



Avian diversity and seasonal abundance in wetland habitats of Maharashtra, India: A review

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Abstract

Wetlands of Maharashtra comprise a diverse network of reservoirs, riverine habitats, marshes, irrigation tanks, crater lakes, coastal mudflats and mangrove-associated ecosystems. These habitats support resident birds as well as seasonal and long-distance migrants and form important feeding, roosting and staging areas within the Central Asian Flyway. This review synthesizes published information on avian diversity, seasonal occurrence, habitat use, feeding ecology, migratory patterns, conservation significance and major threats affecting wetland birds in Maharashtra. Published studies show marked variation in species richness and abundance among wetlands, reflecting differences in water depth, hydrological regime, shoreline structure, vegetation, prey availability and surrounding land use. Ujjani Reservoir and its associated wetlands support a diverse assemblage of aquatic birds, including resident, resident-migratory and migratory species, while Thane Creek supports large coastal waterbird concentrations, including flamingos and shorebirds. Nandur Madhameshwar is an important inland wintering landscape, and Lonar Lake provides habitat for a distinctive assemblage of resident and wintering waterbirds. Across the state, winter generally produces the most conspicuous increase in migratory waterbird abundance, although monsoon, post-monsoon and summer conditions strongly modify habitat availability and bird distribution. The principal pressures include habitat conversion, hydrological alteration, pollution, invasive aquatic vegetation, human disturbance, infrastructure development and climate-related changes. The review indicates that Maharashtra requires longer-term, standardized, multi-season monitoring that links bird counts with hydrological and habitat variables. Conservation should be planned at the level of connected wetland networks rather than isolated water bodies, with stronger integration of Ramsar-site management, the Asian Waterbird Census, local community participation and landscape-scale habitat protection.

Keywords: Avian diversity, wetland birds, seasonal abundance, migratory birds, Maharashtra, Central Asian Flyway, waterbirds, wetland conservation

Introduction

Wetlands are among the most productive ecosystems and provide a combination of aquatic, terrestrial and transitional habitats that support high biological diversity. Their open water, shallow margins, mudflats, marshes, emergent vegetation and adjacent terrestrial habitats offer feeding, nesting, roosting and refuge sites for many bird species. Waterbirds are especially dependent on wetlands because aquatic invertebrates, fish, amphibians, molluscs, seeds and aquatic plants can occur in high concentrations within relatively small areas (Mitsch & Gosselink, 2015) ^[5]. The ecological value of a wetland therefore depends not only on the area of open water but also on the diversity and seasonal availability of associated microhabitats.

India occupies an important position within the migratory network of Asian waterbirds. The Asian Waterbird Census (AWC), coordinated in India by Wetlands International South Asia and the Bombay Natural History Society, provides a long-running framework for monitoring waterbirds and wetlands. The 2006–2015 ^[5, 9] Indian synthesis recorded 170 waterbird species at 1,409 wetlands, including 142 migratory species, illustrating the importance of Indian wetlands within wider flyway systems (Wetlands International South Asia, 2020).

Maharashtra is particularly important because it combines contrasting physiographic regions, including the Western Ghats, the Deccan Plateau, semi-arid interior landscapes and the Arabian Sea coast. Its wetland network includes major

reservoirs such as Ujjani, river-associated wetlands, irrigation tanks, marshes, crater lakes and extensive coastal tidal habitats. The resulting variation in water chemistry, hydrology, vegetation and surrounding land use produces a broad range of conditions for wetland birds.

Several wetlands in Maharashtra have been recognized for their conservation importance under the Ramsar Convention. Nandur Madhameshwar was designated in 2019, while Lonar Lake and Thane Creek were subsequently recognized as Wetlands of International Importance. The Ramsar documentation for Nandur Madhameshwar describes a mosaic of lakes, marshes, intermittent pools, riparian forest and human-made reservoir habitat, while the Thane Creek Ramsar documentation highlights extensive intertidal and mangrove-associated habitat supporting large concentrations of waterbirds (Ramsar Convention Secretariat, 2020a, 2022) ^[8].

Despite substantial ornithological interest, the available evidence remains unevenly distributed among sites. Well-known wetlands have received repeated attention, whereas many smaller reservoirs, irrigation tanks and seasonal wetlands remain poorly documented. Moreover, studies differ in duration, sampling design and reporting units, making direct comparison difficult. The present review therefore brings together available literature to examine the principal patterns of avian diversity and seasonal abundance in Maharashtra's wetlands and to identify priorities for future research and conservation.

Wetland Habitats of Maharashtra

Maharashtra's wetland habitats can be viewed as a connected mosaic rather than as isolated water bodies. Their ecological character is determined by monsoon rainfall, river discharge, reservoir operation, groundwater inputs, tidal exchange, sediment dynamics and human water use. Seasonal changes in these processes alter the availability of feeding and roosting habitat and consequently influence bird distribution.

Large reservoirs and their satellite wetlands are especially important in the semi-arid parts of the state. Fluctuating reservoir margins commonly create shallow-water areas and exposed mudflats that are used by waders and other waterbirds. Ujjani Reservoir provides a strong example. Kumbhar and Mhaske (2021) ^[2] surveyed 15 sites around the reservoir for two years and recorded 81 aquatic bird species belonging to 59 genera, 11 orders and 23 families. The authors also documented variation in microhabitat use, feeding guilds and migratory status, showing that the large reservoir supports several distinct bird assemblages.

Riverine wetlands include backwaters, shallow channels, sandbars, floodplain pools and marshes associated with major rivers. Such habitats can provide feeding and resting areas for herons, egrets, ibises, storks, kingfishers, shorebirds and other species. Their ecological condition is closely linked to the timing and magnitude of river flow and to the maintenance of shallow-water and sedimentary habitats.

Nandur Madhameshwar is an important inland wetland complex created around the Nandur Madhameshwar weir at the confluence of the Godavari and Kadwa rivers. The Ramsar Information Sheet describes a mosaic of permanent freshwater lakes, marshes, intermittent pools, rivers, riparian forest, reservoirs and exposed mudflats. Water levels fluctuate seasonally and exposed streambeds and mudflats provide feeding habitat for waders (Ramsar Convention Secretariat, 2020a). A recent literature-based review reported about 80 migratory bird species at the sanctuary and identified October to March as the principal period of migratory activity (Achegawe *et al.*, 2026) ^[1].

Lonar Lake is ecologically distinctive because it occupies a meteorite-impact crater in basaltic terrain. The Ramsar documentation records several waterbird species at the site and identifies it as a wintering area for species including Garganey and Common Pochard. Woolly-necked Stork and Black-headed Ibis are among the conservation-significant birds associated with the site (Ramsar Convention Secretariat, 2020b).

Coastal wetlands are represented most prominently by Thane Creek and associated mudflats and mangroves. Their tidal hydrology creates feeding areas that are fundamentally different from inland reservoirs. The Ramsar documentation lists numerous ducks, waders, gulls, terns, herons, ibises and flamingos and records more than 20,000 waterbirds as an important site characteristic (Ramsar Convention Secretariat, 2022) ^[8].

Avian Diversity and Community Composition

Wetland bird diversity reflects habitat heterogeneity. Open water supports diving and surface-feeding birds, shallow margins favour herons, egrets and other waders, while

exposed mudflats are used by plovers, sandpipers, godwits and related shorebirds. Emergent vegetation can provide shelter and nesting habitat for rails, crakes and marsh-associated species. Surrounding agricultural fields may also function as complementary feeding habitat.

At Ujjani Reservoir, Kumbhar and Mhaske (2021) ^[2] recorded 81 aquatic bird species and reported Scolopacidae as the dominant family. Their analysis recognized divers, swimmers, large waders, small waders and aerial foragers, demonstrating pronounced microhabitat partitioning. The same study recorded 26 resident species, 19 migratory species and 36 species categorized as resident-migratory, indicating that the reservoir supports both permanent and seasonally mobile components of the avifauna.

Thane Creek demonstrates a contrasting coastal pattern. Lenka *et al.* (2023) ^[3] surveyed four localities using 12 observation points during January and February 2018 and identified 125 bird species belonging to 90 genera, 47 families and 18 orders. Species richness differed among localities, with Bhandup Pumping Station supporting the highest number of species, whereas the Thane Creek Flamingo Sanctuary recorded the greatest number of individuals. The spatial differences emphasize that a wetland complex cannot be treated as ecologically uniform. The diversity recorded in these studies should not be interpreted simply as a function of wetland size. Habitat structure, tidal or freshwater dynamics, food availability and disturbance can produce high local diversity in relatively small sections of a larger wetland. This reinforces the importance of retaining a mosaic of open water, shallow margins, mudflats, vegetation and surrounding terrestrial habitat.

Seasonal Abundance and Migration

Seasonality is a defining feature of wetland bird communities in Maharashtra. The annual monsoon cycle modifies water depth and vegetation, while the arrival and departure of migratory species add a second major source of temporal variation. Consequently, a wetland may support substantially different bird assemblages at different times of the year.

During the monsoon, rainfall increases water levels in reservoirs, lakes and riverine wetlands. Expanded open-water habitat can benefit swimming and fish-eating birds, whereas high water levels may temporarily submerge exposed mudflats used by shorebirds. Monsoon conditions may therefore increase overall wetland productivity without necessarily producing the highest visible abundance of waders.

The post-monsoon period is important because declining water levels often expose shallow margins, mudflats and wet meadows. These areas provide feeding opportunities for waders and other birds. At Nandur Madhameshwar, the Ramsar documentation notes that water gradually recedes after the monsoon and exposes intermittent pools and mudflats, creating a changing feeding landscape (Ramsar Convention Secretariat, 2020a).

Winter is generally the most conspicuous season for migratory waterbirds. The AWC is intentionally conducted mainly during the northern winter because this period corresponds to the non-breeding season of many waterbirds

and provides an opportunity to document their distribution and abundance (Wetlands International South Asia, 2020). At Nandur Madhameshwar, the recent review by Achegawe *et al.* (2026) ^[1] identified October to March as the main period of migratory activity. At Thane Creek, Lenka *et al.* (2023) ^[3] surveyed during January and February and recorded a large and diverse assemblage during the migration and return-migration period.

Summer brings progressive drying to many inland wetlands. Declining water levels can concentrate aquatic organisms in remaining pools and expose large areas of feeding substrate. Some waders may benefit from this concentration of prey, whereas species requiring deeper water may decrease. Thus, summer abundance cannot be interpreted in isolation as either a positive or negative indicator of wetland condition.

Resident and Migratory Birds

Maharashtra's wetland avifauna contains permanent residents, birds undertaking local or regional movements and long-distance migrants. Resident species include numerous herons, egrets, cormorants, kingfishers, lapwings, raptors and other birds capable of exploiting wetlands throughout the year. Their abundance changes with water availability and food resources.

Migratory birds are particularly important because wetlands function as a network of breeding, staging and wintering sites. The AWC synthesis for India recorded 142 migratory waterbird species among 170 waterbird species documented during 2006 ^[9]–2015 (Wetlands International South Asia, 2020). This network perspective is important for Maharashtra because the loss or degradation of one wetland may affect birds that depend on several sites along their migration route.

At Ujjani, the combination of resident, migratory and resident-migratory categories reported by Kumbhar and Mhaske (2021) ^[2] illustrates the complexity of seasonal wetland use. At Nandur Madhameshwar, Achegawe *et al.* (2026) ^[1] identified approximately 80 migratory species across nine orders and 19 families, with Charadriiformes particularly prominent. Such observations support the view that Maharashtra's inland wetlands are important components of the Central Asian Flyway.

Feeding Guilds and Habitat Use

Birds use wetland habitats according to morphological adaptations, prey availability and water depth. Ducks and other swimming birds exploit open water and aquatic vegetation; herons and egrets use shallow margins; shorebirds forage on exposed mud and wet sediment; kingfishers and cormorants depend on fish and aquatic organisms; and raptors use both wetland and surrounding terrestrial habitats.

Kumbhar and Mhaske (2021) ^[2] reported approximately 36% carnivorous, 25% omnivorous, 9% insectivorous, 6% piscivorous and 5% herbivorous species in their Ujjani study, with additional species falling into other feeding categories. Their results show that wetland bird communities represent several trophic pathways rather than a single feeding guild.

At Nandur Madhameshwar, the availability of shallow water, mudflats, marshes and adjoining agricultural areas

allows birds to move between feeding habitats. The Ramsar site documentation notes that exposed streambeds below the weir are used by waders and that seasonal water-level changes alter the extent of available habitat (Ramsar Convention Secretariat, 2020a).

At Thane Creek, tidal mudflats and mangrove-associated habitats provide concentrated feeding opportunities for shorebirds and flamingos. Lenka *et al.* (2023) ^[3] found substantial differences in species richness and abundance among localities within the creek, demonstrating the importance of local habitat characteristics.

Ecological and Conservation Significance

Wetland birds contribute to aquatic food webs through predation, herbivory, scavenging and movement of nutrients. Their dependence on water depth, vegetation and prey resources also makes them useful indicators of wetland ecological condition. Changes in bird communities can provide an early signal of alterations in habitat quality, hydrology or food availability.

The conservation significance of Maharashtra's wetlands is reinforced by the presence of threatened and near-threatened species. At Ujjani, Kumbhar and Mhaske (2021) ^[2] reported six Near Threatened, two Vulnerable and one Endangered species according to the conservation categories used in their study. The Ramsar documentation for Lonar Lake identifies Common Pochard and Woolly-necked Stork among species of conservation concern (Ramsar Convention Secretariat, 2020b). Thane Creek supports a broad assemblage of conservation-significant waterbirds and large concentrations of migratory species (Ramsar Convention Secretariat, 2022; Lenka *et al.*, 2023) ^[3, 8].

These records demonstrate why bird conservation cannot be separated from wetland management. Protecting birds requires maintaining the hydrological and habitat conditions that support their feeding, roosting, nesting and migration requirements.

Major Threats

Habitat conversion is a persistent pressure on wetlands, particularly near expanding urban areas. Roads, buildings, industrial development and changes in agricultural land use can reduce shallow-water and terrestrial feeding habitats even when the main waterbody remains present.

Hydrological alteration is another major concern. Reservoir operation, water abstraction and modified river flows can change the timing and duration of shallow-water habitat. The Nandur Madhameshwar Ramsar documentation records seasonal fluctuations in water level and emphasizes the ecological importance of the resulting mosaic of pools, marshes and exposed mudflats (Ramsar Convention Secretariat, 2020a).

Pollution from domestic sewage, industrial discharges, agricultural runoff and solid waste can alter water quality and food webs. Thane Creek is a particularly important example because it lies within a densely urbanized landscape and receives multiple anthropogenic pressures. Its Ramsar documentation nevertheless demonstrates that the creek continues to support very large waterbird concentrations (Ramsar Convention Secretariat, 2022) ^[8].

Invasive aquatic plants can alter open-water habitat and interfere with bird access to feeding areas. Common water hyacinth is specifically identified as a threat at Nandur Madhameshwar (Ramsar Convention Secretariat, 2020a). Human disturbance from tourism, boating, fishing, livestock activity and unregulated recreation may also affect birds during sensitive feeding and roosting periods.

Climate variability is likely to influence migration timing, water availability and food resources, but Maharashtra-specific long-term datasets remain inadequate for separating climate effects from local habitat change. This is an important research priority rather than a conclusion that can be drawn from short-term observations.

Conservation and Management

Conservation should begin with maintenance of ecological water regimes. Water management should preserve seasonal variability while retaining sufficient shallow-water and mudflat habitat during periods when migratory and resident birds depend on these areas.

Wetland buffers and surrounding landscapes should be included in management planning. Agricultural fields, grasslands, riparian vegetation and village landscapes may provide supplementary feeding and roosting habitat. The ecological boundary of a wetland should therefore not be equated automatically with the visible water surface.

Pollution control requires source-based management, including effective sewage treatment, industrial effluent regulation, solid-waste management and reduction of nutrient-rich runoff. Habitat restoration is unlikely to remain effective if pollutant inputs continue.

Invasive plant management should be based on ecological objectives. Complete removal of vegetation is not always appropriate because some aquatic plants provide nesting or shelter habitat. Management should instead aim to retain a diverse mosaic of open water and vegetated areas.

Standardized bird monitoring should be expanded beyond isolated winter checklists. The AWC provides a valuable foundation for coordinated monitoring, and its long-running dataset demonstrates the value of repeated standardized counts (Wetlands International South Asia, 2020). Multi-season surveys would provide a clearer picture of seasonal habitat use.

India's Wetlands (Conservation and Management) Rules, 2017 ^[4] and associated guidelines emphasize wetland identification, delineation, assessment of ecological character, wise use, regulation of damaging activities and preparation of integrated management plans (Ministry of Environment, Forest and Climate Change, 2017) ^[4]. These principles are directly relevant to avian conservation because bird populations depend on maintenance of wetland ecological character.

Research Gaps and Future Directions

Current evidence is geographically uneven. Prominent wetlands such as Ujjani, Nandur Madhameshwar and Thane Creek have received greater attention than the many smaller reservoirs, irrigation tanks and seasonal wetlands distributed across Maharashtra. A systematic inventory of these smaller sites would improve understanding of the state's wetland network.

Long-term monitoring is another major requirement. Short-duration surveys can establish species presence but cannot reliably identify population trends. Repeated observations using fixed sites and standardized effort are necessary to distinguish annual fluctuation from sustained change.

Future studies should record environmental variables together with bird counts. Water depth, turbidity, dissolved oxygen, conductivity, nutrients, vegetation cover, mudflat area, prey availability and surrounding land use could be analyzed against bird abundance and diversity. Such an approach would move the literature beyond species lists toward explanation of ecological processes.

Migration studies should also consider connectivity among wetlands. Birds may use several reservoirs, riverine wetlands, agricultural fields and coastal sites during migration. Conservation planning should therefore operate at the scale of wetland networks and flyway linkages.

Remote sensing and GIS can help quantify changes in wetland area, shoreline structure, vegetation and land use. Carefully validated citizen-science observations can supplement professional surveys, while photographic records and standardized observation protocols can improve verification. These approaches should complement, rather than replace, systematic field monitoring.

Conclusion

Maharashtra's wetlands support a diverse and seasonally dynamic avifauna composed of resident, locally mobile and long-distance migratory species. The ecological diversity of the state, from inland reservoirs and riverine wetlands to crater lakes and tidal mangrove systems, produces a broad range of feeding and roosting opportunities.

Published evidence from Ujjani Reservoir, Nandur Madhameshwar, Lonar Lake and Thane Creek shows that bird diversity and abundance are closely linked to hydrology, habitat heterogeneity, food availability and seasonal migration. Winter is particularly important for migratory waterbirds, but the ecological importance of monsoon, post-monsoon and summer conditions should not be overlooked.

The major conservation challenge is to maintain wetland ecological character while accommodating human water requirements and surrounding development. Long-term standardized monitoring, protection of wetland buffers, maintenance of ecological water regimes, pollution reduction, invasive-species management and community participation are central to this objective.

Future research should prioritize smaller and poorly documented wetlands, multi-year datasets, quantitative abundance estimates and integrated analyses of bird communities with environmental variables. Maharashtra's wetlands should be managed as interconnected components of wider ecological networks and the Central Asian Flyway. Such an approach will provide a stronger scientific basis for conserving both wetland biodiversity and the migratory birds that depend upon it.

Evidence Summary for Major Wetland Landscapes

The following table summarizes selected Maharashtra wetland landscapes for which published ornithological or Ramsar information is available. The values are taken from the cited sources and are presented as a literature summary rather than as new field observations.

Table 1: Selected wetland landscapes of Maharashtra and published evidence of avian importance.

Wetland / landscape	Habitat character	Published avian evidence	Seasonal / conservation significance
Ujjani Reservoir and associated wetlands	Large freshwater reservoir, shallow margins, mudflats and satellite wetlands	81 aquatic bird species recorded in a two-year survey of 15 sites; resident, migratory and resident-migratory categories reported (Kumbhar & Mhaske, 2021) ^[2] .	Important for resident and wintering waterbirds; habitat diversity across satellite wetlands increases conservation value.
Nandur Madhameshwar	Reservoir, lakes, marshes, intermittent pools, riparian and mudflat habitats	Ramsar documentation recognizes high biodiversity; a recent review reported about 80 migratory bird species (Ramsar Convention Secretariat, 2020a; Achegawe <i>et al.</i> , 2026) ^[1] .	October–March is reported as the main migratory period; seasonal water-level fluctuations create feeding habitat.
Lonar Lake	Crater lake with distinctive closed-basin ecological conditions	Ramsar documentation records a diverse avifauna and identifies several conservation-significant waterbirds (Ramsar Convention Secretariat, 2020b).	Supports resident and wintering birds; ecological uniqueness increases conservation importance.
Thane Creek	Tidal mudflats, mangroves, creeks and intertidal habitat	125 bird species were recorded in a 2018 survey; Ramsar documentation recognizes large concentrations of waterbirds (Lenka <i>et al.</i> , 2023 ^[3] ; Ramsar Convention Secretariat, 2022) ^[8] .	Important for wintering and migratory shorebirds and flamingos; strong urban and pollution pressures.

Seasonal Pattern of Wetland Bird Use

Seasonal interpretation should account for hydrological conditions as well as migration. The following framework synthesizes the recurring patterns described in the reviewed literature; it is not a single-site abundance dataset.

Table 2: General seasonal pattern of wetland bird use in Maharashtra.

Season	Typical wetland condition	Expected avian response	Interpretive consideration
Monsoon	High water levels, renewed inflow, increased aquatic productivity	Open-water birds and fish-eating species may benefit; some exposed feeding areas become submerged.	Lower wader counts do not necessarily indicate poorer wetland condition.
Post-monsoon	Falling water levels, expansion of shallow margins and exposed substrate	Waders and other shallow-water feeders gain access to mudflats and wet margins.	Often a transition period before peak winter migrant abundance.
Winter	Stable feeding areas combined with arrival of many migratory waterbirds	Highest visibility and concentration of many ducks, shorebirds, gulls, terns and other migrants.	The principal period for standardized AWC counts in India.
Summer	Progressive drying and contraction of open water in many inland wetlands	Some species concentrate around remaining pools and exposed feeding areas; deep-water species may decline.	Seasonal drying must be separated from human-induced wetland degradation.

Conservation Priorities and Research Needs

The literature points to several priorities that can be incorporated into future wetland monitoring and management.

Table 3: Priority areas for future avian research and wetland management in Maharashtra.

Priority	Current concern	Recommended approach
Long-term monitoring	Many studies are short-term and site-specific.	Establish fixed observation points and conduct repeated multi-season counts using consistent effort.
Hydrology	Water-level regulation changes shallow-water and mudflat availability.	Record water depth and hydroperiod together with bird counts and incorporate ecological water requirements into reservoir management.
Water quality	Urban, domestic and agricultural pollution can affect food webs.	Combine bird surveys with basic water-quality monitoring and source-based pollution control.
Habitat connectivity	Birds use satellite wetlands, agricultural fields and riverine habitats in addition to main water bodies.	Map wetland networks and protect complementary feeding and roosting habitats.
Small wetlands	Many village tanks and seasonal wetlands remain poorly documented.	Develop district-level inventories and prioritize repeated surveys of representative small wetlands.
Citizen science	Large numbers of observations are available but methods vary.	Use standardized protocols, photographic verification and validation against structured surveys.

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