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Ministry of Environment, Forest and Climate Change

भारतीय वन्यजीव संस्थान
Wildlife Institute of India



STATUS OF WATERBIRDS IN THE GANGA RIVER BASIN

A REVIEW



FEBRUARY, 2025





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EXECUTIVE SUMMARY



The Ganga River Basin is one of the world's major international transboundary river basins, spread over India, Nepal, Bangladesh and Tibet. In India, the basin spread over 11 states, has numerous natural and artificial wetlands that provide refuge to several waterbird species, including winter migrants from Central Asian countries. Numerous independent localized studies on the waterbirds have been conducted in the Ganga River Basin, but the collective and collated information on waterbirds of the basin is missing, ergo, the existing literature was reviewed to compile the information. Google Scholar, Bibliography of South Asian Ornithology database, Waterbirds of India (Bibliography) and several other databases were searched and scrutinized for review of the literature between 1861 and 2023 on the waterbirds in the Ganga River Basin in India using different combinations of keywords.

Out of 3,157 peer-reviewed studies obtained from different sources, only 18% were selected for the review, covering topics like status, diversity, composition, and behavior, mostly (60%) conducted by universities, colleges and institutes. The review revealed that the waterbird centric scientific studies were initiated very late (in the early 21st century) in the basin, however, hunting and individual observations were available from as early as the 19th century. A positive trend is being observed in peer-reviewed studies conducted between 2000 and 2023. Until 2023, 573 peer-reviewed studies were conducted in the different types of wetlands in the basin, of which 234 were used to prepare the waterbird checklist. Studies between 2021 and 2023 show an encouraging trend that will likely continue until 2030. In quality assessment, 25% of peer-reviewed studies were indexed with SCI or SCOPUS; the rest were indexed with NAAS or non-indexed journals.

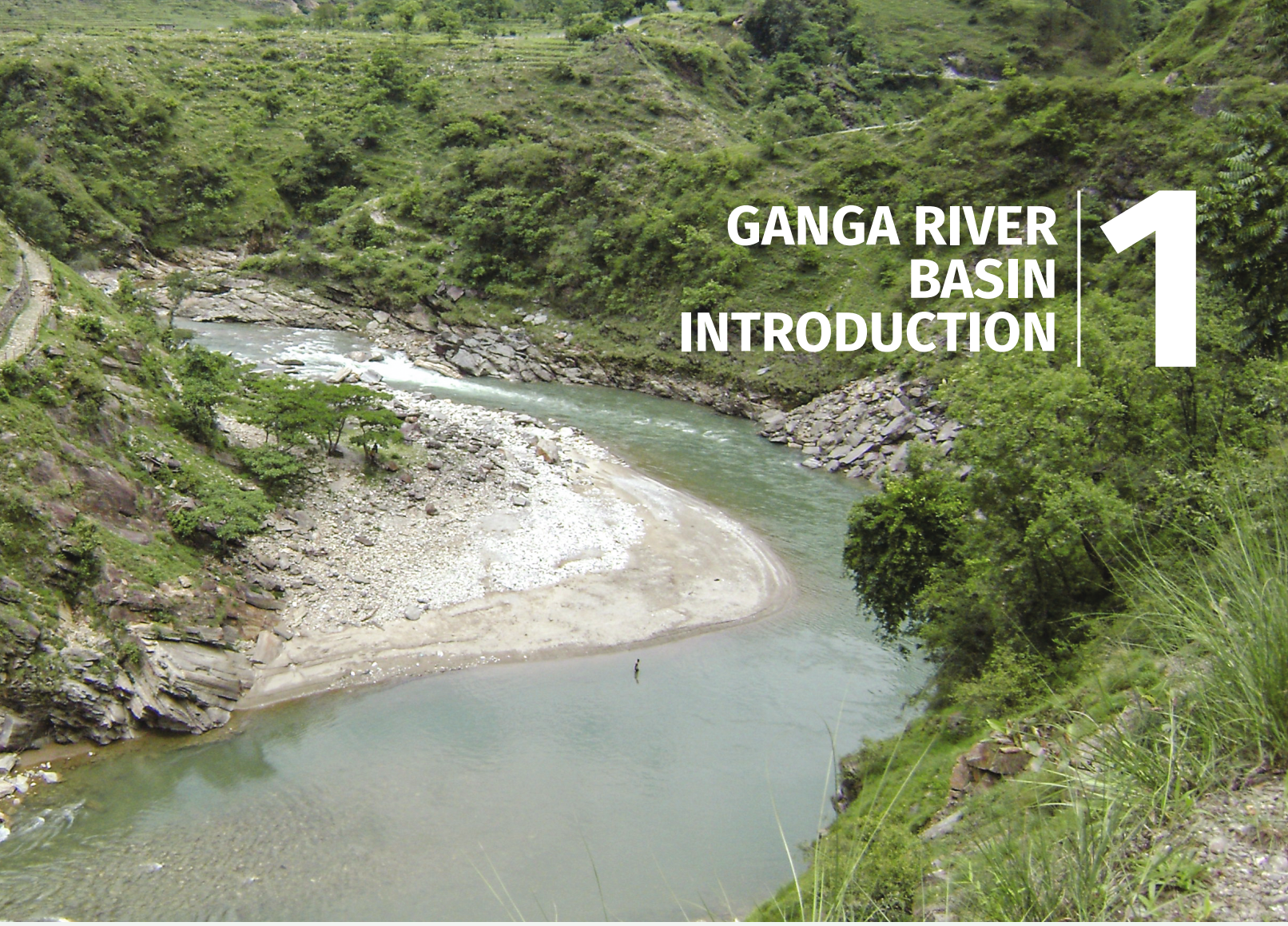
The review complied a total of 236 waterbird species belonging to 32 families and 14 orders from different wetlands of the basin, which includes 52 Threatened or Near Threatened species as per the IUCN Red List. Most of the studies were conducted in the rural and urban wetlands of Uttar Pradesh and Bihar. Studies from the riverine habitats were comparatively less. The major emphasis of these studies was on the diversity and composition of waterbirds, followed by behavioral studies. The number of waterbird species crossed the mark of 100 for most of the basin states, except for Himachal Pradesh and Jharkhand. Altogether, 101 studies were published on the different behavioral aspects, including activity patterns, breeding,

nesting, and migration. Point count and line transect were two key methods used to assess waterbird status however, most of the studies lagged abundance/ density estimations and seasonal information. Out of 573 studies, only 25.65% were carried out across the Ganga River and its tributaries, while the rest were carried out in the inland wetlands like ponds, dams, reservoirs and forest streams. Hunting/Poaching of waterbirds was identified as the most highlighted threat in the reviewed studies, followed by pollution, cattle/grazing and agriculture practices in the waterbird habitats.

We reviewed multinational environment agreements and found that these address most of the threats identified. Out of 48 identified conservation measures, pollution is mentioned mostly, followed by agricultural practices and water availability, fishing and use of chemicals and fertilizers, and poaching and deforestation. However only few of them are specific to waterbirds. Targeted conservation measures are required for the invasive species. The "One Health" concept to ensure prevention on zoonotic diseases should be a priority conservation measures. Intergovernmental Forum on Mining must include biodiversity conservation as one of their major mitigations. At national level, Wild Life (Protection) Act, 1972 and Wetlands (Conservation and Management) Rules, 2017 align with the requirements of waterbird and their habitat conservation in India. Recently, CMS and CITES, enhanced their horizon in working with partner countries, but that requires coordination and effective implementation of policies and regulations on the ground level. National-level conservation measures must incorporate climate change, mining, one-health and forest fire/burning need to be amended to relief.

The systematic review suggests that more collaborative scientifically robust studies are required to enhance the quality and reliability of the data. Long-term monitoring and micro-level studies are recommended to cope with site-specific threats and management challenges. The review underlines more access and subsidies to developing countries like India for open-access journals, which will ensure timely and quality publications. Focus on the socio-ecological, river ecosystem, migration pattern, threatened species and ecosystem service aspects will contribute more to the long-term conservation of waterbirds and wetlands in the Ganga River Basin of India.





GANGA RIVER BASIN INTRODUCTION 1

1.1. Historical and Mythological Significance

Ganga River is personified as a goddess and mother in the Hindu religion and symbolizes divinity and salvation (Sati, 2021). According to Hindu mythology, King *Bhagiratha* performed intense penance to bring the Ganga River from heaven to Earth for the salvation of his cursed ancestors. Bhishma, a stalwart character of the epic *Mahabharata* was known as the son of the Ganga (*Ganga Putra*). As per the Vedic mythology and scriptures, Rishikesh, Haridwar, Prayagraj, and Varanasi are prominent spiritual towns along the Ganga River, across different Indian states. These are sites where devotees immerse themselves in the holy waters, seeking absolution from all their previous sins (Alley, 2002; Sati, 2021). It has been prominently described not just in ancient Indian history but also in European history. The famous Greek historian and traveler *Megasthenes*, was among the first to mention the Ganga River in the ancient Greek records. In Rome, the Fontana dei Quattro Fiumi (Fountain of Four Rivers) sculpture included the Ganga as one of the world's greatest rivers in its design (San Juan, 2012). Apart from the Indus River valley civilization, the Ganga River has witnessed the wrath and glory of different kingdoms, from the Maurayan empire to the colonial Era. In sovereign India, it was declared as the "National River of India" on November 4th, 2008 by the Government of India during the Ganga Basin Ministerial Conference in New Delhi.

1.2. Salient Features of the Ganga River and its Basin

The Ganga River originates from the Gangotri glacier in the Uttarkashi district of Uttarakhand. It traverses as the Bhagirathi till Devprayag where it joins the Alaknada River, and the flow thereafter is known as the Ganga River (Chaturvedi, 2012). It traverses through five states of India for 2525 kilometers and eventually merges into the Bay of Bengal. The Gomti, Ghaghra, Gandak, and Kosi are the major left-bank tributaries, and the Yamuna, Son, Punpun, and Damodar are some of the major right-bank tributaries of the mainstem Ganga (Sati, 2021). The geographical extent of its basin spans over 10,86,000 sq. km in four countries, including India, Nepal, Tibet, and Bangladesh, which extends between 73° 2' to 89° 5' E and 21° 6' to 31° 21' N. The Ganga River Basin covers around 26% of India's geographical area, and has 30% water resources. In India, its basin is spread over 8,61,452 sq. km area in 11 states namely Bihar, Chhattisgarh, Delhi, Haryana, Himachal Pradesh, Jharkhand, Madhya Pradesh, Rajasthan, Uttar Pradesh, Uttarakhand and West Bengal (INDIA-WRIS, 2014; Table 1.1). It is one of the world's most populated rivers basins, with more than 500 million people sustaining on its resources. The annual surface water potential of the Indian Ganga River Basin is estimated at around 525 cubic kilometers, of which 250 cubic kilometers is usable. There are 19 sub-basins and 980

watersheds in the Ganga River Basin. As per the Census of India (2011), there are a total of 2,86,557 villages, 252 districts, and 239 parliamentary constituencies in the Indian Ganga River Basin, with a total population of 32,91,55,760, which is 27.18% of India's population.

Table 1.1 State-wise details of the Ganga River Basin (INDIA-WRIS, 2014)

State	Basin area (sq. km)	Basin percentage
Bihar	93,579.8	10.86
Chhattisgarh	17,907.60	5.85
Delhi	1484.2	0.17
Haryana	34,343	3.99
Himachal Pradesh	4317	0.50
Jharkhand	50,389.14	5.85
Madhya Pradesh	1,81,065.5	21.02
Rajasthan	1,12,496.26	13.06
Uttar Pradesh	2,41,392	28.02
Uttarakhand	52,988.5	6.15
West Bengal	71,489	8.30

1.2.1. Geophysical values and climatic condition

The Ganga River Basin was formed during the middle Miocene period by weathered sediments from the Himalaya deposited across the river basin (Parker, 2000; Singh & Singh, 2005). The basin in India comprises of three topographic divisions: the Himalayan Young Fold Mountains, the Gangetic Plain, and the Central Indian highlands. The highest elevation point of the basin in India reaches up to 7512 m asl in the Greater Himalayan region of Uttarakhand, and the lowest < 5m asl in the Sundarbans. The Central Indian Highlands include Aravali uplands, Bundelkhand upland, Malwa plateau, and Vindhyan ranges. The Sundarbans Delta, formed at the mouth of the Ganga River, is the world's largest river delta. The intact mangrove forests in the Sundarbans of this river delta encompass the world's largest mangrove forests. The basin receives 80% of its total rainwater during three months of monsoon season. The annual precipitation rate varies between 0 and >2700 mm/year (average 1059.74 mm) in permafrost and Sundarbans, respectively. The average temperature in the basin varies between 18.44 and 32.05 °C. The Ganga River Basin has ten major soil types, viz. (1) mountain soil, (2) sub-mountain soil, (3) alluvial soil, (4) red soil, (5) red and yellow soil, (6) mixed red and black soil, (7) deep black soil, (8) medium black soil, (9) shallow black soil, and (10) laterite soil (Mukherjee & Dasgupta 1983, in TERI 2011). Of these soil types, alluvial soil covers almost 52% of the basin area making it the most fertile river basin.

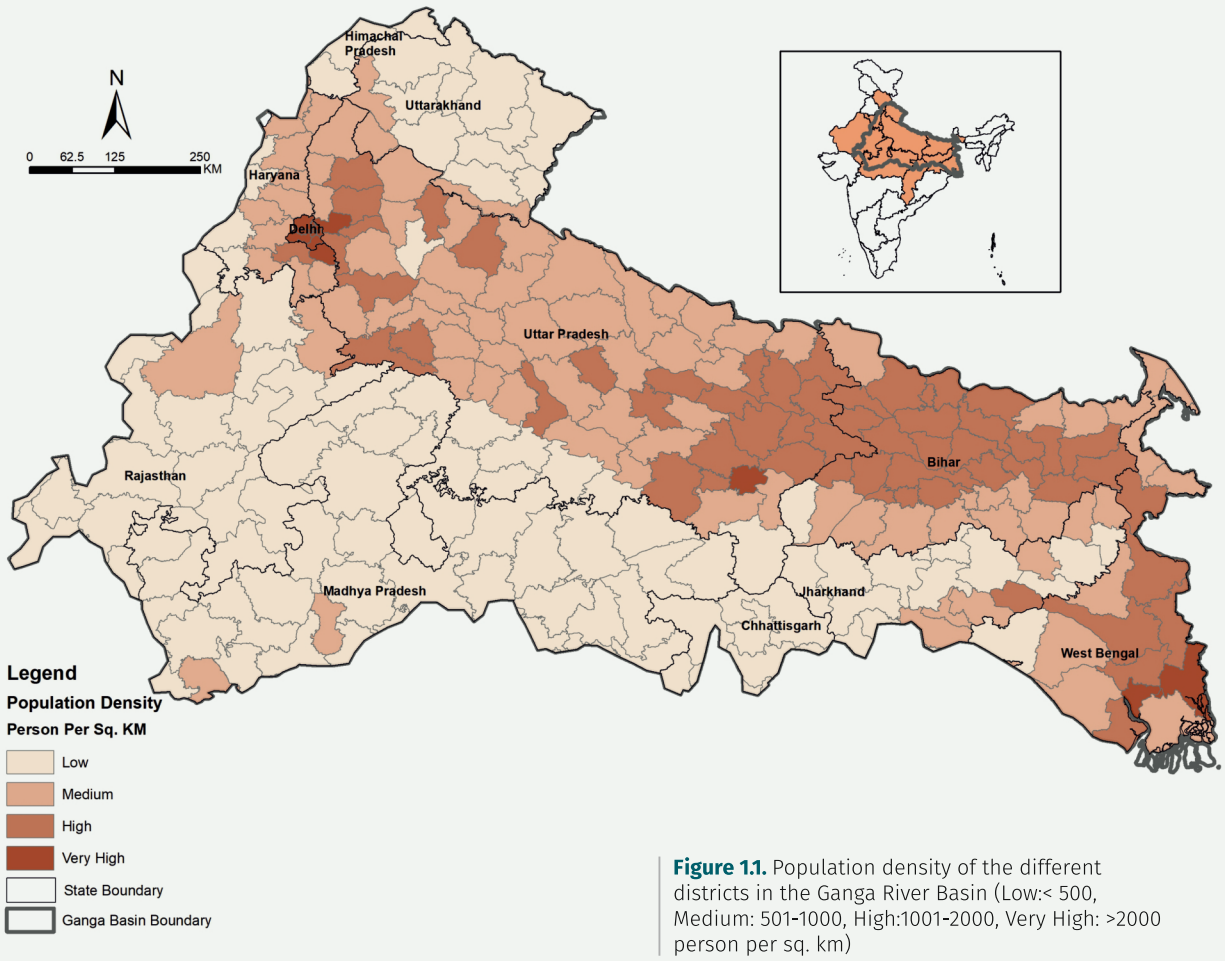


Figure 1.1. Population density of the different districts in the Ganga River Basin (Low:< 500, Medium: 501-1000, High:1001-2000, Very High: >2000 person per sq. km)

1.2.2. Demographic details

The Ganga basin has some of the most densely populated cities in the world, such as New Delhi, and Kolkata. According to INDIA-WRIS (2014) assessment, Uttar Pradesh, Bihar, and West Bengal are the three most populous states, while Uttarakhand, Chhattisgarh and Himachal Pradesh are the least populous states in the Ganga River Basin (Table 1.2). North East Delhi district has the highest human density (36,155 per sq. km) and Uttarkashi has the lowest density (41 per sq. km) in the basin (Census of India, 2011; Figure 1.1). Delhi, Bihar, West Bengal, and Uttar Pradesh are densely populated states of the Ganga River Basin. Besides, Lucknow, Patna, Agra, Meerut, Prayagraj and Hooghly are other major cities and densely populated districts (> 5000 per sq. km) of the basin. Most districts in Uttarakhand, Himachal Pradesh, Madhya Pradesh, Rajasthan, Jharkhand and Chhattisgarh have < 200 per sq. km human density (Census of India, 2011). Delhi (86.2%), Himachal Pradesh (82.8%) and Uttarakhand (78.8%) are the top three states with highest literacy rate in the Ganga River Basin, while Rajasthan (66.1%) and Bihar (61.8%) are with the lowest rate (Census of India, 2011).

Table 1.2 State-wise demographics of the Ganga River Basin (Source: INDIA-WRIS 2014)

Basin State	Population	Contribution in the Basin's population (%)
Bihar	10,40,99,452	18
Chhattisgarh	92,34,725	2
Delhi	1,67,87,941	3
Haryana	1,69,71,939	3
Himachal Pradesh	20,08,306	0.35
Jharkhand	3,03,54,333	5
Madhya Pradesh	5,69,86,999	10
Rajasthan	4,32,14,527	7
Uttar Pradesh	19,98,11,249	35
Uttarakhand	1,00,86,292	2
West Bengal	8,84,57,029	15
Grand Total	57,80,12,792	100

1.2.3. Land Use Land Cover (LULC)

As per the NRSC (2018-19) (Figure 1.2), agriculture predominates the land use with 65% (5,64,866 sq. km) of total basin cover in the Gangetic plains of Uttar Pradesh, Haryana, Bihar, Jharkhand and West Bengal (Table 1.3). Different types of forests contribute 16% as the second most dominant land use class in the Ganga River Basin. The forest is predominantly spread along the Himalayas and central India, with sporadic distribution along the Terai in Uttar Pradesh and Bihar. Built-up class contributed about 4.28% to the land use, with prominent urban conglomerations like Delhi, Kolkata, Agra and Lucknow. River/streams, inland, and coastal wetlands cover about 3.47% of the Ganga River Basin. Permafrost and snow-clad peaks of Uttarakhand and Himachal Pradesh contribute roughly 1% to the land cover, and are the source of the major glacial-fed rivers like the Ganga and Yamuna.

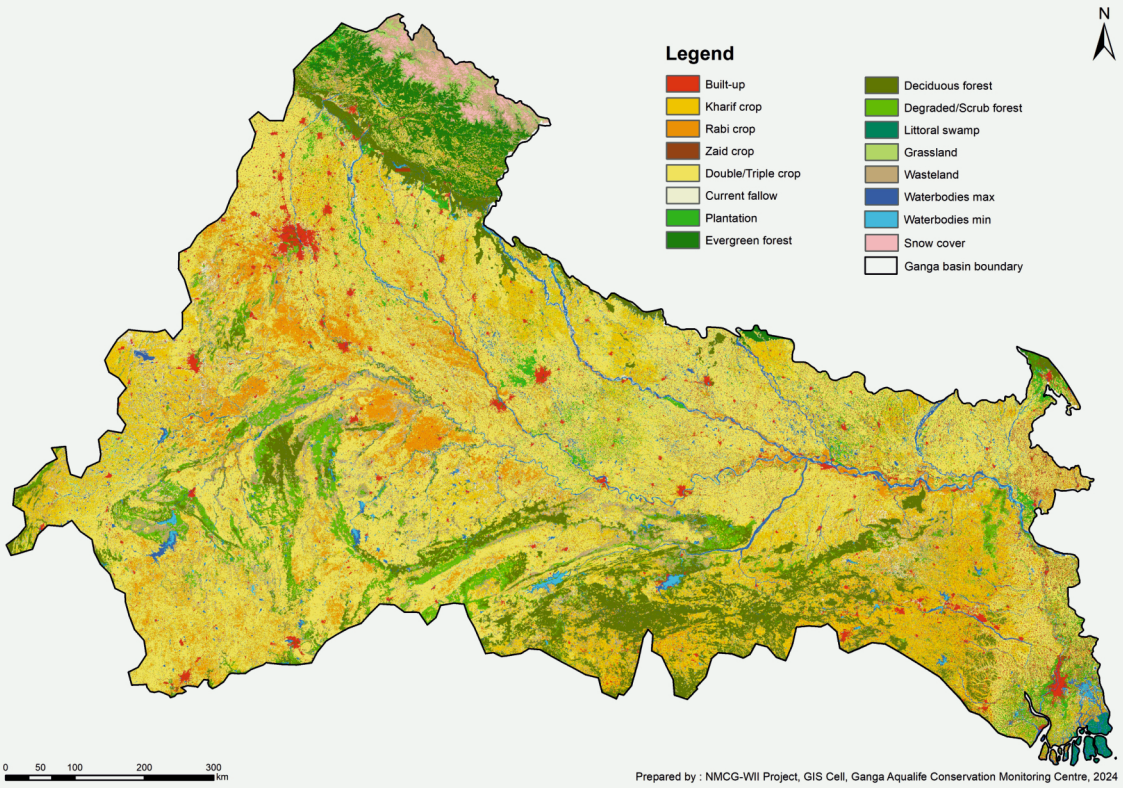


Figure 1.2. Land Use Land Cover map of the Ganga River Basin (Source: NRSC, 2018-19)

Table 1.3. Land Use Land Cover classification statistics of the Ganga River Basin

Class	Area (sq.km)	% of Total Area
Agricultural	5,64,866	65.57
Forest	1,37,816.5	16
Wasteland	76,603.61	8.89
Built-Up	36,908.24	4.28
Waterbodies	29,876.51	3.47
Snow/Glaciers	8056.9	0.94
Grassland	7324.27	0.85

The Ganga River Basin encompasses five biogeographic regions: Himalaya, Semi-Arid, Gangetic plain, Deccan peninsula and the Coasts. Spanning throughout the different biogeographic regions, the Ganga River Basin harbors different forest types viz. Sub-alpine and Alpine Forest, Himalayan Moist Temperate Forest, Sub-Tropical Pine Forest, Sub-Tropical Broadleaf Forest, Tropical Moist Deciduous Forest, Tropical Dry Deciduous Forest, Tropical Thorn Forest, and Littoral and Swamp Forest (Champion & Seth, 1968). Uttarakhand has the maximum forest cover (71.04%) among the 11 Ganga River Basin states followed by Himachal Pradesh (68.16%) and Chhattisgarh (44.25%) while states like Bihar, Haryana and Uttar Pradesh have < 8% forest cover (ISFR, 2023). The basin has 23 National Parks, 111 Wildlife Sanctuaries, five Conservation Reserves, three Biosphere Reserves, 111 Important Bird Areas and 25 RAMSAR sites (Figure 1.4). It has world-renowned Protected Areas (PAs) like Corbett, Ranthambore, Dudhwa, Panna, Valmiki National Parks. Till date, a total 177 species of water and water-associated birds have been recorded from the Ganga River including Threatened species like black-bellied tern (*Sterna acuticauda*), Indian skimmer (Rynchops albicollis) and sarus crane (*Grus antigone*) (WII-NMCG, 2019).

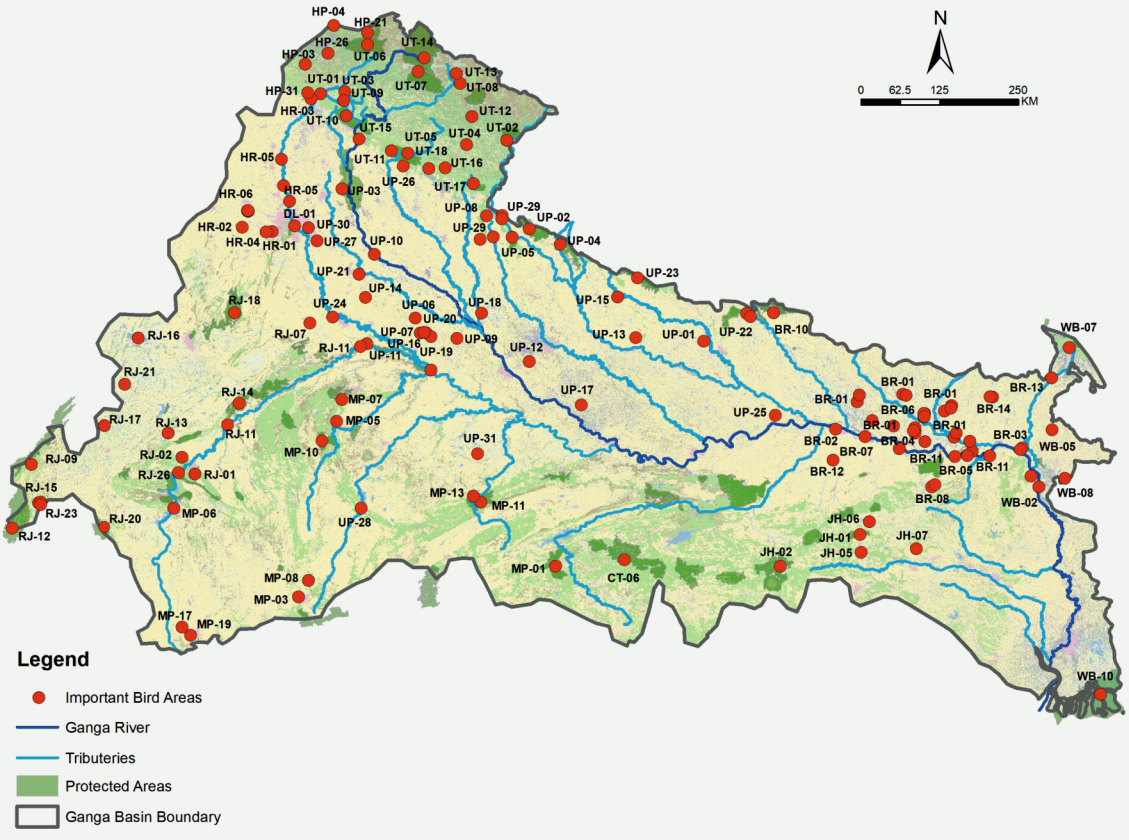


Figure 1.4. Distribution of Important Bird Areas (IBAs) in the Protected and Non-Protected areas of the Ganga River Basin

1.2.4. Status of waterbodies

A total of 7,00,352 different types of waterbodies (ponds, reservoirs, lakes and others) are distributed in the Ganga River Basin in India (MoJS, 2023). Out of these waterbodies, 86% (6,01,633) are categorized as ponds, 8.27% (57,968) as reservoirs and 0.26% (1862) as lakes. Concurrently, through high resolution Resourcesat-2 LISS-IV satellite images with spatial resolution of 5.8 m, Rao et al. (2021) identified 4,707 glacial lakes covering a total area of 20,685.12 ha. in the Ganga River Basin. The mainstem Ganga River has 17 major tributaries, of which, the Gandak, Yamuna, Ghaghra, Sharda, and Ramganga are glacial-fed Himalayan rivers, while the Son, Ken, Betwa and Sindh are peninsular rivers. The four rivers, Yamuna, Son, Ghaghra and Kosi contribute about half of the annual water yield of the mainstem Ganga (Gururaj Prabhu, 2014). The Betwa, Chambal, Gandak, Tons, Ghaghra, Gomti, Yamuna, Hooghly, Kosi, Ken, Mahananda, Sind and Son are the major sub-basins of the Ganga River Basin (Figure 1.5).

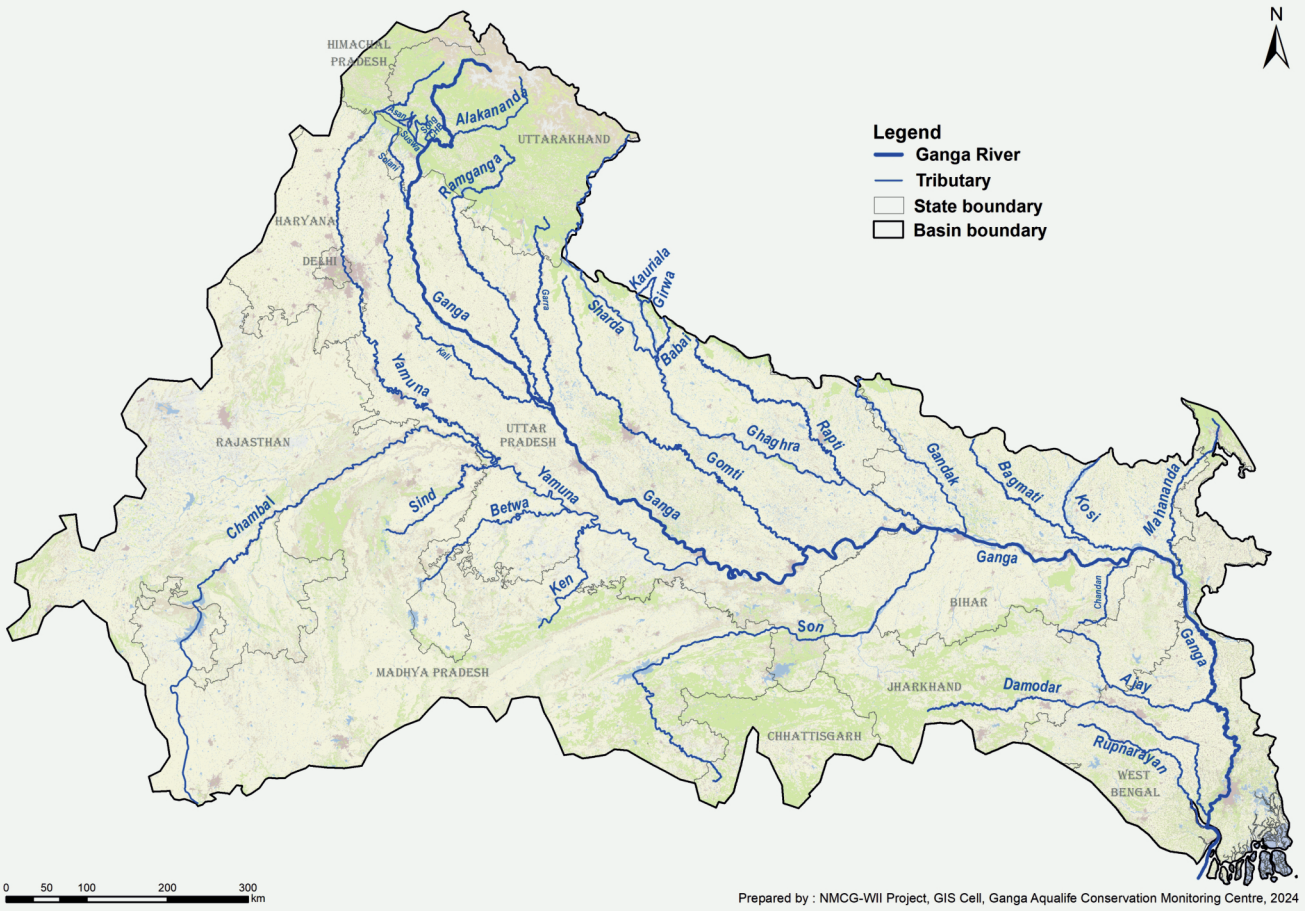


Figure 1.5. Mainstem Ganga and its major tributaries in the Ganga River Basin

1.3. Rationale and Objectives of the Study

The Ganga basin is a mélange of geologically and ecologically intertwined diverse elements. The interplay of these elements is the social and economic fabric of the Ganga basin. Waterbirds are an important ecological element representing the diversity of life forms across the biogeographic regions of the basin. They rely on the basin's wetlands, riverine habitats, and agricultural landscapes. Many studies have been conducted on waterbirds across the basin, but none of them gave a comprehensive account of the waterbirds across the basin. The review of waterbirds was undertaken to- 1) assess the status, diversity and behavioral patterns of the waterbirds in the Ganga River Basin and 2) identify research trends, gaps, and way forward to study and conserve waterbirds in the Ganga River Basin.

1.4. Methodological Framework

The literature review adhered to the established protocol of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Page et al., 2021) within the 11 states of Ganga River Basin. The search process involved systematically scanning the databases for articles, research papers, reports, and other relevant documents that addressed the aquatic avifauna of the specific state, particularly within the context of the Ganga River Basin and its tributaries between years 1800s and 2023. The inclusion criteria for selecting literature encompassed relevance to the study area, focus on avian biodiversity. Upon identifying potential sources, each document underwent a thorough screening process to decipher its suitability for inclusion in the review. This involved evaluating the title, abstract, and keywords to determine alignment with the study's scope. The selected literature was then critically analyzed to extract key findings, insights, and presence of species related to avian biodiversity in the state/basin, with a particular emphasis on the Ganga Basin and its tributaries. Given the variation in waterbird categorization across the literature, standard references such as Kumar et al. (2003) and Gopi et al. (2014) from "Waterbirds of India" were consulted for preparation of waterbird checklist. Different peer-reviewed studies were consulted which either focused on checklist or provided checklist along with their main objectives. Journal Citation Report (JCR) based Science Citation Index (SCI) values were checked for journals and H-Index values were used for the quality evaluation of different journals. To provide conservation and management recommendations, review based identified conservation threats were aligned with the international and national level conservation measures including treaties, conventions, acts, laws and policies.



STATE-WISE SYNTHESIS OF WATERBIRDS 2

Information and results for 11 Ganga basin states are presented, based on the biogeographic zones of the basin, starting from the Himalaya (Uttarakhand and Himachal Pradesh), the Gangetic Plains (Uttar Pradesh and Bihar), the Semi-Arid (Delhi, Haryana, and Rajasthan), Deccan Plateau (Madhya Pradesh, Chhattisgarh, and Jharkhand) and eventually the Coasts (West Bengal).

Uttarakhand

Uttarakhand is the 27th state of India and was carved out from Uttar Pradesh in 2000. This Himalayan state has the headwaters of two major rivers of India, the Ganga and the Yamuna. Some of the major tributaries of the mainstem Ganga River originate within the state. Geographically, mostly state is part of the Himalaya Biogeographic Zone. Eighty-one peer-reviewed studies on water and water-associated bird species were carried out between 1861 and 2023 in Uttarakhand. Of these, 33 studies were selected to prepare the waterbird checklist. A considerable number of peer-reviewed studies were published in SCI and SCOPUS indexed journals followed by NAAS and UGC-Care listed journals. A significant increase in the number of publications was noticed from 1991 to 2023. Altogether, 137 species of waterbirds and water-associated species belonging to 12 orders and 28 families were recorded from Uttarakhand. Charadriiformes (39 species) was the most dominant order followed by Anseriformes (24 species) and Passeriformes (18 species). Anatidae (24 species) was the most dominant family, followed by Scolopacidae (13 species) and Ardeidae (12 species). Of recorded species, 20 were listed as threatened or near threatened species on the IUCN Red List (One species-Critically Endangered (CR), four species-Endangered (EN), five species-Vulnerable (VU), 10 species-Near Threatened (NT)). The pink-headed duck, a previously recorded Critically Endangered (CR) waterbird, now considered extinct from India, was reported from the hunting records of the colonial era for the state of Uttarakhand. Recent studies reported a few uncommon species like bean goose and white-tailed lapwing. Most of the studies were focused on the status and diversity of waterbirds in different regions and PAs (Bhagirathi River Basin, Asan Conservation Reserve). Human induced disturbances such as pollution, encroachment, forest fire and poaching were some key threats identified through the review. Implementing state action plan to conserve avi-fauna could ensure the long-term survival of critical species and their habitats.

Himachal Pradesh

A very small proportion (~8%) of the Ganga River Basin falls within the boundaries of Himachal Pradesh with geographical elements from the Himalaya to the Shiwalik

foothills. The basin is drained by some of the major hill tributaries of the Yamuna River, like Tons, Giri Ganga and Pabbar. Only eight studies were published on the waterbirds of the Ganga River Basin in Himachal Pradesh from the 1800s to 2023. Most of these studies focused on the status or diversity of birds, was prepared on the basis of four studies. Apart from most of the published studies, only Ibis journal was listed in SCI with a JCR Impact factor of 2.1, and other journals were either indexed in NAAS or SCOPUS. The systematic review identified 65 water and water-associated species in the Ganga River Basin of Himachal Pradesh, belonging to 11 orders and 19 families. Passeriformes (15 species) and Anseriformes (11 species) were the most dominant orders, and Anatidae (11 species) and Ardeidae (nine species) were the most dominant families. Out of 65 recorded species, three species, including steppe eagle (EN) and common pochard (VU), were listed as threatened on the IUCN Red List. Most studies used line/trail transect and point count to monitor birds. In Himachal Pradesh, studies were skewed towards the Beas sub-basin (Pong Dam). In toto, Himachal's Ganga River Basin requires more studies on the waterbird species. RAMSAR sites like Renukaji, and tributaries like Tons and Giri Ganga warrant scientifically robust studies on their aquatic birds, especially covering ecological aspects.

Uttar Pradesh

It is India's fourth largest state and most populous state with a high human density (829 persons/ sq. km). The state lies within the tropical zone of the central Asian flyway, resulting in many waterbirds migrating from northern temperate countries and taking refuge in the state's wetlands during the winter. Therefore, these wetlands are important conservation sites, as they support an extensive food chain and rich biodiversity. The state falls within the Gangetic plains and Semi-arid Biogeographic Zones. Of the 424 available studies between 1872 and 2023, 135 were selected for the final review. Most studies were published in SCI/SCOPUS or nationally indexed journals. Of these, 31 included a checklist of waterbirds. Altogether, 179 species belonging to 14 orders and 29 families have been reported from Uttar Pradesh. Charadriiformes (59 species) and Anseriformes (32 species) were the most dominant orders, and Anatidae (32 species) and Scolopacidae (20 species) were the most dominant families. Of the 179 species, 35 are globally threatened, including three CR, four EN, 10 VU, and 18 NT. One previously recorded species, viz. pink-headed duck, is now extinct from the state and the country. Line transect, point count, trail transect, road transect and citizen science methods were used in the reviewed studies. Unregulated fishing, poaching of waterbirds, heavy use of pesticides, riverbank agriculture, livestock grazing, water extraction for different purposes, and damming of the river are severe threats to conservation. Most of the studies on waterbirds were from PAs, but since, the waterbirds are distributed even outside the PA boundaries, there is a need to collect and collate information from their, which include the wetlands, rivers, and agricultural areas.

Bihar

Bihar state's rich history intertwines with ancient Indian civilization. Significant cultural and political changes have marked Bihar's landscape, including the influence of the powerful dynasties of the Mauryas and Guptas. Geographically, Bihar's climate and terrain are shaped by the Himalayas and the rivers originating from there, including the Ganga, Gandak and Kosi rivers. The state's biodiversity is noteworthy, with various habitats supporting a diverse range of flora and fauna, from terrestrial mammals to aquatic species. Demographically, Bihar is one of India's most populous states, with a high population density (1106 persons/ sq. km). The entire state falls under the Ganga River Basin and Gangetic Plains Biogeographic Zone. Studies from 1891 to 2023 focused on various aspects, including waterbirds' status, diversity, nesting behavior, and threats to their conservation. From the literature review, 80 studies were used for synthesis, of which 28 were included in the checklist. Most reviewed studies were indexed NAAS rating journals, and some were in SCI/SCOPUS indexed journals. A total of 164 water and water-associated bird species belonging to 14 orders and 29 families were reported from the state. Charadriiformes (54 species) and Anseriformes (30 species) were the most dominant orders, and Anatidae (30 species) and Scolopacidae (24 species) were the most dominant families. Thirty-one species were listed as Threatened or Near-Threatened (three species-CR, four species-EN, eight species-VU, 16 species-NT) on the IUCN Red List. Sushkin's Goose (*Anser neglectus*) is an extinct species that was reported once from Bihar. Despite the wealth of information available, limitations such as the lack of systematic studies and duplication exist. Moving forward, there is a need for more comprehensive research, especially in understanding and mitigating threats to waterbird populations and their habitats.

Haryana

Haryana is one of the small northern states of India, which falls within the Semi-arid Biogeographic Zone. The state has numerous natural and artificial wetlands, which provide refuge to several waterbird species including winter migrants from the Central Asian countries. A major proportion (~77%) of the state area falls under the Ganga River Basin. Of 214 documents downloaded from different sources, 15% were selected for review, covering topics like status, diversity, composition, and behavior from 1876 to 2023. To date, 35 peer-reviewed studies have been conducted in the wetlands of Haryana, of which 25 studies were included in checklist preparation. A fair proportion of the reviewed studies were published in SCI/SCOPUS indexed journals. A total of 116 waterbird species from 25 families and 11 orders were recorded from different wetlands of Haryana including 13 threatened or near threatened species (two EN species, five VU species, six NT species) on the IUCN Red List. Charadriiformes (33 species) and Anseriformes (22 species) were the most dominant orders, and Anatidae (22 species) and Scolopacidae (14 species) were the most dominant families. Most published studies were from the

rural and urban wetlands of the Gurugram and Kurukshetra districts. The major emphasis of these studies was on the diversity and composition of waterbirds, followed by a few behavioral studies. Point count and line transect were two key field methods used for the assessment of waterbirds however, most of the studies lagged abundance/ density estimations, and seasonal information was also absent in most of the publications. More collaborative, scientifically robust studies are required to enhance the studies' quality and reliability. Long-term monitoring and micro-level studies are recommended to cope with site-specific threats and management challenges. Focusing on the socio-ecological; RET species and ecosystem service aspects will contribute more to the long-term conservation of Haryana's waterbirds and wetlands.

Delhi

Delhi, the National Capital Territory, is India's city and a Union Territory (UT). This UT comprises New Delhi, India's capital, and one of its largest metropolises. Delhi, with a geographical area of 1,483 sq. km and 11,320 persons/ sq. km, is part of the Ganga River Basin. Delhi falls under two Biogeographic Zones namely Semi-arid and Gangetic plains, and is a representative urban conglomeration with mosaic of green spaces, which are part of the green urban spaces and PA network. The green spaces in Delhi offer a mosaic of habitats, which harbors high biodiversity with more than 400 bird species. Of the 132 available studies on waterbirds, 40 peer-reviewed studies were selected in the final review between 1926 and 2023. Of these, 10 were checklists of waterbirds. Altogether, 178 water and water-associated bird species belonging to 13 orders and 28 families were reported from Delhi. Charadriiformes (66 species) and Anseriformes (27 species) were the most dominant orders, and Anatidae (27 species) and Scolopacidae (25 species) were the most dominant families. A total of 34 species are globally threatened, as per the latest IUCN Red List category. Of these, two are CR, four are EN, 10 are VU, and 18 are NT. Line transect, point count, total count, opportunistic observation, and trapping methods were used in these reviewed studies. Historically, Delhi had several ponds and lakes, but many have now been filled, encroached upon, or polluted over the years. Due to rapid urbanization, pollution and encroachment of the waterbodies of Delhi are decreasing in numbers. Loss of waterbodies directly or indirectly reduces the waterbird's diversity and limits them in the National Capital Region. The survival of waterbird species depends upon the conservation and reviving of Delhi's waterbodies, natural forest and artificial ponds.

Rajasthan

Rajasthan, India's largest state, is in the northwest and shares an international border with Pakistan. About 33% area of this state falls under the Ganga River Basin. Rajasthan's biogeography, flora, and fauna are diverse and intriguing, which falls within the Desert and the Semi-arid Biogeographic Zones. Rajasthan, with only 10.4% of India's area, hosts 42% of the country's bird species, including 40% of the country's wetland bird species. Of the 228 studies, 68 peer-reviewed studies were selected for the final review published between 1873 and 2023. Of these, 27 were used in the preparation for the waterbird checklist. Almost half of the studies were indexed in SCI/SCOPUS/UGC-Care/NAAS. Altogether, 157 water and water-associated bird species belonging to 13 orders and 28 families have been reported from the Ganga Basin of Rajasthan. Charadriiformes (59 species) and Pelecaniformes (20 species) were the most dominant orders, and Scolopacidae (24 species) and Anatidae (19 species) were the most dominant families. Of the 157 species, 32 species are globally threatened, as listed in the latest IUCN category. Of these, two species are CR, four are EN, eight are VU, and 18 are NT. The review studies utilized line transect, point count, total count, and boat survey to assess waterbirds' status, while bird ringing, satellite telemetry, and focal and scan sampling methods were used to study the behavior of waterbirds. Most of the studies cited in this review report did their study on the checklist preparation, and some did not adequately define their method. Very few studies are on the behavior and migration of the waterbird species in the Ganga Basin of Rajasthan. Robust methods and long-term studies are required, and a considerable amount of work on the waterbird species needs to be streamlined in policy-making with the involvement of government stakeholders, the local community, and farmers.

Madhya Pradesh

Reminiscence of archaeological and historical epoch portrays Madhya Pradesh as one of India's ancient refuges for human and other species. Natural history records for the state could be traced to the princely states and colonial provinces. Madhya Pradesh is the second largest state in India, with a total population of 72,626,809. With 21% area of Madhya Pradesh in the Ganga River Basin, the state's rivers contribute significantly to the water volume of the mainstem Ganga River. Chambal, Ken, Betwa, Sind, and Son are some of the key tributaries in the Ganga River Basin flowing through Madhya Pradesh. Out of the 615 publications related to the avifaunal literature search from Madhya Pradesh, only 44 peer-reviewed studies were included for the final review from 1931 to 2023. An increasing trend in the published peer-reviewed studies was found between 2001 and 2020. Around 39% of publications were indexed in SCOPUS or SCI journals with an impact factor of 1 - 2.7, and 16% were listed in NAAS rating journals. The detailed review of 23 studied checklists revealed the presence of 143 waterbird species from 27 families and 13 orders within the different palustrine, lacustrine and riverine wetlands of the Ganga River Basin in Madhya Pradesh. Charadriiformes (48 species) and Anseriformes (23 species) were the most dominant orders, and Anatidae (23 species) and Scolopacidae (17 species) were the most dominant families. Of these, 24 species were found to be of global importance, including threatened or near-threatened species listed (one CR species, three EN species, seven VU species, 13 NT species) on the IUCN Red List. Most published studies conducted in the rural and urban wetlands, were from Shivpuri and Sheopur districts. The major emphasis of these studies was on the diversity

and composition of waterbirds, followed by a few behavioral studies. Point count and line transect were key field methods used to assess waterbirds. However, most studies lagged abundance/ density estimates and seasonal variability. Colonial era literature reported migration related studies of waterbirds in the Ganga River Basin of Madhya Pradesh. More collaborative, scientifically sound research is needed to improve the quality and reliability of the studies. Long-term monitoring and micro-level research are also advised in order to address site-specific management issues.

Chhattisgarh

Chhattisgarh, the 26th constituted state of India, was part of Madhya Pradesh until 2000. It harbors some of the finest central Indian forests and rare mineral elements, which fall within Deccan peninsula Biogeographic Zone. Being a land of Gond and Baiga tribes, its cultural integrity is the hallmark of its traditional lifestyle. Only 5.85% area of the Ganga River Basin (17,907.60 sq. km) falls within the boundaries of Chhattisgarh state. Son, a south-bank tributary of the Ganga River originates in this state. The Rihand, Banas, Kanhar and Gopad are key tributaries of the Son River. A total of 281 peer-reviewed studies were found through different web searches. However, only six studies were found relevant to the Ganga River Basin of Chhattisgarh, which covers five northern region districts and were published between 1958 and 2023. Further, only three studies were used to prepare the waterbird checklist for the basin. The studies were published either in SCOPUS or UGC-Care listed journals or non-indexed journals. About 116 water and water-associated bird species belonging to 25 families and 12 orders were recorded from the Ganga River Basin of Chhattisgarh. In taxonomic orders, Charadriiformes (38 species) was the most dominant, followed by Anseriformes and Pelecaniformes (17 species). Anatidae and Scolopacidae were the most dominant families (17 species), followed by Ardeidae (13 species). Of these recorded species, 15 were listed two EN species, four VU species, and nine NT species on the IUCN Red List. Published studies did not use any systematic method to assess the status and diversity of waterbirds. Mainly, poaching, mining and aquatic invasive species were identified as major threats to the aquatic habitats and avi-faunal species. Although it is well understood that Chhattisgarh is comparatively a new state and needs more heed on scientific research on the waterbird studies. The present review accentuates the lack of ornithological research in the Ganga River Basin of the state. Most of the previously published studies were conducted in central or southern Chhattisgarh.

Jharkhand

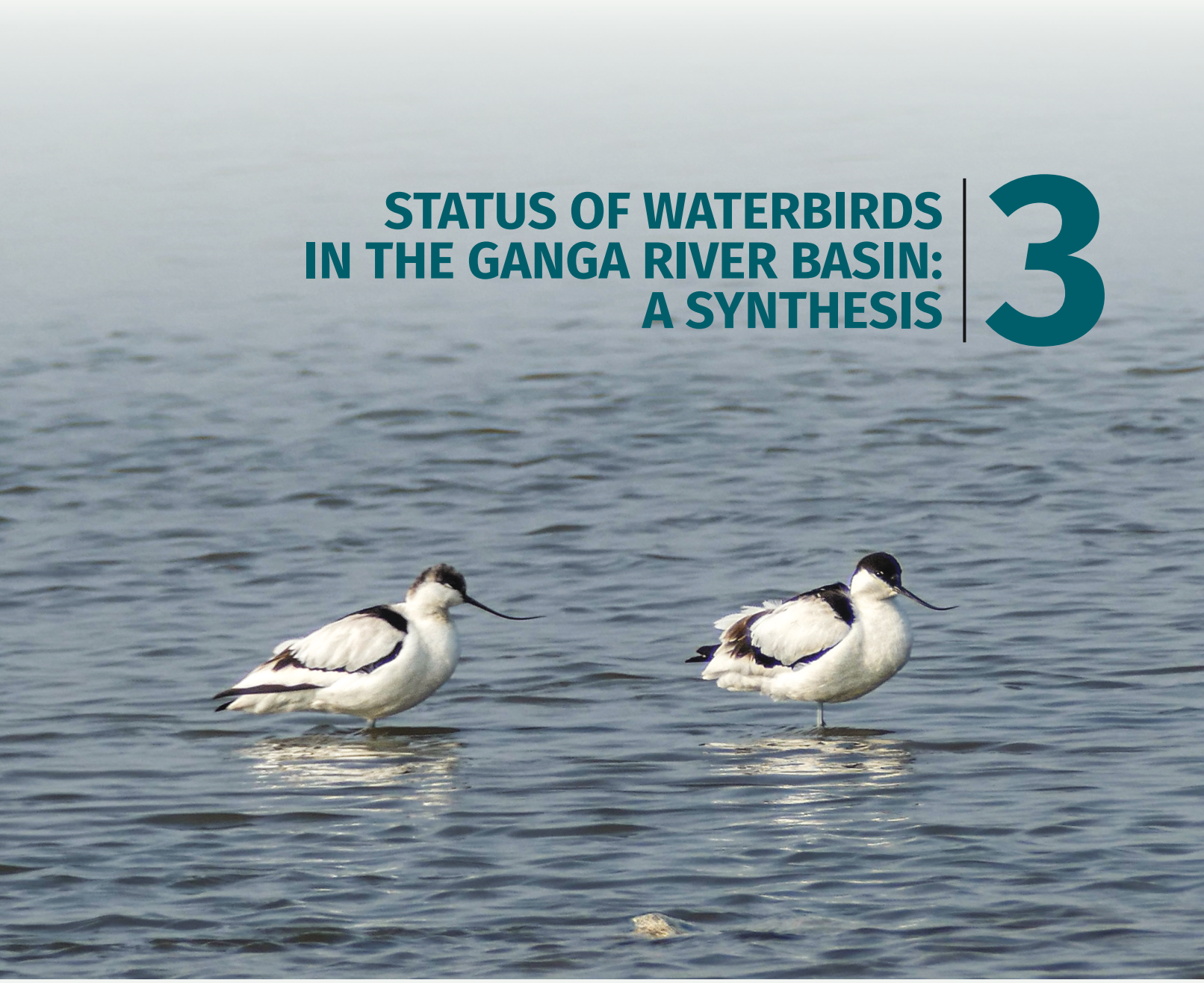
Geographically, Jharkhand is situated in eastern India, featuring a landscape mostly of the Chhotanagpur plateau and the lower Gangetic plains, with an altitudinal range from 6 to 1366 m above msl. It has diverse soil types, including red, laterite, black, red micaceous, and sandy soils. The climate is tropical monsoon, with distinct summer, monsoon, and winter seasons. Land use is dominated by agricultural land and deciduous forests. Jharkhand's Biogeographic Zones include the Deccan peninsula and Gangetic plains, with significant forest cover and various flora and fauna. A total 48 studies were identified and these were published between 1875 and 2023. The review recorded 93 waterbird species belonging to 10 orders and 20 families in the Ganga River basin of Jharkhand, with Charadriiformes (27 species) being the most dominant order and Anatidae (16 species) the dominant family. Among 11 globally threatened species, two were EN, two VU, and seven NT on the IUCN Red List. Only six studies were indexed in NAAS listed journals, indicating a need for more rigorous research. Most studies used direct observation and nest counts, with some employing point counts and transects. Despite the presence of numerous wetlands, systematic scientific studies on waterbirds are limited. Conservation threats include habitat disturbances, hunting, and poaching. Increased focus on ecological studies, particularly in critical habitats like the Udhwa Lake Bird Sanctuary, is necessary for better conservation of waterbirds.

West Bengal

The state of West Bengal, situated in the eastern part of India, shares its borders internationally with Nepal, Bhutan, and Bangladesh. Covering an area of 88,752 sq. km, it is relatively small in size but densely populated, ranking among India's largest states by population. It houses India's second-largest metropolitan area. The entire state is part of the Ganga River Basin with Biogeographic Zones of the Himalaya, the Gangetic plains and the Coast. A thorough exploration of several essential primary search databases for the past 157 years (1866-2023) was undertaken. Of the 177 studies, 59 were selected in the final review and 39 research studies were used in water and water-associated bird checklist preparation. A total of 162 species belonging to 24 families and 11 orders have been reported from West Bengal. Charadriiformes (63 species) and Anseriformes (28 species) were the most dominant orders, and Scolopacidae (30 species) and Anatidae (28 species) were the most dominant families. Thirty-two species are globally threatened, of which three are CR, four are EN, six are VU and 19 species are NT. One species, the pink-headed duck reported earlier from the state is now extinct from the state and also from the country. The reviewed studies deployed a range of methods, which included point count, line transect, boat surveys and total count. Many studies lack thorough methodological descriptions, while some omit bird checklists. Bird migration and foraging studies, particularly within IBAs are insufficient. The transformation of land or islands for agricultural activities, indiscriminate use of pesticides, establishment of ecotourism spots and infrastructure along rivers or wetlands, uncontrolled fishing practices, grazing of livestock, construction of dams on rivers, and hunting of birds pose significant threats to conservation efforts. The small tributaries of the Ganga River and unprotected wetlands require heightened attention and conservation efforts.

STATUS OF WATERBIRDS IN THE GANGA RIVER BASIN: A SYNTHESIS

3



3.1. Trends in Publications

A total of 573 peer-reviewed studies were published from the Ganga River Basin on different aspects of the water and water-associated bird species in 154 international and national journals. Out of these, 234 studies were selected for the preparation of state-wise checklist of waterbirds (Figure 3.1). An increasing trend was found in the published studies from the mid-19th century till date (Figure 3.2). A total of 70 studies were carried out between 2001-2010, and 51 studies between 1991-2000. The review underlines the era of aquatic ornithological research that can be traced back to 1857-60 from the Kumaon region of Uttarakhand (erstwhile part of United Province), which was on the natural history observations in Nainital, Almora and Pithoragarh districts (Irby, 1861). A subsequent study was published on the avian records from different districts of West Bengal during 1866 (Beavan, 1868).

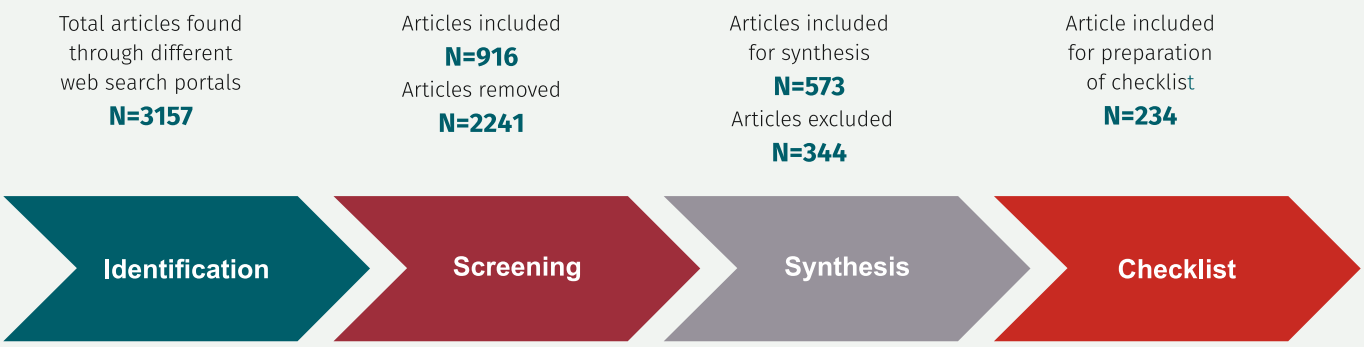


Figure 3.1. Review Process following PRISMA for the Ganga River Basin

The colonial era studies mostly focused on natural history observations and hunting records, and these were predominant in states like Uttarakhand, Uttar Pradesh and Madhya Pradesh. Most of the study sites were either under the direct control of the British Empire or princely states, where British explorers/ ornithologists recorded early accounts of the Indian ornithology. The Post-Independence era studies' shifted their focus from natural history to the ecological aspects covering a variety of topics like population status, distribution, and behavioral aspects, especially foraging, breeding biology and related subjects. Most of the studies were carried out on the status/diversity of waterbirds (58%), followed by natural history related observations and hunting records (23%) and breeding behavioral aspects (10%) (Figure 3.3).

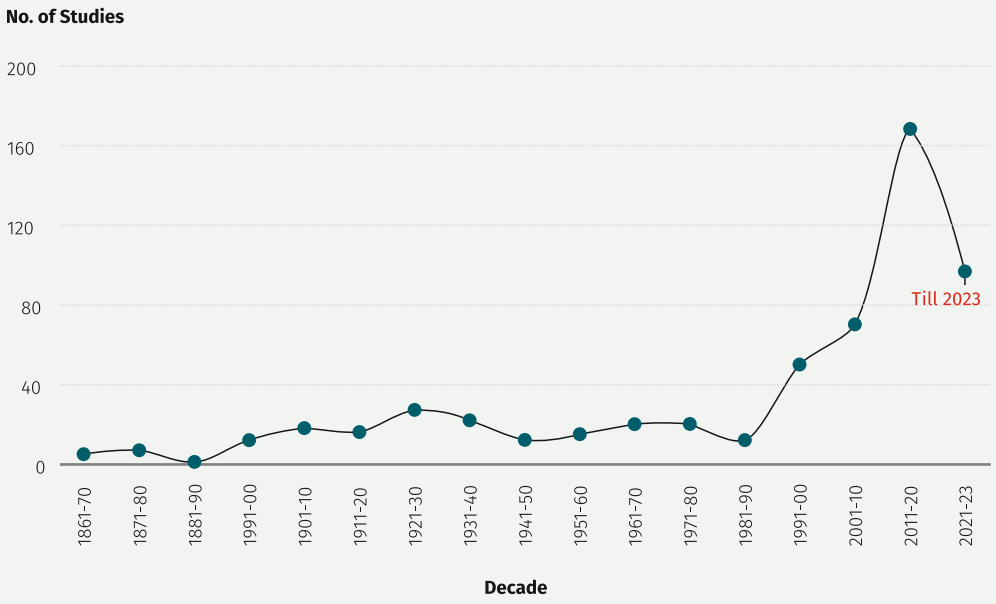


Figure 3.2. Decadal trend of published studies between 1861 and 2023 in the Ganga River Basin (n=573)

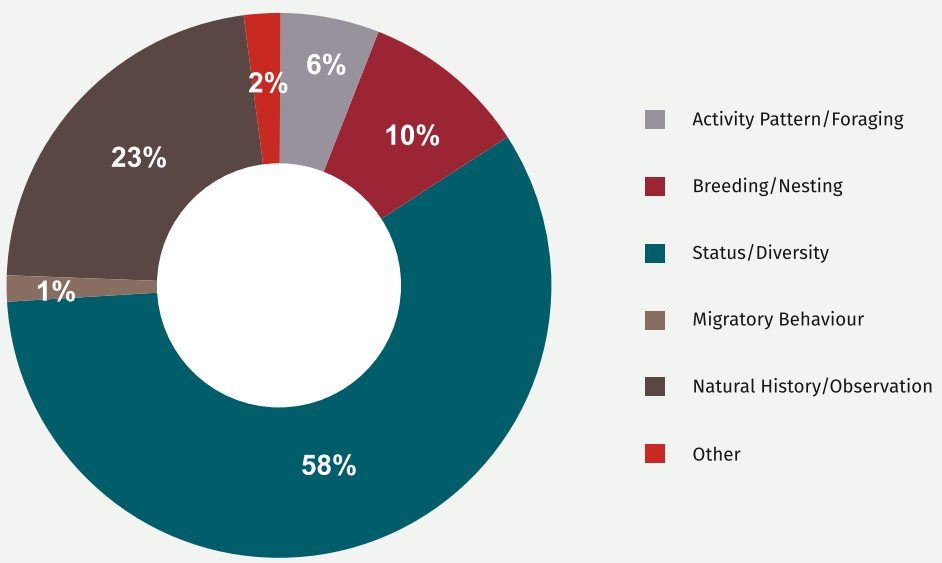


Figure 3.3. Type of peer-reviewed studies conducted in the Ganga River Basin (n=573)

Maximum studies were published from the state of Uttar Pradesh (n=135, 23%), followed by Uttarakhand (81, 14%) and Bihar (80, 14%). In terms of published comprehensive checklists, the highest was from West Bengal (39, 16.66%), followed by Uttarakhand (32; 13.67%), and Uttar Pradesh (31, 13.24%). In contrast, < 10 studies were published from Himachal Pradesh and Chhattisgarh (Figure 3.4).

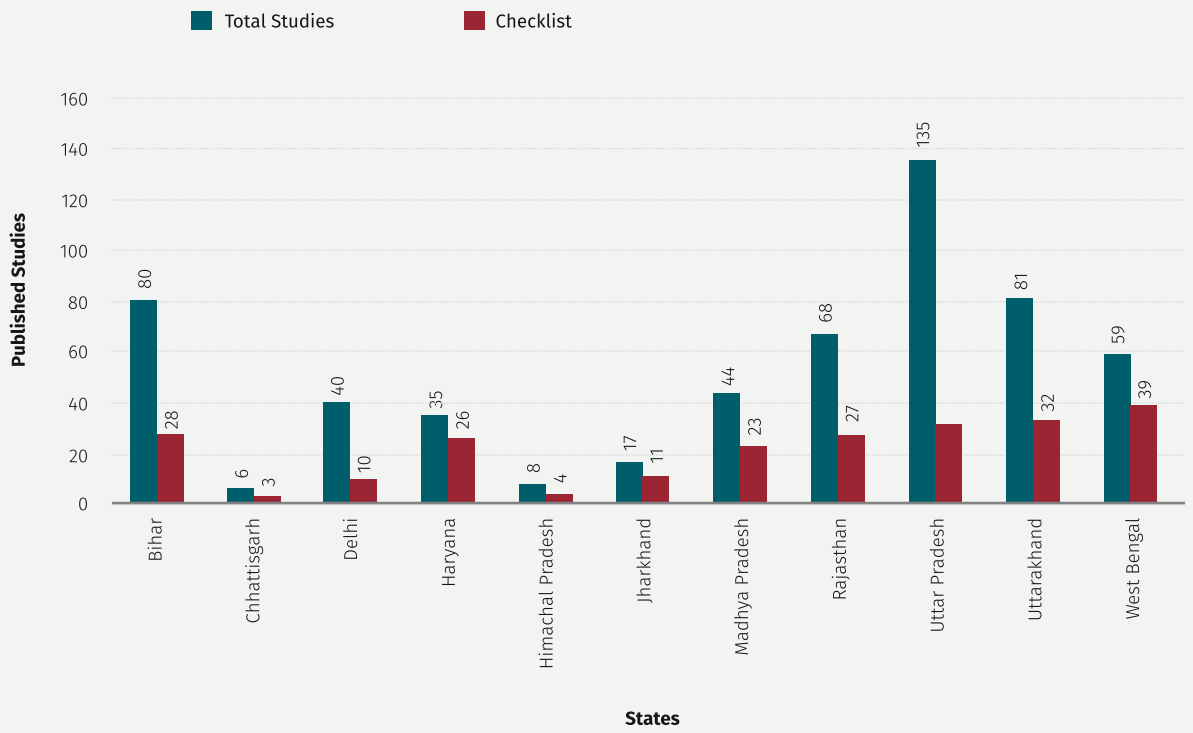


Figure 3.4. Comparative diagram of published studies on the waterbirds in the Ganga River Basin states of India

Among the Ganga River Basin districts of 11 states, more than 10 studies were carried out in the three districts each of Uttar Pradesh (Kheri, Etawah and Gautam Budh Nagar), and Rajasthan (Udaipur, Jaipur and Bharatpur), followed by two districts each of Uttarakhand (Nainital and Dehradun), Delhi (South and South West Delhi) and Bihar (Darbhanga and Bhagalpur), and one district each of West Bengal (Bardhman) and Haryana (Gurugram) (Figure 3.5). While, 41% (n= 110) of the Ganga River Basin districts were not covered in the published studies till 2023.



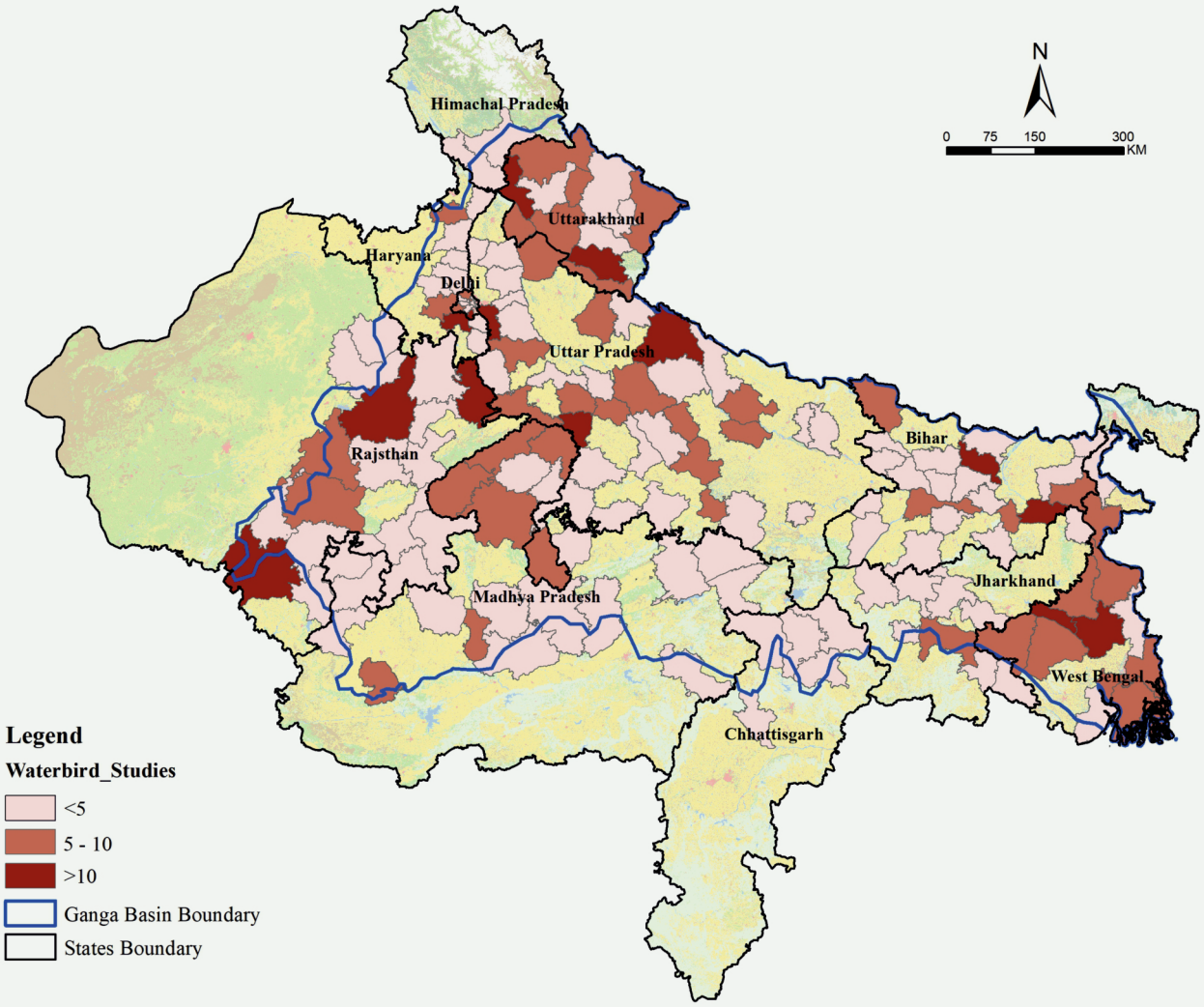


Figure 3.5. Distribution of published studies on the waterbirds in the different districts of the Ganga River Basin states of India



3.1.1. Quality assessment of journals

About 25% of studies were published in Science Citation Index (SCI) or SCOPUS indexed journals, while 37% were in UGC-Care/NAAS rating list journals and the rest were not listed in any authenticated index or were published in predatory journals. Most of the studies (86%) were published in journals without any Journal Citation Rate (JCR) impact factor (IF). Among JCR impact journals, 85% were in low IF (IF= < 3), 9% in moderate IF (IF= ³3 to < 5), and 6% in high IF (³5) journals. For the studies that were published in SCI indexed journals with JCR IF ranged between 0.3 (Waterbirds, published by The Waterbird Society) and 9.8 (Science of the Total Environment). H-index value of journals varied between 1 and 353. The study published in Science of the Total Environment assessed organochlorine contaminants and avifauna of the Mahala water reservoir in the Ganga River Basin of Rajasthan (Misra & Bakre, 1994).

3.1.2. Scientific contribution of academic and other organizations

Altogether, 244 different institutions, universities and organizations worked on the various aspects of waterbirds in the Ganga River Basin states. Of these, 36 (15%) were international affiliations including government organizations, universities and Non-Governmental Organizations (NGOs) of 14 countries. Indian universities (26%) contributed highest on the waterbird research in basin, followed by Indian colleges (22%) and NGOs (14%) (Figure 3.6).

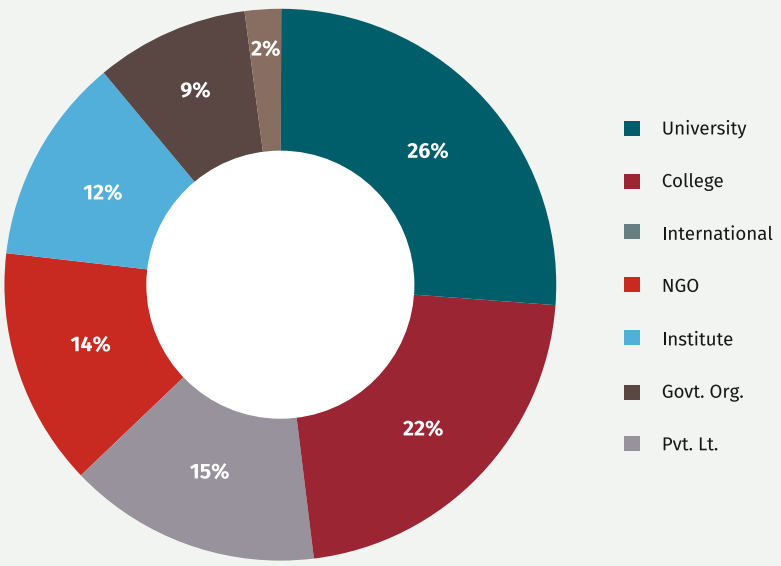


Figure 3.6. Percentage contribution of academic and other organizations towardsstudies on waterbirds in the Ganga River Basin

Among the studies related to the aquatic avifauna in the basin, a total of 6.11% of studies were published by the Wildlife Institute of India (WII), and 4.89% by the Aligarh Muslim University (AMU) in the category of Indian institutions and universities, respectively. NGOs like the Bombay Natural History Society (BNHS) contributed in 5.24% studies, followed by World Wide Fund for Nature-India (WWF) (1.22%), and Nature Conservation Foundation (NCF) (1.05%). Among universities, AMU, Kurukshetra, Lucknow, Graphic Era and Tilka Manjhi Bhagalpur University conducted most of the research in the Ganga River Basin. Central universities like Delhi University and Jawaharlal Nehru University contributed to the ornithological research in Delhi, Haryana and Uttar Pradesh. The United States Geological Survey, Mongolian Academy of Sciences, Chinese Academy of Sciences, Food and Agriculture Organization (FAO), and Environment Agency-Abu Dhabi were some of the leading international organizations that worked in collaboration with Indian academic institutions and NGOs. International Crane Foundation studied different aspects of sarus crane ecology across the wetlands of Uttar Pradesh and Haryana. Among foreign universities, Cardiff University, Yale University, Georgia University, and the University of Alabama contributed to the research.

3.2. Status of Waterbirds in the Ganga River Basin

Through the comprehensive review of the literature, a total of 236 species of water and water-associated bird species were recorded. These 236 species belong to 32 families and 14 orders in the Ganga River Basin (Appendix 2). Scolopacidae (n= 37 species, 16%), Anatidae (37 species, 16%), and Laridae (20 species, 8%) were the three most dominant families in the basin (Figure 3.7), while Charadriiformes (n=87 species, 37%), Anseriformes (37 species, 16%) and Pelecaniformes (26 species, 11%) were the three most dominant orders in the basin (Figure 3.8). Anhingidae, Cinclidae, Falconidae, Haematopodidae, Ibidorhynchidae, Pandionidae, Rostratulidae and Phasianidae families were represented by one species each.

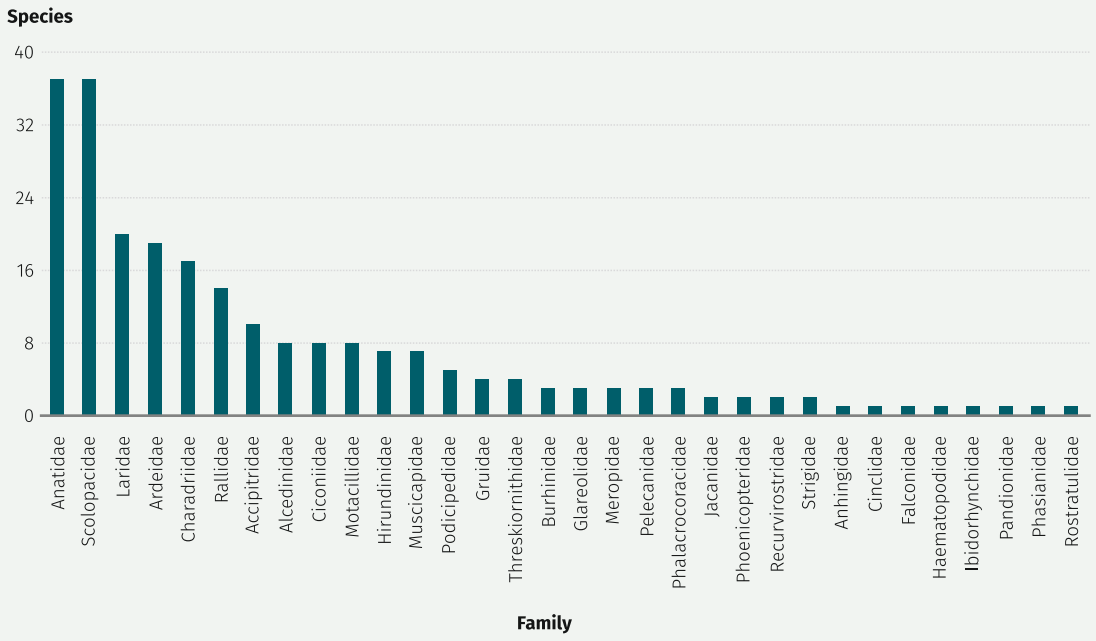


Figure 3.7. Dominance of waterbird families in the Ganga River Basin

In terms of basin states (Figure 3.9), the highest number of species were recorded from the state of Uttar Pradesh (n=179), followed by Delhi (178) and Bihar (164). While, <100 water and water-associated bird species were recorded from the state of Himachal Pradesh (65), followed by Jharkhand (93). The highest family numbers were reported from the states of Bihar and Uttar Pradesh (n=29), followed by Delhi, Rajasthan and Uttarakhand with 28 in each. Forteen orders were reported from Bihar and Uttar Pradesh, followed by Delhi, Rajasthan, and Madhya Pradesh with 13 each, and Haryana, Himachal Pradesh and West Bengal with 11 orders each. Out of 573 studies, only 25.65% were carried out in the different rivers of the Ganga River Basin and the rest were carried out in the inland wetlands like ponds, dams, marshes, swamps, reservoirs and forest streams.

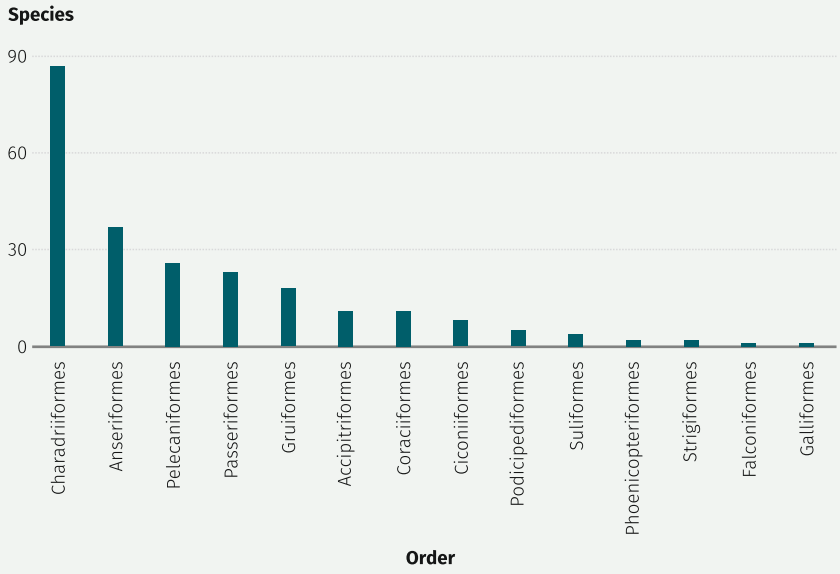


Figure 3.8. Dominance of different waterbird orders in the Ganga River Basin

3.2.1. Threatened species of the Ganga River Basin

Altogether, 52 Threatened and Near Threatened waterbird species have been reported from the 11 states of the Ganga River Basin (Appendix 1; Figure 3.10). Out of these, six species are listed as CR, six as EN, 14 as VU and 26 as NT in the IUCN Red List. The review confirmed the unusual presence of an extinct species known as Sushkin's goose from Bihar during the colonial era, which is still under the purview of taxonomic confusion (Inglis, 1940; Van Impe, 2019). Critically Endangered Baer's pochard, pink-headed duck, Siberian

crane, sociable lapwing (*Vanellus gregarious*), spoon-billed sandpiper (*Calidris pygmaea*) and white-bellied heron (*Ardea insignis*) have been reported from the different basin states of Uttarakhand, Uttar Pradesh, Bihar, Delhi, Madhya Pradesh, Rajasthan, Bihar, Chhattisgarh and West Bengal. Long term population data of Siberian cranes from Keoladeo National Park revealed a declining trend between 1960-61 and 1999-2000 (Boldyrev et al., 2023). Similarly, a record of pink-headed duck from the Ganga River Basin dates back to 1872 when its flock was reported from Khiri, Uttar Pradesh (Tweedie, 1872). Later, Buckxill (1924) reported the last sightings of pink-headed duck in Maldah district, which was earlier common in certain parts of West Bengal, now considered extinct from India.

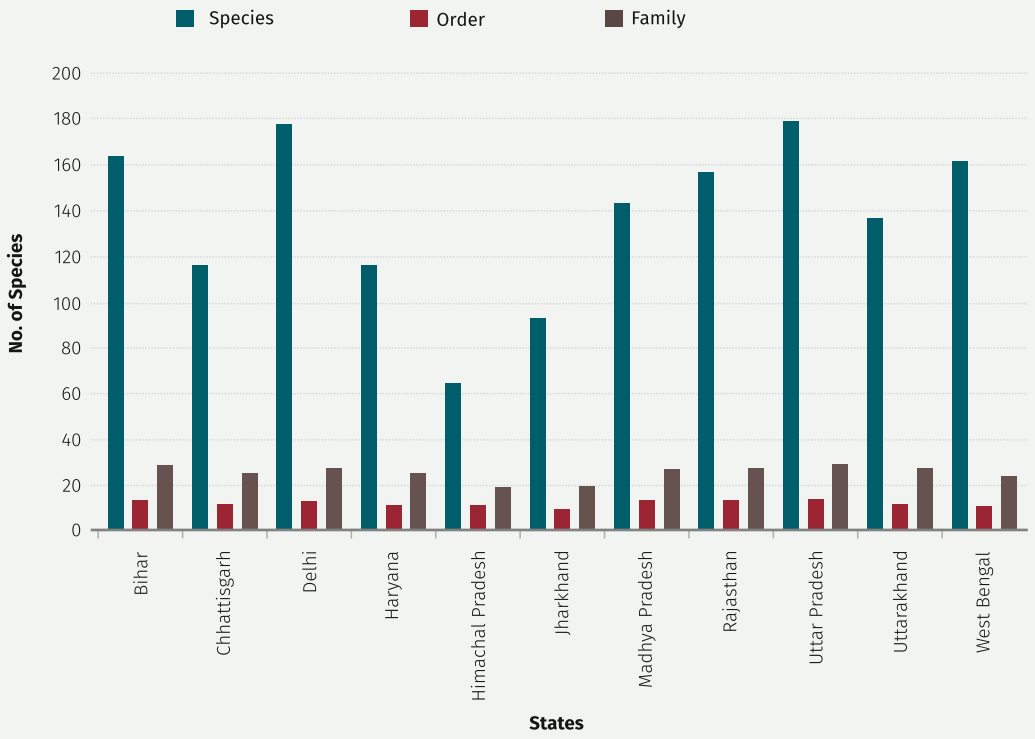


Figure 3.9. Status of waterbirds in the Ganga River Basin states

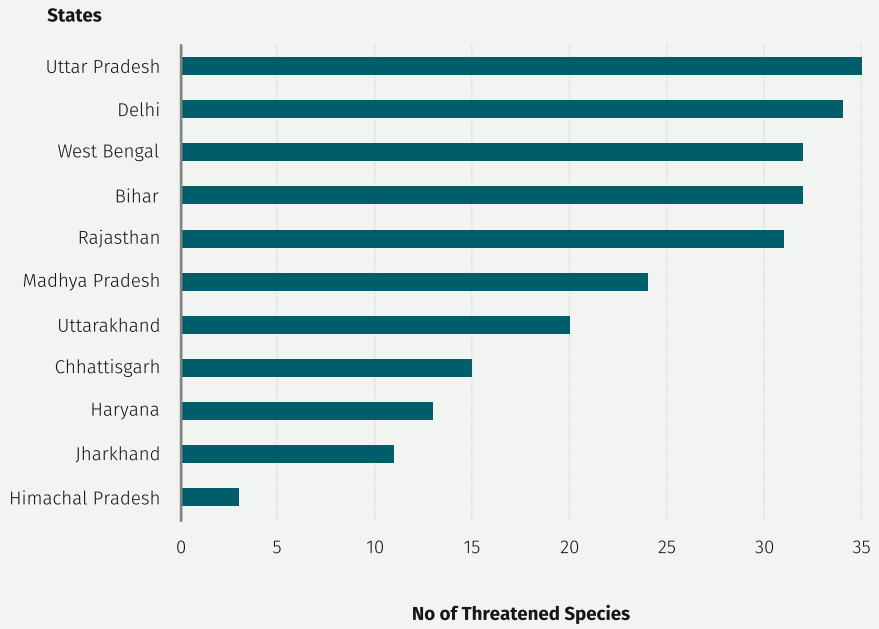


Figure 3.10. Number of Threatened and Near Threatened species in the Ganga River Basin states

3.2.2. Count and other monitoring techniques

Different types of methods were used to assess the status and diversity of waterbirds in the Ganga River Basin, 14% of the studies used line transect and 16% used point count. Some of these studies used a combination of line and point transects (6%) to estimate the waterbird population. However, most of these studies did not use distance sampling to estimate the abundance of waterbirds, rather provided categorical changes in abundance like common, very common, and abundant. Only one study provided distance sampling-based density estimates of waterbirds (Aggarwal et al., 2015). While a couple of studies provided density estimates without incorporating detection probability (Sundar et al., 2015; Mishra et al., 2023) and some of the studies were restricted to species encounter rates and abundance estimates (Ganguli, 1961; Tyabji, 1961; Ouweneel, 1984; Lodhi & Rao, 2017; Bhattacharjee & Adhikari, 2022). In addition, belt transects were used by a few studies (< 1%) (Joshi et al., 2021; Joshi & Kumar, 2022). Some of the published studies used boat (~4%) (Zockler et al., 2005; Chakrabarti, 2011; Bashir et al., 2012) and vehicle (< 1%) transects to assess the status of waterbirds (Kittur & Sundar, 2021; Arya et al., 2021). Some studies relied on total counts (5%) with different combinations like trail transect, shoreline walk, and total visual count (Rahmani, 1988; Kumar & Choudhary, 2010; Tak et al., 2010; Sundar et al., 2015). Records of rare and unusual species were mostly through opportunistic sightings or hunting/capture records that mostly belonged to the colonial era when naturalists relied on invasive techniques like hunting, capturing, and collection.

3.2.3. Behavioral studies

Behavioral studies were mostly done using focal and scan sampling methods to study the activity and breeding behavior of waterbirds in the Ganga River Basin. Waterbird migration has intrigued ornithologists since the 19th Century and it was first studied using ringing, and in the post-independent era, satellite transmitters were used for studying bird migration (Javed et al., 2000; Takekawa et al., 2009; Kalra et al., 2011; reviewed in Mahar et al., 2014). Till 2023, a total of 101 studies have been carried out on the different behavioral aspects of waterbirds in the Ganga River Basin. Of these, 14% studies focused on activity patterns, 58% on breeding/nesting, 19% on foraging behavior, 1% on defense mechanism and nine on migration (Figure 3.11). Their winter, fall and spring migration routes were tracked between Central Asian countries and the Indian sub-continent. The earliest migration study using a tarsus aluminium ring can be traced back to 1910 from Madhya Pradesh, where a few individuals of Eurasian coot were fitted with the rings with unique number on them and a same individual was reported later from USSR (Editors, 1936). A migration study on Indian skimmer has been attempted in Chambal WLS using rings (Shaikh et al., 2021). Capturing and tagging of wetland related birds are restricted to a few areas like Sur Sarovar National Park and Keoladeo National Park. Javed et al. (2000) carried out first telemetry study on bar-headed goose in the Indian sub-continent and tracked spring migration till Tibetan wetlands from Bharatpur (Rajasthan). Later, interesting findings were recorded in the published studies, such as the revelation of leap-frog migration pattern in bar-headed goose, which was earlier reported in passerines (Takekawa et al., 2009). Kalra et al. (2011) studied the migration of bar-headed goose in Sur Sarovar, where four individuals migrated towards China during the summer season [Average Distance = 998.50 km ± 220.17 (SD)] similar to the previous study (average distance = 800 km) by Takekawa et al. (2009), however, Keoladeo individuals migrated towards Nepal.

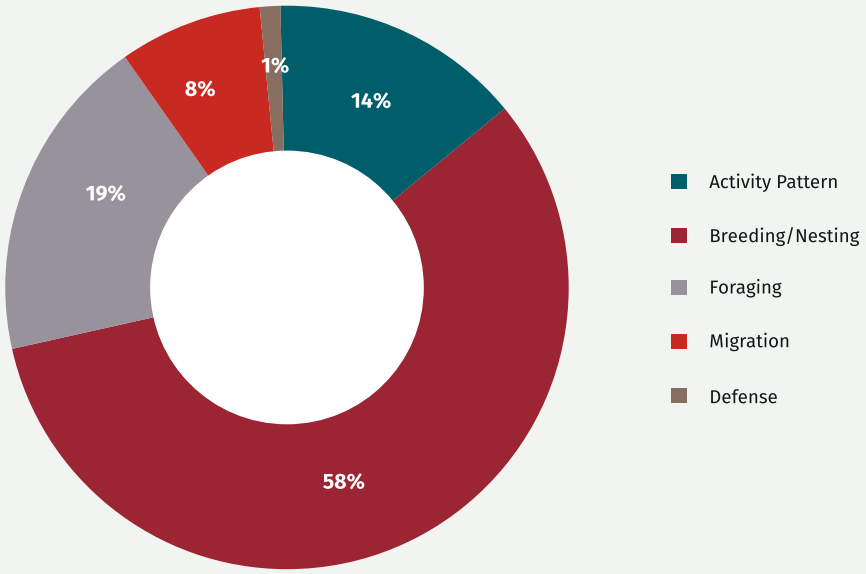


Figure 3.11. Categories of behavioral studies conducted in the Ganga River Basin (n=101)

Activity pattern and foraging behavior of waterbirds were investigated in the states of Haryana (Kumar & Rana, 2021), West Bengal (Mukherjee et al., 2020), Delhi (Sen, 1944; Urfi,1988, 1993; Mahendiran & Urfi, 2010), Uttar Pradesh (Law, 1930; Rahmani, 1991; Maheswaran, 1996; Gopi Sundar, 2004, 2005; Roy et al., 2022) and Rajasthan (Abdulali, 1947; Bates,1948). To check the dietary spectrum of little cormorants, cattle egrets and Indian pond herons, fecal samples were collected and their laboratory analysis was carried out where unusual occurrences of color rubber bands were found (Francis et al., 2020). Events of klepto-parasitism were observed among three sympatric cormorant species (Mahendiran & Urfi, 2010), and commensalism between northern pintail and little grebe (Rahmani, 1991). Organo-chlorine compounds were also investigated using post-mortem reports of waterbirds (Misra & Bakre, 1994). Sen (1944) recorded an unusual feeding behavior of a white-throated kingfisher on a small terrestrial bird (most likely an oriental white eye). A substantial amount of literature remains grey as unpublished records, which need to be explored.

3.3. Conservation Threats

Out of 573 reviewed studies, 32% mentioned threats related to waterbirds or their habitats in the Ganga River Basin. Most of the studies only highlighted threats related to their study sites or species. While most of the studies were qualitative or merely mentioned threats in the studies, a few (1%) studies quantified factors affecting waterbirds or their habitats. A comprehensive diagram of different threats has been given in Figure 3.12. Out of 23 identified categories of threats, poaching/hunting was found to be a prime threat (15.54%) to waterbirds. Besides, pollution (9.22%), cattle grazing & agriculture expansion (7.26%), and water level fluctuation (5.87%) were also highlighted as threats affecting waterbirds and their habitats in the basin.

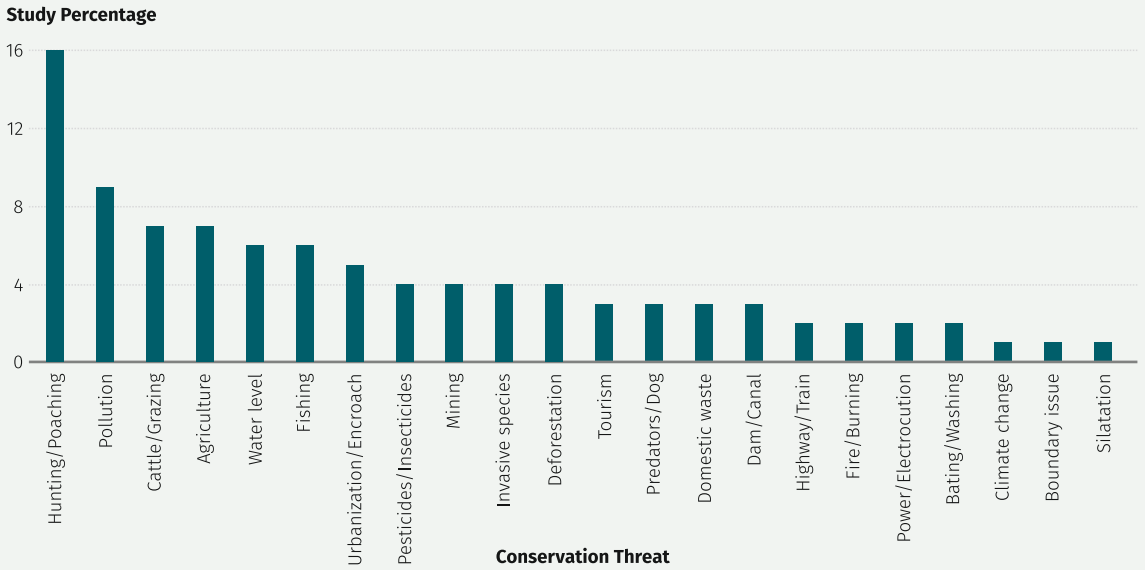


Figure 3.12. Threats mentioned to waterbirds and their habitats in the literature reviewed for the Ganga River Basin (n=183)

Apart from Himachal Pradesh, 23 conservation threats were mentioned in the published studies of all other basin states (Figure 3.13). Hunting/Poaching was found prevalent in the studies from the states of Uttar Pradesh, Bihar, Madhya Pradesh, Uttarakhand, Jharkhand, and West Bengal. Pollution related threats were predominant in the nine states of the basin, including Uttar Pradesh, West Bengal, and Haryana. Grazing and the problem of feral cattle was mostly mentioned in the published studies from Rajasthan, Bihar, Uttarakhand and West Bengal. The agricultural expansion was perceived as a threat to waterbird conservation in the states of Uttar Pradesh, Madhya Pradesh, Bihar and West Bengal. The boundary related issues of the wetland were highlighted only in the state of Jharkhand, while bathing and washing were found prevalent in the published studies from West Bengal and Haryana. The presence of dams/canals/barrages was highlighted in the states of Madhya Pradesh, Jharkhand, and Uttarakhand. Studies from Madhya Pradesh, Rajasthan, and West Bengal highlighted climate change as one of the conservation threats in their study sites. Among biological threats, aquatic invasive species like Pontederia spp., (Eichorina), Typha spp., Lemna spp. Nymphoides spp., Najas spp., and Phragmites spp. were highlighted as threats to waterbird habitats in the states of Uttar Pradesh, West Bengal, Uttarakhand, Bihar, and Haryana. The free-ranging dogs and other predators were noted to be problematic for waterbirds in Rajasthan, Uttar Pradesh, Bihar, and Haryana.

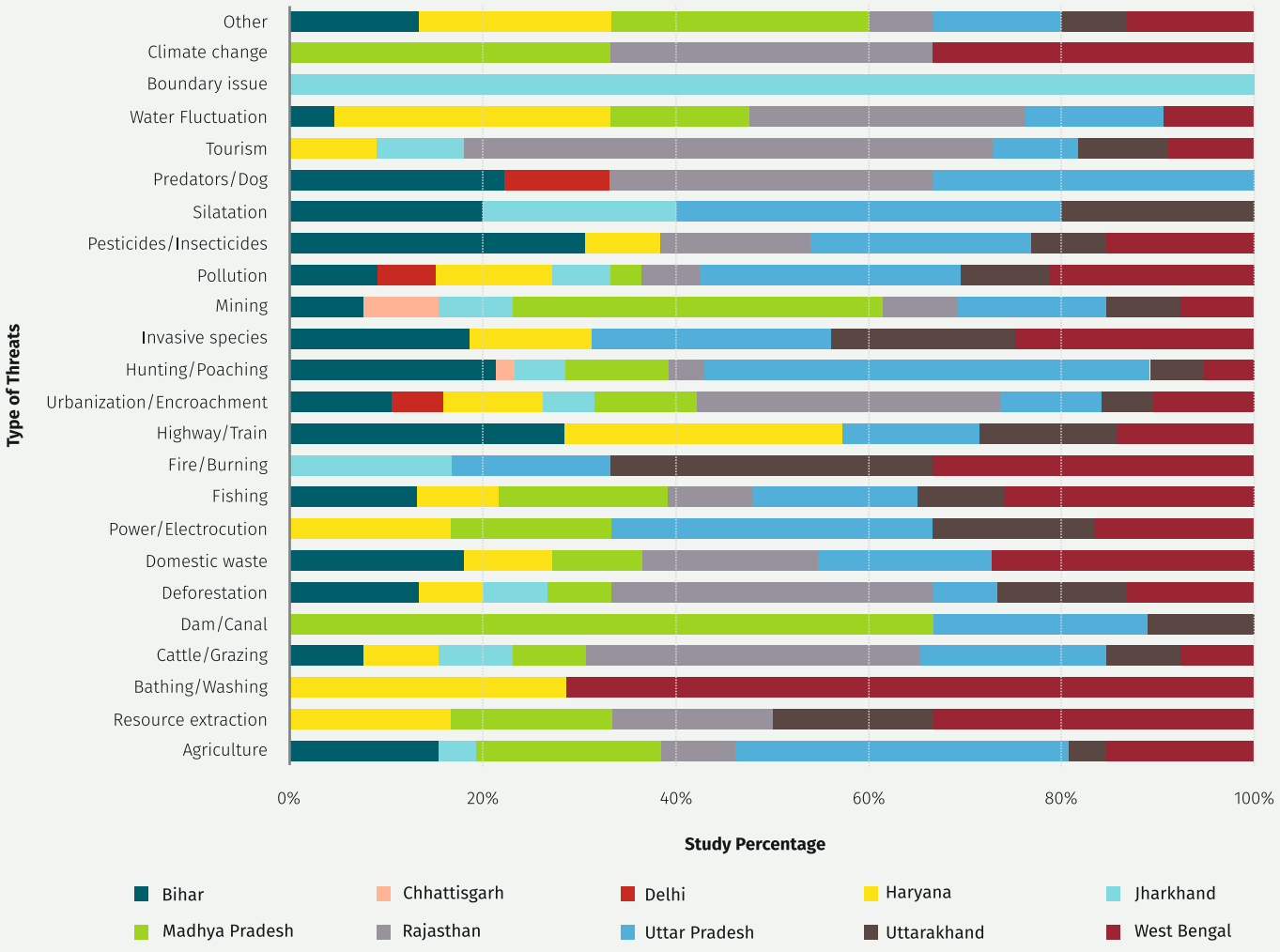


Figure 3.13. Ratio of types of threat mentioned in studies across various states of the Ganga River Basin (n=183)



4 INTERNATIONAL AND NATIONAL CONSERVATION MEASURES IN CONTEXT OF WATERBIRDS



Forty-eight international and national conservation measures (treaties, conventions, acts, laws and policies) exist for biodiversity conservation (Table 4.1). The focus of most of these is on biodiversity conservation and sustainability. Only three of them explicitly mention the birds or aves. Three of these conservation measures are focused on migratory birds, of which only one is particularly for waterbirds (Table 4.1). Among the national level conservation measures, the Indian Wild Life (Protection) Act, 1972 provides legal protection to each bird species found in India along with other taxa. Similarly, CITES has listed some bird species in their appendices to restrict their international trade. The other national level conservation and environment protection laws/policies focus on the threatened species across the taxa, including the waterbirds. However, most of these measures have scope for conservation and protection of the habitat through improvement of the water quality, water availability, waste management, restriction on land use, and infrastructural changes. Some of these, such as Municipality acts across the states, can be utilized or reinforced to conserve urban wetlands and spaces for waterbirds (migratory and non-migratory). Some of these legislative measures have implications regarding the prey base of the waterbirds and thus need stringent implementation or even amendment to include the section on the conservation of prey base preferred by the aves or even other taxa. Of the international and national conservation measures, key threats like pollution are mentioned by 26 of them, followed by agricultural practices/water availability (20), fishing/use of chemicals and fertilizers (17), and poaching/deforestation (15). Most of these measures have mentioned threats and provided guidelines and regulations to deal with them prudently. The threats mentioned above were also primarily highlighted in reviewed studies on the waterbirds of the Ganga River Basin.



Table 3.1. International and national policies, conventions, and treaties for waterbird conservation and their implication for threats to waterbird conservation

	International/Regional/National level Treaty/ Protocol/ Law/Policy	Focus taxa for conservation	Hunting/ Poaching	Pollution	Cattle/Grazing impact	Agriculture practices	Water availability	Fishing	
International	2030 Agenda for Sustainable Development and COP22	General	■	■		■	■	■	
	BirdLife's Global Important Bird Area Programme, 1979	Aves	■						
	Convention on Biological Diversity, 1992	General							
	Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), 1973	Endangered Flora and Fauna	■					■	
	Convention on Migratory Species (CMS), 1979	Migratory Species	■					■	
	Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention), 2016	General		■			■		
	International Convention for the Prevention of Pollution from Ships (MARPOL)-1978	General		■					
	International Panel on Climate Change (IPCC), 1988	General		■		■	■		
	International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) 2001	General							
	International Water Law	None							
	Kunming-Montreal Global Biodiversity Framework (GBF), 2022	General		■		■		■	
	Other Effective Area-Based Conservation Measures (OECMs), 2010	General			■	■		■	
	RAMSAR Convention, 1971	Waterbirds		■			■		
	Rio+20 Conference, 2012	General		■		■	■		
	The Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development, 2002	None							
	The Paris Agreement, 2016	General							
	The United Nations Convention to Combat Desertification, 1994	General		■	■	■	■		
	UN Tourism Framework Convention on Tourism Ethics, 2019	General							
	UNESCO-WHO 1972	General		■					
	United Nations Framework Convention on Climate Change (UNFCCC), 1992	General		■		■	■		
	UNESCO World Heritage Convention, 1972	General					■		
	UNESCO Man and Biosphere Programme (MAB), 1971	General	■			■			

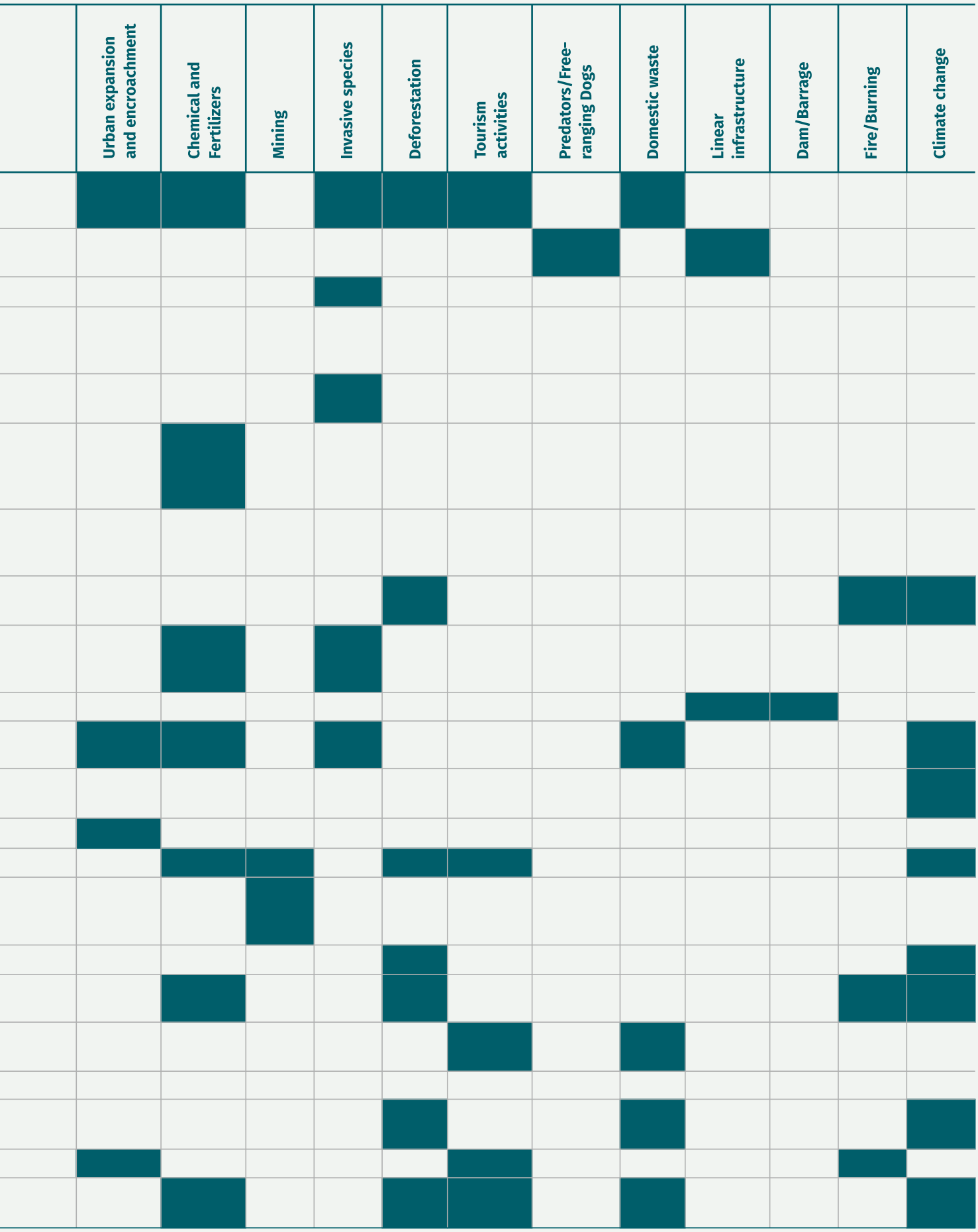

Urban expansion and encroachment
Chemical and Fertilizers
Mining
Invasive species
Deforestation
Tourism activities
Predators/Free-ranging Dogs
Domestic waste
Linear infrastructure
Dam/Barrage
Fire/Burning
Climate change

Table 3.1. International and national policies, conventions, and treaties for waterbird conservation and their implication for threats to waterbird conservation

	International/Regional/National level Treaty/ Protocol/ Law/Policy	Focus taxa for conservation	Hunting/ Poaching	Pollution	Cattle/Grazing impact	Agriculture practices	Water availability	Fishing	
Regional	Asia Pacific Migratory waterbird Conservation Strategy, 1996	Migratory Waterbirds	■	■		■	■	■	
Regional	East Asia Summit	General	■	■		■	■	■	
National	Agriculture Policy Vision, 2020	None				■	■	■	
National	Air (Prevention and Control of Pollution) Act, 1981	None		■					
National	Biological Diversity Act, 2002	General				■			
National	Constitution of India (Article 48 and 51)	General	■	■	■	■			
National	Environment Protection Act, 1986	General		■					
National	Inland Fisheries and Aquaculture Bill, 2019	General		■		■	■	■	
National	Forest Right Act (FRA), 2006	General	■		■			■	
National	Indian Fisheries Act, 1897	Fishes						■	
National	Indian Forest Act, 1927	General	■		■		■	■	
National	The Bharatiya Nyaya Sanhita, 2023 (replaced Indian Penal Code, 1860)	General	■						
National	The Mines and Minerals (Regulation and Development) Act, 1957	None		■					
National	Motor Vehicle Act, 1988	None		■					
National	Municipalities Acts of Indian States	None		■					
National	National Fisheries Policy, 2020	Fishes		■			■	■	
National	National Mission on Sustainable Agriculture, 2014	None				■	■	■	
National	National Project on Organic Farming (NPOF), 2004	None				■			
National	Noise Pollution (Regulation and Control) Rules, 2000	None		■					
National	Prevention of Cruelty to Animals Act, 1960	None	■						
National	State Panchayati Raj Acts	None		■	■	■	■	■	
National	Water (Prevention and Control of Pollution) Act, 1974	None		■			■		
National	Wetlands (Conservation and Management) Rules, 2017	General	■	■	■	■	■	■	
National	Wild Life (Protection) Act, 1972	Flora and fauna	■		■		■	■	
National	Hydro Power Policy, 2008	General	■	■		■	■		
National	National Water Policy, 2005	General		■		■	■		

Urban expansion and encroachment
Chemical and Fertilizers
Mining
Invasive species
Deforestation
Tourism activities
Predators/Free-ranging Dogs
Domestic waste
Linear infrastructure
Dam/Barrage
Fire/Burning
Climate change

4.1. Policy Recommendations

Based on international and national level measures, threat specific recommendations are provided in Table 4.2. On the international level, most of the conservation measures have overlooked many of the threat categories that require proper mention and solution, for instance, a global treaty on plant and animal invasive species treaty that would address a major threat to native biodiversity, especially to waterbirds and their habitats, is still in a draft form. Conservation measures also missed the mining of mineral resources in crucial habitats and ecosystems, which need to be included as core objective. Nature-based solutions need to be considered key remedies to different anthropogenic threats to biodiversity rather than adopting absolute mechanistic approaches that require additional resources. The Intergovernmental Forum on Mining, Minerals, Metals, and Sustainable Development must target biodiversity conservation more inclusively. Elements of forest fire require the heed of global policy makers since it is considered one of the major threats to biodiversity and a triggering factor for climatic vulnerabilities as well. Oil spills could also be included as one of the challenges in policies and legislation related to maritime or water treaties. Oil-related hazards are pernicious to marine and estuarine ecosystems; thus, there is a need to set proper guidelines for preventive measures. With increasing threats of pandemics/zoonotic diseases, specifically avian influenza, the "One Health" concept is required to shape policies more pragmatically (WHO-EPI-WIN, 2023). Globally, 78 avian species were identified as negatively affected by free-ranging dogs, thus necessitating their regulation inside PAs and critical waterbird habitats (Doherty et al., 2017). India, one of the most rabid infested countries in Asia (Hampson et al., 2015), needs more comprehensive and clear guidelines regarding feral/free-ranging dogs causing harm to wildlife and humans, conflict of interest among different stakeholders cause hindrance in managing dog populations.

On the regional level, two measures highlight the environment and sustainable development goals, which fall within the purview of conservation and management of waterbirds in the Central Asian and East Australian Asian Flyways. In country specific conservation measures, threats are dealt more explicitly, covering almost all threat categories. Nonetheless, some threat categories require special mentions and remedies, such as the issue of mining and forest fire/burning in and around aquatic habitats. Even linear infrastructure challenges must be aligned sustainably with increasing demand for transportation, water, and electricity (NBWL, 2011). Wetlands (Conservation and Management) Rules, 2017 corroborate wetland and waterbird management solutions and regulations. On the basin or country level, Panchayat and Municipality rules may also be aligned with the requirement of wetland-based ecosystem services and waterbird conservation through the active participation of local communities and stakeholders. The national level mining act may also include biodiversity conservation and sustainable harvesting. Considering the challenges of climate change to all spheres of life, it should be included in the national level conservation measures, especially related to pollution, agriculture, urbanization, and water resources that target future resilience.

4.2. Limitations and Way Forward

Literature based assessment highlights the urgency of quality studies on the waterbirds from the riverine habitats of the Ganga River Basin. Information on island nesting birds along the rivers in the Ganga basin is scant and sporadic. There was duplication or repetition in ~1% of the published studies that certainly were related to checklists. As most of the studies were not even published in quality journals, the reliability of published data also raises questions and dubious findings. Lack of collaboration among the regional institutions and organizations appears to be a limitation of quality publications. Studies with multiple collaborators and acclaimed institutions have certainly improved the quality of the published studies. Our synthesis of the quality of publications has unveiled lacunae in Indian academic institutions in multiple steps. During the review, most high-impact journals were found to be non-open access or hybrid, limiting the accessibility to readers from poor/developing countries as they cannot pay access charges. An average open-access article publishing charges vary in between 1000 and 4000$ USD, which is not feasible of most of researchers and academicians in India. Earlier, most of the waterbird related studies were published in Indian journals like JBNHS and Indian Forester, thus accessibility and timely volume publications from these journals are required. The early archives of these journals should be indexed properly and made available enabling access to historical data for time series and other related studies. Universities and institutions should also provide exposure to their students and faculties about ethics in scientific publications, especially on plagiarism, predatory journals and open access. India's New education policy (NEP) unveils some of these aspects on its agenda as "One Nation One Subscription (ONOS)" (NEP, 2020; 2024). This scheme initiated from January, 2025 will ensure access of over 13,000 scholarly journals to 6300 Indian academic institutions and universities.

Most studies were carried out on the status and distribution of species or assemblages. Often, publications misconstrued bird assemblage with the community without studying relations and interactions among them. Many such studies claimed to be seasonal but did not depict seasonality in their results, introductions, methods or discussions. Comparatively, behavioral studies were carried out more precisely, showing patterns. Nevertheless, studies on avian disease still lag in India, especially concerning migratory species. Handful studies have been conducted in India, focusing on southern states or laboratories. Even migration related studies were uncommon till 2023, the recent body of literature highlights the urgency of migration pattern-related studies in India. Further, such studies had limited sample size (< 10 individuals) due to paucity of funds and permit related issues in India. Almost 30% of the reviewed studies claimed to follow the line or point transect method. However, the utility of such methods was not fully realized as most of the studies did not provide population estimates.

Only a few studies provided density or abundance estimates for waterbirds in their study sites. Similarly, behavioral observations were also limited, sometime related to opportunistic observations, there are < 10 studies focusing on the migration behavior of waterbirds in the Ganga River Basin. The behavioral studies were dominated by activity patterns, foraging and breeding like topics, but even breeding/nesting related studies mainly relied on ad-libitum observation, breeding productivity or success related studies are still uncommon from the basin. Most of the studies did not conduct threat assessments or quantify them; < 5 studies determined the relation between species and threats. Otherwise, studies mentioned several threats in their synthesis or discussion section without assessing them. In addition, a few studies were carried out in the riverine habitats, most of the studies focused on lacustrine or palustrine or artificial waterbodies, while some were carried out in the mosaic of habitats or PAs, which covered wetlands. The river habitats are understudied and require dedicated river-centric studies in the Ganga River Basin. To date, none of the comparable data is available to check trends in abundance or diversity on the spatio-temporal scale. Under the National Mission for Clean Ganga (NMCG), WII is studying the mainstem Ganga, and its tributaries since 2015 (WII-NMCG, 2019). A baseline data has been generated for almost all aquatic vertebrate taxa as diversity or abundance indices. Similarly, more studies are essential in the other basins and tributaries to formularize river management requirements.

Table 4.2. Threats and their corresponding policies, with implication for waterbirds and their habitats

Conservation Threat	International & Regional treaties, conventions, acts, laws and policies	National acts, laws and policies	Purpose	Conservation implications for waterbirds and their habitats
Hunting/ Poaching	2030 Agenda for Sustainable Development and COP22; BirdLife's Global Important Bird Area Programme, 1979; Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), 1973; Convention on Migratory Species (CMS), 1979; UNESCO Man and Biosphere Programme (MAB), 1971; Asia Pacific Migratory waterbird Conservation Strategy, 1996; East Asia Summit	Constitution of India (Article 48 and 51); Forest Right Act (FRA), 2006; Indian Forest Act, 1927; Wild Life (Protection) Act,1972; The Bharatiya Nyaya Sanhita, 2023; Prevention of Cruelty to Animals Act, 1960; Wetlands (Conservation and Management) Rules, 2017; Hydro Power Policy, 2008	To impose restrictions on cruelty, trade and illegal hunting.	Ensures protection of waterbird species and other wild flora and fauna. It prevents poaching at state, national and international level.
Pollution	2030 Agenda for Sustainable Development and COP22; Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention), 2016; International Convention for the Prevention of Pollution from Ships (MARPOL)-1978; International Panel on Climate Change (IPCC), 1988; Kunming-Montreal Protocol (GBF) 2030; UNESCO-WHO 1972; RAMSAR Convention 1971; Other Effective Area-Based Conservation Measures (OECMs); Rio+20 Conference, 2012; The United Nations Convention to Combat Desertification, 1994; United Nations Framework Convention on Climate Change (UNFCCC), 1992; Asia Pacific Migratory waterbird Conservation Strategy, 1996; East Asia Summit	Air (Prevention and Control of Pollution) Act, 1981; Constitution of India (Articles 48 and 51); Environment Protection Act, 1986; Inland Fisheries and Aquaculture Bill, 2019; The Mines and Minerals (Regulation and Development) Act, 1957; Motor Vehicle Act, 1988; Municipalities Acts of Indian States; National Fisheries Policy, 2020; Noise Pollution (Regulation and Control) Rules, 2000; State Panchayati Raj Acts; Water (Prevention and Control of Pollution) Act, 1974; Wetlands (Conservation and Management Rules) 2017; Hydro Power Policy, 2008; National Water Policy, 2005	To prevent pollution influx in and around wetland habitats. To prevent disturbance or harm to waterbirds owing to pollutants.	Could abate or prevent adverse effects of pollutants on waterbirds and their habitats.

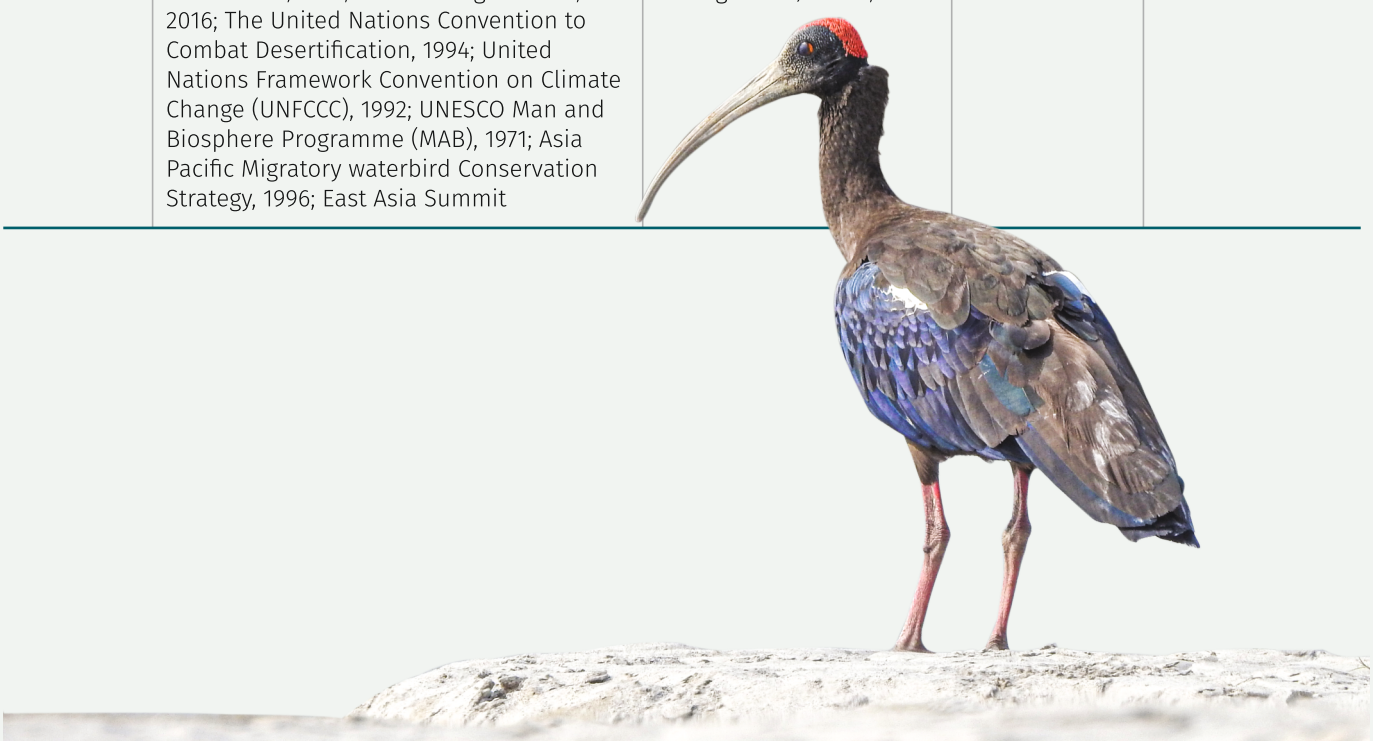
Conservation Threat	International & Regional treaties, conventions, acts, laws and policies	National acts, laws and policies	Purpose	Conservation implications for waterbirds and their habitats
Cattle/ Grazing impact	Other Effective Area-Based Conservation Measures (OECMs), 2010; The United Nations Convention to Combat Desertification, 1994	Constitution of India (Article 48 and 51); Forest Right Act (FRA), 2006; Indian Forest Act 1927; State Panchayati Raj Acts; Wetlands (Conservation and Management) Rules, 2017; Wild Life (Protection) Act,1972;	To enable sustainable pastoralism and prevent cruelty against livestock. Regulate grazing practices inside protected areas.	Will ensure the protection of wetland habitats and the prevention of zoonotic disease transfer without harming pastoralist practices.
Agriculture practices	2030 Agenda for Sustainable Development and COP22; International Panel on Climate Change (IPCC), 1988; Kunming-Montreal Global Biodiversity Framework (GBF), 2022; Other Effective Area-Based Conservation Measures (OECMs), 2010; Rio+20 Conference, 2012; The United Nations Convention to Combat Desertification, 1994; United Nations Framework Convention on Climate Change (UNFCCC), 1992; UNESCO Man and Biosphere Programme (MAB), 1971; Asia Pacific Migratory waterbird Conservation Strategy, 1996; East Asia Summit	Agriculture Policy Vision, 2020; Biological Diversity Act, 2002; Constitution of India (Articles 48 and 51); National Inland Fisheries and Aquaculture Bill, 2019; National Mission on Sustainable Agriculture, 2014; National Project on Organic Farming (NPOF), 2004; State Panchayati Raj Acts; Wetlands (Conservation and Management) Rules, 2017; Hydro Power Policy, 2008; National Water Policy, 2005	To increase agricultural productivity of rain-fed areas in a sustainable manner by adopting appropriate farming system-based approaches (appropriate land use and judicious application of fertilizers). To promote organic farming through the use of traditional resources and to empower farmers through their own institutional development.	It could reduce the load of fertilizers and chemicals in water and soil, and will promote organic crop that will eventually benefit waterbirds and their wetland habitats.
Water availability	2030 Agenda for Sustainable Development and COP22; Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), 1973; Convention on Migratory Species (CMS), 1979; Kunming-Montreal Global Biodiversity Framework (GBF), 2022; Other Effective Area-Based Conservation Measures (OECMs), 2010; Asia Pacific Migratory waterbird Conservation Strategy, 1996; East Asia Summit	Agriculture Policy Vision, 2020; National Inland Fisheries and Aquaculture Bill, 2019; Indian Forest Act, 1927; National Fisheries Policy, 2020; National Mission on Sustainable Agriculture, 2014; State Panchayati Raj Acts; Water (Prevention and Control of Pollution) Act, 1974; Wetlands (Conservation and	To ensure optimum water flow in rivers and other wetlands of the basin. To protect wetland ecosystems and maintain nesting and roosting sites of waterbirds.	Could maintain e-flow in rivers and other wetlands for maintaining ecological integrity of aquatic ecosystems in the Ganga River Basin and elsewhere, and will prevent sudden water level fluctuations to protect crucial

Conservation Threat	International & Regional treaties, conventions, acts, laws and policies	National acts, laws and policies	Purpose	Conservation implications for waterbirds and their habitats
Water availability		Management) Rules, 2017; Wildlife (Protection) Act, 1972; Hydro Power Policy, 2008; National Water Policy, 2005		roosting and nesting sites of waterbirds.
Fishing	2030 Agenda for Sustainable Development and COP22; Convention on Biological Diversity, 1992; Convention on Migratory Species (CMS), 1979; International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) 2001; Kunming-Montreal Global Biodiversity Framework (GBF), 2022; Asia Pacific Migratory waterbird Conservation Strategy, 1996; East Asia Summit	Agriculture Policy Vision, 2020; National Inland Fisheries and Aquaculture Bill, 2019; Forest Right Act (FRA), 2006; Indian Fisheries Act, 1897; Indian Forest Act, 1927; National Fisheries Policy, 2020; National Mission on Sustainable Agriculture, 2014; State Panchayati Raj Acts; Wetlands (Conservation and Management) Rules, 2017; Wildlife (Protection) Act, 1972	To promote sustainable fish harvest and construction of fish friendly developmental structures to maintain gene flow. To conserve endemic and threatened ichthyofauna of the Ganga River Basin.	Will promote sustainable harvest of fish stocks aligning with fulfilment of food provisioning and economic benefits to fishing community and other stakeholders. Further, there will be control on spread of invasive fish species in freshwater aquatic system to conserve indigenous fish species.
Urban expansion and encroachment	2030 Agenda for Sustainable Development and COP22; Kunming-Montreal Global Biodiversity Framework (GBF), 2022; RAMSAR Convention, 1971; UNESCO World Heritage Convention, 1972; Asia Pacific Migratory waterbird Conservation Strategy, 1996; East Asia Summit	National Inland Fisheries and Aquaculture Bill, 2019; Municipalities Acts of Indian States; State Panchayati Raj Acts; Wetlands (Conservation and Management) Rules, 2017	To ensure encroachment-free wetlands and sustainable green urban expansion in the Ganga River Basin by adopting green mechanisms (eco-friendly measures).	Could regulate urban expansion to meet human needs of housing and boarding, especially in and around urban spaces. Securing wetland in human dominated landscapes (urban and rural) will only protect waterbirds and their habitats but also provide ecosystem provisioning to people (eg. meet water demand, flood resistance).
Chemical and Fertilizers	2030 Agenda for Sustainable Development and COP22; Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention), 2016; International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) 2001; Kunming-Montreal Global Biodiversity Framework (GBF), 2022; Rio+20 Conference, 2012; The United Nations Convention to Combat Desertification, 1994; UNESCO Man and	Agriculture Policy Vision, 2020; Inland Fisheries and Aquaculture Bill, 2019; Indian Fisheries Act, 1897; Indian Forest Act, 1927; The Bharatiya Nyaya Sanhita, 2023; National Mission on Sustainable Agriculture, 2014; National Project on Organic Farming (NPOF), 2004; Water (Prevention	To regulate chemical flow of industries and other sources in air and water by adopting appropriate measures to minimize damage and	Could reduce load of chemicals in water and soil, and will promote use of Sewage Treatment Plants to minimize release of pollutants in water that will eventually benefit waterbirds

Conservation Threat	International & Regional treaties, conventions, acts, laws and policies	National acts, laws and policies	Purpose	Conservation implications for waterbirds and their habitats
Chemical and Fertilizers	Biosphere Programme (MAB), 1971; Asia Pacific Migratory waterbird Conservation Strategy, 1996	and Control of Pollution) Act, 1974; Wetlands (Conservation and Management) Rules, 2017	maximize benefits to natural environment especially aquatic To promote organic farming through the use of traditional resources and to empower farmers through their own institutional development.	and their wetland habitats. Similarly, judicious use and production of fertilizer will be beneficial for aquatic habitats of the Ganga River Basin.
Mining	Rio+20 Conference, 2012; The Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development, 2002; East Asia Summit	The Mines and Minerals (Regulation and Development) Act, 1957; Wetlands (Conservation and Management) Rules, 2017; Wildlife (Protection) Act, 1972	To regulate mining activities in and around crucial waterbird habitats, and also promote judicious use of mineral resources and green options to reduce demand of mining in river habitats.	Could regulate mining activities in crucial waterbird habitats and ensure free flowing rivers in the Ganga River Basin.
Invasive species	2030 Agenda for Sustainable Development and COP22; Convention on Biological Diversity, 1992; Convention on Migratory Species (CMS), 1979; International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) 2001; Kunming-Montreal Global Biodiversity Framework (GBF), 2022; Asia Pacific Migratory waterbird Conservation Strategy, 1996; East Asia Summit	National Inland Fisheries and Aquaculture Bill, 2019; Wetlands (Conservation and Management) Rules, 2017; Wildlife (Protection) Act, 1972	To maintain ecological integrity of aquatic habitats by prevention of introduction/spread of invasive species s and to ensure implementation of rules/acts in the Ganga River Basin.	Will improve ecosystem health and long-term survival of endemic and threatened species of Indian waters through adoption of scientific management and prevention of invasive alien species (plant/animal).
Deforestation	2030 Agenda for Sustainable Development and COP22; International Panel on Climate Change (IPCC), 1988; Rio+20 Conference, 2012; The Paris Agreement, 2016; The United Nations Convention to Combat Desertification, 1994; United Nations Framework Convention on Climate Change (UNFCCC), 1992; UNESCO Man and Biosphere	Constitution of India (Article 48 and 51); Inland Fisheries and Aquaculture Bill, 2019; Indian Forest Act, 1927; State Panchayati Raj Acts; Wetlands (Conservation and Management) Rules, 2017;	To conserve forest ecosystem, maintain ecological balance and provide	Will conserve forest habitats around aquatic habitats (especially swamps) that will improve water

Conservation Threat	International & Regional treaties, conventions, acts, laws and policies	National acts, laws and policies	Purpose	Conservation implications for waterbirds and their habitats
Deforestation	Programme (MAB), 1971; East Asia Summit	Wildlife (Protection) Act, 1972; Hydro Power Policy, 2008	alternative resources to dependent communities to fulfil their demands, which usually they harvest from forests (fuelwood, fodder etc.).	table in riparian zone and trees will provide nesting and roosting sites to waterbirds.
Tourism activities	2030 Agenda for Sustainable Development and COP22; Rio+20 Conference, 2012; UN Tourism Framework Convention on Tourism Ethics, 2019; UNESCO World Heritage Convention, 1972; UNESCO Man and Biosphere Programme (MAB), 1971; Asia Pacific Migratory waterbird Conservation Strategy, 1996	Wetlands (Conservation and Management) Rules, 2017; Wildlife (Protection) Act, 1972	To promote sustainable and nature friendly tourism in and around wetland habitats to minimize loss and maximize benefits.	Will enable positive aspects of tourism like informed tourists, economic benefits to local community aiming at wetland protection.
Predators/ Free-ranging Dogs	BirdLife's Global Important Bird Area Programme, 1979	Municipalities Acts of Indian States; State Panchayati Raj Acts; Wildlife (Protection) Act, 1972	To regulate free-ranging dog population in and around crucial waterbird habitats.	Will regulate dog and other predators around waterbird habitats and prevent predation of waterbirds including endemic and threatened species.
Domestic waste	2030 Agenda for Sustainable Development and COP22; Kunming-Montreal Global Biodiversity Framework (GBF), 2022; UN Tourism Framework Convention on Tourism Ethics, 2019; United Nations Framework Convention on Climate Change (UNFCCC), 1992; UNESCO Man and Biosphere Programme (MAB), 1971; Asia Pacific Migratory waterbird Conservation Strategy, 1996; East Asia Summit	National Inland Fisheries and Aquaculture Bill, 2019; Municipalities Acts of Indian States; Water (Prevention and Control of Pollution) Act, 1974; Wetlands (Conservation and Management) Rules, 2017; National Water Policy, 2005	To prevent pollution influx in and around wetland habitats.	Could abate or prevent adverse effect of pollutants on waterbirds and their habitats.
Linear infrastructure	BirdLife's Global Important Bird Area Programme, 1979; International Water Law	Forest Right Act (FRA), 2006; Indian Forest Act, 1927; Municipalities Acts of Indian States; State Panchayati Raj Acts; Wetlands (Conservation and Management) Rules, 2017; Hydro Power Policy, 2008; National Water Policy, 2005	To ensure ecological connectivity and unpolluted waterbird habitats.	Will regulate and minimize harmful impacts of liner infrastructures in and around waterbird habitats.

Conservation Threat	International & Regional treaties, conventions, acts, laws and policies	National acts, laws and policies	Purpose	Conservation implications for waterbirds and their habitats
Dam/ Barrage	International Water Law	National Inland Fisheries and Aquaculture Bill, 2019; Municipalities Acts of Indian States; Wetlands (Conservation and Management) Rules, 2017; Hydro Power Policy, 2008; National Water Policy, 2005	To ensure optimum water flow in rivers and other wetlands of the basin to protect wetland ecosystems and maintain nesting and roosting sites of waterbirds.	Could maintain e-flow in rivers and other wetlands for ecological integrity of aquatic ecosystems in the Ganga River Basin and elsewhere, and will prevent sudden water level fluctuations to protect crucial roosting and nesting sites of waterbirds.
Fire/ Burning	International Panel on Climate Change (IPCC), 1988; The United Nations Convention to Combat Desertification, 1994; UNESCO World Heritage Convention, 1972; East Asia Summit	Indian Forest Act, 1927; The Bharatiya Nyaya Sanhita, 2023; Wildlife (Protection) Act, 1972	To promote control fire under supervision of line agencies and discourage crop/ residual burning by providing alternatives to farmers and others.	Will control habitat destruction due to uncontrolled fire events and may solve issue of air and water pollution during stubble burning.
Climate change	International Panel on Climate Change (IPCC), 1988; Kunming-Montreal Global Biodiversity Framework (GBF), 2022; Other Effective Area-Based Conservation Measures (OECMs), 2010; Rio+20 Conference, 2012; The Paris Agreement, 2016; The United Nations Convention to Combat Desertification, 1994; United Nations Framework Convention on Climate Change (UNFCCC), 1992; UNESCO Man and Biosphere Programme (MAB), 1971; Asia Pacific Migratory waterbird Conservation Strategy, 1996; East Asia Summit	Biological Diversity Act, 2002; National Mission on Sustainable Agriculture, 2014; Wetlands (Conservation and Management) Rules, 2017	To strengthen the response to the threat of climate change.	Could conserve waterbirds and their habitats from impact of climate change in long run.





REFERENCES

Abdulali, H. (1947). Peculiar behaviour of the darter (Anhinga melanogaster Pennant). Journal of Bombay Natural History Society, 47(3): 549.

Aggarwal, A., Tiwari, G., & Harsh, S. (2015). Avian diversity and density estimation of birds of the Indian Institute of Forest Management Campus, Bhopal, India. Journal of Threatened Taxa, 7(2): 6891-6902.

Alley, K. D. (2002). On the banks of the Gaṅgā?: When wastewater meets a sacred river. University of Michigan Press. ISBN no. 978-0-472-09808-8

Arya, S.K., Rawat, G.S. & Gopi, G.V. (2021). Distribution and Abundance of Raptors in Kailash Sacred. Proceedings of Zoological Society. Landscape, Western Himalaya, India. Proceedings of Zoological Society, 74: 327-338.

Bates, R.S.P. (1948). Peculiar behaviour of the darter (Anhinga melanogaster Pannant). Journal of Bombay Natural History Society, 48(4): 810-811.

Bashir, T., Behera, S. K., Khan, A., & Gautam, P. (2012). An inventory of mammals, birds and reptiles along a section of the river and banks of upper Ganges, India. Journal of Threatened Taxa, 2900-2910.

Beavan, R. C. (1868). Notes on various Indian birds. Ibis,10(4): 370-406.

Bhattacharjee, K. & Adhikari, S. (2022). A checklist of avifauna from different habitats of semi-arid landscape in western parts (Mandsaur and Ratlam districts) of Madhya Pradesh, India. Journal of Threatened Taxa 14(5): 20988-21001. https://doi.org/10.11609/jott.6705.14.5.20988-21001

Boldyrev, S.L., Levykh, A. Y., & Zamyatin, D.O. (2023). Wetlands dynamics analysis: a case study of Keoladeo National Park (India), the wintering grounds of West Siberian white crane population. Samara Journal of Science, 12(3): 27-35.

Buckxill, S. J. A. (1924). VI.-The Disappearance of the Pink-headed Duck (*Rhodonessa caryophyllacea* Lath.). Ibis, 66(1): 146-151.

Champion, H. G., & Seth, S. K. (1968). A revised survey of the forest types of India.

Chakrabarti, R. (2011). Mammalian and avian faunal diversity in Damodar Valley under DVC project area. No. 328. Records of Zoological Survey of India.

Chaturvedi, M. C. (2012). Ganga-Brahmaputra-Meghna waters: advances in development and management. CRC Press. ISBN-13:978-1-4398-7376-2

Census of India (2011). https://www.census2011.co.in <downloaded on 26 April, 2024>

Doherty, T. S., Dickman, C. R., Glen, A. S., Newsome, T. M., Nimmo, D. G., Ritchie, E. G. et al. (2017). The global impacts of domestic dogs on threatened vertebrates. Biological Conservation, 210: 56-59. https://doi.org/10.1016/j.biocon.2017.04.007

Editors (1936). Migration of wildfowl. Journal of the Bombay Natural History Society, 38(3): 627-628.

Francis, A., Prusty, B. A. K., & Azeez, P. A. (2020). Ingestion of unusual items by wetland birds in urban landscapes. Current Science, 118(6): 977.

Ganguli, U. (1961). Birds at the Najafgarh Jheel. Newsletter for Birdwatchers, 1(10): 1.

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

Gopi Sundar, K.S. (2004). Observations on breeding Indian Skimmers Rynchops albicollis in the National Chambal Sanctuary, Uttar Pradesh, India. Forktail, 20: 89-90.

Gopi Sundar, K.S. (2005). An instance of mortality and notes on behaviour of Black-necked Storks Ephippiorhynchus asiaticus. The Journal of Bombay Natural History Society, 102(1): 99-102.

Gururaj Prabhu, K. (2014). Topographical Description of the Ganga River and its Tributaries. International Journal of Research and Analytical Reviews, 1(1): 686-97.

Hampson, K., Coudeville, L., Lembo T., et al. (2015). Estimating the global burden of endemic canine rabies. PLoS Negl Trop Dis; 9: e0003709. 10.1371/journal.pntd.0003709

INDIA-WRIS (2014). India-Water Resources Information System: www.india-wris.nrsc.gov.in <downloaded on 24 April, 2024>

Inglis, C. M. (1940): Records of some rare or uncommon geese, ducks and other water birds in north Bihar. Journal Bengal Natural History Society, 15: 56-60.

Indian State of Forest Report (2023). Forest Survey of India, Ministry of Environment, Forest and Climate Change (MoEF & CC), Government of India. ISBN 978-81-950073-9-4.

Irby, L. H. (1861). Notes on birds observed in Oudh and Kumaon. Ibis, 3: 217-251.

Javed, S., Takekawa, J. Y., Douglas, D. C., Rahmani, A. R., Kanai, Y., Nagendran, M., Choudhary, B. C. & Sharma, S. (2000). Tracking the spring migration of a bar-headed goose (*Anser indicus*) across the Himalaya with satellite telemetry. Global Environmental Research, 4(2): 195-205.

Joshi, K.K., Bhatt, D. & Arya, A.K. (2021). Avian diversity in forest, agriculture and water stream habitats of Dehradun Valley, Uttarakhand, India. Biodiversity Data Journal, 9: e61422. https://doi.org/10.3897/BDJ.9.e61422

Joshi, K. & Kumar, D. (2022). Avian species composition and distribution along elevational zone in forest habitat of Nainital district (Western Himalaya) of Uttarakhand, India. Trees, Forests and People, 7: 100177.

Kalra, M., Kumar, S., Rahmani, A. R., Khan, J. A., Belal, S. M., & Khan, A. M. (2011). Satellite tracking of Bar-headed Geese Anser indicus wintering in Uttar Pradesh, India. Journal of the Bombay Natural History Society, 108(2):79-94.

Kittur, S., & Sundar, K. G. (2021). Of irrigation canals and multifunctional agroforestry: Traditional agriculture facilitates Woolly-necked Stork breeding in a north Indian agricultural landscape. Global Ecology and Conservation, 30: e01793.

Kumar, B. N., & Choudhary, S. K. (2010). Avifauna of Jagatpur wetland near Bhagalpur (Bihar, India). Indian Birds, 6: 15-17.

Kumar, A., & Rana, S. (2021). Behavioural Patterns and Activity Budgeting of Greater Flamingo, *Phoenicopterus roseus* in Najafgarh Jheel Bird Sanctuary (Drain), Haryana, India. Asian Journal of Conservation Biology, 10(2).

Kumar, A., Sati, J.P. & Tak, P.C. (2003). Checklist of Indian Waterbirds. BUCEROS, 8(1): 30.

Law, S.C. (1930). Fish-eating habit of the Sarus Crane (*Antigone antigone*). Journal of Bombay Natural History Society, 34(2): 582-583.

Lodhi, R. K., & Rao, R. J. (2017). Status of Avian Diversity and their Population in Samoha Dam District Shivpuri, Madhya Pradesh. Octa Journal of Environmental Research, 5(3).

Mahar, N., Habib, B., Gopi, G. V., Hussain, S. A., Suhail, I. and Takpa, J. (2014). Telemetry studies with special reference to Bar-headed Goose (*Anser indicus*): A Review. (eds) Gopi, G. V., Hussain S. A. Waterbirds of India. ENVIS Bulletin: Wildlife and Protected Areas, 16: 306-313. Wildlife Institute of India. ISSN: 0972-088X

Mahendiran, M., & Urfi, A. J. (2010). Foraging patterns and kleptoparasitism among three sympatric cormorants (*Phalacrocorax* spp.) from the Delhi region, North India. Hydrobiologia, 638, 21-28.

Maheswaran, G. (1996). Grey-headed Fishing Eagle, *Ichthyophaga ichthyaetus ichthyaetus* (Horsfield) feeding on turtle. Journal of Bombay Natural History Society, 93: 294.

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., Pande, C.B. & Alshehri, F. (2023). Physicochemical Parameters of Water and Its Implications on Avifauna and Habitat Quality. Sustainability, 15(12): 9494. https://doi.org/10.3390/su15129494

Misra, V., & Bakre, P. P. (1994). Organochlorine contaminants and avifauna of Mahala water reservoir, Jaipur, India. Science of the Total Environment, 144(1-3): 145-151.

Mukherjee, K.N. & Dasgupta, S.P. (1983). Soil map of the Ganga basin. Center for Study of Man and

Environment. Graphic offset press (P) Ltd., Calcutta, India

Mukherjee, A., Pal, S., & Mukhopadhyay, S. K. (2020). Diurnal time-activity budget and foraging techniques of red-crested pochards (*Netta rufina*) wintering at the wetlands of West Bengal, India. Turkish Journal of Zoology, 44(5), 424-439.

National Board of Wildlife NBWL (2011). Guidelines for linear infrastructure intrusions in natural areas: roads and powerlines. Ministry of Environment, Forest and Climate Change, Government of India. https://moef.gov.in/uploads/2018/04/FIRSTDraft-guidelines-roads-and-powerlines.pdf

National Education Policy (NEP) (2020). Ministry of Human Resource Development. Government of India. Pp. 65.

National Remote Sensing Centre (2019). Land Use Land Cover (2018-2019). National Remote Sensing Centre (NRSC), ISRO, Government of India, Hyderabad, India.

Ouweneel, GeL. (1984). Status of Bar-headed Goose in India. Dutch Birding, 6: (4) 141.

Page, M.J., McKenzie, J.E., Bossuyt, P.M., Boutron, I., Hoffmann, T.C., Mulrow, C.D., Shamseer, L., Tetzlaff, J.M., Akl, E.A., Brennan, S.E., Chou, R., Glanville, J., Grimshaw, M., Hróbjartsson, A., Lalu, M.M., Li, T., Loder, E.W., Mayo-Wilson, E., McDonald, S., McGuinness, L.A., Stewart, L.A., Thomas, J., Tricco, A.C., Welch, V.A., Moher, W.D. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. International Journal of Surgery, 88, 105906.

Parker, G. (2000). Progress in the modeling alluvial fans. J. Hydraul. Res., 37(6): 804-824.

Praveen J., & Jayapal, R., 2025. Checklist of the birds of India (v9.0). Website: http://www.indianbirds.in/india/ [Date of publication: 01 January 2025].

Rahmani, A. R. (1991). Feeding association of the Little Grebe *Podiceps ruficollis* (Pallas) ducks. The Journal of Bombay Natural History Society, 88: 279-280.

Rahmani, A. R. (1988). Dihaila Jheel-a new candidate for the Ramsar Convention. Oryx, 22(4), 211-215.

Rao B. S., Gupta, A., Ruhi, S., Maheshwari, P. Venkat Raju, V., Rao, V. (2021). Glacial Lake Atlas of Ganga River Basin. National Remote Sensing Centre, ISRO, Hyderabad, India, pp. 1-194.

Roy, S., Kittur, S., & Sundar, K. G. (2022). Sarus Crane *Antigone antigone* trios and their triets: Discovery of a novel social unit in cranes. Ecology, 103(6): e3707.

San Juan, R. M. (2012). The transformation of the Río de La Plata and Bernini's Fountain of the Four Rivers in Rome. Representations, 118(1), 72-102.

Sati, V. P. (2021). The Ganges: Cultural, Economic and Environmental Significance. Springer International Publishing.

Sen, S. N. (1944). Food of the White-breasted Kingfisher (*Halcyon smyrnensis fusca*). Journal of the Bombay Natural History Society, 44(3), 475.

Shaikh, P., Panigrahi, M., & Katti, T. (2021). Indian Skimmer *Rynchops albicollis* (Swainson, 1838) Migration in India: Resighting Records of Birds Colour Tagged in National Chambal Sanctuary, Madhya Pradesh, India. Journal of the Bombay Natural History Society, 118(1), 26-31.

Singh, D.S. and Singh, I.B. (2005). Facies Architecture of the Gandak Megafan, Ganga Plain, India. Spl. Publ., Pal. Soc. India, 2:125-140.

Sundar, K. G., Chauhan, A. S., Kittur, S., & Babu, S. (2015). Wetland loss and waterbird use of wetlands in Palwal district, Haryana, India: the role of agriculture, urbanization and conversion to fish ponds. Wetlands, 35(1), 115-125.

Tak, P. C., Sati, J. P., & Rizvi, A. N. (2010). Status of waterbirds at Hathnikund Barrage wetland, Yamunanagar District, Haryana, India. Journal of Threatened Taxa, 841-844.

Takekawa, John, Shane R. Heath, David C. Douglas, William M. Perry, Salim Javed, Scott H. Newman, Rajendra N. Suwal et al. (2009) Geographic variation in Bar-headed Geese *Anser indicus*: connectivity of wintering areas and breeding grounds across a broad front. Wildfowl 59: 100-123.

TERI (2011). National Ganga River Basin Authority (NGRBA), Environmental and Social Management Framework (ESMF). Volume 1-Environmental and Social Analysis. Web sources. http://gangapedia.iitk.ac.in/?q=content/grbemp-reports-1

Tweedie, M. (1883). Letter about Pink-headed Duck from Kheri. Journal of Bombay Natural History Society. 10: 518-519.

Tyabji, N. S. (1961). Birds of Najafgarh. Newsletter for Birdwatchers. 1: (11) 4-7.

Urfi, A. J. (1988). Painted Stork *Mycteria leucocephala* (Pennant) swallowing a snake. Journal of the Bombay Natural History Society, 86: 96.

Urfi, A. J. (1993). Breeding patterns of Painted storks (*Mycteria leucocephala* pennant) at Delhi zoo, India. Colonial waterbirds, 16(1): 95-97.

Van Impe, J. (2019). The mystery of Sushkin, 1897. Victim of the Tunguska disaster? A Hungarian story. Ornis Hungarica, 27(2), 20-58.

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

WHO-EPI-WIN (2023). EPI-WIN: WHO Information Network for Epidemics. https://www.who.int/teams/epi-win

Zockler, C., Balachandran, S., Bunting, G. C., Fanck, M., Kashiwagi, M., Lappo, E. G., ... & Webb, K. (2005). The Indian Sunderbans: an important wintering site for Siberian waders. Bulletin-Wader Study Group, 108, 42.

APPENDIX 1. Threatened and Near Threatened Species of the Ganga River Basin

S.No.	Order	Family	Common Name	Scientific Name	IUCN Red list status	IWPA Status
1	Anseriformes	Anatidae	Baer's Pochard	*Aythya baeri* (Radde, 1863)	CR	Sch.-I
2	Anseriformes	Anatidae	Common Pochard	*Aythya ferina* (Linnaeus, 1758)	VU	Sch.-I
4	Anseriformes	Anatidae	Ferruginous Duck	*Aythya nyroca* (Güldenstädt, 1770)	NT	Sch.-II
5	Anseriformes	Anatidae	Lesser White-fronted Goose	*Anser erythropus* (Linnaeus, 1758)	VU	Sch.-II
6	Anseriformes	Anatidae	Long-tailed Duck	*Clangula hyemalis* (Linnaeus, 1758)	VU	Sch.-II
7	Anseriformes	Anatidae	Marbled Duck	*Marmaronetta angustirostris* (Ménétriés, 1832)	NT	Sch.-I
8	Anseriformes	Anatidae	Pink-headed Duck	*Rhodonessa caryophyllacea* (Latham, 1790)	CR	Sch.-I
9	Anseriformes	Anatidae	Red-breasted Goose	*Branta ruficollis* (Pallas, 1769)	VU	Sch.-II
10	Galliformes	Phasianidae	Swamp Francolin	*Ortygornis gularis* (Temminck, 1815)	NT	Sch.-I
11	Phoenicopteriformes	Phoenicopteridae	Lesser Flamingo	*Phoeniconaias minor* (Geoffroy Saint-Hilaire, E, 1798)	NT	Sch.-II
12	Podicipediformes	Podicipedidae	Horned Grebe	*Podiceps auritus* (Linnaeus, 1758)	VU	Sch.-II
13	Gruiformes	Gruidae	Sarus Crane	*Grus antigone* (Linnaeus, 1758)	VU	Sch.-I
14	Gruiformes	Gruidae	Siberian Crane	*Leucogeranus leucogeranus* (Pallas, 1773)	CR	Sch.-I
15	Charadriiformes	Burhinidae	Beach Thick-knee	*Esacus magnirostris* (Vieillot, 1818)	NT	Sch.-II
16	Charadriiformes	Burhinidae	Great Thick-knee	*Esacus recurvirostris* (Cuvier, 1829)	NT	Sch.-II
17	Charadriiformes	Haematopodidae	Eurasian Oystercatcher	*Haematopus ostralegus* Linnaeus, 1758	NT	Sch.-II
18	Charadriiformes	Charadriidae	Grey Plover	*Pluvialis squatarola* (Linnaeus, 1758)	VU	Sch.-II
19	Charadriiformes	Charadriidae	Northern Lapwing	*Vanellus vanellus* (Linnaeus, 1758)	NT	Sch.-II
20	Charadriiformes	Charadriidae	River Lapwing	*Vanellus duvaucelii* (Lesson, 1826)	NT	Sch.-II
21	Charadriiformes	Charadriidae	Sociable Lapwing	*Vanellus gregarius* (Pallas, 1771)	CR	Sch.-I
22	Charadriiformes	Scolopacidae	Asian Dowitcher	*Limnodromus semipalmatus*) (Blyth, 1848	NT	Sch.-II
23	Charadriiformes	Scolopacidae	Bar-tailed Godwit	*Limosa limosa* (Linnaeus, 1758)	NT	Sch.-II
24	Charadriiformes	Scolopacidae	Black-tailed Godwit	*Limosa lapponica* (Linnaeus, 1758)	NT	Sch.-II
25	Charadriiformes	Scolopacidae	Broad-billed Sandpiper	*Calidris falcinellus* (Pontoppidan, 1763)	VU	Sch.-II
26	Charadriiformes	Scolopacidae	Curlew Sandpiper	*Calidris ferruginea* (Pontoppidan, 1763)	VU	Sch.-II
27	Charadriiformes	Scolopacidae	Eurasian Curlew	*Numenius arquata* (Linnaeus, 1758)	NT	Sch.-II
28	Charadriiformes	Scolopacidae	Dunlin	*Calidris alpina* (Linnaeus, 1758)	NT	Sch.-II
29	Charadriiformes	Scolopacidae	Great Knot	*Calidris tenuirostris* (Horsfield, 1821)	EN	Sch.-I

S.No.	Order	Family	Common Name	Scientific Name	IUCN Red list status	IWPA Status
30	Charadriiformes	Scolopacidae	Long-billed dowitcher	*Limnodromus scolopaceus* (Say, 1822)	NT	Sch.-II
31	Charadriiformes	Scolopacidae	Nordmann's Greenshank	*Tringa guttifer* (Nordmann, 1835)	EN	Not listed
32	Charadriiformes	Scolopacidae	Ruddy Turnstone	*Arenaira interpres* (Linnaeus, 1758)	NT	Sch.-II
33	Charadriiformes	Scolopacidae	Red Knot	*Calidris canutus* (Linnaeus, 1758)	NT	Sch.-II
34	Charadriiformes	Scolopacidae	Red-necked Stint	*Calidris ruficollis* (Pallas, 1776)	NT	Sch.-II
35	Charadriiformes	Scolopacidae	Spoon-billed Sandpiper	*Calidris pygmaea* (Linnaeus, 1758)	CR	Sch.-I
36	Charadriiformes	Scolopacidae	Wood Snipe	*Gallinago nemoricola* Hodgson, 1836	VU	Sch.-I
37	Charadriiformes	Laridae	Black-bellied Tern	*Sterna acuticauda* Gray, JE, 1831	EN	Sch.-I
38	Charadriiformes	Laridae	Indian Skimmer	*Rynchops albicollis* Swainson, 1838	EN	Sch.-I
39	Charadriiformes	Laridae	River Tern	*Sterna aurantia* Gray, JE, 1831	VU	Sch.-I
40	Ciconiiformes	Ciconiidae	Black-necked Stork	*Ephippiorhynchus asiaticus* (Latham, 1790)	NT	Sch.-II
41	Ciconiiformes	Ciconiidae	Greater Adjutant	*Leptoptilos dubius* (Gmelin, JF, 1789)	NT	Sch.-I
42	Ciconiiformes	Ciconiidae	Lesser Adjutant	*Leptoptilos javanicus* (Horsfield, 1821)	NT	Sch.-I
43	Ciconiiformes	Ciconiidae	Woolly-necked Stork	*Ciconia episcopus* (Boddaert, 1783)	NT	Sch.-II
44	Pelecaniformes	Pelecanidae	Dalmatian Pelican	*Pelecanus crispus* Bruch, 1832	NT	Sch.-II
45	Pelecaniformes	Pelecanidae	Spot-billed Pelican	*Pelecanus philippensis* Gmelin, JF, 1789	NT	Sch.-II
46	Pelecaniformes	Ardeidae	White-bellied Heron	*Ardea insignis* Hume, 1878	CR	Sch.-I
47	Accipitriformes	Accipitridae	Eastern Imperial Eagle	*Aquila heliaca* Savigny, 1809	VU	Sch.-I
48	Accipitriformes	Accipitridae	Greater Spotted Eagle	*Clanga clanga* (Pallas, 1811)	VU	Sch.-I
49	Accipitriformes	Accipitridae	Grey-headed Fish Eagle	*Haliaeetus ichthyaetus* (Horsfield, 1821)	NT	Sch.-I
50	Accipitriformes	Accipitridae	Lesser Fish Eagle	*Haliaeetus humilis* (Müller and Schlegel, 1841)	NT	Sch.-I
51	Accipitriformes	Accipitridae	Pallas's Fish Eagle	*Haliaeetus leucoryphus* (Pallas, 1771)	EN	Sch.-I
52	Accipitriformes	Accipitridae	Steppe Eagle	*Aquila nipalensis* Hodgson, 1833	EN	Sch.-I
53	Coraciiformes	Alcedinidae	Black-capped Kingfisher	*Halcyon pileata* (Boddaert, 1783)	VU	Sch.-II

APPENDIX 2: Distribution of aquatic avifauna based on reviewed studies in the Ganga River Basin states

Order	Family	Common Name	Scientific Name	Feeding Guild	IUCN Red list status	IWPA status	Residential status	Bihar	Chhattisgarh	Delhi	Haryana	Himachal Pradesh	Jharkhand	Madhya Pradesh	Rajasthan	Uttar Pradesh	Uttarakhand	West Bengal
Anseriformes	Anatidae	Baer's Pochard	*Aythya baeri* (Radde, 1863)	H	CR	Sch.-I	WM	+		+						+		+
		Baikal Teal	*Sibirionetta formosa* (Georgi, 1775)	H	LC	Sch.-II	WM	+		+				+		+		+
		Bar-headed Goose	*Anser indicus* (Latham, 1790)	H	LC	Sch.-II	R/WM	+	+	+	+		+	+	+	+	+	+
		Taiga Bean-Goose	*Anser fabalis* (Latham, 1787)	H	LC	Sch.-II	WM										+	
		Common Goldeneye	*Bucephala clangula* (Linnaeus, 1758)	C	LC	Sch.-II	WM	+								+		+
		Common Merganser	*Mergus merganser* Linnaeus, 1758	C	LC	Sch.-II	R/WM	+						+		+	+	+
		Common Pochard	*Aythya ferina* (Linnaeus, 1758)	H/C	VU	Sch.-I	WM	+	+	+	+	+		+	+	+	+	+
		Common Shelduck	*Tadorna tadorna* (Linnaeus, 1758)	C/H	LC	Sch.-II	WM	+		+	+	+		+	+	+		+
		Common Teal	*Anas crecca* Linnaeus, 1758	H	LC	Sch.-II	WM	+	+	+	+	+	+	+	+	+	+	+
		Cotton Pygmy Goose	*Nettapus coromandelianus* Gmelin, JF, 1789)	H/C	LC	Sch.-I	R/LM	+	+	+	+	+	+	+	+	+	+	+
		Eastern Spot-billed Duck	*Anas zonorhyncha* Swinhoe, 1866	H/C	LC	Sch.-II	WM	+										
		Eurasian Wigeon	*Mareca penelope* (Linnaeus, 1758)	H/C	LC	Sch.-II	WM	+	+	+	+		+	+	+	+	+	+
		Falcated Duck	*Mareca falcata* (Georgi, 1775)	H	LC	Sch.-II	WM	+		+	+					+	+	+
		Ferruginous Duck	*Aythya nyroca* (Güldenstädt, 1770)	O	NT	Sch.-II	R/WM	+	+	+	+			+	+	+	+	+
		Fulvous Whistling Duck	*Dendrocygna bicolor* (Vieillot, 1816)	H	LC	Sch.-I	R/LM	+					+	+		+		+
		Gadwall	*Mareca strepera* (Linnaeus, 1758)	H/C	LC	Sch.-II	WM	+	+	+	+	+	+	+	+	+	+	+
		Garganey	*Spatula querquedula* (Linnaeus, 1758)	H/C	LC	Sch.-II	WM	+	+	+	+	+	+	+	+	+	+	+
		Greater Scaup	*Aythya marila* (Linnaeus, 1761)	C/H	LC	Sch.-II	WM			+	+			+		+		
		Greater White-fronted Goose	*Anser albifrons* (Scopoli, 1769)	H	LC	Sch.-II	WM	+		+						+		+
		Greylag Goose	*Anser anser* (Linnaeus, 1758)	H	LC	Sch.-II	WM	+	+	+	+		+	+	+	+	+	+
		Indian Spot-billed Duck	*Anas poecilorhyncha* Forster, JR, 1781	H/C	LC	Sch.-II	R/LM	+	+	+	+	+		+	+	+	+	+
		Knob-billed Duck	*Sarkidiornis melanotos* (Pennant, 1769)	H/C	LC	Sch.-II	R/LM	+	+	+	+	+	+	+	+	+	+	+
		Lesser Whistling Duck	*Dendrocygna javanica* (Horsfield, 1821)	H/C	LC	Sch.-II	R/LM	+	+	+	+	+	+	+	+	+	+	+

Order	Family	Common Name	Scientific Name	Feeding Guild	IUCN Red list status	IWPA status	Residential status	Bihar	Chhattisgarh	Delhi	Haryana	Himachal Pradesh	Jharkhand	Madhya Pradesh	Rajasthan	Uttar Pradesh	Uttarakhand	West Bengal
Anseriformes	Anatidae	Lesser White-fronted Goose	*Anser erythropus* (Linnaeus, 1758)\	H	VU	Sch.-II	WM			+						+		
		Long-tailed Duck	*Clangula hyemalis* (Linnaeus, 1758)	C	VU	Sch.-II	WM										+	
		Mallard	*Anas platyrhynchos* Linnaeus, 1758	H/C	LC	Sch.-II	R/WM	+		+	+	+	+	+	+	+	+	+
		Marbled Duck	*Marmaronetta angustirostris* (Ménétriés, 1832)	H/C	NT	Sch.-I	WM	+		+						+	+	
		Northern Pintail	*Anas acuta* Linnaeus, 1758	H/C	LC	Sch.-II	WM	+	+	+	+	+	+	+	+	+	+	+
		Northern Shoveler	*Spatula clypeata* (Linnaeus, 1758)	C/H	LC	Sch.-II	WM	+	+	+	+		+	+	+	+	+	+
		Pink-headed Duck	*Rhodonessa caryophyllacea* (Latham, 1790)	O	CR	Sch.-I	R	+								+	+	+
		Red-breasted Goose	*Branta ruficollis* (Pallas, 1769)	H	VU	Sch.-II	WM									+		
		Red-crested Pochard	*Netta rufina* (Pallas, 1773)	H/C	LC	Sch.-II	WM	+	+	+	+		+	+	+	+	+	+
		Ruddy Shelduck	*Tadorna ferruginea* (Pallas, 1764)	O	LC	Sch.-II	R/ WM/ PM	+	+	+	+		+	+	+	+	+	+
		Smew	*Mergellus albellus* (Linnaeus, 1758)	C	LC	Sch.-II	WM			+						+		+
		Sushkin's Goose*	*Anser neglectus* Suskin, 1897	H	EX	Not listed	WM	+										
		Tufted Duck	*Aythya fuligula* (Linnaeus, 1758)	C/H	LC	Sch.-II	WM	+	+	+	+		+	+	+	+	+	+
		Tundra Swan	*Cygnus columbianus* (Ord, 1815)	H	LC	Sch.-II	WM				+							
Galliformes	Phasianidae	Swamp Francolin	*Ortygornis gularis* (Temminck, 1815)	O	NT	Sch.-I	R	+								+		
Phoenicopteriformes	Phoenicopteridae	Greater Flamingo	*Phoenicopterus roseus* Pallas, 1811	C/H	LC	Sch.-II	R/WM/ LM	+		+	+			+	+	+		
		Lesser Flamingo	*Phoeniconaias minor* (Geoffroy Saint-Hilaire, E, 1798)	H/C	NT	Sch.-II	R/LM			+				+	+	+		
Podicipediformes	Podicipedidae	Black-necked Grebe	*Podiceps nigricollis* Brehm, CL, 1831	C	LC	Sch.-II	WM			+				+	+	+		+
		Great Crested Grebe	*Podiceps cristatus* (Linnaeus, 1758)	C/H	LC	Sch.-II	R/WM	+	+	+	+		+	+	+	+	+	+
		Horned Grebe	*Podiceps auritus* (Linnaeus, 1758)	C	VU	Sch.-II	WM			+							+	
		Little Grebe	*Tachybaptus ruficollis* (Pallas, 1764)	C	LC	Sch.-II	R/LM	+	+	+	+	+	+	+	+	+	+	+
		Red-necked Grebe	*Podiceps grisegena* (Boddaert, 1783)	C	LC	Sch.-II	WM											+

Order	Family	Common Name	Scientific Name	Feeding Guild	IUCN Red list status	IWPA status	Residential status	Bihar	Chhattisgarh	Delhi	Haryana	Himachal Pradesh	Jharkhand	Madhya Pradesh	Rajasthan	Uttar Pradesh	Uttarakhand	West Bengal
Gruiformes	Rallidae	Baillon's Crake	*Zapornia pusilla* (Pallas, 1776)	H/C	LC	Sch.-II	R/WM		+	+				+	+	+	+	+
		Brown Crake	*Zapornia akool* (Sykes, 1832)	C/H	LC	Sch.-II	R/LM		+	+				+	+	+		
		Brown-cheeked Rail	*Rallus indicus* Blyth, 1849	O	LC	Sch.-II	WM	+										
		Common Moorhen	*Gallinula chloropus* (Linnaeus, 1758)	O	LC	Sch.-II	R/WM	+	+	+	+	+	+	+	+	+	+	+
		Eurasian Coot	*Fulica atra* Linnaeus, 1758	H/C	LC	Sch.-II	R/WM	+	+	+	+	+	+	+	+	+	+	+
		Grey-headed Swamphen	*Porphyrio poliocephalus* (Latham, 1801)	H/C	LC	Sch.-II	R/LM	+	+	+	+		+	+	+	+	+	+
		Little Crake	*Zapornia parva* (Scopoli, 1769)	C	LC	Sch.-II	WM						+					
		Ruddy-breasted Crake	*Zapornia fusca* (Linnaeus, 1766)	C/H	LC	Sch.-II	R/WM			+					+	+	+	+
		Slaty-breasted Rail	*Lewinia striata* (Linnaeus, 1766)	O	LC	Sch.-II	R/LM		+							+		+
		Slaty-legged Crake	*Rallina eurizonoides* (Lafresnaye, 1845)	O	LC	Sch.-II	R/LM		+						+			
		Spotted Crake	*Porzana porzana* (Linnaeus, 1766)	C	LC	Sch.-II	WM			+						+		
		Water Rail	*Rallus aquaticus* Linnaeus, 1758	C/H	LC	Sch.-II	R/WM	+		+					+			+
		Watercock	*Gallicrex cinerea* (Gmelin, JF, 1789)	H/C	LC	Sch.-II	R/LM	+	+	+					+	+	+	+
		White-breasted Waterhen	*Amaurornis phoenicurus* (Pennant, 1769)	O	LC	Sch.-II	R	+	+	+	+	+	+	+	+	+	+	+
	Gruidae	Common Crane	*Grus grus* (Linnaeus, 1758)	H/C	LC	Sch.-I	WM	+		+			+	+	+	+		
		Demoiselle Crane	*Anthropoides virgo* (Linnaeus, 1758)	H	LC	Sch.-I	WM			+	+		+	+	+	+	+	
		Sarus Crane	*Antigone antigone* (Linnaeus, 1758)	H/C	VU	Sch.-I	R/LM	+	+	+	+		+	+	+	+	+	
		Siberian Crane	*Leucogeranus leucogeranus* (Pallas, 1773)	H	CR	Sch.-I	WM							+	+			
Charadriiformes	Burhinidae	Beach Thick-knee	*Esacus magnirostris* (Vieillot, 1818)	C	NT	Sch.-II	R								+			+
		Great Thick-knee	*Esacus recurvirostris* (Cuvier, 1829)	C	NT	Sch.-II	R/LM		+	+			+	+	+	+	+	+
		Indian Thick-knee	*Burhinus indicus* (Salvadori, 1865)	C	LC	Sch.-II	R/LM	+	+	+	+		+	+	+	+	+	

Order	Family	Common Name	Scientific Name	Feeding Guild	IUCN Red list status	IWPA status	Residential status	Bihar	Chhattisgarh	Delhi	Haryana	Himachal Pradesh	Jharkhand	Madhya Pradesh	Rajasthan	Uttar Pradesh	Uttarakhand	West Bengal
Charadriiformes	Recurvirostridae	Black-winged Stilt	*Himantopus himantopus* (Linnaeus, 1758)	C/H	LC	Sch.-II	R/LM	+	+	+	+	+	+	+	+	+	+	+
		Pied Avocet	*Recurvirostra avosetta* Linnaeus, 1758	C	LC	Sch.-II	R/WM	+		+	+			+	+	+	+	
	Ibidorhynchidae	Ibisbill	*Ibidorhyncha struthersii* Vigors, 1832	C	LC	Sch.-II	R/AM										+	
	Haematopodidae	Eurasian Oystercatcher	*Haematopus ostralegus* Linnaeus, 1758	C	NT	Sch.-II	WM											+
	Charadriidae	Common Ringed Plover	*Charadrius hiaticula* Linnaeus, 1758	C	LC	Sch.-II	WM			+		+		+	+	+		+
		Caspian Plover	*Charadrius asiaticus* Pallas, 1773	C	LC	Sch.-II	WM			+								
		Eurasian Golden Plover	*Pluvialis apricaria* (Linnaeus, 1758)	C/H	LC	Sch.-II	WM	+										
		Greater Sand Plover	*Charadrius leschenaultii* Lesson, 1826	C	LC	Sch.-II	WM			+					+			+
		Grey Plover	*Pluvialis squatarola* (Linnaeus, 1758)	C	VU	Sch.-II	WM			+				+	+	+		+
		Grey-headed Lapwing	*Vanellus cinereus* (Blyth, 1842)	C	LC	Sch.-II	WM	+	+	+			+	+		+	+	+
		Kentish Plover	*Charadrius alexandrinus* Linnaeus, 1758	C	LC	Sch.-II	R/WM	+	+	+	+		+	+	+	+	+	+
		Lesser Sand Plover	*Charadrius mongolus* Pallas, 1776	C	LC	Sch.-II	R/WM	+		+				+	+			+
		Little Ringed Plover	*Charadrius dubius* Scopoli, 1786	C	LC	Sch.-II	R/WM	+	+	+	+	+	+	+	+	+	+	+
		Long-billed Plover	*Charadrius placidus* Gray, JE and Gray, GR, 1863	C	LC	Sch.-II	WM									+	+	
		Northern Lapwing	*Vanellus vanellus* (Linnaeus, 1758)	C	NT	Sch.-II	WM	+		+				+	+	+	+	+
		Pacific Golden Plover	*Pluvialis fulva* (Gmelin, JF, 1789)	C/H	LC	Sch.-II	WM	+		+	+		+	+	+			+
		Red-wattled Lapwing	*Vanellus indicus* (Boddaert, 1783)	C	LC	Sch.-II	R/LM	+	+	+	+	+	+	+	+	+	+	+

Order	Family	Common Name	Scientific Name	Feeding Guild	IUCN Red list status	IWPA status	Residential status	Bihar	Chhattisgarh	Delhi	Haryana	Himachal Pradesh	Jharkhand	Madhya Pradesh	Rajasthan	Uttar Pradesh	Uttarakhand	West Bengal
Charadriiformes	Charadriidae	River Lapwing	*Vanellus duvaucelii* (Lesson, 1826)	C	NT	Sch.-II	R/LM	+	+	+	+	+	+	+	+	+	+	+
		Sociable Lapwing	*Vanellus gregarius* (Pallas, 1771)	I	CR	Sch.-I	WM			+					+	+		
		White-tailed Lapwing	*Vanellus leucurus* (Lichtenstein, MHC, 1823)	C	LC	Sch.-II	WM			+	+			+	+	+	+	
		Yellow-wattled Lapwing	*Vanellus malabaricus* (Boddaert, 1783)	C	LC	Sch.-II	R/LM	+	+	+	+	+	+	+	+	+	+	+
Charadriiformes	Rostratulidae	Greater Painted -snipe	*Rostratula benghalensis* (Linnaeus, 1758)	O	LC	Sch.-II	R/LM	+	+	+	+			+	+	+	+	+
Charadriiformes	Jacanidae	Bronze-winged Jacana	*Metopidius indicus* (Latham, 1790)	H/C	LC	Sch.-II	R	+	+	+	+		+	+	+	+	+	+
		Pheasant-tailed Jacana	*Hydrophasianus chirurgus* (Scopoli, 1786)	H/C	LC	Sch.-II	R/LM /SM	+	+	+	+		+	+	+	+	+	+
Charadriiformes	Scolopacidae	Asian Dowitcher	*Limnodromus semipalmatus* (Blyth, 1848)	C	NT	Sch.-II	WM			+					+			+
		Bar-tailed Godwit	*Limosa lapponica* (Linnaeus, 1758)	C	NT	Sch.-II	WM	+	+	+								+
		Black-tailed Godwit	*Limosa limosa* (Linnaeus, 1758)	C/H	NT	Sch.-II	WM	+	+	+	+			+	+	+		+
		Broad-billed Sandpiper	*Calidris falcinellus* (Pontoppidan, 1763)	C	VU	Sch.-II	WM	+		+					+			+
		Common Greenshank	*Tringa nebularia* (Gunnerus, 1767)	C	LC	Sch.-I	WM	+	+	+	+	+	+	+	+	+	+	+
		Common Redshank	*Tringa totanus* (Linnaeus, 1758)	C	LC	Sch.-II	R/WM	+	+	+	+			+	+	+	+	+
		Common Sandpiper	*Actitis hypoleucos* (Linnaeus, 1758)	C	LC	Sch.-II	R/WM	+	+	+	+	+	+	+	+	+	+	+
		Common Snipe	*Gallinago gallinago* (Linnaeus, 1758)	C	LC	Sch.-II	R/WM	+	+	+	+		+	+	+	+		+
		Curlew Sandpiper	*Calidris ferruginea* (Pontoppidan, 1763)	C	VU	Sch.-II	WM	+		+	+			+	+	+		+
		Dunlin	*Calidris alpina* (Linnaeus, 1758)	C	NT	Sch.-II	WM	+		+				+	+	+		+
		Eurasian Curlew	*Numenius arquata* (Linnaeus, 1758)	C	NT	Sch.-II	WM	+	+	+	+		+	+	+	+	+	+
		Eurasian Woodcock	*Scolopax rusticola* Linnaeus, 1758	C/H	LC	Sch.-II	R/AM/ WM								+		+	
		Great Knot	*Calidris tenuirostris* (Horsfield, 1821)	C	EN	Sch.-I	WM											+

Order	Family	Common Name	Scientific Name	Feeding Guild	IUCN Red list status	IWPA status	Residential status	Bihar	Chhattisgarh	Delhi	Haryana	Himachal Pradesh	Jharkhand	Madhya Pradesh	Rajasthan	Uttar Pradesh	Uttarakhand	West Bengal
Charadriiformes	Scolopacidae	Green Sandpiper	*Tringa ochropus* Linnaeus, 1758	C	LC	Sch.-II	R/WM	+	+	+	+		+	+	+	+	+	+
		Jack Snipe	*Lymnocryptes minimus* (Brünnich, 1764)	C/H	LC	Sch.-II	WM	+	+	+				+	+	+		+
		Little Stint	*Calidris minuta* (Leisler, 1812)	C/H	LC	Sch.-II	WM	+	+	+	+		+	+	+	+	+	+
		Long-billed Dowitcher	*Limnodromus scolopaceus* (Say, 1822)	C	NT	Sch.-II	WM			+								
		Long-toed Stint	*Calidris subminuta* (von Middendorff, 1853)	C	LC	Sch.-II	WM	+										
		Marsh Sandpiper	*Tringa stagnatilis* (Bechstein, 1803)	C	LC	Sch.-II	WM	+	+	+	+	+	+	+	+	+	+	+
		Nordmann's Greenshank	*Tringa guttifer* (Nordmann, 1835)	C	EN	Not listed	WM		+								+	
		Pin-tailed Snipe	*Gallinago stenura* (Bonaparte, 1831)	C	LC	Sch.-II	WM	+	+	+			+		+	+	+	+
		Red Knot	*Calidris canutus* (Linnaeus, 1758)	C	NT	Sch.-II	WM											+
		Red-necked Phalarope	*Phalaropus lobatus* (Linnaeus, 1758)	C	LC	Sch.-II	WM	+		+					+	+		
		Red-necked Stint	Calidris ruficollis (Pallas, 1776)	O	NT	Sch.-II	WM											+
		Ruddy Turnstone	*Arenaria interpres* (Linnaeus, 1758)	C	NT	Sch.-II	WM	+		+					+			+
		Ruff	*Calidris pugnax* (Linnaeus, 1758)	C/H	LC	Sch.-II	WM/PM	+		+	+			+	+	+		+
		Sanderling	*Calidris alba* (Pallas, 1764)	C	LC	Sch.-II	WM								+			+
		Solitary Sandpiper	*Tringa solitaria* Wilson, 1813	C	LC	Not listed	WM		+									
		Solitary Snipe	*Gallinago solitaria* Hodgson, 1831	C	LC	Sch.-II	R/AM/ WM										+	+
		Spoon-billed Sandpiper	*Calidris pygmaea* (Linnaeus, 1758)	C	CR	Sch.-I	WM											+
		Spotted Redshank	*Tringa erythropus* (Pallas, 1764)	C	LC	Sch.-II	WM	+		+	+			+	+	+		+
		Swinhoe's Snipe	*Gallinago megala* (Swinhoe, 1861)	C	LC	Sch.-II	WM											+
		Temminck's Stint	*Calidris temminckii* (Leisler, 1812)	C/H	LC	Sch.-II	WM	+	+	+	+		+	+	+	+	+	+
		Terek Sandpiper	*Xenus cinereus* (Güldenstädt, 1775)	C	LC	Sch.-II	WM/PM	+		+				+	+	+		+
		Whimbrel	*Numenius phaeopus* (Linnaeus, 1758)	C	LC	Sch.-II	WM	+		+								+
		Wood Sandpiper	*Tringa glareola* Linnaeus, 1758	C	LC	Sch.-II	WM	+	+	+	+		+	+	+	+	+	+
		Wood Snipe	*Gallinago nemoricola* Hodgson, 1836	C	VU	Sch.-I	R/AM/ WM		+							+		

Order	Family	Common Name	Scientific Name	Feeding Guild	IUCN Red list status	IWPA status	Residential status	Bihar	Chhattisgarh	Delhi	Haryana	Himachal Pradesh	Jharkhand	Madhya Pradesh	Rajasthan	Uttar Pradesh	Uttarakhand	West Bengal
Charadriiformes	Glareolidae	Collared Pratincole	*Glareola pratincola* (Linnaeus, 1766)	C	LC	Sch.-II	WM							+				
		Oriental Pratincole	*Glareola maldivarum* Forster, JR, 1795	C	LC	Sch.-II	R/LM/ SM		+	+					+	+		+
		Small Pratincole	*Glareola lactea* Temminck, 1820	C	LC	Sch.-II	R/LM	+	+	+	+			+	+	+	+	+
Charadriiformes	Laridae	Black Tern	*Chlidonias niger* (Linnaeus, 1758)	C	LC	Sch.-II	PM			+						+		
		Black-bellied Tern	*Sterna acuticauda* Gray, JE, 1831	C	EN	Sch.-I	R	+	+	+			+	+	+	+	+	+
		Black-headed Gull	*Chroicocephalus ridibundus* (Linnaeus, 1766)	C	LC	Sch.-II	R/WM	+	+	+	+		+	+	+	+	+	+
		Bridled Tern	*Onychoprion anaethetus* (Scopoli, 1786)	C	LC	Sch.-II	R											+
		Brown-headed Gull	*Chroicocephalus brunnicephalus* (Jerdon, 1840)	C	LC	Sch.-II	R/WM	+	+	+	+		+	+	+	+	+	+
		Caspian Gull	*Larus cachinnans* Pallas, 1811	C	LC	Sch.-II	WM/PM			+	+					+	+	+
		Caspian Tern	*Hydroprogne caspia* (Pallas, 1770)	C	LC	Sch.-II	WM	+								+		
		Common Tern	*Sterna hirundo* Linnaeus, 1758	C	LC	Sch.-II	R/WM	+		+						+		+
		Gull-billed Tern	*Gelochelidon nilotica* (Gmelin, JF, 1789)	C	LC	Sch.-I	WM	+	+	+				+	+	+		+
		Indian Skimmer	*Rynchops albicollis* Swainson, 1838	C	EN	Sch.-I	R/LM	+		+				+	+	+		+
		Lesser Black-backed Gull	*Larus fuscus* Linnaeus, 1758	C	LC	Sch.-II	WM			+					+	+		
		Little Gull	*Hydrocoloeus minutus* (Pallas, 1776)	C	LC	Sch.-II	WM			+						+		
		Little Tern	*Sternula albifrons* (Pallas, 1764)	C	LC	Sch.-II	R/WM	+	+	+				+	+	+	+	+
		Mew Gull	*Larus canus* Linnaeus, 1758	C	LC	Sch.-II	WM			+						+		
		Pallas's Gull	*Ichthyaetus ichthyaetus* (Pallas, 1773)	C	LC	Sch.-II	WM	+		+	+			+	+	+	+	+
		River Tern	*Sterna aurantia* Gray, JE, 1831	C	VU	Sch.-I	R	+	+	+	+		+	+	+	+	+	+
		Slender-billed Gull	*Chroicocephalus genei* (Breme, 1839)	C	LC	Sch.-II	WM	+		+						+		+
		Sooty Tern	*Onychoprion fuscatus* (Linnaeus, 1766)	C	LC	Sch.-II	R	+										
		Whiskered Tern	*Chlidonias hybrida* (Pallas, 1811)	C	LC	Sch.-II	R/WM/ PM	+	+	+	+		+	+	+	+	+	+
		White-winged Tern	*Chlidonias leucopterus* (Temminck, 1815)	C	LC	Sch.-II	WM/PM			+					+	+		

Order	Family	Common Name	Scientific Name	Feeding Guild	IUCN Red list status	IWPA status	Residential status	Bihar	Chhattisgarh	Delhi	Haryana	Himachal Pradesh	Jharkhand	Madhya Pradesh	Rajasthan	Uttar Pradesh	Uttarakhand	West Bengal
Ciconiiformes	Ciconiidae	Asian Openbill	*Anastomus oscitans* (Boddaert, 1783)	C	LC	Sch.-II	R/LM	+	+	+	+		+	+	+	+	+	+
		Black Stork	*Ciconia nigra* (Linnaeus, 1758)	C	LC	Sch.-II	WM/PM	+	+	+	+	+		+	+	+	+	+
		Black-necked Stork	*Ephippiorhynchus asiaticus* (Latham, 1790)	C	NT	Sch.-II	R	+		+	+			+	+	+	+	+
		Greater Adjutant	*Leptoptilos dubius* (Gmelin, JF, 1789)	O	NT	Sch.-I	R/LM	+		+			+		+	+		+
Ciconiiformes	Ciconiidae	Lesser Adjutant	*Leptoptilos javanicus* (Horsfield, 1821)	C	NT	Sch.-I	R/LM	+	+				+	+	+	+	+	+
		Painted Stork	*Mycteria leucocephala* (Pennant, 1769)	C	LC	Sch.-II	R/LM	+	+	+	+			+	+	+	+	+
		White Stork	*Ciconia ciconia* (Linnaeus, 1758)	C	LC	Sch.-I	WM	+		+	+	+		+	+	+		+
		Woolly-necked Stork	*Ciconia episcopus* (Boddaert, 1783)	C	NT	Sch.-II	R	+	+	+	+		+	+	+	+	+	+
Suliformes	Anhingidae	Oriental Darter	*Anhinga melanogaster* Pennant, 1769	C	NT	Sch.-II	R/LM	+	+	+	+	+	+	+	+	+	+	+
Suliformes	Phalacrocoracidae	Great Cormorant	*Phalacrocorax carbo* (Linnaeus, 1758)	C	LC	Sch.-II	R/WM	+	+	+	+	+	+	+	+	+	+	+
		Indian Cormorant	*Phalacrocorax fuscicollis* Stephens, 1826	C	LC	Sch.-II	R/LM	+	+	+	+	+	+	+	+	+	+	+
		Little Cormorant	*Microcarbo niger* (Vieillot, 1817)	C	LC	Sch.-II	R/LM	+	+	+	+	+	+	+	+	+	+	+
Pelecaniformes	Pelecanidae	Dalmatian Pelican	*Pelecanus crispus* Bruch, 1832	C	NT	Sch.-II	WM	+		+				+	+	+		
		Great White Pelican	*Pelecanus onocrotalus* Linnaeus, 1758	C	LC	Sch.-II	R/WM	+		+	+			+	+	+		
		Spot-billed Pelican	*Pelecanus philippensis* Gmelin, JF, 1789	C	NT	Sch.-II	R/LM	+						+	+	+		
Pelecaniformes	Ardeidae	Black Bittern	*Ixobrychus flavicollis* (Latham, 1790)	C	LC	Sch.-II	R/LM	+	+	+					+	+	+	+
		Black-crowned Night Heron	*Nycticorax nycticorax* (Linnaeus, 1758)	C	LC	Sch.-II	R/LM	+	+	+	+	+	+	+	+	+	+	+
		Cattle Egret	*Bubulcus ibis* (Linnaeus, 1758)	C	LC	Sch.-II	R/AM	+	+	+	+	+	+	+	+	+	+	+
		Chinese Pond Heron	*Ardeola bacchus* (Bonaparte, 1855)	C	LC	Sch.-II	R/LM											+
		Cinnamon Bittern	*Ixobrychus cinnamomeus* (Gmelin, JF, 1789)	C	LC	Sch.-I	R/LM	+	+	+	+		+	+		+	+	+

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Pelecaniformes	Ardeidae	Goliath Heron	*Ardea goliath* (Cretzschmar, 1829)	C	LC	Sch.-II	R											+
		Great Bittern	*Botaurus stellaris* (Linnaeus, 1758)	C	LC	Sch.-I	WM	+	+	+			+	+		+		+
		Great Egret	*Ardea alba* Linnaeus, 1758	C	LC	Sch.-II	R/LM	+	+	+	+	+	+	+	+	+	+	+
		Grey Heron	*Ardea cinerea* Linnaeus, 1758	C	LC	Sch.-II	R/WM	+	+	+	+	+	+	+	+	+	+	+
		Indian Pond Heron	*Ardeola grayii* (Sykes, 1832)	C	LC	Sch.-II	R/LM	+	+	+	+	+	+	+	+	+	+	+
		Intermediate Egret	*Ardea intermedia* Wagler, 1829	C	LC	Sch.-II	R/LM	+	+	+	+	+	+	+	+	+	+	+
		Little Bittern	*Ixobrychus minutus* (Linnaeus, 1766)	C	LC	Sch.-II	R/LM	+							+	+		
		Little Egret	*Egretta garzetta* (Linnaeus, 1766)	C	LC	Sch.-II	R/LM	+	+	+	+	+	+	+	+	+	+	+
		Pacific Reef Egret	*Egretta sacra* (Gmelin, JF, 1789)	C	LC	Sch.-II	R								+			
		Purple Heron	*Ardea purpurea* Linnaeus, 1766	C	LC	Sch.-II	R/LM	+	+	+	+	+	+	+	+	+	+	+
		Striated Heron	*Butorides striata* (Linnaeus, 1758)	C	LC	Sch.-II	R	+	+	+	+	+	+	+	+	+	+	+
		Western Reef Egret	*Egretta gularis* (Bosc, 1792)	C	LC	Sch.-II	R/LM	+		+	+			+		+		
		White-bellied Heron	*Ardea insignis* Hume, 1878	C	CR	Sch.-I	R	+										
		Yellow Bittern	*Ixobrychus sinensis* (Gmelin, JF, 1789)	C	LC	Sch.-II	R/LM	+	+	+				+	+	+	+	+
Pelecaniformes	Threskiornithidae	Black-headed Ibis	*Threskiornis melanocephalus* (Latham, 1790)	C	LC	Sch.-II	R/LM	+	+	+	+	+	+	+	+	+	+	+
		Eurasian Spoonbill	*Platalea leucorodia* Linnaeus, 1758	C	LC	Sch.-I	R	+	+	+	+			+	+	+	+	+
		Glossy Ibis	*Plegadis falcinellus* (Linnaeus, 1766)	C	LC	Sch.-II	R/WM/ LM	+	+	+	+			+	+	+	+	+
		Red-naped Ibis	*Pseudibis papillosa* (Temminck, 1824)	C	LC	Sch.-II	R	+	+	+	+		+	+	+	+	+	+
Accipitriformes	Pandionidae	Osprey	*Pandion haliaetus* (Linnaeus, 1758)	C	LC	Sch.-I	R/WM	+	+	+	+			+	+	+	+	+

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Accipitriformes	Accipitridae	Brahminy Kite	*Haliastur indus* (Boddaert, 1783)	C	LC	Sch.-I	R/LM	+	+	+	+		+	+	+	+	+	+
		Eastern Imperial Eagle	*Aquila heliaca* Savigny, 1809	C	VU	Sch.-I	WM	+		+					+			
		Greater Spotted Eagle	*Clanga clanga* (Pallas, 1811)	C	VU	Sch.-I	R/WM	+		+	+			+	+	+		+
		Grey-headed Fish Eagle	*Haliaeetus ichthyaetus* (Horsfield, 1821)	C	NT	Sch.-I	R		+	+			+		+	+		+
		Lesser Fish Eagle	*Haliaeetus humilis* (Müller and Schlegel, 1841)	C	NT	Sch.-I	R/AM									+	+	
		Pallas's Fish Eagle	*Haliaeetus leucoryphus* (Pallas, 1771)	C	EN	Sch.-I	R/WM	+		+	+		+	+	+	+	+	+
		Steppe Eagle	*Aquila nipalensis* Hodgson, 1833	C	EN	Sch.-I	WM	+		+	+	+			+	+	+	
		Western Marsh Harrier	*Circus aeruginosus* (Linnaeus, 1758)	C	LC	Sch.-I	WM	+	+	+	+		+	+	+	+	+	+
		White-bellied Sea-Eagle	*Haliaeetus leucogaster* (Gmelin, JF, 1788)	C	LC	Sch.-I	WM											+
		White-tailed Sea Eagle	*Haliaeetus albicilla* (Linnaeus, 1758)	C	LC	Sch.-I	WM			+	+					+	+	+
Strigiformes	Strigidae	Brown Fish Owl	*Ketupa zeylonensis* (Gmelin, JF, 1788)	C	LC	Sch.-I	R	+	+	+		+		+	+	+	+	
		Tawny Fish Owl	*Ketupa flavipes* (Hodgson, 1836)	C	LC	Sch.-I	R										+	
Coraciiformes	Alcedinidae	Black-capped Kingfisher	*Halcyon pileata* (Boddaert, 1783)	C	VU	Sch.-II	R/LM	+						+		+		
		Blue-eared Kingfisher	*Alcedo meninting* Horsfield, 1821	C	LC	Sch.-II	R					+	+				+	+
		Collared Kingfisher	*Todiramphus chloris* (Boddaert, 1783)	C	LC	Sch.-II	R											+
		Common Kingfisher	*Alcedo atthis* (Linnaeus, 1758)	C	LC	Sch.-II	R	+	+	+	+	+	+	+	+	+	+	+
		Crested Kingfisher	*Megaceryle lugubris* (Temminck, 1834)	C	LC	Sch.-II	R	+				+					+	
		Pied Kingfisher	Ceryle rudis (Linnaeus, 1758)	C	LC	Sch.-II	R	+	+	+	+	+	+	+	+	+	+	+
		Stork-billed Kingfisher	*Pelargopsis capensis* (Linnaeus, 1766)	C	LC	Sch.-II	R	+	+			+		+	+	+	+	+
		White-throated Kingfisher	*Halcyon smyrnensis* (Linnaeus, 1758)	C	LC	Sch.-II	R/LM	+	+	+	+	+	+	+	+	+	+	+

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Coraciiformes	Meropidae	Blue-cheeked Bee-eater	*Merops persicus* Pallas, 1773	I	LC	Sch.-II	SM/PM			+	+	+		+	+	+		
		Blue-tailed Bee-eater	*Merops philippinus* Linnaeus, 1767	I	LC	Sch.-II	R/WM	+		+	+		+	+	+	+	+	+
		Chestnut-headed Bee-eater	*Merops leschenaulti* Vieillot, 1817	I	LC	Sch.-II	R	+	+	+		+	+		+	+	+	
Falconiformes	Falconidae	Peregrine Falcon	*Falco peregrinus* Tunstall, 1771	C	LC	Sch.-I	R/WM	+	+	+				+	+	+	+	+
Passeriformes	Hirundinidae	Barn Swallow	*Hirundo rustica* Linnaeus, 1758	I	LC	Sch.-II	R/WM	+	+	+	+	+	+	+	+	+	+	+
		Grey-throated Martin	*Riparia chinensis* (Gray, JE, 1830)	I	LC	Sch.-II	R/LM	+	+	+	+	+		+	+	+	+	+
		Pale Martin	*Riparia diluta* (Sharpe and Wyatt, 1893)	I	LC	Sch.-II	R/WM	+		+	+					+		
		Red-rumped Swallow	*Cecropis daurica* (Laxmann, 1769)	I	LC	Sch.-II	R/WM/ SM	+	+	+	+	+	+	+	+	+	+	+
		Sand Martin	*Riparia riparia* (Linnaeus, 1758)	I	LC	Sch.-II	R/WM	+	+	+	+	+		+		+		+
		Streak-throated Swallow	*Petrochelidon fluvicola* (Blyth, 1855)	I	LC	Sch.-II	R/SM	+	+	+	+	+		+	+	+	+	+
		Wire-tailed Swallow	*Hirundo smithii* Leach, 1818	I	LC	Sch.-II	R/SM	+	+	+	+	+	+	+	+	+	+	+
Passeriformes	Muscicapidae	Black-backed Forktail	*Enicurus immaculatus* (Hodgson, 1836)	C	LC	Sch.-II	R										+	
		Little Forktail	*Enicurus scouleri* Vigors, 1832	C	LC	Sch.-II	R/AM					+					+	
		Plumbeous Water Redstart	*Phoenicurus fuliginosus* Vigors, 1831	C/H	LC	Sch.-II	R/AM	+		+		+				+	+	
		Slaty-backed Forktail	*Enicurus schistaceus* (Hodgson, 1836)	C	LC	Sch.-II	R/AM										+	
		Spotted Forktail	*Enicurus maculatus* Vigors, 1831	C	LC	Sch.-II	R/AM					+					+	
		White-capped Redstart	*Phoenicurus leucocephalus* Vigors, 1831	C/H	LC	Sch.-II	R/WM/ AM	+		+		+			+		+	
		White-tailed Stonechat	*Saxicola leucurus* (Blyth, 1847)	C	LC	Sch.-II	R/LM			+						+		
Cinclidae		Brown Dipper	*Cinclus pallasii* Temminck, 1820	C	LC	Sch.-II	R/AM					+					+	

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	Motacillidae	Citrine Wagtail	*Motacilla citreola* Pallas, 1776	C	LC	Sch.-II	R/WM/ AM	+	+	+	+		+	+	+	+	+	+
		Grey Wagtail	*Motacilla cinerea* Tunstall, 1771	C	LC	Sch.-II	R/WM/ AM	+	+	+	+	+	+	+	+	+	+	+
		Red-throated Pipit	*Anthus cervinus* (Pallas, 1811)	C	LC	Sch.-II	PM			+						+		
		Rosy Pipit	*Anthus roseatus* Blyth, 1847	C	LC	Sch.-II	R/WM/ AM	+	+	+	+					+	+	
		Water Pipit	*Anthus spinoletta* (Linnaeus, 1758)	C	LC	Sch.-II	WM			+	+		+	+				
		Western Yellow Wagtail	*Motacilla flava* Linnaeus, 1758	C	LC	Sch.-II	R/WM/ AM/PM	+	+	+	+	+	+	+	+	+	+	+
		White Wagtail	*Motacilla alba* Linnaeus, 1758	C	LC	Sch.-II	R/WM/ PM	+	+	+	+	+	+	+	+	+	+	+
		White-browed Wagtail	*Motacilla maderaspatensis* Gmelin, JF, 1789	C	LC	Sch.-II	R	+	+	+	+	+	+	+	+	+	+	+

***Sushkin's Goose: Extinct / Taxonomic confusion on species level**



NOTE

NMCG

National Mission for Clean Ganga,
Department of Water Resources,
River Development & Ganga
Rejuvenation, Ministry of Jal Shakti,
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