



## The exposure risk of pollution on Water Birds of Eastern Uttar Pradesh

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### Abstract

The wetlands of Uttar Pradesh are resourceful station for water birds during migratory and breeding season, their biogeographic distribution is significant in the ecosystem of the area. The eastern zone of Uttar Pradesh (U.P.) is gifted with natural wetlands and nearby increase in industrialization and anthropogenic activities, had raised the contaminants of the area, which resulted in change of dynamics and distribution of local and migratory water bird diversity. In this study we have correlated the significance of water birds with wetland ecosystem. The information available on wetlands pollution, plume modification, weather variation, bird population, migration flyway used, breeding performance, feeding habits, contamination level in the eggs, tissues, feces of the region is used, the response had been segregated and analyzed. The results depict that water turbidity, habitat modifications, heavy metal deposition, micro plastics are stressors affecting the wetland health and affecting the decline of water bird diversity. The future conservation potential may be expanded based on geospatial applications and remote sensing technology for the wetland mapping and biomonitoring of the region. The polluted zones may be segregated for strategical survey and mitigation of polluted wetlands for restoration and conservation of natural habitat. The water birds may also be effective bio indicator of pollution in mapping structure, being the living entity nesting in the ecosystem, it indicates the endpoints of changing condition of the ecosystem.

**Keywords:** Migratory birds, pollution, conservation, geospatial network, biomonitoring

### Introduction

The eastern region Uttar Pradesh comprise of many natural wetlands, which are resourceful reservoirs of shallow rivers, freshwater marshes and, natural floodplain lands. The terrain is mostly flat with average elevation of 100m above the sea level. The major contributors for inflow are rivers like Ganges, Ghagra, Gomti, Yamuna, Son, Ken, Chambal, Betwa, Gandak, Ramganga which creates perennial sources of water. The different natural and manmade wetlands with morphological features are ponds, lakes, waterlogged areas, oxbow lake, canals, riverine basins and streams. The marshy and swamp locations are sites actively used by water birds for congregation, roosting, foraging and nesting by different species<sup>[3]</sup>. The exponential increase in an urbanization and industrialization had surged extension for xenobiotics in the environment and the extent of contamination present in the *terai* region of Uttar Pradesh, such as paint, manures, industrialization, discharge from mines, hazardous waste disposal, large scale use of fertilizers and pesticides and open incineration had increased during course of time. The anthropogenic activities also load the fresh water supply with contaminants, cause heavy metal deposition through soil and water<sup>[4]</sup>. These contaminants reach the higher tropic level of ecosystem through bacteria, macro invertebrates and small aquatic organisms, thus affecting the dependent avian fauna. The sources of pollutants like heavy metals, micro plastics, chemical pollutants etc., precipitating in the bio geological cycle and reaches the aquatic and terrestrial lives dependent on wetlands<sup>[4]</sup>. Long-term negligence of accumulated chemical pollutants, heavy metal deposition in feeding, foraging and breeding of water bird diversity causes adverse effects on their reproductive cycle and physiological damages. Heavy metal like Hg, Pb, As and Se are prominently found as trace on the birds of different feeding guilds and resident forest birds<sup>[5]</sup>. The bird diversity of Uttar Pradesh is rich and precious for the worldwide flora and fauna and at the risk of pollution. The

study aimed to find the importance of wetland habitats in the region, and key conservation issues for water bird diversity.

### Environmental Characteristics of Wetland in the region:

The state of Uttar Pradesh spans vast number of fresh water wetlands along with valuable Ramasar sites, the eastern Uttar Pradesh comprise of nineteen district sharing its borders with other states Bihar, Chhattisgarh, Madhya Pradesh and neighboring country Nepal. The eastern Uttar Pradesh districts namely Pilibhit, Shahjahanpur, Lakhimpur-Kheri, Sitapur, Bahraich, Brabanki, Faizabad, Gonda, Balrampur, Siddharthnagar, Basti, Sant Kabirnagar, Maharajganj, Kushinagar, Gorakhpur, Deoria, Shrawasti, Sultanpur and Pratapgarh, are rich in biodiversity where the wetlands occupancy is almost 5.16% of total geographic area, with variation in pre and post monsoon acquisition of data. The district wise wetland distribution is from 1.22% to 11.7% of the total geographic area<sup>[4]</sup>. The climate is subtropical where winters are dry and suitable for diversity of migratory birds. The predomination of rainfall over the region is visible by frequent flooding, droughts and soil salinity. All the nearby agriculture lands are majorly rice and wheat grown regions. Other crops grown are pigeon peas, mung, beans and barley. During winter mustard, rapeseed, peas and chickpeas are commonly grown crops which are providing feeding resources to nesting water birds in surrounding agriculture lands. The eastern forest circuit consist of Suheldeo Wildlife Sanctuary, Parvati Aranga Bird Sanctuary and Sohagibarwa Wildlife Sanctuary which include many districts having water reservoirs, aquatic habitat and vegetation (Table no.1). The landscape of eastern UP vegetation in the foothills of Himalayas covers the Terai region, which occasionally flood the region creating a water filled lands during the monsoon season. The various reports on water quality shows water turbidity changes in the wetland<sup>[6]</sup>.

**Table 1:** Different circuits of Uttar Pradesh and the regions under protected area [22]

S. No.	Circuit	Protected Areas
1	Western Wildlife Circuit	Amangarh, Bijnore; Shivalik, Saharanpur; Hastinapur Wls
2	Lion Safari and Riverine Circuit	Taj Nature Walk, Agra; Bear Rescue Centre, Agra; National Chambal Safari, Etawah; Lion Safari, Etawah
3	Terai Tiger Circuit	Chuka, Pilibhit Tiger Reserve; Dudhwa National Park; Katerniaghat Wls; Kishanpur Wls
4	Bundhelkhand Adventure Circuit	Devgarh, Lalitpur; Chitrakoot; Kalinjar, Banda; Mahavir Swami Wls; Vidyasagar Bird Sanctuary
5	Vindhya Mountain Circuit	Kaimur Wls; Chandraprabha Wls; Hathinala, Renukoot; Vijaygarh, Sonbhadra; Chunar/Vindham, Mirzapur
6.	Western Bird/Wetland Circuit	Okhla Bird Sanctuary, Surajpur Wetland, Patna Wls, Sarsai Nawar Wetland, Saman Wls, Manipur; Sur Sarovar Bird Sanctuary
7.	Central Bird/Wetland Circuit	Nawabganj Bird Sanctuary, Sandi Bird Sanctuary, Samaspur Bird Sanctuary, Lakh Bhabosi Bird Sanctuary
8.	Ganges Basin Circuit	Narora, Bulandshahar; Kannauj; Bithoor, Kanpur;
9.	Eastern Wildlife Circuit	Suheldev Wls; Sohagibarwa Wls; Parvati Aranga Bird Sanctuary

**Biodiversity of Water Birds in the region:** These wetlands of eastern Uttar Pradesh are home for many water and migratory birds, reaching the destination from Central Asian Flyway and Asian-Australian Flyway, along with more than sixty percent bird species of eastern region. The present population and species diversity of water birds had declined over a decade [9]. The breeds like Swamp Francolin *Francolinus gularis* and Bengal Florican *Houbaropsis bengalensis*. The endangered species Oriental White-backed Vulture *Gyps bengalensis*, Long-billed Vulture *G. indicus* and Slender-billed Vulture *G. tenuirostris* have been reported in this region [10]. Species like Bengal Florican, the white-headed ducks *Oxyura leucocephala* and Florican *Sypheotides indica* and Greater Adjutant *Leptoptilos dubius* has not been seen lately [11]. A record of two species the Black-necked Stork and Rufous-rumped Grassbird *Graminicola bengalensis* (earlier known as Large Grass Warbler), were majorly distributed birds in the region [12]. The presence of rarest bird of its genus, a resident of Mongolian mountains white throat Bushchat or Hodgson's Stonechat *Saxicola insignis*, was seen throughout the winter season in the region [13]. The wetlands of eastern UP were station to many marsh dependent duck species like Striated Marsh Warbler or Grass bird (*Megalurus palustris*), Bristled Grassbird *Chaetornis striatus*, Rufous-rumped Grassbird *Graminicola bengalensis*, Yellow-bellied Prinia *Prinia flaviventris*, Swamp Francolin *Francolinus gularis*, Bengal Florican *Houbaropsis bengalensis*, but lack of conservation and extreme anthropogenic activities have reduced their numbers in the wetlands. One species of pink headed duck *Rhodonessa caryophyllacea*, has become extinct from this place over the period of time. The reduction in number of migratory water birds arriving had also been reported, their arrival timing starts by the month of November and continues for two months before they start leaving towards their homes, this change is seen as critical point of climate change as the. Few migratory birds such as *Greylag Goose*, *Pintail*, *Common teal*, *Cotton teal*, *Red Crested pochard*, *Brahmini duck*, *Gadwall*, *Shoveller*, *Wigeon*, *Coot* and *Mallard* stay for longer period for breeding and nesting the eggs, and require ambient food habitats in the marshy wetlands and depend on various aquatic planktons and fishes for their survival. The Continuous industrialization and development had left the wetlands filled with various pollutants and heavy metals discharge in the aquatic ecosystem has inhibited the bird cycle in the region [13]. The local bird diversity of the area in Nawabganj Bird Sanctuary, includes *Sarus crane*, *Painted Stork*, *White Ibis*,

*Black Ibis*, *Dabchick*, *whistling teal*, *Open billed stork*, *White necked stork*, *Black necked stork*, *Spoon bill*, *Pheasant tailed jacana*, *Broze winged Jacana*, *Purple moorhen*, *White breasted water hen*, *Indian Moorhen*, *Grebe*, *Cormorant Darter*, *Lapwing*, *Egret*, *Purple heron*, *Pond heron*, *Stone curlew*, *King fisher*, *Night jar*, *Tern vulture*, *Kite*, *Partridge*, *Hawk*, *Koel*, *Dove*, *Pigeon*, *King crow*, *Baya*, *Muniya*, *Golden oriole*, *Barbet*, *Babler*, *Indian roller*, *Bee eater*, *Parakeet*, *Drongo*, *Hoopoe*, *Finch*, *Peacock*, *Brain fever bird*, *Comb duck* etc, are diversity enriched in this area [15]. In the vast diversity of twelve hundred bird species in India, eastern UP is home to almost many of them including 46 threatened species. Recent reports list 298 species, out of which 10% were under threatened, which represents importance of conservation strategies for protecting the beautiful biodiversity in the region [16]. The migratory bird *Amur Falcons* of south eastern Siberia and north China used to station in large flocks in the wetlands before migrating towards Arabian Sea to rest in Southern Africa for winters has been reduced in recent years. Other such migratory birds which were coming for breeding in Suhelwa sanctuary, like *Falcated Teal*, *Black headed Grebe*, *Black capped Kingfisher* and *Forktail* have reduced in number. It has been reported that critically endangered *Yellow Breasted Bunting* was spotted in the area [17]. The decline of birds is supported by the changes in the geographic alterations of the wetlands due to various human activities and building structures near the swamp areas [13]. A turning point in the stationing of these migratory birds have reduced due to various factors in the region like air pollution, floods, industrial drainage which has changed the various abiotic and biotic factors.

**Flyways of Migratory Water Birds in the region:** The migratory birds generally follow a common route of movement called migratory flyways depending on mountain ranges, water bodies, coastal locations for navigating them route they follow during migration. The common flyways come into north south axis, the usage of flyways depend on the requirement of migratory species and time spent in winters before returning to their destinations. The migratory bird species *Whimbrel Numenius*, *Ruddy turnstone*, *Arenaria interpres* and *Sanderling Calidris alba* utilize the complete flyway, while few species choose shortest route and use part of the flyways [18, 19]. There are nine different flyways reported up to date (Table 2). The migratory birds coming to India adopt the central flyway covering Eurasia between Arctic to Indian Ocean [20]. The critically

endangered birds are observed in this route such as *White-bellied Heron Ardea insignis* and *Northern Bald Ibis Geronticus eremita*, the endangered *Greater Adjutant Stork Leptoptilos dubius*, the vulnerable *Lesser Adjutant Stork Leptoptilos javanicus* and *Black-necked Crane Grus nigricollis* and near threatened *Flamingo Phoeniconaias minor* and *Pygmy Cormorant Microcarbo pygmaeus* [21-23]. The routes are inhibited by various factors such as climate, temperature and availability of good amount of food sources

which are mostly aquatic organisms [24]. The pollution in the environment is again a serious challenge which is reducing the population of flocks covering the flyways [25]. The broad flyways are changed slightly due wind directions; birds fly at a height up to 900m with a speed ranging from 40 Km/hr. to 120Km/hr., for long period of time covering average distance of 240 to 1000Km per day from their origin in Asian, European, African and Arctic continents before reaching the stations for resting [26-28].

**Table 2:** A total of five types of pollution indicator species identified [59]

Type of Species	Function
Sentinel	Extremely vulnerable animals for specific area to provide early warning signs of ecosystem contamination
Detectors	These are species that are unique to a particular area and exhibit demonstrable responses to environmental changes, such as adjustments in behavior, mortality, or age-class structure. It also react quickly to changes in the environment
Exploiters	These are the kinds of species that, by virtue of their very existence, can signal environmental damage. The ability of exploiter species to make use of a polluted environment determines whether or not they will survive. Because rivals cannot survive in the distorted environment, they frequently thrive in disturbed or contaminated places
Accumulators	These are species that accumulate pollution in significant amounts in their skin, feathers, lungs, liver, and kidney tissues

### Challenges and Key issues of Water Bird Population Decline:

The region of eastern Uttar Pradesh is prominent part Central Asian Flyway and wetlands are important station for water birds. The suitable environment, food resource availability at the wetland ecosystem make them secure sites for roosting and wintering nest of many avifauna diversity [29]. The decline trend observed in recent decades indicate the effect of pollution and increased anthropogenic activities in this region [31]. The natural disasters such as thunderstorm, floods, diseases are common in the area are another factor for diversity loss [32]. The water quality deterioration in the wetlands and addition of pollutants, oil spills, radiation and industrial influence have reduced the aquatic zooplanktons and fishes in the water bodies and rivers. The human fish harvesting from the wetlands had also created scarcity of food resources [33]. It has often observed that human interference, like livestock grazing and visitors without proper guidance in the region affect the behavior of these moving birds, they are terrified and disturbed in the area [34]. The livestock grazing near the waterbodies causes soil erosion and siltation of region, which are harmful for water birds [35]. The agriculture land encroachment and harvesting of aquatic reeds in the wetlands leads to habitat degradation again making a prominent challenge for survival of migratory birds in this region [36]. The human activities such as hunting and poaching, dispose of micro plastics is also challenge for these migratory birds [37]. The artificial electrical lights sources are causing serious threats to the bird flyways, they have changed their course of flight directions, the industrial pollution in close proximity of wetland habitat responsible for air pollution releasing heavy smoke and gases in the environment generates difficulty for the migratory birds to find the stations thus a change of route is observed within due course of time [38]. The migratory birds during visit carry pollutants, heavy metals and harmful traces on their journey to far places are other challenges to the ecosystem [39].

### Conservation Strategies for Water Birds in the region:

The strategic methods for conservation of natural habitats are area which is still evolving and globally acknowledged, no one defined methodology is followed in each and every

sites, due to different measures of threats observed [40]. The conservation strategies are composed of many factors interlinked at each stage to develop a suitable mitigation strategy for the conservation of migratory birds. Following are sustainable techniques.

**1. Conservation potential of Wetland Habitats:** The conservation of natural habitat is foremost need for migratory as well as local bird species. The wetland ecosystem sustains the biogeochemical cycles and maintain the ecosystem [41]. The water cycle includes the flow velocity and wave actions which affects the depth, frequency and time duration of the wetlands. The wetlands play important part in energy transfer through food webs and maintain the biodiversity [42]. The wetlands have their own cleaning system through oxygenated water columns maintained by macrophytes [43]. The waste assimilation capacity is a characteristic feature of wetlands, beside this it also stabilizes shore lines and controls soil erosion, during floodplains they accumulate sediments which increases its soil fertility for growing vegetation [44-45]. However extensive usage of the wetlands for Human activities have made it essential to determine the importance of wetlands area in the region and its impact on local environment and weather changes. There are various causes for the changing environmental status of wetlands which need to be identified are heavy contamination of metals, chemical pollutants and micro plastics, the deposition of pesticides flown though agriculture fields increase the water toxicity and becomes again challenging for the conservation, Studies suggest stream acidification had affected the egg shell thinning, and transfer of contaminants in the food web is another concerned [46]. Many studies report the deposition of trace and major elements in the trophic ecology of Antarctica, and other Siberian regions. The benefits of wetlands for fresh water supply, food and other resources, to maintain the biodiversity and climate change mitigation will be helpful. The important sites for migration can be achieved through dedicated use of wetlands for migration and maintaining the character of the ecosystem [47].

- 2. Convention for Water Birds in the region:** The concerned global initiative for conservation of migration routes and migratory animals through convention is a treaty of United Nations called "Convention on the Conservation of Migratory Species of Wild Animals", signed in 1979 in Bonn Convention. The conservation of migratory birds had been extended through outreach modules for awareness such as bird festivals, exhibitions and bird watching excursions. The studies based on Flyways and Conservation has reported many changes in population statistics over the years. The studies based on migratory birds had observed distribution of transfer of contaminants to other far regions in Antarctica, which is increasing burden of pollutants far from place of exposure. Pharmaceuticals and agricultural chemicals waste disposed in the water bodies may enter the tissues and feathers of the birds or ingested through preys<sup>[48]</sup>.
- 3. Monitoring strategies for Water Bird diversity through Geospatial applications:** The conservation of migratory birds needs a sustainable monitoring, the Geographic Information System (GIS) has been useful tool in getting the most information on landscape studies. The datasets received from satellites like space-borne, airplanes, Unmanned Aerial Vehicles (UAV), Google Earth Engine (GEE) may provide high end computational spatial temporal data sets for evaluation [49]. The informative data available on Landsat series, National Oceanographic and Atmospheric Advanced Very High-Resolution Imaging Spectrometer (NOAA AVHRR), Moderate Resolution Imaging Spectrometer (MODIS), Sentinel 1,2 and 3, Advanced Land Observing Satellite (ALOS) are some of the resources based on Java Script based algorithms. The other remote sensing soft wares which help in geo-spatial studies are Earth Resources Data Analysis System (ERDAS), Imagine and Environment for Visualizing Images (ENVI) for estimating Vegetation Mapping (Fraction Absorbed Photo Synthetically Active Radiation FAPER, Leaf Area Index (LAI), Canopy Water Content (CWC), Fraction Vegetation Cover (FVC) utilized for agricultural applications. However, utilization of these tools is scarce in the research area for vegetation of Uttar Pradesh so far and needs to be extended on wide scale to understand the factors and changes in the topography of landscape<sup>[50]</sup>. The remote sensing technology derives images using single band density slicing, supervised and unsupervised classification and spectral water indexes. The derivation of Normalized Difference Water Index (NDWI) has been widely for vegetation, built up and soil distribution. The other soft wares like MNDWI (Mean Normalized Difference Water Index), AWEL (Automated Water Extraction Index), TCW (Tasseled Cap Wetness) which have improved the bandwidth of infrared wavelengths have also been used for analysis<sup>[51]</sup>. The information induced systematic real time migration data sets could be helpful for developing simulation models for migration routes mapping, mitigation and wetland restorations for conservation of declining migratory birds visiting the region.
- 4. Bio-monitoring tools of migratory birds:** The evident role of wetlands in the lifecycle of migratory birds have been established, still the changes occurring in the trophic ecology needs to be understood through bioaccumulation of chemical fertilizers, pollutants and various heavy metals in the environments as food sources, foraging habitat. The reported studies show reduction in crane population every year nestling in India subcontinent<sup>[52]</sup>. Other studies based on geese flock observed reduction in population approximately 50%, these studies set alarming condition which needs strategical analysis of prey consumption, dispersal, breeding patterns and flyways to conserve the losing diversity in migrant species. The approach to Bio monitor the migrant birds to identify the underlying cause of changes would be helpful in restoration of the habitats and conservation of the migrant diversity<sup>[53]</sup>. There are different features of migratory avian species that make them a specific indicator of ecosystem. They rank high in trophic levels at food web, reside in close exposure to contaminants, easy to spot and speciation make them good bio indicators. Many studies based on migratory birds as bio-indicator of pollution has observed the concentration many heavy metals such as Cadmium, Nickel, Zinc, Chromium, lead etc. in varying concentrations<sup>[54]</sup>. There are two methods, invasive and noninvasive for biomonitoring the environmental changes.
- 5. Invasive tools: Bones, Tissue and Blood:** The animal tissue, bones were significant sources to study the exposure level of pollutant through food consumption, and the physiological changes, diseases and symptoms are studied. The studies have shown the effect of cadmium in bone deformities, reduction in bone volumes and kidney failures, the other studies on heavy metal exposure observed acid phosphatase deposition in tibia bone, triggering osteoblast apoptosis in avian taxa<sup>[55]</sup>. The common effluent from industries Nickel and Lead and Mercury showed increased alkaline phosphatase activities. It decreases the metabolic rate, inhibiting signaling pathway and reproductive life cycle of avian diversity residing beside the polluted water bodies, the increased concentration of trace elements like Zinc, Copper, Cadmium and Chromium in the food chain in agriculture sector impacts the ecosystem at various trophic levels<sup>[56]</sup>. Many studies based on risk effects of high concentration of heavy metals showed deposition of heavy metals in tissues, and disturbance in digestive and respiratory system of different aerial species. The studies on native and wild birds belonging to specific habitat observed the distribution, feeding habits and life cycle were good bio-indicators of the habitat. Others studies showed the soft tissues can be used as bio indicators of heavy metal deposition in the population and its negative effect were found in reproductive rates, immunity and physiology. The report on Cadmium, Copper and Manganese at higher concentration showed the renal toxicity among bird population, which may be an important factor of mortality<sup>[57]</sup>.

**6. Non-invasive tools: Feathers, Eggs and Excreta:** The non-invasive methods include collecting the feathers, eggs and excreta for determining the nature of contaminant affecting bird species and interpreting the causation factor responsible for the changes. This type of techniques is successful in covering wide geographic regions, due to foraging, and controlling the food chain at higher position in particular habitat. This method of biomonitoring is useful in endangered bird species, since the during molting process feathers are shredded once were part of body feathers and attached with very fine nerve endings, a useful information on body of avian species can be analyzed. Another stage of collecting feather samples is during egg hatching period where local environments conditions can be assessed within the food consumption. Many studies reportedly determined the concentration of heavy metals and chemical pollutant in the ecosystem <sup>[58]</sup>. The other important biomonitoring tool for the migratory birds are eggs, the female hatches egg at specific time period window, which can be significant bio monitor signal to formulate the local exposure level, type of local anthropogenic activities and changes affecting the decline in bird population <sup>[59]</sup>. The other non-invasive tool for biomonitoring is eggs of migratory birds, studies based on collection of eggs had provided insight in the egg quality, egg size, hatchability and fertility also egg shell investigation provides increase metal concentration deposition as the outcome of local environment of the birds where it is nesting during the breeding season <sup>[60]</sup>. The bird's excreta are another source to survey the issues related to decline in population and diversity studies. The studies based on excreta may describe diet changes and food availability in the habitat. The pesticides, industrial pollutants and other contaminants the wild birds have faced major fatality, and their adaptive nature has linked to climate changes and can provide as indicators for different hazardous effects in the habitat.

### Conclusion

The tropical climate of Indian sub-continent is always an attractive destination, due to the easiest approach in central flyway and various wetlands this becomes an important nesting place for migratory birds, the conservation of this natural habitat is foremost importance, many strategical programs have been implemented for the conservation of migratory birds, but equally important conservation of natural wetland of eastern Uttar Pradesh needs attention. The country wide network of conservationist and naturalist as well as secure studies based on geo spatial mitigation modelling and biomonitoring research programs needs attention. The habitat must be analyzed frequently for quality of water bodies, and marshy soils, mapping the unsettled areas and ecological diversity index may be helpful in understanding the visiting trends, resident ratio, and feeding and reproductive behavior, the methodological ways should be adapted for conservation of biodiversity in migratory birds.

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