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Original Research Paper

Evaluation Of Habitat And Avian Diversity Of Migratory Birds At Nawabganj Bird Sanctuary, Unnao, Uttar Pradesh, India

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Abstract

Wetlands are highly productive ecosystems that support diverse biological communities and provide essential habitats for numerous avian species. Shaheed Chandra Shekhar Azad Bird Sanctuary (formerly Nawabganj Bird Sanctuary), a Ramsar-designated wetland in Uttar Pradesh, serves as an important habitat for resident and migratory birds along the Central Asian Flyway (CAS). This study assessed the status of avian diversity and evaluated the ecological condition of the wetland ecosystem through systematic field investigations conducted over a year, supported by records from the Uttar Pradesh Forest Department and relevant secondary sources. Avian diversity, habitat characteristics, and selected physicochemical parameters, including temperature, turbidity, pH, and nitrate and phosphate concentrations, were analyzed to understand their relationship with bird distribution and abundance. The sanctuary supports more than 250 bird species (U.P. Ecotourism Board), with prominent representation from families such as Anatidae, Ardeidae, and Rallidae, and migratory waders of the order Charadriiformes. Seasonal variations in avian composition and abundance are influenced by multiple ecological factors, including environmental cues, climatic conditions, food availability, and habitat suitability. Despite its ecological importance, wetlands are experiencing increasing pressure from altered hydrological conditions, irregular rainfall patterns, invasive species proliferation, agricultural runoff-induced eutrophication, tourism-related disturbances, and human–wildlife interactions. These factors contribute to habitat degradation and may influence the migratory patterns and population trends of ecologically sensitive bird groups. The findings highlight the importance of avian diversity as an indicator of wetland health and emphasize the need for integrated conservation approaches, continuous ecological monitoring, habitat restoration, and sustainable management practices involving both institutional frameworks and local communities to maintain the ecological integrity of this wetland ecosystem.

Keywords: Wetland, biodiversity, invasive species, avifauna, Nawabganj Bird Sanctuary, habitat conservation, water management

INTRODUCTION

India hosts a multitude of wetlands of various types. Some are transient, emerging during the monsoon and vanishing during the dry season. The wealth of resources found in these habitats is advantageous to migratory birds from both Asia and Europe (Khalid et al., 2023). One of the most amazing environmental phenomena is avian migration, which is defined as the regular seasonal migration of birds from their breeding grounds to their wintering grounds. The intricate relationships between energy needs, reproductive advantages, and survival tactics propel these migrations. There are many different types of migratory behavior, ranging from short distances or partial migration within temperate regions to long transcontinental journeys of thousands of kilometers. A combination of internal biological processes and external environmental elements, such as changes in day length, endogenous seasonal rhythms, temperature fluctuations, and the availability of seasonal resources, controls the start, direction, and length of migration. To maximize survival and procreation, birds employ a range of adaptive strategies during their migration cycle, including optimizing flight times, building up energy reserves, and choosing appropriate resting locations. Advances in genetic, physiological, and ecological research have demonstrated the interdependence of these processes: habitat choice determines survival outcomes during migration, physiological adaptations support long-term flights, and genetic mechanisms influence migration behavior and timing. (Sokolovskis, 2015)

One of the major migratory routes in the world, the Central Asian Flyway (CAF), connects the Indian subcontinent's wintering regions with the Arctic's breeding grounds. It supports the seasonal migrations of millions of migratory birds, including waterfowl, waders, raptors, and other birds, and stretches from the Arctic regions of Russia to Central Asia, the Tibetan Plateau, and the Indian Ocean, spanning over 30 countries in Asia. Migration continues. In the densely populated and intensively cultivated landscape of the Gangetic plains of Uttar Pradesh, the remaining wetland habitats are becoming increasingly important for conserving migratory birds. The extensive conversion of natural wetlands by drainage, agricultural expansion, pollution, and other anthropogenic activities has led to the

degradation of suitable habitats for these species. Protected wetlands, such as the Nawabganj Bird Sanctuary, serve as critical ecological stepping stones and provide crucial resting and wintering places for migratory species navigating highly altered landscapes (Ma et al., 2010).

The variety and abundance of bird species in a given location can provide insights into the overall health of the ecosystem. A healthy environment with a range of habitats frequently supports more bird species than an unhealthy environment. Changes in bird variety and abundance can be important indicators of environmental health, as birds are highly sensitive to changes in their habitat, including factors such as food availability, vegetation structure, pollution levels, and climate (Khan et al., 2025).

MATERIALS AND METHODS

Study Area

This study was conducted at the Nawabganj Bird Sanctuary (figs. 1 and 2), which is located along National Highway 25 in the Unnao district of Uttar Pradesh. Established in 1984 under the Wildlife Conservation Act of 1972, the sanctuary encompasses an area of roughly 224.60 ha and is home to a diverse range of flora and fauna communities. The adjacent canal supports the wetland-dependent biodiversity by keeping water available in the sanctuary. The wetland's natural scenic value, especially that of the well-known Lake Moti, has also made it a more popular tourist destination (Kumar et al., 2015).

The Indian state of Uttar Pradesh's Unnao district is home to the Shaheed Chandra Shekhar Azad Bird Sanctuary. Under the terms of the Wildlife (Protection) Act, 1972, the region was designated a Protected Area in 1984. In 2015, the "Nawabganj Bird Sanctuary" was renamed the "Shaheed Chandra Shekhar Azad Bird Sanctuary." Situated along an extremely busy arterial road that connects the state capital of Lucknow and the industrial city of Kanpur, it spans an area of 224.60 hectares (26° 37' 14.862" N and 26° 36' 7.186" N latitudes and 80° 38' 42.173" E and 80° 40' 6.046" E longitudes). It was designated as a Ramsar Site in 2020 and is a wetland of conservation significance for birds and biodiversity (Rahmani et al., 2016).

The sanctuary is located in Biogeographic Zone 7, Gangetic Plains, Biotic Province – 7A Upper Gangetic Plains (Rodgers et al., 1988). The Sanctuary is made up of a mix of wetlands that are nearly always under water and some areas that are submerged during the monsoon and for a while after (Rodger et al., 1988). The habitat ranges from a submerged area with a sheet of water to wooded areas with patches of grassy and shrubby vegetation. As a result, many niches are home to a wide variety of organisms, including numerous lepidopterans. In winter, the temperature is 2°C, and in summer, it is 48°C. During the coldest months, there is pool frost, and during the dry summer months, the region is lashed by "loo" winds. Rainfall averages between 90 and 100 cm per year (Taslima, 2023).

As of August 4, 2026, India had 101 Ramsar sites totaling 1,387,741 hectares (14,005.12 km^2). According to the Ramsar Convention, these wetlands are considered to be of international significance (List of Ramsar sites in India, Wikipedia). India currently boasts one of the largest networks of Ramsar wetlands in Asia. Uttar Pradesh is one of the states with the most recognized wetlands in the nation, with 13 Ramsar wetlands. On September 19, 2019, the Nawabganj bird sanctuary was added to the Ramsar list due to its ecological significance and ability to support migratory waterbirds. The Sanctuary's significance for conservation was further recognized in 2015 when it was formally renamed Shaheed Chandra Shekhar Azad Bird Sanctuary. Shaheed Chandra Shekhar Azad National Bird Sanctuary, which spans nearly 224,600 hectares, is a dynamic wetland ecosystem where a number of ecological processes work together to support high biodiversity productivity. A shallow, naturally occurring lake system with a gently sloping basin is the shrine's principal feature.

Rather than having a single dominant ecosystem type, the sanctuary's ecological significance is mainly due to the variety and spatial arrangement of its habitats. A range of ecological niches is created by the coexistence of various microhabitats, such as open water zones, marshes, reed-covered areas, grasslands, and wooded patches, which support species with various habitat and behavioral needs. For diving waterbirds, such as the common pochard and tufted duck, which rely on submerged vegetation and aquatic prey resources, open aquatic areas are crucial feeding habitats. Many secretive wetland birds, such as bitterns and the Purple Swamphen, find refuge, nesting opportunities, and breeding habitats in the dense emergent vegetation dominated by *Phragmites karka* (narkul/tall reed) and *Typha angustata* (narrow-leaf cattail).

Both migratory and resident waders, who depend on exposed mudflats to search for aquatic invertebrates, find suitable feeding grounds in the shallow marshes and sporadically flooded grassland areas surrounding the lake. Herbivorous waterfowl, such as grazing species like the Northern Pintail, are also supported by these habitats. Larger birds like storks, cormorants, and raptors can rest, nest, and roost in the vegetated areas surrounding the wetland, which include plantation forests and sporadic woodland habitats. This adds to the wetland's ecological value. Mammals like the Golden Jackal, reptiles like the Indian Python, small terrestrial mammals, fish, amphibians, and a variety of aquatic and terrestrial plant communities are all supported by this intricate habitat network, which fosters the growth of a diverse food web that extends beyond avifaunal communities. Additionally, the sanctuary's conservation is strengthened by its location within the Ganga basin.

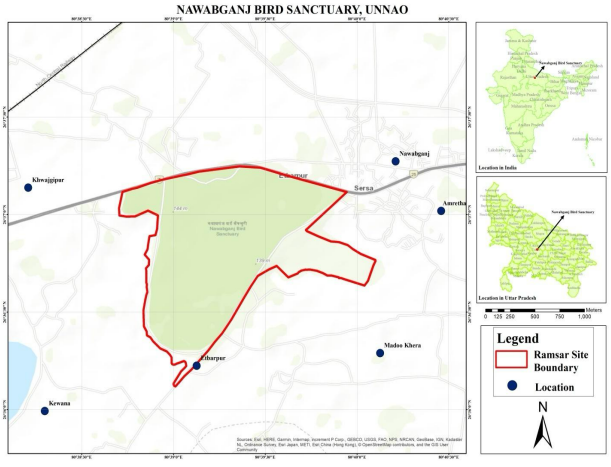

Fig. 1: Site Map (Source: Ramsar Site Information Service)



Fig. 2: Satellite map of Nawabganj Bird Sanctuary

Bird Survey

With a focus on the migration months of October to March, the current study evaluated the avifaunal diversity and composition of Nawabganj Bird Sanctuary in Uttar Pradesh. To maximize bird detection and minimize variations related to daily activity patterns, a seasonal field survey was carried out during the study period at standardized observation timings. In the summer, surveys were conducted from 06:00 AM to 09:00 AM and from 03:00 PM to 06:00 PM, while in the winter, they were conducted from 07:00 AM to 10:00 AM and from 02:00 PM to 05:00 PM. Within predetermined sampling areas, avian surveys were conducted using a combination of line transect and point count techniques. Birds were recorded on both sides of line transects that were roughly 1 to 100 meters wide while walking continuously along a predetermined route that stretched up to 2 kilometers without interruption. In order to minimize disruption to birds and guarantee precise documentation of species presence and abundance, observations were carried out with great care. A Canon EOS 700D DSLR camera was used to capture photographic records for later verification and documentation. Seasonal variation in avifaunal diversity, habitat utilization, and species composition were all noted during field observations. Standard ornithological field guides, such as The Birds of the Indian Subcontinent by Ali and Ripley (1995) and Birds of the Indian Subcontinent by Grimmett et al., were used for bird identification. (1998) and Salim Ali's book The Book of Indian Birds (2002). When necessary, photographic records and updated taxonomic references were used for further verification. (Singh and Khalid, 2022).

A consolidated species inventory comprising common names, scientific names, IUCN categories, population-trend categories, and observed counts was created from bird observations. The winter season (October–March), when the sanctuary serves both migratory and resident birds, was highlighted in the survey. The original survey protocol's description of photographic verification and standard Indian ornithological field guides served as the basis for species identification (Kumar et al., 2015).

A few glimpses of the wetland site and avian diversity found there:



Fig. 3: Bronze-winged jacana (*Metopidius indicus*)

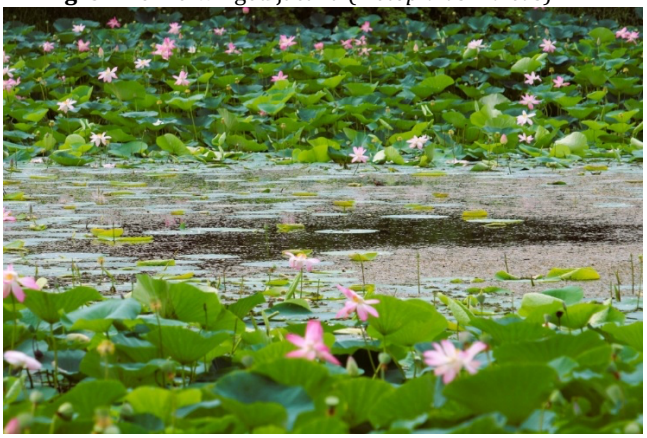

Fig. 4: View of the Nawabganj bird sanctuary



Fig. 5: Common myna (*Acridotheres tristis*)



Fig. 6: View of the Nawabganj bird sanctuary



Figure 7: Indian roller (*Coracias benghalensis)*



Fig. 8: Shikra (female) (*Accipiter badius)*



Fig 9: Peacock *(Pavo cristatus)*



Fig. 10: Flock of Asian openbill storks *(Anastomus oscitans)*



Fig. 11: Oriental magpie-robin *(Copsychus saularis)*



Fig 12: Brown-headed barbet *(Psilopogon zeylanicus)*

Avifaunal Diversity Analysis

The total number of different bird species identified was used to calculate species richness (S). The total number of individuals observed in all species was used to compute total abundance (N). The contribution of each family to the overall species richness was expressed using the **Relative Diversity Index (RDi)** where RDi = (number of species in a family / total number of species) × 100.

The Shannon-Wiener diversity index was computed using the formula $H' = -\Sigma$ (pi ln pi), where 'pi' is the percentage of individuals that belong to species 'i'

The formula for calculating Margalef richness was $DMg = (S - 1) / \ln(N)$.

Pielou's evenness was determined as $J' = H' / \ln(S)$, and Simpson diversity was expressed as 1 − D.

Simpson's concentration of dominance was calculated as $D = \Psi\pi^2$.

Berger-Parker dominance was computed using the formula d = Nmax / N, where Nmax is the most prevalent species' abundance. (Bollarapu et al., 2021; Simpson, 1949; Pielou, 1966).

The recorded abundance of 465 individuals and the 106-species inventory were used to calculate these indices. The Materials and Methods section contains the formulas, and the Results and Discussion section reports the calculated values.

RESULTS AND DISCUSSIONS

Avifaunal Composition

At Nawabganj Bird Sanctuary, 106 bird species from 18 orders and 48 families were identified. The order with the greatest number of species was Passeriformes, which was followed by Pelecaniformes, Anseriformes, and Charadriiformes. At the family level, Cisticolidae and Muscicapidae each contributed five species, while Anatidae and Ardeidae each contributed nine. Each of the

families Accipitridae, Columbidae, Rallidae, and Picidae contributed four species.

Order	Family	Sl. No.	Common name	Scientific name	IUCN status	Feeding Guild	Count
Accipitriformes	Accipitridae	1	Black Kite	*Milvus migrans*	LC	Carnivore	11
		2	Booted Eagle	*Hieraaetus pennatus*	LC	Carnivore	1
		3	Egyptian Vulture	*Neophron percnopterus*	E	Scavenger	2
		4	Oriental Honey-buzzard (Crested Honey Buzzard)	*Pernis ptilorhynchus*	LC	Insectivore	2
Anseriformes	Anatidae	5	Bar-headed Goose	*Anser indicus*	LC	Herbivore	5
		6	Cotton Pygmy-Goose (Cotton Teal)	*Nettapus coromandelianus*	LC	Omnivore	4
		7	Eurasian Wigeon	*Mareca penelope*	LC	Herbivore	3
		8	Gadwall	*Mareca strepera*	LC	Herbivore	8
		9	Indian Spot-billed Duck	*Anas poecilorhyncha*	LC	Omnivore	9
		10	Knob-billed Duck (Comb Duck)	*Sarkidiornis melanotos*	LC	Herbivore	6
		11	Northern Pintail	*Anas acuta*	LC	Omnivore	1
		12	Northern Shoveler	*Spatula clypeata*	LC	Omnivore	5
		13	Ruddy Shelduck (Brahminy Duck)	*Tadorna ferruginea*	LC	Herbivore	1
	Dendrocygnidae	14	Lesser Whistling-Duck	*Dendrocygna javanica*	LC	Herbivore	13
Apodiformes	Apodidae	15	Little Swift (Indian House Swift)	*Apus affinis*	LC	Insectivore	11
Bucerotiformes	Bucerotidae	16	Indian Grey Hornbill	*Ocyceros birostris*	LC	Frugivore	7
	Upupidae	17	Common Hoopoe	*Upupa epops*	LC	Insectivore	1
Charadriiformes	Burhinidae	18	Indian Thick-knee (Indian Stone-curlew)	*Burhinus indicus*	LC	Insectivore	1
	Charadriidae	19	Red-wattled lapwing	*Vanellus indicus*	LC	Insectivore	17
		20	Yellow-wattled lapwing	*Vanellus malabaricus*	LC	Insectivore	1
	Jacanidae	21	Bronze-winged Jacana	*Metopidius indicus*	LC	Insectivore	9
		22	Pheasant-tailed Jacana	*Hydrophasianus chirurgus*	LC	Insectivore	3
	Recurvirostridae	23	Black-winged Stilt	*Himantopus himantopus*	LC	Insectivore	9
	Scolopacidae	24	Common Sandpiper	*Actitis hypoleucos*	LC	Insectivore	1
		25	Green Sandpiper	*Tringa ochropus*	LC	Insectivore	2
		26	Wood Sandpiper	*Tringa glareola*	LC	Insectivore	5

Ciconiiformes	Ciconiidae	27	Asian Openbill	*Anastomus oscitans*	LC	Molluscivore	25
Columbiformes	Columbidae	28	Eurasian Collared Dove	*Streptopelia decaocto*	LC	Granivore	5
		29	Laughing Dove (Little Brown Dove)	*Spilopelia senegalensis*	LC	Granivore	9
		30	Rock Pigeon (Blue Rock Pigeon)	*Columba livia*	LC	Granivore	7
		31	Spotted Dove	*Spilopelia chinensis*	LC	Granivore	11
Coraciiformes	Alcedinidae	32	Common Kingfisher (Small Blue Kingfisher)	*Alcedo atthis*	LC	Granivore	3
	Coraciidae	33	Indian Roller	*Coracias benghalensis*	LC	Piscivore	3
	Halcyonidae	34	White-throated Kingfisher	*Halcyon smyrnensis*	LC	Insectivore	3
	Meropidae	35	Asian Green Bee-eater	*Merops orientalis*	LC	Carnivore	4
Cuculiformes	Cuculidae	36	Asian Koel	*Eudynamys scolopaceus*	LC	Insectivore	3
		37	Common Hawk-Cuckoo	*Hierococcyx varius*	LC	Frugivore	1
		38	Greater Coucal	*Centropus sinensis*	LC	Insectivore	2
Galliformes	Phasianidae	39	Grey Francolin	*Ortygornis pondicerianus*	LC	Omnivore	1
		40	Indian Peafowl	*Pavo cristatus*	LC	Omnivore	5
Gruiformes	Rallidae	41	Eurasian Coot	*Fulica atra*	LC	Granivore	2
		42	Eurasian Moorhen	*Gallinula chloropus*	LC	Omnivore	5
		43	Grey-headed Swamphen (Purple Swamphen)	*Porphyrio poliocephalus*	LC	Herbivore	6
		44	White-breasted Waterhen	*Amaurornis phoenicurus*	LC	Omnivore	9
Passeriformes	Alaudidae	45	Indian Bushlark (Red-winged Bushlark)	*Plocealauda erythroptera*	LC	Herbivore	1
	Campephagidae	46	Small Minivet	*Pericrocotus cinnamomeus*	LC	Omnivore	1
	Cisticolidae	47	Ashy Prinia	*Prinia socialis*	LC	Granivore	2
		48	Common Tailorbird	*Orthotomus sutorius*	LC	Insectivore	5
		49	Grey-breasted Prinia	*Prinia hodgsonii*	LC	Insectivore	1
		50	Plain Prinia	*Prinia inornata*	LC	Insectivore	1
		51	Zitting Cisticola	*Cisticola juncidis*	LC	Insectivore	1
	Corvidae	52	House Crow	*Corvus splendens*	LC	Insectivore	19
		53	Large-billed Crow	*Corvus macrorhynchos*	LC	Insectivore	7
		54	Rufous Treepie	*Dendrocitta vagabunda*	LC	Omnivore	5
	Dicaeidae	55	Pale-billed Flowerpecker	*Dicaeum erythrorhynchos*	LC	Omnivore	1
	Dicruridae	56	Ashy Drongo	*Dicrurus*	LC	Omnivore	1

				leucophaeus			
		57	Black Drongo	*Dicrurus macrocercus*	LC	Frugivore	4
		58	White-bellied Drongo	*Dicrurus caerulescens*	LC	Insectivore	1
	Estrildidae	59	Indian Silverbill (White-throated Munia)	*Euodice malabarica*	LC	Insectivore	2
		60	Red Avadavat	*Amandava amandava*	LC	Granivore	1
		61	Scaly-breasted Munia (Spotted Munia)	*Lonchura punctulata*	LC	Granivore	1
	Hirundinidae	62	Barn Swallow	*Hirundo rustica*	LC	Granivore	2
	Leiothrichidae	63	Jungle Babbler	*Argya striata*	LC	Granivore	9
	Motacillidae	64	Citrine Wagtail	*Motacilla citreola*	LC		3
		65	Grey Wagtail	*Motacilla cinerea*	LC	Granivore	2
		66	Paddyfield Pipit	*Anthus rufulus*	LC	Granivore	8
	Muscicapidae	67	Black Redstart	*Phoenicurus ochruros*	LC	Granivore	2
		68	Brown Rock Chat	*Oenanthe fusca*	LC	Granivore	2
		69	Indian Robin	*Copsychus fulicatus*	LC	Granivore	2
		70	Oriental Magpie-Robin	*Copsychus saularis*	LC	Granivore	5
		71	Pied Bushchat	*Saxicola caprata*	LC	Granivore	1
	Nectariniidae	72	Purple Sunbird	*Cinnyris asiaticus*	LC	Granivore	2
	Oriolidae	73	Black-hooded Oriole	*Oriolus xanthornus*	LC	Nectarivore	1
	Paridae	74	Cinereous Tit	*Parus cinereus*	LC	Frugivore	5
	Pycnonotidae	75	Red-vented Bulbul	*Pycnonotus cafer*	LC	Granivore	5
		76	Red-whiskered Bulbul	*Pycnonotus jocosus*	LC	Frugivore	7
	Sittidae	77	Indian Nuthatch	*Sitta castanea*	LC	Frugivore	2
	Stenostiridae	78	Grey-headed Canary-Flycatcher	*Culicicapa ceylonensis*	LC	Insectivore	1
	Sturnidae Sturnidae	79	Brahminy Starling	*Sturnia pagodarum*	LC	Insectivore	2
		80	Common Myna	*Acridotheres tristis*	LC	Omnivore	8
		81	Indian Pied Starling (Pied Myna)	*Gracupica contra*	LC	Omnivore	5
	Zosteropidae	82	Indian White-eye (Oriental White-eye)	*Zosterops palpebrosus*	LC	Omnivore	5
Pelecaniformes	Ardeidae	83	Black Bittern	*Ixobrychus flavicollis*	LC	Omnivore	1
		84	Black-crowned Night Heron	*Nycticorax nycticorax*	LC	Carnivore	1
		85	Cinnamon Bittern	*Botaurus cinnamomeus*	LC	Carnivore	1

		86	Eastern Cattle Egret	*Ardea coromanda*	LC	Carnivore	3
		87	Grey Heron	*Ardea cinerea*	LC	Insectivore	4
		88	Indian Pond-Heron	*Ardeola grayii*	LC	Piscivore	5
		89	Little Egret	*Egretta garzetta*	LC	Carnivore	4
		90	Medium Egret (Intermediate Egret)	*Ardea intermedia*	LC	Piscivore	2
		91	Purple Heron	*Ardea purpurea*	LC	Carnivore	2
	Threskiornithidae	92	Eurasian Spoonbill	*Platalea leucorodia*	LC		1
		93	Red-naped Ibis (Indian Black Ibis)	*Pseudibis papillosa*	LC	Carnivore	1
Piciformes	Megalaimidae	94	Brown-headed Barbet	*Psilopogon zeylanicus*	LC	Omnivore	1
		95	Coppersmith Barbet	*Psilopogon haemacephalus*	LC	Frugivore	2
	Picidae	96	Black-rumped Flameback (Lesser Goldenbacked Woodpecker)	*Dinopium benghalense*	LC	Frugivore	1
		97	Brown-capped Pygmy Woodpecker (Indian Pygmy Woodpecker)	*Yungipicus nanus*	LC	Insectivore	2
		98	Eurasian Wryneck	*Jynx torquilla*	LC	Insectivore	1
		99	Yellow-crowned Woodpecker	*Leiopicus mahrattensis*	LC	Insectivore	1
Podicipediformes	Podicipedidae	100	Little Grebe	*Tachybaptus ruficollis*	LC	Insectivore	5
Psittaciformes	Psittaculidae	101	Plum-headed Parakeet	*Psittacula cyanocephala*	LC	Piscivore	1
		102	Rose-ringed Parakeet	*Psittacula krameri*	LC	Granivore	19
Strigiformes	Strigidae	103	Jungle Owlet	*Glaucidium radiatum*	LC	Herbivore	1
		104	Spotted Owlet	*Athene brama*	LC	Carnivore	2
Suliformes	Anhingidae	105	Oriental Darter	*Anhinga melanogaster*	LC	Carnivore	14
	Phalacrocoracidae	106	Little Cormorant	*Microcarbo niger*	LC	Piscivore	15

Table 1: List of Water birds at Nawabganj Bird Sanctuary (Legend: LC- Least Count, E- Endangered)

Avifaunal Diversity

There were N = 465 individuals and S = 106 species in the final inventory. 38 species (35.85%) came from the Passeriformes, 11 from the Pelecaniformes (10.38%), 10 from the Anseriformes (9.43%), 9 from the Charadriiformes (8.49%), and 6 from the Piciformes (5.66%). Each of the following groups contributed four species (3.77%): Accipitriformes, Columbiformes, Coraciiformes, and Gruiformes. Three species (2.83%) were contributed by Cuculiformes, two species (1.89%) by five orders, and one species (0.94%) by three orders. The number of species in each family was used to calculate the values of the Relative Diversity Index (RDi). Anatidae and Ardeidae (9 species each; 8.49%) had the highest RDi values, followed by Cisticolidae and Muscicapidae (5 species each; 4.72%).

S. No.	List of Avian Families	No. of Species	Rdi Value
3	Accipitridae	4	3.78
4	Anatidae	9	8.5
5	Dendrocygnidae	1	0.95
6	Apodidae	1	0.95
7	Bucerotidae	1	0.95
8	Upupidae	1	0.95
9	Burhinidae	1	0.95
10	Charadriidae	2	1.89

11	Jacanidae	2	1.89
12	Recurvirostridae	1	0.95
13	Scolopacidae	3	2.84
14	Ciconiidae	1	0.95
15	Columbidae	4	3.78
16	Alcedinidae	1	0.95
17	Coraciidae	1	0.95
18	Halcyonidae	1	0.95
19	Meropidae	1	0.95
20	Cuculidae	3	2.84
21	Phasianidae	2	1.89
22	Rallidae	4	3.78
23	Alaudidae	1	0.95
24	Campephagidae	1	0.95
25	Cisticolidae	5	4.72
26	Corvidae	3	2.84
27	Dicaeidae	1	0.95
28	Dicruridae	3	2.84
29	Estrildidae	3	2.84
30	Hirundinidae	1	0.95
31	Leiothrichidae	1	0.95
32	Motacillidae	3	2.84
33	Muscicapidae	5	4.72
34	Nectariniidae	1	0.95
35	Oriolidae	1	0.95
36	Paridae	1	0.95
37	Pycnonotidae	2	1.89
38	Sittidae	1	0.95
39	Stenostiridae	1	0.95
40	Sturnidae	3	2.84
41	Zosteropidae	1	0.95
42	Ardeidae	9	8.5
43	Threskiornithidae	2	1.89
44	Megalaimidae	2	1.89
45	Picidae	4	3.78
46	Podicipedidae	1	0.95
47	Psittaculidae	2	1.89
48	Strigidae	2	1.89
49	Anhingidae	1	0.95
50	Phalacrocoracidae	1	0.95

Table 2: Relative Diversity Index of Avian families

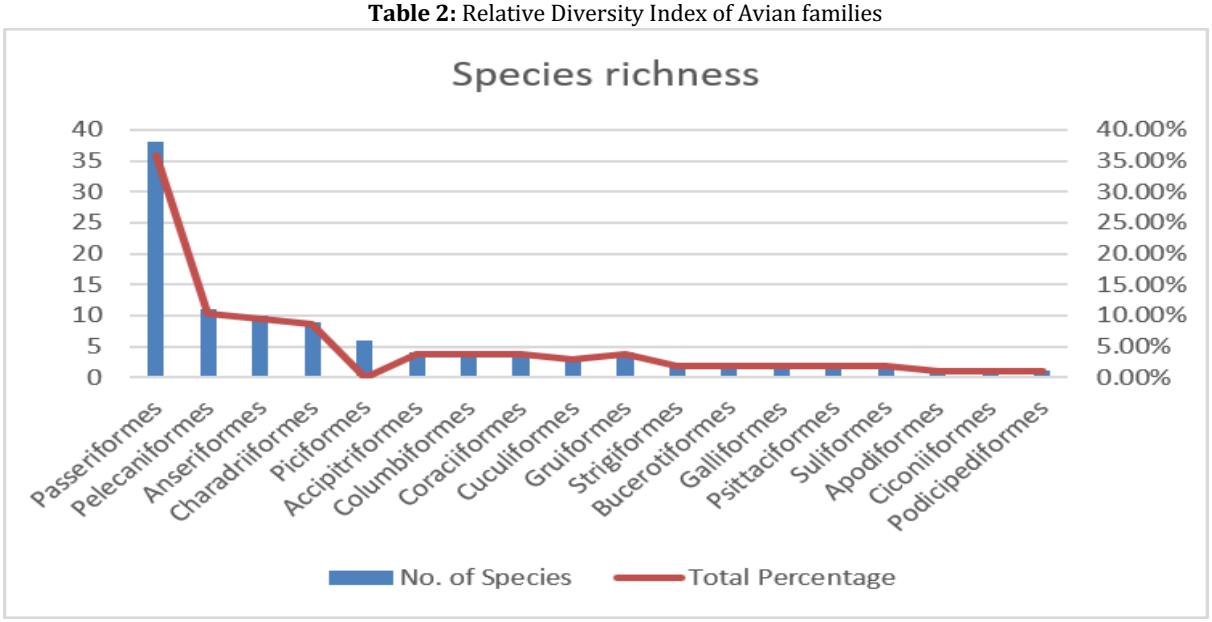

Fig 13: Total percentage clustered column chart for the no. of species belonging to different orders present at Nawabganj Bird Sanctuary.

Shannon–Wiener diversity index: H′ = 4.2546.
Margalef richness index: DMg = (106 + 1) / ln (465) = 17.0953.
Simpson concentration of dominance: D = 0.019309;
Simpson diversity (1 D) = 0.980691.
Pielou's evenness: J′ = 4.254645 / ln (106) = 0.9123.
Berger–Parker dominance: The Asian Openbill (*Anastomus oscitans*) was the most abundant species in the dataset (Nmax = 25), giving d = 25/465 = 0.05376 (5.38%).

When combined, the calculated indices show low concentration of dominance, high evenness, and high species richness in relation to the number of individuals sampled. Furthermore, the low Berger-Parker value suggests that no single species was responsible for a significant percentage of the individuals that were observed. These indices characterize the composition of the bird community that was sampled; they should not be used as a direct indicator of the general health of wetlands.

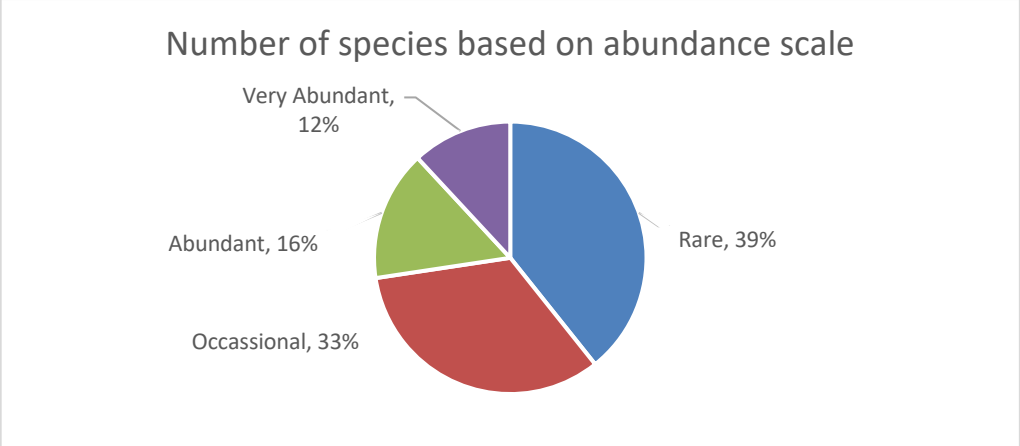

Fig 14: Pie chart for number of species based on abundance scale avian population

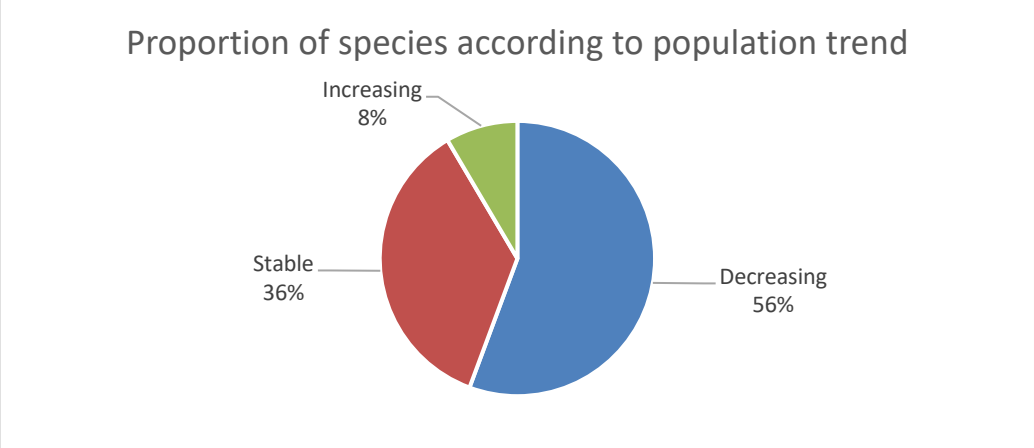

Fig 15: Pie chart for proportion of avian species according to population trend

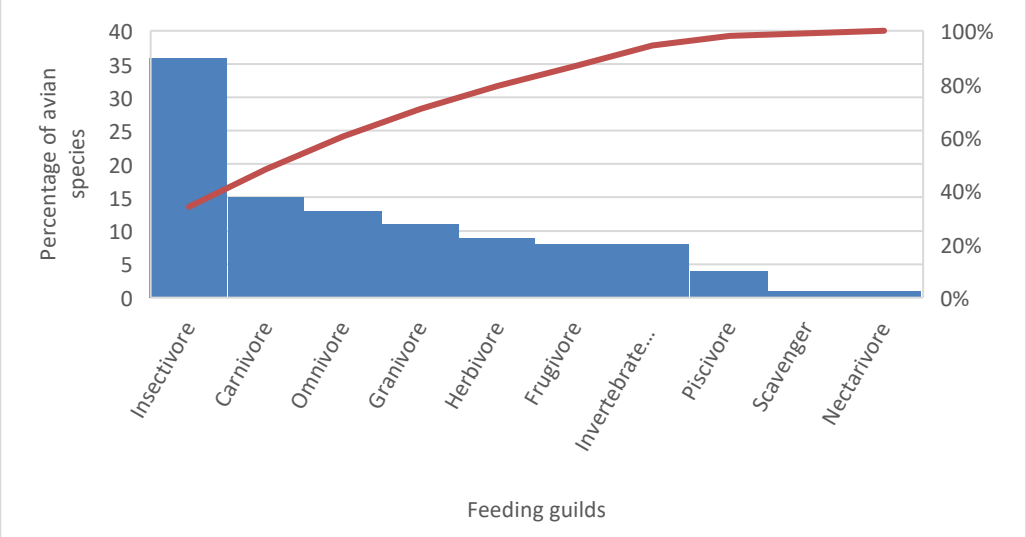

Fig 16: Clustered bar chart for guild-wise percentage of avian species

Aquatic Vegetation Assessment

Using available field and record data, aquatic vegetation

was qualitatively assessed, with a focus on plant occurrence, current status, and ecological significance to waterbirds (Singh and Garg, 2018). Vegetation observations are interpreted as habitat-context information rather than as a quantitative relationship between vegetation and birds because the current dataset did not systematically quantify plant abundance, percentage cover, and spatial distribution (Qiu et al., 2024).

Water Quality Analysis

For the measured parameters—pH, conductivity, turbidity, TDS, TSS, COD, BOD, DO, alkalinity, hardness, major ions, nutrients, specific metals, and total coliforms—physicochemical water-quality observations were compiled for 2025. In cases where the source table contained a Class-C standard, the observed value was compared to that standard. Rather than being seen as a stand-alone factor influencing bird occurrence, water quality was seen as one part of the wetland habitat system (Verma et al., 2025).

Aquatic Vegetation Status and Avian Importance

For wetland creatures, aquatic vegetation offers marginal habitat, food sources, shelter, and structural complexity. The type, density, % cover, spatial distribution, and amount of open water maintained all affect its ecological significance. Therefore, improved habitat conditions are not always indicated by the mere existence of a plant species. (Kawatsu et al., 2015 and Klaassen et al., 2007).

Plant species	Occurrence	Status	Significance
Hydrilla verticillata (Hydrilla)	Reported in the deeper parts of the wetland	Regular	Provides underwater habitat and supports small aquatic organisms that birds feed on
Ceratophyllum demersum (Hornwort)	Reported as aquatic vegetation	Regular	Provides shelter for aquatic organisms and supports the food chain
Trapa natans (water chestnut)	Found mainly in shallow water	Common	Provides feeding and resting areas for some birds, but too much can reduce open water
Nelumbo nucifera (Lotus)	Reported extensively in the wetland	Regular	Provides cover and habitat for birds and aquatic organisms; too much can reduce open-water space
Nymphaea pubescens (Water lily)	Reported from the sanctuary	Regular	Provides floating leaves, cover, and feeding opportunities.
Eichhornia crassipes (Water hyacinth)	Reported in the wetland	Occasional (Needs close monitoring because it can spread rapidly)	Small amounts may provide shelter, but dense mats can block open water and reduce feeding areas for migratory birds.
Typha angustifolia (Narrow-leaved cattail)	Found mainly around the wetland margins	Common (along margins)	Provides shelter and nesting areas for some birds, but dense growth can reduce shallow feeding areas
Ipomoea carnea (Bush morning glory)	Reported around wetland margins	Common (along margins)	Can provide some cover, but excessive growth may replace native plants and reduce habitat variety.
Spirodela polyrhiza (Greater duckweed)	Reported in earlier vegetation records	Occasional	Can provide food and support aquatic productivity, but too much floating cover can reduce open water.

Table 3: List of frequently found vegetative species at the Nawabganj bird sanctuary (Warma et al., 2024).

According to the information that is currently available, emergent, free-floating, floating-leaved, and submerged vegetation may all work together to provide various bird groups with habitat resources. On the other hand, excessive growth of emergent or floating vegetation may diminish shallow and open-water feeding habitat. This suggests that rather than maximizing vegetation cover, vegetation management should concentrate on preserving a heterogeneous mosaic. But many researchers have used *Trapa natans* as a plant of interest to remove heavy metals from water, thereby lowering the level of heavy metal contamination

Physicochemical Water Quality and Its Implications for Waterbirds

Near-neutral water, detectable dissolved oxygen, moderate dissolved solids and hardness, significant oxygen demand, detectable nutrients, and a variety of dissolved and microbiological parameters were all shown in the 2025 water-quality dataset. According to the tabulated values, BOD was above the specified Class-C limit, but pH, TDS, chloride, sulfate, nitrate, copper, zinc, lead, cadmium, and total coliform were all within the specific standards given in the source table.

Parameters	Result	Standard (IS-2296 Class-C)	Status
pH	7.38	6.0–9.0	Within standard
Conductivity	359		
Turbidity	54		
Total Dissolved Solids (TDS)	252	≤1500	Within standard
Total Suspended Solids (TSS)	76.5		
Chemical Oxygen Demand (COD)	112		

Biochemical Oxygen Demand (BOD, 5 days at 20°C)	10.5	≤3.0	Above standard
Dissolved Oxygen (DO)	4.6		
Alkalinity as $CaCO_3$	100		
Total Hardness as $CaCO_3$	112		
Calcium (Ca)	30.4		
Chloride (Cl)	24	≤600	Within standard
Sodium (Na)	17.3		
Sulfate (SO_4^{2-})	24.9	≤400	Within standard
Nitrate Nitrogen (NO_3-N)	6.35	≤50	Within standard
Total Chromium (Cr)	BDL		Below detection limit
Phosphate (PO_4)	0.28		
Copper (Cu)	0.07	≤1.5	Within standard
Zinc (Zn)	0.13	≤15	Within standard
Lead (Pb)	BDL	≤0.1	Below detection limit
Cadmium (Cd)	BDL	≤0.01	Below detection limit
Total Coliform	270	≤5000	Within standard

Table 4: Physicochemical water quality results of Nawabganj Bird Sanctuary, 2025

The recorded pH of 7.38 indicates near-neutral to slightly alkaline conditions. Dissolved oxygen was 4.6 mg L^{-1}. Its importance to birds is mainly indirect because aquatic organisms, including fish and invertebrates, can form important prey resources. The DO value should therefore be interpreted together with BOD, COD, temperature, water depth, and biological measurements rather than as direct evidence of bird stress. (Ma et al., 2010)

BOD was 10.5 mg L^{-1} and COD was 112 mg L^{-1} in the tabulated dataset. The elevated BOD indicates substantial oxygen demand associated with biodegradable organic matter. High oxygen demand can reduce oxygen availability under favorable conditions for decomposition and may alter aquatic prey communities. Such effects could subsequently influence waterbirds through food-web pathways (Verma et al., 2025).

TDS was 252 mg/L and conductivity was 359, while alkalinity and hardness were 100 and 112 mg/L, respectively, in the tabulated dataset. These variables describe the ionic and buffering characteristics of the water and are more appropriately interpreted as environmental context than as direct indicators of bird habitat quality. (Ma et al., 2010)

Nitrate nitrogen was 6.35 mg/L and phosphate was 0.28 mg/L in the tabulated dataset. Nutrient availability can influence primary production, microbial activity, and aquatic vegetation. However, bird responses are expected to occur mainly through changes in vegetation, prey availability, and habitat structure rather than through direct effects of these concentrations on birds.

Turbidity was 54 in the tabulated dataset. Because the table does not provide a corresponding standard, the value should be interpreted cautiously. Turbidity can arise from runoff, sediment resuspension, water-level fluctuations, and biological activity, and a single measurement cannot distinguish natural hydrological variation from anthropogenic influence.

Overall, the water-quality results suggest a wetland with generally near-neutral water chemistry but with elevated organic oxygen demand requiring ecological attention. The combination of BOD, COD, and DO is particularly relevant to the aquatic food web. Nevertheless, a direct causal relationship between these water-quality observations and the recorded bird community cannot be established from the present dataset because bird and water-quality observations were not analyzed through spatially matched or multivariate models. (Balapure et al., 2013; Singh & Khalid, 2022).

INTEGRATED ECOLOGICAL INTERPRETATION

Together, the avifaunal, vegetation, and water-quality data show that Nawabganj Bird Sanctuary is a heterogeneous wetland mosaic that can sustain a taxonomically diverse bird community. Even though the Asian Openbill was the most prevalent species in the available count data, the high evenness and low dominance values show that no single species dominated the recorded community. Several habitat components are used when waterfowl, waders, herons, rails, kingfishers, cormorants, and other groups associated with wetlands are present (Bibhu et al., 2021; Rajpar et al., 2014).

Therefore, one of the main conclusions of this study is that an integrated monitoring framework that links bird assemblages with vegetation structure, hydrology, water quality, food resources, and anthropogenic pressure should be used to assess the wetland health at Nawabganj Bird Sanctuary. Compared to a single biodiversity index or water-quality metric, this method would offer more convincing evidence for conservation decisions. (barey et al., 2022)

CONCLUSION

The results of this study directly relate to Sustainable Development Goal 6 (Clean Water and Sanitation) (United Nations, 2026a), specifically Target 6.3 (improving water quality by reducing pollution) and Target 6.6 (protecting and restoring water-related ecosystems, including wetlands). Additionally, the study supports SDG 15 (Life on Land) (United Nations., 2026b), specifically the preservation and sustainable use of terrestrial and inland freshwater ecosystems and their biodiversity.

With 106 species from 18 orders and 48 families, Nawabganj Bird Sanctuary is home to a varied avifaunal community. The recorded community was not heavily dominated by a small number of species, as evidenced by the high Shannon diversity ($H' = 4.255$), Pileous evenness ($J' = 0.912$), Margalef richness (DMg = 17.095), and low Simpson dominance (D = 0.0193). The sanctuary offers a variety of feeding, refuge, roosting, and nesting opportunities due to its habitat mosaic of open water, marshes, aquatic vegetation, grassland, and wooded areas.

Although BOD (10.5 mg L^{-1}) exceeded the specified Class-C limit, the 2025 water-quality results show generally

near-neutral conditions, while COD (112 mg L^{-1}) and DO (4.6 mg L^{-1}) show that oxygen-demanding processes require ongoing monitoring. The conditions like water quality and bird diversity may indirectly impact birds through changes in aquatic organisms and prey availability.

The ecological state of Nawabganj can generally be better understood as the result of interconnected habitat, vegetation, hydrological, and water-quality factors rather than just one. Understanding long-distance migrants' movements, migration routes, stopovers, and staging places is key to their conservation (Javed et al., 2003).

In addition to other issues, the sanctuary also has simian issues. Many families of monkeys now call this region home. They prowl the ground and leap from tree to tree. When monkeys are playing, birds avoid the vicinity. Monkeys annoy birds that would rather sit on the ground and eat insects or just walk on the grass to take a break from flying. The area was designated as a sanctuary in 1984. It is like a small island of biological diversity among a vast expanse of agricultural fields where intensive agriculture is practiced with chemical fertilizers, insecticides, and pesticides. The adjoining four-lane highway, which connects the state capital of Lucknow to the industrial city of Kanpur, is usually always congested with traffic. The surrounding little settlement of Nawabganj has evolved into a substantial urban area, with the population census numbers showing an increase from 7,691 in 1991 to 11,545 in 2011 (Taslima et al., 2023). Thus, the anthropogenic pressure on the area has increased considerably. Even then the conservation efforts being practiced have resulted in it being declared a Ramsar site and a Birding Area of Significance.

Management should be given top priority in order to avoid excessive macrophyte proliferation, maintain habitat heterogeneity, protect open-water and shallow feeding areas, and monitor bird populations and water quality. Long-term, regular monitoring that includes bird counts, quantitative vegetation assessment, repeated water-quality sampling, hydrology, and anthropogenic pressures will be essential to assessing future changes in this Ramsar wetland.

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