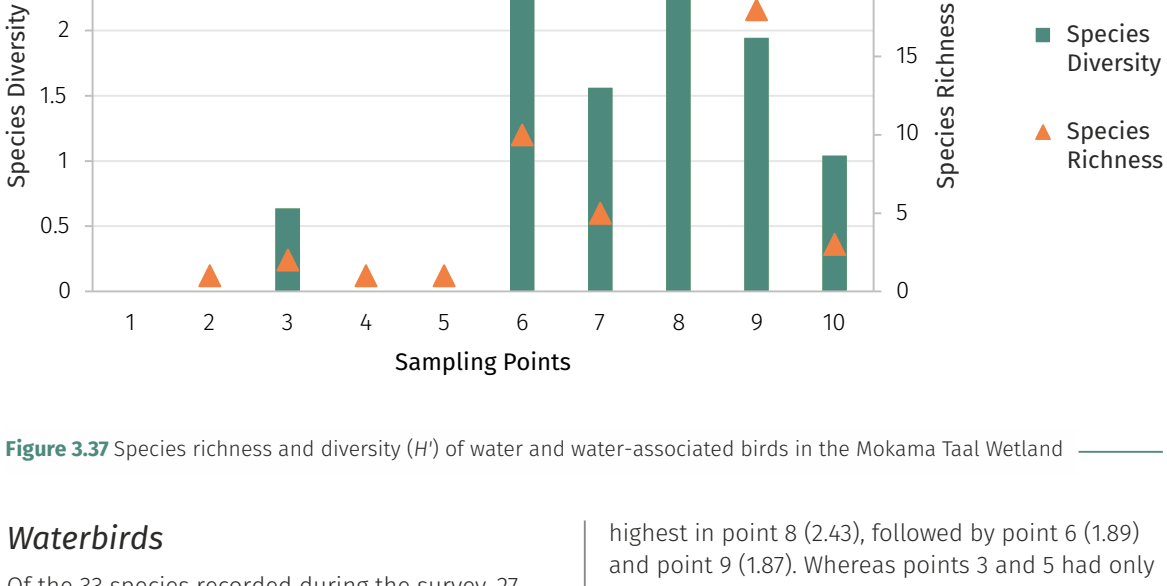


Figure 3.37 Species richness and diversity (*H'*) of water and water-associated birds in the Mokama Taal Wetland

Waterbirds

Of the 33 species recorded during the survey, 27 species (81.82%) were waterbirds. The highest richness of waterbird species was recorded in point 8 (19 species), followed by point 9 (15 sp.) and point 6 (7 sp.). Overall waterbird diversity was highest in point 8 (2.43), followed by point 6 (1.89) and point 9 (1.87). Whereas points 3 and 5 had only one species, and points 1, 2, and 4 with no species.

Water-associated Birds

Only six species out of 33 species (25%) were identified as water-associated species. The highest

species richness of water-associated birds was in points 6 and 9 (3 species), followed by points 8 (2 sp.). The highest species diversity value was found in point 9 (1.10), followed by point 6 (1) and point 8 (0.69). Whereas only one species represented points 2, 3, 4, and 7, and no species was recorded in points 1, 5, and 10.

Relative abundance

In terms of the combined relative abundance of water and water-associated species, the Asian openbill (21.11%) was the most abundant, followed by the little cormorant (14.24%) and ferruginous duck (8.14%), while seven species (0.34%) were least abundant. Point 9 (56.27%) was recorded as the most abundant point, followed by point 8 (32.54%) and point 6 (4.41%). At the same time, point 5 (0.34%) was the least abundant.

Waterbirds

Of the 27 waterbird species, the Asian openbill (24.73%) was the most abundant, followed by the little cormorant (15.05%) and ferruginous duck (8.60%). In contrast, black-winged stilt (*Himantopus himantopus*), great egret (*Ardea alba*), glossy ibis, and great cormorant (0.36%) were least abundant. Point 9 (58.42%) was recorded as the most abundant point, followed by point 8 (33.69%) and point 6 (3.23%). Whereas points 3 and 5 (0.36%) were the least abundant.

Water-associated Birds

Out of the six water-associated species, the western yellow wagtail (50%) was the most abundant, followed by white-throated kingfisher (18.75%) and peregrine falcon (12.50%). Point 4 (50%) was the highest abundant point, followed by point 3 (39.47%) and point 1 (7.89%).

Feeding Guild and Residential Status

Overall, Carnivore (72.73%, 24 species) was the most dominant feeding guild, followed by Herbivore/Carnivore (18.18%, 6 sp.), and Omnivore (6.06%, 2 sp.), while Carnivore/Herbivore (3.03%, 1 sp.) was the least (Figure 3.38). In terms of residential status, most of the species (42%, 14 species) were categorised as R/LM, followed by R/WM (27%, 9 sp.), WM and R (6%, 2 sp.). Six groups (R/AM, R/LM/SM, R/WM/AM, R/WM/AM/PM, R/WM/LM and R/WM/PM) were represented by only one species (3%) each.

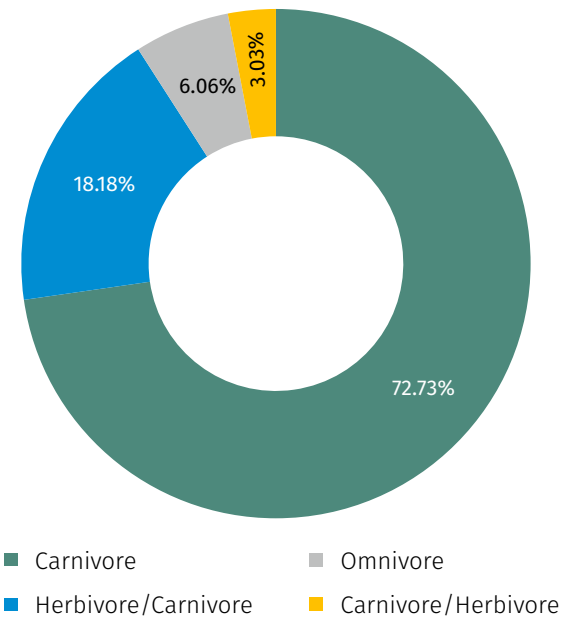


Figure 3.38 Proportion of the different Feeding Guilds of the water and water-associated birds in the Mokama Taal Wetland

Physio-chemical properties and anthropogenic stressors

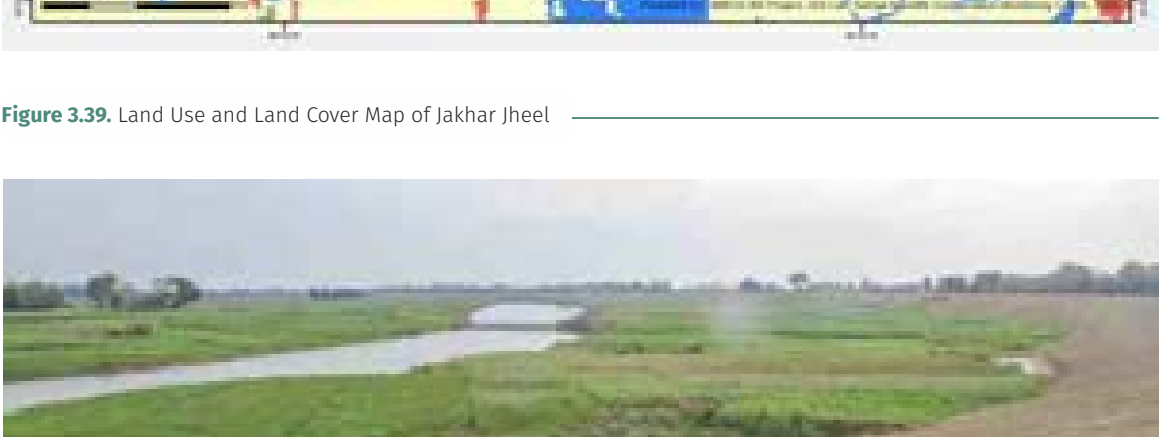
The average pH of the Mokama wetland was measured as 8.05 ±0.61 (range 7.8 - 9.3) and salinity as 0.2 ppt. Average air temperature was recorded as 25.9 °C ±3.44, and water temperature as 22.85 °C ±2.20. All ten sampling points were devoid of any litter, fishing, drainage, water pumps, and grazing activities. However, agricultural land surrounds the wetland, and there is a high level of extraction of vegetation/biomass in and around it. This wetland has shrunk significantly over the years, and most of the area has been converted to agricultural land. The highway has obstructed the water inflow. Invasive species, *Pontederia crassipes,* covered almost 60% of the area in three sampling sites (8-10). The wetland requires immediate attention from the concerned authorities for revival.

2. JAKHAR JHEEL

Jakhar Jheel is an ox-bow type wetland (25 52' 54" N, 86 02' 42.5" E) with ~4 sq. km area located in proximity to the Shivaji Nagar block of the Bagmati River in Samastipur district of Bihar (Figure 3.39). The wetland lies at a mean elevation of 65 m asl, which falls under the 7-Gangetic Plain Biogeographic zone and 7B-Lower Gangetic Plain biogeographic province (Rodgers et al. 2000). Jakhar Jheel holds water in its narrow channel for most of the seasons. The wetland is surrounded by agricultural land. Mahadeva is the nearest village to the wetland, which is separated by a motorable road. The peripheral villages of the lake are Jakhar, Aura, and Shankarpur. According to the Census of India (2011), the total household of the three villages is 2,012, with a population of 10,426 and a sex ratio of 880 females per 1,000 males. The literacy rate was 56% (male 69%, female 41%) for the age group above six years (Census of India 2011).

Four points were identified for studying the waterbird congregation in the Jakhar Jheel.

Figure 3.39. Land Use and Land Cover Map of Jakhar Jheel



Altogether, 77 individuals of 19 water and water-associated bird species were recorded from the Jakhar Jheel Wetland, belonging to 8 orders, 10 families, and 16 genera in four sampling points during one occasion (total survey effort = 2.48 hrs). Pelecaniformes (7 species) was the most dominant order, followed by Coraciiformes and Gruiformes (3 sp.) (Figure 3.40a). Ardeidae (6 species) was the most dominant family, followed by Alcedinidae, and Rallidae (3 sp.) (Figure 3.40b). All species are in the least concern category as per the IUCN Red List.

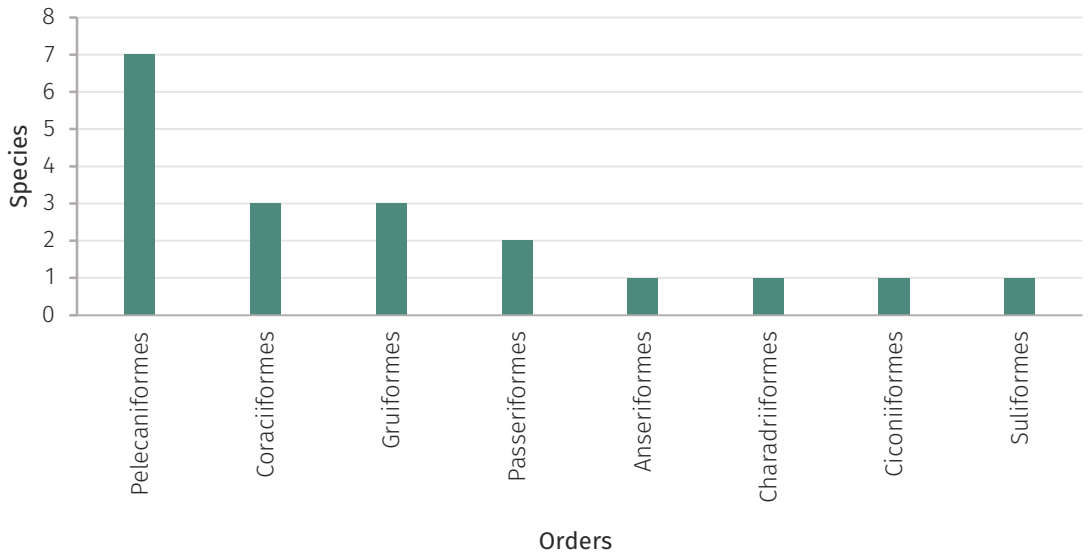


Figure 3.40a Order-wise composition of species recorded in the Jakhar Jheel Wetland

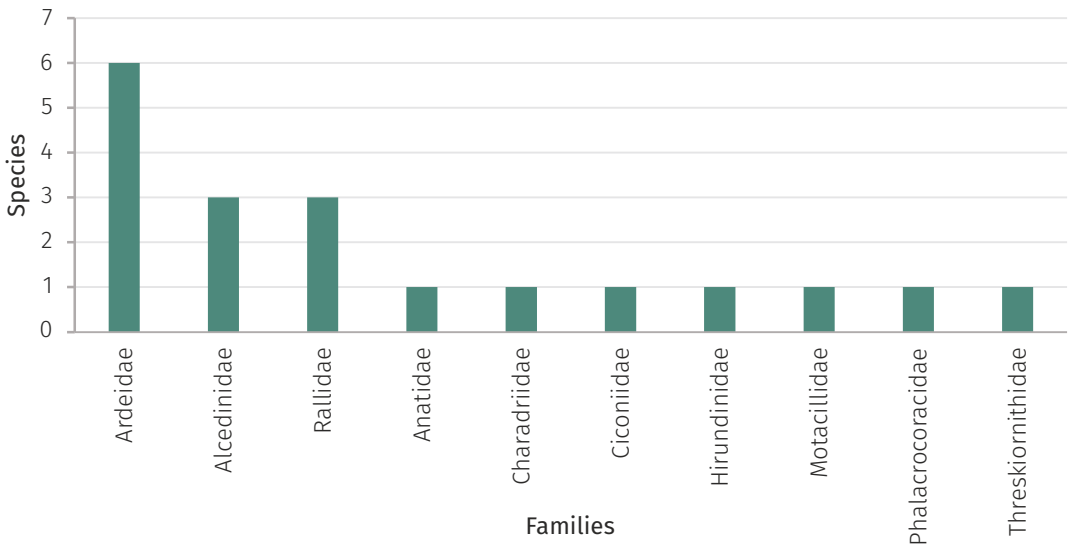


Figure 3.40b. Family-wise composition of species recorded in the Jakhar Jheel Wetland

Richness and Diversity

Of four sampling points, the overall species richness of water and water-associated species was found highest in point 1 (15 species), followed by point 2 (8 sp.) while points 3 and 4 had 3 species each (Figure 3.41). Overall species diversity was found to be highest in point 1 (2.52), followed by point 2 (1.69) and point 3 (1.04). Whereas point 4 had the least diversity value (0.60) (Figure 3.41).

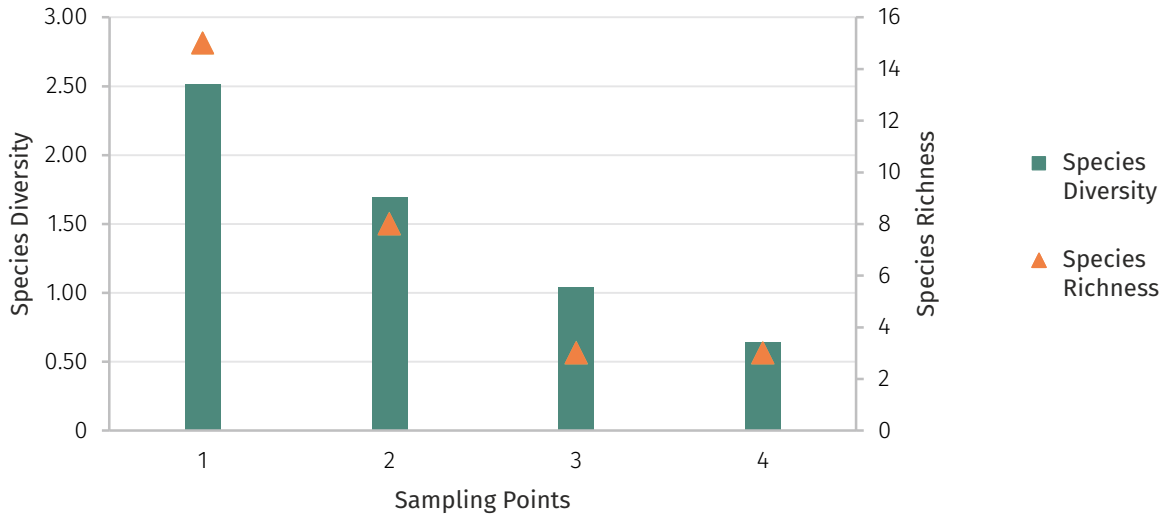


Figure 3.41. Species richness and diversity value (*H'*) of water and water-associated birds in the Jakhar Jheel Wetland

Waterbirds

Of the 19 species recorded during the survey, 14 species (74%) were categorized in the waterbird group. The highest richness of waterbird species was recorded in point 1 (11 species), followed by points 2 (7 sp.), while points 3 and 4 had only 3 species each. The highest species diversity value was found in point 1 (2.28), followed by point 5 (1.88) and point 2 (1.86). Whereas point 4 (0.6) had the least diversity value.

Water-associated Birds

Only five species out of 19 species (26%) were identified as water-associated species. The highest species richness (4 species) and species diversity (1.09) of water-associated birds was in point 1 (4 species). Whereas points 2 was represented by only one species, and points 3 and 4 had no species.

Relative abundance

In terms of the combined relative abundance of water and water-associated species, the Asian openbill (33.77%) was the most abundant, followed by the little cormorant and Indian pond-heron (9.09%), while common teal, grey heron (*Ardea cinerea*), purple heron (*Ardea purpurea*), intermediate egret, pied kingfisher and white-throated kingfisher (1.30%) were least abundant. Point 1 (38.96%) was recorded as the most abundant point, followed by point 2 (37.66%) and point 4 (12.99%), while point 3 (10.39%) was the least abundant.

Waterbirds

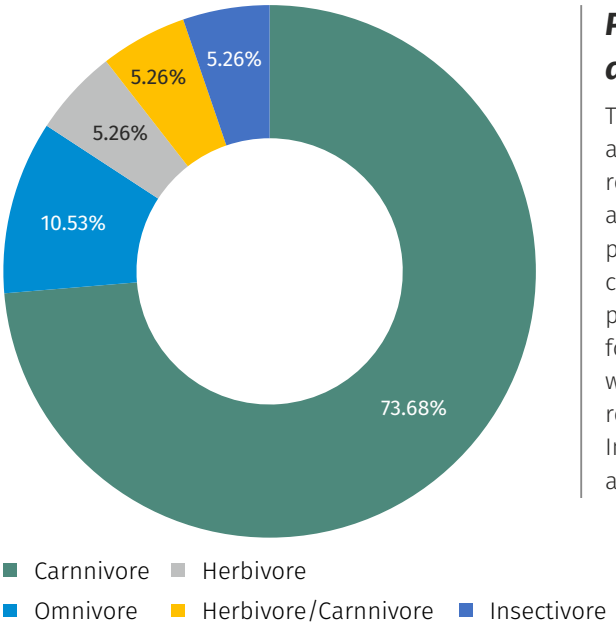
Of the 14 waterbird species, the Asian openbill (40%) was the most abundant, followed by the little cormorant and Indian pond-heron (10.8%), while common teal, grey heron, intermediate egret and purple heron (1.54%) were least abundant. Point 2 (41.54%) was recorded as the most abundant point, followed by point 1 (30.77%) and point 4 (15.38%), while point 3 (12.31%) was the least abundant.

Water-associated Birds

Out of the five water-associated species, the grey-throated martin (50%) was the most abundant, followed by the white wagtail and common kingfisher (16.67%). Point 1 (83.33%) was recorded highest abundant point, followed by point 2 (16.67%). Whereas points 3 and 4 had no species.

Feeding Guild and Residential Status

Overall, Carnivore (73.68%, 14 species) was the most dominant feeding guild, followed by omnivore (10.53%, 2 sp.), while herbivore, herbivore/carnivore, and insectivore (5.26%, 1 sp.) were the least dominant (Figure 3.42). Out of 19 species, R/LM (53%, 10 species) dominated the residential group, followed by R (21%, 4 sp.), R/WM (11%, 2 sp.). While R/AM, R/WM/PM, and WM groups were represented by one species each (5%).



Physio-chemical properties and anthropogenic stressors

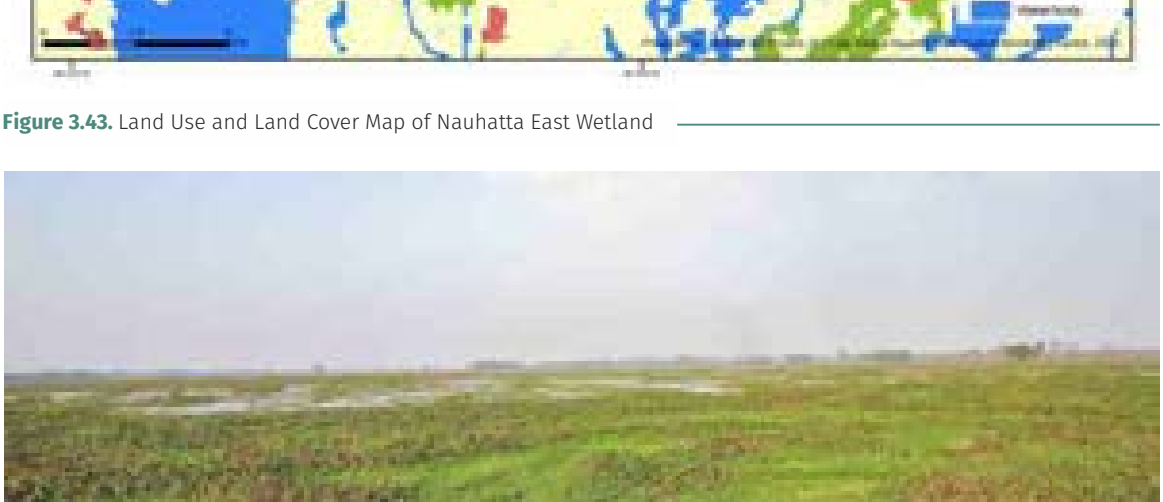
The average pH value of the wetland was measured as 7.91, and salinity as 0.2 ppt. Air temperature was recorded as 21°C, and water temperature was about 22.5°C. Fishing was noted to be a seasonal practice for non-commercial use (self-consumption). Agriculture was practised in a small proportion of the wetland. No outlet, water pump for water extraction, mining, grazing, or powerline was recorded in the wetland. Washing/bathing was recorded as a regular practice in the wetland. Invasive species were also not recorded in and around the wetland.

Figure 3.42. Proportion of the different Feeding Guilds of the water and water-associated birds in the Jakhar Jheel Wetland

3. NAUHATTA EAST WETLAND

Nauhatta is a natural wetland (25o 58' 47.34" N, 86o 29' 24.13" E) located near Kosi River in Saharsa district of Bihar (Figure 3.43). The wetland comprises mosaics of semi urban landscape lies at mean elevation of 65 m asl., agriculture and wetlands with an area of around 8 sq. km., which falls within the 7-Gangetic Plain Biogeographic zone and 7B-Lower Gangetic Plain biogeographic province (Rodgers et al. 2000). Nauhatta Purani Bajjar is the nearest village from the wetland, and is bifurcated by a road into two large sections. The village has a total of 909 households with a population of 5,103 and a sex ratio of 977 females per 1,000 males (Census of India 2011). The literacy rate of the village is 72% (male 81%, female 64%) for the age group above six years. Six points were identified for studying the waterbird congregation in the Nauhatta wetland.

Figure 3.43. Land Use and Land Cover Map of Nauhatta East Wetland



A total of 244 individuals of 26 water and water-associated bird species were recorded from the Nauhatta Wetland, belonging to 9 orders, 11 families, and 20 genera in six sampling points during one occasion (total survey effort = 3.98 hrs). Pelecaniformes (7 species) was the most dominant order, followed by Charadriiformes and Passeriformes (4 sp.) (Figure 3.44a). Ardeidae (7 species) was the most dominant family, followed by Motacillidae, Rallidae, and Alcedinidae (3 sp.) (Figure 3.44b). Out of 26 recorded species, the common pochard is listed as VU, and the lesser adjutant is listed as NT on the IUCN Red List.

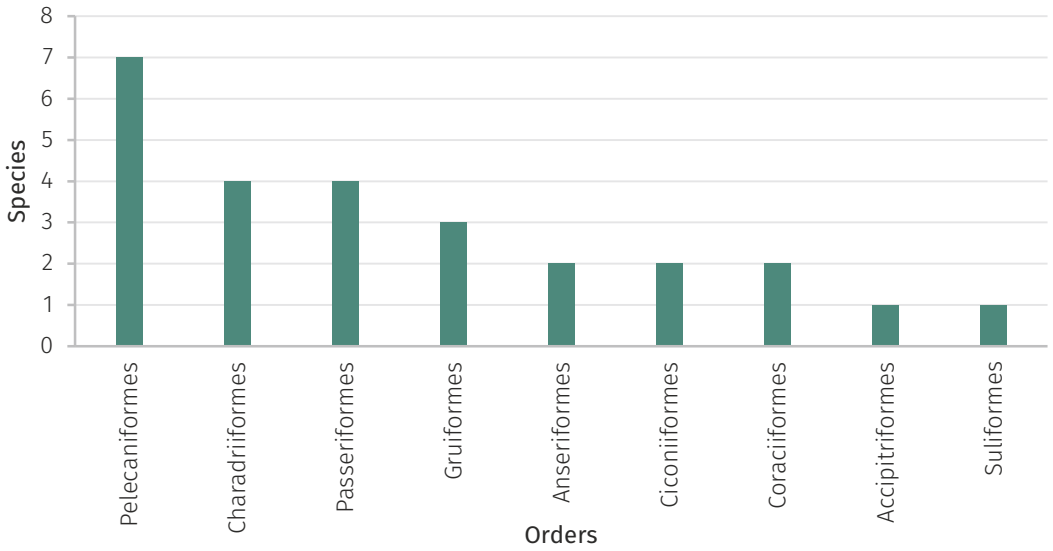


Figure 3.44a. Order-wise composition of species recorded in the Nauhatta Wetland

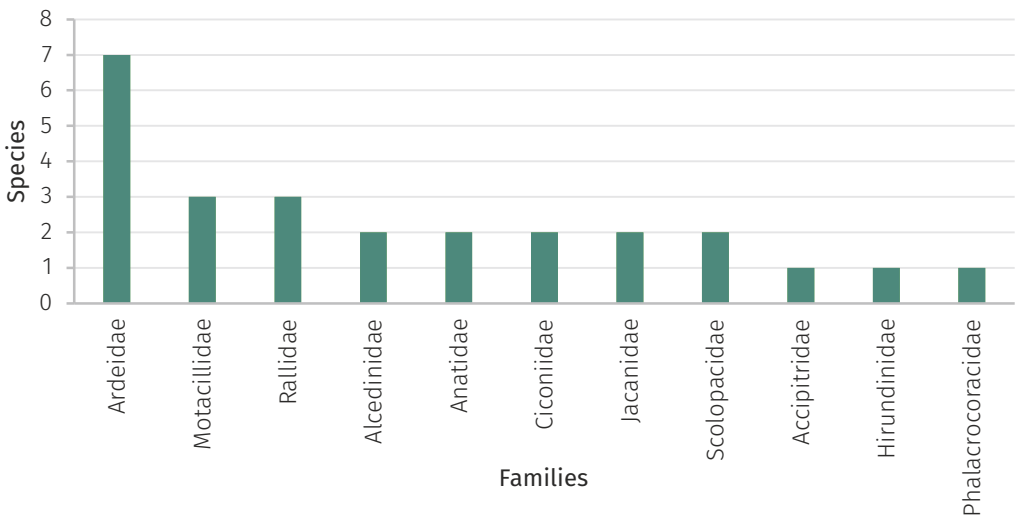


Figure 3.44b. Family-wise composition of species recorded in the Nauhatta Wetland

Richness and Diversity

Of six sampling points, the overall species richness of water and water-associated species was found to be highest in point 1 (11 species), followed by point 3 (12 sp.) and point 5 (10 sp.) (Figure 3.45). Overall species diversity was highest at point 1 (2.17), followed by point 5 (2.04) and point 2 (1.98). Point 4 had the least species richness (2 species) and diversity value (0.56) (Figure 3.45).

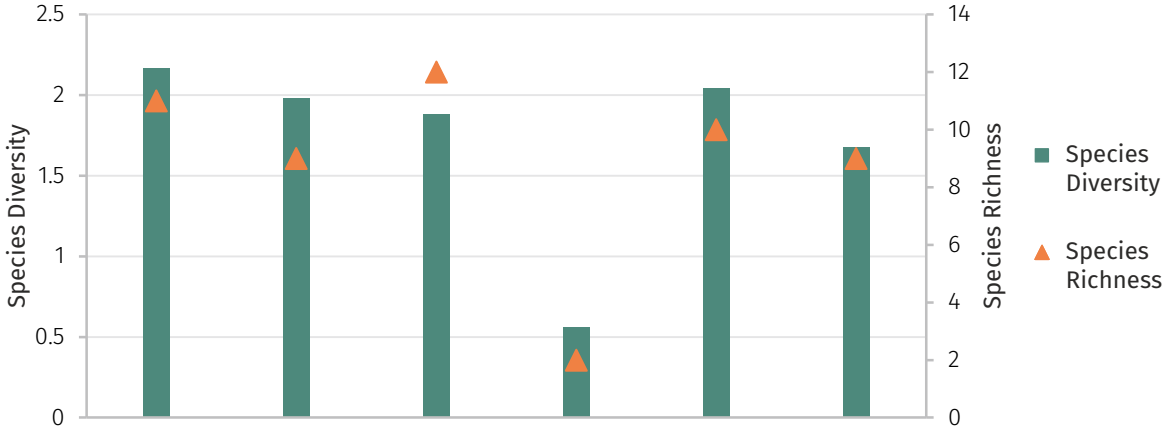


Figure 3.45 Species richness and diversity (*H'*) of water and water-associated birds in the Nauhatta Wetland

Waterbirds

Of the 26 recorded species, 19 species (73.08%) were waterbirds. The highest species richness of waterbirds was recorded at point 3 (11 species), followed by point 1 (10 sp.) and points 2, 5, and 6 (8 sp.). The highest species diversity value was observed at point 1 (2.11), followed by point 5 (1.88) and point 2 (1.86). Whereas point 4 had only one species.

Water-associated Birds

Only seven species out of 26 species (26.92%) were identified as water-associated species. The highest species richness (2 Species) and diversity value (0.50) of water-associated birds was in point 5, and the rest of the points had only one species.

Relative abundance

In terms of the combined relative abundance of water and water-associated species, the Asian openbill (20.90%) was the most abundant, followed by the little cormorant (13.93%) and eastern cattle egret (10.66%). In comparison, eight species (0.41%) were recorded as the least abundant. Point 5 (28.69%) was recorded to be the most abundant, followed by point 1 (22.95%) and point 6 (19.67%), while point 4 (3.28%) was the least abundant.

Waterbirds

Of the 20 waterbird species, the Asian openbill (21.98%) was the most abundant, followed by the little cormorant (14.66%) and eastern cattle egret

(11.21%), while white-breasted waterhen, green sandpiper, black-crowned night heron (*Nycticorax nycticorax*), and grey heron (0.43%) were the least abundant. Point 5 (28.02%) was recorded as the most abundant point, followed by point 1 (23.71%) and point 6 (20.26%), while point 4 (2.59%) was the least abundant.

Water-associated Birds

Out of the eight water-associated species, the grey-throated martin (33.33%) was the most abundant, followed by the white wagtail and white-browed wagtail (16.67%). Point 5 (41.67%) was recorded highest abundant point, followed by points 2 and 4 (16.67%). Points 2, 3, and 6 (8.33%) were the least abundant.

Feeding Guild and Residential Status

Overall, Carnivore (69.23%, 18 species) was the most dominant feeding guild, followed by Herbivore/Carnivore (19.23%, 5 sp.), and Omnivore (7.69%, 2 sp.), while Insectivore (3.57%, 1 sp.) was the least dominant (Figure 3.46). Out of 26 species, 11 species (42%) belonged to R/LM, four species (15%) to two groups (WM and R), two species (12%) to R/WM, while one species (4%) each to R/AM, R/LM/SM, R/WM/AM and R/WM/PM.

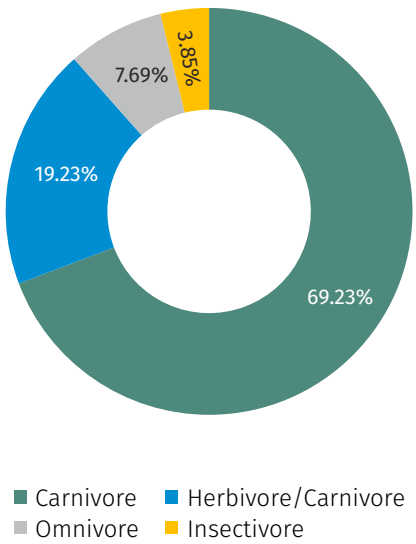


Figure 3.46. Proportion of the different Feeding Guilds of the water and water-associated birds in the Nauhatta Wetland

Physio-chemical properties and anthropogenic stressors

The average pH value of the wetland was 8.90 ±1.60 (7.04-10.07), and salinity was 0.20 ppt. The mean air temperature was recorded as 24.80 °C ± 1.10, and the mean water temperature was 24.24 °C ± 1.29. The Nauhatta wetland was devoid of litter and agriculture practices. Commercial fishing was observed at all sampling points. Floating vegetation occupied half of the wetland. Multiple power lines were found (~15) intersecting the wetland at multiple locations. There was no sign of drainage, industrial outlet, water extraction pump, washing/bathing, grazing and mining activities in the wetland. Floating macrophytes covered 20-50% wetlands at all sampling points, mostly invasive species, *Pontederia crassipes*.

3.1.4. JHARKHAND

The state of Jharkhand falls under two biogeographic zones, the Deccan peninsula (6B) and the Gangetic plains (7B) (Rodgers et al. 2000). The state harbours around 138,539 wetlands covering 236.77 sq. km area, mostly consisting of tanks and ponds dominate numerically (135,235), followed by reservoirs (1,487) and rivers/streams (1,247), reflecting the predominance of small artificial wetlands in the plateau state's terrain (Gupta et al. 2024). The state has five designated IBAs and one Ramsar site (Udhwa Lake Bird Sanctuary). A total of four wetlands were identified and surveyed, namely Udhwa Lake, Brahma Jamalpur Wetland, Konar Dam and Patratu Dam, during February 2024 (Figure 3.47).

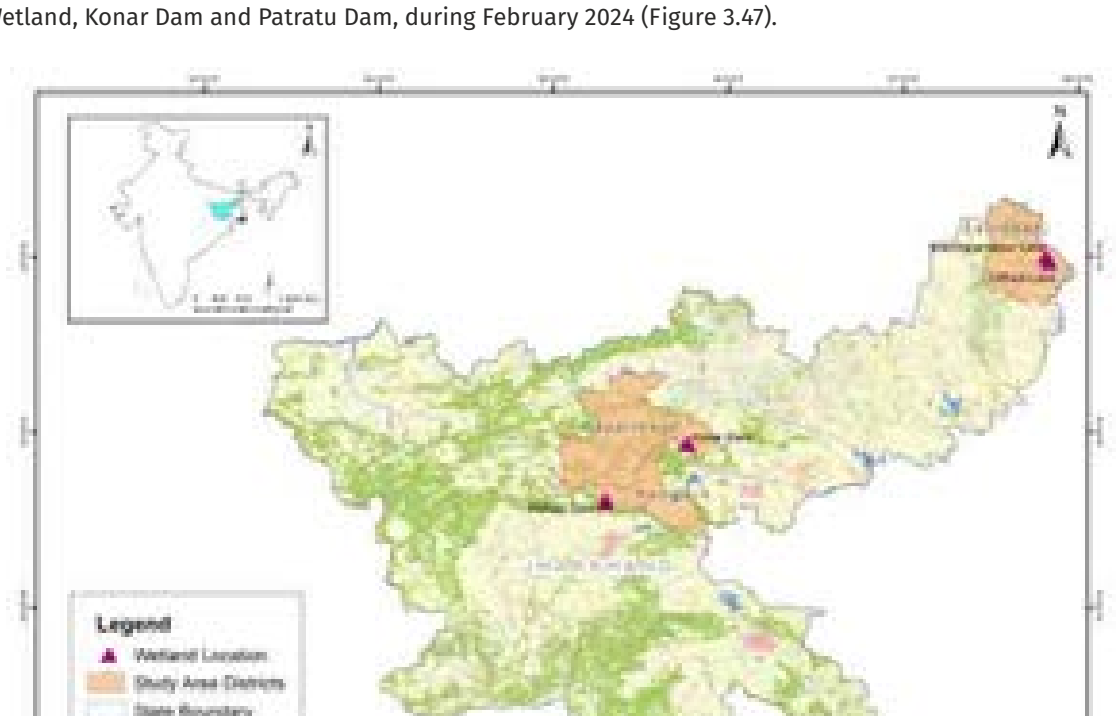


Figure 3.47 Map showing location of select wetlands of Jharkhand

Overall, 50 water and water-associated bird species were recorded from the selected wetlands of Jharkhand, of which 42 were waterbirds and 8 were water-associated bird species (Annexure 1). Of the 50 species, three were in the NT category as per the IUCN Red List. Among the four surveyed wetlands in Jharkhand, Udhwa wetland was found to be the most diverse wetland in terms of water and water-associated birds. The highest average species diversity was recorded in Udhwa wetland (2.16±0.46), followed by Brahma Jamalpur Wetland (1.53±0.70), Konar Dam (1.01±0.03) and Patratu Dam (0.77±0.82) (Figure 3.48).

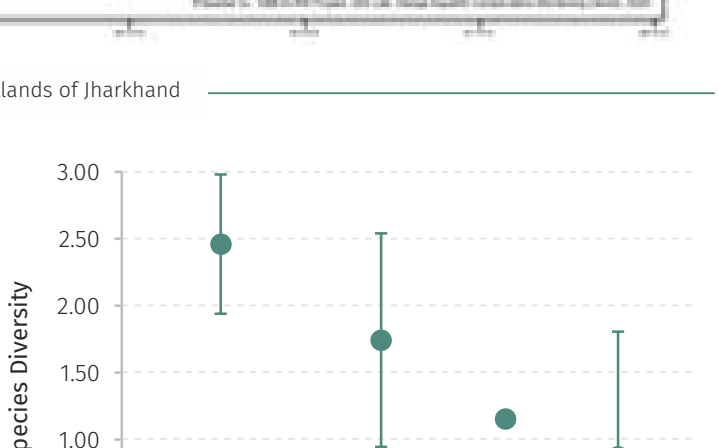


Figure 3.48. Average species diversity (*H'*) of water and water-associated birds in the surveyed wetlands of Jharkhand

1. UDHWA WETLAND

Udhwa wetland is a part of the Udhwa Lake wildlife (Bird) sanctuary located in Sahibganj district of Jharkhand (24° 58' 26.84" N, 87° 49' 14.76" E) (Figure 3.49). This natural wetland covers a 5.65 sq. km area that lies at a mean elevation of 42 m asl. Udhwa is known as one of the key waterbird habitats in the state of Jharkhand, which resulted in its designation as an IBA and Ramsar site. The wetland is situated within the 7-Gangetic Plain Biogeographic zone and 7B-Lower Gangetic Plain biogeographic province (Rodgers et al. 2000) in the Ganga River's backwaters, connected to the Ganga River by a channel called Udhwa Nala. The wetland provides refuge to some of the threatened species like band-tailed fish eagle (*Haliaeetus leucoryphus*), common pochard (*Aythya ferina*) and lesser adjutant stork (*Leptoptilos javanicus*).

There are a total of 24 villages under the eco-sensitive zone of the Udhwa Lake Bird Sanctuary. Of these 24 villages, six villages, namely, Chatradiha and Panchwara of Udhwa block, and Jamnagar, Lakhipur Sajanpur, Bramhajamalpur (or Berhale), and Paranpur of Rajmahal block, are the enclave villages of Udhwa lake (The Gazette of India, 2019). The five villages, except Panchwara, have a total of 4,893 households, with a population of 26,858 and a sex ratio of 967 females per 1,000 males (Census of India 2011). The literacy rate of the four villages is 45% (male 52%, female 38%) for the age group above six years.

Three points were selected for studying the waterbird congregation in the Udhwa wetland.

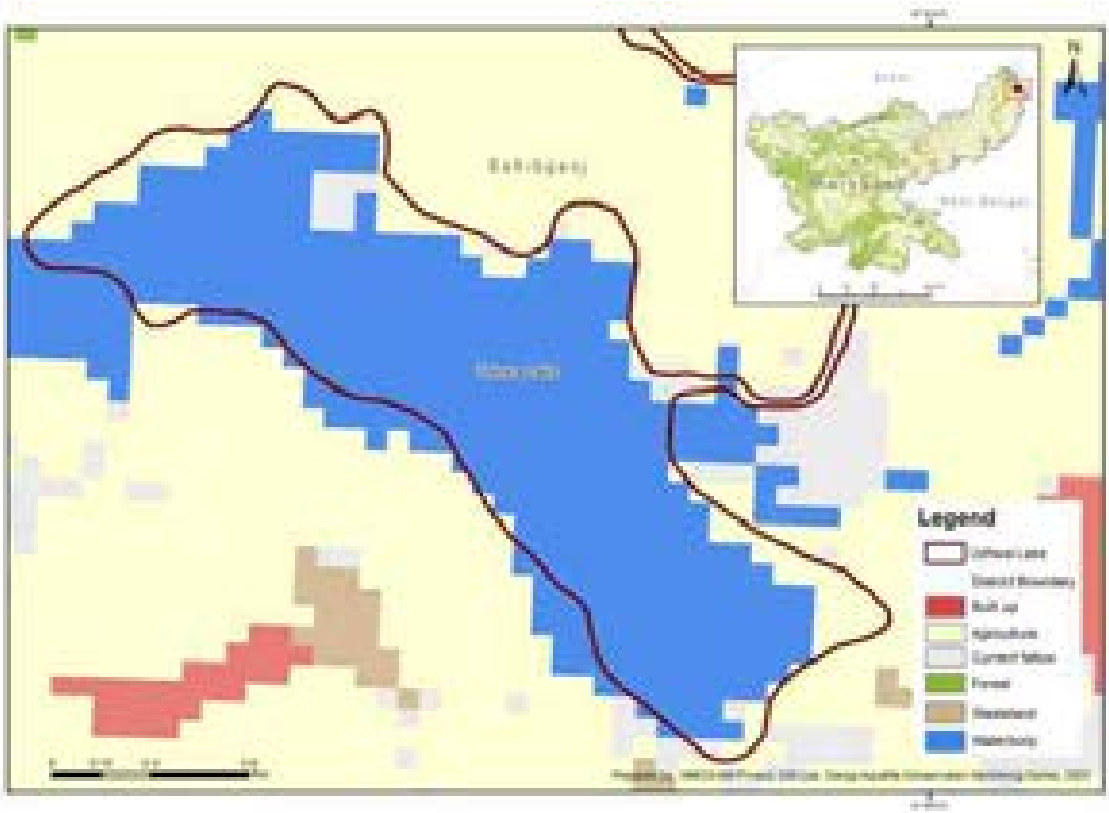


Figure 3.49. Land Use and Land Cover Map of Udhwa Wetland

Altogether, 272 individuals of 37 water and water-associated bird species were recorded from the Udhwa Wetland, belonging to 9 orders, 16 families, and 29 genera in three sampling points during one occasion (total survey effort of 3.32 hrs). Charadriiformes (7 species) was the most dominant order, followed by Anseriformes and Pelecaniformes (7 sp.) (Figure 3.50a). Anatidae (7 species) was the most dominant family, followed by Ardeidae (6 species), Alcedinidae, and Laridae (3 sp.) (Figure 3.50b). Out of 37 recorded species, only the greater adjutant (*Leptoptilos dubius*) was in the NT category, while the rest were in the LC category on the IUCN Red List.

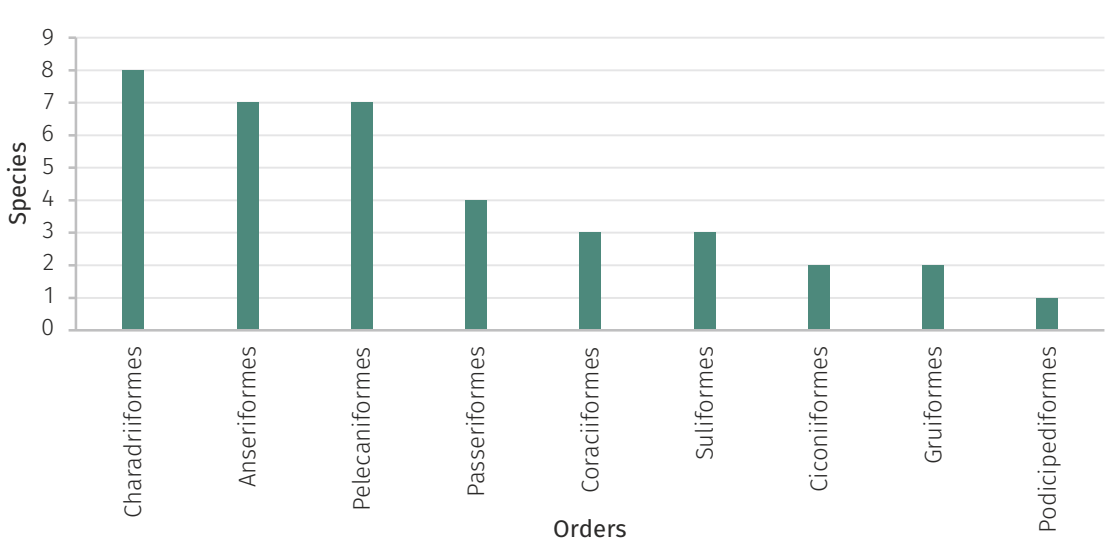


Figure 3.50a. Order-wise composition of species recorded in the Udhwa Wetland

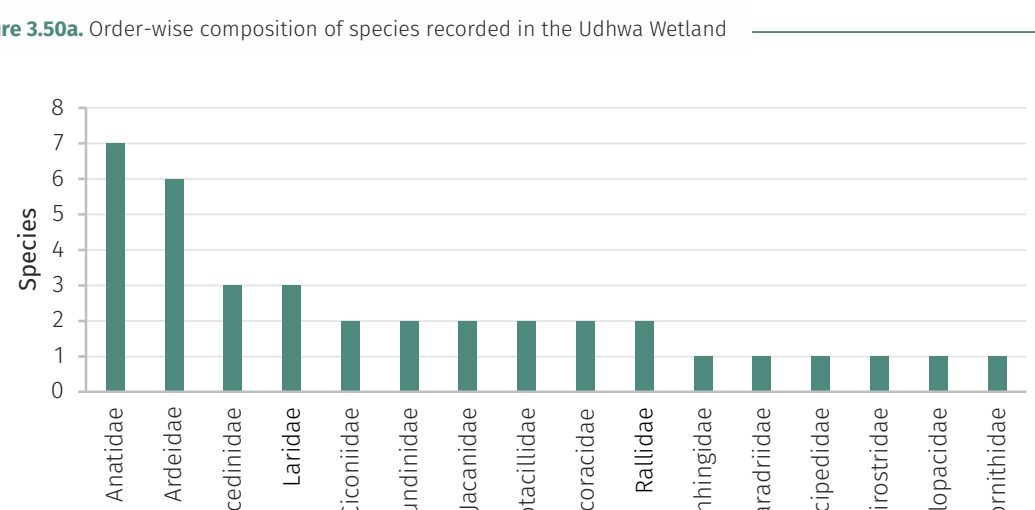
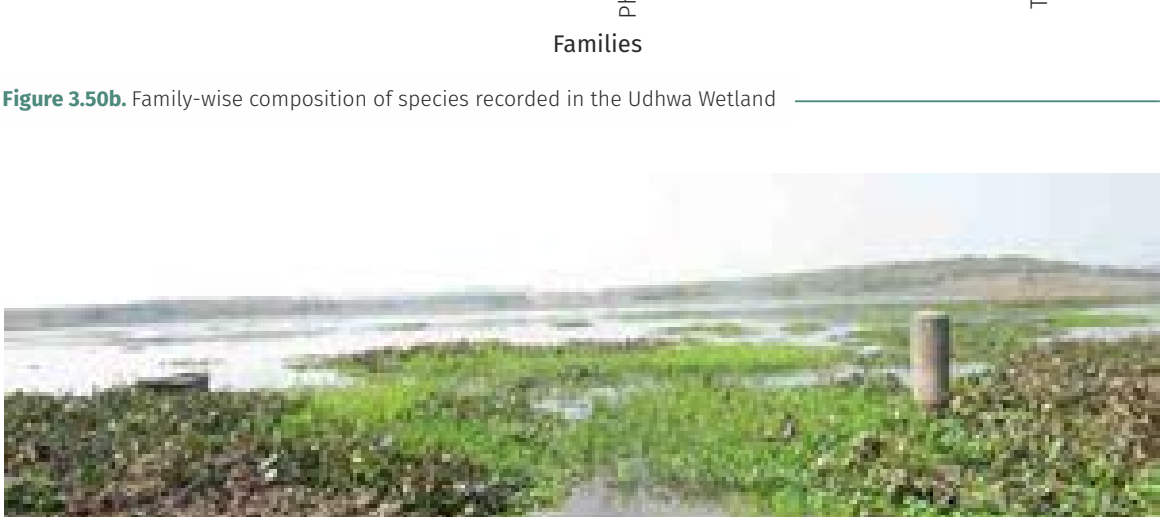


Figure 3.50b. Family-wise composition of species recorded in the Udhwa Wetland



Richness and Diversity

Of three sampling points, the species richness of water and water-associated species was found highest in point 3 (20 species), followed by point 1 (17 sp.) and point 2 (9 sp.) (Figure 3.51). Overall species diversity was highest in point 3 (2.65), followed by point 1 (2.10) and point 2 (1.74) (Figure 3.51).

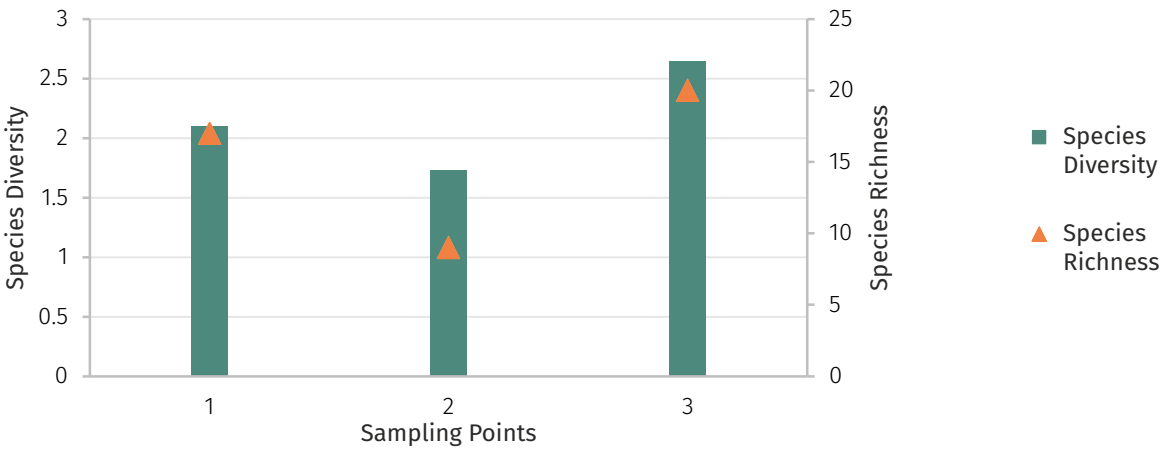


Figure 3.51. Species richness and diversity (*H'*) of water and water-associated birds in the Udhwa Wetland

Waterbirds

Of 37 species recorded during the survey, 30 species (81.08%) were waterbirds. The highest richness (18 species) and diversity value (2.54) of waterbird species was recorded in point 3, followed by point 1 (12 sp., *H'*= 1.96) and point 2 (9 sp., 1.74).

Water-associated Birds

Only 7 species out of 37 species (18.92%) were water-associated. The highest species richness (5 Species) and diversity value (1.43) of water-associated birds was in point 1, followed by point 3 (2 sp., 0.45), while no species were recorded in point 2.

Relative abundance

In terms of the combined relative abundance of water and water-associated species, the little cormorant (18.28%) was the most abundant, followed by the grey-headed swamphen (*Porphyrio poliocephalus*) (14.78%) and little egret (13.17%), while nine species (0.27%) were least abundant. Point 1 (64.25%) was recorded as the most abundant sampling point, followed by point 3 (22.58%) and point 2 (13.17%).

Waterbirds

Of 30 waterbird species, the little cormorant (19.05%) was the most abundant, followed by the grey-headed swamphen (15.41%) and little egret (13.73%), while mallard, black-winged stilt, wood sandpiper, oriental darter, and grey heron (0.28%) were least abundant. Point 1 (64.43%) was recorded as the most abundant point, followed by point 3 (21.85%) and point 2 (13.73%).

Water-associated Birds

Out of the seven water-associated species, the barn swallow (33.33%) was the most abundant, followed by citrine wagtail (26.67%) and white wagtail (13.33%). Point 1 (60%) was recorded as the most abundant point, followed by point 3 (40%).

Feeding Guild and Residential Status

Overall, Carnivore (59.46%, 22 species) was the most dominant feeding guild, followed by Herbivore/Carnivore (24.32%, 9 sp.), Carnivore/Herbivore, and Insectivore (5.41%, 2 sp.). Omnivore and Insectivore (2.70%, 1 sp.) were the least dominant feeding guild (Figure 3.52). The Udhwa wetland was dominated by R/LM (41%, 15 species), followed by WM (22%, 8 species), R/WM (19%, 7 species), and R (8%, 13 species). In comparison, R/LM/SM, R/WM/AM, R/WM/PM and R/WM/SM groups were represented by only one species each (3%).

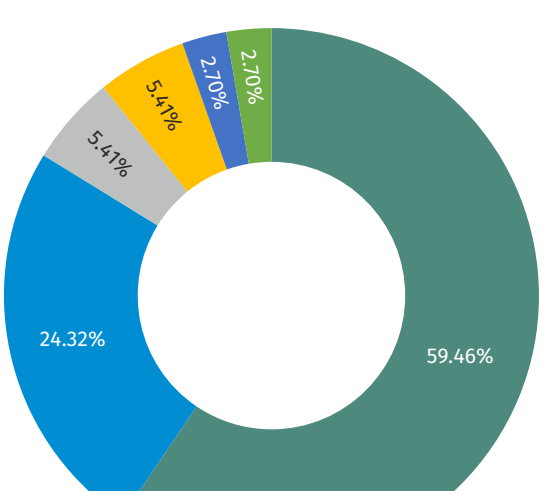


Figure 3.52. Proportion of the different Feeding Guilds of the water and water-associated birds in the Udhwa Wetland

Physio-chemical properties and anthropogenic stressors

The average pH value of the Udhwa wetland was 7.58 ±1.04 (6.76- 8.75), while salinity was 0.13 ppt ±0.12 (<0.2 ppt). The mean air temperature of the wetland was recorded as 25 °C ±2, and water temperature as 24.83°C ±2.93. Fish boats and nets were found at all three sampling points during wetland monitoring, and fishing activities varied seasonally. No sign of plastic debris or grazing was observed. Vegetation/biomass extraction was found to be an occasional practice in the wetland. Floating vegetation cover was recently removed from the waterbody, and no drainage, industrial outlets, power lines, mining, grazing, or washing were observed in the Udhwa wetland. Invasive species, *Pontederia crassipes,* covered 20-50% of the entire wetland area.

2. BRAHMA JAMALPUR WETLAND

Brahma Jamalpur (also known as Berhale Jheel) wetland is a natural wetland, covering 4.1 sq. km area. It is part of the Udhwa Lake Wildlife Sanctuary and lies at a mean elevation of 45 meters above sea level (m asl). The Bramha Jamalpur Lake (24°59' 35.75" N; 87°48' 31.32" E) is located in the Rajmahal Sub-Division of Sahebganj District in the state of Jharkhand (Figure 3.53). It is situated 6 km away from the sub-district headquarters of Rajmahal (tehsildar office) and 50 km away from the district headquarters of Sahibganj. Brahma Jamalpur falls within the 7-Gangetic Plain Biogeographic zone and 7B-Lower Gangetic Plain Biogeographic province (Rodgers et al. 2000).

Five points were selected for studying the waterbird congregation in the Brahma Jamalpur Wetland.

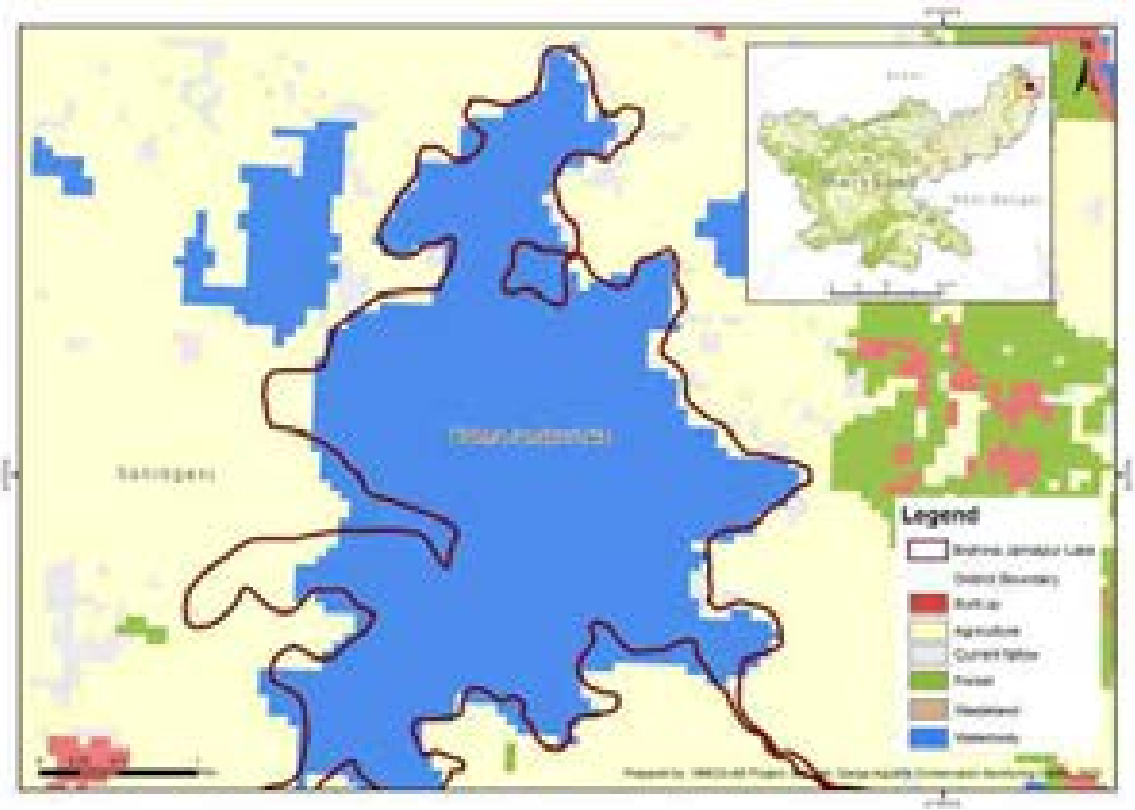


Figure 3.53. Land Use and Land Cover Map of Brahma Jamalpur Wetland

A total of 870 individuals of 31 water and water-associated bird species were recorded from Brahma Jamalpur, belonging to 9 orders, 12 families, and 25 genera at five sampling points during one occasion (Total survey effort of 3.4 hrs). Pelecaniformes (7 species) was the most dominant order, followed by Anseriformes and Charadriiformes (5 sp.) (Figure 3.54a). The Ardeidae (7 species) was the most dominant family, followed by Anatidae (5 species) and Scolopacidae (4 species) (Figure 3.54b). Out of 31 recorded species, the Asian woolly-necked stork and the lesser adjutant were listed as NT species, while the rest were listed as LC on the IUCN Red List.

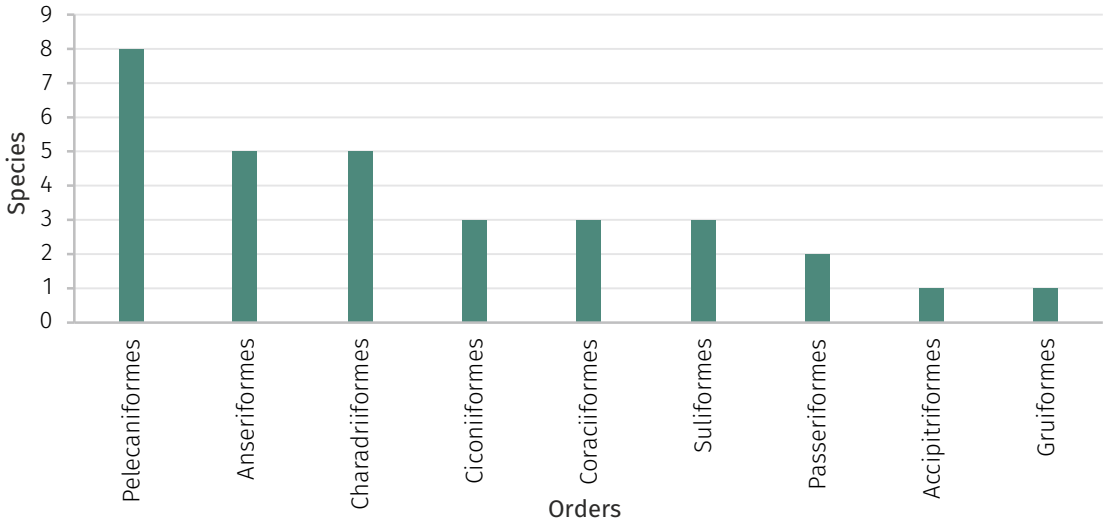


Figure 3.54a. Order-wise composition of species recorded in the Brahma Jamalpur Wetland

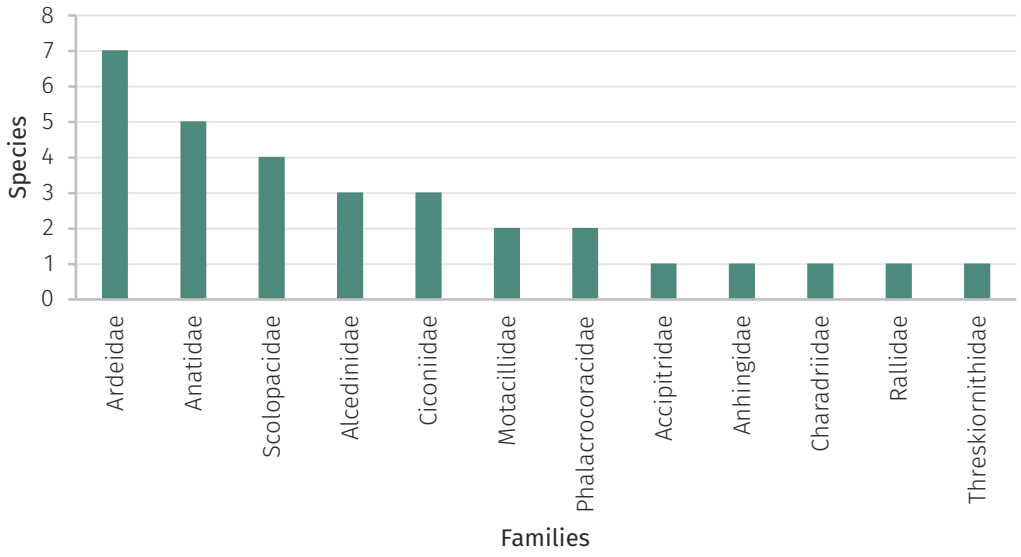


Figure 3.54b. Family-wise composition of species recorded in the Brahma Jamalpur Wetland

Richness and Diversity

Of the five sampling points, the overall species richness of water and water-associated species was found to be highest at point 1 (12 species), followed by point 2 (10 species) and point 5 (9 species) (Figure 3.55). Overall species diversity was found to be highest at point 1 (2.34), followed by point 2 (1.89) and point 5 (1.81) (Figure 3.55).

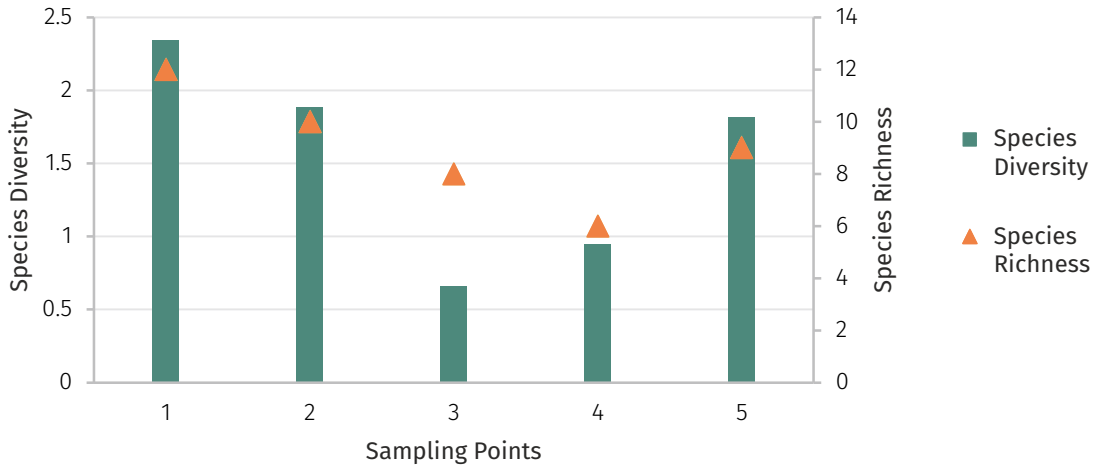


Figure 3.55. Species richness and diversity (*H'*) of water and water-associated birds in the Brahma Jamalpur Wetland

Waterbirds

Of the 31 species recorded during the survey, 25 species (83.78%) were waterbirds. The highest richness of waterbird species was recorded at point 5 (8 species), followed by points 1, 2, and 3 (7 sp.). The highest species diversity value was found at point 1 (1.79), followed by point 5 (1.74) and point 2 (1.60).

Water-associated Birds

Only 6 out of 31 species (16.22%) were water-associated species. The highest species richness (5 Species) and diversity value (1.61) of water-associated birds was at point 1, followed by point 2 (3 sp., 1.04). Only one species was found at each point(s) 3 and 5, while no species was found at point 4.

Relative abundance

In terms of the combined relative abundance of water and water-associated species, the Asian openbill (49.43%) was the most abundant, followed by the gadwall (28.74%) and grey-headed swamphen (9.54%), while seven species (0.11%) were least abundant. Point 4 (45.40%) was recorded as the most abundant point, followed by point 3 (43.56%) and point 5 (4.94%), while point 1 (1.95%) was the least abundant.

Waterbirds

Of the 25 waterbird species, the Asian openbill (50%) was the most abundant, followed by the gadwall (29.10%) and grey-headed swamphen (9.66%), while common sandpiper, green sandpiper, black-crowned night heron, and little egret (0.12%) were least abundant. Point 4 (45.98%) was recorded as the most abundant point, followed by point 3 (44%) and point 5 (4.89%), while point 1 (1.40%) was the least abundant.

Water-associated Birds

Out of the six water-associated species, the white-throated kingfisher (36.36%) was the most abundant, followed by the common kingfisher (18.18%). Sampling Point 1 (45.45%) was the most abundant, followed by point 2 (36.36%). Whereas points 3 and 5 (9.09%) were least abundant, and point 4 had no species.

Feeding Guild and Residential Status

Overall, Carnivore (80.65%, 25 species) were the most dominant feeding guild, followed by Herbivore/Carnivore (12.90%, 4 sp.), while Carnivore/Herbivore (3.23%, 1 sp.) and Herbivore (3.23%, 1 sp.) were the least (Figure 3.56).

Almost half of the species fell within the category of R/LM (48%, 15 species), followed by WM (19%, 6 sp.), R/WM (13%, 4 sp.), and R (10%, 3 sp.). While three groups, R/AM, R/WM/AM, and R/WM/PM were represented by only one species each (3%).

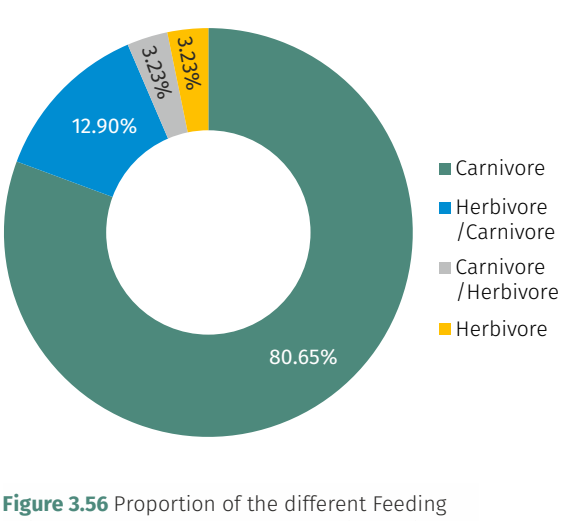


Figure 3.56 Proportion of the different Feeding Guilds of the water and water-associated birds in the Brahma Jamalpur Wetland

Physio-chemical properties and anthropogenic stressors

The average pH (7.1) and salinity (0.2 ppt) values were measured uniform across all five sampling points. The air temperature of the wetland was recorded as 27°C, and the water temperature was 26.2 °C. Among anthropogenic pressures, a couple of boats were recorded at three sampling points, which appeared to be a seasonal practice. Agricultural practice was prominent in all sampling points. Stressors such as drainage, industrial/storm outlets, water extraction pumps, electric power lines, mining, washing/bathing, and grazing were absent from the wetland. The waterbody was colourless and odourless. Floating macrophytes were found to be in a small proportion of the wetland, mostly infested with *Pontederia crassipes*.

3. KONAR DAM

The Konar Dam, built on the Konar River, lies at a mean elevation of 438 m above sea level. The Konar dam reservoir is spread over an area of 27.92 sq km, but its catchment is 997 sq. km and is situated in Hazaribagh district of Jharkhand (23°55' 44.70" N and 85°45' 41.16" E), just 30 km above the confluence of the Damodar and Konar rivers (Figure 3.57). The reservoir falls within the 6-Deccan Peninsula biogeographic zone and 6B-Deccan Peninsula-Chotta Nagpur province (Rodgers et al. 2000). The dam was primarily constructed to fulfil water requirements for the Bokaro thermal plant and other industries, along with flood control and irrigation (PSC 2020; Chaudhuri et al. 2015). According to the Census of India (2011), the Bishnugarh block has a total of 26,309 households, with a population of 156,477 and a sex ratio of 980 females per 1,000 males. The literacy rate of the block is 62% (male 76%, female 48%) for the age group above six years. Two points were selected for studying the waterbird congregation in the Konar Dam.

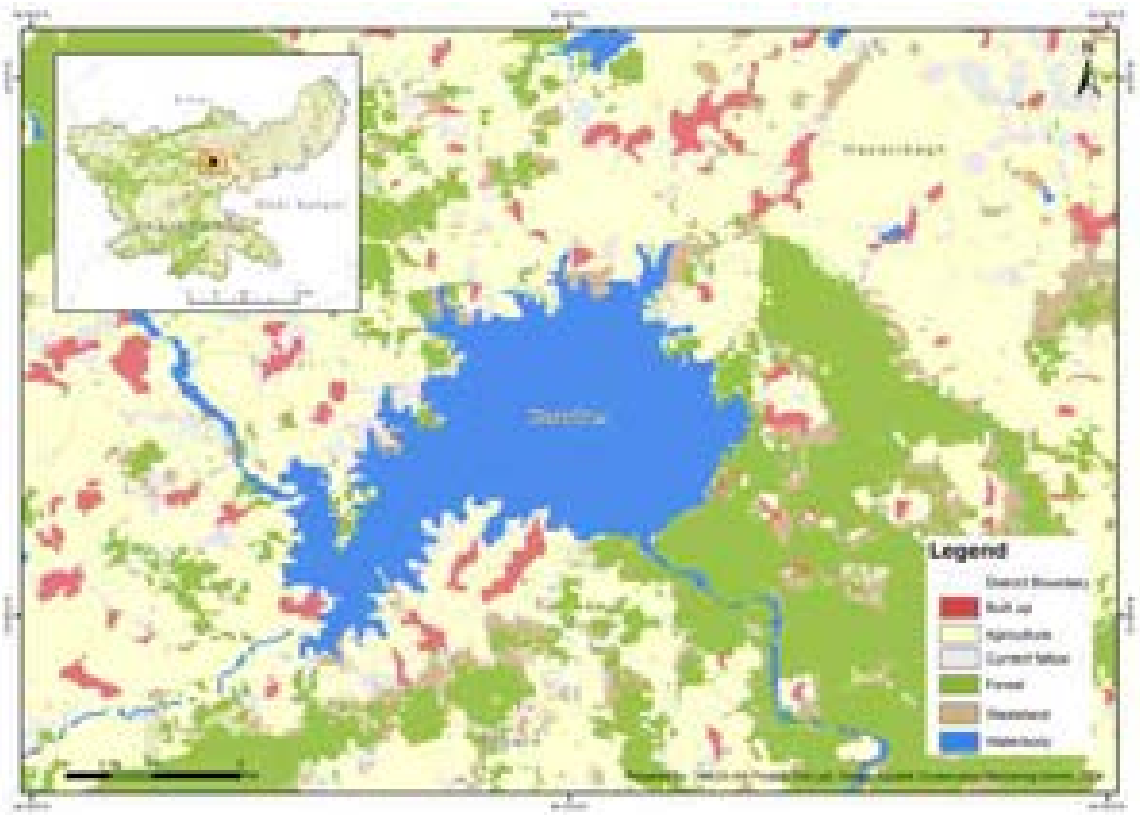


Figure 3.57. Land Use and Land Cover Map of Konar Dam

A total of 273 individuals of 9 waterbird species were recorded from the Konar Dam, belonging to 6 orders, 7 families, and 9 genera from two sampling points during one occasion (total survey effort = 1.99 hrs). Anseriformes (3 species) was the most dominant order, followed by Charadriiformes (2 sp.), and the rest had only one species (Figure 3.58a). Anatidae (2 species) was the most dominant family, and the rest were represented by one species (Figure 3.58b).

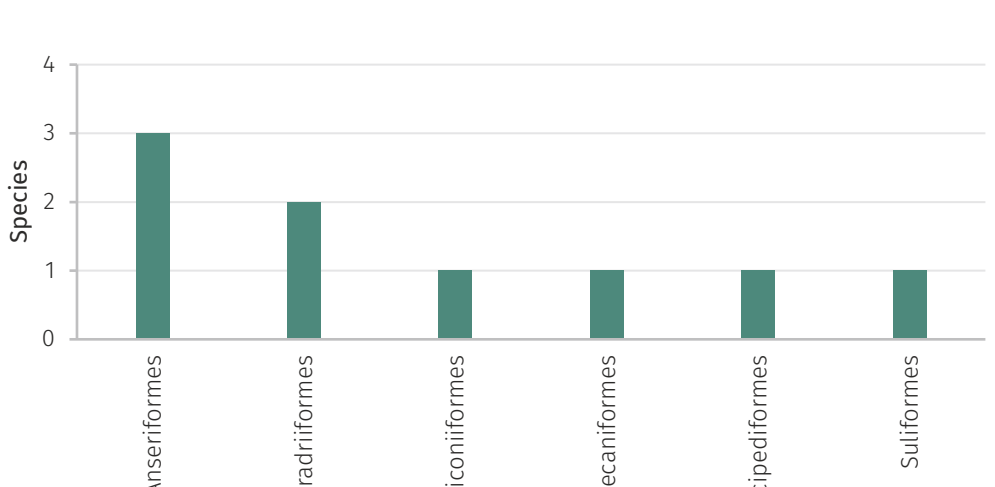


Figure 3.58a. Order-wise composition of species recorded in the Konar Dam

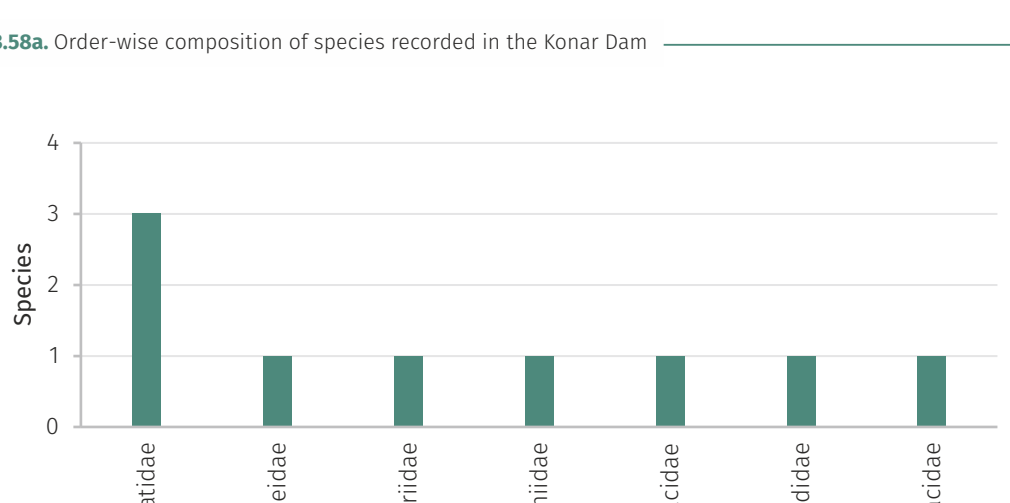


Figure 3.58b. Family-wise composition of species recorded in the Konar Dam

Richness and Diversity

Of two sampling points, the overall species richness of water and water-associated species was found to be highest at point 1 (8 species), followed by point 2 (3 species). Overall species diversity was found to be highest at point 2 (1.04), followed by point 1 (0.99) (Figure 3.59).

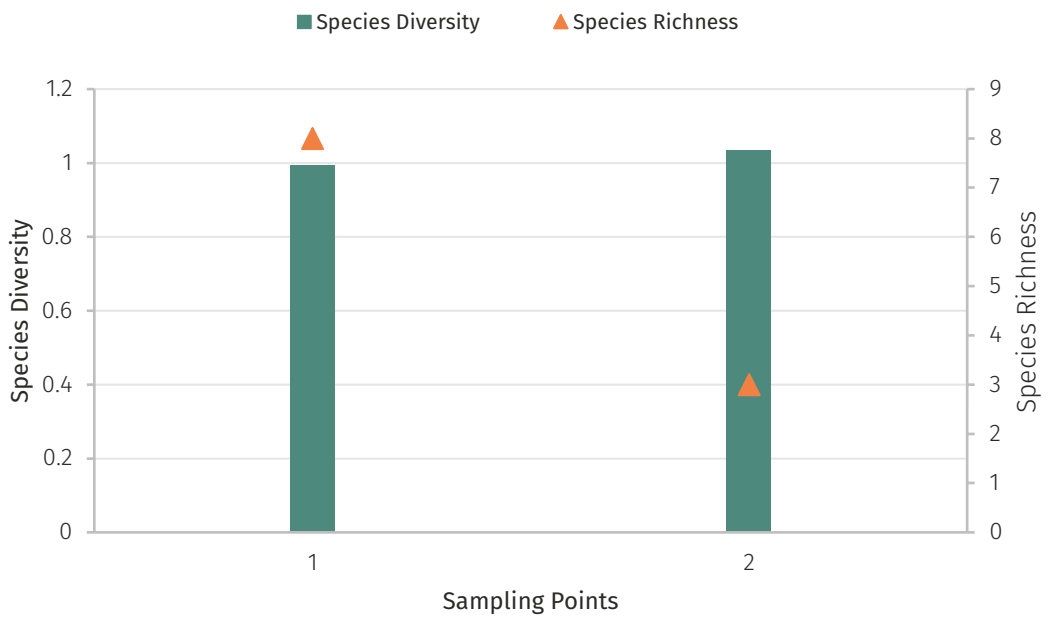


Figure 3.59 Species richness and diversity (*H'*) of water and water-associated birds in the Konar Dam

Relative abundance

Of the nine waterbird species, the gadwall (70.33%) was the most abundant, followed by the northern pintail (10.62%) and little cormorant (5.86%), while the marsh sandpiper and red-wattled lapwing (0.37%) were least abundant. Point 1 (95.97%) was recorded as the most abundant point, followed by point 2 (4.03%).

Feeding Guild and Residential Status

Overall, Carnivore (55.56%, 5 species) were the most dominant feeding guild, followed by Herbivore/Carnivore (22.22%, 2 sp.) and Herbivore/Carnivore (22.22%, 2 sp.) (Figure 3.60). Most of the species fall within the group of WM (44%, 4 species), followed by R/LM (33%, 3 sp.), R/WM (11%, 1 species) and R/AM (11%, 1 sp.). Anatidae was found to be the most dominant family of the WM group.

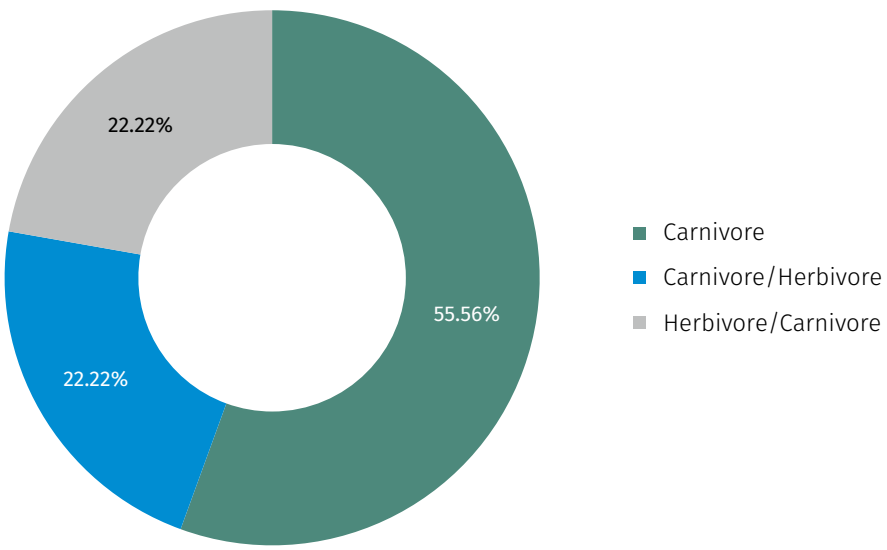


Figure 3.60 Proportion of the different Feeding Guilds of the water and water -associated birds in the Konar Dam

Physio-chemical properties and anthropogenic stressors

The Konar dam was sampled at two points, and the average pH value of the water was observed to be 7.8 ± 0.09, while the salinity was 0.06 ppt. The DO value of water was measured as 8.83 mg/L. The mean air temperature was 27.3°C and the mean water temperature was 22.7°C. Agriculture, fishing, drainage, outlet, water extraction pumps, electric power lines and mining activities were not found at the sampling sites. Washing/bathing were found to be rare activities in the dam, and grazing was observed at one of the sites. The water was odourless but greenish, perhaps indicating the presence of algae. No floating vegetation or invasive species were recorded from the selected points of wetland.

4. PATRATU DAM

Patratu is an artificial reservoir that lies between Latitude 23°36'13"N to 23°36'18"N and Longitude 85°16'50"E to 85°18'54"E at a mean elevation of 420 m asl in Ramgarh district of Jharkhand (Figure 3.61). The reservoir located on the Nalkarni River, a tributary of the Damodar River, spans an area of 212.38 sq km (Pandey et al. 2016). It falls within the 6-Deccan Peninsula biogeographic zone and the 6B-Deccan Peninsula-Chotta Nagpur province (Rodgers et al. 2000). There are 14 villages around the dam, namely, Talapur Talatanr, Palani, Netua, Barghutua, Melani, Chetma, Hariharpur, Arasaha, Jarad, Kini, Rasda, Gegda, Labga, and Bartua. These villages have 3,114 households, with a population of 15,826 and a sex ratio of 931 females per 1,000 males (Census of India 2011). The Chetma village has the least number of households (28), with a population of 139, while the Talapur Talatanr village has the highest number of households (594), with a population of 2,946. The literacy rate in the 14 villages is 68% (male 79%, female 56%) for the age group above six years. Two points were selected for studying the waterbird congregation in the Patratu Dam.

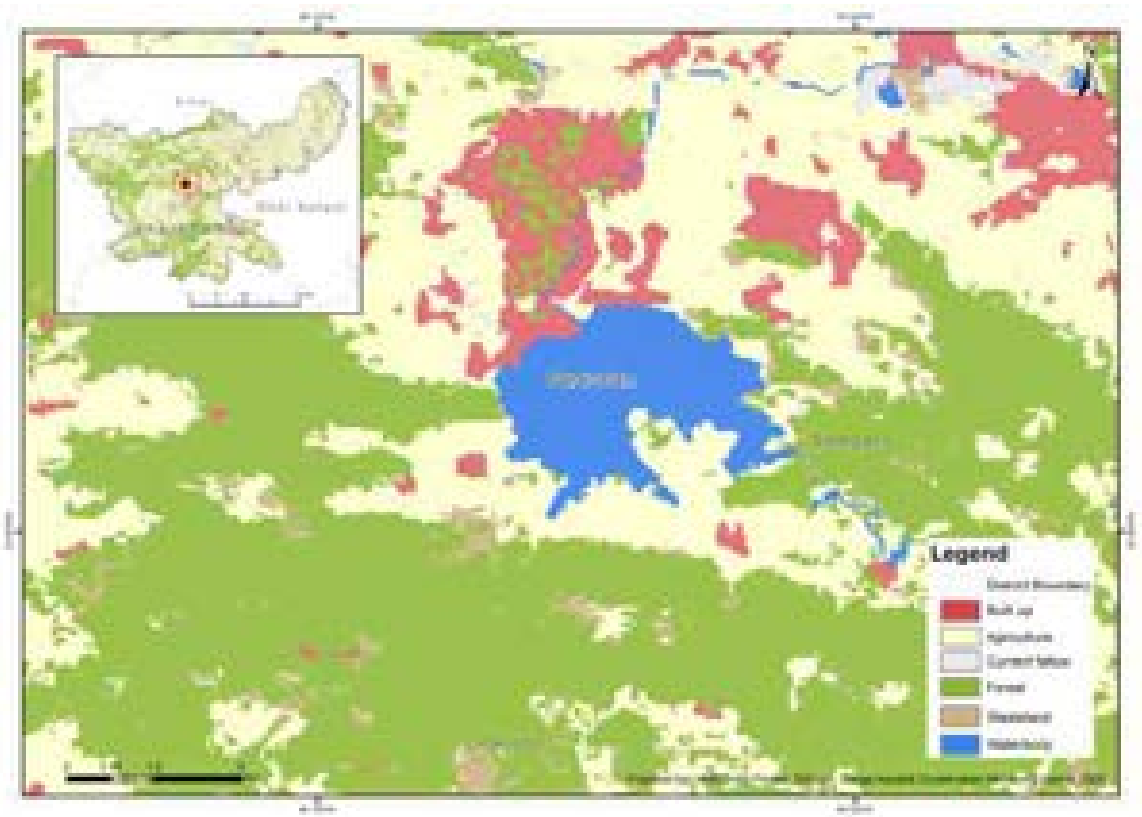


Figure 3.61. Land Use and Land Cover Map of Patratu Dam

During the present survey, a total of 69 individuals of 7 water and water-associated bird species were recorded from the Patratu Dam, belonging to 5 orders, 5 families, and 7 genera at two sampling points during a single occasion (total survey effort = 1.99 hrs). Pelecaniformes and Suliformes (2 species) were the most dominant order, followed by Charadriiformes, Ciconiiformes, and Passeriformes (1 sp.) (Figure 3.62a). Ardeidae and Phalacrocoracidae (2 species) were the most dominant families, followed by Ciconiidae, Laridae, and Hirundinidae (1 species) (Figure 3.62b). Of the 7 bird species, six were waterbirds and one was water-associated.

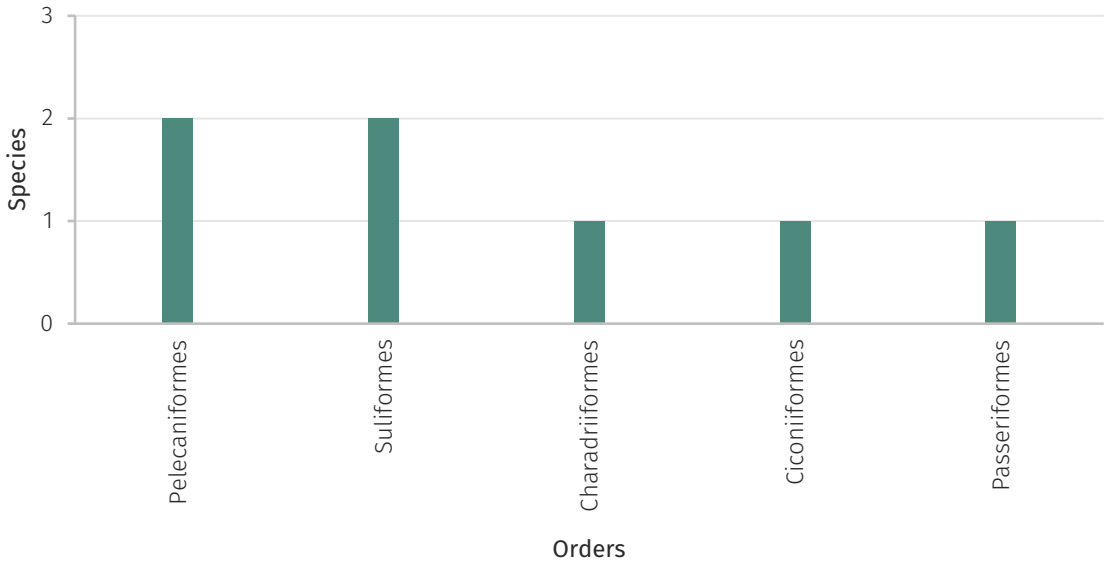


Figure 3.62a. Order-wise composition of species recorded in the Patratu Dam

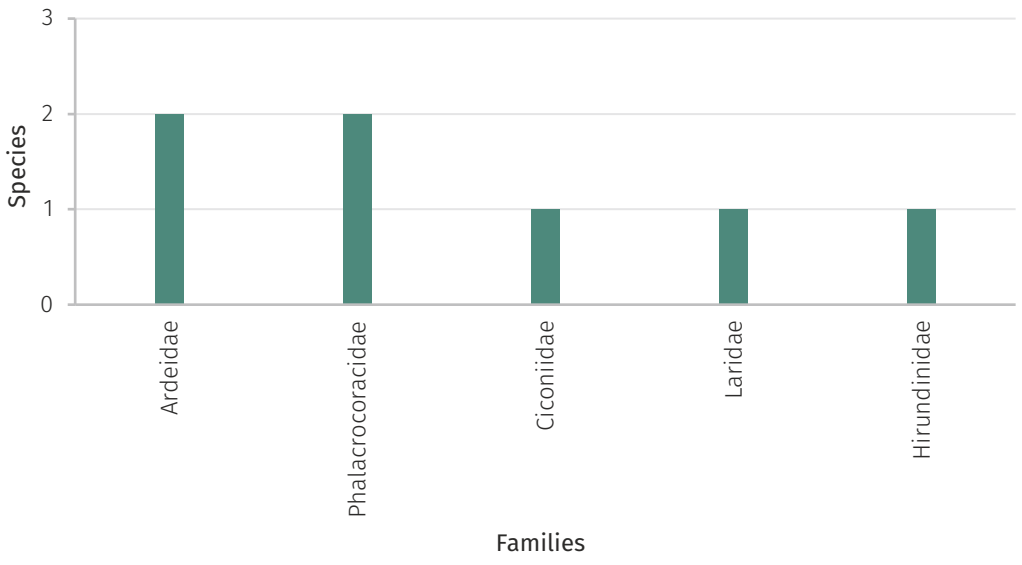


Figure 3.62b. Family-wise composition of species recorded in the Patratu Dam

Richness and Diversity

Out of the two sampling points, the overall species richness and diversity values of water and water-associated species were found to be highest at point 1 (5 species, 1.35), followed by point 2 (2 sp., 0.19) (Figure 3.63).

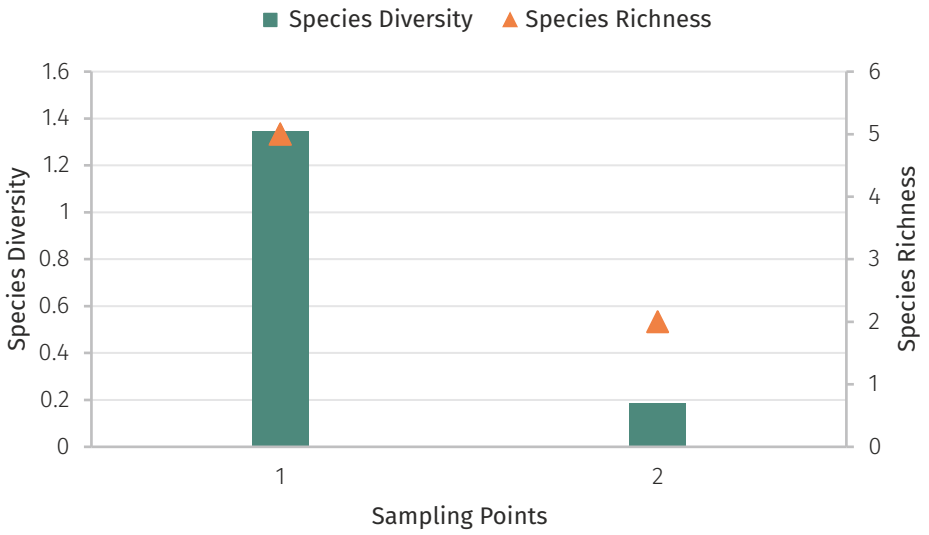


Figure 3.63. Species richness and diversity (*H'*) of water and water-associated birds in the Patratu Dam

The highest richness (5 species) and diversity (1.35) of waterbird species were recorded at point 1, while only one species was recorded at point 2.

Relative abundance

In terms of the combined relative abundance of water and water-associated species, the brown-headed gull (59.42%) was the most abundant, followed by the little cormorant (18.84%) and great cormorant (7.25%), while the Asian openbill and eastern cattle egret (2.90%) were least abundant. Point 2 (62.32%) was the most abundant sampling point, followed by point 1 (37.68%).

Waterbirds

Of the six waterbird species, the brown-headed gull (61.19%) was the most abundant, followed by the little cormorant (19.40%) and great cormorant (7.46%), while the Asian openbill and eastern cattle egret (2.99%) were least abundant. Point 2 (61.19%) was recorded as the most abundant point, followed by point 1 (38.81%).

Feeding Guild and Residential Status

Only two feeding guilds were present in the Patratu Dam, Carnivore (85.71%, 6 species) and Insectivore (14.29%, 1 sp.) (Figure 3.64). Out of seven species, three species each (43%) were R/WM and R/LM. Only one species (14%) represented R/AM.

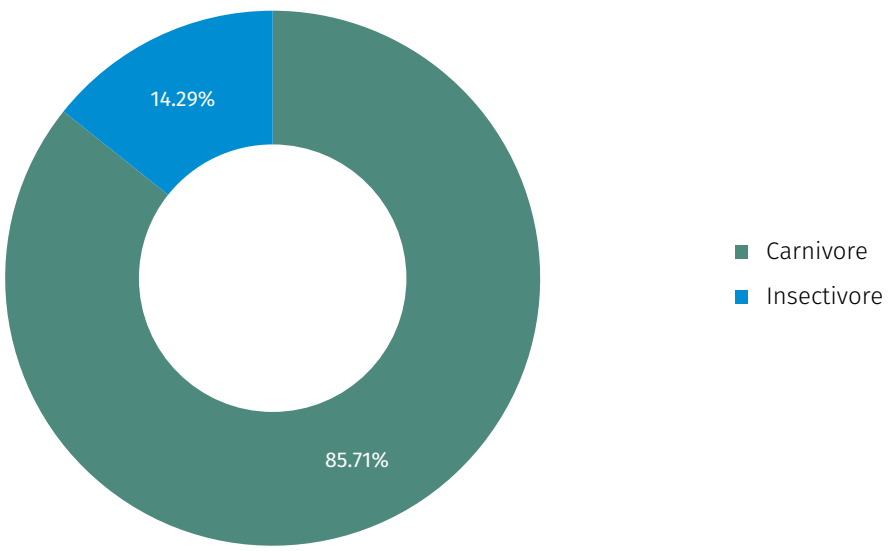


Figure 3.64 Proportion of the different Feeding Guilds of the water and water-associated birds in the Patratu Dam

Physio-chemical properties and anthropogenic stressors

The value of pH was measured as 7.97, salinity as 0.07 ppt, and DO as 12.4 mg/l, from the two sampling sites of Patratu dam. The average air temperature was recorded as 28.8 °C, and the water temperature was 24.55 °C. Litter was found to be high in and around the wetland, and recreational boating was also observed. Fishing activities using boats and trap/drag nets were recorded from the dam. Vegetation covered about 50% of the wetland area at point 1, but no sign of biomass extraction was recorded. Hydrological connectivity remains intact throughout the year. Agriculture, drainage, outlet, water extraction pumps, electric power lines, grazing and mining activities were not observed at either of the sampling sites. Washing or bathing was a rare event. The water was greenish and odourless, indicating the presence of algae. *Pontederia crassipes*, an invasive species, infested 5-10% of both sampling sites.

3.1.5. WEST BENGAL

Located in the eastern region of India, the state of West Bengal is the mouth of the Ganga River, where it merges into the Bay of Bengal in Sundarbans. The state of West Bengal has four biogeographic zones, namely, the Himalaya (2C - Central Himalaya), the Gangetic Plain (7B - Lower Gangetic Plain), the Coast (8B - East Coast), and the Deccan Peninsula (6B - Chhota Nagpur). Biogeographic zones and provinces (Rodgers et al. 2000). West Bengal also holds a significant place in the richness of wetland biodiversity (Mukherjee 2008; SAC 2010). The wetlands of West Bengal provide essential breeding grounds, resting places, and feeding areas for thousands of migratory birds each year. The state has a total of 398,732 wetlands, which span approximately 11,773.535 sq. km. These wetlands comprise primarily tanks/ponds (383,995), followed by aquaculture ponds (5,307) and inland waterlogged areas (2,399) (Gupta et al. 2024). These wetlands are used for fish farming by the people. The state is relatively small in size, covering an area of 88,752 sq. km, but is densely populated, ranking among India's largest states in terms of human population. To date, the state has two designated Ramsar sites and 10 IBAs. A total of six wetlands were identified and surveyed in February and March 2024 (Figure 3.65).

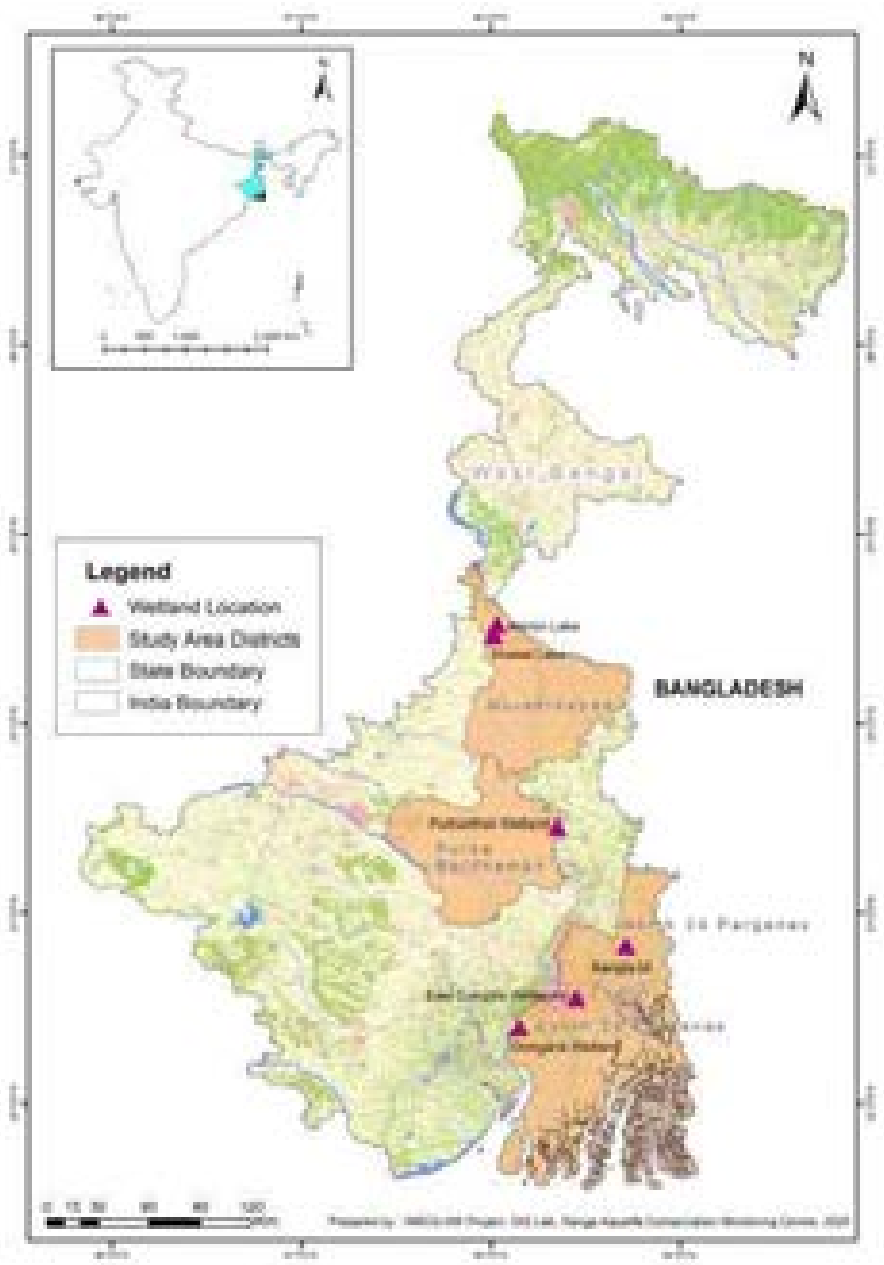


Figure 3.65 Map showing locations of select wetlands in West Bengal

During the present survey, a total of 25 water and water-associated bird species were recorded from the six wetlands of West Bengal, of which 22 were waterbirds and 3 were water-associated bird species (Annexure 1). All the bird species recorded were listed as LC in the IUCN Red List. Among the surveyed wetlands in West Bengal, Sheeal Lake was found to be the most diverse wetland in terms of water and water-associated birds. The average species diversity of Sheeal Lake was 1.74±0.31, Purbasthali wetland (1.72±0.31), Ahiran wetland (1.56), Dongaria wetland (1.50), East Kolkatta wetland (1.31±0.04), and Nangla Beel wetland (1.19) (Figure 3.66).

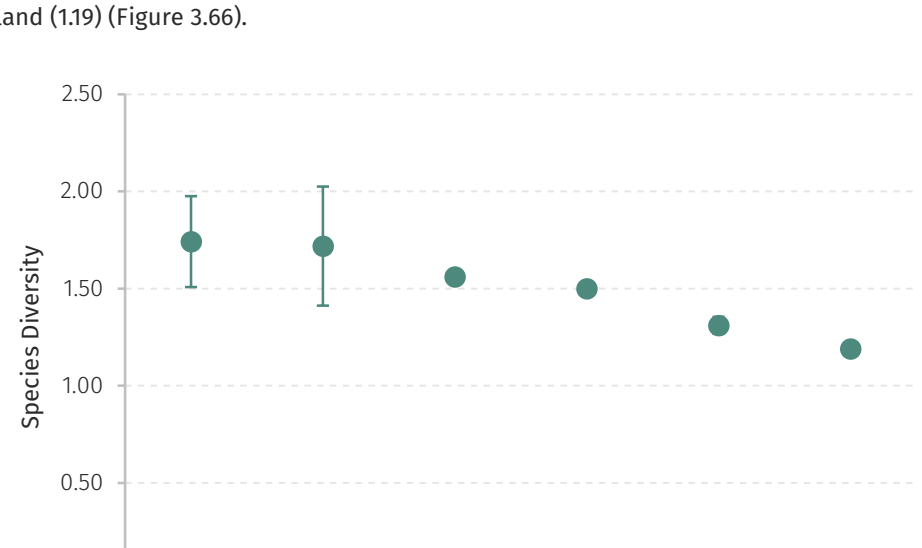


Figure 3.66 Average species diversity (*H'*) of water and water-associated birds in the surveyed wetlands of West Bengal

1. AHIRAN WETLAND (AHIRON)

Ahiran, a perennial freshwater wetland lake, is located between 24°52'31.03" N, 88° 03'42.38" E and 24°52'90.97" N, 88° 02'98.18" E at an elevation of 38 m asl near Ahiran village in Suti I CD block under Jangipur Subdivision of Murshidabad district in the state of West Bengal (Figure 3.67). This perennial wetland is near the Farakka Feeder Canal and Falgu River. It spreads over 0.06 sq. km during the rainy season, and in the dry season, the area decreases to around 0.055 sq. km (Mistry and Mukherjee 2015). The wetland falls within the 7-Gangetic Plain Biogeographic zone and 7B-Lower Gangetic Plain biogeographic province (Rodgers et al. 2000).

The Ahiran village is located in the vicinity of the wetland and has a total of 3,483 households with a population of 17,079 and a sex ratio of 965 females per 1,000 males (Census of India 2011). The literacy rate of the village is 66% (male 72%, female 61%) for the age group above six years. Sampling was undertaken at one location in the Ahiran Wetland.

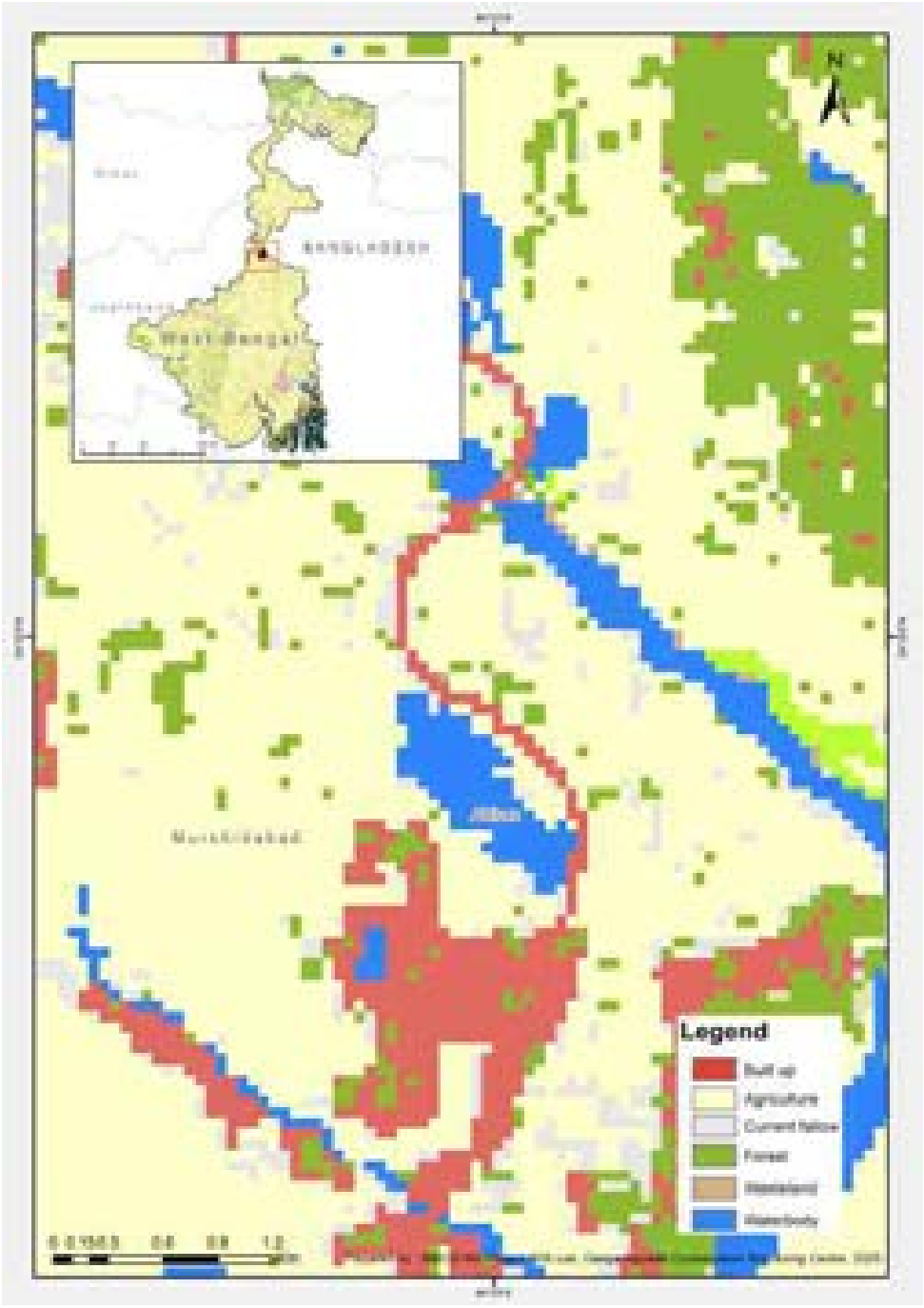


Figure 3.67. Land Use and Land Cover Map of Ahiran Wetland, West Bengal

A total of 27 individuals of 6 waterbird species were recorded from one sampling point of the Ahiran wetland. These bird species belonged to 5 orders, 5 families, and 6 genera (total survey effort = 0.83 hrs). Charadriiformes (3 species) was the most dominant order, followed by Pelecaniformes, Suliformes, and Gruiformes (1 sp.) (Figure 3.68a). Jacanidae (2 sp.) was the most dominant family, followed by Ardeidae, Charadriidae, Phalacrocoracidae, and Rallidae (1 sp.) (Figure 3.68b). The overall species diversity was 1.56.

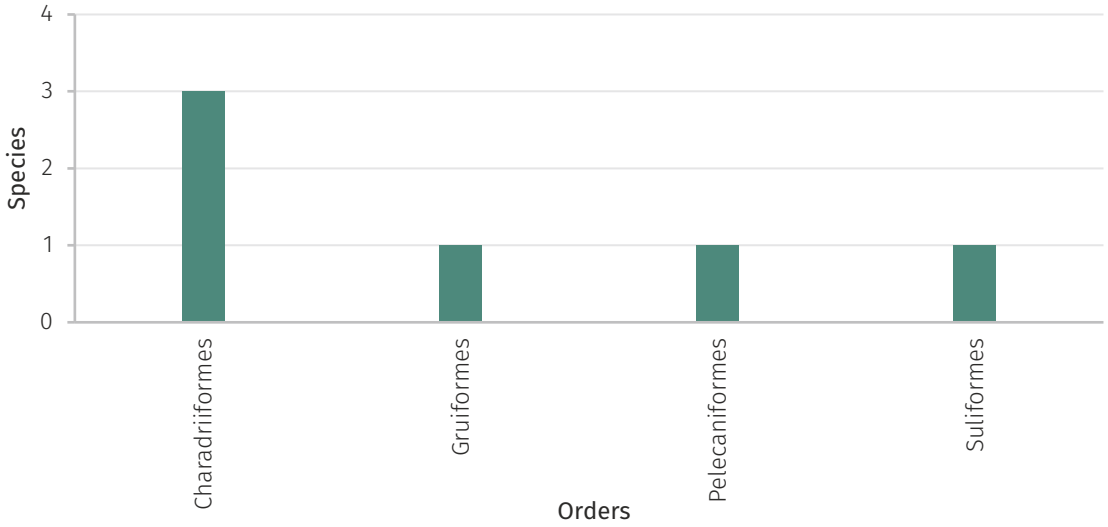


Figure 3.68a. Order-wise composition of species recorded in the Ahiran Wetland

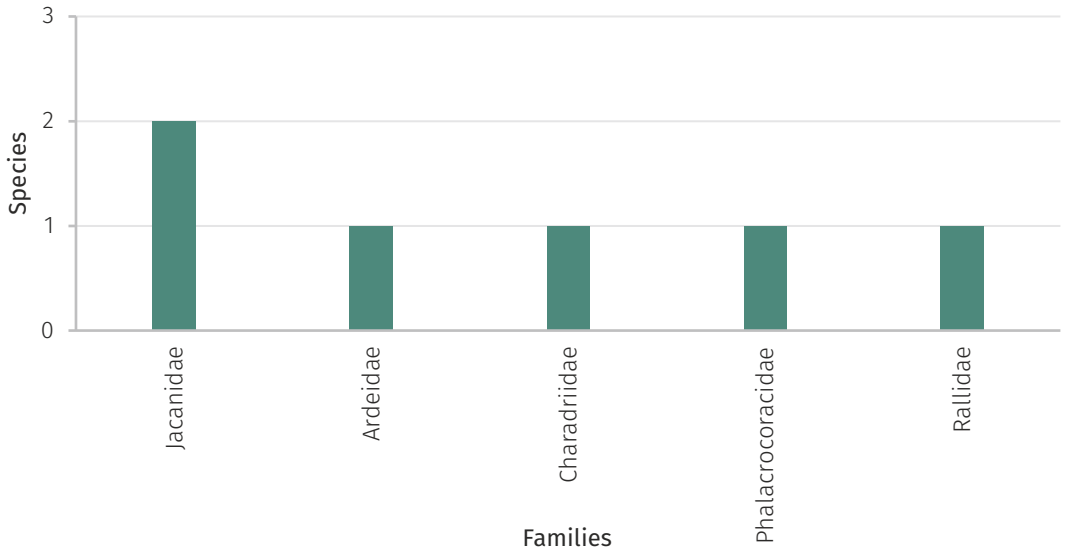


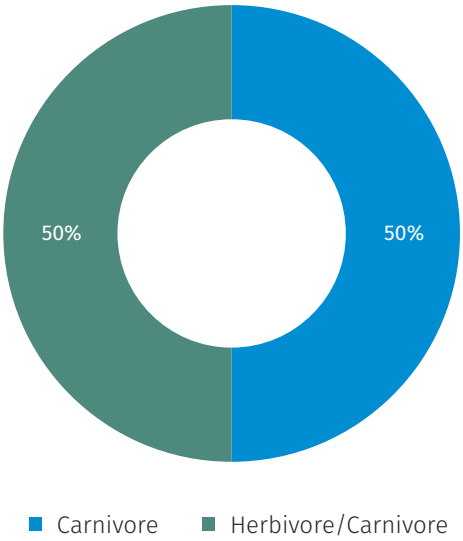
Figure 3.68b. Family-wise composition of species recorded in the Ahiran Wetland

Relative abundance

The grey-headed swamphen (44.44%) was the most abundant species, followed by the bronze-winged jacana (Metopidius indicus) and red-wattled lapwing (14.81%). The little cormorant and pheasant-tailed jacana (Hydrophasianus chirurgus) (7.41%) were least abundant.

Feeding Guild and Residential Status

Carnivore and Herbivore/Carnivore, only two feeding guilds were recorded in equal proportion (50%, 3 species) (Figure 3.69). In terms of residential status, half of the recorded species belonged to the group of R/LM (50%, 3 species), and R, R/AM, and R/LM/SM groups were represented by one species (17%) each.



Physio-chemical properties and anthropogenic stressors

The DO value of the wetland was recorded as 2.6 mg/l value of, pH as 7.59, salinity as 0.11 ppt, air temperature as 25 °C and water temperature as 18.8 °C. Agriculture was predominant around the wetland area, but fishing was absent. Submerged and free-floating vegetation covered 60% of the wetland area. Hydrological connectivity remained intact without any barrier. Anthropogenic stressors-drainage outlets, water pumps, powerlines, mining, grazing and bathing/washing were also not found in the Ahiran wetland. The odourless water was greenish. Invasive species, *Pontederia crassipes* covered ~60% of the wetland area.

Figure 3.69. Proportion of the different Feeding Guilds of the water and water-associated birds in the Ahiran Wetland

2. DONGARIA WETLAND

Dongaria wetland is situated at Madhya Raipur village in Budge Budge II block of South 24 Parganas district in West Bengal. It lies between 22° 24' 2.47" N, 88° 9' 3.18" E and 22°23' 47" N 88° 8' 59.79" E and covers around 0.76 sq. km area (Figure 3.70). It is adjacent to the Dongaria Water Treatment Plant and about 1 km from the Hooghly River. The wetland falls under the 8-Coast biogeographic zone and 8B-East Coast biogeographic province (Rodgers et al. 2000).

The wetland is surrounded by two villages (viz., Dongaria, Godakhali) and one town (viz., Dakshin Raipur). According to the Census of India (2011), Dongaria and Godakhali have a total household of 2,447 with a population of 10,150, while Dakshin Raypur has 3,351 households with 14,076 people. Dongaria and Godakhali have a sex ratio of 953 females per 1,000 males as compared to 943 females per 1,000 males in Dakshin Raipur. The literacy rate of the two villages and one town is 76% (male 81%, female 71%) for the age group above six years. Only one point was selected for studying the waterbird congregation in the Dongaria Wetland.

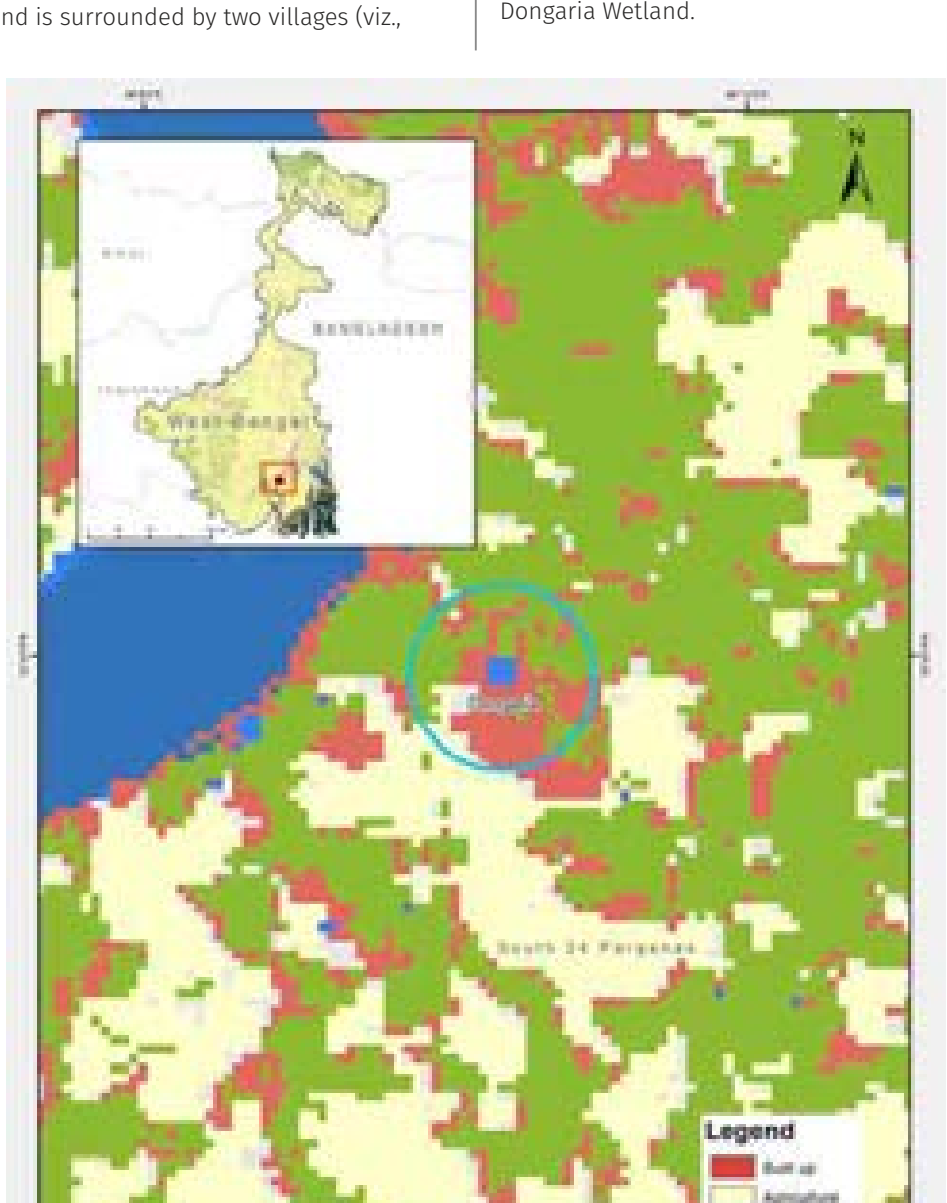


Figure 3.70. Land Use and Land Cover Map of the Dongaria Wetland, West Bengal

Altogether, only 11 individuals of 5 waterbird species were recorded from the Dongaria Wetland, belonging to 2 orders, 2 families, and 3 genera in one sampling point during one occasion (total survey effort = 1.16 hrs). Pelecaniformes (4 species) was the most dominant order, followed by Ciconiiformes (1 sp.) (Figure 3.71a). Ardeidae (4 species) was the most dominant family, followed by Ciconiidae (1 species) (Figure 3.71b). The overall species diversity value was 1.50.

In terms of relative abundance, the Asian openbill, eastern cattle egret, and Indian pond heron (44.44%) were the most abundant species, followed by the grey heron and purple heron (9.09%).

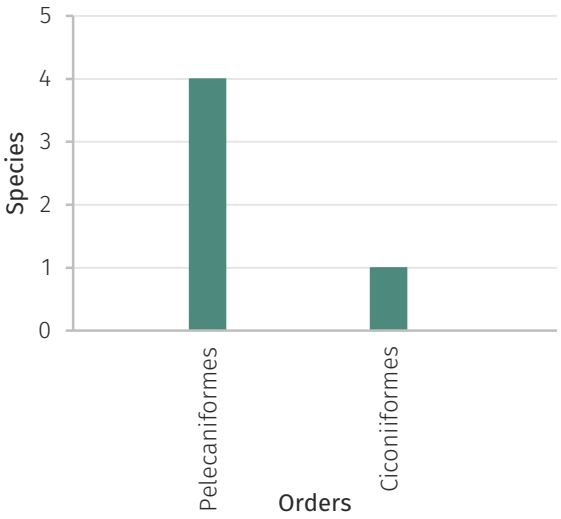


Figure 3.71a. Order-wise composition of species recorded in the Dongaria Wetland

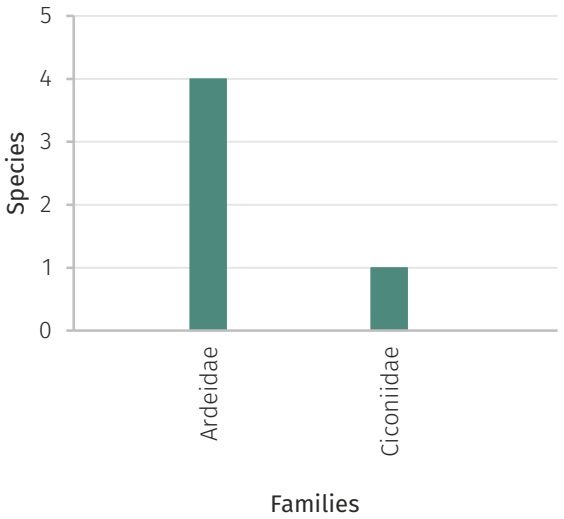


Figure 3.71b. Family-wise composition of species recorded in the Dongaria Wetland

Feeding Guild and Residential Status

All five species belonged to the Carnivore feeding guild. In terms of their residential status, half of the species belonged to the group of R/LM (50%, 3 species), and R/AM (25%) and R/WM (25%) were represented by one species each.

Physio-chemical properties and anthropogenic stressors

The DO value of the wetland was 3.4 mg/L, with a pH value of 7.52 and a salinity value of 0.15 ppt. Air temperature was recorded as 27.5 °C, and water temperature was 23.4 °C. Agriculture was restricted to a small part of the wetland, while fishing activity was absent. Wetland was almost (>50%) covered with floating-leaved emergent. The wetland receives treated water from the nearby sewage treatment plant (STP). Most of the stressors were found to be absent from the wetland, except one drainage, grazing activity and medium-level floating debris (thermocol and plastic). *Typha* spp., *Alocasia* spp. and *Pontederia crassipes* covered 50% of the wetland area.

3. EAST KOLKATA WETLANDS

One of India's most ecologically subsidised and resourceful wetlands is the East Kolkata wetland, which is located between 22°27' 00" N and 88°27' 00" E, and comprises an area of 125 sq km (EKWMA-WISA 2021) (Figure 3.72). The wetland lies at a mean elevation of 20 m asl. It falls within the 8-Coast biogeographic zone and 8B-East Coast biogeographic province (Rodgers et al. 2000). This wetland is a large aboriginal knowledge-based aquaculture system. It is a perfect example of a multiple-use yet ecologically rich wetland, which treats wastewater generated from the Kolkata megalopolis and uses it in pisciculture and agriculture (Ghosh and Das 2020). This wetland was designated as "Wetlands of International Importance" and added to the Ramsar list in 2002.

The East Kolkata Wetlands complex comprises 37 revenue villages, spanning two districts, North 24 Parganas and South 24 Parganas, in West Bengal (EKWMA-WISA 2021). The complex is governed by two Municipal Corporations and seven Gram Panchayats. The cumulative population of the 37 villages is 1.15 million, with a population density of 866 individuals per sq. km (Census of India 2011). The livelihoods of wetland communities are closely associated with wetland resources, as 74% of the working population relies on fish farming, agriculture, and horticulture for sustenance (EKWMA-WISA 2021). According to Fisheries Department records, the average annual fish production from the EKW from 2015 to 2020 is estimated at 22,000 MT (EKWMA-WISA 2021). The East Kolkata Wetlands complex has also facilitated a consistent production exceeding 50,000 MT of vegetables along with irrigation to 2,850 hectares of paddy fields each year (Under2 Coalition 2024). Two points were selected for studying the waterbird congregation in the East Kolkata Wetlands.

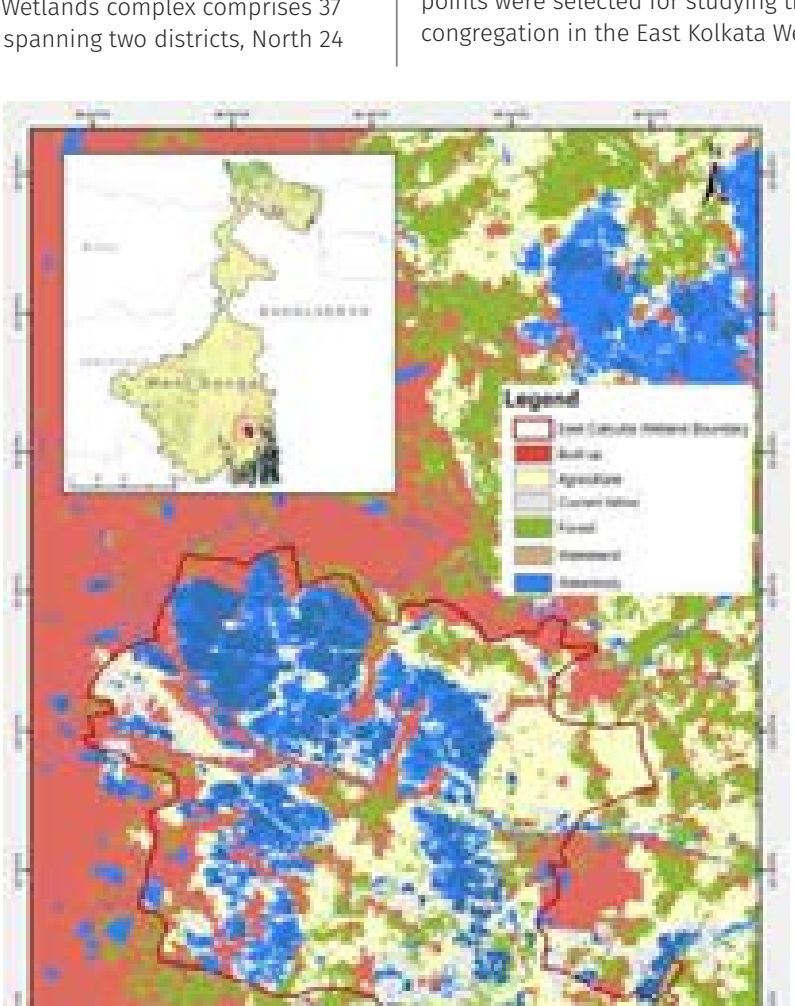


Figure 3.72. Land Use and Land Cover Map of East Kolkata Wetlands, West Bengal

A total of 41 individuals of 6 water and water-associated bird species were recorded from the East Kolkata Wetlands, belonging to 3 orders, 3 families, and 5 genera in two sampling points during one occasion with a total survey effort of 2.99 hrs. Pelecaniformes (2 species) was the most dominant order, followed by Suliformes (2 sp.) and Passeriformes (1 sp.) (Figure 3.73a). Ardeidae (3 species) was the most dominant family, followed by Phalacrocoracidae (2 sp.), and Hirundinidae (1 species) (Figure 3.73b). Of the six water and water-associated bird species, five were categorised as waterbirds and one as water-associated.

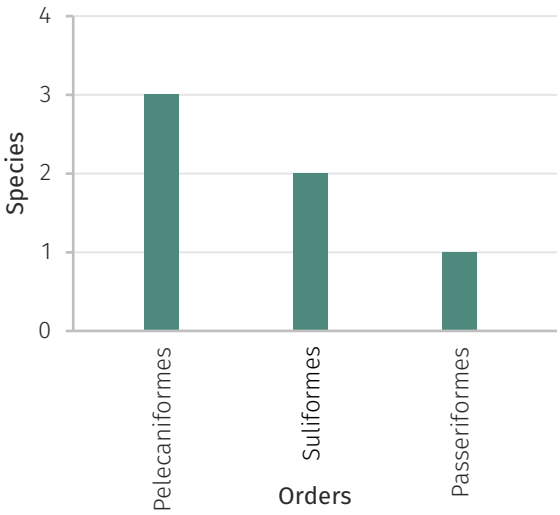


Figure 3.73a. Order-wise composition of species recorded in East Kolkata Wetlands

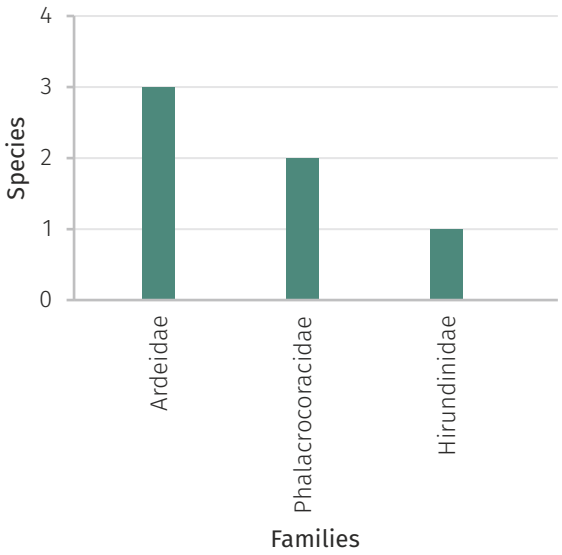


Figure 3.73b. Family-wise composition of species recorded in East Kolkata Wetlands

Richness and Diversity

Of two sampling points, the overall species richness of water and water-associated species was found to be highest at point 2 (6 species), followed by point 1 (4 sp.) (Figure 3.74). Overall species diversity was found to be highest at point 1 (1.34), followed by point 2 (1.28) (Figure 3.74).

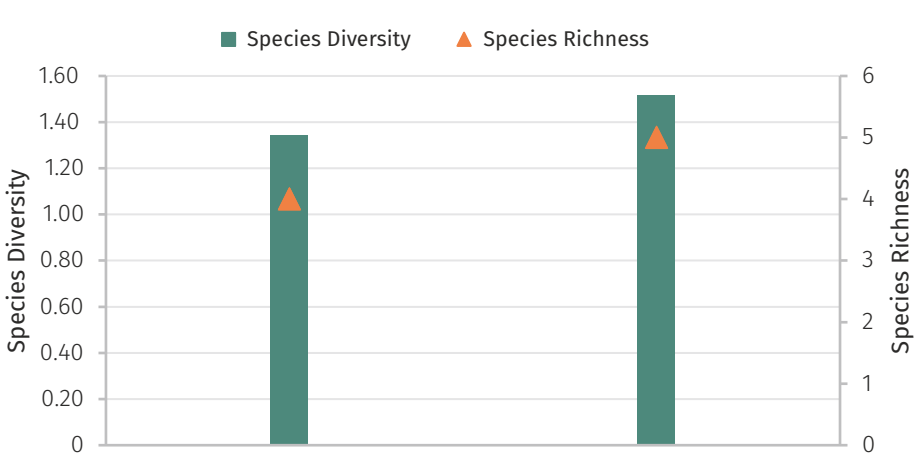


Figure 3.74. Species richness and diversity (*H'*) of water and water-associated birds in the East Kolkata Wetlands

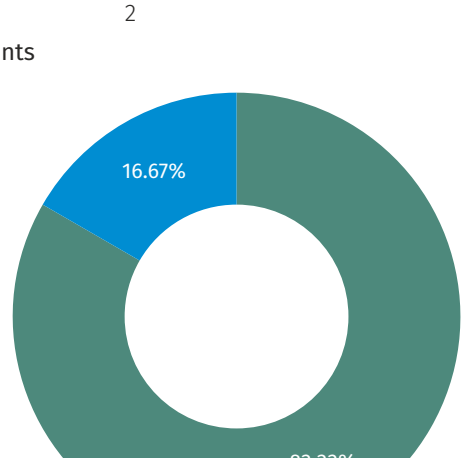


Figure 3.75. Proportion of the different Feeding Guilds of the water and water-associated birds in the East Kolkatta Wetlands

Waterbirds

Of the 6 species recorded during the survey, 5 species (83.33%) were waterbirds. The highest richness of waterbird species was recorded at point 2 (5 species), followed by point 1 (4 sp.). Overall highest species diversity was found at point 2 (0.52), followed by point 1 (1.34).

Relative Abundance

In terms of relative abundance, the barn swallow (43.90%) was the most abundant species, followed by the Indian pond heron and little cormorant (17.07%), while the grey heron (2.44%) was the least abundant.

Waterbirds

Of the 5 waterbird species, the Indian pond heron and little cormorant (30.43%) were the most abundant species, followed by eastern cattle egret and Indian cormorant (17.39%), the grey heron (4.35%) was the least abundant. Point 2 (65.63%) was recorded as the most abundant point, followed by point 1 (34.38%).

Feeding Guild and Residential Status

Carnivore (83.33%, 5 species) and Insectivore (16.67%, 1 sp.), only two feeding guilds were recorded in the East Kolakata wetlands (Figure 3.75). Out of six species, four (67%) belonged to R/LM, and one species each belonged to R/AM (17%) and R/WM (17%) groups.

Physio-chemical properties and anthropogenic stressors

The average DO value was measured as 5.12 mg/L, pH as 6.98 and salinity as 0.11 ppt. Air water temperature was 29.55 °C, and water temperature was 24.5 °C in the wetland. Agriculture activities were not practised in and around the wetland, but commercial fishing was quite prominent in the wetland, mostly using cast nets. Vegetation almost covered 50% of the wetland area, where biomass extraction was found to be an occasional practice. There was no barrier to the hydrological connectivity of the wetland. Drainage, outlet, water extraction pumps, electric power lines, grazing and mining activities were absent at both sampling sites. Washing/bathing was occasional in one of the sample sites. Water was greenish and odourless. Floating macrophytes covered less than 20% of the wetland area at both sampling sites. Invasive species, *Pontederia crassipes*, covered 5% and 20% of sampling points 1 and 2, respectively.

4. NANGLA BEEL WETLAND

Nangla Beel is situated at Nangla village in the Habra-I subdivision of North Twenty-Four Parganas district in West Bengal. It lies between 22°49' 32.23" N 88°41' 31.50" E and 22°49' 35.19" N 88°43' 40.70" E (Figure 3.76) and spreads over 4.5 sq. km in the central western region of the district. The wetland is 35.4 km away from the Hooghly River. It is a rain-fed wetland, which lies at a mean elevation of 21 m asl. The wetland falls under the 8-Coast biogeographic zone and 8B-East Coast biogeographic province (Rodgers et al. 2000).

According to the Census of India (2011), the Nangla village has 892 households with a population of 3,605. Other villages peripheral to the wetland are Kashipur, Panchghara, Kharo, Phultala, Simulpur, and Tunighata. The seven villages have 6,473 households, with a population of 27,473 and a sex ratio of 930 females per 1,000 males (Census of India 2011). The literacy rate of these villages is 84% (male 88%, female 78%) for the age group of above six years. One sampling point was selected for studying the waterbird congregation in the Ahiran Wetland.

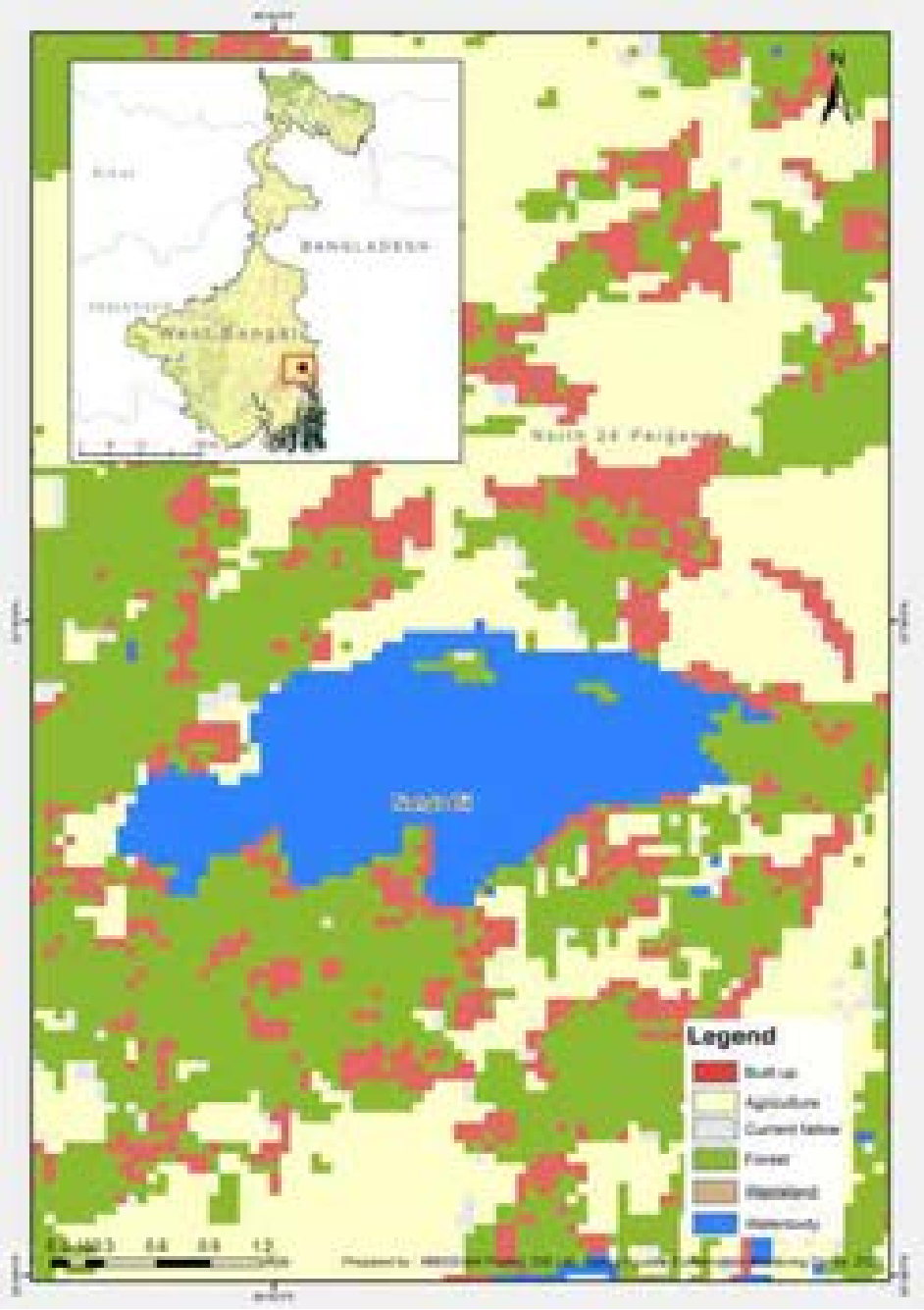


Figure 3.76 Land Use and Land Cover Map of the Nangla Beel, West Bengal

A total of 52 individuals of 6 water and water-associated bird species were recorded from the Nangla Beel Wetland, belonging to 6 orders, 6 families, and 6 genera in one sampling point during one occasion (total survey effort = 0.98 hrs).

All the orders and families had only one species (Figure 3.77a; b). Of the six water and water-associated bird species, four were categorised as waterbirds and one as water-associated. The overall species diversity value was recorded as 1.37.

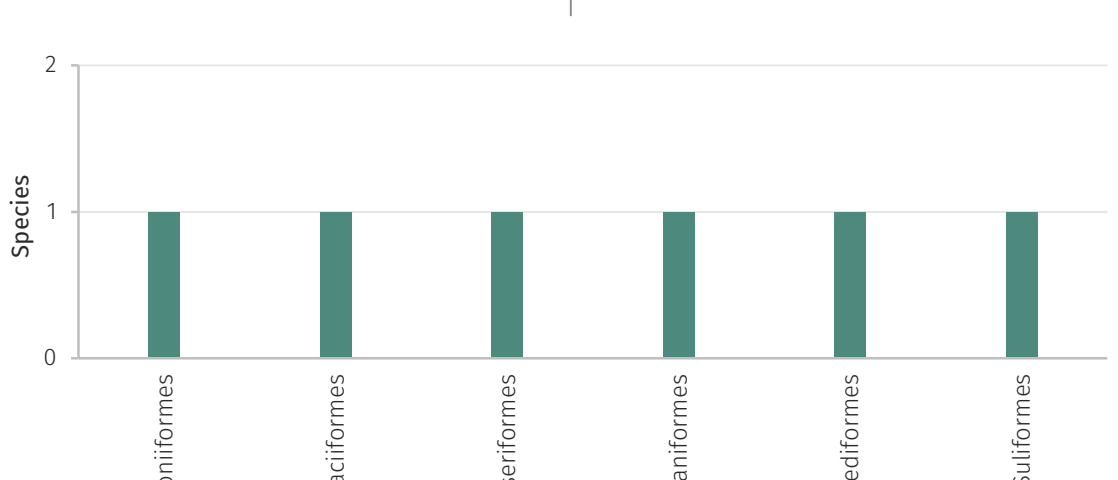


Figure 3.77a. Order-wise composition of species recorded in the Nangla Beel Wetland

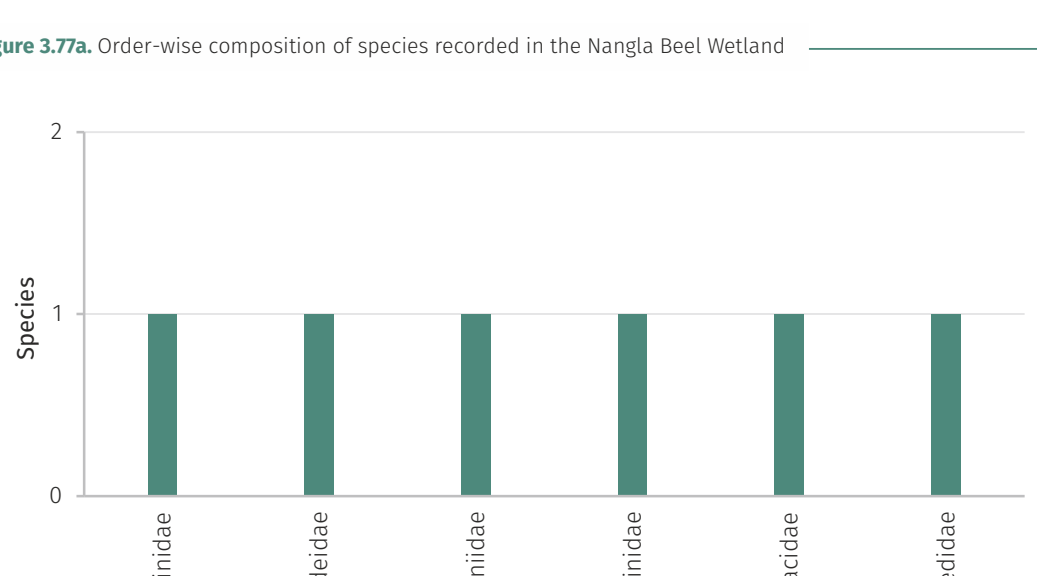


Figure 3.77b. Family-wise composition of species recorded in the Nangla Beel Wetland

Relative Abundance

In terms of combined relative abundance, the Asian openbill (61.54%) was the most abundant species, followed by the barn swallow (17.31%), white-throated-kingfisher (9.62%), while the intermediate egret (1.92%) was the least abundant.

Point 2 (73.17%) was recorded as the most abundant point, followed by point 1 (26.83%).

Waterbirds

The Asian openbill (84.21%) was the most abundant species, followed by white-throated little grebe (7.89%) and little cormorant (5.26%), while the intermediate egret (2.63%) was the least abundant.

Water-associated Birds

The barn swallow (64.29%) was the most abundant species, followed by the white-throated kingfisher (35.71%).

Feeding Guild and Residential Status

Carnivore (83.33%, 5 species) and Insectivore (16.67%, 1 sp.) were the two feeding guilds recorded in the Nangla Beel (Figure 3.78). Similarly, only two residential groups were identified for the six recorded species, R/LM (83%, 5 species), and R/WM (17%, 1 sp.).

Physio-chemical properties and anthropogenic stressors

The average DO value of the Nangla Beel wetland was measured as 3.69 mg/l, pH value as 6.88, and salinity as 0.12 ppt during the survey. Air and water temperatures were recorded as 29 °C and 24.2 °C, respectively. Agriculture was prominent around the wetland, and the wetland is used seasonally for commercial fishing. Vegetation/ biomass extraction was found to be an occasional practice, and the wetland was covered with vegetation (submerged and free-floating). Hydrological connectivity remained seasonal in the wetland with no anthropogenic pressures like drainage, outlet, water extraction pumps, electric power lines, grazing, washing/bathing and mining activities. The waterbody was brownish but odourless. *Pontederia crassipes* and *Alocasia* covered almost 30% of the wetland.

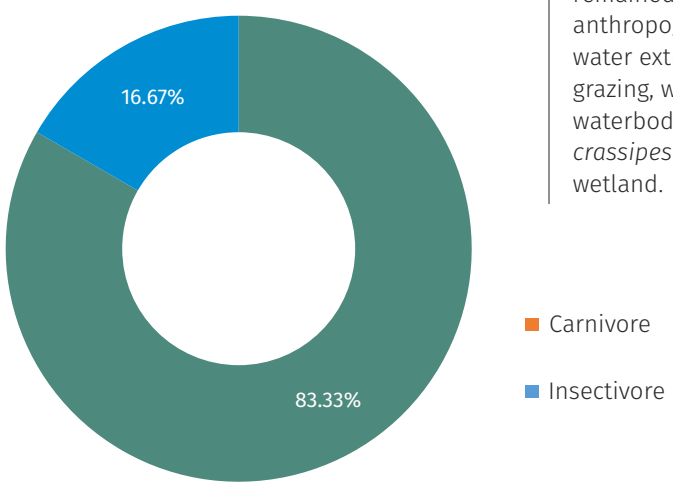


Figure 3.78 Proportion of the different Feeding Guilds of the water and water-associated birds in the Nangla Beel Wetland

5. PURBASTHALI WETLAND

Purbasthali oxbow lake, also known as 'Chupi Kasthashali Pakhiralay', is an ecologically significant wetland of West Bengal which extends between the geographical coordinates of 88° 19' 45" to 88° 21' 54" E and 23° 25' 54" to 23° 27' 54" N. It is located at a mean elevation of 27 m asl (Figure 3.79) in the Kalna subdivision of Purba Bardhaman district. The wetland falls within the 7-Gangetic Plain Biogeographic zone and 7B-Lower Gangetic Plain Biogeographic province (Rodgers et al. 2000). This crescent-shaped natural freshwater lake has been formed by the meandering of the Hooghly River over the years and has gradually transferred into a closed loop. This lake has a narrow channel at its southern end, which links the river and creates a unique combination of lentic and lotic habitats. (Ganesan and Khan 2007). The length of the lake is almost 10 km, and it spreads over almost 3.5 sq. km. This Ramsar site is famous for its rich biodiversity, mainly for migratory birds, and it plays a notable role in the neighbourhood (Chowdhury 2017). It is 900 m away from the Hooghly River, and human settlements are very high around the wetland.

There are a total of 11 villages peripheral to the lake under three blocks, namely, the Nabadwip block of Nadia (Indrakpur, Sankarpur), Purbasthali - I (Nama Bhandartikuri, Bhandartikuri, Ekdala, Paranpur, Ramchandrapur), and Purbasthali - II (Purbastali, Palaspuli, Kashthashali, Chupi) blocks of Purba Bardhaman. The total number of households in the 10 villages, excluding Ekdala, is 6,668, with a population of 28,015 (Census of India 2011). The village-wise household numbers range from 59 in Ramchandrapur to 1,596 in Chupi. The population is dominated by the village of Chupi (7,159), followed by Palaspuli (4,642), Kashthasali (4,343), and Purbbasthali (4,207). The sex ratio of the 10 villages is 945 females per 1,000 males, while the literacy rate for the age group above six years is 74% (male 80%, female 69%) (Census of India 2011). The economically weak people from fringe villages usually gather a variety of green leafy vegetables (such as Kalmi I*pomoea aquatic*, Susni *Marsilea minuta*, Hinche *Enhydra fuctuans*, and Malancha/Chechi) from the banks, as well as frequently catch fish and periwinkles/snails for their daily sustenance (Mandal et al. 2021). Households characterised by poverty, landlessness, low social status, and limited education exhibit a greater dependence on wetland products than those with sufficient economic resources. Households with larger family sizes have extracted greater quantities of wetland products, while upper-caste individuals have primarily utilised wetlands for irrigation purposes (Mandal et al. 2021). Two points were selected for studying the waterbird congregation in the Purbasthali Wetland.

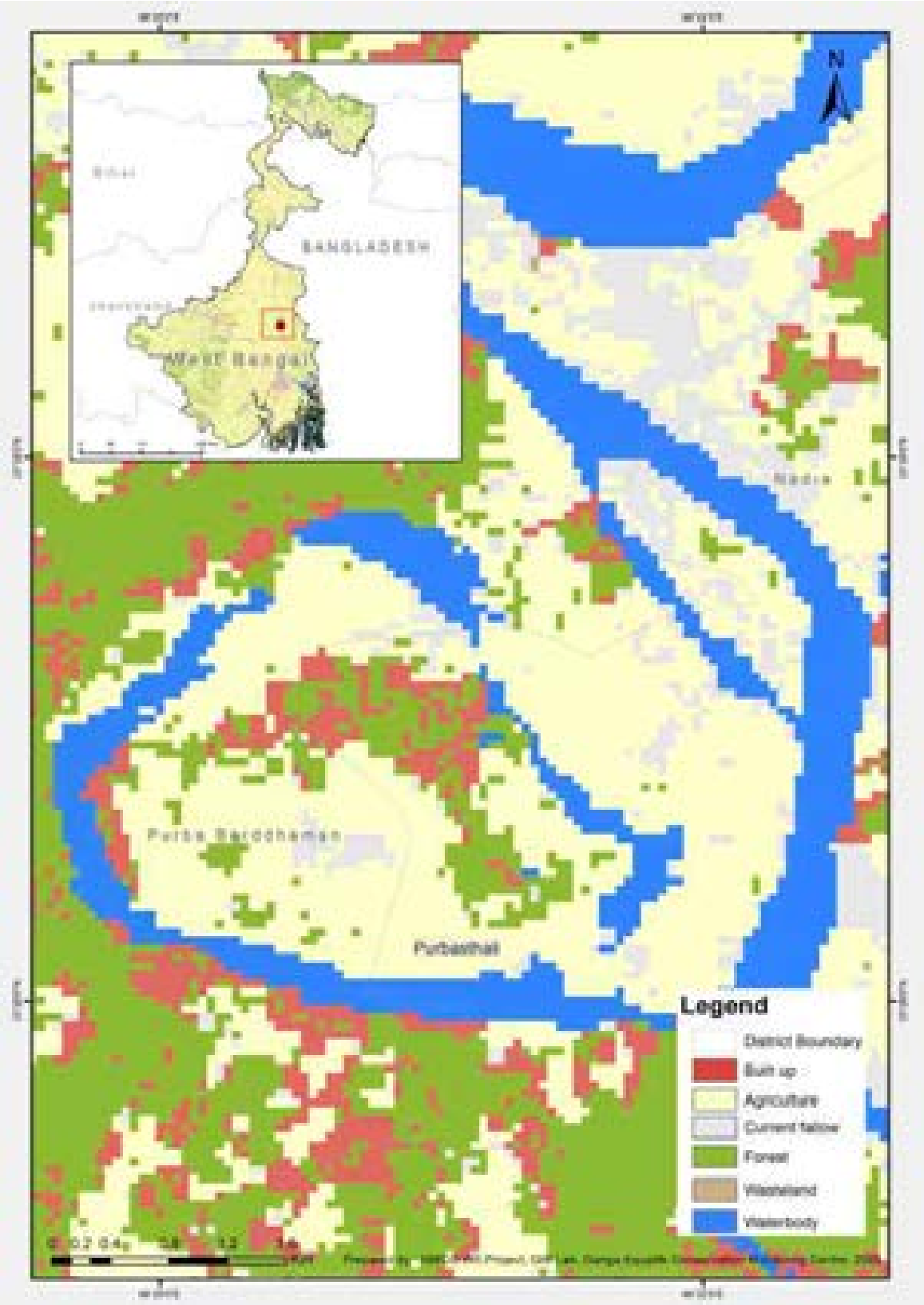


Figure 3.79. Land Use and Land Cover Map of the Purbasthali Wetland, West Bengal

A total of 299 individuals of 19 water and water-associated bird species were recorded from the Purbasthali Wetland, belonging to 9 orders, 10 families, and 17 genera in two sampling points during one occasion, with total survey efforts of 2.59 hrs. Anseriformes, Charadriiformes, Gruiformes,

and Pelecaniformes (3 species) were the most dominant orders, followed by Coraciiformes and Suliformes (2 sp.) (Figure 3.80a). Anatidae, Ardeidae, and Rallidae (3 species) were the most dominant families, followed by Alcedinidae, Jacanidae, and Phalacrocoracidae (2 sp.) (Figure 3.80b).

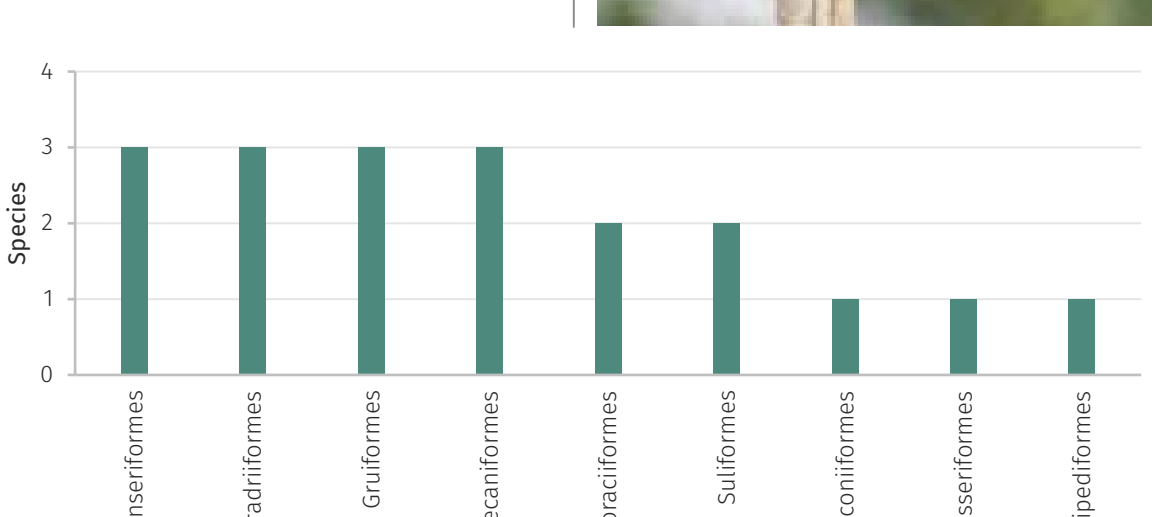


Figure 3.80a. Order-wise composition of species recorded in the Purbasthali Wetland

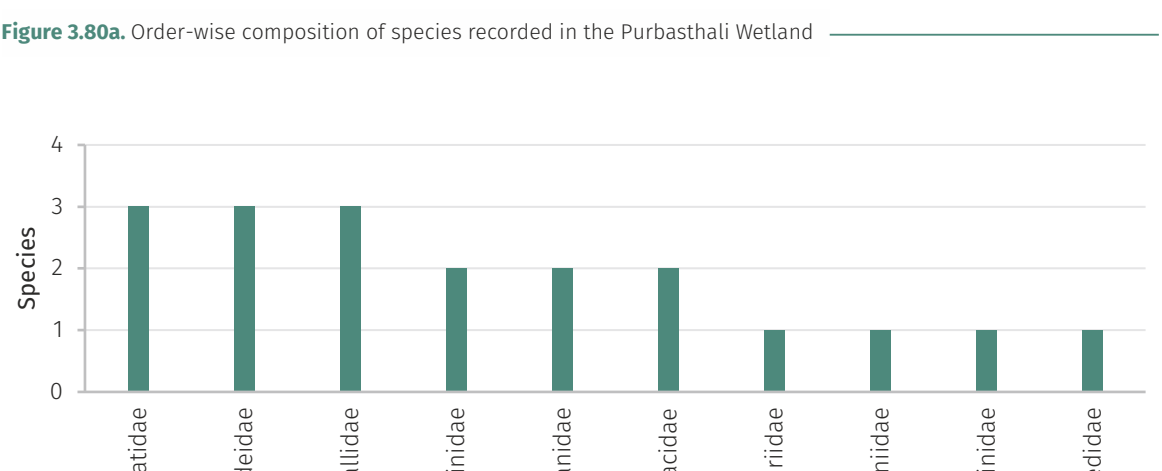


Figure 3.80b. Family-wise composition of species recorded in the Purbasthali Wetland

Richness and Diversity

Of two sampling points, the overall species richness of water and water-associated species was found to be highest in point 2 (13 species), followed by point 1 (10 sp.) (Figure 3.81). Overall species diversity was found to be highest in point 1 (1.94), followed by point 2 (1.50) (Figure 3.81).

Figure 3.81. Species richness and diversity (*H'*) of water and water-associated birds in the Purbasthali Wetland

Waterbirds

Of the 19 species recorded during the survey, 16 species (84.21%) were waterbirds. The highest richness of waterbird species was recorded at point 2 (12 species), followed by point 1 (7 sp.). Overall species diversity was found to be highest in point 1 (1.58), followed by point 2 (1.45).

Water-associated Birds

Only 3 species out of 18 species (15.79%) were identified as water-associated species. The highest species richness (3 species) and diversity value (0.89) of water-associated birds was at point 1, while point 2 had only one species.

Relative abundance

In terms of the combined relative abundance of water and water-associated species, the lesser whistling-duck (36.12%) was the most abundant species, followed by red-crested pochard (30.77%) and grey-headed swamphen (6.35%). The common moorhen (Gallinula chloropus) and purple heron (0.33%) were least abundant. Point 2 (75.25%) was recorded as the most abundant sampling point, followed by point 1 (24.75%).

Waterbirds

Of the 16 waterbird species, the lesser whistling-duck (38.30%) was the most abundant species, followed by red-crested pochard (32.62%) and grey-headed swamphen (6.74%), while common moorhen and purple heron (0.35%) were the least abundant. Point 2 (78.72%) was recorded as the most abundant point, followed by point 1 (21.28%).

Water-associated Birds

Out of the 3 water-associated species, the barn swallow (52.94%) was the most abundant species, followed by the white-throated kingfisher (29.41%) and common kingfisher (17.65%). Point 1 (82.35%) was recorded highest abundant point, followed by point 2 (17.65%).

Feeding Guild and Residential Status

Overall, Carnivore (52.63%, 10 species) was the most dominant feeding guild, followed by Herbivore/Carnivore (36.84%, 7 sp.), while Insectivore and Omnivore (5.26%, 1 sp.) were the least dominant (Figure 3.82). Out of 19 species, 11 species (58%) belonged to R/LM, three species (16%) to WM, two species (11%) to R, and one species each to WM (5%), R/AM (5%) and R/LM/SM (5%) groups.

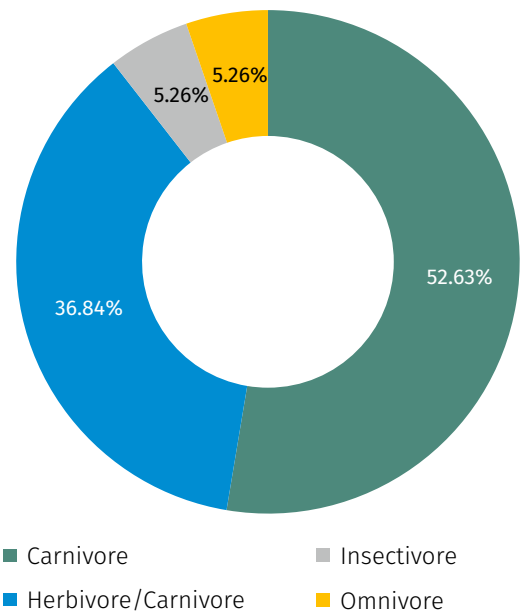


Figure 3.82. Proportion of the different Feeding Guilds of the water and water-associated birds in the Purbasthali Wetland

Physio-chemical properties and anthropogenic stressors

The pH value was measured as 7.55, and the salinity as 0.11 ppt. Air temperature was recorded as 24.25 °C, and water temperature was 24.25 °C. DO of the wetland was measured as 8.56 mg/L. The wetland was surrounded by rice and jute crops. Commercial and self-consumption fishing activities remained low in the wetland using nets. Half of the wetland was covered with vegetation (submerged and free-floating), and with occasional biomass extraction. Any barrier did not disrupt hydrological connectivity. A total of seven water extraction pumps were functioning at the wetland for irrigation purposes. Bathing/washing practices were rare in the wetland. The wetland was free of stressors like drainage, outlets, powerlines, mining, and grazing. Invasive species, *Pontederia crassipes* infested 50% of the total wetland area.

6. SHEEAL LAKE

Sheeal Lake is an uncelebrated yet ecologically significant wetland in West Bengal. This secluded wetland is located at 24°29' 14.59" N 88° 0' 20.83" E and 24°27' 51.95" N 87° 59' 23.04" E at Kanupur panchayat under Raghunathganj-I block in Murshidabad district (Figure 3.83). This crescent-shaped freshwater lake lies at a mean elevation of 38 m asl, covers almost 5 sq km and provides a suitable habitat for waterbirds. The wetland falls within the 7-Gangetic Plain Biogeographic zone and 7B-Lower Gangetic Plain biogeographic province (Rodgers et al. 2000).

The lake is surrounded by 13 villages and one town under the two blocks Raghunathganj-I and Suti-I (viz., Ghorsala, Umarpur, Takshak, Sakhalipara, Bagha, Jarur, Barala, Bainda, Baidara in Raghunathganj-I block; Banshabati, Nazirpur, Raturi, Aluani, and Srirampur in Suti-I block). The total households surrounding the wetland and excluding Srirampur village are 9,740, with a population of 45,957 and a sex ratio of 968 females per 1,000 males (Census of India 2011). The literacy rate of the villages and one town is 61% (male 65%, female 57%) for the age group above six years. The highest population is recorded in Ghorsala (7,837), followed by Jarur (6435), Bangasbati (6,378), and Barala villages (5,580) (Census of India 2011). Two points were selected for studying the waterbird congregation in Sheeal Lake.

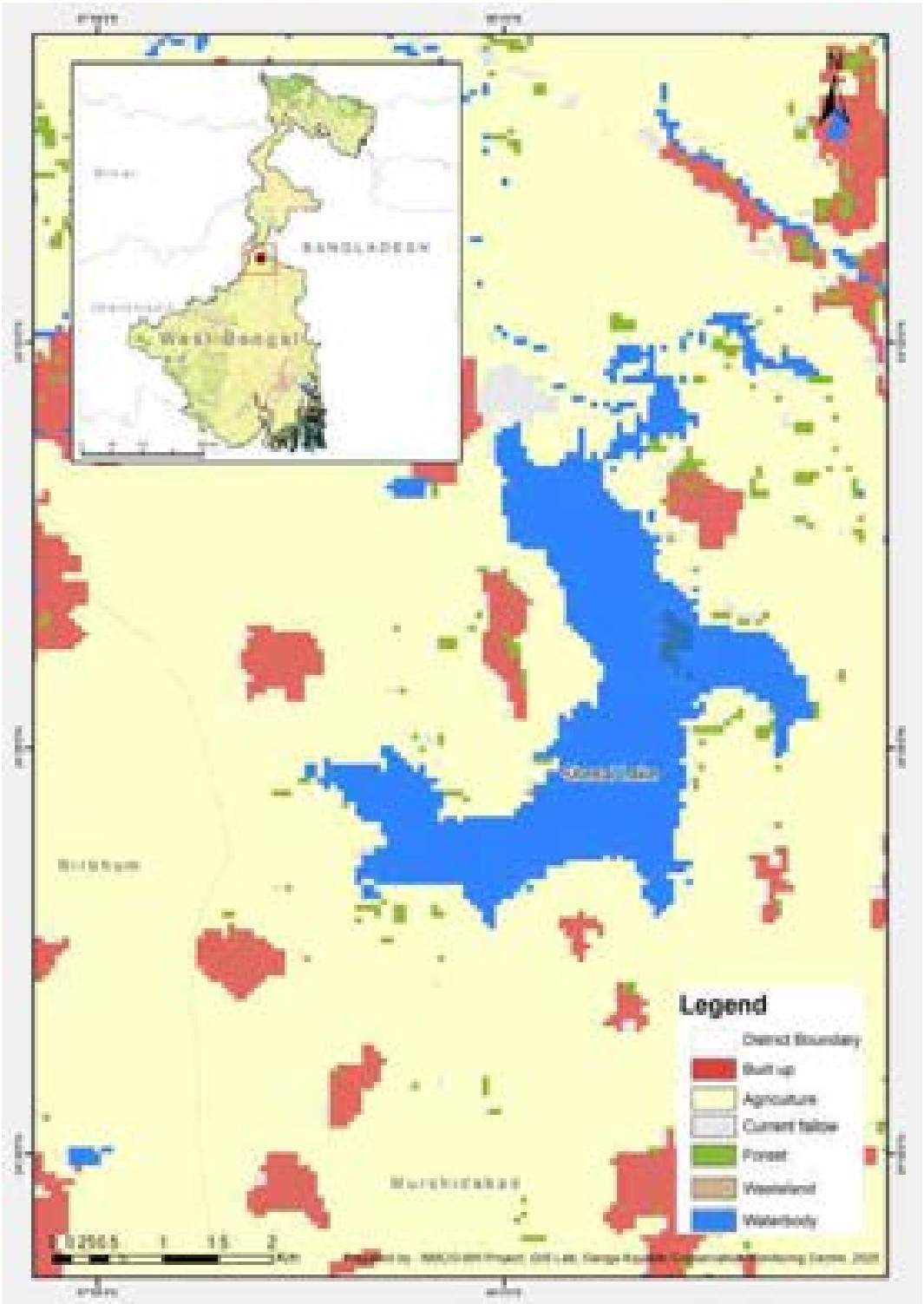


Figure 3.83. Land Use and Land Cover Map of the Sheeal Lake, West Bengal

Altogether, 346 individuals of 15 water and water-associated bird species were recorded from the Sheeal Lake, belonging to 6 orders, 9 families, and 11 genera in two sampling points during one occasion (total survey effort = 2.27 hrs). Pelecaniformes (7 species) was the most dominant order, followed by Charadriiformes (3 sp.), and Suliformes (2 sp.) (Figure 3.84a). Ardeidae (6 species) was the most dominant family, followed by Phalacrocoracidae (2 sp.), and the rest of the families were represented by only one species (Figure 3.84b).

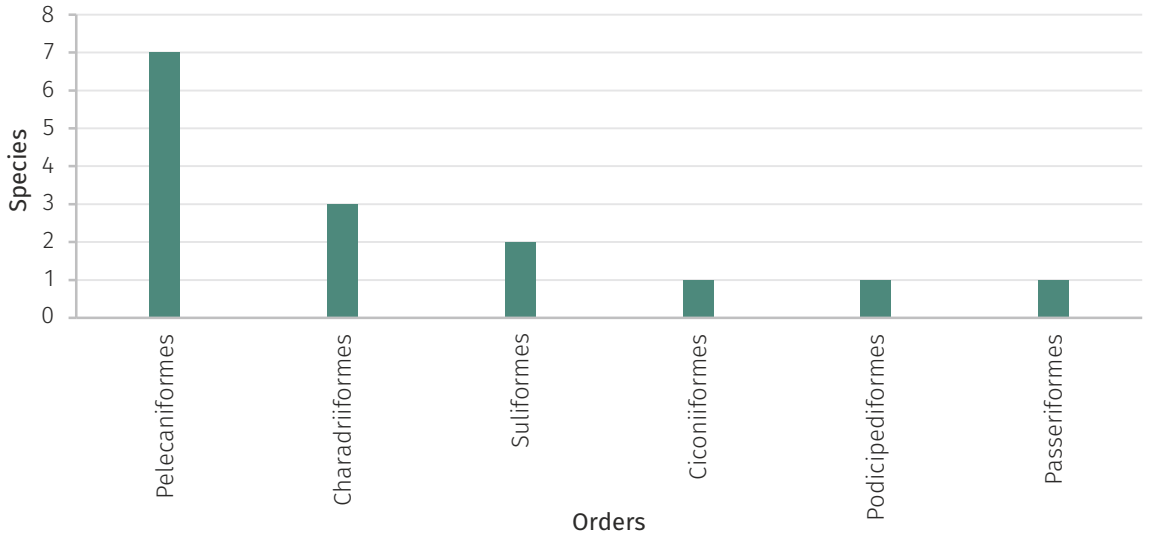


Figure 3.84a. Order-wise composition of species recorded in the Sheeal Lake

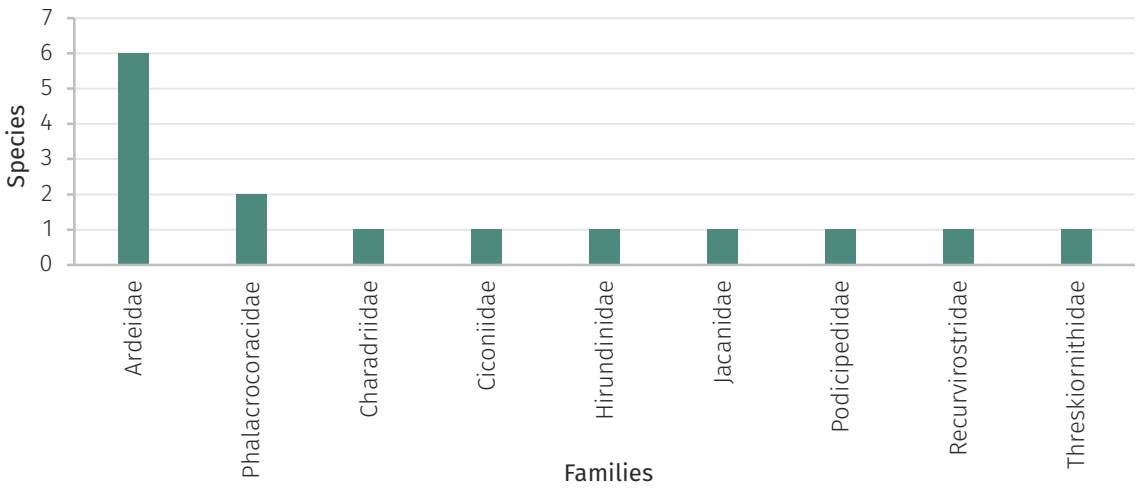


Figure 3.84b. Family-wise composition of species recorded in the Sheeal Lake

Richness and Diversity

Of two sampling points, the overall species richness of water and water-associated species was found to be highest at point 2 (11 species), followed by point 1 (9 sp.) (Figure 3.85). Overall species diversity was found to be highest at point 1 (1.91), followed by point 2 (1.58) (Figure 3.85).

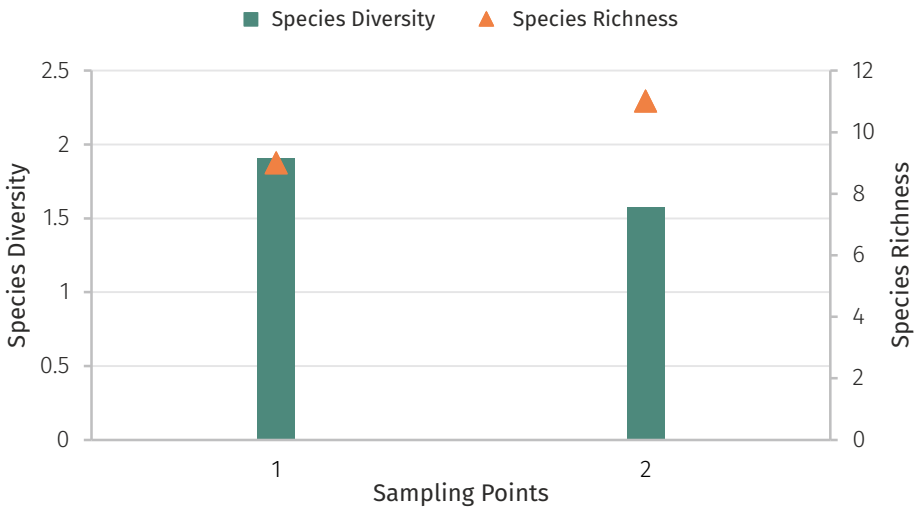


Figure 3.85. Species richness and diversity value (*H'*) of water and water-associated birds in the Sheeal Lake

Waterbirds

Of the 15 species recorded during the survey, 14 species (93.33%) were waterbirds. The highest richness of waterbird species was recorded in point 2 (11 species), followed by point 1 (8 sp.). Overall species diversity value was found to be highest at point 1 (1.75), followed by point 2 (1.58).

Relative abundance

In terms of the combined relative abundance of water and water-associated species, the grey-headed lapwing (*Vanellus cinereus*) (35.26%) was the most abundant species, followed by eastern cattle egret (27.17%) and Asian openbill (5.20%), the grey heron (0.29%) was the least abundant. Point 2 (76.30%) was recorded as the most abundant point, followed by point 1 (23.70%).

Waterbirds

Of the 16 waterbird species, the grey-headed lapwing (36.53%) was the most abundant species, followed by eastern cattle egret (28.14%) and Asian openbill (5.39%), while grey heron (0.30%) was the least abundant. Point 2 (79.04%) was recorded as the most abundant point, followed by point 1 (20.96%).

Feeding Guild and Residential Status

Overall, Carnivore (80%, 12 species) was the most dominant feeding guild, followed by Herbivore/Carnivore, Carnivore/Herbivore, and Insectivore (6.67%, 1 sp.) (Figure 3.86). In terms of residential status of 15 recorded species, 10 species (67%) belonged to R/LM, followed by R/WM (13%, 2 sp.), and WM, R/AM and R/LM/SM groups were represented by only one species each (7%).

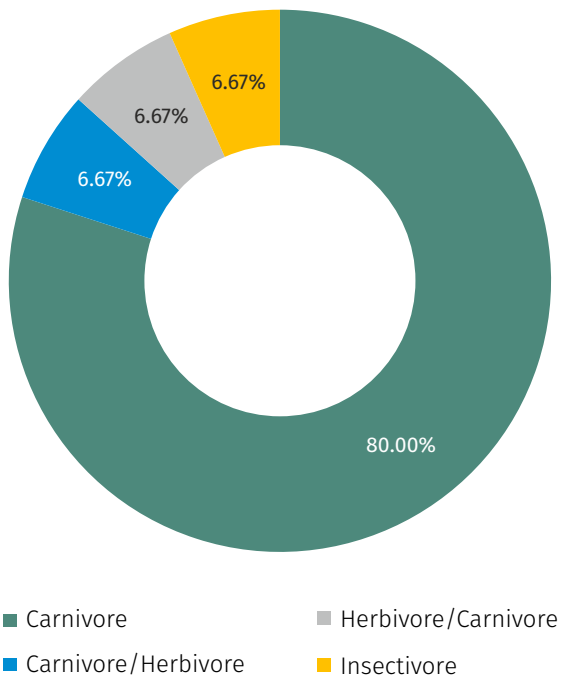
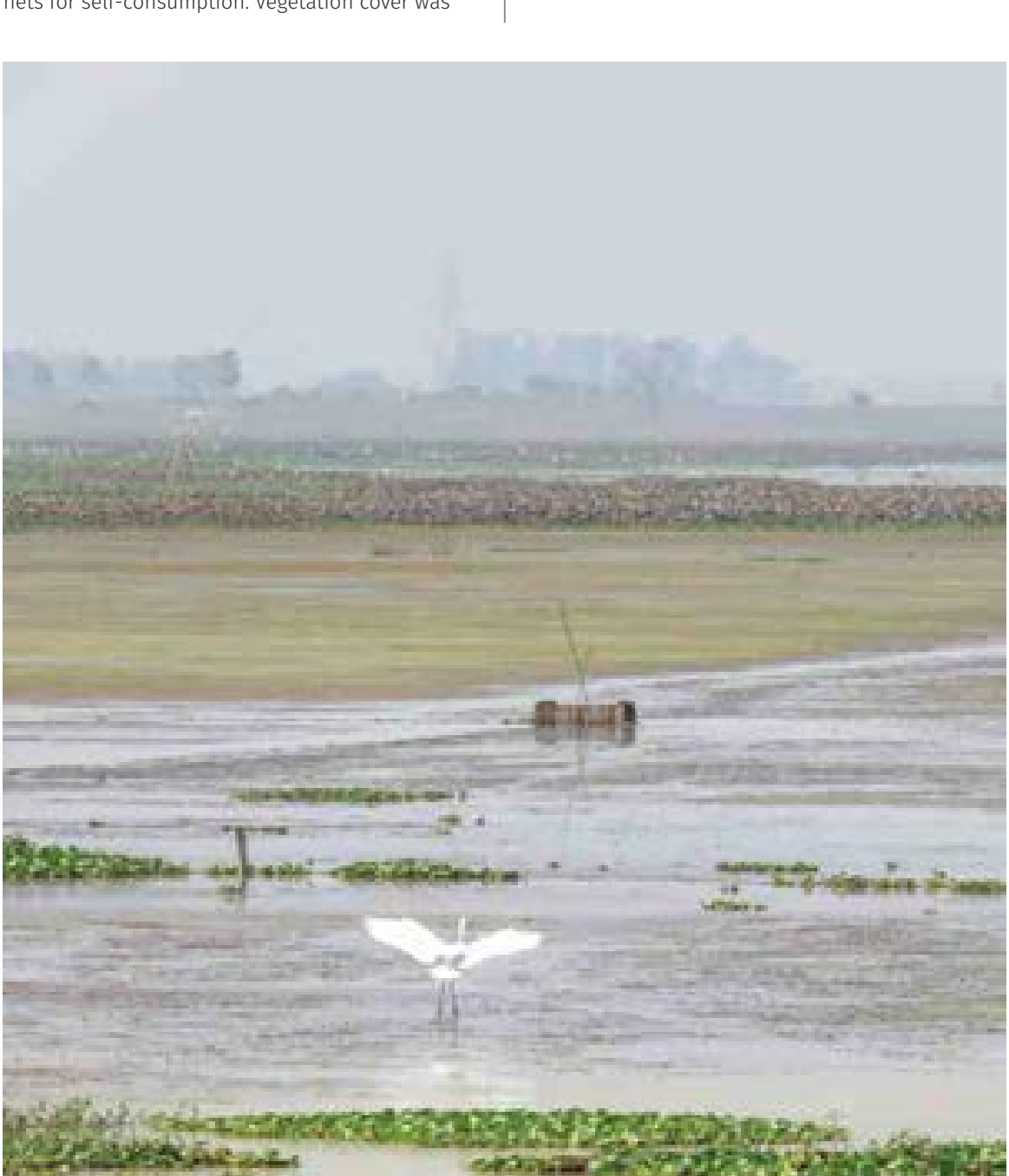


Figure 3.86. Proportion of the different Feeding Guilds of the water and water-associated birds in the Sheeal Lake

Physio-chemical properties and anthropogenic stressors

The average DO value of the wetland was measured as 4.26 mg/l, pH as 7.85, and salinity as 0.1 ppt. The average air temperature was recorded as 25.3°C, and the water temperature was 22.95 °C. The wetland was dominated by rice crops and weekly fishing activities using hooks, trap nets and nets for self-consumption. Vegetation cover was found to be < 20% with negligible biomass extraction. A total of five water extraction pumps were recorded, which were most likely used for irrigation purposes. The Sheeal wetland remains free of most anthropogenic stressors except low floating debris (thermocol) and invasive species, such as *Pontederia crassipes* and *Alocasia* spp., which covered almost 20% of the wetland area.



04

SYNTHESIS

1.1. STATUS OF AVIFAUNA IN THE SELECT WETLANDS

In toto, 41,366 individuals of 90 water and water-associated bird species were recorded from 20 selected wetlands of the Ganga River basin, belonging to 11 orders, 21 families, and 61 genera. Charadriiformes (24 species) was the most dominant order, followed by Anseriformes (18) and Pelecaniformes (12) (Figure 4.1a). Anatidae (18 species) was the most dominant family, followed by Scolopacidae (10 sp.), and Ardeidae (9 sp.) (Figure 4.1b). Out of 90 recorded species, one species was listed as EN, four species as VU, and seven species as NT on the IUCN Red List (Table 4.1, Figure 4.2). Of these, the steppe eagle, common pochard, ferruginous duck, and black-tailed godwit are migratory to the Indian sub-continent (BirdLife International 2025).

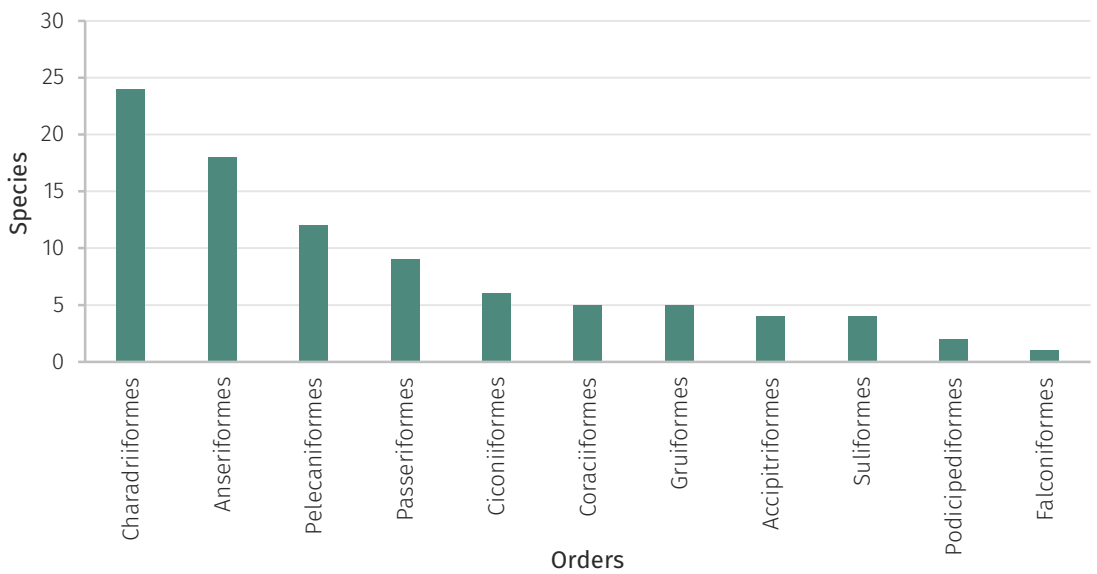


Figure 4.1. (a) Order-wise and water and water-associated species recorded in the select wetlands of the Ganga River Basin

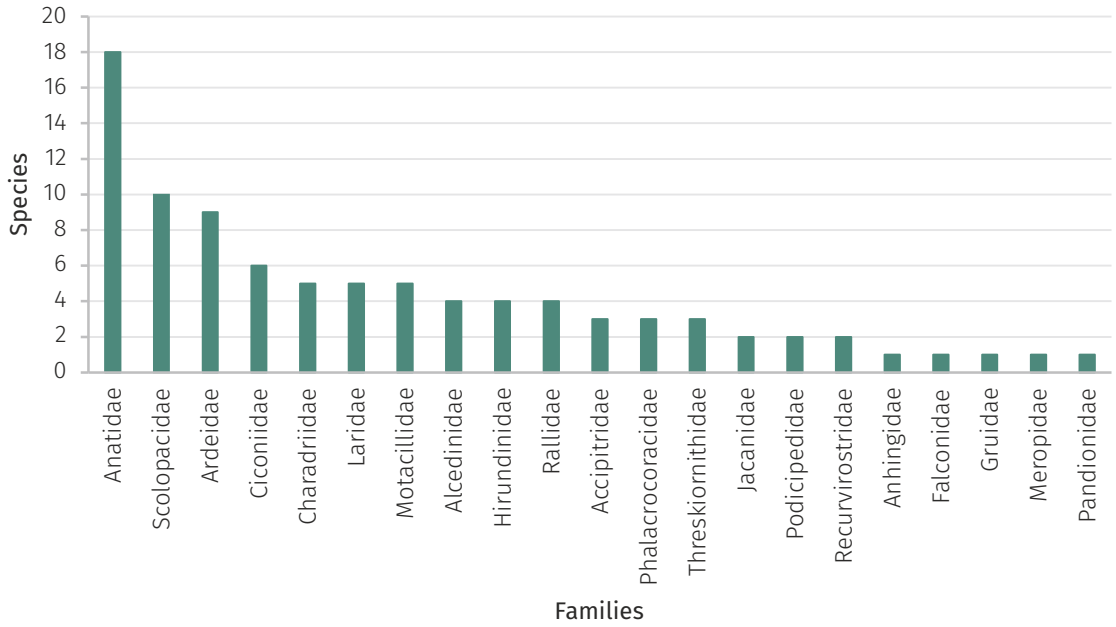


Figure 4.1. (b) Family-wise water and water-associated species recorded in the select wetlands of the Ganga River Basin

Table 4.1. Globally threatened species recorded from the select Wetlands

Order	Family	English Name	Scientific Name	IUCN	IWPA
Accipitriformes	Accipitridae	Steppe Eagle	*Aquila nipalensis* Hodgson, 1833	EN	Sch.-I
Anseriformes	Anatidae	Common Pochard	*Aythya ferina* (Linnaeus, 1758)	VU	Sch.-I
Gruiformes	Gruidae	Sarus Crane	*Antigone antigone* (Linnaeus, 1758)	VU	Sch.-I
Charadriiformes	Laridae	River Tern	*Sterna aurantia* Gray, 1831	VU	Sch.-I
Accipitriformes	Accipitridae	Greater Spotted Eagle	*Clanga clanga* (Pallas, 1811)	VU	Sch.-I
Anseriformes	Anatidae	Ferruginous Duck	*Aythya nyroca* (Güldenstädt, 1770)	NT	Sch.-II
Charadriiformes	Charadriidae	River Lapwing	*Vanellus duvaucelii* (Lesson, 1826)	NT	Sch.-II
Charadriiformes	Scolopacidae	Black-tailed Godwit	*Limosa limosa* (Linnaeus, 1758)	NT	Sch.-II
Ciconiiformes	Ciconiidae	Asian Woolly-necked Stork	*Ciconia episcopus* (Boddaert, 1783)	NT	Sch.-II
Ciconiiformes	Ciconiidae	Black-necked Stork	*Ephippiorhynchus asiaticus* (Latham, 1790)	NT	Sch.-II
Ciconiiformes	Ciconiidae	Greater Adjutant	*Leptoptilos dubius* (Gmelin, 1789)	NT	Sch.-I
Ciconiiformes	Ciconiidae	Lesser Adjutant	*Leptoptilos javanicus* (Horsfield, 1821)	NT	Sch.-I

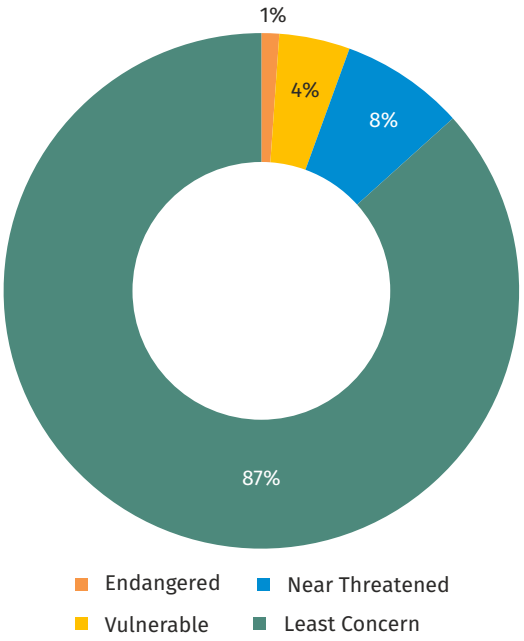
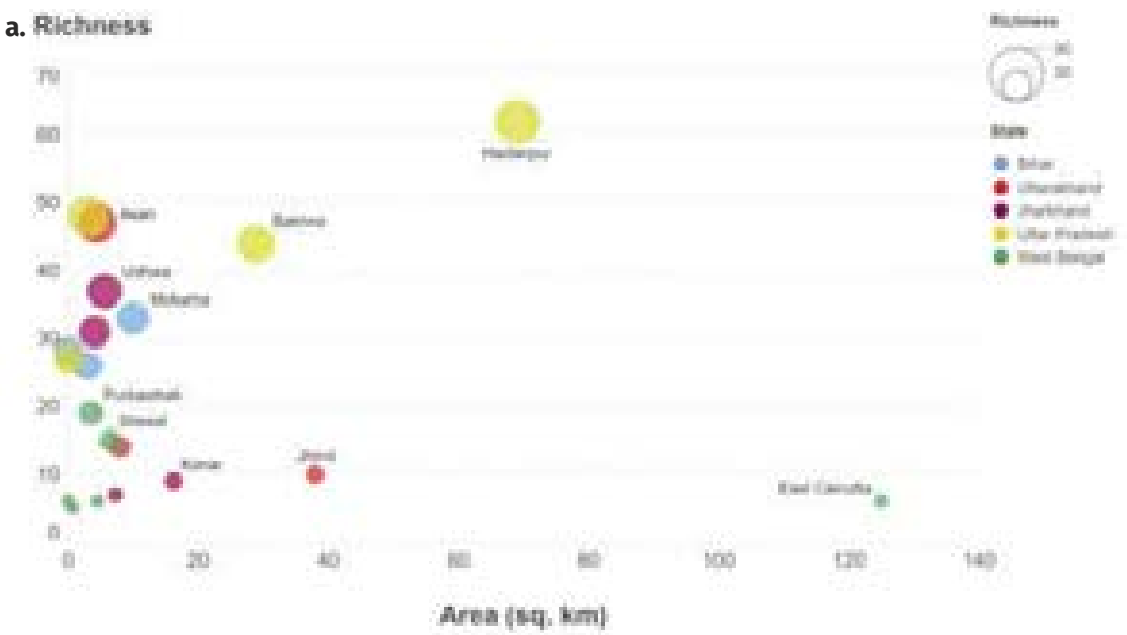


Figure 4.2. Status of wetland bird species as per the IUCN Red List

Among the 20 wetlands, species richness (total no. of species) of water and water-associated species was found to be highest for the Haiderpur wetland (62 species), followed by Surajpur (48 sp.) and the Asan CR (47 sp.), while the least was at Dongaria wetland (5 sp.) (Figure 4.3a). Overall species Shannon diversity index (*H'*) value was found to be highest at Surajpur (2.23±0.40), followed by Udhwa (2.16±0.46) and Haiderpur (2.06±0.41), while the lowest was Patratu Dam (0.77±0.82) (Figure 4.3b). Most of the wetlands were small in size (< 10 sq. km), and they were found to be high in species richness and diversity. Haiderpur was found to be

the most abundant wetland in terms of population, followed by Asan CR and Surajpur (Figure 4.3c). The largest wetland, East Kolkata, was found to have a low abundance (<50 individuals). Most of the wetlands' abundance was restricted to <300 individuals, irrespective of their size. About 500 studies have been published on waterbirds in the Ganga River basin till 2023, mainly on the status and diversity of waterbirds (Mahar et al. 2025). Arya et al. (2020) reported ~80 species of waterbirds from Haiderpur wetland. A few of the studies in the basin recorded more than 100 species of waterbirds in their respective sites (Javed and Rahmani 1998; Urfi 2003; Dey et al. 2014; Kumar and Kanaujia 2015), while some recorded <100 species in different wetlands of the Ganga River basin (Prakash et al. 2012; Manral and Khudsar 2013; Kanaujia et al. 2014; Dey et al. 2014; Kumar et al. 2015, 2016; Ansari 2017; Mazumdar 2017; Kushwaha and Kumar 2018; Arya et al. 2020; Joshi et al. 2021; Singh et al. 2021; Yashmita-Ulman and Singh 2022; Kumar et al. 2023; Anand et al. 2022; Alam et al. 2022; Mukhopadhyay and Mazumdar 2019; Chatterjee et al.,2023).



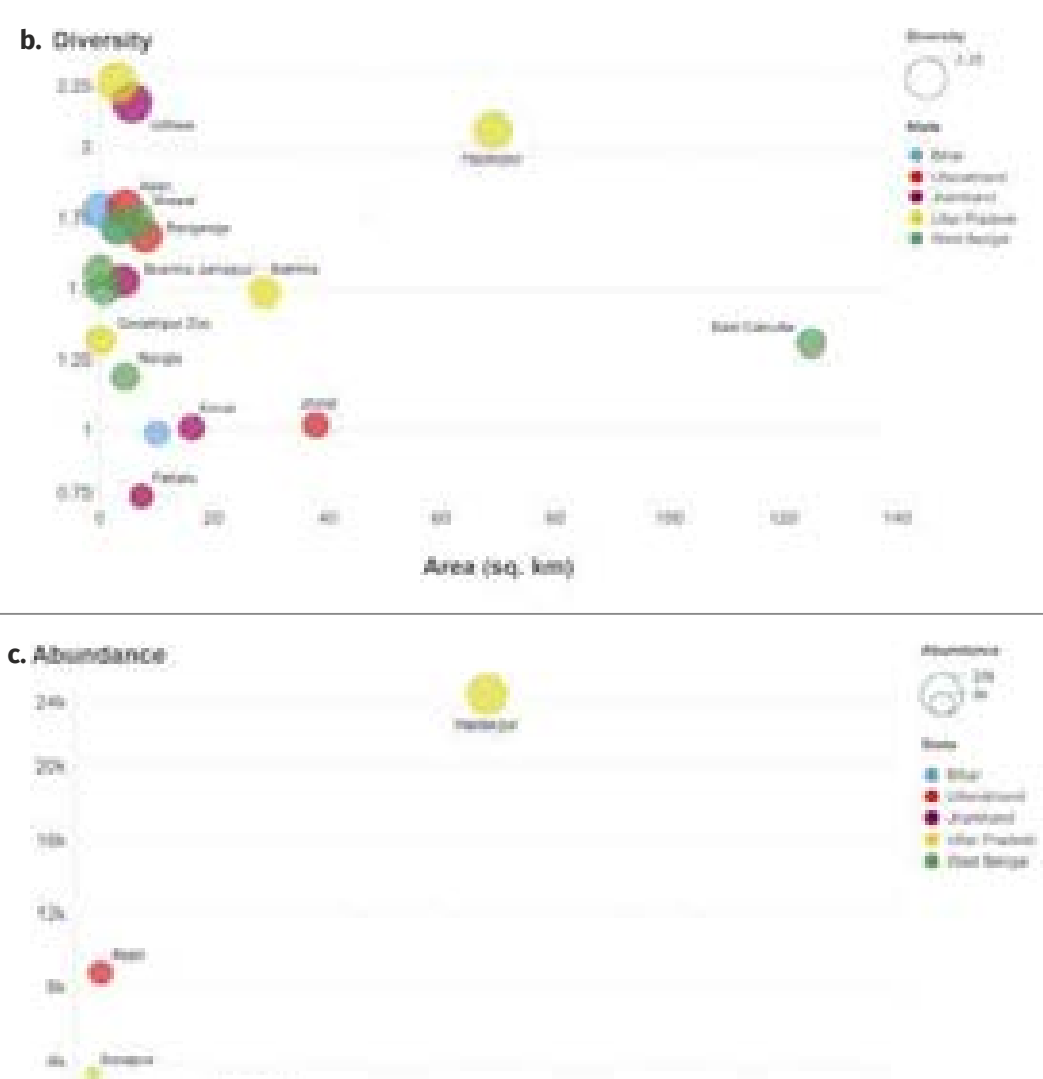


Figure 4.3. (a) Species richness and **(b)** diversity (*H'*) and **(c)** abundance of water and water-associated birds in the select wetlands of the Ganga River Basin

Of 90 recorded species during the survey, 71 species (78.89%) belonged to the waterbird group in the 20 select wetlands. The highest richness of waterbird species was recorded at Haiderpur (54 species), followed by Surajpur (40 sp.), and Udhwa (37 sp.). Overall waterbird diversity value was found to be highest at Udhwa BS (2.16±0.46), followed by Surajpur (2.05±0.51) and Haiderpur (2.01±0.42). Only 19 species out of 90 species (21.11%) were identified as water-associated. The highest species richness of water-associated birds was at Asan CR (11 species), followed by Haiderpur, Surajpur, and Bakhira WLS (7 sp.). The highest species diversity value was recorded at Surajpur (1.02±0.47), followed by Gorakhpur Zoo (0.70±0.72) and Nangla Beel (0.65). Whereas, Patratu dam, East Kolkata, and Sheeal Lake had only one species, and no species was recorded in Konar dam, Ahiran, and Dongaria wetland.

In terms of the combined relative abundance of water and water-associated birds, the gadwall (15.74%) was recorded as the most abundant species, followed by Eurasian coot (13.20%) and Eurasian wigeon (10.16%), while greater adjutant, greater spotted eagle, steppe eagle, mallard, whiskered tern, marsh sandpiper, black-necked stork, and stork-billed kingfisher (0.002%) were some of the least abundant species. Haiderpur wetland (57.63%) was recorded as the most abundant wetland, followed by Asan CR (21.25%) and Surajpur wetland (7.95%), while Dongaria wetland (0.03%) was the least abundant.

Out of the 71 waterbird species, the gadwall (16.07%) was the most abundant, followed by

Eurasian coot (13.48%) and Eurasian wigeon (10.38%), while mallard, whiskered tern, marsh sandpiper, and black-necked stork (0.002%) were least abundant. Haiderpur wetland (58.66%) was recorded as the most abundant wetland for waterbirds, followed by Asan CR (20.66%) and Surajpur wetland (7.91%), while Dongaria wetland (0.03%) was the least abundant. Out of the 19 water-associated species, the barn swallow (33.56%) was the most abundant species, followed by the grey-throated martin (19.59%) and white-throated kingfisher (9.39%). In contrast, the stork-billed kingfisher (0.11%) was the least abundant species. Asan CR (51.20%) was recorded as the most abundant wetland for water-associated birds, followed by Haiderpur wetland and Surajpur wetland (9.51%).

Feeding guilds provide the information on the assemblage or community structure and resource partitioning (Polla et al. 2018; Chatterjee et al. 2020). Overall, Carnivore (60%, 54 species) was found to be the most dominant feeding guild, followed by Herbivore/Carnivore (17.78%, 16 sp.) and Carnivore/Herbivore (7.78%, 7 sp.), while Herbivore (3.33%, 3 sp.) was the least dominant in the 20 select wetlands (Figure 4.4). Dominant Carnivore guild indicates high availability of fish and other vertebrate prey items in the wetlands (Paszkowski and Tonn 2006; Abhilash et al. 2024). In addition, most of the large winter migrants cover long distances during migration and contain large home ranges, thus tend to exploit high protein and fat diets to recover from nutrient deficiencies (Namgail et al. 2014). Sometimes diet ratio fluctuates owing to season, food availability, fecundity and life stage, particularly carnivores often intake a small herbivory proportion in their diet, and likewise herbivores feed on vertebrate and invertebrate prey items (Laguna et al. 2021; Verstijnen et al. 2021).

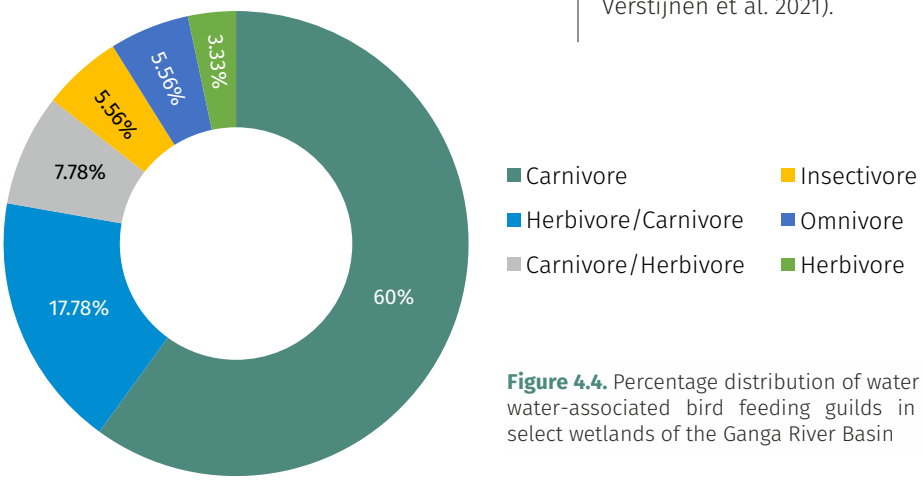


Figure 4.4. Percentage distribution of water and water-associated bird feeding guilds in the select wetlands of the Ganga River Basin

In terms of the residential status of birds, R/LM (30%, 27 species) was the most dominant group, followed by WM (23%, 21 sp.), R/WM (22%, 20 sp.), and R (12%, 11 sp.) in the Ganga River basin. While two species represented R/WM/AM, and remaining six groups (R/AM, R/LM, R/LM/SM, R/SM, R/WM, R/WM/AM, R/WM/AM/PM, R/WM/LM, R/WM/PM, R/WM/SM) were represented by only one species each. Similar patterns have been observed in previous studies across the basin where winter migratory species were found in high proportion (Pandey et. al. 1994; Gupta and Kaushik 2010; Biswas and Banerjee 2016; Ansari 2017; Debnath et al. 2018; Mandal et al. 2021; Yadav et al. 2023).

4.2. PHYSIO-CHEMICAL PROPERTIES AND ANTHROPOGENIC STRESSORS

The average salinity value of select freshwater wetlands was recorded between 0.06 and 0.4 ppt, highest for Jhilmil Jheel and Baan Ganga wetlands of Uttarakhand and lowest for Konar and Patratu dams in Jharkhand, while pH was recorded highest for Nauhatta in Bihar and lowest for Haiderpur and Nangla Beel wetlands in Uttar Pradesh and West Bengal, respectively (Figure 4.5). Ambient air and water temperature were recorded highest in East Kolkata (West Bengal) wetland, and the lowest for Baan Ganga (Uttarakhand). The ambient air temperature of select wetlands during the winter season varied between 16.66 and 29.55 °C, and water temperature varied between 15.06 and 26.20 °C (Figure 4.5). In addition, information on DO of eight select wetlands in Jharkhand and West Bengal was also measured, maximum value recorded for Patratu dam (12.4 mg/L) and the minimum for Ahiran and Dongaria wetlands (<3 mg/L). The optimal or acceptable DO level was recorded for the Sheeal Lake and East Kolakata wetlands (4-8 mg/L).

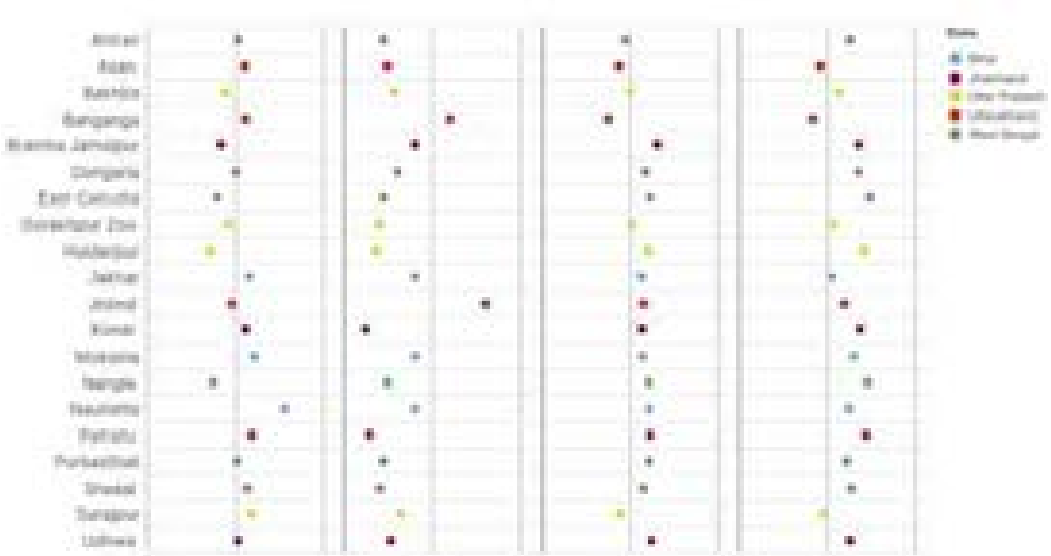


Figure 4.5. Different Physiochemical Parameters of the select wetlands (average values)

4.3. KEY CHALLENGES FOR THE SELECT WETLANDS

The Mokama (Bihar), Baan Ganga (Uttarakhand), and East Kolkata (West Bengal) wetlands have reduced significantly in their sizes owing to encroachment, diversion of water sources, and loss of hydrological connectivity due to physical barriers. Out of these wetlands, Mokama is designated as an IBA and KBA (RAMSAR 2025), however, the condition of the wetland has deteriorated manifold in the last 20 years. A highway bifurcated the wetland and barred water influx into the wetland. The encroachment for agriculture has changed the land use of the wetland to a great extent. Similarly, Baan Ganga has also faced agriculture induced land use changes, which reduced the wetland area. East Kolkata wetlands have witnessed land use changes in the last 20 years (Parihar et al. 2013), urban encroachment and overwhelming fish farming have negatively impacted avifaunal diversity. Waterbirds are known to survive in optimal water conditions, for instance, neither acidic nor basic pH values are suitable (Ma et al. 2010; Mishra et al. 2023). Similarly, other water parameters are known to influence waterbirds in combination with other anthropogenic factors (Ma et al. 2010; Fox et al. 2025).

The Surajpur wetland in Noida and most of the surveyed wetlands in West Bengal consist of mosaics of different habitats in the urban landscape, which have also witnessed several changes in land use. Unauthorised construction and conversion of agricultural lands into residential and commercial spaces is one of the key threats to Surajpur wetland. The discharge of untreated wastewater from nearby industries has severely polluted the wetland (Ansari et al. 2015). One hundred eight villages encircle the Bakhira wetland, and the residents depend on the wetland for their livelihood through activities such as fishing, farming, and collecting firewood and fodder (Kashyap et al. 2024). Often, local villagers extract grasses from the wetland, livestock feed and fuel purposes, and people regularly wash their clothes in the Bakhira wetland (Mishra et al. 2016). Udhwa wetland is facing encroachment by agriculture expansion. The Ahiran wetland is heavily impacted by runoff containing pesticides and chemical fertilisers from nearby agricultural activities.

Additionally, local villagers are expanding their agricultural lands and grazing activities into the wetland, leading to a gradual shrinking of its area (Mondal and Roy 2014). Cattle grazing in Haiderpur wetland was found prominent on the northern side, especially during the dry season (Rana et al. 2025). Brahmajamalpur wetland is shallow, with an average depth of 0.7 m, and is abundant in aquatic weeds, mainly *Pontederia crassipes, Salvinia cuculata, Marsilea minuta, Ipomoea aquatica, Hydrilla vaticillata,* which almost cover the entire surface. It dries up in the hot summer months and is used for summer cultivation by the local people. Similarly, Nauhatta wetland and Surajpur are infested with invasive species, and the waterbody is choking owing to the rapid invasion of *Pontederia crassipes*.

05

POLICY INSIGHTS AND CONSERVATION IMPLICATIONS

5.1 WETLAND POLICY EVOLUTION IN INDIA

Policies and regulations regarding wetland and water conservation in India followed a trajectory similar to the policies regarding other natural resources. The pre-1970s era focused on exploitation or extractive usage of the resources, including water. There was limited formal recognition of wetlands in the legislative documents. The wetlands were viewed as wastelands and hence their conversion was rampant The United Nation's Stockholm Conference on Human Environment in 1972 was the precursor for the changes in the protection of natural ecosystems in India as well. The Indian Wild Life (Protection) Act of 1972, got impetus from the Stockholm Declaration of 1972. The Indian Wild Life (Protection) Act of 1972 was the first directive that provided wetlands some protection by the virtue of these ecosystems being the habitat of the species and thereby getting incidental protection. Yet, the importance of wetlands as an important hydrological feature was undermined and overlooked. Taking cue from the Stockholm Declaration, the Indian Constitution was amended in 1976 and articles 48A and 51A(g) were inserted in the Constitution. The Article 51A (g) states that "it shall be the duty of every citizen of India to protect and improve the natural environment, including forests, lakes, rivers and wildlife and to have compassion for living creatures", thus this 42nd amendment of the Constitution acknowledged the lakes and rivers as part of the natural environment.

Taking cure from the Stockholm Declaration and the amendment in the Indian Constitution, the legislative framework in India for the natural resources, including water, was strengthened. The 1974's Water (prevention and control of pollution), Act was the first act to address the issue of pollution of water, including rivers, streams, wells and maintain and restore the water quality. The Act established the State Pollution Control Boards (SPCB) and Central Pollution Control Board (CPCB), to ensure the provisions of the Act. This was followed by the Water (Prevention and Control of Pollution) Cess Act, 1977, which levied cess to the industries and local authorities and aid functioning of the SCPBs and CPCB. Both these acts did not mention waterbodies, or wetlands explicitly. The Forest (Conservation) Act, 1980 also did not mention wetlands overtly. The amendment to this act made in 1988, placed monitoring mechanism for water pollution in areas leased for mining.

At the global forum, the Ramsar Convention, brought attention of the conservationist and the governments to the wetlands ecological value. India acceded to the Ramsar Convention on Wetlands of International Importance in 1982 and started recognizing the wetlands for their ecological role. The Environment (Protection) Act (EPA), 1986 is the landmark umbrella legislation, which aims at protection of the environment inclusive of air, water, land and it is the first act which acknowledges the inter-relationship between these and with life forms including humans. In 1986-87 the Ministry of Environment, Forest and Climate Change (MoEFCC) established the National Wetlands Conservation Program (NWCP), with the aim to provide policy framework for conservation of the wetlands. The NWCP, was the first measure which aimed at conserving the wetlands of national importance, through implementation of management action plans. It took a comprehensive approach towards wetland conservation through boundary demarcation, catchment treatment, controlling pollution and biodiversity conservation. Following this, National Lake Conservation Plan (NLCP) was prepared and implemented in 2001, which focused on restoring and conserving urban and semi-urban lakes, and other unique freshwater ecosystems such as high altitude lakes, through an integrated ecosystem approach. Later in 2006, during the era where focus of the policies was on sustainability, inclusiveness, climate change, the National Environment Policy (NEP) was framed. The NEP, 2006 gave a comprehensive directive on inclusiveness, equity, integrated management for natural resources including wetlands. This policy provided framework and guidelines for integrating conservation and wise-use of wetlands in river basin management. This policy provided a set of actions for conservation of wetlands, which include, setting up of legal regulatory mechanism, inventorization of wetlands, community and stakeholder participation, integrate wetland conservation with sectoral development. 2006 also saw a major development in terms of notification of the Environment Impact Assessment (EIA), under the provision of Rule 5 of the EPA for imposing restrictions and prohibition of activities, without prior approval, in view of the potential impact of these activities on environment.

Soon, thereafter the National Action Plan on Climate Change (NAPCC), was launched in 2008. The NAPCC has eight missions, with one mission on water, viz. the National Water Mission, which focuses on conservation of wetlands through a list of actions mentioned in the NAPCC document. Following NAPCC, and with EPA (1986) as the guiding act, the policies and acts were drafted specifically for the wetlands, the pioneer among these was the Wetlands (Conservation and Management) Rules of 2010. The Rule has provision for constitution of the Central Wetlands Regulatory Authority, along with the protection of wetlands which were deemed to be ecologically sensitive and rich, the Ramsar Wetlands, high altitude wetlands. The Rules also laid down the guidelines for restricted activities within these wetlands. The Wetlands (Conservation and Management) Rules 2017, superseded the 2010 Rules, which resulted in creation of State Wetlands Regulatory Authority, which shifted management from Central to State authorities, with National Wetlands Committee playing the advisory role. The 2017 Rules excluded river channels, paddy fields, man-made water bodies created for drinking and irrigation purpose and other uses.

The MoEFCC, merged the NWCP and NLCP, and created National Plan for Conservation of Aquatic Ecosystems (NPCA) in 2013, with the aim to have a unified and common approach for conservation and management of the wetlands and urban and semi-urban lakes. The NPCA recommended integrated management of the wetlands. The NPCA guidelines of 2019, superseded the guidelines of NLCP, 2008 and guidelines for conservation and management of wetlands, 2009. Apart from integrated approach towards wetland management the NPCA 2019 guidelines emphasized on cross-sectoral governance, built upon the Wetlands (Conservation and Management), Rules 2017. The NPCA guidelines 2019 were revised in 2024, with the aim to mainstream wetland conservation in state level policy and decision making, and stakeholder participation. The most recent amendment in the EIA notification 2006, done in March 2025, provides for avoidance of extraction and borrowing land

upto 1 km from the wetland and water bodies.

The policies on wetland saw a gradual evolution, from non-existence to a formal legal framework, acknowledging the ecological role of the wetlands, as habitat of species, for human's well-being on wetlands (Figure 5.1). The policy evolution in India followed the evolution of contemporary global policies with respect to natural resources. These policies and guidelines will provide much needed impetus for conservation of wetlands in India. The policies provide regulations for integrated management, sectoral coherence and research, which will bridge the policy-science-practice interface.

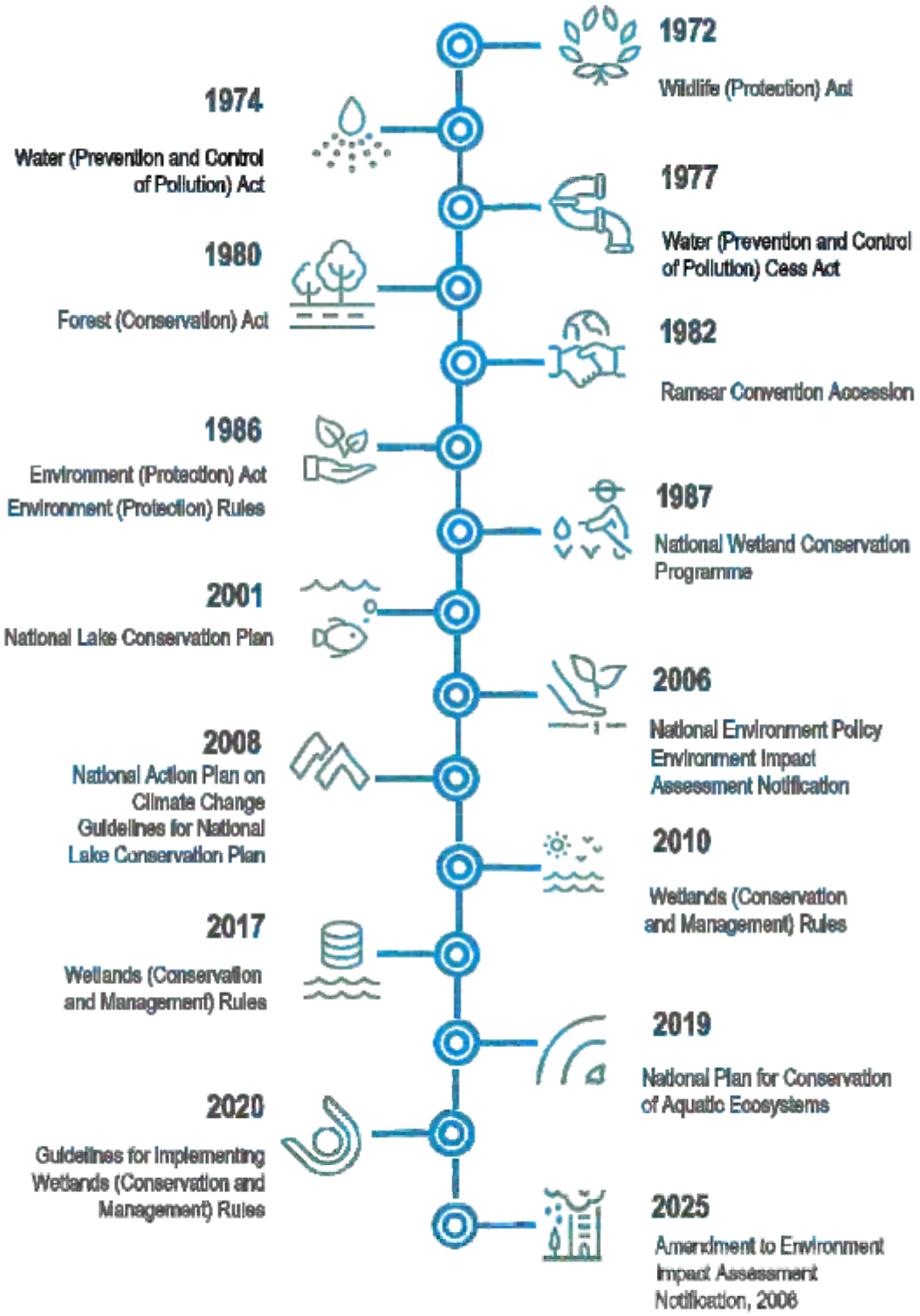


Figure 5.1 Evolution of policies related to wetland conservation in India

5.2 CONSERVATION AND MANAGEMENT IMPLICATIONS FOR THE SURVEYED WETLANDS

Most of the surveyed wetlands fall within the jurisdiction of irrigation and forest departments, thus coordination between these line agencies is required to meet the demands of agriculture as well as wildlife. Ownership of these wetlands sometimes lies with Panchayats and private individuals or firms. Thus, in such cases, wetlands demand a high level of coordination between the concerned government departments and the owner. Most of the Indian waterbodies are owned by either village panchayats or private firms/individuals (MoJS 2023). Here, we present the wetland-specific recommendations, which are based on the present survey and thorough review of policy documents like management plans, basin management plans, and published literature-

- Asan wetland hosts a significant waterbird population in the state of Uttarakhand. The wetland has been protected under the purview of the Indian Wild Life (Protection) Act (1972) and is also recognised as a Ramsar site. The wetland is located in the close vicinity of Dehradun, the capital city of Uttarakhand. The growing population around the Dehradun city is putting pressure on the land resources and has changed the LULC of the district in the recent few years. The headwaters of the Asan River have lost their character and hydrological connectivity due to development pressures. The sewage inflow into the River and the wetland needs to be checked and managed. The current master development plan of Dehradun does not address the waste and sewage issue in the Asan headwaters (Anon, ND). Apart from off-site inflow, there is also a need to manage the on-site waste disposal in and around the wetland, especially from nearby villages and tourism areas. Frequent patrols would regulate the unauthorised movement of the crowd towards the embankment side and abate disturbance to waterbirds. Fostering awareness in the youth and children of nearby villages regarding wildlife tourism potential, and income generation could prepare a cadre of local guardians for wildlife protection. In addition, management of invasive species like *Pontederia crassipes, Ipomoea carnea, Lantana camara*, *Ageratina adenophora, Parthenium hysterophorus* and restoring natural vegetation would enhance suitable habitats for waterbirds (Mishra et al. 2023). Bird reflectors could be used to avoid mortality due to the power lines.
- Jhilmil Jheel has been protected under the purview of the Indian Wild Life (Protection) Act (1972), as Conservation Reserve. It harbours small water pools and a marsh area. Although the wetland habitat provides excellent habitat for swamp deer, water and water-associated species were not common. Perhaps the nearby channel of the Ganga River provides better habitat for them, and Jhilmil might work as an additional grazing ground for them. Grazing activities need to be regulated in the wetland to avoid any potential threat to the dwindling population of swamp deer (Paul et al. 2020). Eucalyptus plantation around the wetland needs to be replaced by native/water-retaining tree species that would improve habitat quality in the near future.
- Over the last two decades, the Baan Ganga wetland has been reduced in its extent and altered due to land use changes. The hydrological connectivity of the wetland has also been disrupted, as a result of which the wetland has shrunk in its extent. The wetland is surrounded by agricultural land, which indicates possibilities of chemical discharge from the crops. Nonetheless, the wetland harbours around 10 water and water-associated species. Prompt conservation actions are required to restore this wetland.
- Gorakhpur Zoo wetland is located inside the zoo campus and is fully protected by the forest department. Having an excellent opportunity, there is a need to maintain habitat heterogeneity to attract different types of waterbirds into the wetland. Although it's a small wetland, it provides a safe refuge to migratory as well as resident waterbirds, and it requires special attention from the wetland authorities. Nearby swamp area, along with a small forest patch (*Syzygium cumini, Terminalia arjuna, etc.*), has the potential to provide roosting and nesting habitats for the colonial waterbirds (heronries/ rookeries).
- Bakhira wetland is notified as a wildlife sanctuary, under the purview of the Indian Wild Life (Protection) Act (1972), but the demarcation of boundaries and, settlement of ownership of land are yet to be done. Apart from land rights settlement, there is also a need for demarcation of wildlife and tourism

zones. Sustainable fisheries and capacity building of staff are key measures to encourage patrolling by the Forest Department (Johnson et al. 2021). The wetland requires long-term monitoring of biodiversity that can be formalised as an annual exercise coinciding with the Annual Waterfowl Count and Citizen Science initiatives. The waterbody needs to be managed intensively, providing a mosaic of habitats to different waterbird groups. Shrinking wetland area and heavy dependence of the local people on the sanctuary's natural resources are also a matter of concern, which requires urgent attention of the concerned authorities (Mishra et al. 2020; Kashyap et al. 2024).

- Being an urban wetland, Surajpur is prone to multiple threats, including an influx of untreated effluent into the waterbody. Periodic management of invasive species has to be taken up, and habitat heterogeneity could also be maintained to increase waterbird diversity through active management practices, including deep water pools, marshland, shallow water, and native emergent vegetation. Trees around the wetland would also provide habitat for roosting and nesting of large waders.
- Haiderpur wetland is one of the key wetlands in the Upper Ganga River system, as it is one of the last refuges for swamp deer. Being part of the Hastinapur WLS, the wetland has been protected under the purview of the Indian Wild Life (Protection) Act (1972) and is also recognised as a Ramsar site. The wetland also hosts many waterbird species that need special attention, considering that multiple villages surround the wetland. A small proportion of the wetland is utilised for agricultural practices, which need to be monitored, and any probable encroachment must be prevented. Fishing and grazing rights have to be documented, as people from far off are known to carry out fishing activities within the wetland. Grazing pressure should also be restricted and discouraged near waterbird habitats. Water regimes play a vital role in shaping the availability of natural resources, and frequent patrolling in and around inconspicuous parts of the wetland is required to regulate unsustainable fishing activities and the extraction of other biological resources. *Pistia stratiotes* and *Pontederia crassipes* are some aquatic invasive species that need to be managed with the support of the local community members.
- Mokama Taal is one of the most vulnerable wetlands in the state of Bihar, which has been depleted significantly over the last few years. Firstly, the wetland needs to be revived and the chocked water channel needs to be reconnected to the waterbody that was obstructed by the highway construction. Secondly, boundary demarcation and ownership need to be finalised so that the encroached area can be revived as a wetland. Presently, the biodiversity value of this wetland remains very low, particularly for waterbirds. The restoration would require political will and the active participation of stakeholders.
- Seasonality plays a vital role in maintaining the water regime of Jakhar Jheel, particularly during the monsoon season. Although the wetland is free of severe pollutants, bathing and washing activities need to be regulated, and a suitable habitat for waterbirds needs to be conserved. There is also a need to urgently revive the hydrological connectivity of the wetland with the Bagmati River.
- Fishing activities in Nauhatta East wetland could be a significant threat to associated waterbird species that need to be regulated. Existing clusters of powerlines could also cause problems for water and associated bird species, they need to be modified as shockproof, or the use of reflectors on the power lines may be introduced to reduce mortality risk. *Pontederia crassipes* has infested a large proportion of wetlands, which requires periodic removal.
- Udhwa wetland falls within the Protected Area boundary. Seasonal fishing activities need to be regulated, and invasive species require removal from the waterbody and surrounding habitats. Another key threat, poaching, needs to be dealt with strict implementation of all prescribed laws by strengthening the forest staff (Tiwari 2021). The recommendations of the Management Plan should be implemented for the betterment of Udhwa WLS.
- Brahma Jamalpur wetland has similar issues to Udhwa. Both wetlands are connected through a water stream. The wetland is heavily utilised for agricultural practices, with the presence of water hyacinth, which needs periodic management of the wetland. The management recommendations of the management plan should also be implemented on the Brahma Jamalpur wetland (Tiwari 2021).
- Konar and Patratu Dams have the potential to

provide a pristine habitat to several waterbird species. Konar was found to be free of any anthropogenic pressures, whereas Patratu was prone to different anthropogenic threats, of which fishing requires regulation, especially during peak waterbird arrival seasons. At present, invasive species like *Pontederia crassipes* are restricted to a few patches but require attention to remove before infestation spreads.

- Ahiran wetland is undergoing several changes. Agricultural (rice) practice in and around the wetland contributes to chemical run-off and has altered the land use type, which needs to be checked by the authorities. Invasive species have increasingly infested wetland areas, thus requiring periodic removal to conserve the waterbody for waterbirds. Few local communities are found to be involved in poaching activities, mass awareness and implementation of law are much needed in the Ahiran wetland (Mistry and Mukherjee 2015).
- Invasive species have infested more than half of the Dongaria wetland, which requires management intervention to clear floating weeds like water hyacinth. This wetland receives water from near the STP, and grazing activities can be managed with the cooperation of local people by ensuring the sustenance of their cattle as well as waterbirds and other associated species.
- Being an urban wetland, East Kolkata Wetlands are facing immense pressure from multiple directions. Invasive species infest a large proportion of waterbodies, and continuous unregulated fishing poses a disturbance to waterbirds. Being a designated Ramsar site, such activities should be regulated by the EKWA and the Forest Department. The encroachment of wetland habitat remains a long-standing issue that requires special attention. In addition to encroachment, unsustainable fishing practices have left significantly less scope for waterbirds to live in harmony with humans (Naskar et al. 2021; Chakraborty et al. 2023).
- Nangla Beel has been encroached significantly by agriculture on wetland edges, which needs to be prevented by demarcating the boundaries of the wetland area. The dependence of people on the wetland should also be regulated, with seasonal waterbird aggregation, particularly unsustainable fishing methods.
- Agricultural related encroachment in and around the Purbasthali wetland needs special attention from the authorities. Invasive species have infested almost half of the wetland and should be periodically managed with the help of local people and concerned authorities. The Sheeal lake is also facing similar issues, but has more unsustainable fishing activities, which need to be regulated, and invasives should also be managed scientifically (Mandal et al. 2021).

We surveyed an array of wetlands in the Ganga River Basin to understand the ecological significance and threats faced by these wetlands. The policies on wetland conservation of the Government of India are applicable to all these studied wetlands.This assessment underscores the need for stricter implementation of these policy measures, including integrated wetland management, localized management actions through community engagement, and scientific monitoring. Enhancing wetland monitoring, ensuring ecological flow, and restoring connectivity between rivers and wetlands are imperative to safeguarding these vital ecosystems and the biodiversity they support.

On a broader spectrum, the Government of India (GoI) has emphasized wetland conservation in the recent past. India harbors the largest network of RAMSAR sites in South Asia (RAMSAR 2025). Additionally, as a one more positive step, the MoEFCC has unveiled a dedicated wetland portal, and also declared Indore and Udaipur, two cities as India's pioneer cities to be accredited as “Wetland Cities” under the Ramsar Convention, which shows commitment towards conservation and management of Indian wetlands (Figure 5.2).

In addition to the MoEFCC, the Ministry of Jal Shakti is also actively conserving the waterbodies, which involves encouraging formation of multiple waterbodies as “Amrit Sarovar” in each district of India, which will ensure to fulfil water demand and recharge groundwater. Encouraging blue-green infrastructure could work wonders for the urban and semi-urban landscapes, including waterbodies and green spaces (Perrelet et al. 2024) (Figure 5.2). NITI Ayog (2023) highlighted GoI's efforts across different Indian states, focusing on five broader areas i) policy-led interventions, ii) watershed development, iii) smart water infrastructure, iv) wastewater treatment and its reuse, and v) climate resilient water management. At present, Indian wetlands are facing immense pressure, and they need to be conserved through nature-based solutions, viz., phytoremediation and bioremediation (NITI Ayog 2023). Waterbird

conservation also demands connectivity among wetland habitats, thus nearby satellite wetlands should also be focused on for effective management as they serve as foraging or roosting sites. The long-term (annual) wetland and waterbird/ other taxa monitoring with the help of various research and enthusiastic groups should be encouraged in select wetlands. Additionally, research activities should also be promoted, focusing on management and conservation challenges. Eventually, for the conservation and management of the select wetlands, ongoing international and national schemes and plans could be aligned as per the demands of each particular wetland.

Figure 5.2. Government initiatives for wetland conservation

REFERENCES

Abhilash HR, Sathish SV, Siddaramaiah B (2024) Species composition, diversity and foraging guilds of avifauna in two freshwater lakes of Mysore district, Karnataka, India. *Ornis Hung*, 32:60-73.

Adhikari, B. S., & Babu, M. M. (2008). Floral diversity of Baanganga Wetland, Uttarakhand, India. *Check list*, 4(3), 279-290.

Alam, A., Gopal Sharma, M. S., Maaz, M., & Yasmin, S. (2022). Avifauna along Ganges near Patna, Bihar, India. *Journal of Entomology and Zoology Studies*, 10(6): 183-188.

Amat, J. A., & Green, A. J. (2010). Waterbirds as bioindicators of environmental conditions. Conservation monitoring in freshwater habitats: *A practical guide and case studies*, 45-52.

Anand, A., Singh, A. K., Abhishek, & Kumar, A. (2022) Avifaunal Diversity and Status Assessment in Kaimur Wildlife Sanctuary, Bihar, India. I*ndian Journal of Natural Sciences*, 13 (74): 48711- 48724

Anon (2006). An ecological assessment of Baan Ganga wetland, Uttaranchal. Final Report submitted to Uttaranchal Forest Department. Wildlife Institute of India, Pp. II + 87.

Anon (ND). Dehradun Master Plan, 2041. Draft. Town and Country Planning Department, Uttarakhand. Chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/http://mddaonline.in/wpcontent/uploads/2023/04/Dehradun-Master-Plan-2.0A.pdf

Ansari, N. A. (2017). Monitoring of water bird population with an account of heronry at Surajpur lake, an urban wetland in National Capital Region, India. *Indian Journal of Animal Sciences*, 87(12), 1504-1512.

Ansari, N. A., Khan, A. A., & Ram, J. (2016). Vascular plants of Surajpur wetland, National Capital Region, India. *Indian Journal of Plant Sciences*, 5(1), 54-69.

Arya, A.K., Joshi, K.K., Bachheti, A. and Deepti (2020) A Study of Waterbirds Diversity in Selected Wetlands of Uttarakhand (Western Himalayas), India. *International Journal of Advanced Research in Engineering and Technology* (IJARET), 11(5), 2020.

Arya, A.K., Joshi, K.K., Bachheti, A., Raturi, V., Dubey, V., Bhatnagar, P., & Rawat, R. (2020).

Avian survey at Haiderpur Wetland in Hastinapur Wildlife Sanctuary Uttar Pradesh, India. *Journal of Environment and Bio-Sciences*, 34(2): 107-114.

Badola, R. (2006). Socio-Economic Status of the Local Communities in the Baan Ganga Wetland Area. In "An ecological assessment of Baan Ganga wetland, Uttaranchal." Final Report submitted to Uttaranchal Forest Department. Wildlife Institute of India. Pp. 59-68. https://wii.gov.in/images/images/documents/publications/rr_2006_baan_ganga_report.pdf

Bibby, C. J., Jones, M., & Marsden, S. (1998). Bird surveys. London: *Expedition Advisory Centre*, 1-137.

Biswas, S., & Banerjee, A. (2016). Studies on avifaunal diversity of Santragachi Wetland, West Bengal, India. Asian Journal of Water, *Environment and Pollution*, 13(3), 29-36.

Census of India (2011). https://www.census2011.co.in

Chakraborty, P., Shappell, N. W., Mukhopadhyay, M., Onanong, S., Rex, K. R., & Snow, D. (2021). Surveillance of plasticizers, bisphenol A, steroids and caffeine in surface water of River Ganga and Sundarban wetland along the Bay of Bengal: occurrence, sources, estrogenicity screening and ecotoxicological risk assessment. *Water Research*, 190, 116668.

Chakraborty, S. K., Sanyal, P., & Ray, R. (2023). Wetlands Ecology: Eco-biological Uniqueness of a Ramsar Site (East Kolkata Wetlands, India). Springer Nature.

Chatterjee, Asitava; Adhikari, Shuvadip; Pal, Sudin; Mukhopadhyay, Subhra Kumar (2020). Foraging guild structure and niche characteristics of waterbirds wintering in selected sub-Himalayan wetlands of India. *Ecological Indicators*, 108, 105693.

Chatterjee, L., Khan, A., Panja, B., Samanta, T., Jana, S., & Roy, A. B. (2023). Inventory of migratory waterbirds in the coastal areas of Purba Medinipur district, West Bengal, India. *Cuadernos de Biodiversidad*, (65), 23-35. https://doi.org/10.14198/cdbio.23488

Chaudhuri, D., C, Dubey A K and Pandey S B (2015). An Overview of Konar Dam on Need ofRehabilitation Compendium of Technical Papers, First National Dam Safety Conference,(Chennai) pp 269-74.

Das, B. K., Sahu, S. K. and Parida, P. K., (2022). Inland water bodies of Bihar, ICAR-CIFRI, Barrackpore. ISBN: 81-85482-43-8.

Das, S., Bhunia, G. S., Bera, B., & Shit, P. K. (2022). Evaluation of wetland ecosystem health using geospatial technology: evidence from the lower Gangetic flood plain in India. *Environmental Science and Pollution Research*, 29(2), 1858-1874.

Davidson, N. C. (2014). How much wetland has the world lost? Long-term and recent trends in global wetland area. *Marine and Freshwater Research*, 65(10), 934-941.

Davidson, N. C., & Finlayson, C. M. (2018). Extent, regional distribution and changes in area of different classes of wetland. Marine and Freshwater Research, 69(10), 15251533.

Debanshi, S., & Pal, S. (2020). Wetland delineation simulation and prediction in deltaic landscape. Ecological indicators, 108, 105757.

Debnath, S., Biswas, S., & Panigrahi, A. K. (2018). Present status and diversity of avian fauna in Purbasthali bird sanctuary, West Bengal, India. Agricultural Science Digest-A Research Journal, 38(2), 95-102.

Dey, S., Dey, S., Choudhary, S. K., & Kelkar, N. (2014). An annotated bird checklist of the Vikramshila Gangetic Dolphin Sanctuary, Bhagalpur, Bihar, India, with an assessment of threats to bird conservation. Forktail, 34a, 40.

EKWMA-WISA (2021). Integrated Management Plan of East Kolkata Wetlands (Management Action Plan 2021-2026). East Kolkata Wetlands Management Authority and Wetlands International South Asia. Pp 272.

Fluet-Chouinard, E., Stocker, B. D., Zhang, Z., Malhotra, A., Melton, J. R., Poulter, B., ... & McIntyre, P. B. (2023). Extensive global wetland loss over the past three centuries. Nature, 614(7947), 281-286.

Fox, A. D., Jørgensen, H. E., Jeppesen, E., Lauridsen, T. L., Søndergaard, M., Fugl, K., ... & Musilová, Z. (2025). Breeding waterbird species as ecological indicators of shifts from turbid to clear water conditions in northwest European shallow eutrophic lakes. *Hydrobiologia*, 852(2), 411-423.

Ganesan, L., & Khan, R. A. (2007). Studies on the ecology of zooplankton in a floodplain wetland of West Bengal, India. *Proceedings of Taal*, 67-73.

Garg, J., & Patel, J. (2007). National wetland inventory and assessment, technical guidelines and procedure manual. Retrieved from Space Applications Centre, Indian Space Research Organisation (ISRO), Ahmedabad, India.

Garg, J., Singh, T., & Murthy, T. (1998). Wetlands of India. SAC, Indian Space Research Organisation, Ahmedabad.

Ghosh, S., & Das, A. (2020). Wetland conversion risk assessment of East Kolkata Wetland: A Ramsar site using random forest and support vector machine model. *Journal of Cleaner Production*, 275, 123475.

Gopal, B. (2013). Future of wetlands in tropical and subtropical Asia, especially in the face of climate change. *Aquatic sciences*, 75, 39-61.

Gopi, G.V., Arya, S. and Hussain, S. A. (2014). Waterbirds of India: An Introduction. In Gopi, GV & Hussain, SA (eds.) Waterbirds of India. *ENVIS Bulletin: Wildlife Protected Areas*, 6, 10-23.

Gupta, P. K., Patel, J. G., Singh, R. P., Bahuguna, I. M., & Kumar, R. (2021). Space based observation of Indian wetlands. Space Applications Centre, ISRO.

Gupta, P.K., Patel, J.G., Bhanderi, R.J., Parmar, M., Rathore, B.P., Mishra, I., Ramakrishnan, R., Chander, S., Dubey, A., Gujrati, A., Wadhwa, C., Roy, S., Singh, R.P., Bahuguna, I.M., Kumar, R., Oza, S.R., Sharma, R., and Dhar, D. (2024). Indian wetlands: A high resolution remote sensing assessment and analysis, space applications centre, ISRO Ahmedabad, India.

Gupta, R. C., and Kaushik, T. K. (2010). Determination of spectrum of winter migratory birds in Yamuna Nagar district in Haryana (India). *Environment Conservation Journal*, 11(3), 37-43.

Haider, A. A., Hassan, M. I. B., & Rasib, A. W. B. (2023). Geospatial Approach to Wetland Vulnerability Assessment for Northwest Bangladesh. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 48, 139-143.

IPBES (2018): Summary for policymakers of the assessment report on land degradation and restoration of the Intergovernmental SciencePolicy Platform on Biodiversity and Ecosystem Services. R. Scholes, L. Montanarella, A. Brainich, N. Barger, B. ten Brink, M. Cantele,B. Erasmus, J. Fisher, T. Gardner, T. G. Holland, F. Kohler, J. S. Kotiaho, G. Von Maltitz, G. Nangendo, R. Pandit, J. Parrotta, M. D. Potts, S. Prince, M. Sankaran and L. Willemen (eds. 2018). IPBES secretariat, Bonn, Germany. Pp. 44.

Javed, S. & Rahmani, A.R. (1998). Conservation of the avifauna of Dudhwa National Park, India. *Forktail*, 55-64.

Jha, K. K., & Mckinley, C. R. (2015). Composition and dynamics of migratory and resident avian population in wintering wetlands from northern India. *Notulae Scientia Biologicae*, 7(1), 1-15.

Johnson, J.A., K. Sivakumar, C. Vijaykumar, P. S. Mondal, P. Mitra, V.K. Dubey and A. Sharma, (2021). Detailed Project Report of Bakhira Bird Sanctuary, Uttar Pradesh, India. Wildlife Institute of India, Dehradun, Pp. 1-81

Joshi, K., Kumar, D., Arya, A.K., & Bachheti, A. (2021). An Assessment of Water bird species and associated water bird composition in the Haiderpur Wetland of Hastinapur Wildlife sanctuary Uttar Pradesh, India. *Asian Journal of Conservation Biology*, 10(1), 141-5.

Joshi, O., Singh, N., & Sathiyaselvam, P. (2024). Waterbird diversity of Saman Wetland Complex in Uttar Pradesh: a crucial site for the India's National Action Plan on migratory birds. *Journal of Threatened Taxa*, 16(6), 25373-25384.

Kanaujia, A., Kumar, A., Kumar, A., Kushwaha, S., & Kumar, A. (2014). Blooming Faunal Diversity of Nawabganj Bird Sanctuary, Unnao, Uttar Pradesh, India. *G-Journal of Environmental Science and Technology*, 2(2), 14-24.

Kashyap, P., Shukla, A., & Singh, A. (2024). A framework for the sustainable utilization, conservation, and management of Bakhira Tal wetland, Sant Kabir Nagar, UP, India. *South India Journal of Social Sciences*, 22(2).

Kumar, A., & Kanaujia, A. (2015). Lakh Bahosi Bird Sanctuary: A Waterbird Abode. *International Journal of Current Research*, 7(07): 18151-18159

Kumar, A., Kanaujia, A., Kushwaha, S., & Kumar, A. (2015). A Biodiversity Hub: Sandi Bird Sanctuary, Hardoi, Uttar Pradesh, India. *International Journal of Applied Biology and Pharmaceutical Technology*, 6(2): 273-288.

Kumar, A., Sati, J.P., Tak, P.C., & Alfred, J.R.B. (2005). Handbook on Indian wetland birds and their conservation. Zoological Survey of India, Kolkata.

Kumar, D., Kushwaha, S., Maheshwari, S. K., & Namdev, A. (2016). Avifaunal diversity of Govind Sagar dam in Lalitpur, Uttar Pradesh. *International Journal of Research in BioSciences*, 5(4): 43-55.

Kumar, M., Kumar, A., & Bhardwaj, S.K. (2023). Diversity, composition and conservation status of avian fauna in the forest and the wetland sites of Hastinapur wildlife sanctuary, India. *Environment Conservation Journal*, 24(2): 334-342.

Kushwaha, S., & Kumar, A. (2018). Occurrence and Distribution of Stork Species in Bundelkhand Region, the Drought Prone Landscape of India. *International Journal of Trend in Scientific Research and Development* (IJTSRD), 3(1), 958-965.

Laguna, C., López-Perea, J. J., Feliu, J., Jiménez-Moreno, M., Martín-Doimeadios, R. C. R., Florín, M., & Mateo, R. (2021). Nutrient enrichment and trace element accumulation in sediments caused by waterbird colonies at a Mediterranean semiarid floodplain. *Science of the Total Environment*, 777, 145748.

Li, D., Boleam A., Delany S., Martakis, G. and Quintero J.O. (2009). Status of waterbirds in Asia: results of the Asian waterbird census: 1987-2007. *Wetlands International*, Pp. 296.

Ma, Z., Cai, Y., Li, B., & Chen, J. (2010). Managing wetland habitats for waterbirds: an international perspective. *Wetlands*, 30(1), 15-27.

Mahapatra, A., Hore, U., Singh, A., & Kumari, M. (2024). The effect of urbanization on the shrinkage of wetlands in the Noida-Greater Noida region and its surrounding suburban areas. *Ecological Frontiers*, 44(1), 96-104.

Mahar, N., Rawat, A.P., Kumari, P., Talreja, A., Gokulakrishnan, G., Barthwal, S., Badola, R., and Hussain, S.A. (2025). Status of Waterbirds in the Ganga River Basin: A Review. Ganga Aqualife Conservation Monitoring Centre. Wildlife Institute of India. Pp. 50. ISBN No. 978-93-49520-58-5

Mandal, M. H., Roy, A., Ghosh, S., Basak, A., & Siddique, G. (2021). Assemblage of wetland bird Species in Purbasthali Oxbow Lake, West Bengal, India: Implications for Management. *Ornis Hungarica*, 29(2), 25-45.

Manral, U., & Khudsar, F. A. (2013). Assessment of wetland water quality and avian diversity of a human-modified foodplain wetland on River Yamuna. *Notulae Scientia Biologicae*, 5(1), 25-33.

Manral, U., Raha, A., Solanki, R., Hussain, S. A., Mohan, D., Talukdar, G., and Veeraswami, G. G. (2012). Hydrological characteristics and flood plain vegetation of human impacted wetlands: A case study from Okhla Bird Sanctuary, National Capital Region, India. *Asian journal of conservation Biology*, 1(2), 110-119.

Mansfield, I., Reynolds, S. J., Lynch, I., Matthews, T. J., & Sadler, J. P. (2024). Birds as bioindicators of plastic pollution in terrestrial and freshwater environments: A 30 year review. *Environmental Pollution,* 123790.

Mazumdar, S. (2019, December). Composition of avian communities in a human-modified wetland Okhla bird sanctuary, India: with notes on conservation initiatives. *Proceedings of the Zoological Society*, 72 (4), 319-333.

Millennium Ecosystem Assessment (MA). (2003). Ecosystems and human well-being: A framework for assessment. Island Press. Ministry of Jal Shakti (2023). First Census Report of Water Bodies. Vol. 1. Department of Water Resources, River Development and Ganga Rejuvenation. Minor Irrigation (statistics) Wing. Pp. 179.

Mishra, A. P., Kumar, S., Patra, R., Kumar, A., Sahu, H., Chandra, N., ... & Alshehri, F. (2023). Physicochemical parameters of water and its implications on avifauna and habitat quality. *Sustainability*, 15(12), 9494.

Mishra, H., Kumar, V., & Kumar, A. (2016). Diversity and population status of waders (Aves) of Bakhira Tal, a natural wetland in District Sant Kabir Nagar, Uttar Pradesh, India. *Biodiv. J*, 7, 331-336.

Mishra, H., Kumar, V., & Kumar, A. (2020). Population structure and habitat utilization of migratory birds at Bakhira Bird Sanctuary, Uttar Pradesh, India. *Pakistan Journal of Zoology*, 52(1), 247.

Mistry, J., and Mukherjee, S. (2015). Status and threats of water birds in Ahiran lake, Murshidabad, West Bengal, India. *International journal of plant, animal and environmental sciences*, 5(2), 59-64.

Mitsch, W. J., Bernal, B., & Hernandez, M. E. (2015). Ecosystem services of wetlands. In International Journal of Biodiversity Science, Ecosystem Services & Management (Vol. 11, Issue 1, pp. 1-4). Taylor & Francis.

Mitsch, W. J., Bernal, B., & Zhang, L. (2023). Wetlands (6th ed.). John Wiley & Sons. Modi, A., Bhagat, C., Mohapatra, P.K. (2023). Impact of Urbanization on Ganga River Basin: An Overview in the Context of Natural Surface Water Resources. In: Thambidurai, P., Dikshit, A.K. (eds) Impacts of Urbanization on Hydrological Systems in India. Springer, Cham.

Mondal, A., & Roy, D. (2014). An environmental study of Ahiron lake of Murshidabad district. J *Eng Comput Appl Sci*, 3(12), 1-6.

Mukhopadhyay, S., & Mazumdar, S. (2019). Habitat-wise composition and foraging guilds of avian community in a suburban landscape of lower Gangetic plains, West Bengal, India. *Biologia*, 74(8), 1001-1010.

Murthy, T. V. R., Patel, J. G., Panigrahy, S., & Parihar, J. S. (Eds.). (2013). National Wetland Atlas: Wetlands of International Importance under Ramsar Convention. Space Applications Centre, ISRO. http://www.sac.isro.gov.in

Namgail, T., Takekawa, J. Y., Bala-Chandran, S., Sathiyaselvam, P., Mundkur, T., & Newman, S. H. (2014). Space use of wintering waterbirds in India: Influence of trophic ecology on home-range size. *Current Zoology*, 60(5), 616-621.

Naskar, A., Alam, I., Majumder, A., & Maheswaran, G. (2021). Recently resighted population of Blue-breasted Quail (Synoicus chinensis) in and around East Kolkata Wetland is under threat due to development activities. *Records of the Zoological Survey of India*, 527-535.

National Wetland Atlas. (2011). https://saconenvis.nic.in/publication%5CNWIA_National_atlas.pdf

Nelms, S. E., Duncan, E. M., Patel, S., Badola, R., Bhola, S., Chakma, S., ... & Koldewey, H. (2021). Riverine plastic pollution from fisheries: Insights from the Ganges River system. *Science of the Total Environment*, 756, 143305.

Nguyen, H. H., Dargusch, P., Moss, P., & Tran, D. B. (2016). A review of the drivers of 200 years of wetland degradation in the Mekong Delta of Vietnam. *Regional Environmental Change*, 16(8), 2303-2315. https://doi.org/10.1007/s10113-016-0941-3

NITI Aayog (2023) "COMPENDIUM OF BEST PRACTICES IN WATER MANAGEMENT - 3.0, 2023" Panda, C. K., Kumar, R., & Meena, L. K. (2019). Lentil production economics and constraints: An empirical study in Mokama taal of Bihar.

Pandey, S., Joshua, J., Rai, N.D., Mohan, D., Rawat, G.S., Sankar, K., Katti, M.V., Khati, D.V.S. & Johnsingh, A.J.T. (1994). Birds of Rajaji National. Park, India. *Forktail*.

Parihar, S. M., Sarkar, S., Dutta, A., Sharma, S., & Dutta, T. (2013). Characterizing wetland dynamics: a post-classification change detection analysis of the East Kolkata Wetlands using open source satellite data. *Geocarto International*, 28(3), 273-287.

Paszkowski, C. A., & Tonn, W. M. (2006). Foraging guilds of aquatic birds on productive boreal lakes: environmental relations and concordance patterns. *Hydrobiologia*, 567, 19-30.

Paul, S., Sarkar, D., Patil, A., Ghosh, T., Talukdar, G., Kumar, M., ... and Mondol, S. (2020). Assessment of endemic northern swamp deer (Rucervus duvaucelii duvaucelii) distribution and identification of priority conservation areas through modeling and field surveys across north India. *Global Ecology and Conservation*, 24, e01263.

Perrelet, K., Moretti, M., Dietzel, A. et al. Engineering blue-green infrastructure for and with biodiversity in cities. npj Urban Sustain 4, 27 (2024). https://doi.org/10.1038/s42949-024-00163-y

Polla, W.M., Di Pasquale, V., Rasuk, M.C., Barberis, I., Romano, M., Manzo, R.A., Paggi, J.C., Farías, M.E., Contreras, M., Devercelli, M. (2018). Diet and feeding selectivity of the Andean flamingo *Phoenicoparrus andinus* and Chilean flamingo *Phoenicopterus chilensis* in lowland wintering areas. *Wildfow* , 68, 3-29.

Prakash, S., Mishra, A., Dwivedi, M., Mishra, A., Ranjan, M., and Raziuddin, M. (2012). Avian diversity of Udhuwa Lake Bird Sanctuary (IBA), Sahibganj, Jharkhand, India. *Columban J. Life Sci.*, 13 (1&2), 57-71.

Precision Survey Consultancy (PSC) (2020). Sedimentation Survey Report of Konar Reservoir under NHP. Report submitted to Damodar Valley Corporation, Jharkhand by Precision Survey Consultancy, Howrah. https://nhp.mowr.gov.in/docs/NHP/Sedimentation%20Studies/Report/4023/Sedimentation%20Report%20of%20Konar%20Reservoir%2010.09.2020.pdf

Prins, H. H., and Namgail, T. (Eds.). (2017). Bird migration across the Himalayas: wetland functioning amidst mountains and glaciers. Cambridge University Press.

R Core Team (2024). R: The R Project for Statistical Computing. https://www.r-project.org/

Rahmani, A. R., Islam, M. Z., and Kasambe, R. M. (2016). Important Bird and Biodiversity Areas in India priority sites for conservation: Revised and updated 2nd ed. India Volume I. *Bombay Natural History Society*. Pp. i-xii, 1-1992.

Rajora, K., & Sarma, K. (2024). Assessment of Pollution Status in Surajpur Wetland using multivariate statistical analysis, Uttar Pradesh, India. *Environmental Earth Sciences*, 83(12), 381.

Ramsar (2020). Asan Conservation Reserve, India. Ramsar Information Sheet. https://rsis.ramsar.org/RISapp/files/RISrep/IN2437RIS_2010_en.pdf

RAMSAR (2025). https://www.ramsar.org/country-profile/india

Ramsar Convention on Wetlands (2018). Global Wetland Outlook: State of the World's Wetlands and their Services to People. Gland, Switzerland: Ramsar Convention Secretariat.

Ramsar Convention on Wetlands (ND). Factsheet. Wetlands and biodiversity. 1-2. https://www.ramsar.org

Ramsar Sites Information Service. (2025). Ramsar Sites Information Service. Ramsar Convention Secretariat. https://rsis.ramsar.org/

Reis, V., Hermoso, V., Hamilton, S. K., Ward, D., Fluet-Chouinard, E., Lehner, B., & Linke, S. (2017). A global assessment of inland wetland conservation status. *Bioscience,* 67(6), 523-533.

Rodgers, W.A., Panwar, H.S. and Mathur, V.B. (2000). Wildlife Protected Area Network in India: A Review. Wildlife Institute of India, Dehradun. ISBN. 81-85496-08-0

SAC (2011). 'National Wetland Atlas'. SAC/EPSA/ABHG/NWIA/ATLAS/34/2011, Space Applications Centre (ISRO), Ahmedabad, India.

Sharma, E., Ramachandran, A., Dobriyal, P., Badola, S., Koldewey, H., Hussain, S. A., and Badola, R. (2025). Mapping the Distribution and Discharge of Plastic Pollution in the Ganga River. *Sustainability,* 17(11), 4932.

Singh, K.P., Riyaz, M., Singh, G., & Syed, S. (2021). Avifaunal diversity of Jodhpur Jhal Wetland Mathura (Uttar Pradesh) India: A preliminary survey. *Journal on New Biological Reports*, 95-108.

Sinha, S.P., Gangwar, R. and Tewari, R. (2007) Report on the Swamp Deer study in Jhilmil Jheel Conservation Reserve, Haridwar Forest Division, Uttarakhand. Project funded by Uttarakhand Forest Department and Report submitted to Uttarakhand Forest Department, Dehra Dun. Pp. 202.

Space Applications Centre (SAC). (2025). Wetlands Information System. https://vedas.sac.gov.in/wetlands/index.html

Sutherland, W.J. ed. (2006). Ecological census techniques: a handbook. Cambridge university press.

The Gazette of India (2019). Ministry of Environment, Forest and Climate Change Notification. REGD. NO. D. L.-33004/99. New Delhi. https://moef.gov.in/uploads/2018/12/udwa-lake.pdf

Tiwari, M. (2021). Management plan of Udhuwa lake bird sanctuary (2021-2031).

Tiwari, R. & G.S. Rawat. (2013). Assessment of swamp deer habitat in and around Jhilmil Jheel Conservation Reserve, Haridwar, Uttarakhand, India. *International Journal of Conservation Science*, 4 (2): 243-249.

UKFD-WWF Wetlands of Uttarakhand (2012), Report jointly published by the Uttarakhand Forest Department and WWF India. Pp 194.

Under2 Coalition (2024). East Kolkata Wetlands (EKW): A community led nature-based solution to combat climate change. https://www.theclimategroup.org/media/27366/download

Urfi, A.J. (2003). The birds of Okhla barrage bird sanctuary, Delhi, India. *Forktail*, 19: 39-50.

Verstijnen, Y. J., Maliaka, V., Catsadorakis, G., Lürling, M., & Smolders, A. J. (2021). Colonial nesting waterbirds as vectors of nutrients to Lake Lesser Prespa (Greece). *Inland Waters*, 11(2), 191-207.

WII-GACMC (2022). Conservation Plan of Haiderpur Wetland, Uttar Pradesh (2022 - 23 to 2031 - 32) Draft. Ganga Aqualife Conservation Monitoring Centre, Wildlife Institute of India, Dehra Dun, India. Pp. 130

WII-GACMC. (2018). Ganga River - State of Biodiversity at a glance. Ganga Aqualife Conservation Monitoring Centre, Wildlife Institute of India.

WII-NMCG (2019). Biodiversity profile of the Ganga River, Wildlife Institute of India, Dehradun, Uttarakhand, India. Pp. 223. ISBN no. 81-85496-41-2

Yadav, S. R., Ravikant, S. K. J., Jangra, L., & Yadav, K. (2023). Assessment of Bird Diversity along Yamuna River, Haryana, India. *Indian Journal of Ecology*, 50(6), 2110-2113.

Yashmita-Ulman, Singh, M. (2022). Avifaunal diversity in unprotected wetlands of Ayodhya District, Uttar Pradesh, India. *Journal of Threatened Taxa*, 14(8): 21561-21578. http://doi.org/10.11609/jott.7067.14.8.21561-21578

ANNEXURE 1. Checklist of water and water-associated bird species in the select wetlands of the Ganga River Basin

Checklist						
English Name	**Order**	**Family**	**Scientific Name**	**IUCN**	**IWPA**	**Feeding Guild**
Bar-headed Goose	Anseriformes	Anatidae	*Anser indicus* (Latham, 1790)	Least Concern	Schedule-II	H
Common Pochard	Anseriformes	Anatidae	*Aythya ferina* (Linnaeus, 1758)	Vulnerable	Schedule-I	H/C
Common Teal	Anseriformes	Anatidae	*Anas crecca* Linnaeus, 1758	Least Concern	Schedule-II	H
Cotton Pygmy-Goose	Anseriformes	Anatidae	*Nettapus coromandelianus* (Gmelin, 1789)	Least Concern	Schedule-I	H/C
Eurasian Wigeon	Anseriformes	Anatidae	*Mareca penelope* (Linnaeus, 1758)	Least Concern	Schedule-II	H/C
Ferruginous Duck	Anseriformes	Anatidae	*Aythya nyroca* (Güldenstädt, 1770)	Near Threatened	Schedule-II	O
Gadwall	Anseriformes	Anatidae	*Mareca strepera* (Linnaeus, 1758)	Least Concern	Schedule-II	H/C
Garganey	Anseriformes	Anatidae	*Spatula querquedula* (Linnaeus, 1758)	Least Concern	Schedule-II	H/C
Greylag Goose	Anseriformes	Anatidae	*Anser anser* (Linnaeus, 1758)	Least Concern	Schedule-II	H
Indian Spot-billed Duck	Anseriformes	Anatidae	*Anas poecilorhyncha* Forster, 1781	Least Concern	Schedule-II	H/C
Knob-billed Duck	Anseriformes	Anatidae	*Sarkidiornis melanotos* (Pennant, 1769)	Least Concern	Schedule-II	H/C
Lesser Whistling-Duck	Anseriformes	Anatidae	*Dendrocygna javanica* (Horsfield, 1821)	Least Concern	Schedule-II	H/C
Mallard	Anseriformes	Anatidae	*Anas platyrhynchos* Linnaeus, 1758	Least Concern	Schedule-II	H/C
Northern Pintail	Anseriformes	Anatidae	*Anas acuta* Linnaeus, 1758	Least Concern	Schedule-II	H/C
Northern Shoveler	Anseriformes	Anatidae	*Spatula clypeata* (Linnaeus, 1758)	Least Concern	Schedule-II	C/H
Red-crested Pochard	Anseriformes	Anatidae	*Netta rufina* (Pallas, 1773)	Least Concern	Schedule-II	H/C
Ruddy Shelduck	Anseriformes	Anatidae	*Tadorna ferruginea* (Pallas, 1764)	Least Concern	Schedule-II	O
Tufted Duck	Anseriformes	Anatidae	*Aythya fuligula* (Linnaeus, 1758)	Least Concern	Schedule-II	C/H
Common Moorhen	Gruiformes	Rallidae	*Gallinula chloropus* (Linnaeus, 1758)	Least Concern	Schedule-II	O
Eurasian Coot	Gruiformes	Rallidae	*Fulica atra* Linnaeus, 1758	Least Concern	Schedule-II	H/C
Grey-headed Swamphen	Gruiformes	Rallidae	*Porphyrio poliocephalus* (Latham, 1801)	Least Concern	Schedule-II	H/C
White-breasted Waterhen	Gruiformes	Rallidae	*Amaurornis phoenicurus* (Pennant, 1769)	Least Concern	Schedule-II	O

	Uttarakhand			Uttar Pradesh				Bihar			Jharkhand				West Bengal					
Residential Status	ACR	JJ	BG	HW	SW	BBS	GZW	MTW	JJW	NW	UBS	BJW	KD	PD	AW	DW	EKW	NBW	PW	SL
R/WM	0	0	0	66	563	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WM	480	0	0	177	111	0	0	6	0	14	0	0	0	0	0	0	0	0	0	0
WM	54	0	0	152	30	0	42	0	1	0	3	3	0	0	0	0	0	0	0	0
R/LM	0	0	0	0	0	1	0	4	0	0	0	0	0	0	0	0	0	0	8	0
WM	1163	0	0	2891	162	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
R/WM	0	0	0	307	0	0	47	24	0	0	0	0	0	0	0	0	0	0	0	0
WM	1231	0	0	4542	114	25	160	0	0	0	17	250	192	0	0	0	0	0	0	0
WM	0	0	0	79	0	0	2	0	0	0	4	0	0	0	0	0	0	0	0	0
WM	6	0	0	0	798	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R/LM	136	0	0	35	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R/LM	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R/LM	0	0	0	0	8	71	84	0	0	0	0	15	0	0	0	0	0	0	108	0
R/WM	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
WM	811	0	0	3000	128	0	0	0	0	0	2	0	29	0	0	0	0	0	0	0
WM	685	0	0	2551	442	0	0	0	0	0	2	3	0	0	0	0	0	0	0	0
WM	1245	0	0	22	0	217	0	0	0	6	14	0	0	0	0	0	0	0	92	0
R/WM/PM	195	2	0	57	16	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WM	435	0	0	912	6	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0
R/WM	335	0	0	168	58	8	20	12	2	5	0	0	0	0	0	0	0	0	1	0
R/WM	1176	0	0	4052	94	15	109	22	0	0	5	0	0	0	0	0	0	0	4	0
R/LM	15	0	0	172	124	23	54	6	4	18	55	83	0	0	12	0	0	0	19	0
R	4	0	1	2	86	3	9	0	2	1	0	0	0	0	0	0	0	0	0	0

Checklist						
English Name	**Order**	**Family**	**Scientific Name**	**IUCN**	**IWPA**	**Feeding Guild**
Sarus Crane	Gruiformes	Gruidae	*Antigone antigone* (Linnaeus, 1758)	Vulnerable	Schedule-I	H/C
Grey-headed Lapwing	Charadriiformes	Charadriidae	*Vanellus cinereus* (Blyth, 1842)	Least Concern	Schedule-II	C
Red-wattled Lapwing	Charadriiformes	Charadriidae	*Vanellus indicus* (Boddaert, 1783)	Least Concern	Schedule-II	C
River Lapwing Lapwing	Charadriiformes	Charadriidae	*Vanellus duvaucelii* (Lesson, 1826)	Near Threatened	Schedule-II	C
White-tailed	Charadriiformes	Charadriidae	*Vanellus leucurus* (Lichtenstein, 1823)	Least Concern	Schedule-II	C
Yellow-wattled Lapwing	Charadriiformes	Charadriidae	*Vanellus malabaricus* (Boddaert, 1783)	Least Concern	Schedule-II	C
Bronze-winged Jacana	Charadriiformes	Jacanidae	*Metopidius indicus* (Latham, 1790)	Least Concern	Schedule-II	H/C
Pheasant-tailed Jacana	Charadriiformes	Jacanidae	*Hydrophasianus chirurgus* (Scopoli, 1786)	Least Concern	Schedule-II	H/C
Black-headed Gull	Charadriiformes	Laridae	*Chroicocephalus ridibundus* (Linnaeus, 1766)	Least Concern	Schedule-II	C
Brown-headed Gull	Charadriiformes	Laridae	*Chroicocephalus brunnicephalus* (Jerdon, 1840)	Least Concern	Schedule-II	C
Pallas's Gull	Charadriiformes	Laridae	*Ichthyaetus ichthyaetus* (Pallas, 1773)	Least Concern	Schedule-II	C
River Tern	Charadriiformes	Laridae	*Sterna aurantia* Gray, 1831	Vulnerable	Schedule-I	C
Whiskered Tern	Charadriiformes	Laridae	*Chlidonias hybrida* (Pallas, 1811)	Least Concern	Schedule-II	C
Black-winged Stilt	Charadriiformes	Recurvirostridae	*Himantopus himantopus* (Linnaeus, 1758)	Least Concern	Schedule-II	C/H
Pied Avocet	Charadriiformes	Recurvirostridae	*Recurvirostra avosetta* Linnaeus, 1758	Least Concern	Schedule-II	C
Black-tailed Godwit	Charadriiformes	Scolopacidae	*Limosa limosa* (Linnaeus, 1758)	Near Threatened	Schedule-II	C/H
Common Greenshank	Charadriiformes	Scolopacidae	*Tringa nebularia* (Gunnerus, 1767)	Least Concern	Schedule-I	C
Common Redshank	Charadriiformes	Scolopacidae	*Tringa totanus* (Linnaeus, 1758)	Least Concern	Schedule-II	C
Common Sandpiper	Charadriiformes	Scolopacidae	*Actitis hypoleucos* (Linnaeus, 1758)	Least Concern	Schedule-II	C
Common Snipe	Charadriiformes	Scolopacidae	*Gallinago gallinago* (Linnaeus, 1758)	Least Concern	Schedule-II	C
Green Sandpiper	Charadriiformes	Scolopacidae	*Tringa ochropus* Linnaeus, 1758	Least Concern	Schedule-II	C
Little Stint	Charadriiformes	Scolopacidae	*Calidris minuta* (Leisler, 1812)	Least Concern	Schedule-II	C/H

	Uttarakhand			Uttar Pradesh				Bihar			Jharkhand				West Bengal					
Residential Status	ACR	JJ	BG	HW	SW	BBS	GZW	MTW	JJW	NW	UBS	BJW	KD	PD	AW	DW	EKW	NBW	PW	SL
R/LM	0	0	0	8	0	121	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WM	0	0	0	8	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	122
R/LM	21	108	1	49	85	69	55	7	2	0	2	2	1	0	4	0	0	0	2	0
R/LM	18	0	1	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WM	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R/LM	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R	0	0	0	27	30	7	42	9	0	13	6	0	0	0	4	0	0	0	5	0
R/LM/SM	0	0	0	23	3	49	0	12	0	4	6	0	0	0	2	0	0	0	5	8
R/WM	0	0	0	50	0	0	0	0	0	0	22	0	0	0	0	0	0	0	0	0
R/WM	0	0	0	0	0	0	0	0	0	0	2	0	0	41	0	0	0	0	0	0
WM	59	0	1	13	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0
R	0	0	1	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R/WM/PM	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R/LM	13	0	0	184	108	2	0	1	0	0	1	0	0	0	0	0	0	0	0	9
R/WM	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WM	0	0	0	509	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WM	2	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R/WM	5	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R/WM	0	0	0	0	2	3	0	3	0	0	0	1	0	0	0	0	0	0	0	0
R/WM	7	0	0	0	0	0	0	2	0	0	0	3	0	0	0	0	0	0	0	0
R/WM	2	0	0	1	3	8	3	7	0	1	0	1	0	0	0	0	0	0	0	0
WM	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Checklist						
English Name	**Order**	**Family**	**Scientific Name**	**IUCN**	**IWPA**	**Feeding Guild**
Temminck's Stint	Charadriiformes	Scolopacidae	*Calidris temminckii* (Leisler, 1812)	Least Concern	Schedule-II	C/H
Wood Sandpiper	Charadriiformes	Scolopacidae	*Tringa glareola* Linnaeus, 1758	Least Concern	Schedule-II	C
Marsh Sandpiper	Charadriiformes	Scolopacidae	*Tringa stagnatilis* (Bechstein, 1803)	Least Concern	Schedule-II	C
Great Crested Grebe	Podicipediformes	Podicipedidae	*Podiceps cristatus* (Linnaeus, 1758)	Least Concern	Schedule-II	C/H
Little Grebe	Podicipediformes	Podicipedidae	*Tachybaptus ruficollis* (Pallas, 1764)	Least Concern	Schedule-II	C
Asian Openbill	Ciconiiformes	Ciconiidae	*Anastomus oscitans* (Boddaert, 1783)	Least Concern	Schedule-II	C
Asian Woolly-necked Stork	Ciconiiformes	Ciconiidae	*Ciconia episcopus* (Boddaert, 1783)	Near Threatened	Schedule-II	C
Black-necked Stork	Ciconiiformes	Ciconiidae	*Ephippiorhynchus asiaticus* (Latham, 1790)	Near Threatened	Schedule-II	C
Greater Adjutant	Ciconiiformes	Ciconiidae	*Leptoptilos dubius* (Gmelin, 1789)	Near Threatened	Schedule-I	O
Lesser Adjutant	Ciconiiformes	Ciconiidae	*Leptoptilos javanicus* (Horsfield, 1821)	Near Threatened	Schedule-I	C
Painted Stork	Ciconiiformes	Ciconiidae	*Mycteria leucocephala* (Pennant, 1769)	Least Concern	Schedule-II	C
Oriental Darter	Suliformes	Anhingidae	*Anhinga melanogaster* Pennant, 1769	Least Concern	Schedule-II	C
Great Cormorant	Suliformes	Phalacrocoracidae	*Phalacrocorax carbo* (Linnaeus, 1758)	Least Concern	Schedule-II	C
Indian Cormorant	Suliformes	Phalacrocoracidae	*Phalacrocorax fuscicollis* Stephens, 1826	Least Concern	Schedule-II	C
Little Cormorant	Suliformes	Phalacrocoracidae	*Microcarbo niger* (Vieillot, 1817)	Least Concern	Schedule-II	C
Black-headed Ibis	Pelecaniformes	Threskiornithidae	*Threskiornis melanocephalus* (Latham, 1790)	Least Concern	Schedule-II	C
Glossy Ibis	Pelecaniformes	Threskiornithidae	*Plegadis falcinellus* (Linnaeus, 1766)	Least Concern	Schedule-II	C
Red-naped Ibis	Pelecaniformes	Threskiornithidae	*Pseudibis papillosa* (Temminck, 1824)	Least Concern	Schedule-II	C
Black-crowned Night Heron	Pelecaniformes	Ardeidae	*Nycticorax nycticorax* (Linnaeus, 1758)	Least Concern	Schedule-II	C
Eastern Cattle-Egret	Pelecaniformes	Ardeidae	*Ardea coromanda* (Boddaert, 1783)	Least Concern	Schedule-II	C
Great Egret	Pelecaniformes	Ardeidae	*Ardea alba* Linnaeus, 1758	Least Concern	Schedule-II	C
Grey Heron	Pelecaniformes	Ardeidae	*Ardea cinerea* Linnaeus, 1758	Least Concern	Schedule-II	C
Indian Pond-Heron	Pelecaniformes	Ardeidae	*Ardeola grayii* (Sykes, 1832)	Least Concern	Schedule-II	C

	Uttarakhand			Uttar Pradesh				Bihar			Jharkhand				West Bengal					
Residential Status	ACR	JJ	BG	HW	SW	BBS	GZW	MTW	JJW	NW	UBS	BJW	KD	PD	AW	DW	EKW	NBW	PW	SL
WM	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WM	3	0	0	0	13	19	0	0	0	4	1	3	0	0	0	0	0	0	0	0
WM	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
R/WM	7	0	0	1	0	2	0	0	0	0	0	0	14	0	0	0	0	0	0	0
R/LM	72	0	0	1	9	33	5	6	0	0	2	0	0	0	0	0	0	3	16	13
R/LM	0	0	0	137	0	60	0	69	26	51	19	430	4	2	0	3	0	32	5	18
R	0	51	0	3	1	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
R	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R/LM	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
R/LM	0	0	0	0	0	1	0	3	0	15	0	4	0	0	0	0	0	0	0	0
R/LM	11	0	0	97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R/LM	0	0	0	108	1	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0
R/WM	27	0	0	2006	39	0	1	1	0	0	6	2	0	5	0	0	0	0	0	0
R/LM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	4	7
R/LM	93	0	8	128	6	103	3	42	7	34	68	4	16	13	2	0	7	2	7	14
R/LM	0	0	0	27	9	1	0	0	0	0	2	25	0	0	0	0	0	0	0	12
R/WM/LM	0	0	0	314	47	8	0	1	0	0	0	0	0	0	0	0	0	0	0	0
R	0	35	0	18	0	35	0	2	2	0	0	0	0	0	0	0	0	0	0	0
R/LM	0	0	0	65	2	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
R/AM	3	30	0	236	4	201	46	12	5	26	0	2	4	2	3	3	4	0	3	94
R/LM	11	0	1	292	0	9	0	1	0	7	23	6	0	0	0	0	0	0	2	8
R/WM	2	0	1	47	8	5	5	4	1	1	1	0	0	0	0	1	1	0	0	1
R/LM	7	0	2	9	43	22	20	5	7	11	7	4	0	4	0	3	7	0	0	14

Checklist						
English Name	**Order**	**Family**	**Scientific Name**	**IUCN**	**IWPA**	**Feeding Guild**
Intermediate Egret	Pelecaniformes	Ardeidae	*Ardea intermedia* Wagler, 1829	Least Concern	Schedule-II	C
Little Egret	Pelecaniformes	Ardeidae	*Egretta garzetta* (Linnaeus, 1766)	Least Concern	Schedule-II	C
Purple Heron	Pelecaniformes	Ardeidae	*Ardea purpurea* Linnaeus, 1766	Least Concern	Schedule-II	C
Striated Heron	Pelecaniformes	Ardeidae	*Butorides striata* (Linnaeus, 1758)	Least Concern	Schedule-II	C
Greater Spotted Eagle	Accipitriformes	Accipitridae	*Clanga clanga* (Pallas, 1811)	Vulnerable	Schedule-I	C
Steppe Eagle	Accipitriformes	Accipitridae	*Aquila nipalensis* Hodgson, 1833	Endangered	Schedule-I	C
Western Marsh Harrier	Accipitriformes	Accipitridae	*Circus aeruginosus* (Linnaeus, 1758)	Least Concern	Schedule-I	C
Osprey	Accipitriformes	Pandionidae	*Pandion haliaetus* (Linnaeus, 1758)	Least Concern	Schedule-I	C
Common Kingfisher	Coraciiformes	Alcedinidae	*Alcedo atthis* (Linnaeus, 1758)	Least Concern	Schedule-II	C
Pied Kingfisher	Coraciiformes	Alcedinidae	*Ceryle rudis* (Linnaeus, 1758)	Least Concern	Schedule-II	C
Stork-billed Kingfisher	Coraciiformes	Alcedinidae	*Pelargopsis capensis* (Linnaeus, 1766)	Least Concern	Schedule-II	C
White-throated Kingfisher	Coraciiformes	Alcedinidae	*Halcyon smyrnensis* (Linnaeus, 1758)	Least Concern	Schedule-II	C
Blue-tailed Bee-eater	Coraciiformes	Meropidae	*Merops philippinus* Linnaeus, 1767	Least Concern	Schedule-II	I
Peregrine Falcon	Falconiformes	Falconidae	*Falco peregrinus* Tunstall, 1771	Least Concern	Schedule-I	C
Barn Swallow	Passeriformes	Hirundinidae	*Hirundo rustica* Linnaeus, 1758	Least Concern	Schedule-II	I
Eastern Red-rumped Swallow	Passeriformes	Hirundinidae	*Cecropis daurica* (Laxmann, 1769)	Least Concern	Schedule-II	I
Grey-throated Martin	Passeriformes	Hirundinidae	*Riparia chinensis* (Gray, 1830)	Least Concern	Schedule-II	I
Wire-tailed Swallow	Passeriformes	Hirundinidae	*Hirundo smithii* Leach, 1818	Least Concern	Schedule-II	I
Citrine Wagtail	Passeriformes	Motacillidae	*Motacilla citreola* Pallas, 1776	Least Concern	Schedule-II	C
Grey Wagtail	Passeriformes	Motacillidae	*Motacilla cinerea* Tunstall, 1771	Least Concern	Schedule-II	C
Western Yellow Wagtail	Passeriformes	Motacillidae	*Motacilla flava* Linnaeus, 1758	Least Concern	Schedule-II	C
White Wagtail	Passeriformes	Motacillidae	*Motacilla alba* Linnaeus, 1758	Least Concern	Schedule-II	C
White-browed Wagtail	Passeriformes	Motacillidae	*Motacilla maderaspatensis* Gmelin, 1789	Least Concern	Schedule-II	C

ACR: Asan Conservation Reserve; **JJ:** Jhilmil Jheel; **BG:** Baan Ganga; **HW:** Haiderpur Wetland; **SW:** Surajpur Wetland; **BBS:** Bakhira Bird Sanctuary; **GZW:** Gorakhpur Zoo Wetland; **MTW:** Mohkama Taal Wetland; **JJW:** Jakhar Jheel Wetland; **NW:** Nauhatta Wetland; **UBS:** Udhwa Bird Sanctuary; **BJW:** Brahma Jamapur Wetland; **KD:** Konar Dam; **PD:** Patratu Dam; **AW:** Ahiran Wetland; **DW:** Dongaria Wetland; **EKW:** East Kolkata Wetlands; **NBW:** Nangla Beel Wetland; **PW:** Purbasthali Wetland; **SL:** Sheeal Lake.

	Uttarakhand			Uttar Pradesh				Bihar			Jharkhand				West Bengal					
Residential Status	ACR	JJ	BG	HW	SW	BBS	GZW	MTW	JJW	NW	UBS	BJW	KD	PD	AW	DW	EKW	NBW	PW	SL
R/LM	1	6	2	99	10	38	0	3	1	8	28	5	0	0	0	0	0	1	0	12
R/LM	13	8	2	114	4	63	4	13	4	12	49	1	0	0	0	0	0	0	0	0
R/LM	23	0	0	18	8	16	9	2	1	0	2	3	0	0	0	1	0	0	1	2
R	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R/WM	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WM	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WM	0	0	0	2	3	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0
R/WM	0	0	0	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R	1	0	1	0	0	1	0	0	2	0	1	2	0	0	0	0	0	0	3	0
R	1	0	1	0	0	4	2	0	1	1	1	1	0	0	0	0	0	0	0	0
R	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
R/LM	3	11	2	8	15	10	12	3	1	1	1	4	0	0	0	0	0	5	5	0
R/WM	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R/WM	0	0	0	0	0	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0
R/WM	221	0	0	0	12	0	2	0	0	0	5	0	0	2	0	0	18	9	9	12
R/WM/SM	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
R/LM	114	0	0	24	19	0	0	0	6	4	0	0	0	0	0	0	0	0	0	0
R/SM	69	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R/WM/AM	0	0	0	0	12	11	0	1	0	0	4	2	0	0	0	0	0	0	0	0
R/WM/AM	22	19	0	25	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
R/WM/AM/PM	3	0	0	6	11	1	0	8	0	0	0	0	0	0	0	0	0	0	0	0
R/WM/PM	6	0	0	0	9	17	11	1	2	2	2	1	0	0	0	0	0	0	0	0
R	5	0	0	0	0	0	9	0	0	2	0	0	0	0	0	0	0	0	0	0

Ministry of Environment, Forest and Climate Change

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

NMCG

National Mission for Clean Ganga,
Department of Water Resources,
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GACMC/NCRR

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Design and layout
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Photo Credit
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