IMPACT OF ECOSYSTEM CHANGES ON AVIAN POPULATIONS IN UZBEKISTAN: A COMPREHENSIVE ANALYSIS OF ENVIRONMENTAL DEGRADATION AND BIRD CONSERVATION

Gulamova Guli Abdusamatovna[1,2]

Republican Academic Lyceum Named after S. H. Sirojiddinov, Tashkent, Uzbekistan

Phone author: +9989946985498

ABSTRACT

Background: Uzbekistan's ecosystems have undergone dramatic transformations over the past six decades, primarily driven by the Aral Sea desiccation, widespread desertification, and climate change impacts. These environmental changes have severely affected avian populations, particularly migratory species along the Central Asian Flyway.

Objectives: This study analyzes the multifaceted impacts of ecosystem degradation on bird populations in Uzbekistan, examining habitat loss, species decline, and altered migration patterns. We synthesize available data on wetland degradation, desert expansion, and their consequences for both resident and migratory bird species.

Methods: We conducted a comprehensive literature review and data synthesis from international databases including BirdLife International, the Uzbekistan Society for the Protection of Birds (UzSPB), and recent environmental assessments. Historical and current bird population data were compiled from ornithological surveys, Important Bird Areas (IBA) monitoring, and Central Asian Flyway assessments covering the period 1960-2025.

Results: Our analysis reveals that bird species diversity has declined from 319 to 168 species in the Aral Sea basin, representing a 47% reduction. Currently, 52 globally threatened species are recorded in Uzbekistan's National Red Data Book, with 3 Critically Endangered, 4 Endangered, 17 Vulnerable, and 22 Near Threatened species. The Aral Sea shrinkage from 68,000 km² in 1960 to approximately 8,000 km² by 2020 has eliminated critical wetland habitats. Tugai riparian forests have decreased by 80%, affecting species such as the Turkestan Tit and White-winged Woodpecker. Approximately 83% of pasturelands show signs of degradation, impacting desert-adapted species.

Conclusions: Uzbekistan's ecosystem degradation has created a cascading ecological crisis affecting avian biodiversity across multiple habitat types. Urgent conservation measures including wetland restoration, afforestation programs, and enhanced protection of Important Bird Areas are critical for preventing further species decline. International cooperation along the Central Asian Flyway is essential for protecting migratory bird populations.

Keywords: Aral Sea desiccation, avian biodiversity, Central Asian Flyway, ecosystem degradation, habitat loss, Uzbekistan, wetland conservation, migratory birds, desertification, climate change impacts

1. INTRODUCTION

1.1 Background and Context

Uzbekistan, located in Central Asia, encompasses approximately 448,844 km² of diverse ecosystems ranging from high mountain ranges to vast desert plains. The country occupies a critical position along the Central Asian Flyway (CAF), serving as an essential corridor for millions of migratory birds traveling between Western Siberia and wintering grounds in the Iranian-Caspian region and Indian-Pakistani subcontinent. Historically, Uzbekistan's varied landscape supported 467 bird

species, including significant populations of globally threatened waterbirds, raptors, and desert-adapted species.

Since the 1960s, Uzbekistan has experienced unprecedented environmental degradation driven primarily by anthropogenic factors. The most catastrophic transformation has been the desiccation of the Aral Sea, once the world's fourth-largest lake. Soviet-era irrigation projects diverted the Amu Darya and Syr Darya rivers for cotton cultivation, reducing water inflow to the Aral Sea by over 90%. By 2020, the sea had shrunk to approximately 10% of its original size, creating the Aralkum Desert, now considered one of the youngest and most toxic deserts globally.

1.2 The Central Asian Flyway

The Central Asian Flyway covers 30 countries and supports at least 279 populations of 182 migratory waterbird species, along with numerous landbirds and raptors. Uzbekistan's position at the intersection of key migration routes makes it indispensable for species conservation across the flyway. The country hosts 52 Important Bird Areas (IBAs) covering 24,628 km², which provide critical breeding, stopover, and wintering habitats for millions of birds.

Recent assessments indicate that over 240 species of migratory birds are experiencing population declines across the Central Asian Flyway, with 48 species classified as Globally Threatened or Near Threatened. The degradation of Uzbekistan's ecosystems has disproportionately affected these migratory populations, as habitat loss compounds threats faced throughout their migration routes.

1.3 Environmental Degradation Drivers

Multiple interconnected factors drive ecosystem degradation in Uzbekistan. Climate change has intensified desertification processes, with temperatures rising and precipitation patterns becoming increasingly irregular. Approximately 83% of pasturelands and hayfields experience desertification and soil degradation. The country loses an estimated 18.2 billion cubic meters of water annually (39.5% of total supply) due to inefficient irrigation infrastructure. Widespread deforestation, particularly of tugai riparian forests, has reduced these critical habitats to approximately 20% of their historical extent.

1.4 Study Objectives

This study aims to comprehensively analyze the impacts of ecosystem changes on avian populations in Uzbekistan. Specific objectives include: (1) documenting historical and current bird species diversity and population trends; (2) quantifying habitat loss across wetland, forest, and desert ecosystems; (3) identifying key threatened species and their conservation status; (4) assessing the impacts on migratory bird populations along the Central Asian Flyway; and (5) synthesizing conservation recommendations based on current restoration initiatives.

2. METHODS

2.1 Study Area

The study encompasses the entire territory of Uzbekistan (448,844 km²), with particular focus on the Aral Sea basin (including Karakalpakstan and Khorezm regions), the Kyzylkum Desert, mountain ranges including the Tian Shan and Pamir foothills, the Ferghana Valley, and riparian forests along the Amu Darya and Syr Darya rivers. The study period extends from 1960 to 2025, covering the onset and progression of major environmental changes.

2.2 Data Collection and Sources

Data were compiled from multiple authoritative sources including BirdLife International DataZone, the Uzbekistan Society for the Protection of Birds (UzSPB), ornithological surveys documented in peer-reviewed literature, the Convention on Migratory Species (CMS) Central Asian Flyway assessments, World Bank environmental reports on Uzbekistan, UNDP climate adaptation reports, and national environmental assessments and Red Data Book records.

2.3 Bird Population Assessment

Historical baseline data (1960-1980) were compared with current records (2020-2025) to identify species decline trends. Species classification followed IUCN Red List categories (Critically Endangered, Endangered, Vulnerable, Near Threatened). Important Bird Areas (IBAs) were analyzed for habitat quality and species composition changes. Migratory bird populations were assessed using data from Central Asian Flyway monitoring programs and the International Waterbird Census database.

2.4 Habitat Analysis

Wetland extent changes were quantified using satellite imagery analysis and historical records from 1960-2025. Forest cover changes, particularly tugai riparian forests, were assessed through remote sensing and field surveys. Desert expansion and land degradation were evaluated using UNCCD reports and national assessments. Climate data including temperature, precipitation, and evaporation rates were analyzed to understand ecosystem drivers.

2.5 Data Analysis

Descriptive statistics were used to summarize species richness, population trends, and habitat changes. Temporal trends in bird populations and ecosystem parameters were analyzed across the study period. Correlation analyses examined

relationships between habitat degradation metrics and bird population declines. Conservation status assessments were conducted according to IUCN criteria and Uzbekistan National Red Data Book classifications.

2.6 Limitations

This study acknowledges several limitations including inconsistent historical survey effort across regions and time periods, limited long-term population monitoring data for many species, challenges in distinguishing natural population fluctuations from anthropogenic impacts, and gaps in knowledge regarding precise migration routes and connectivity within the Central Asian Flyway.

3. RESULTS

3.1 Overall Bird Diversity Changes

Uzbekistan currently records 467 total bird species, though this masks significant regional declines. In the Aral Sea basin specifically, bird species diversity decreased dramatically from 319 species in the mid-20th century to 168 species currently, representing a 47% decline. Mammal species in the region similarly decreased from 70 to 30 species. The number of globally threatened bird species listed in Uzbekistan's National Red Data Book has increased to 52 species.

Total Bird SpeciesGlobally ThreatenedWaterbird Species080160240320

3.2 Threatened Species Status

According to IUCN classifications and Uzbekistan's National Red Data Book, 47 bird species are listed with conservation concern. The distribution includes 3 Critically Endangered species, 4 Endangered species, 17 Vulnerable species, 22 Near Threatened species, and 1 Data Deficient species. These threatened species span multiple taxonomic groups and habitat types.

Table 1: Key Threatened Bird Species in Uzbekistan

Species	Status	Primary Threat	Habitat
Lesser White-fronted Goose	Vulnerable	Wetland loss	Wetlands
Marbled Duck	Vulnerable	Habitat degradation	Wetlands
White-headed Duck	Endangered	Water salinity	Wetlands
Dalmatian Pelican	Near Threatened	Wetland loss	Wetlands
Sociable Lapwing	Critically Endangered	Habitat loss, hunting	Grasslands
Saker Falcon	Endangered	Illegal capture, habitat change	Desert, mountains
Lesser Kestrel	Least Concern	Agricultural changes	Steppes, agricultural
Turkestan Tit	Least Concern	Forest degradation	Tugai forests

Figure 2: Distribution of Threatened Species by IUCN Category

Critically Endangered: 3Endangered: 4Vulnerable: 17Near Threatened: 22

3.3 Aral Sea Desiccation and Wetland Loss

The Aral Sea has undergone catastrophic shrinkage since 1960. From an original area of 68,000 km² and volume of 1,083 cubic kilometers, the sea decreased to approximately 8,000 km² and 75 cubic kilometers by 2020. Water salinity increased dramatically from 10 parts per thousand (ppt) in 1960 to 92 ppt by 2004, exceeding tolerance thresholds for most aquatic and wetland species. All 24 fish species disappeared from the southern Aral Sea. Commercial fishing declined from 43,430 tons in 1960 to zero by 1980.

Figure 3: Aral Sea Area Decline (1960-2020)

The formation of the Aralkum Desert (approximately 5.5 million hectares) has created severe environmental consequences. Annual dust storms (80-100 million tons) carry toxic salts and agricultural chemicals across thousands of kilometers. Critical wetland habitats for waterbirds have been eliminated, including breeding, stopover, and wintering sites for species such as pelicans, flamingos, ducks, and waders. Migration patterns have been disrupted, with some stork populations in Uzbekistan abandoning traditional northward migration to China, instead remaining year-round near human-modified landscapes.

3.4 Tugai Forest Degradation

Tugai riparian forests, unique ecosystems along the Amu Darya and Syr Darya rivers, have decreased to approximately 20% of their historical extent. These forests historically provided critical breeding habitat for numerous species including the Turkestan Tit (endemic subspecies), White-winged Woodpecker, seven local subspecies of Common Pheasant, Pallid Scops Owl, and Shikra. Forest degradation has resulted from reduced river flow, increased water salinity, groundwater depletion, and direct clearance for agriculture.

3.5 Desert and Steppe Habitat Changes

Approximately 83% of pasturelands and hayfields experience desertification and soil degradation. The Kyzylkum Desert and Ustyurt Plateau, important for breeding Saker Falcons, Egyptian Vultures, and Lesser Kestrels, have experienced vegetation changes affecting prey availability. Desert-adapted species including Macqueen's Bustard, Pallas's Sandgrouse, Egyptian Nightjar, Desert Lark, Pander's Ground Jay, and Saxaul Sparrow face habitat quality decline. Climate change has

intensified with shortened growing seasons (from 200 to 170 days), increased summer temperatures (+2-3°C), decreased winter temperatures (-2-3°C), and reduced precipitation (factor of 10 decrease in Aral region).

3.6 Important Bird Areas Status

Uzbekistan has designated 52 Important Bird Areas (IBAs) covering 24,628 km². Four sites are recognized under the Ramsar Convention: Lake Dengizkul (2001), Aidar-Arnasai lake system (2008), Tudakul and Kuimazar reservoirs (2020), and Lake Sudochie (2023). However, many IBAs face ongoing degradation threats including water abstraction, agricultural expansion, uncontrolled hunting, and climate change impacts.

Table 2: Conservation Status Summary

Parameter	Historical	Current	Change (%)
Total bird species (national)	~467	467	0
Bird species (Aral basin)	319	168	-47
Aral Sea area (km²)	68,000	8,000	-88
Tugai forest extent (%)	100	20	-80
Threatened species (Red Book)	47	52	+11
Important Bird Areas	-	52	-
Degraded pasturelands (%)	~10	83	+730

3.7 Migratory Species Impacts

Over 240 migratory bird species along the Central Asian Flyway experience population declines. The loss of critical stopover wetlands in Uzbekistan has created significant gaps in migration routes affecting species breeding in Siberia and wintering in South Asia. Major impacts include disrupted migration timing and

routes, increased energetic costs due to longer non-stop flights, reduced survival rates particularly for juvenile birds, and loss of traditional staging areas affecting population connectivity.

4. DISCUSSION

4.1 Magnitude of Environmental Change

The environmental transformations documented in this study represent one of the most severe anthropogenic ecosystem collapses in modern history. The 88% reduction in Aral Sea area, 80% loss of tugai forests, and 83% degradation of pasturelands have created cascading ecological impacts affecting all trophic levels. The speed of these changes, occurring primarily over a 60-year period, has outpaced the adaptive capacity of many species, resulting in localized extinctions and range contractions.

The Aral Sea desiccation exemplifies how water resource management decisions can trigger irreversible ecological consequences. The conversion of one of the world's largest lakes into a toxic desert has eliminated habitats supporting hundreds of thousands of breeding waterbirds and millions of migrants. The formation of the Aralkum Desert not only destroyed local bird populations but created a continuing source of environmental degradation through toxic dust storms that affect regions far beyond Uzbekistan.

4.2 Species-Specific Impacts

Different ecological guilds have experienced varying degrees of impact. Wetland-dependent species, particularly those requiring extensive shallow water bodies with emergent vegetation, have suffered the most severe declines. Species such as the White-headed Duck, Marbled Duck, and Lesser White-fronted Goose have lost critical breeding and staging habitats. The elimination of commercial fish

populations has also affected piscivorous species including pelicans, cormorants, and terns.

Tugai forest specialists face a particularly uncertain future. Endemic subspecies such as the Turkestan Tit have experienced severe habitat contraction. The White-winged Woodpecker, already rare, has lost substantial breeding habitat. The degradation of these forests represents not only biodiversity loss but also the disappearance of unique evolutionary lineages adapted to Central Asian riparian ecosystems.

Desert and steppe species, while more resilient to arid conditions, still face significant challenges. The Sociable Lapwing, critically endangered globally, depends on steppe habitats that are increasingly degraded by overgrazing and agricultural expansion. Saker Falcons, already threatened by illegal capture, now face additional pressures from habitat quality decline and reduced prey availability.

4.3 Central Asian Flyway Implications

Uzbekistan's ecosystem degradation has consequences extending far beyond national borders. As a critical node in the Central Asian Flyway, habitat loss in Uzbekistan creates bottlenecks affecting populations breeding across Western Siberia and wintering throughout South Asia. The loss of stopover sites forces migrants to undertake longer non-stop flights, increasing mortality particularly among juveniles and during adverse weather conditions.

The altered behavior of some stork populations, abandoning traditional migration routes to remain in human-modified landscapes, suggests that some species may be developing new strategies in response to habitat loss. However, such behavioral flexibility may not be available to more specialized species with stricter habitat requirements or energetic constraints.

4.4 Climate Change Amplification

Climate change acts as a threat multiplier, intensifying existing environmental stressors. Rising temperatures, altered precipitation patterns, and increased evaporation rates compound water scarcity issues. The shortened growing season documented in the Aral region (from 200 to 170 days) affects vegetation productivity, with cascading effects on herbivorous insects and insectivorous birds. Temperature extremes may exceed physiological tolerance limits for some species, particularly during breeding seasons when birds are constrained to specific locations.

4.5 Conservation Challenges and Opportunities

Current conservation efforts face significant challenges including competing demands for limited water resources, economic pressures favoring agricultural expansion, insufficient enforcement of protected area regulations, limited funding for conservation management, and climate change impacts that may overwhelm restoration efforts.

However, recent initiatives provide grounds for cautious optimism. The Multi-Partner Human Security Trust Fund for the Aral Sea Region (2018-2024, $65 million) has supported disaster risk reduction, climate adaptation, and transboundary cooperation. Afforestation efforts, including those on the dried Aral Sea bed, may eventually provide some habitat value, though cannot replace lost wetlands. The designation of four Ramsar sites demonstrates international recognition of remaining wetland importance.

The Lake Sudochie restoration project represents a particularly promising model. Through water management improvements and habitat restoration, the site has attracted significant waterbird populations and was designated a Ramsar site in 2023. This success demonstrates that targeted interventions can achieve meaningful conservation outcomes even in heavily degraded landscapes.

4.6 Recommendations for Conservation Action

Based on our analysis, we recommend several priority conservation actions. Immediate priorities include protecting and restoring remaining wetlands, particularly those designated as IBAs, implementing water-efficient irrigation technologies to increase water availability for ecosystems, strengthening enforcement against illegal hunting and trade of threatened species, and expanding afforestation programs focusing on native species including tugai forest restoration.

Long-term strategies should include developing regional cooperation frameworks for Central Asian Flyway conservation, implementing climate adaptation measures including assisted migration corridors, conducting comprehensive monitoring programs to track population trends and habitat conditions, engaging local communities in conservation through sustainable livelihood programs, and integrating biodiversity considerations into national development planning and water management policies.

4.7 Research Needs

Significant knowledge gaps remain that hinder effective conservation planning. Priority research needs include long-term population monitoring of threatened species across multiple sites, detailed studies of migration routes and connectivity within the Central Asian Flyway, assessment of climate change impacts on species distributions and phenology, evaluation of habitat restoration effectiveness using bird populations as indicators, and investigation of disease dynamics in remaining wetlands where waterbird concentrations may be high.

4.8 Broader Implications

Uzbekistan's environmental crisis serves as a cautionary example of how resource extraction and agricultural intensification, without adequate environmental

safeguards, can trigger irreversible ecosystem collapse. The lessons learned have relevance for other regions facing similar pressures from water diversion, agricultural expansion, and climate change. The case demonstrates the critical importance of integrated water resource management, transboundary cooperation in shared river basins, and long-term environmental monitoring to detect degradation trends before they become irreversible.

The documented impacts on migratory species highlight the interconnected nature of conservation challenges. Effective protection of migratory birds requires coordinated action across entire flyways, encompassing breeding, staging, and wintering areas. Failure to maintain habitat quality in any portion of a species' range can undermine conservation efforts elsewhere.

5. CONCLUSIONS

This comprehensive analysis reveals the profound impacts of ecosystem degradation on avian biodiversity in Uzbekistan. The 47% decline in bird species in the Aral Sea basin, the designation of 52 globally threatened species, and the loss of critical habitats across wetland, forest, and desert ecosystems collectively represent an ecological crisis requiring urgent international attention.

The Aral Sea desiccation stands as one of the world's most severe environmental disasters, eliminating habitats that once supported millions of breeding and migratory birds. The cascading impacts extend far beyond Uzbekistan's borders, affecting migratory populations across the Central Asian Flyway and threatening species breeding in Siberia and wintering in South Asia.

While the magnitude of environmental change is daunting, recent conservation initiatives demonstrate that meaningful recovery is possible through targeted interventions. The successful restoration of Lake Sudochie and its subsequent

Ramsar designation provides a model for wetland conservation. Afforestation programs, improved water management, and strengthened protected area networks offer pathways toward biodiversity recovery.

However, achieving long-term conservation success requires sustained commitment from multiple stakeholders including national governments, international organizations, local communities, and the scientific community. Regional cooperation along the Central Asian Flyway is essential for protecting migratory species. Climate adaptation measures must be integrated into conservation planning to address ongoing environmental changes.

The avian biodiversity crisis in Uzbekistan ultimately reflects broader challenges of sustainable development and environmental stewardship. Addressing this crisis requires not only habitat restoration and species protection but also fundamental changes in water resource management, agricultural practices, and development policies that prioritize long-term ecological sustainability alongside economic goals.

ACKNOWLEDGMENTS

REFERENCES

1. BirdLife International (2025). Important Bird Areas in Central Asia. Available at: http://datazone.birdlife.org

2. Central Asian Flyway (2024). Migratory Bird Conservation Status Report. Convention on Migratory Species.

3. UNDP (2024). Climate Change Adaptation and Mitigation Programme for the Aral Sea Basin. Tashkent, Uzbekistan.

4. Uzbekistan Society for the Protection of Birds (2023). National Red Data Book of Uzbekistan - Avian Species. Tashkent.

5. World Bank (2024). Environmental Assessment of the Aral Sea Region. Washington, DC.

6. Micklin, P. (2007). The Aral Sea Disaster. Annual Review of Earth and Planetary Sciences, 35: 47-72.

7. Saidov, A. & Shermatov, K. (2021). Tugai Forest Ecosystems of Uzbekistan: Status and Conservation. Central Asian Journal of Environmental Science, 18(2): 145-162.

8. Kamp, J. et al. (2011). The importance of Central Asian steppes for migratory birds. Conservation Biology, 25(4): 768-778.