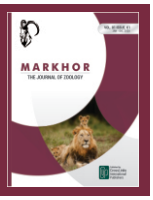
DOI: https://doi.org/10.54393/mjz.v6i4.185

MARKHOR
THE JOURNAL OF ZOOLOGY
https://www.markhorjournal.com/index.php/mjz
ISSN (E): 2790-4385, (P): 2790-4377
Volume 6, Issue 4 (Oct - Dec 2025)



Review Article

OPEN ACCESS

A Review Analysis on Climate Impacts, Migration Patterns, Habitat Loss, and Hunting on Avian Diversity in Pakistan

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ARTICLE INFO

Keywords:
Avian Diversity, Climate Change, Habitat Loss, Hunting, Migration, Wetlands, Conservation, Desert Birds, Coastal Birds

How to cite:
Sana, I., Mukhtar, A., Mumtaz, U., & Khan, B. N. (2025). A Review Analysis on Climate Impacts, Migration Patterns, Habitat Loss, and Hunting on Avian Diversity in Pakistan: Climate Impacts, Migration Patterns, Habitat Loss, and Hunting on Avian Diversity . MARKHOR (The Journal of Zoology), 6(4), 08-13. https://doi.org/10.54393/mjz.v6i4.185

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Received Date: 27th September, 2025
Revised Date: 27th October, 2025
Acceptance Date: 18th December, 2025
Published Date: 31st December, 2025

ABSTRACT

Pakistan has more than 790 species of birds living in different ecosystems, with 225 nationally significant wetlands, of which 19 are Ramsar wetlands with critical arid, coastal, and montane habitats. The country is a critical location of migratory and resident avifauna due to its location on the Indus Flyway. This is, however not the case as the avian diversity is threatened to extinction by habitat loss, climate change, hunting, and pollution. It is a systematic literature review that identifies these threats in important biomes of Pakistan (2012-2025). Results show that there have been drastic reductions in the number of birds in well-known wetlands such as Taunsa Barrage and Uchali Lake due to change of land use, illegal studies, and variability in migration due to climate change. Other understudied pressures in desert and coastal ecosystems that are mentioned through the analysis include overgrazing in Cholistan and mangrove loss in the Indus Delta. Some of the conservation measures that are discussed are habitat restoration, increased enforcement of the law, community involvement, and adaptation to changes in climate. This is an appeal to call on concerted, biome-specific conservation to protect the avian diversity in Pakistan as the environment keeps mounting pressure on it.

INTRODUCTION

Birds are vertebrates that are very important insect predators, seed predators, scavengers, and pollinators, and can enable stability of an ecosystem to be ensured [1]. About 13 percent of the world's bird species (10,900 species) are endangered by BirdLife International [1]. In addition to their ecological role, birds play key cultural, economic, and recreational roles, and thus, conserving them is crucial to the well-being of biodiversity and human life. The Indo-Pak subcontinent has about 2,060 species of birds, which is a qualification of the richness of the habitats that exist within the region: mountains, lowlands, and the wetlands [2]. Pakistan, which is located in the Palearctic, Oriental, and Ethiopian region supports more than 790 birds, including resident, migrant, and seasonal birds [3]. It is also located in the Indus Flyway that is among the main migratory pathways in the world. While wetlands such as the 225 nationally significant sites and 19 Ramsar sites are critical for migratory and resident birds like the Siberian crane and Houbara bustard [4], Pakistan's avian diversity is also sustained by other key ecosystems. These include the arid and semi-arid regions of Cholistan and Thar, coastal mangroves of the Indus Delta, and montane forests of the northern highlands. Each biome supports unique avian assemblages, yet non-wetland ecosystem sparticularly

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deserts and coasts. remain understudied and are experiencing rapid degradation due to climate change, habitat conversion, and unsustainable resource use. Urban sprawl, land conversion, and deforestation are key factors that contribute to the reduction of the avian population [5]. Climate change also increases these threats, whereby temperature and precipitation patterns change, causing range shifts, interrupted migration, and poor breeding success [6, 7]. It is forecasted using models that in northern Pakistan, appropriate habitats to Galliformes species could decrease by approximately 47 percent by the year 2050-2070 [8]. Alterations in wetland hydro-regimes, lakes drying out earlier, and decreased food at stopovers are a threat to migratory species [9]. There is additional pressure through pollution, hunting, and the use of pesticides [10]. The surveys at Taunsa Barrage, Uchali complex, and northern highlands show that the diversity and abundance of birds have decreased significantly [11]. The homogenization of other ecostructures, such as urban Lahore and Faisalabad, is seen to be substituting the diversity of avifauna by a few scavenger species [12]. These trends reflect international losses since close to fifty percent of all the waterbirds experience a decline in population because of the loss of wetlands [13]. Considering the ecological importance of Pakistan, there is an urgent need to study the information on the threats to the avian diversity in Pakistan comprehensively. Synthesizing the results of various areas like the northern highlands, Taunsa Barrage, Uchali Complex, and urban centers, it tries to find out the patterns of species disappearance in space, the gaps in conservation, and the combination of measures to provide sustainable conservation of the bird species in the Pakistani critical areas and the migration routes.

This study aims to evaluate the significant threats affecting avian diversity in Pakistan that include climate change, habitat loss, migratory patterns, and hunting.

A thorough literature search was conducted for peer-reviewed English publications (2003-2025) using databases including Web of Science, Scopus, Google Scholar, and Semantic Scholar. Search strings combined broader terms (e.g., "avifauna," "bird*") with specific threats ("climate change," "habitat fragmentation," "illegal hunting") and geographical terms ("Pakistan," "Indus," "Balochistan," "Sindh"). To mitigate bias towards well-studied wetlands. To ensure comprehensive coverage and mitigate bias toward well-studied wetlands and highlands, the search strategy explicitly included terms related to underrepresented ecosystems: "desert birds," "coastal birds," "arid zone," "mangrove," "Indus Delta," "Cholistan," "Thar desert," "Makran coast," "coastal avifauna," and "sand-dune species." This approach aimed to capture studies from all major biomes, although the available literature remained disproportionately focused on wetlands and northern regions. etlands and highlands, specific terms like "desert birds," "coastal birds," "arid zone," and "mangrove" were included. Studies were screened based on relevance, methodological rigor, and geographical coverage, prioritizing those with quantitative data but including qualitative reviews to identify gaps. Based on each of the studies, data regarding title, study area, publication year, objectives, and methods (number of points, transects, questionnaires, satellite imagery, GIS, or camera trapping) were gathered. Approximately 38 studies were found that were mostly related to Punjab and Khyber Pakhtunkhwa (wetlands: Taunsa Barrage, Uchali Wetlands, Chashma Barrage; cities: Lahore, Islamabad, Faisalabad). Field surveys and interviews were employed in the hunting studies to record the practice of trapping, shooting, and netting of bustards, cranes, and partridges.

Key Factors Affecting Avian Diversity in Pakistan: Climate Changes

The avian diversity in Pakistan is facing grave threats due to changes in distribution, migration, and reproduction of birds across the world because of the phenomenon of climate change [7, 14]. In Pakistan, the abundance of birds is very sensitive to temperature and rainfall, and changes in land-use, particularly in the northern parts. Extreme weather, temperature changes, and precipitation amount changes influence the food availability, breeding rates, and timing [8]. By 2070, the habitat suitability of the Galliformes and other indicator species in the highlands of the north could be reduced to up to 47 percent. It is also predisposing to diseases, since the variation of climates amplifies the spread of the pathogens due to the variation in humidity levels and temperature [15]. This is especially true of specialized or range-restricted birds, which reflect the global trends in extinction [16]. Effective mitigation includes establishing protected climate refugia and ecological corridors in the northern highlands, ensuring sustainable water flows to wetlands, and implementing early-warning systems for extreme weather impacts on breeding sites. The Indus Flyway of Pakistan links the West Asian and the East African migratory pathways, which subject birds to habitat destruction, contamination, and urbanization [17]. Among the factors that destroy migration are climate change and changes in land-use [18]. Power line collisions, as observed in Great Bustards, also enhance mortality during migration [19]. The reduction in the waterbird population at other locations, such as Taunsa Barrage and Uchali wetlands, is indicative of the wider global trends whereby 38-55% of migratory species are depleting [11, 13]. To defend the migratory flyways, there should be a concerted effort by all countries in order to counteract climate and habitat pressures.

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Habitat loss

The primary threat to world biodiversity is habitat loss, which is caused by natural and human actions, including deforestation, agriculture, mining, and urbanization [7, 20]. Forest fragmentation in regions such as Barali Kass (Azad Kashmir), Taunsa Barrage, and Swat has seriously affected the bird population, especially the frugivorous and insectivorous birds in Pakistan [21]. The decrease in species richness occurs in even those areas that are highly diverse, such as the endangered Steppe Eagle and Western Tragopan [22]. Wetlands and grasslands have been destroyed by agricultural expansion and the use of pesticides, and this has affected the habitats of waterfowl as observed at Taunsa Barrage and Uchali Complex [11]. The development in Lahore and Islamabad has also encroached on the original habitat, with scavenger colonies occupying the natural habitat [12]. These losses interfere with the ecosystem services, leading to pests and decreased forest regeneration. Mitigation requires enforcing Ramsar site protections, restoring degraded forests and deserts with native species, and promoting bird-friendly agricultural practices such as maintaining hedgerows and reducing pesticide use.

Hunting

Bird conservation is also a huge problem in the world due to hunting, which is aggravated by increasing population and habitat invasion [23]. Commercial and recreational hunting has led to drastic degradations in Pakistan, even in the hunted areas. The abundance of birds is reduced by 58% in the hunted areas [24]. Economically important species in the black partridge (80%), chukar (98%), grey partridge (70%), and see-see partridge (40%) have declined drastically [10]. Hunting is the Pathan tribes' traditional hunting, where they use trapping apparatus known as seya, and foreign dignitaries hunt the Houbara bustard in Punjab [25]. Lax enforcement, political influence, and poorly armed wildlife departments facilitate the illegal hunting and trade [26]. Mitigation strategies include strengthening wildlife law enforcement with increased patrols in hotspots like Chashma and Taunsa, providing alternative livelihoods such as eco-tourism and poultry farming to local communities, and launching targeted awareness campaigns against illegal hunting.

Summary of Key Factors Threatening Bird Diversity

These four threats include climate change, broken migration, loss of habitat, and poaching of birds in Pakistan [27]. Climate change will shift distributions, breeding, and food supply, and key habitats are estimated to disappear by almost fifty percent by 2070 [28]. There are degradation, poaching, and urbanization of the habitats that are causing the decline of migratory birds along the Indus Flyway. Deforestation, agricultural activities, and encroachment of wetlands seriously impair the survival of species such as the Western Tragopan and the Steppe Eagle [29]. Conservation Conventional and commercial hunting, such as black partridge and houbara bustard, exerts an aggravating impact. The most serious threat is habitat loss, and it should be given the first priority when it comes to conservation efforts [30]. The analysis shows habitat loss as the most severe threat to Pakistan's avian diversity, followed by hunting, climate change, and pollution (Figure 1).

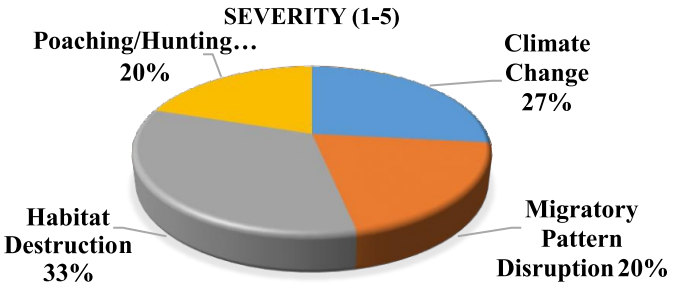

Figure 1: Severity of Threats in Pakistan

This visual summary supports the regional findings in Table 1 and highlights the need to prioritize habitat restoration and anti-poaching measures in conservation planning (Table 1).

Table 1: Case Studies and Regional Evidence

Study Area	Key Threats	References
Northern highlands	Habitat models predict a 35% decline in suitable Galliformes habitat by 2050 and 47% by 2070 due to fragmentation and predation pressures.	[29]
Khyber Pakhtunkhwa	Reductions in precipitation and the loss of rainfed land would cause a considerable loss in the richness of wintering species of birds.	[6]
Taunsa Barrage	Documented 171 species of birds, 14 with declining population and habitat destruction, pesticide application, and poaching.	[13]
District Jhang	Captured 54 species representing 15 orders; poaching is the primary challenge to the existence of birds.	[27]
District Layyah	Surveyed 223 species of which 16 species are IUCN Red-listed; the most important threat is hunting.	[31]
Uchali Complex	Documented 139 species; the survival of birds is endangered by poaching, contact with pesticides, and fishing.	[11]
Chiniot	Documented 87 species in 70 genera; urbanization and seasonality decrease the abundance and richness of avian species.	[32]
Lahore	272 species found; excessive human activities, degradation, and planting of exotic trees (Eucalyptus) diminish the passerine richness.	[12]

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Faisalabad	26 species were seen in 19 families; urbanization is causing loss of diversity and scavenger birds are prevailing in urban areas.	[33]
Islamabad	230 species documented; constant surveillance is required to reverse habitat destruction, climatic effects, and human intrusion.	[2]
Punjab University New Campus	Documented 76 species; the development of land-use encourages the disruption of migration and the homogenization of species.	[34]
Wetlands	Hunting in 6 wetlands has a 42.46% impact on 73 species of waterbirds; the most common group is Anseriformes.	[18]
Darazinda Tehsil	The hunting and deforestation led to a reduction in the population of birds by 36% in 10-15 years.	[10]
Keti Bunder Tehsil	49 species were observed; the population was decreasing because of pollution and other human activities.	[3]
Cholistan Desert	Desertification, overgrazing, and illegal hunting threaten Macqueen's Bustard and other arid-zone specialists.	[35]

DISCUSSION

In Pakistan, avian diversity is severely endangered both by natural and anthropogenic processes. Climate change, heat waves, unpredictable precipitation, and droughts interfere with food supply, breeding, and migration [10]. These factors, together with habitat loss, hunting, and pollution, produce a compounding effect on the population of birds throughout the country [7] as shown in Table 1. The loss of habitat is a major cause of avian loss on a national scale; its effects on different ecosystems are diverse. Mangrove deforestation to aquaculture development poses a danger to piscivorous avian species in the Indus Delta, such as the Indian Skimmer (Rynchops albicollis). Conversely, the range-restricted species that are directly threatened by the fragmentation of temperate forests in the northern highlands include the Western Tragopan (Tragopan melanocephalus). This local quality highlights the importance of conservation policies that are specific to a particular region, as opposed to policies that are uniform [18]. The wetlands, such as Uchali Complex and Taunsa Barrage are being degraded, hunted, and encroached, leading to a decline in the wetland, which is a risk to migratory stopovers along indus flyway [11]. This interdependence of threats, which is aggravated by lax enforcement and cultural hunting beliefs, is reflective of the global trends in which 40-50% of waterbirds may become extinct [20]. Frugetivorous and insectivorous birds decrease forest regeneration, crop production, and urban scavengers prevail, leading to the depletion of biodiversity, the outbreak of pests, and an imbalance in the ecosystem [21, 32]. Conservation of avian in Pakistan needs a specific attack. Poor wetlands require hydrological rehabilitation, eradication of invasive plants, and buffers [4], whereas arid areas such as Cholistan need planting of native vegetation and curbing overgrazing as an anti-desertification strategy. Mangroves along the coasts of the Indus Delta need to be replenished using the force of the law and community-based efforts. To the wildlife laws, harder penalties and more patrols through GPS and drones would be necessary to reduce illegal hunting, particularly of the Houbara bustard [36]. By involving local communities as custodians of the wetland, illegal activities are minimized, and because of the eco-tourism activities in places such as Deosai National Park, alternative means of earning are generated. The insectivorous birds are supported by such practices in farming as integrated pest management, hedgerows, and reduced pesticide application, which are friendly to birds. The protection of the Ram barsar site keeps the survival of migratory birds in the Indus Flyway route, but the conservation of climate refugia in the highlands of the North by GIS modelling and the restoration of ecological corridors keeps species adapting to climate change [37]. Remote sensing and citizen science tools such as eBird Pakistan are useful in real-time monitoring of habitats and help in adaptive management of the habitat over a long period of time. The avian diversity of Pakistan must be conserved in the long term through the integrated application of these strategies, facilitated by research and cross-sector cooperation [38].

CONCLUSIONS

It makes the conclusion that the direct mitigation measures must involve enhancing anti-poaching legislation, rehabilitating important wetlands, and initiating community conservation efforts in desert and coastal areas. Climate adaptation plans can only be undertaken in the long-term in conjunction with sustainable land-use policies and national habitat corridors. Although wetlands and highlands still need to be maintained, there is a need to save the desert and coastal ecosystems that are understudied and threatened. Future research must prioritize: (1) long-term monitoring in underrepresented deserts and coasts; (2) quantitative studies on hunting pressure and trade networks; and (3) climate vulnerability assessments for range-restricted species. Addressing these gaps will inform targeted, evidence-based conservation in Pakistan.

DOI: https://doi.org/10.54393/mjz.v6i4.185

Authors Contribution

Conceptualization: BNK
Methodology: IS, BNK
Formal analysis: AM, UM, BNK
Writing and Drafting: IS, AM, BNK
Review and Editing: IS, AM, UM, BNK

All authors approved the final manuscript and take responsibility for the integrity of the work.

Conflicts of Interest

All the authors declare no conflict of interest.

Source of Funding

The author received no financial support for the research, authorship and/or publication of this article.

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