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Wetland Birds and Ecosystem Health: Insights from the Navi Mumbai–Uran Coastal Wetlands

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Abstract

Wetlands are among the most productive ecosystems and support a rich diversity of bird species that are closely linked to aquatic habitats. Wetland birds play crucial ecological roles and are widely recognized as sensitive indicators of ecosystem health due to their dependence on water quality, hydrological regimes, and habitat structure. This chapter examines the ecological importance, behavioural adaptations, and conservation significance of wetland birds, with special emphasis on the coastal wetland complex of Navi Mumbai–Uran along the Maharashtra coast. The chapter discusses major groups of wetland birds, their feeding, breeding, and social behaviours, and highlights their use as bio indicators of environmental change. It further explores key conservation challenges, habitat protection and restoration strategies, and the role of local communities, citizen science, and environmental education in wetland bird conservation. By integrating ecological insights with regional examples, this chapter underscores the importance of safeguarding wetlands to ensure the long-term survival of wetland bird populations and the sustainability of vital ecosystem services.

Keywords: Wetland birds; Coastal wetlands; Bio indicators; Behavioural adaptations; Bird diversity; Conservation strategies; Navi Mumbai–Uran wetlands

1. Introduction to Wetland Birds

Definition of Wetlands and Wetland Birds

Wetlands are among the most productive ecosystems on Earth, characterized by the presence of standing or slow-moving water, water-saturated soils, and hydrophytic vegetation adapted to anaerobic conditions. Ecologically, wetlands function as transitional zones between terrestrial and aquatic systems and include marshes, swamps, floodplains, mangroves, estuaries, tidal mudflats, and shallow coastal waters. The internationally accepted Ramsar definition emphasizes wetlands as areas where water is the primary factor controlling the environment and associated biological communities (Ramsar Convention Secretariat, 2016).

Wetland birds, often referred to as *waterbirds*, are avian species that depend directly or indirectly on wetlands for essential life processes such as feeding, breeding, roosting, and migration stopovers. These birds exhibit a close ecological association with aquatic habitats and show morphological, physiological, and behavioural adaptations that allow them to exploit wetland resources efficiently (Kushlan, 1993;

Delany & Scott, 2006). Wetland birds play a pivotal role in linking aquatic and terrestrial food webs and are widely recognized as bioindicators of wetland health, responding rapidly to changes in hydrology, water quality, and habitat structure (Bibby et al., 2000; Ma et al., 2010).

Major Groups of Wetland Birds

Wetland birds represent a functional ecological assemblage rather than a single taxonomic group, encompassing several avian orders that utilize wetland habitats in different ways. These groups are often classified based on feeding strategy, habitat use, and morphological adaptations.

1. **Waterfowl**

Waterfowl, belonging primarily to the family Anatidae, include ducks, geese, and swans that are highly adapted for life in open water and shallow wetlands. They possess webbed feet for swimming and specialized bills for dabbling, grazing, or diving. Waterfowl feed on aquatic vegetation, seeds, invertebrates, and small vertebrates and are integral to nutrient redistribution within wetlands (Baldassarre & Bolen, 2006). In the wetlands of Navi Mumbai and Uran, species such as the Indian Spot-billed Duck (*Anas poecilorhyncha*), Northern Shoveler (*Spatula clypeata*), and Garganey (*Spatula querquedula*) are commonly recorded during winter, reflecting the importance of these wetlands as seasonal foraging habitats for migratory waterfowl (Prasad et al., 2002; Prakash et al., 2016).



2. **Waders or Shorebirds**

Waders, also known as shorebirds, mainly belong to the order Charadriiformes and are adapted to forage in shallow waters, mudflats, and intertidal zones. They are characterized by long legs and elongated or sensitive bills, enabling them to probe sediments for benthic invertebrates such as polychaetes, molluscs, and crustaceans (Piersma et al., 1996). Shorebirds are particularly dependent on coastal wetlands during migration, when they require nutrient-rich stopover sites to replenish energy reserves (Newton, 2008). The mudflats of Uran and adjoining Navi Mumbai wetlands support large numbers of migratory waders, including the Little Stint (*Calidris minuta*), Curlew Sandpiper (*Calidris ferruginea*), Lesser Sand Plover (*Charadrius mongolus*), and Bar-tailed Godwit (*Limosa lapponica*), highlighting the global significance of these habitats along the Central Asian Flyway (Prasad et al., 2002; Balachandran, 2006).



3. **Piscivorous and Large Wading Birds**

Piscivorous wetland birds include herons, egrets, storks, ibises, and spoonbills, which primarily feed on fish, amphibians, and other aquatic organisms. These birds are typically associated with shallow freshwater and estuarine wetlands, where they employ specialized hunting techniques such as stalking, ambush, or tactile feeding (Kushlan, 1978). Large wading birds are sensitive to changes in water depth and prey availability, making them valuable indicators of wetland productivity (Gawlik, 2002). Species such as the Painted Stork (*Mycteria leucocephala*), Black-headed Ibis (*Threskiornis melanocephalus*), Little Egret (*Egretta garzetta*), and Grey Heron (*Ardea cinerea*) are frequently observed in Uran wetlands, particularly in creeks and shallow tidal zones (Prakash et al., 2016; Patil et al., 2020).



4. **Flamingos and Filter-feeding Specialists**

Flamingos represent a highly specialized group of wetland birds adapted for filter feeding in saline and alkaline wetlands. Using lamellated bills, they feed on algae, diatoms, and small invertebrates, thereby influencing primary productivity and nutrient cycling within wetlands (Mascitti & Kravetz, 2002). The Greater Flamingo (*Phoenicopterus roseus*) and Lesser Flamingo (*Phoeniconaias minor*) are iconic winter visitors to the wetlands of Navi Mumbai and Uran, where they exploit shallow mudflats and salt pans for feeding (Prasad et al., 2002; Tatu et al., 2019).



Wetland Birds of Navi Mumbai and Uran: Ecological Significance

The coastal wetlands of Uran, including Panje–Dongri, Bhendkhal, and adjoining mudflats, constitute one of the most important wetland complexes along the Maharashtra coast. These wetlands support high species richness and large congregations of migratory waterbirds, fulfilling criteria for international conservation importance (Prasad et al., 2002). The regular occurrence of threatened and near-threatened species, along with large migratory assemblages, underscores the role of these wetlands as critical stopover, feeding, and wintering grounds in the Indian subcontinent (Balachandran, 2006).

Wetland Birds as Indicators of Ecosystem Health

Wetland birds are widely recognized as one of the most effective biological indicators of ecosystem health due to their strong dependence on wetland habitats and their sensitivity to changes in hydrology, water quality, and habitat structure. Because they occupy multiple trophic levels and integrate ecological processes over space and time, changes in wetland bird communities often reflect underlying environmental disturbances well before these changes become evident through physico-chemical measurements alone (Kushlan, 1993; Gregory et al., 2003).

Sensitivity of Wetland Birds to Water Quality and Habitat Changes

Wetland birds exhibit high sensitivity to water quality parameters such as nutrient concentration, salinity, dissolved oxygen, and contamination by heavy metals and pesticides. Degradation of water quality can directly affect prey availability—such as fish, macro-invertebrates, and aquatic vegetation—leading to reduced foraging efficiency, altered behaviour, and declines in reproductive success (Gawlik, 2002; Ma et al., 2010). For example, eutrophication resulting from nutrient enrichment can initially increase food availability but often leads to hypoxic conditions that negatively impact fish and invertebrate populations, thereby affecting piscivorous and wading birds (Kingsford & Norman, 2002). Habitat alteration, including wetland drainage, reclamation, mangrove removal, and changes in water depth regimes, has a profound influence on wetland bird assemblages. Many wetland birds are habitat specialists with narrow ecological requirements; slight modifications in water depth can render wetlands unsuitable for certain feeding guilds while favouring others (Colwell & Taft, 2000). Shorebirds, for instance, require exposed mudflats with

soft sediments, whereas ducks and flamingos depend on shallow open waters with high primary productivity (Piersma et al., 1996; Mascitti & Kravetz, 2002).

Additionally, wetland birds are sensitive to anthropogenic disturbances, such as increased human activity, industrial pollution, noise, and light pollution, which can disrupt feeding, roosting, and breeding behaviour (Burger & Gochfeld, 1998). Long-lived species such as storks and herons tend to accumulate contaminants over time, making them particularly useful for monitoring long-term environmental contamination and ecosystem degradation (Kushlan, 1993).

Use of Bird Diversity and Abundance as Bio indicators

Bird species diversity, abundance, and community composition are commonly used as measurable indicators to assess wetland condition and ecological integrity. High species richness and the presence of habitat-specialist and migratory species generally indicate structurally complex and productive wetlands, whereas simplified bird communities dominated by a few generalist species often reflect habitat degradation (Bibby et al., 2000; Gregory et al., 2003). Changes in bird abundance, particularly in migratory wetland birds, provide early warning signals of ecosystem stress at both local and landscape scales. Migratory species rely on a network of wetlands across flyways; therefore, declines at a particular site may indicate broader regional or global environmental problems (Newton, 2008). Studies have shown strong correlations between wetland bird assemblages and environmental variables such as water depth, vegetation heterogeneity, prey biomass, and nutrient status, validating their use in ecological monitoring programmes (Gawlik, 2002; Ma et al., 2010).

Several indices and assessment frameworks incorporate wetland birds as biological indicators, including multimetric indices based on feeding guilds, trophic structure, and breeding success. These approaches are increasingly used in wetland management and conservation planning, as bird-based indicators are cost-effective, non-invasive, and relatively easy to monitor over long periods (Gregory et al., 2005; López-López et al., 2011). Consequently, wetland birds serve not only as indicators of present ecosystem conditions but also as predictors of future ecological change.

Behavioural Adaptations of Wetland Birds

Wetland birds exhibit a wide range of behavioural adaptations that enable them to exploit highly variable and often challenging wetland environments. These adaptations are closely linked to the spatial and temporal heterogeneity of wetlands, where water depth, prey availability, salinity, and vegetation structure can change rapidly. Behavioural flexibility in feeding, breeding, and social organization allows wetland birds to maximize resource use, reduce competition, and enhance survival and reproductive success (Kushlan, 1978; Denny, 1994).

Feeding Strategies of Wetland Birds

Feeding behaviour in wetland birds is highly specialized and reflects both prey type and habitat conditions. One of the most common strategies is probing, employed primarily by waders and shorebirds, where birds use elongated and sensitive bills to probe soft mud or sand in search of benthic invertebrates such as

worms, molluscs, and crustaceans. Species such as sandpipers and godwits rely on tactile foraging, often feeding in shallow water or exposed mudflats where prey density is high (Piersma et al., 1996). Filter feeding is a specialized strategy observed in birds such as flamingos and some ducks, where lamellated bills are used to filter algae, plankton, and small invertebrates from water or wet sediments. This feeding mode allows exploitation of food resources that are unavailable to most other bird groups and plays an important role in regulating primary productivity and nutrient cycling in wetlands (Mascitti & Kravetz, 2002; Baldassarre & Bolen, 2006).

Diving behaviour is characteristic of birds that forage in deeper water, such as cormorants, grebes, and diving ducks. These species actively pursue fish or aquatic invertebrates underwater, often exhibiting physiological adaptations such as increased oxygen storage and controlled buoyancy. Diving efficiency and prey capture success are closely linked to water clarity and prey distribution, making these birds sensitive to changes in wetland conditions (Wanless et al., 1997). Stalking and ambush feeding is typical of large wading birds such as herons, egrets, and storks. These birds move slowly through shallow water or remain motionless while visually locating prey, striking rapidly with their bills. Such feeding behaviour is highly dependent on water depth and prey visibility, and even minor alterations in hydrology can significantly affect feeding success (Kushlan, 1978; Gawlik, 2002).

Breeding and Nesting Behaviour in Wetlands

Wetland birds exhibit diverse breeding strategies that reflect the instability and unpredictability of wetland habitats. Many species synchronize their breeding with seasonal water availability, ensuring that food resources are abundant during the energetically demanding periods of egg laying and chick rearing (Kingsford & Norman, 2002). Changes in water level can influence nest site selection, clutch size, and breeding success. Nesting sites range from ground nests on mudflats or floating vegetation to tree and shrub nests near water bodies. Ground-nesting species, such as plovers and terns, often rely on open substrates for camouflage, whereas ducks and jacanas may use dense emergent vegetation to conceal nests from predators (Colwell & Taft, 2000). Colonial nesting is common among herons, egrets, storks, and spoonbills, where large numbers of birds nest together, often in trees or reed beds within or adjacent to wetlands. Colonial breeding may reduce predation risk and enhance information sharing about food resources (Kushlan & Hancock, 2005).

Breeding behaviour in wetlands is particularly vulnerable to habitat disturbance. Flooding, drainage, vegetation removal, and human interference can lead to nest failure and reduced reproductive output, making breeding success an important indicator of wetland health (Ma et al., 2010).

Social Behaviour and Flocking

Social behaviour is a prominent feature of many wetland bird species, especially outside the breeding season. Flocking behaviour is commonly observed during feeding, roosting, and migration, offering several ecological advantages. Large flocks enhance predator detection, reduce individual predation risk through the dilution effect, and improve foraging efficiency by facilitating information transfer about food availability (Beauchamp, 2012).

Migratory wetland birds often form mixed-species flocks, particularly on productive mudflats and shallow wetlands, where different species exploit slightly different food niches. Such associations reduce direct competition while allowing collective vigilance (Piersma et al., 1996). In contrast, territorial behaviour is more pronounced during the breeding season, when individuals or pairs actively defend nesting sites and nearby feeding areas to ensure sufficient resources for offspring (Newton, 2008). Social hierarchies are also evident in some waterfowl and colonial breeders, influencing access to preferred feeding or nesting sites. These behavioural patterns reflect complex social organization shaped by ecological pressures and resource distribution within wetlands (Baldassarre & Bolen, 2006).

Conservation Strategies and Community Participation

The long-term conservation of wetland birds depends on integrated strategies that combine habitat protection, ecological restoration, and active participation of local communities. Given the rapid loss and degradation of wetlands worldwide, conservation approaches increasingly recognize the need to link scientific management with public engagement, policy support, and environmental education to ensure sustainable wetland use (Finlayson et al., 2011; Ma et al., 2014).

Habitat Protection and Restoration

Protection of wetland habitats is the most effective strategy for conserving wetland bird populations. Legal protection through the designation of protected areas, Ramsar sites, and Important Bird and Biodiversity Areas (IBAs) has been shown to significantly enhance the persistence of wetland bird communities by limiting habitat conversion and regulating anthropogenic pressures (BirdLife International, 2014; Ramsar Convention Secretariat, 2016). Maintaining natural hydrological regimes is particularly critical, as water depth, seasonal flooding, and salinity strongly influence food availability, nesting success, and species composition of wetland birds (Kingsford, 2000; Gawlik, 2002).

Wetland restoration aims to reverse ecological degradation by re-establishing natural processes such as water flow, vegetation structure, and nutrient cycling. Restoration measures—including removal of invasive species, re-vegetation with native plants, creation of shallow foraging zones, and controlled water-level management—have been demonstrated to improve habitat suitability for a wide range of wetland bird species (Zedler & Kercher, 2005; Moreno-Mateos et al., 2012). Successful restoration not only increases bird abundance but also enhances species diversity and breeding success, indicating recovery of ecosystem function (Ma et al., 2010).

Role of Local Communities and Citizen Science

Local communities play a crucial role in the conservation of wetlands and associated bird life, particularly in regions where wetlands support livelihoods such as fishing, agriculture, and salt production. Community-based conservation approaches that involve stakeholders in decision-making processes have proven effective in reducing habitat degradation and promoting sustainable resource use (Berkes, 2004; Pretty & Smith, 2004). When local residents perceive tangible benefits from wetland conservation—such as improved fisheries or ecotourism opportunities—long-term stewardship of habitats becomes more likely. Citizen science has emerged as a powerful tool for monitoring wetland bird populations at large

spatial and temporal scales. Programmes involving volunteers in bird surveys, migration counts, and habitat assessments generate valuable long-term datasets that complement professional research and inform conservation planning (Dickinson et al., 2010; Sullivan et al., 2014). Data collected through citizen science initiatives have been instrumental in detecting population trends, identifying key wetland sites, and evaluating the effectiveness of conservation interventions, thereby strengthening evidence-based management (Greenwood, 2007).

Importance of Awareness and Education

Environmental awareness and education are essential components of wetland bird conservation, as they foster public support and behavioural change necessary for protecting fragile ecosystems. Education programmes that highlight the ecological roles of wetland birds—such as nutrient cycling, pest regulation, and their value as bioindicators—help bridge the gap between scientific knowledge and public perception (Jacobson et al., 2006). Incorporating wetland conservation themes into school curricula, community workshops, and nature interpretation centres has been shown to improve environmental literacy and pro-conservation attitudes (Monroe et al., 2007). Awareness initiatives also play a key role in mitigating human-induced threats such as pollution, encroachment, and disturbance. By promoting responsible tourism, sustainable livelihoods, and compliance with conservation regulations, education efforts contribute to reducing pressures on wetlands and enhancing the resilience of wetland bird populations (Ballantyne & Packer, 2011). Ultimately, informed and engaged communities form the foundation for successful and enduring wetland conservation.

Conclusion

Wetland birds represent one of the most visible and ecologically significant components of wetland ecosystems. Their close dependence on water regimes, habitat structure, and food availability makes them sensitive responders to environmental change, positioning them as reliable indicators of wetland health and integrity. Through their diverse feeding strategies, breeding behaviours, and social organization, wetland birds contribute substantially to ecosystem functioning by regulating prey populations, facilitating nutrient cycling, and linking aquatic and terrestrial food webs. The behavioural adaptations of wetland birds—ranging from specialized foraging techniques to flexible breeding and social strategies—highlight their evolutionary responses to the dynamic and often unpredictable nature of wetland environments. However, these same specializations also render them highly vulnerable to habitat loss, hydrological alteration, pollution, and human disturbance. Declines in wetland bird diversity and abundance often reflect broader ecosystem degradation, underscoring the urgency of conserving wetlands not only for avifauna but also for the multitude of ecosystem services they provide.

Effective conservation of wetland birds requires a holistic approach that integrates habitat protection and restoration with active community participation and informed management. Legal safeguards, restoration of natural hydrological processes, and maintenance of habitat heterogeneity are fundamental to sustaining viable wetland bird populations. Equally important is the involvement of local communities and citizen scientists, whose participation enhances monitoring efforts, promotes stewardship, and bridges the gap between scientific research and on-ground conservation action. Education and awareness initiatives

further strengthen conservation outcomes by fostering environmental responsibility and long-term public support.

In the face of accelerating climate change and increasing anthropogenic pressures, the future of wetland birds depends on adaptive management strategies grounded in scientific evidence and social engagement. Recognizing wetland birds as both ecological assets and conservation ambassadors can help mobilize collective efforts to safeguard wetlands. Ultimately, conserving wetland birds is inseparable from conserving wetlands themselves, ensuring the resilience of these vital ecosystems for future generations.

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