Zoodiversity, 60(2): 139–148, 2026

DOI 10.15407/zoo2026.02.139
UDC 598.2:574.1(540)

PATTERNS OF AVIFAUNAL DIVERSITY IN A LANDSCAPE OF CUTTACK, ODISHA, INDIA

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urn:lsid:zoobank.org:pub:876355AC-397C-4F20-8E1C-36D5F5504E3B

Patterns of avifaunal diversity in a landscape of Cuttack, Odisha, India. Bhatt, J. P., Onkari, R. & Arya. S. — A total of 78 bird species, categorised into 36 families, were documented in and around the Sri Sri University campus, which encompasses a variety of land-use types. The study was conducted over a two-month period, from September to October 2021, with observations performed every five days. The study area, located in Cuttack, Odisha, is an isolated landscape bordered by urban and rural settlements, comprising managed areas, wilderness, wetlands, and agricultural patches. Species richness was highest in managed areas and lowest in agricultural patches. Although the study was limited to two months, comparison with year-round monitoring indicated that approximately 84% of all local species were recorded. The study highlighted that **avian** species responded distinctly to isolated microhabitats within the landscape and demonstrated that a managed ecosystem fosters bird diversity. Findings revealed that avifaunal species richness was well sustained in this isolated landscape, although land use and land cover had a measurable impact on diversity. Habitat heterogeneity emerged as a crucial factor in enhancing bird diversity. Based on these findings, it can be inferred that moderate human disturbance does not adversely affect bird diversity, provided the ecosystem is managed in an environmentally responsible manner.

Key words: ecosystem, heterogeneity, impact, land use, restoration, wetland.

Introduction

The transformation of natural ecosystems into human-dominated systems is linked to biodiversity threats and negative impacts on ecosystem resilience, functioning, and processes overall (Lambin et al., 2000; Li et al., 2007; Choudaj & Wankhade, 2021). Bird species inhabiting isolated and fragmented areas are particularly vulnerable to human activities (Yue et al., 2018). In general, human-induced activities are recognised as having detrimental effects on biodiversity (Mzuza et al., 2019; Bufebo & Elias, 2021). Numerous studies have demonstrated a relationship between habitat factors — such as vegetation, noise, traffic, and human movement — and bird diversity (Clergeau et al., 1998).

Habitat restoration, widely recognised as one of the best strategies for restoring biodiversity, can mitigate the negative impacts of human activities, especially at the microhabitat level (Melo et al., 2020). Bird communities often show rapid improvements following landscape restoration, as birds are more sensitive to environmental changes and easier to survey compared to other groups, such as mammals and reptiles (Ferenc et al., 2014). One of the most effective habitat restoration methods is planting vegetation, which provides essential shelter and food for bird species. This leads to a positive correlation between vegetation cover and bird populations (Lube et al., 2008). Additionally, researches indicate that landscaping significantly influences avian diversity not only in the restored area but also in neighbouring patches (e. g. Lerman et al., 2021).

The primary objectives of this study are to (i) enhance our understanding of how rehabilitating a degraded landscape can become hospitable to bird species and (ii) predict the impacts of human activities on avifauna. This study will be helpful in providing insights into the development of a green campus by adopting a sustainable approach.

Materials and Methods

Study area

The focus area of this study is the Sri Sri University campus and its surroundings, located in the Vidyadharpur division of Cuttack district in Odisha. The area is situated between 20.450°–20.466° N latitude and 85.791°–85.800° E longitude. The study area (nearly 12,36,340 m²) was divided into four microhabitat categories: managed patch (Sri Sri University South Campus), wild patch (part of the Sri Sri University North Campus), wetlands adjacent to the campus, and agricultural land (Fig. 1). Before the establishment of the university in 2009, the area (south and north parts) was barren and severely affected by stone quarries, dominated by grasses and shrubs. The university's development began with extensive plantations, particularly in the southern part (managed patch). The plantation included various species such as *Albizia richardiana*, *Alstonia scholaris, Anacardium occidentale*, *Azadirachta indica*, *Cassia fistula*, *Ficus religiosa*, *F. benghalensis*, *Lagerstroemia speciosa*, *Plumeria rubra*, *Saraca asoca*, etc. The managed patch, approximately 3,51,340 m² (28.4% of the total study area), is used for various academic activities (anthropogenic activities) and habitat restoration practices. Along with infrastructural facilities, the managed patch

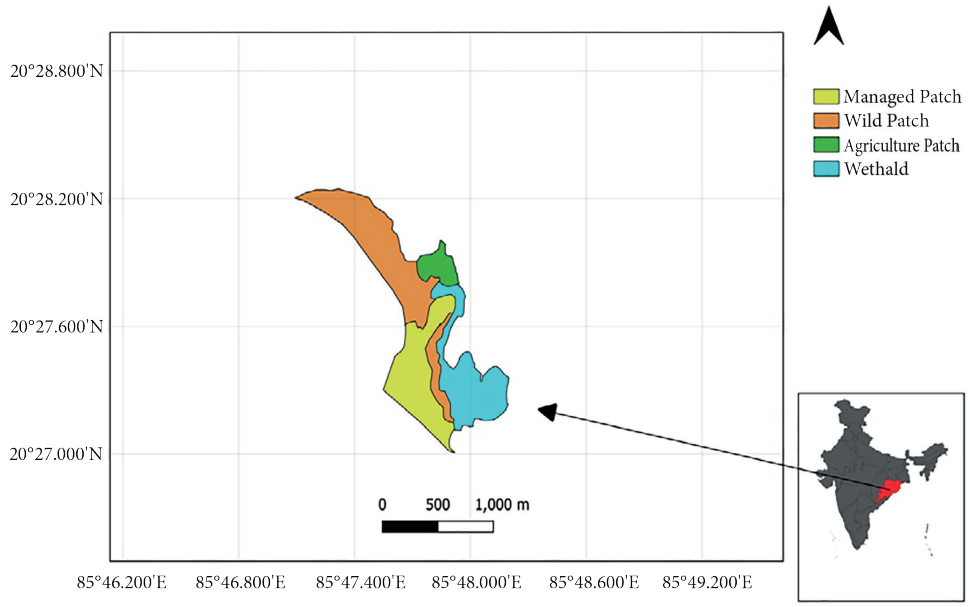

Fig. 1. Study area showing different landscape patches

harbors various tree species, farmland, and grass-fens. The area is relatively disturbed due to academic activities.

In contrast, the northern part (wild patch) remains relatively wild with no academic activities. The wild patch, approximately 4,10,000 m² (33.1% of the total study area), is primarily a barren grass-fen and scrubland dominated by herbaceous plant species. The wilderness is well-maintained in this patch, with shrubs and grasses predominating on the north campus. Both parts (south and north) are characterised by abandoned quarry sites, which were repurposed for building construction using a sustainable approach.

The eastern side of the university campus is surrounded by wetlands, approximately 4,06,000 m² (32.8% of the total study area). The wetlands and their surroundings are relatively less disturbed compared to the managed patch. The wetlands include marshes and open water, with the smaller wetlands being isolated. These small wetlands are surrounded by settlements on all sides and are regularly subject to encroachment. A relatively small patch of agricultural land, totaling 69,000 m² (5.5% of the total study area), is under the jurisdiction of the villagers and is adjacent to the wetlands. This heterogeneous landscape provides an ideal setting for studying avifauna within the context of landscape and restoration ecology.

Bird sampling

The survey was conducted during September and October 2021. Each land use category was thoroughly surveyed for 15 days, with an interval of 5 days between each survey. The survey was conducted on two weekend days, ensuring that all land uses were covered on the day of the survey. The survey was completed in the morning hours (between 6:00 AM and 8:00 AM) using the complete count method. This method involves counting bird species in a defined area and was adopted with slight modifications from Greene (2012). The complete count method was chosen due to the small sizes of the patches ranging from 69,000 m² to 4,10,000 m².

All avifaunal species perched on bushes, ground, and tree canopies in both managed and wild patches were recorded. For wetlands, all species inhabiting open water, river swamps, and wet meadows were included in the record. In agricultural patches, only those species found perching on farmland, trees/bushes within the agricultural land, and crop plants were recorded. Species flying over tree canopies and those perching on electric wires and poles were not considered.

Bird species were identified with the help of visual observations using a field guidebook (Grewal et al., 2002). The bird calls as indirect evidences were also used to record the bird species. As a taxonomy source, we used Clements et al. (2023). The uncertain calls of birds were not recorded. The checklist of the bird species followed IUCN redlist for the standard common and scientific names (https://www.iucnredlist.org/; 2024-1). Each species was assessed using the IUCN redlist to determine its conservation status (https://www.iucnredlist.org/ 2024-1). For assessing the migratory habits of species, we followed Bal et al. (2018). Considering a land use type (patch) as a unit, the frequency percentage, probability of occurrence, and relative diversity (La Torre-Cuadros et al., 2007; Byju et al., 2023). of each species as follows:

$$Frequency\ (\%) = \frac{Number\ of\ land\ use\ categories\ in\ which\ ith\ species\ occur}{Total\ number\ of\ land\ use\ categories\ studied} \times 100$$

$$Probability\ of\ Occurrence\ (\%) = \frac{Number\ of\ days\ for\ which\ ith\ species\ was\ spotted}{Total\ number\ of\ days\ of\ survey} \times 100$$

$$Relative\ diversity\ (RDi) = \frac{Number\ of\ birds\ species\ in\ a\ family}{Total\ number\ of\ species\ in\ patch} \times 100$$

Similarity matrix

The Jaccard similarity matrix was calculated to observe the similarity between the landscape patches. For the purpose of similarity matrix, the presence and absence (P-A) of species as 1 and 0, respectively was denoted.

Results

A total of 78 species of birds were recorded across all landscape patches during the survey. Species richness ranged from 21 to 48 species, with the highest number in the managed landscape patch and the lowest in the agricultural patch (see Table 1 in the supplementary materials). Only four species, namely the Red-wattled Lapwing, *Vanellus indicus* (Boddaert, 1783), White-breasted Kingfisher, *Halcyon smyrnensis* (Linnaeus, 1758), Jungle Myna, *Acridotheres fuscus* (Wagler, 1827) and Indian Pied Starling, *Gracupica contra* (Linnaeus, 1758), were found in all landscape patches with a 100% frequency.

The managed patch recorded a total of 48 bird species. The most common species in this patch, all with 100% occurrence, were the Cattle Egret, *Ardea ibis* (Linnaeus, 1758), Rock Pigeon, *Columba livia* (Gmelin, 1789), Eastern Spotted Dove, *Spilopelia chinensis* (Scopoli, 1786), Rufous Treepie, *Dendrocitta vagabunda* (Latham, 1790), Black Drongo, *Dicrurus macrocercus* (Vieillot, 1817), Jungle

Babbler, *Argya striata* (Dumont, 1823), Red-vented Bulbul, *Pycnonotus cafer*, Red-whiskered Bulbul, *P. jocosus* (Linnaeus, 1766), and *Acridotheres tristis*. The managed patch was under restoration (regular plantation) and influenced by human activities.

The wild patch recorded a total of 40 bird species. The *Spilopelia chinensis* and *Dicrurus macrocercus* were the only species with 100% occurrence in the wild patch. In the wetland area, the most common species, all with 100% occurrence, were the Indian Pond Heron *Ardeola grayii*, White-breasted Waterhen, *Amaurornis phoenic-*

Table 2. **Relative diversity of the avifaunal families in different land use categories**

Family	Land use categories			
	MP	WP	WTL	AP
Phasianidae	0	2.5	0	4.55
Rallidae	0	0	11.54	0
Anatidae	0	0	11.54	0
Ardeidae	4.17	2.5	19.23	0
Ciconiidae	0	0	7.69	0
Phalacrocoracidae	0	0	7.69	0
Recurvirostridae	0	0	3.85	0
Scolopacidae	0	0	7.69	0
Charadriidae	2.08	2.5	3.85	9.09
Accipitridae	6.25	0	0	0
Falconidae	0	2.5	0	0
Upupidae	2.08	2.5	0	0
Alcedinidae	2.08	2.5	7.69	4.55
Coraciidae	2.08	2.5	0	0
Meropidae	2.08	2.5	3.85	0
Picidae	0	2.5	0	0
Cuculdae	8.33	0	0	4.55
Columbidae	6.25	7.5	3.85	9.09
Megalaimidae	4.17	2.5	0	0
Psittaculidae	2.08	0	0	0
Strigidae	2.08	0	0	0
Corvidae	6.25	5	0	0
Dicruridae	2.08	2.5	0	4.55
Hirundinidae	2.08	2.5	0	0
Cisticolidae	2.08	2.5	0	0
Estrildidae	4.17	10	0	4.55
Leiothrichidae	2.08	2.5	0	0
Paradoxornithidae	2.08	2.5	0	0
Laniidae	2.08	0	0	4.55
Pycnonotidae	4.17	5	0	4.55
Sturnidae	8.33	12.5	7.69	18.18
Sylvidae	6.25	2.5	0	0
Muscicapidae	6.25	10	3.85	9.09
Nectariniidae	4.17	2.5	0	0
Oriolidae	2.08	2.5	0	0
Motacillidae	2.08	5	0	22.73

MP = Managed patch, WP = Wild patch, WTL = wetland patch, AP = agriculture patch.

Table 3. **Jaccard similarity index for avifaunal species in the present study area**

Landscape categories	Managed patch	Wild Patch	Wetland Patch	Agricultural Patch
Managed Patch	1	0.65454	0.1111	0.2692
Wild Patch		1	0.1355	0.3125
Wetland Patch			1	0.1162
Agricultural Patch				1

urus (Pennant, 1769), *Ardea ibis*, Great Cormorant, *Phalacrocorax carbo* (Linnaeus, 1758), Little Cormorant, *Microcarbo niger* (Vieillot, 1817), and Tufted Duck, *Aythya fuligula* (Linnaeus, 1758).

The agricultural patch recorded a total of 21 species, with the Yellow Wagtail, *Motacilla flava* (Linnaeus, 1758) being the only species with 100% occurrence (see Table 1 in the supplementary materials). A higher number of specialists were found in the wetland, with 17 out of 26 species being specific to this habitat. The majority of the species (nearly 68%) were residents, followed by winter visitors (30.7%) (see Table 1 in the supplementary materials).

The families Columbidae, Estrildidae, Sturnidae, Muscicapidae, and Corvidae recorded relatively high diversity in both managed and wild patches, while the family Cuculidae recorded exclusively high diversity in the managed patch. The families Rallidae, Anatidae, and Ardeidae were found to have high relative diversities in the wetland patch. The families Charadriidae, Columbidae, Sturnidae, Muscicapidae, and Motacillidae were dominant in the agricultural patch in terms of relative density (Table 2). The maximum similarity in species composition was recorded between the managed and wild patches (Table 3).

Discussion

Plant species composition, canopy cover, agricultural practices, developmental stages, and other factors play crucial roles in structuring avian diversity at the landscape level (Tena et al., 2007; Choudaj & Wankhade, 2021; Byju et al., 2023). Heterogeneous conditions are correlated with increased avian diversity (see Hovick et al., 2015). Therefore, the variation in avian richness among different patches (higher richness in managed and wild patches and lower richness in agricultural and wetland patches) can be attributed to differences in patch heterogeneity (see Byju et al., 2023). Plantation activities, infrastructure development, and farming practices enhanced heterogeneity in the managed landscape of the study area, which in turn seemed to favor relatively high bird diversity (see Mooney, 2011; Hovick et al., 2015). The managed patch recorded considerably higher diversity compared to the wild patch, indicating that ecological restoration had positive impacts on bird diversity (Bennett et al., 2022). This patch of landscape is under the regular plantation drive and farm practices for the academic purpose.

The species composition of birds in the wetland patch showed minimal similarities with other patches due to their specific food, shelter, and habitat requirements (Rajpar & Zakaria, 2009). Most wetland bird species were waders, swim-

mers, and divers. Only a few aerial foragers like *Halcyon smyrnensis*, Common Kingfisher, *Alcedo atthis* (Linnaeus, 1758), Blue-tailed Bee-eater, *Merops philippinus* (Linnaeus, 1767) and wader species — *Ardea ibis*, Little Stint, *Calidris minuta* (Leisler, 1812), *Vanellus indicus*, and Little Ringed Plover, *Thinornis dubius* (Scopoli, 1786) shared terrestrial ecosystems. The low richness in agricultural areas can be attributed to the limited number of microhabitats and the high presence of specialist species (Zakaria et al., 2009). For example, the wetland had only two microhabitats (swampy marshes and open water), while the agricultural land was under a single land use. Furthermore, differences in the size of landscape patches (the agricultural area is smaller) can be attributed to variations in avifaunal diversity.

Though the wetlands in the present study area are very small, fragmented, and seasonally affected, they are useful for breeding, nesting, roosting, and foraging. The study revealed that these small and unmanaged wetlands have the potential to support rich avian diversity (see Panda et al., 2021). The wetland areas adjacent to the university campus were disturbed due to agricultural practices and human encroachment. Additionally, the agricultural sprawl is anticipated to pose serious threats to the avifaunal species of the wetlands (Sohil & Sharma, 2020). Considering the ecological significance and anthropogenic stresses, the conservation and management of these small and fragmented wetlands are warranted (Panda et al., 2021). The variation in the relative diversity of bird families among different land-use categories indicated that bird species had their microhabitat preferences. Understanding these preferences can play an important role in landscape-level management (Preiszner & Csörgő, 2008).

Most of the species recorded in the study were generalists and widely distributed. Notably, the House Sparrow, *Passer domesticus* ((Linnaeus, 1758), a common and cosmopolitan bird found across India, was absent from the study. This absence was unexpected, especially since Bal et al. (2018) documented its presence in neighbouring areas. Consequently, ecological stresses on House Sparrows, as reported in various regions (Walidia & Bhatt, 2022), cannot be ruled out.

Conclusion

This study focuses on a single season due to the limited size of the study area. It is evident that bird species composition varies seasonally (Panda et al., 2021). However, for this small landscape, it can be inferred that there was no significant seasonal change in species composition, as confirmed by our subsequent surveys. These surveys, conducted in the following months, revealed a total of 93 species in this landscape, 84% of which are included in the present study.

Notably, land use and land cover changes, habitat loss, and fragmentation are major threats to bird diversity. These findings suggest that habitat restoration practices positively affect avifaunal richness even with moderate human disturbance (e. g., Clough et al., 2009). The managed and wild patches are under the jurisdiction of Sri Sri University, where regular restoration and conservation

practices are conducted. The university participates in all SDGs (Sustainable Development Goals) related activities, including 'Life on Land (SDG 15),' making such activities essential for the university. Wetland birds accounted for a significant portion of the species richness in this study. Wetlands play a crucial role in the dispersal of species and the flow of energy between landscape patches (Regester et al., 2008). A regular monitoring of wetlands and their avifaunal diversity is essential for effective bird conservation strategies.

Acknowledgements. We gratefully acknowledge the assistance of Mr. Arvind Negi from the Department of Environmental Science at Delhi University for his help in the graphics. We also thank the editor and reviewers for their constructive suggestions.

Supplementary materials. Supplementary materials for this article are available on the Zenodo repository at https://doi.org/10.5281/zenodo.19386032.

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Received 9 April 2025
Accepted 22 April 2026