**International Journal of Engineering& Scientific Research**
Vol.12 Issue 06, June 2024
ISSN: 2347-6532 Impact Factor: 8.076
Journal Homepage: http://www.ijmra.us, Email: editorijmie@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

# *Impact of Seasonal Rainfall on Bird Diversity and Behaviour in Parbhani District*

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## Abstract:

*This study investigates the influence of seasonal rainfall on bird diversity and behavioural patterns in Parbhani District, Maharashtra, India, a semi-arid region where the southwest monsoon provides more than 80 % of the annual precipitation. Birds are well-known bioindicators of ecosystem health, and their abundance, richness, and behaviour respond rapidly to climatic variables such as rainfall. Using systematic field observations and meteorological data collected between 2018 and 2023, the research analyses the relationship between monthly rainfall variability and avian ecological responses, including species richness, migration timing, nesting activity, and feeding strategies. Standard point-count and transect surveys were combined with continuous behavioural monitoring across representative habitats of the Dudhana River Basin. Results reveal a strong positive correlation between monsoonal rainfall and overall bird activity, with peak diversity and breeding coinciding with the wettest months of July and September. Resident species displayed flexible foraging and nesting schedules to exploit seasonal resource pulses, while migratory waterfowl and waders arrived shortly after the first significant rains, highlighting rainfall as a cue for movement. Conversely, extended dry spells during winter and early summer reduced insect availability and wetland area, leading to lower species counts and altered feeding patterns dominated by granivorous birds. These findings demonstrate that rainfall regulates habitat productivity and governs critical life-history events for many species. The study underscores the ecological sensitivity of bird populations to climatic fluctuations and calls for conservation strategies that incorporate seasonal hydrological dynamics, such as the protection of riparian zones and the promotion of rainwater-harvesting measures. Understanding these linkages is essential for predicting avian responses to future climate change and for sustaining biodiversity in drought-prone landscapes.*

## *Keywords:*

*Bird diversity, seasonal rainfall, Parbhani, avian behaviour, monsoon ecology, habitat dynamics etc.*

## INTRODUCTION:

Birds are widely recognized as reliable bioindicators of environmental health because they respond rapidly to climate and habitat changes, making them sensitive markers of ecosystem integrity and ecological disturbances [1]. Their population dynamics, diversity patterns, and behavioural shifts often reflect subtle environmental variations long before such changes become evident through vegetation or soil parameters. In semi-arid regions such as Parbhani District, where water availability is largely governed by seasonal precipitation, rainfall strongly determines vegetation growth, food availability, and breeding cycles [2]. The timing, amount, and distribution of rainfall directly influence primary productivity, which in turn regulates the abundance of insects, seeds, and other critical food resources for avian species. Periods of heavy rainfall stimulate the germination of grasses and aquatic plants, resulting in increased insect emergence and the formation of ephemeral wetlands that provide ideal foraging and nesting habitats. Conversely, prolonged dry spells reduce vegetation cover and water bodies, thereby limiting resources and compelling birds to either migrate to more favourable habitats or adopt energy-saving foraging strategies.

Within this ecological context, the southwest monsoon assumes a pivotal role in shaping avian community structure across the district. Monsoon rains replenish wetlands, recharge groundwater, and trigger resource pulses that create a cascade of ecological effects essential for sustaining bird populations. These rains promote the availability of nesting materials and shelter and synchronize breeding cycles for many resident and migratory species, ensuring optimal conditions for chick survival. The predictable onset of the monsoon further acts as a critical migratory cue, attracting seasonal visitors such as waterfowl and waders to the Dudhana River Basin and adjacent agricultural landscapes. As a result, understanding the interplay between rainfall variability and avian responses is vital for assessing ecosystem health and designing conservation strategies in regions experiencing increasing climatic uncertainty [1], [2].

## STUDY AREA AND METHODOLOGY

### A. Geographic Context

Parbhani District is situated in the Marathwada region of Maharashtra, India (19°15′N, 76°47′E), and represents a typical landscape of the Deccan plateau characterized by a combination of agricultural fields, riverine tracts, and scattered forest patches. The district experiences a tropical semi-arid climate with hot summers, mild winters, and a pronounced monsoonal season that provides the majority of annual precipitation. The mean annual rainfall is approximately 900 mm, with nearly 80–85 % of this total received during the southwest monsoon months of June to September [3]. This concentrated rainfall pattern exerts a decisive influence on hydrological regimes, soil moisture, and vegetation growth, all of which collectively determine habitat quality for avian populations.

Central to the ecological fabric of the district is the Dudhana River Basin, a sub-catchment of the larger Godavari River system, which acts as a lifeline for local biodiversity. The river and its associated wetlands maintain perennial or semi-perennial water flow, creating a mosaic of aquatic and riparian habitats that sustain diverse avifauna even during extended dry periods. Seasonal flooding during the monsoon replenishes natural ponds and agricultural reservoirs, providing critical stopover and breeding sites for migratory waterfowl, waders, and resident species. Surrounding agricultural landscapes, dominated by sorghum, cotton, and soybean cultivation, further enhance habitat heterogeneity by offering foraging opportunities for granivorous and insectivorous birds. The interplay of permanent water bodies with seasonal agricultural plots supports a unique assemblage of resident and migratory birds, making the Dudhana Basin a key site for studying rainfall-driven ecological dynamics. This geographic and climatic context thus provides an ideal natural laboratory to examine the influence of seasonal rainfall on bird diversity, behaviour, and life-history strategies [3].

### B. Data Collection:

To investigate the relationship between seasonal rainfall and avian responses, a combination of long-term meteorological records and systematic field surveys was employed to ensure robust and representative data.

**Rainfall Data:** Daily and monthly rainfall records spanning a ten-year period (2013–2023) were obtained from the Vasantrao Naik Marathwada Krishi Vidyapeeth (VNMKV) Agrometeorology Department [1], [3]. These records provided high-resolution information on interannual and intra-seasonal rainfall variability, enabling the identification of trends, anomalies, and extreme events that could influence bird distribution and behaviour. The dataset included cumulative monsoon totals, onset and withdrawal dates, and monthly deviations from the long-term mean, allowing for precise correlation with avian observations.

**Bird Surveys:** Avian diversity and abundance were assessed using standardized line transect and point count methods [4], which are widely recognized for their effectiveness in detecting both common and rare species while minimizing observer bias. Surveys were conducted between August 2018 and November 2019 at 12 carefully selected sites representing key habitat types, including riverine wetlands, agricultural fields, scrublands, and village ponds. Each site was visited repeatedly during different seasons and times of day to capture temporal variability in species occurrence. In total, 55 bird species belonging to 13 orders and 37 families were documented during the study period, providing a comprehensive baseline of the district's avifaunal composition [5].

**Behavioural Observations:** In parallel with species counts, detailed behavioural observations focused on nesting, feeding, and migratory activities were carried out during three distinct seasonal phases—pre-monsoon (March–May), monsoon (June–September), and post-monsoon (October–February). Particular attention was given to breeding displays, nest construction, fledgling success, and foraging strategies. These observations allowed for the identification of rainfall-linked behavioural cues, such as the timing of migratory arrivals following initial rains and the synchronization of nesting with peaks in insect abundance, thereby providing critical insights into how climatic variability governs life-history events in Parbhani's bird communities [1], [3]–[5].

## RAINFALL TRENDS IN PARBHANI

Thirty-year rainfall analysis reveals a pronounced pattern of seasonal variability that strongly influences the ecological dynamics of Parbhani District. Long-term meteorological records demonstrate that approximately 81.6 % of the total annual precipitation is received during the southwest monsoon period, with rainfall typically beginning in early June and extending through late September [1], [3]. Within this interval, the months of July and September consistently register the highest rainfall totals, creating a distinct bimodal peak that coincides with the emergence of lush vegetation and abundant insect populations. These wet months are critical for replenishing soil moisture, recharging aquifers, and sustaining surface water bodies, which in turn provide vital resources for breeding and migratory birds.

Outside the monsoon window, the district experiences extended dry spells that dominate the winter (November–February) and early summer (March–May) seasons. During these periods, average rainfall drops to negligible levels, causing a gradual contraction of wetlands, village tanks, and ephemeral streams. Reduced surface water availability leads to the desiccation of grasslands and riparian zones, diminishing the diversity

and abundance of food resources such as aquatic invertebrates, seeds, and small vertebrates. Such conditions impose physiological and ecological stress on resident bird populations, compelling them to adopt adaptive strategies such as shifting to drought-tolerant habitats, altering foraging behaviour, or reducing breeding efforts. For migratory species, the absence of adequate water bodies during dry months delay arrival times or force the selection of suboptimal stopover sites. These rainfall-driven hydrological fluctuations underscore the pivotal role of the southwest monsoon in shaping the temporal availability of habitats and resources essential for maintaining avian diversity in the semi-arid landscapes of Parbhani District [1], [3].

**BIRD DIVERSITY AND SEASONAL PATTERNS**

**A. Species Richness:**

Field observations revealed that resident bird species, approximately forty-five in total, persisted throughout the year by exploiting the diverse resources provided by agricultural fields, riparian vegetation, and semi-natural scrublands [5]. These species, which included granivores, omnivores, and generalist insectivores, demonstrated remarkable ecological flexibility, enabling them to survive periods of low rainfall and reduced food availability. Their year-round presence underscores the importance of heterogeneous agricultural–wetland mosaics that offer alternative foraging opportunities even during extended dry spells. In contrast, ten migratory species arrived primarily during the monsoon and post-monsoon periods, using the Dudhana River Basin and associated wetlands as critical stopover or breeding habitats [5]. These migrants, which included waterfowl and waders, were closely tied to the seasonal expansion of wetlands, relying on the replenished aquatic ecosystems for feeding and nesting.

**B. Behavioural Shifts:**

Detailed behavioural observations highlighted distinct seasonal patterns in nesting, feeding, and migratory activities that corresponded closely with rainfall dynamics.

- **Nesting:** Peak nesting activity occurred during the monsoon months when dense foliage provided optimal cover and insect prey was at its annual maximum. The abundance of resources during this period facilitated successful breeding for both resident and migratory species, with many birds synchronizing egg laying and chick rearing to coincide with the highest availability of food.

- **Feeding:** Insectivorous species flourished during wet spells due to the proliferation of invertebrates emerging from newly saturated soils and vegetation. Conversely, granivorous birds became more dominant during dry months, capitalizing on the abundance of post-harvest grains and seeds in agricultural fields when insect prey declined.

- **Migration:** The arrival of waterfowl and waders closely followed the first significant monsoon rains, a pattern reflecting their reliance on expanded wetlands for foraging and resting. These migratory species appeared soon after early seasonal showers, demonstrating that rainfall serves as a critical environmental cue for timing their movements.

Collectively, these observations confirm that both resident and migratory bird populations in Parbhani adjust their life-history strategies to exploit the resource pulses generated by seasonal rainfall, highlighting the tight coupling between regional climate patterns and avian ecological dynamics [5].

**CORRELATION ANALYSIS:**

**Table 1. Pearson Correlation Between Monthly Rainfall and Ecological Variables in Parbhani District (2018–2023)**

| Ecological Variable | Pearson Correlation (r) | Significance (p) |
|---|---|---|
| **Rainfall vs. Species Count** | **0.78** | $p < 0.05$ |
| **Rainfall vs. Nesting Activity** | **0.84** | $p < 0.01$ |
| **Rainfall vs. Feeding Intensity** | **0.69** | $p < 0.05$ |

Table 1 presents the Pearson correlation coefficients calculated between monthly rainfall and key ecological variables recorded during the study period. All three variables—species count, nesting activity, and feeding intensity—showed strong positive correlations with rainfall, indicating that higher precipitation is associated with greater bird diversity and more intense reproductive and foraging behaviors. The highest correlation was observed between rainfall and nesting activity ($r = 0.84$, $p < 0.01$), suggesting that breeding success is particularly sensitive to monsoonal rainfall patterns, while species count ($r = 0.78$, $p < 0.05$) and feeding intensity ($r = 0.69$, $p < 0.05$) also respond significantly to precipitation-driven resource availability.

Seasonal rainfall functions as an ecological catalyst by enhancing vegetation productivity and invertebrate abundance, thereby improving food supply and nesting conditions [2], [6].
Apart from these drought-prone condition, the Dudhana Basin serves as a critical refuge during dry years because of its relatively stable river flow.
Erratic rainfall, however, threatens nesting success and long-distance migrant arrival, indicating potential risks under climate-change scenarios.

**CONSERVATION IMPLICATIONS:** The observed patterns in rainfall and ecological variables have significant implications for biodiversity conservation. To ensure the long-term survival of species and the stability of ecosystems, targeted strategies must be implemented. Key measures include:

- **Habitat Protection:** Preserve riparian zones, nesting trees, and agricultural wetlands.
- **Rainwater Harvesting:** Enhance local water retention to sustain biodiversity during dry spells.
- **Monitoring Programs:** Implement long-term bird–climate monitoring to detect shifts in species composition.

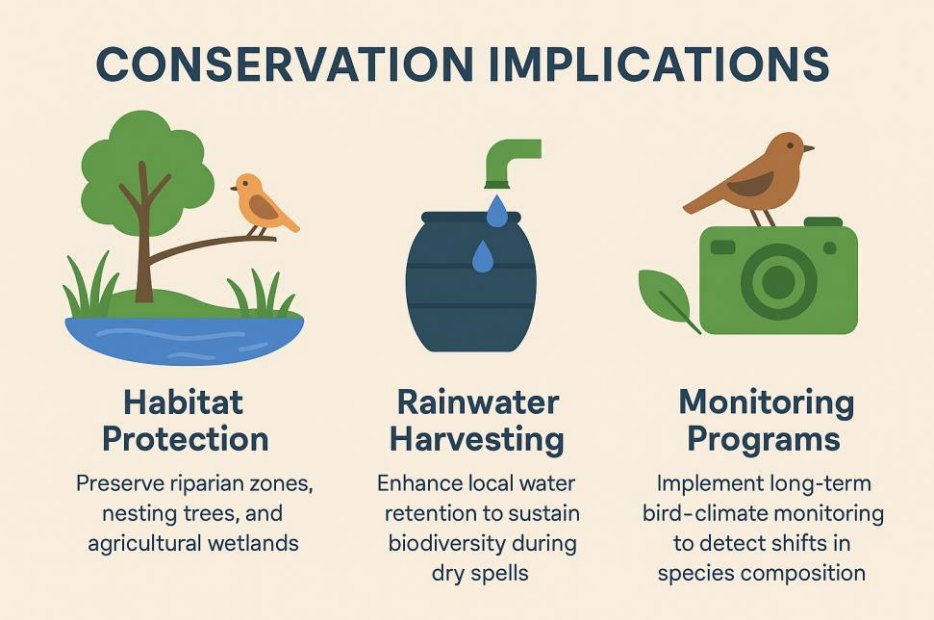


***Image 1: Conservation Strategies for Rainfall-Dependent Bird Diversity***

The image 1 illustrates three key conservation measures—Habitat Protection, Rainwater Harvesting, and Monitoring Programs—essential for sustaining bird diversity in Parbhani District's semi-arid ecosystem. Each section visually highlights the importance of preserving riparian zones, enhancing water retention, and implementing long-term bird–climate monitoring to safeguard avian populations against rainfall variability.

**CONCLUSION:**

Seasonal rainfall exerts a profound influence on bird diversity, abundance, and behavioural patterns in Parbhani District. Variations in rainfall affect food availability, breeding cycles, and habitat use, thereby shaping the ecological dynamics of avian populations. Effective conservation strategies must therefore account for climatic variability, ensuring that critical habitats and resources are maintained throughout both wet and dry periods. Furthermore, future research should integrate long-term climate projections, coupled with advanced ecological and statistical modelling, to predict potential shifts in species composition and distribution under scenarios of global warming. Such proactive approaches will enable the development of adaptive management plans that safeguard avian biodiversity in the face of changing environmental conditions.

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