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### Original Article



## Comparison of Avian Niche Communities between Agricultural and Peri-urban Landscapes of Nankana Sahib and Hafizabad

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### ABSTRACT

This comparative field study was conducted in the Nankana Sahib and Hafizabad districts in Punjab, Pakistan, between October 2024 and January 2025. **Objectives:** To study the avian community structure in both agricultural and peri-urban environments to determine the impact of land-use changes on biodiversity. **Methods:** The surveys were conducted during dawn and dusk. The point count method was employed to record avian diversity. **Results:** Systematic surveys provided the records of thirty-two avian species that belonged to ten orders and twenty-four families, Passeriformes being the most numerically dominant taxonomic group. Compared to the monocultural agricultural settings of Hafizabad (Shannon Wiener=2.881; Simpson=0.918), Nankana Sahib, a peri-urban heterogeneous setting, had a greater richness of species and a higher diversity index (Shannon Wiener=3.078; Simpson=0.936). Functional guild analysis revealed that Nankana Sahib has a higher guild structure that includes nectarivores and omnivores, and Hafizabad has an insectivore and granivore composition, presumably due to intensive farming activities. The low Pearson correlation ( $r = 0.177$ ) of the two sites reflects the unequal community structures, which can be explained by the unequal land-use regimes. **Conclusions:** The results thus indicate the ecological trade-offs of urbanization and agricultural intensification, and the need to conserve sites specific to avian biodiversity, i.e., restore habitat, use less pesticides, and maintain ecosystem services in the agroecosystems of Punjab.

### INTRODUCTION

Pakistan enjoys a pantropic diversity of ecosystems that attract rich avian fauna feeding across these habitats [1]. Birds are recognized as crucial bio-indicators of ecosystem health due to their sensitivity to environmental changes and habitat alterations [2]. Their diverse feeding habits, mobility, and trophic variability make them effective sentinels of biodiversity and environmental quality across space and time. Monitoring avian community structures helps evaluate habitat integrity and guide biodiversity conservation efforts [3]. Rapid urbanization and agricultural intensification in South Asia, especially in

Pakistan, have caused significant habitat modifications that influence avifaunal diversity and community structure [4, 5]. Urban sprawl and habitat loss lead to the disappearance of native vegetation and increased disturbance, negatively affecting species richness and evenness [6, 7]. Yet, agroecosystems can still provide essential habitats for resident and migratory birds due to available food and nesting sites [8]. Stripes of color and the changed behavior of birds provide an excellent visual effect that attracts human interest to the natural environments and their corresponding habitats, and therefore, the birds



stand out among the other species. Ecological value is indicated by the species richness of a particular region, which gives an indicator of the natural habitat. Avian species play critical ecological roles in agroecosystems. Seed dispersal maintains biodiversity, scavenging reduces disease spread, predation controls pest populations, and pollination supports both ecological resilience and crop productivity [9]. Despite their ecological and economic importance, avian services remain undervalued in Pakistan due to limited data, highlighting the need for site-specific studies [10]. The province of Punjab, forming the agrarian core of Pakistan, is sustained by an extensive canal-irrigated system and fertile alluvial plains. Districts like Nankana Sahib and Hafizabad represent two contrasting land-use systems: peri-urban mosaics with wetlands and croplands in Nankana Sahib, and intensive wheat-cotton monocultures in Hafizabad. The region is about bigger than 205,000 square kilometers; it is semi-arid and it is watered by the sophisticated system of canals and rivers, including the Chenab, Ravi, and Sutlej rivers, which supply the system of farming, based on wheat and cotton, that sustains millions of people and the rural economy of this region. An example given of this agrarian environment is the Districts of Nankana Sahib and Hafizabad, which are at the heart of Punjab's central region. Nankana Sahib-bordered by the Ravi River, harbours croplands, wetlands, and waterholes which provide a habitat to a variety of bird species, whereas the agricultural-based topography in Hafizabad supports limited habitats. Such areas are the best to test the influence of land-use heterogeneity on the avifaunal diversity. In Pakistan, more than 793 species of avian are documented, and 328 species are in Punjab. Such common species as *Passer domesticus*, *Acridotheres tristis*, and *Psittacula krameri*, as well as winter migrants such as *Motacilla citreola* and *Emberiza schoeniclus*, are found. Avian in Nankana Sahib and Hafizabad, e.g., *Coturnix coturnix*, *Streptopelia* spp., and *Bubulcus ibis*, is also important in the control of pests, seed dispersal, and bioindication of the quality of the soil and water. Nevertheless, the expansion of pesticide applications, monocultures, and urbanization in Punjab is breaking the habitats and changing the composition of the bird communities [11, 12]. Lahore, Sheikhupura peri-urban spillover has resulted in agribusiness-industrial mosaics, which exacerbate the degradation and pollution of the habitat even further. The urban population of Punjab is approximately more than 40 percent of the total population, with an estimated doubling in 2050, making it a source of habitat degradation and pollution. This shift introduces a gradient of change in land-use, which disturbs the avian behavior due to the growth of impervious surfaces, anthropogenic sound, and artificial light. Of special concern to Punjab are migratory water birds, which are part of the wetlands and have been

recorded to have declined at Ramsar sites around Nankana Sahib due to altered hydrology and contamination. Despite these challenges, little is known about how avian communities differ between peri-urban and intensive agricultural systems in central Punjab.

This study aimed to enlist and identify avian species, estimate their population abundance, compare species richness and diversity indices, and assess how urbanization and land-use intensity affect community composition and functional guilds.

## METHODS

The avian diversity surveys were conducted at different sites of Nankana Sahib and Hafizabad, Punjab, Pakistan during dawn and dusk. Nankana Sahib city, Nankana Sahib and Kuriala, a village of Hafizabad was selected. For Nankana Sahib, surveys were conducted in fields, near graveyard, rice sheller, gurdwara and in human settlements. For Kuriala, the sites were fields, along the canal edges, graveyard, rice sheller and human settlements. Nankana Sahib is a relatively ancient and culturally important city located in the Pakistani province of Punjab. It lies approximately between latitudes 31°26' to 31°27' North and longitudes 73°41' to 73°43' East. Temperatures often hit above 40 °C in summer, thus creating an unfriendly climatic condition, and in winter, the weather is cool and somewhat dry, offering some respite against the extended heat of the summer season. The agrarian landscape that surrounds Nankana Sahib is majorly an irrigated plain with cultivated crops, which in turn provide a wide range of habitats to the avian life [13]. Punjab province also comprises the site of Hafizabad, a region with a lot of research interest as it is characterized by the well recorded topographical, climatic, and agricultural features. This location lies between latitude 32 and longitude 72 to 73 to the North and East respectively. The climatic conditions in this area show a significant season change; the weather in winter is generally moderate therefore alleviating the excessive summer heat which is characterized with temperatures that often exceed 40 °C [14]. From October 2024 to January 2025, surveys were conducted to determine the richness and diversity of urban birds. To look at every chance, a total of 10 surveys were carried out from dawn to dusk at each site. Surveys were to have 10-minute point count replicates, therefore, the same intensity of sampling in both the areas. To observe the species richness, surveys of avian diversity was conducted at each sampling location. For surveys of bird diversity, the point count approach was employed [15]. Binoculars were used to examine the birds, and a variety of field books were consulted to identify the avian diversity. At each location, the weather, GPS using Store Coordinates, kind of bird, and number of birds were noted. The avian

species observed are listed in Table 1. Based on the dietary habits, the birds were grouped into various feeding guilds. In the present study, 6 different guilds were identified. At each of the sampling sites, species richness was also calculated for each of the observed feeding guilds [16]. Species-to-guild assignments were based on established literature and regional dietary references. At each sampling, the birds' species and number were counted. For these species, various diversity indices were calculated, including Simpson's Dominance, Simpson's Diversity, Shannon-Wiener, Evenness, Menhinick's Index, Margalef's Index, and Berger-Parker Index [17]. These indices help to give a clear portrayal of species richness, abundance, and community balance in avian species. To statistically evaluate whether diversity differences between Nankana Sahib and Hafizabad were significant, independent-

samples t-tests (after verifying normality via the Shapiro-Wilk test) were performed for Shannon and Simpson indices. Where normality assumptions were not met, Mann-Whitney U tests were applied. Statistical analyses were conducted using SPSS v 27.0, with  $p < 0.05$  considered significant.

## RESULTS

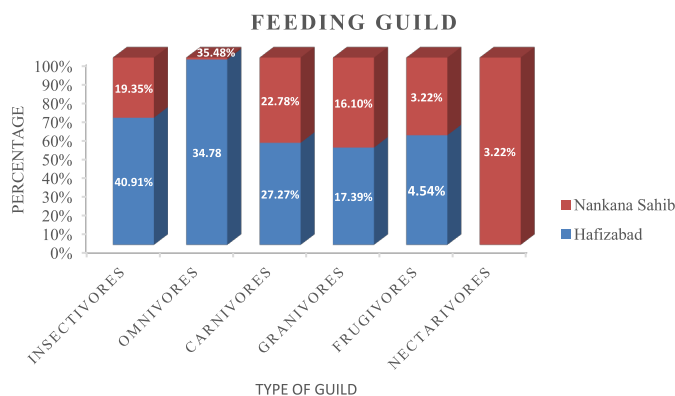
Bird surveys were conducted over the course of six months, and a total of 32 species were recorded across Nankana Sahib and Hafizabad. These birds were from 10 orders and 24 families. The most diverse order is Passeriformes with 13 families. All the avian species recorded were of least concern according to the IUCN Red List (Table 1).

**Table 1:** List of Avian Diversity Recorded During the Surveys in Nankana Sahib and Hafizabad

Sr. No.	Order	Family	Scientific Name	Common Name	Local Name	IUCN Status
1	Accipitriformes	Accipitridae	<i>Milvus migrans</i>	Black Kite	Cheel	LC
2	Anseriformes	Anatidae	<i>Anas platyrhynchos</i>	Mallard Duck	—	LC
3	Bucerotiformes	Bucerotidae	<i>Ocyrceros birostris</i>	Indian Grey Hornbill	—	LC
4	—	Upupidae	<i>Upupa epops</i>	Eurasian Hoopoe	HudHud	LC
5	Charadriiformes	Charadriidae	<i>Vanellus indicus</i>	Red-wattled Lapwing	Titahri	LC
6	Columbiformes	Columbidae	<i>Columba livia</i>	Blue Rock Pigeon	Kabootar	LC
7	—	—	<i>Spilopelia senegalensis</i>	Laughing Dove	Hanwa	LC
8	—	—	<i>Streptopelia tranquebarica</i>	Red Collared Dove	Lal Kabootar	LC
9	Coraciiformes	Alcedinidae	<i>Alcedo atthis</i>	Common Kingfisher	—	LC
10	—	—	<i>Halcyon smyrnensis</i>	White throated Kingfisher	Ram Chirya	LC
11	—	Coraciidae	<i>Coracias benghalensis</i>	Indian Roller	Neelkanth	LC
12	Cuculiformes	Cuculidae	<i>Eudynamys scolopaceus</i>	Asian Koel	Kokila	LC
13	Galliformes	Phasianidae	<i>Coturnix coturnix</i>	Common Quail	Batar	LC
14	Passeriformes	Cisticolidae	<i>Prinia buchanani</i>	Rufous fronted Prinia	—	LC
15	—	Corvidae	<i>Corvus splendens</i>	House Crow	Kauwa	LC
16	—	—	<i>Corvus culminatus</i>	Pheasant Crow	Murgh Panna	LC
17	—	—	<i>Dendrocitta vagabunda</i>	Rufous Treepie	—	LC
18	—	Dicruridae	<i>Dicrurus macrocercus</i>	Black Drongo	Kauwa	LC
19	—	Emberizidae	<i>Emberiza schoeniclus</i>	Reed Bunting	—	LC
20	—	Estrildidae	<i>Lonchura punctulata</i>	Scaly-breasted Munia	—	LC
21	—	Motacillidae	<i>Anthus rufulus</i>	Paddyfield Pipit	—	LC
22	—	Muscicapidae	<i>Luscinia megarhynchos</i>	Nightingale	—	LC
23	—	Nectariniidae	<i>Cinnyris asiaticus</i>	Purple Sunbird	—	LC
24	—	Passeridae	<i>Passer domesticus</i>	House Sparrow	Ghurri	LC
25	—	Ploceidae	<i>Ploceus philippinus</i>	Baya Weaver	Baya	LC
26	—	Pycnonotidae	<i>Pycnonotus cafer</i>	Red-vented Bulbul	Bulbul	LC
27	—	Sturnidae	<i>Acridotheres tristis</i>	Common Myna	Maina	LC
28	—	—	<i>Acridotheres ginginianus</i>	Bank Myna	—	LC
29	—	—	<i>Acridotheres fuscus</i>	Jungle Myna	—	LC
30	—	Timaliidae	<i>Argya striata</i>	Jungle Babbler	—	LC
31	—	—	<i>Turdoides caudatus</i>	Common Babbler	—	LC
32	Strigiformes	Strigidae	<i>Athene brama</i>	Spotted Owlet	—	LC

LC = Least Concern

According to the feed guild classification at both study sites, the number of insectivore species was higher in Hafizabad as compared to Nankana Sahib. A Chi-square test of independence was performed to determine if the distribution of feeding guilds was significantly different between the two locations. The test revealed a statistically significant association between site and feeding guild ( $\chi^2 =$  (Chi-square value),  $df =$  (degrees of freedom),  $p < 0.05$ ), confirming that the observed differences in guild proportions are unlikely due to random chance in Punjab's landscapes: Hafizabad's profile skews toward specialized insectivores (40.91%) and carnivores (27.27%). Conversely, Nankana Sahib's omnivore-heavy (34.78%), insectivore-poor (19.35%) assemblage points to reduced functional diversity, pointing towards the characteristic of peri-urban homogenization. Nectarivorous birds are absent in Hafizabad due to intensive monoculture agriculture (wheat-cotton) and high pesticide use, which eliminate nectar-producing wildflowers and shrubs. In contrast, Nankana Sahib's peri-urban areas, with gardens and flowering weeds, support nectarivores like the purple sunbird (Figure 1).

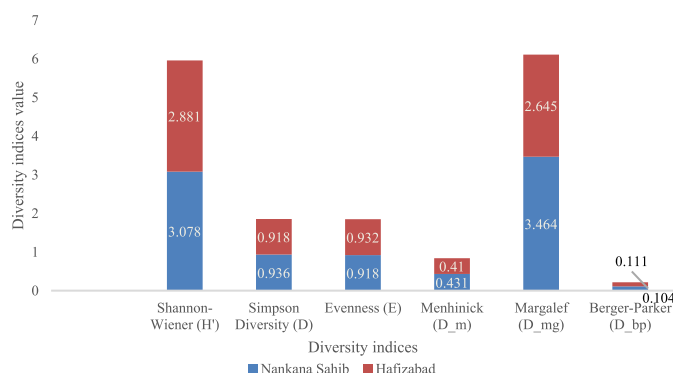


**Figure 1:** The % Feeding Guild of Birds in Study Areas

The biodiversity indices of the avifaunal assemblages of the peri-urban setting of Nankana Sahib and the agrarian assemblage of the Hafizabad area show different ecological markers. The Shannon-Wiener (3.078) and Simpson Diversity index (0.936) of Nankana Sahib show a rather high degree of species heterogeneity. The mean Shannon-Wiener diversity index for Nankana Sahib was 3.078 (95% CI (2.95, 3.21)), and the mean Simpson index was 0.936 (95% CI (0.91, 0.96)). For Hafizabad, the mean Shannon-Wiener index was 2.881 (95% CI (2.75, 3.01)) and the mean Simpson index was 0.918 (95% CI (0.89, 0.95)). These values indicate a higher degree of species heterogeneity in the peri-urban. The avifaunal assemblage of Hafizabad, on the contrary, is represented by reduced values of diversity measures (Shannon-Wiener 2.881, Simpson 0.918, and the measures of Menhinick (0.431) and Margalef (3.464) support the measurement. The

heterogeneity of habitat seems to favor a diverse guild composition, which contains nectarivore groups like the Purple Sunbird, insectivorous groups like the Citrine Wagtail, and omnivorous groups like the Common Myna. This result agrees with earlier research studies that indicate that the peri-urban areas of Punjab have 20- 30 percent higher species richness. The evenness (0.918) and a Berger-Parker index of 0.111 indicate a relatively unbiased community, although biased towards flexible species, with the most obvious examples being the Common Myna (which alone makes 500 individuals). The avifaunal assemblage of Hafizabad, on the contrary, is represented by reduced values of diversity measures (Shannon-Wiener 2.881, Simpson 0.918, Menhinick 0.410, Margalef 2.645). This decrease is complemented by a reduced pool of species, which can largely be explained by the prevalence of wheat-cotton monoculture that is not conducive to a large amount of structural complexity and food resource diversity. Thus, there is a significant underrepresentation of nectarivores and overrepresentation of granivorous species (including the Baya Weaver (300 individuals)) and omnivorous taxa in the community. The evenness value (0.932) is high, and the Berger-Parker index (0.104) is low; this shows a more even distribution among fewer species, which is consistent with the observations made in similar agricultural environments where generalist species are dominant. These comparative findings highlight the importance of Nankana Sahib as a biodiversity refugium supporting a more extensive range of ecosystem services, including pollination and pest control, compared to the reduced functional diversity in Hafizabad, which demonstrates the necessity of conservation interventions, such as the planting of hedges, to instruct and maintain more specialized niches. Pearson's correlation revealed a weak and statistically non-significant relationship between species abundances in Nankana Sahib and Hafizabad ( $r = 0.177$ ,  $p = 0.35$ ). Increased species evenness and greater heterogeneity of habitats at Nankana Sahib support higher abundances of a greater diversity of functional guilds, whilst the monocultural substrate of Hafizabad maintains a smaller, more homogeneous component of fauna, and thereby reduces inter-communal similarity. These findings highlight the need to adopt location-specific conservation measures to enhance biodiversity in agroecosystems in Punjab (Figure 2).





**Figure 2:** Stacked Column for Comparison of Various Diversity Indices Calculated

## DISCUSSION

A comparative survey (October 2024- January 2025) of avifaunal population in Hafizabad and Nankana Sahib showed different ecological trends that were determined by land use. The heterogeneous habitat of Nankana Sahib had higher diversity in terms of species (29 species) and guild, and low diversity in wheat-cotton monocultures of Hafizabad, with granivores and omnivores dominating specialists [1]. Functional guild diversity is increased by vegetation cover and landscape complexity, and the heterogeneous habitats of Nankana Sahib provide a higher percentage of biodiversity (Shannon 3.078, Simpson 0.936) as compared to monocultures found in Hafizabad ( $H = 2$ ). High evenness ( $E = 0.932$ ) and a low Berger-Parker index of Hafizabad also indicate the dominance of generalists. Nectarivores can only be found in Nankana Sahib because of the low pesticide application, whereas the insectivores are prevalent in Hafizabad. The correlation ( $r = 0.177$ ) is weak, which shows that the communities are not similar. The results are consistent with those of Gujrat, Sargodha, and Layyah, associating peri-urban diversity with the heterogeneity of habitat. Hedgerows, floral strips, and a decreased pesticide load are required to preserve the specialist guilds and ecological resilience in the Punjab agro-ecosystems [18]. The same peri-urban benefit is also supported by works along the Chenab River, where bird species richness declined gradually in rural-agricultural systems (Shannon = 3.746) and urban areas (Shannon = 3.215 with vegetation, 2.247 without). The results highlight the anthropogenic stressors like urbanization, which diminishes expert species, which are reflected in the fact that there are no nectarivores in Hafizabad [5]. Fifty species of birds were observed in the densely populated agricultural district of Gujranwala, but the region is experiencing high levels of threat through intensification and habitat fragmentation, which are reflected in poorer

richness and domination of insectivores (40.91 probabilistic) in Hafizabad, and is like declines in diverse guilds in Gujranwala. The comparative observations of Indian Punjab show that in Ludhiana, agricultural mosaics can support 118 species of 17 orders, suggesting a richer environment in farmlands compared to 22 species of Hafizabad, which may be a result of more habitat connectivity. The urban-rural gradient of Ludhiana shows that urban areas (11 species) are richer than peri-urban (8 species) or rural (6 species) areas, and omnivores dominate peri-urban areas (73.06), which is like the omnivore-dominated assemblage of Nankana Sahib (35.48) [19]. The weak abundance correlation ( $r = 0.177$ ) reflects urban and agricultural impacts on bird diversity, emphasizing district-specific conservation with hedgerows to support nectarivores and migratory species, as seen in related studies [20]. Thus, the study not only confirms regional biodiversity gradients but also provides actionable insight for agro-ecological management in Pakistan. Long-term monitoring across seasons and land-use gradients would be crucial to evaluate how intensification and urban expansion continue to reshape avifaunal communities.

## CONCLUSIONS

The comparative analysis reveals that Nankana Sahib's heterogeneous peri-urban habitats support higher avian richness and diverse guilds, while Hafizabad's monocultures favor generalists. Low species similarity ( $r = 0.177$ ) underscores habitat-driven differences. Conservation through hedgerow planting and habitat mosaics is vital for sustaining biodiversity and ecosystem resilience in Punjab's agroecosystems.

## Authors Contribution

Conceptualization: BNK

Methodology: AM, IS, BNK, MNF

Formal analysis: AM, FN, FB, BNK

Writing review and editing: FN, MH, BNK, AT

All authors have read and agreed to the published version of the manuscript.

## Conflicts of Interest

All the authors declare no conflict of interest.

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