



## Effect of Weather Change on Bird Migration — A Study with Special Reference to Rajasthan, India

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### Abstract

Climate and weather-pattern changes are altering the phenology, routes, and wintering patterns of migratory birds globally. Rajasthan — with its arid to semi-arid zones, large shallow saline wetlands (e.g., Sambhar), and unique desert ecosystems — is an important stopover and wintering region for many migratory waterbirds and passerines. This paper synthesizes meteorological trends for Rajasthan and recent avian monitoring studies to evaluate how changing temperature and precipitation regimes influence arrival/departure timing, species composition, habitat use, and conservation risks for migratory birds in the region. Evidence indicates later monsoon onset, greater interannual rainfall variability, and warming trends across Rajasthan; these changes correlate with altered wetland hydroperiods, shifting food availability, and documented changes in species occurrence and abundance at key sites. The paper proposes targeted monitoring, wetland management, and policy measures to buffer migratory populations against ongoing climatic changes.

**Keywords:** *migratory birds, phenology, Rajasthan, climate change, wetlands, Sambhar Lake, migration timing*

### 1. Introduction

Migratory birds rely on predictable seasonal cues — temperature, day length and precipitation-driven resource pulses — to time long-distance movements, breeding, and stopover refueling. When weather patterns shift, these cues and the habitats they depend on may no longer align, producing phenological mismatch, reduced survival, or range shifts (e.g., northward shifts for some taxa). India is both a passage and destination region for many Palearctic migrants; Rajasthan, located in northwest India, hosts several wetlands and desert habitats critical to wintering and passage migrants. Understanding links between regional weather change and migration dynamics is essential for conservation planning in Rajasthan's fragile ecosystems. Recent regional climate analyses and bird monitoring projects provide the basis for this synthesis.<sup>[1]</sup>

### 2. Objectives

1. Summarize the recent (post-2016) climatic trends in Rajasthan relevant to migratory bird ecology (temperature, rainfall, monsoon variability).<sup>[1]</sup>
2. Review documented changes in migratory bird timing, abundance and species composition at Rajasthan wetland and desert sites.<sup>[2]</sup>
3. Evaluate mechanisms linking weather change to observed avian responses (wetland hydroperiod, food availability, phenological mismatch).<sup>[2]</sup>
4. Recommend monitoring and management interventions to reduce climate-driven risks to migratory birds in Rajasthan.



### **3. Study Area — Rajasthan (brief)**

Rajasthan covers diverse landscapes from the Thar Desert in the west to semi-arid plains and seasonal wetlands in the east. Important bird habitats include saline lakes (Sambhar, Didwana), reservoirs, seasonal marshes, and steppe/desert fringe areas that attract Palearctic migrants (e.g., Anatidae, shorebirds, some passerines). Hydrology is strongly monsoon-driven; thus changes in monsoon timing, intensity, and interannual variability can have outsized ecological effects.<sup>[3]</sup>

### **4. Literature Review (selected recent findings)**

#### **1) 4.1 Regional climate trends relevant to avifauna**

Analyses of IMD and station data show warming across Rajasthan and varied rainfall trends between divisions; many districts now experience greater interannual variability and shifts in monsoon patterns (e.g., delayed onset in places, more extreme intra-season rainfall events). Trend analyses (2016 datasets and IMD reports) document statistically significant warming and localized changes in precipitation patterns that alter wetland hydroperiods.<sup>[1]</sup>

#### **2) 4.2 Evidence for bird distribution and phenology shifts in India / South Asia**

Recent modeling and empirical studies indicate that long-distance migratory birds are particularly vulnerable: projected range contractions and shifts, altered arrival/departure dates, and increased mismatch with food availability. In India, large-scale species distribution modeling shows many migratory species' wintering ranges are susceptible to climate change effects.<sup>[1]</sup>

#### **3) 4.3 Local monitoring evidence (Rajasthan wetlands)**

Targeted monitoring at some major saline lakes in Rajasthan (Sambhar) and other wetlands between 2015-2016 documented changes in total counts, species composition and timing compared with earlier baselines — linked to water availability changes, saltpan encroachment, and drying trends in specific years. These studies combine field counts with remote sensing to connect wetland area/hydrology with bird numbers.<sup>[2]</sup>

#### **4) 4.4 Mechanisms: hydroperiod, prey phenology, and extreme events**

Changes in precipitation and evaporation regimes alter wetland hydroperiods (shorter or more unpredictable flooding), reducing invertebrate and fish production or shifting their seasonal peaks. Heat extremes can affect prey availability and increase physiological stress on birds during stopovers. These mechanisms are supported by multi-region studies linking climate anomalies to migration timing and reproductive outcomes.<sup>[4]</sup>

### **5. Methods — how this paper was prepared**

This is a synthesis study combining (a) an analysis of recent peer-reviewed literature (2016–2017), (b) government meteorological reports (IMD), and (c) published field monitoring at key Rajasthan sites (2016–2017): I searched scientific databases and authoritative reports for studies on bird migration, Rajasthan climate trends and wetland condition. Where published monitoring datasets existed (e.g., Sambhar wetland studies), I synthesized results linking hydrology and bird counts. No new field data were



collected for this paper; conclusions synthesize and interpret published evidence and modeled projections.<sup>[4]</sup>

## 6. Results — synthesis of observed and projected impacts

### 5) 6.1 Climatic changes in Rajasthan (2016–2017 and projections)

- **Warming trend:** Multi-station analyses show rising mean temperatures across divisions (notable increases in mean annual and seasonal maximum temperatures). This trend increases evapotranspiration and can reduce wetland persistence.<sup>[2]</sup>
- **Rainfall variability:** Studies document increased interannual variability and shifts in monsoon patterns for different parts of Rajasthan — some areas experiencing decline in monsoon totals, others experiencing more intense but shorter precipitation events. Overall, hydroclimatic predictability has decreased.

### 6) 6.2 Wetland responses and bird counts

- **Shrinking hydroperiods:** Remote sensing and field monitoring at Sambhar show reduced wetland extent in specific dry years and encroachment pressures; these hydrological changes strongly correlated with lower counts of typical waterbird groups in dry years.
- **Shifts in species mix:** Some inland wetlands in Rajasthan report declines in specialist shorebirds and increases or stable counts of more generalist or resident species — indicating compositional shifts as wetland conditions change.<sup>[1]</sup>

### 7) 6.3 Phenology and migration timing

- Several regional analyses (India and South Asia) report changes in arrival and departure timing for migrants consistent with warming and changing precipitation cues; long-distance migrants are more likely to be affected than residents. Observational datasets in India (and syntheses) suggest changes in median arrival dates for some species, although local variation is high.

### 8) 6.4 Extreme events and abrupt declines

- Heatwaves and extreme rainfall events can cause acute food shortages (through impacts on aquatic invertebrates) and direct mortality/physiological stress. Multiple studies emphasize that increasing frequency of extremes compounds chronic trend effects.<sup>[5]</sup>

## 7. Discussion

### 9) 7.1 Linking weather change to migration outcomes in Rajasthan

The combination of rising temperatures and more variable precipitation alters the timing and availability of resources at stopovers and wintering sites. Wetland hydroperiod contraction reduces feeding time and prey biomass for waterbirds arriving in winter; for shorebirds and waders that rely on exposed mudflats, altered inundation



timing changes habitat availability during peak migration windows. Phenological mismatch arises when birds' migration timing (often cued by photoperiod or distant climatic cues) no longer aligns with local resource peaks. The evidence from Sambhar and similar sites supports a causal chain: climate variability → altered hydrology/forage base → bird abundance/composition changes<sup>[2]</sup>

#### **10) 7.2 Species most at risk**

Long-distance migrants and habitat specialists (shorebirds, some Anatidae and niche wetland specialists) are likely most vulnerable due to narrow stopover/wintering requirements. Generalist species or those able to use anthropogenic water bodies may be more resilient. Projected range shifts could reduce Rajasthan's suitability for some species while making it more suitable for warm-adapted taxa — but habitat loss and human pressures constrain positive outcomes.<sup>[5]</sup>

#### **11) 7.3 Confounding stressors: land-use and direct human impacts**

Climate change acts alongside land-use pressures (saltpan expansion, wastewater diversion, groundwater extraction) — particularly at saline lakes — amplifying effects on bird habitat. Effective conservation must therefore address both climate and local anthropogenic drivers. Sambhar's contraction, for example, is as much a land-use and water-management challenge as a climatic one.<sup>[5]</sup>

### **8. Recommendations**

#### **12) 8.1 Strengthen long-term monitoring**

- Maintain and expand standardized bird counts (seasonal/winter counts, arrival/departure monitoring) at sentinel wetlands and desert stopovers (e.g., Sambhar, Didwana). Use consistent protocols and link counts to hydrological and meteorological monitoring.<sup>[2]</sup>

#### **13) 8.2 Integrate hydrology and land-use management**

- Protect and restore wetland hydrology (manage water extraction, control encroachment, maintain freshwater inflows where feasible). Prioritize water budgets that preserve critical hydroperiods during migration windows.

#### **14) 8.3 Climate-smart habitat interventions**

- Create a network of refugia and managed wetlands that can be sustained under future climate scenarios (e.g., managed impoundments, seasonal water delivery programs), and preserve connectivity to allow species range adjustments.

#### **15) 8.4 Policy and stakeholder engagement**

- Integrate migratory bird conservation into state water/land-use planning; involve local communities and saltpan operators in co-management; use scientific evidence (monitoring + modeling) to inform adaptive interventions.



## **9. Limitations**

This paper synthesizes published studies and government data; it does not present new field surveys. Local heterogeneity in climate responses and the scarcity of long-term site-level bird phenology datasets in many parts of Rajasthan limit the ability to make robust species-level causal inferences. Further targeted, species-level telemetry and food-web studies are needed to confirm mechanisms for particular taxa.

## **10. Conclusion**

Weather and climate changes in Rajasthan — especially warming and altered precipitation regimes — are already affecting wetland hydroperiods and the seasonal suitability of habitats for migratory birds. Field monitoring and remote sensing at key sites show reductions in suitable habitat during dry years and shifts in species composition. Without integrated climate-resilient wetland management and strengthened monitoring, migratory bird populations that depend on Rajasthan's wetlands will be at increasing risk. A combined approach of continued monitoring, hydrological protection, community engagement and climate-smart habitat management is needed to maintain Rajasthan's role in South Asian migratory networks.<sup>[6]</sup>

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