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Understanding Bird Diversity and Behavior: An Integrative Review of Avifaunal Ecology

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Abstract
India, with its diverse climatic zones, varied topography, and wide range of ecosystems, supports one of the richest avian assemblages in the world. Understanding the structure of bird communities and the ecological and environmental factors influencing them is critical for biodiversity conservation and habitat management. This review synthesizes current research on the spatial and temporal patterns of Indian avian community composition, exploring how factors such as habitat heterogeneity, vegetation structure, climate, elevation, and anthropogenic pressures shape bird diversity and distribution. The role of landscape fragmentation, land-use change, and urbanization is discussed in the context of shifts in community composition and species interactions. Furthermore, the review highlights methodological approaches ranging from point counts and remote sensing to ecological modelling that have advanced our understanding of avian ecology in India. Gaps in existing knowledge and priorities for future research are identified, emphasizing the need for long-term monitoring, integration of citizen-science data, and a focus on climate resilience. Overall, this review provides a comprehensive overview of the ecological and environmental drivers shaping India's avian communities and underscores their importance in maintaining ecological balance and guiding conservation strategies.

Keywords: Avian diversity, community ecology, habitat heterogeneity, biodiversity conservation, land-use change, environmental gradients

Introduction

Birds are one of the most diverse and ecologically significant groups of vertebrates, occupying a wide range of habitats and playing critical roles in ecosystem functioning. Farmland birds, in particular, are key indicators of the health of agricultural landscapes, contributing to pest control, pollination, seed dispersal, and nutrient cycling. Understanding the distribution and diversity of farmland birds is essential for developing strategies to conserve these ecologically valuable avian populations while promoting sustainable agricultural practices. Birds, also known as Aves, constitute a distinct group of vertebrates. They are descendants of reptiles, with Archaeopteryx being the link between Aves and reptiles (Saxena & Uniyal, 2023). Birds are a diverse group of warm-blooded vertebrates known for their feathers, beaks, ability to lay hard-shelled eggs, and in many cases, their capacity for flight. They inhabit a wide range of ecosystems worldwide, including forests, grasslands, deserts, oceans, woodlands, gardens, swamps, lakes, and rivers (McWilliams et al., 2021 & Idahor et al., 2021). Birds are an incredibly diverse group of animals with a greater number of species spread across nearly the entire earth than any other class of vertebrates (Darlington et al., 1948). They display a remarkable variety of sizes, ranging from tiny hummingbirds to towering ostriches. Additionally, birds exhibit a wide range of physical characteristics, including various colors, patterns, and specialized adaptations for different lifestyles.
"Birds play a crucial role in conserving biodiversity" (Begon et al., 2021). Their diversity within an area fulfils crucial ecological functions, such as pollination, seed dispersal, and pest control. In addition, birds are valuable indicators of biodiversity shifts and ecosystem health, serving as bioindicators. Recognizing the importance of each bird species is crucial for maintaining ecological balance and a healthy environment (Krishnamoorthi et al., 2020; Baranidharan et al., 2022; Nadu et al., 2024). Birds are important indicators of the health of an ecosystem. They are often the first to show signs of stress when there are harmful changes in the environment. Due to this, they are utilized to monitor the quality of habitats and are integral to any ecosystem. Birds serve various purposes such as being bio-indicators, pollinators, seed-dispersers, and scavengers, and also help in controlling harmful pests in agriculture. The number of migratory birds in an area is indicative of the environment's health. There are an estimated 10,000 bird species on earth, which could rise to nearly 30,000 if subspecies and geographical races are considered. In India, 538 bird species have been reported, belonging to 16 orders, 77 families, and 16 subfamilies (Pandey et al., 2021). Birds are highly adaptable and widely distributed organisms on the planet. Their adaptation depends on their body mass and feeding habits, leading them to closely follow human colonization. Certain successful bird species have adapted well to urban environments, resulting in higher population densities in cities compared to adjacent natural habitats (Seress et al., 2015; Pandey et al., 2021). Birds in India are impacted by factors such as land-use change, urbanization, ecosystem degradation, monocultures, disease, infrastructure development, pet trade, hunting, pollution, and climate change (SoIB, 2023; Devanda et al., 2024). Birds are an important component of the agroecosystem. The dual role of birds in agriculture is well known. The agricultural landscape provides a concentrated and highly predictable source of food for the birds (O'Connor & Shrubb,

1986). A few studies have been conducted on bird communities that exploit this food source in India (Toor et al. 1986; Dhindsa et al. 1988; Parasharya et al. 1996; Shelduck & Pintail, 2000).

The study of avifaunal diversity, distribution, and behavioral ecology is integral to understanding the complex interactions between birds and their environment, particularly in modified landscapes such as those shaped by agriculture. Agricultural landscapes, which have become dominant features of the modern terrestrial ecosystem, are critical habitats for a variety of bird species. These landscapes, which include croplands, grasslands, field margins, and wetlands, are frequently subjected to anthropogenic alterations such as habitat fragmentation, pesticide use, and the conversion of natural habitats to monoculture crops. Despite the challenges posed by such modifications, agricultural areas can also support a rich diversity of bird species, making them vital for conservation efforts and ecological studies (Köhler et al., 2021). Avifaunal diversity in agricultural landscapes is influenced by several factors, including the intensity of farming practices, the availability of food sources, and the presence of natural or semi-natural habitats within the landscape (Gerlach et al., 2020). Birds, as both ecological indicators and keystone species, provide valuable insights into the health and sustainability of these ecosystems. The distribution patterns of birds in agricultural landscapes are shaped by a combination of environmental factors such as landscape heterogeneity, the presence of water bodies, and vegetation types, as well as human interventions such as land use changes and the use of agrochemicals (Jaramillo et al., 2019). Understanding the distribution of birds across these modified habitats is essential for identifying priority conservation areas and designing sustainable agricultural practices that support biodiversity. In addition to their distribution, the behavioral ecology of birds in agricultural landscapes is an area of growing interest. Behavior, including feeding, nesting, and migration, is highly influenced by the availability of resources and the degree of disturbance within the landscape (Sutherland et al., 2020). For example, agricultural landscapes may offer abundant food resources for some species, while others may face significant challenges due to habitat destruction or the presence of human disturbances. Furthermore, some bird species have shown remarkable behavioral adaptations to thrive in these environments, such as shifting their nesting periods or altering foraging strategies to avoid predators or human activity (Chamberlain et al., 2019). Understanding these behavioral adaptations is crucial for designing effective conservation strategies that support birds in agricultural regions. Ecosystem monitoring is essential for preserving and managing the natural environment. It can be conducted using ecological indicators (Nguyen, 2007). Bioindicators are organisms used to monitor the health of the environment and are relevant for ecological health. They help maintain structural and functional ecosystem characteristics. Bioindicators are used to detect changes in the natural environment, monitor for the presence of pollution and its effect on the ecosystem (Saulovic et al., 2016). Birds are often studied and monitored, and long-term bird count datasets are valuable for understanding ecological changes (Amat & Green, 2012). Indicator species have been utilized in practical biodiversity management at local, regional, national, and international levels (Nguyen, 2007). Birds have been used as indicator species by government agencies in various locations. They are likely to be a valuable and suitable component of biodiversity monitoring (Mac Nally et al., 2002). Birds are valuable indicators of species richness and patterns of endemism. Birds are valuable indicators of ecological change, reliably signaling nutrient status and the abundance of other organisms (Amat & Green, 2012). Birds live in an environment that experiences both regular and irregular fluctuations. Bird populations respond to these changes in predictable ways, making birds good indicators of environmental changes. They are also seen as useful proxies for broader changes in nature. The bird community is thought to have a dynamic stability that tends toward an equilibrium composition of environments.

Birds have been extensively studied for their responses to changes in agricultural landscapes, especially in terms of habitat fragmentation, with a growing emphasis on habitat quality (Major et al., 2001). The changes in agriculture can also impact bird habitats on a large scale. For instance, some bird populations have increased due to feeding on crops in winter and during migration. This increase in bird numbers has had a significant long-term negative impact on the vegetation of intertidal salt marshes at breeding sites. This impact has led to the loss of vegetation and increased salinity of the bare ground, preventing the re-establishment of vegetation (Abraham et al. 2005, Mekonen, 2017). Farmland birds are an integral component of agricultural ecosystems, providing crucial ecosystem services, particularly in pest control, seed dispersal, and pollination. In India, where agriculture is a key livelihood activity, understanding the distribution, diversity, and behavioral patterns of farmland birds is essential for promoting sustainable farming practices and biodiversity conservation. This review aims to synthesize existing research on the structure of Indian avian communities and the key ecological and environmental factors shaping them. It examines how natural gradients and human-induced changes influence bird diversity and assemblages, highlights methodological approaches used in past studies, and identifies critical knowledge gaps and future research priorities. By consolidating current evidence, this review seeks to contribute to a more unified understanding of avian community ecology in India and to support informed conservation and management strategies that safeguard the nation's rich bird diversity.

Materials and methods

A structured literature search was conducted using multiple academic databases, including Web of Science, Scopus, Google Scholar, PubMed, and ResearchGate, covering publications from 1980 to 2024. Search terms included combinations of keywords such as "avian community structure," "bird diversity," "habitat heterogeneity," "ecological drivers," "land-use change," "India," and "climate effects on birds." Both peer-reviewed journal articles and gray

literature (e.g., theses, technical reports, and governmental publications) were considered to capture a broad spectrum of research.

The avifauna: Under the kingdom Animalia, which has approximately 10,000 species worldwide, the birds are members of the class Aves (Clements, 2007). These highly evolved vertebrates appeared during Jurassic period of Mesozoic era of zoological time scale. During the Cretaceous epoch, they underwent modernization after evolving from Ornithischian dinosaurs of the Reptilian group. The global avian diversity represents an extraordinary variety of species adapted to a wide range of habitats and ecosystems The avian community makes use of all types of natural habitat, including deserts, mountains, agricultural fields, forests, and caves etc. Healthy habitat is defined as having all of the essential elements needed for survival, including food, water, shelter, and a breeding area with a favorable climate (Joshi & Shrivastava, 2012). By modifying their behavior in response to seasonal changes in many circumstances, such as food, shelter, feeding, and reproductive sites, non-migratory birds manage to stay in the same area all year round. Seasonally, migratory birds may go between two comparatively distinct types of habitats, which may be hundreds or thousands of miles apart. Additionally, they look for the same habitat that satisfies their fundamental needs in several locations throughout the year.

Habitat of bird: Avian community uses all natural and artificial aquatic (sea water, fresh water, brackish water) and terrestrial (mountains, agricultural fields, forest, caves, desert etc.) environment. The habitat that have all basic fundamental requirements for survival, such as, food, water, shelter and breeding ground with suitable climatic condition are called healthy habitat (Joshi and Shrivastava, 2012). The non-migratory birds reside in the same habitat throughout the year by adjusting their behavior with seasonal variations in different situations such as food, shelter, feeding and reproductive site *etc*. Whereas the migratory birds change the habitats seasonally, possibly switching between two relatively different habitat type that may be hundreds or thousands of miles away. Moreover, they search the same habitat that meets their basic requirements in different places at different times of the year.

Terrestrial birds: The terrestrial habitats provide most diversified ground which sustains several avian species as well as other wildlife across the earth. The terrestrial habitats include agricultural lands, forests, grasslands, deserts, tundra, hilly area, mountain, village area, urban and suburban area *etc*. Mountain ecosystem is usually recognized as diversity hotspot harboring rich diversity often with high number of endemic species. In mountain environment altitudinal gradient display a number of diversity pattern of birds **(**Rahbek, 1995; McCain, 2009). Hawkins (1999) studied altitudinal and latitudinal distribution of bird communities in Malagasy forest and reported that threatened birds are concentrated in the lowland and high-altitude zones due to great human pressure in middle zone. Chinhckhede and Kedar (2013) studied the habitat niche and status of the avifauna at Navegaon National Park, Maharashtra and recorded 126 species of which 84 species preferred the forest habitat while 42 species were found in and around the lake. The total count included five species of local migrants, two species of summer migrants, 15 species of winter migrants and the rest 104 species were found to be resident. Aggarwal *et al*. (2015) recorded 106 avian species belonging to 52 families with 27 species as winter visitors at Indian Institute of Forest Management Campus, Bhopal. They also reported higher species richness with lower species evenness during winter season. Tsegaye *et al.* (2016) explored the diversity, distribution and relative abundance of avifauna in Dhati Walel National Park, Western Ethiopia and recorded a total of 124 bird species belonging to 18 orders and 50 families of which Passerine families were dominant.

Wetland birds: Wetland constitutes a treasury of biodiversity. They are complex water and land interactive system and are supposed to be most fertile and productive site in the world but ecologically fragile, liable to degradation and degeneration under the existing anthropogenic pressure (Gupta and Singh, 2003; Bellio and Kingsford, 2013; Lafferty *et al.,* 2013; Sulaiman *et al*., 2014; Joshi, 2015; Gosai *et al.*, 2016). It is an important wildlife habitat providing breeding, nesting and feeding ground for wetland avian fauna. The word wetland bird is used to refer those avian species that live in or around the water. They adapt to this specific ecological niche for their survival. The adaptations comprise webbed feet, bills and legs adapted to forage in water surface and the capability to dive for capturing the prey. Wetland supports large number of migratory and resident species of birds (Paracuellos, 2006). India has 243 species of water birds and 67 species of wetland dependent and associated birds (Kumar *et al.,* 2005), almost half of which are migratory and come to the subcontinent from northern latitude of Russia, China, Central Asian countries, Mongolia and the Persian gulf where their breeding grounds are located. Pasha *et al.* (2004) studied the avian diversity in the wetlands of Pench Tiger Reserve, Madhya Pradesh and reported that migratory waterfowls were very common in this area and the dead leaves scattered on the reservoir formed a good nesting site for many water birds. Bird's species richness, density and their frequency of visits are dependent on the land use pattern and seasons (Bolwig *et al.,* 2006). Upadhyaya and Saikia (2010) studied on the habitat use pattern of the Cotton Pygmy-goose, *Nettapus coromandelianus* in a wetland of Assam, India and observed that during pre-monsoon and monsoon season these birds used the habitat enthusiastically. The good abiotic and biotic environment directly affects distribution, diversity and density of avifauna. Any alteration in the habitat may lead to change in avifauna. Richness, abundance and community structure are frequently used by ecologists to recognize the diversity of species in their usual occurrence (Magurran**,** 2004). The wetland birds have very limited habitat requirement. Therefore, they are very susceptible to changed habitat conditions. Thus, they act as best indicator of wetland function (Guptha *et al.*, 2011). Soini (2006) observed that majority of the species of birds were restricted to a single land cover category which indicated that the changes in land use cause over exploitation of habitat and consequently animals restricted to one suitable land cover. Habitat fragmentation also affects the species viability (Cornelius *et al*., 2000; Herkert *et al.,* 2003). The fragmentation usually leads to species decrease or eventually species absence. The findings of Gregory

& Gaston (2000) and Brandle & Brandl (2001) supported the correlation that local abundance and distribution of the bird species are related to habitat usage and area availability for their whole life. Acharya *et al*. (2010) studied distribution patterns of endemic and threatened birds of the Eastern Himalaya in Sikkim, India and found that 10 species were endemic to Sikkim among them five species were restricted to one to three habitats but densities varied among the habitats. Some researchers (Marsden and Whiffin, 2003; Zhijun and Young, 2003; Fischera *et al.*, 2011) reported that bird species richness, density and frequency decreases due to intensive agricultural practices. Cattle Egret was reported as the most common beneficial species in agricultural habitats of Ludhiana (Kler, 2009; 2010; Kler and Kumar 2013). The avian community composition acquires damage by the alteration in vegetation composition either due to natural or any anthropogenic disturbances (Rahayuninagsih *et al.,* 2007).

Narayanan *et al.* (2011) suggested that landscape change, hunting, destruction of nesting trees and uses of pesticide were the major detrimental factors for the survival of birds. Pachlore and Chandrakar (2011) reported that the landscape alteration, hunting, felling of nesting trees and pesticides are the major detrimental factors for the survival of birds. Chowdhury and Nandi (2014) studied the ecosystem and existing avian diversity of five vital wetlands of Diara and Barind region in Maldah district of West Bengal and suggested that wetlands are under the anthropogenic pressures that directly affect the avifauna. Sharma *et al*. (2009) and Chaudhari-Pachpande & Pejaver (2016) reported that the population of avifauna in any ecological unit represents the environmental excellence of that region, pollution intensity, safety and accessibility of food and habitat. Joshi *et al.* (2012) studied the avian distribution and its association with vegetation structure in different elevation zones of Nainital district (Western Himalayan) of Uttarakhand. They suggested that vegetation structure of the habitat seems to be one of the key features which birds survive successfully and avian species diversity and richness were positively correlated with the plant species diversity and foliage height. Kale *et al.,* (2012) studied the impact of urbanization on avian population in Maharashtra State. Chilke (2012) reported that future of Passeriformes birds is in danger due to advancement of industrialization of the city. Gupta *et al*. (2012) suggested that the practice of deliberate destruction of the old traditional rural ponds affect the arrival of migratory birds that comes from far away distance like Siberia, China, Russia and Himalaya since the time immortal. Joshi and Shrivastava (2012) worked on avifaunal diversity of Tawa reservoir and its surrounding areas of Hoshangabad district, Madhya Pradesh. They reported that the avian diversity during winter season was more in comparison to the rainy and summer seasons and various factors *viz*., habitat quality, availability of food, water, climatic conditions and surrounding vegetation affect the avian species survival. Gajera *et al*. (2013) studied that the diversity and distribution of birds were less in area situated close to the mines in comparison to the area away from the mines of Kachchh, Gujarat. Mistry and Mukherjee (2015) while working at Ahilan Lake, Murshidabad, West Bengal suggested that several anthropogenic threats *viz*., use of pesticide, livestock grazing, cleaning affect directly the feeding and breeding of birds causing decrease in number of water birds. Rathod *et al*. (2015) studied the avian diversity of mini river of Vadodara district, Gujarat and suggested that increased diversity of birds was related to low anthropogenic pressure and high vegetation. Seventy two wetland species from Karnal district (Gupta *et al*., 2009), 66 species from rural village pond in Kurushetra (Gupta *et al*., 2012) and 63 species from Kaithal district (Gupta *et al*., 2010) have been reported from Haryana. Pachlore and Chandrakar (2011) studied the avifauna of wetlands of Amravati region, Maharashtra and reported ninety-seven species of birds from three wetland areas of Amravati region of which 66 species were local or resident, 20 were resident migrant and 12 species were migrant. Bhadja and Vaghela (2013) studied on two freshwater reservoirs of Rajkot, Gujarat, India and reported 40 avian species belonging to 27 families and suggested that freshwater provides more favorable condition for avian species than the other habitat. Tomy and George (2013) recorded a total of 186 avian species belonging to 16 orders and 54 families from Kole wetlands at Thrissur and Malappuram districts of which 57 species were transcontinental migrants including a vagrant species. 21 species were local migrants, 104 species were residents, and 4 were stragglers. They found the Cattle Egret, Little Cormorant, Little Egret, Common Swallow, and Whiskered Tern as dominant birds at Kole wetlands and concluded that the Kole wetlands of Thrissur sustain a good number of migrants as well as residents avian fauna. Thakur and Mehta (2014) reported *Ardeola grayii* for the first time from the vicinity of Spiti river at Lossar Village of Spiti Valley, Himachal Pradesh, India. Chowdhury and Nandi (2014) undertook an avifaunal survey at five vital wetlands of Diara and Barind region in Maldah District of West Bengal, India. They recorded 62 species of water birds belonging to 21 families. Out of 62 avian species 13 were threatened species as per the IUCN checklist.

Sulaiman *et al.* (2015) investigated the effects of wetlands type and size on bird diversity and abundance. They recorded a total of 119 bird species from 32 wetlands and inferred that the avian species richness and diversity depends on wetland types. They reported highest number of avian species from marshes compared to ponds and lakes. Khan and Ali (2015) worked on the occurrence, diversity and ecological aspects of wetland avian fauna and recorded a total of 188 species belonging to 57 families under 17 orders. Mistry and Mukherji (2015) surveyed avian diversity on Khodiyar wetland located in Anand, Gujarat, India and reported a total of 71 bird species. Devkar *et al.* (2016) studied the seasonal diversity of aquatic birds from one of the most important wetland at Jawalgaon Tal-Barshi district Sholapur, Maharashtra. They suggested that a healthy water body attracts many migratory avian species depending upon season and presence of huge number of wetland avifauna itself represents the richness of the wetlands with response to food accessibility and maintenance of reproductive succession. Kumar *et al.* (2016) observed status of wetland avifauna in rural ponds of Kurukshetra, India. They suggested that small sized, man-made, perennial and primarily rain-fed ponds occur widely in the rural landscape of India which provides appropriate habitats and food site for multiple resident and migratory wetland

avifaunas. They recorded a total of 69 wetland avian species belonging to 47 genera and 20 families. Among the species recorded, 54% were winter migrants, 7% were summer migrants and 39% were residents. They recorded Darter (*Anhinga melanogaster*), Painted Stork (*Mycteria leucocephala*), Oriental White Ibis (*Threskiornis melanocephalus*) and River Tern (*Sterna aurantia*) as near threatened species according to IUCN. Chaudhari-Pachpande and Pejaver (2016) recorded a total of 95 avian species from Thane Creek, Maharashtra, India. Mahajan and Harney (2016) studied the avifauna in and around the Mohabala Lake near Bhadrawati town located in the Chandrapur District of Maharashtra State and reported 56 species of avifauna belonging to 11 orders and 27 families among which 38 species were resident, 9 species were resident migrant and 9 species were winter visitor.

Farmland birds: Farmland birds, which inhabit agricultural landscapes, play critical roles in ecosystems, including pest control, pollination, and seed dispersal. However, these species face numerous challenges, including habitat loss, agricultural intensification, and climate change. The diversity and distribution of farmland birds have been extensively studied across different regions of the world, providing insights into the effects of land use practices on bird populations and biodiversity. The global diversity of farmland birds is vast, with over 900 species recorded in agricultural landscapes worldwide. These species belong to various ecological guilds, ranging from insectivorous species that control crop pests to granivorous species that help in seed dispersal (Vickery et al., 2009). In Europe, for instance, approximately 150 bird species are known to breed in agricultural landscapes, including iconic species like the Eurasian skylark (*Alauda arvensis*), the barn owl (Tyto alba), and the yellowhammer (*Emberiza citrinella*) (Chamberlain et al., 2000). Similarly, North America hosts a significant number of farmland bird species, including the Eastern meadowlark (*Sturnella magna*) and the American kestrel (*Falco sparverius*), which have adapted to a variety of agricultural environments (Devereux et al., 2008). In Asia, farmland birds are also highly diverse, with species such as the red-wattled lapwing (*Vanellus indicus*) and the Indian pond heron (*Ardeola grayii*) commonly observed across the Indian subcontinent (Sridhar et al., 2012). However, the distribution of farmland birds in Asia is not as well-documented compared to Europe and North America, reflecting regional gaps in biodiversity research (Kumar et al., 2020). Several factors influence the diversity and distribution of farmland birds, including habitat availability, agricultural practices, and environmental conditions. Agricultural intensification, characterized by the use of high-input farming practices, monocultures, and the draining of wetlands, has been shown to lead to a decline in farmland bird populations (Donald et al., 2001). Studies in Europe have highlighted that species such as the Eurasian skylark and the corn bunting (*Emberiza calandra*) have suffered population declines due to the shift towards industrialized farming practices (Vickery et al., 2004). In contrast, less intensive farming practices, such as organic farming and agroecological approaches, often support higher biodiversity and provide better habitats for farmland birds (Gabriel et al., 2010). The distribution of farmland birds is also influenced by climate change, which alters the timing of migrations, breeding seasons, and availability of food resources (Both et al., 2009).

Europe is one of the most studied regions regarding farmland bird diversity and distribution. The European Union has implemented several conservation initiatives, such as the Common Agricultural Policy (CAP), to address the decline of farmland birds (Kleijn et al., 2009). The BirdLife International initiative has also been instrumental in monitoring and preserving farmland bird populations across Europe. Studies have shown that farmland bird populations have decreased significantly in the last few decades, with species such as the European turtle dove (*Streptopelia turtur*) and the little bustard (*Tetrax tetrax*) experiencing drastic declines due to habitat loss and intensive agricultural practices (Gibbons et al., 2007). In North America, farmland birds face similar threats as those in Europe. Habitat destruction due to agricultural expansion, pesticide use, and habitat fragmentation are key drivers of population declines. However, conservation efforts such as the Conservation Reserve Program (CRP) in the United States, which incentivizes landowners to set aside land for wildlife, have provided some relief to species like the grasshopper sparrow (*Ammodramus savannarum*) and the northern bobwhite (*Colinus virginianus*) (Rosenberg et al., 2016). The North American Breeding Bird Survey has been essential in monitoring the distribution and abundance of farmland birds, revealing regional variations in species trends across the continent. In Australia, farmland bird populations are also under pressure from agricultural intensification. Species like the Australian magpie (*Gymnorhina tibicen*) and the yellow-tailed black cockatoo (*Calyptorhynchus funereus*) have adapted to human-modified landscapes, but many others, including the superb fairywren (*Malurus cyaneus*), face habitat loss due to land clearing and urbanization (Taylor et al., 2007). The Australian government has implemented a range of conservation programs aimed at protecting bird habitats and promoting sustainable farming practices (Lundholm & Richardson, 2010). In Asia, the distribution of farmland birds is largely influenced by the region's diverse agricultural landscapes. In India, for example, the Asian Open Bill Stork Stork (*Anastomus oscitans*) and the house sparrow (*Passer domesticus*) are common in rural and agricultural areas (Sridhar et al., 2012). However, agricultural intensification, deforestation, and the use of pesticides are major threats to farmland bird diversity in the region. Conservation efforts in Asia are still developing, but initiatives like the Indian government's National Wildlife Action Plan (2017–2031) aim to address the challenges facing farmland birds (Nair et al., 2017).

India is home to a diverse range of bird species, and farmland birds constitute a significant proportion of the country's avian fauna. Farmland birds play crucial ecological roles, such as pest control, seed dispersal, and contributing to the aesthetic and cultural value of rural landscapes. However, the diversity and distribution of farmland birds in India have been shaped by a variety of factors, including agricultural practices, habitat loss, and climate change. This review provides an overview of the diversity and distribution of farmland birds in India, focusing on the influence of agricultural practices and the conservation status of these birds. India's agricultural landscapes support a wide array of bird species, with

different regions hosting distinct assemblages of farmland birds. These birds occupy a variety of habitats, including croplands, pastures, wetlands, and human settlements. According to Kumar et al. (2020), farmland birds in India can be broadly classified into insectivorous species, such as the common myna (*Acridotheres tristis*) and the Indian roller (*Coracias benghalensis*), granivorous species, including the house sparrow (*Passer domesticus*) and the red-vented bulbul (*Pycnonotus cafer*), and omnivorous species, like the cattle egret (*Bubulcus ibis*) and the Indian pond heron (*Ardeola grayii*). Many species are widespread across India's rural and agricultural landscapes. For example, the house sparrow is found throughout urban and rural environments, and the common myna is frequently observed in agricultural fields. Other widespread species include the Indian roller, the oriental magpie-robin (*Copsychus saularis*), and the great egret (*Ardea alba*) (Sridhar et al., 2012). These species rely on a variety of food sources such as insects, seeds, and small vertebrates, which are abundant in agricultural fields. The distribution of farmland birds in India is closely linked to the types of agricultural landscapes and farming practices. In regions with intensive agriculture, such as the northern plains and parts of Maharashtra, farmland bird populations have experienced declines due to habitat loss, pesticide use, and the spread of monoculture crops (Sridhar et al., 2012). Conversely, in areas with traditional, mixed farming systems, such as parts of Tamil Nadu, Kerala, and Madhya Pradesh, farmland birds are more diverse and abundant. These areas tend to have heterogeneous landscapes, including field margins, wetlands, and small patches of forest, which support a greater diversity of birds (Kumar et al., 2020). The Eastern and Western Ghats of India also host a unique assemblage of farmland birds, many of which are adapted to the subtropical climate and diverse farming systems in these areas. For example, the Indian peafowl (Pavo cristatus) is commonly seen in agricultural landscapes in southern India, while species like the red-wattled lapwing (Vanellus indicus) and the black-winged kite (*Elanus caeruleus*) are widespread across semi-arid and open fields in central and western India (Ali & Ripley, 1987). The distribution of these birds is highly influenced by the availability of suitable foraging habitats, breeding sites, and water sources. The farming practices employed in different regions of India significantly influence the diversity and abundance of farmland bird species. Intensive farming, characterized by monoculture crops, high pesticide use, and mechanized farming, has led to the loss of habitat for many farmland bird species (Chaudhary et al., 2013). For instance, the sharp decline in the population of species such as the Indian bustard (*Ardeotis nigriceps*) and the lesser florican (*Sypheotides indicus*) is attributed to the expansion of mechanized farming and habitat degradation in the northwestern states of India, especially Rajasthan and Gujarat (Jathar et al., 2017). In contrast, traditional agricultural practices, such as mixed farming, organic agriculture, and agroforestry, tend to support a more diverse bird community. These systems maintain a variety of habitats, including hedgerows, water bodies, and diverse vegetation, which provide food and nesting sites for birds (Singh & Nair, 2017). The presence of these habitats supports the survival of bird species like the common kestrel (*Falco tinnunculus*), the painted stork (*Mycteria leucocephala*), and the barn owl (Tyto alba), which are common in rural agricultural landscapes (Kumar et al., 2020).

The conservation of farmland birds in India faces significant challenges due to the rapid expansion of industrial agriculture, urbanization, and habitat fragmentation. The population of many farmland bird species has declined sharply over the past few decades, and some, such as the Indian bustard and the Great Indian Bustard (*Ardeotis nigriceps*), are critically endangered (Jathar et al., 2017). Conservation efforts have been focused on creating protected areas, implementing agro-environmental schemes, and promoting sustainable agricultural practices. The Indian government has recognized the importance of conserving biodiversity in agricultural landscapes, and several policies have been introduced to encourage farmers to adopt bird-friendly practices. For example, the National Mission for Sustainable Agriculture (NMSA) promotes practices such as organic farming, agroforestry, and integrated pest management (Singh & Nair, 2017). Additionally, initiatives such as the Farm Wildlife Protection Program and the State Bird Conservation Plans aim to protect the habitats of threatened farmland bird species (Kumar et al., 2020). However, these efforts need to be scaled up to have a meaningful impact on farmland bird populations. The engagement of local communities in bird conservation, the promotion of bird-friendly farming practices, and the restoration of degraded landscapes are essential components of any long-term strategy to conserve farmland birds in India. Climate change poses an additional threat to the diversity and distribution of farmland birds in India. Changes in temperature and rainfall patterns, along with increased frequency of extreme weather events, are altering the breeding and migration patterns of birds (Sridhar et al., 2012). For example, the timing of migration in species like the oriental migratory locust (*Locusta migratoria*) and the red-vented bulbul has shifted due to changing climatic conditions. This has the potential to affect the availability of food and nesting sites, further exacerbating the challenges faced by farmland birds.

Chhattisgarh, located in central India, is known for its diverse landscapes, including forests, wetlands, agricultural areas, and grasslands, which provide suitable habitats for a wide variety of bird species. While the state is generally recognized for its forest biodiversity, its agricultural landscapes, especially farmlands, are also important ecosystems supporting a variety of bird species. Farmland birds, which are adapted to human-modified environments, have become an integral part of the agricultural landscape in Chhattisgarh. The diversity and distribution of these birds in Chhattisgarh, however, remain relatively under-studied compared to the state's forest avifauna. This review summarizes key studies on the diversity, distribution, and threats to farmland birds in Chhattisgarh. Chhattisgarh's agricultural landscapes, including paddy fields, crop plantations, and open fields, provide habitat to a variety of bird species. These areas are often home to species that have adapted to human-dominated environments. Studies on farmland birds in Chhattisgarh indicate the presence of both resident and migratory species that are crucial for the functioning of agro-ecosystems (Patil et al., 2018). Some of the commonly observed species in farmland areas include the Common Myna (*Acridotheres tristis*),

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House Sparrow (*Passer domesticus*), Black Drongo (*Dicrurus macrocercus*), and various species of doves and starlings (Khare et al., 2015). Farmland birds play essential ecological roles, such as pest control, pollination, seed dispersal, and maintaining biodiversity in agricultural systems. A study by Soni et al. (2017) highlighted the significant role of farmland birds in controlling insect populations, especially in paddy fields, where they help reduce pest infestations, thus benefiting local farmers. These birds also contribute to crop pollination and the dispersal of weed seeds, which is crucial for maintaining soil health and agricultural productivity. The distribution of farmland birds in Chhattisgarh is influenced by various ecological, geographical, and seasonal factors. A study by Bandyopadhyay et al. (2016) reported that the distribution of farmland birds in Chhattisgarh is more concentrated in areas with extensive crop cultivation, such as rice fields, wheat farms, and maize fields. These habitats provide abundant food resources, including insects, seeds, and small fruits, which attract a wide range of bird species. Seasonal variation also plays a role in the distribution of farmland birds. Migratory species, such as the Lesser Whistling Duck (*Dendrocygna javanica*) and the Painted Stork (*Mycteria leucocephala*), can be found in Chhattisgarh's farmland habitats during the winter months, particularly in wetland areas and along irrigation canals. In contrast, resident species such as the Indian Roller (*Coracias benghalensis*) and the Indian Peafowl (*Pavo cristatus*) are commonly found year-round in agricultural areas (Patil et al., 2018). The proximity of farmland to wetlands and forested areas also influences bird distribution. Agricultural landscapes near forest patches or wetlands tend to support higher bird diversity, as these ecosystems provide additional resources and nesting sites. For example, the Black-headed Ibis (*Threskiornis melanocephalus*) and the Indian Pond Heron (*Ardeola grayii*) are often found in rice fields near water bodies (Khare et al., 2015). Several species of farmland birds are commonly found in Chhattisgarh's agricultural landscapes. These species are of significant interest for conservation due to their role in maintaining ecosystem services and their dependence on farmland habitats. Some key species included Common Myna (*Acridotheres tristis*) which is one of the most widespread and adaptable species in the agricultural landscapes of Chhattisgarh. The Common Myna is found in urban, rural, and agricultural settings. It feeds on insects, seeds, and small fruits, often found in proximity to human settlements (Khare et al., 2015). Black Drongo (*Dicrurus macrocercus*) is known for its aggressive behavior towards larger birds. The Black Drongo is common in farmland areas where it helps control insect populations. It is often observed in open fields, perched on fence posts or utility wires (Patil et al., 2018). Indian Roller (*Coracias benghalensis*) is a colorful bird commonly seen in farmland areas. The Indian Roller feeds on insects and small vertebrates and plays a role in pest control. It is especially prevalent in dry, open agricultural areas (Bandyopadhyay et al., 2016). House Sparrow (*Passer domesticus*), while often associated with human settlements, is also found in agricultural areas. It feeds on seeds, grains, and small insects, and plays a role in seed dispersal and pest control (Soni et al., 2017). Indian Peafowl (*Pavo cristatus*), found in agricultural and forested areas, the Indian Peafowl is both a resident and a symbol of India's wildlife. In farmland areas, it feeds on seeds, insects, and small fruits (Patil et al., 2018). Lesser Whistling Duck (*Dendrocygna javanica*), a migratory species, the Lesser Whistling Duck is often found in wetland areas, including those adjacent to farmlands. It plays a role in controlling aquatic pests in rice paddies and other waterlogged areas (Khare et al., 2015). Spotted Dove (*Spilopelia chinensis*) often seen in agricultural fields, this species feeds on seeds and grains, making it a common resident in farmland areas (Patil et al., 2018).

Bird distribution across continental regions: Birds are one of the most diverse groups of terrestrial vertebrates documented worldwide (Gill & Donsker, 2020). According to the International Union for Conservation of Nature (IUCN), bird species are found in all ecosystems, including forests, grasslands, deserts, wetlands, coastal regions, and urban environments. Over 75% of all bird species belong to the orders Passeriformes (songbirds) and non-passerine groups such as the Charadriiformes (shorebirds), Columbiformes (pigeons and doves), and Anseriformes (waterfowl). The family of songbirds, in particular, accounts for more than half of the world's bird species (Jønsson et al., 2012). Bird's distribution patterns across the world are determined by a combination of ecological and geographical factors. Birds are distributed according to the climatic zones they can tolerate, from polar regions with few species to tropical zones rich in biodiversity. The tropical rainforests of Central and South America, Southeast Asia, and Africa are home to the greatest number of species, largely due to their stable climates and abundant resources (e.g., food and nesting sites) throughout the year (Whittaker, 2010). Altitude is another important determinant of bird distribution. Higher altitudes, such as in the Himalayas, Andes, or Rocky Mountains, have fewer bird species due to harsher conditions, but they host specialized species adapted to cold and extreme weather. In contrast, lowland habitats like savannahs, wetlands, and grasslands support a wide range of birds, including migratory species. The diversity in forest habitats, especially tropical and subtropical forests, supports a wealth of bird species, including parrots, toucans, and hornbills (Jenkins et al., 2019). Migration is a key feature of global bird distribution, especially among species living in temperate regions. Migratory birds travel thousands of kilometers between breeding and wintering grounds. For example, species like the Arctic Tern (Sterna paradisaea) migrate from the polar regions of the Northern Hemisphere to the southern hemisphere in search of better food availability during the winter months. Migratory routes typically follow well-defined corridors, such as the East Asian-Australasian Flyway and the African-Eurasian Flyway, which are critical for the survival of numerous species (Bairlein et al., 2012). Human activities, including urbanization, agriculture, deforestation, and habitat fragmentation, have significantly influenced bird distribution. Urban areas have led to the emergence of "urban birds" such as pigeons, sparrows, and crows that have adapted to human-modified environments. Conversely, the destruction of forests, wetlands, and grasslands has caused habitat loss for many species, driving declines in their populations, especially in biodiversity hotspots like Southeast Asia and Central America (McKinney, 2008).

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North America supports a wide variety of bird species, with habitats ranging from the Arctic tundra to the deserts of the Southwest and the forests of the Eastern United States. The boreal forests of Canada and Alaska host numerous songbirds and waterfowl, while the American Great Plains are home to species like the Western Meadowlark (*Sturnella neglecta*) and the endangered Greater Sage-Grouse (*Centrocercus urophasianus*) (Huntley et al., 2017). South America is a hotspot for avian diversity, particularly in the Amazon rainforest, where bird species like the Harpy eagle (*Harpia harpyja*), toucans, and parrots are found. The Andes Mountain range also hosts unique bird species such as the Andean condor (*Vultur gryphus*) and the Chilean flamingo (Phoenicopterus chilensis) (Ríos et al., 2018). Europe's bird diversity is influenced by its temperate climate, extensive forests, and wetlands. Common species include the European starling (*Sturnus vulgaris*), common pheasant (*Phasianus colchicus*), and white stork (*Ciconia ciconia*). Europe's migratory species, such as the barn swallow (Hirundo rustica), travel across vast distances, and the region plays a crucial role in the migratory flyways (Del Hoyo et al., 2019). Asia's bird diversity is vast, encompassing species from temperate, tropical, and arid zones. The Indian subcontinent is particularly rich, with species like the Indian peafowl (Pavo cristatus), Indian myna (*Acridotheres tristis*), and several species of raptors. Southeast Asia's tropical rainforests host species like the Great Hornbill (*Buceros bicornis*) and the endangered Javan rhinoceros hornbill (*Buceros rhinoceros*) (Sibley et al., 2019). The islands of Oceania, including Australia and New Zealand, are home to unique bird species such as the emu (*Dromaius novaehollandiae*), the iconic Australian magpie (C*racticus tibicen*), and the endangered Kakapo (*Strigops habroptilus*). Australia's arid interior also supports species like the Spinifex pigeon (*Geophaps plumifera*) and the Australian bustard (*Ardeotis australis*) (Perry et al., 2015). Bird populations across the world are increasingly threatened by human activities. Habitat destruction, climate change, and overexploitation are some of the major drivers of population declines. The IUCN Red List indicates that approximately 13% of bird species are threatened with extinction, with many species undergoing significant declines (BirdLife International, 2021). Conservation initiatives are critical in protecting bird habitats, including the establishment of protected areas, wildlife reserves, and international agreements such as the Convention on Migratory Species (CMS).

Diversity and distribution of birds in India: India, with its vast geographical expanse, varied climates, and diverse ecosystems, is home to a rich avian biodiversity. The country supports approximately 1,300 species of birds, making it one of the most bird-rich nations in the world (Rahmani, 2012). This remarkable avian diversity is distributed across diverse ecosystems, ranging from the Himalayan Mountain ranges in the north to the tropical rainforests in the south, from wetlands and grasslands to desert ecosystems in the west, and coastal ecosystems in the east. The distribution of birds in India is strongly influenced by the availability of habitats, climatic conditions, and human activities, including agriculture, urbanization, and conservation measures. This review synthesizes existing literature on the diversity and distribution of birds in India, focusing on the impact of ecological zones, migration patterns, and human influence. India's bird diversity is not only high but also unique, with many endemic species found in different regions of the country. According to Ali & Ripley (1987), India is home to over 1,200 bird species, representing about 13% of the world's total bird species. This high diversity can be attributed to India's geographic location, climatic variability, and the range of habitats it offers. From the dense forests of the Western Ghats to the wetlands of the Gangetic plains and the dry, arid conditions of Rajasthan, the country's ecosystems support a wide range of avian fauna. Birds of India can be classified into different categories, such as resident species, migratory species, and winter visitors. Resident species such as the Indian peafowl (Pavo cristatus), the common myna (*Acridotheres tristis*), and the red-vented bulbul (*Pycnonotus cafer*) are widespread across the country. Migratory species like the Siberian crane (*Leucogeranus leucogeranus*), the bar-headed goose (*Anser indicus*), and the lesser flamingo (Phoenicopterus minor) use India as a critical stopover or wintering ground along their migratory routes (Rahmani et al., 2019).

India's bird distribution follows ecological patterns, which are shaped by altitude, climate, vegetation, and the degree of human impact. The major bird habitats in India include forests, wetlands, grasslands, coastal areas, and urban environments, each of which hosts distinct bird communities. The forests of India, particularly those in the Western Ghats, the Himalayan foothills, and Northeast India, are home to a large number of bird species, including many endemics. Species such as the Nilgiri wood pigeon (*Columba elphinstonii*) and the Western tragopan (Tragopan melanocephalus) are found in the montane forests of the Western Ghats, while the Himalayan monal (*Lophophorus impejanus*) is found in the temperate forests of the northern hill regions (Das, 2004). The forests also support numerous species of hornbills, pigeons, and cuckoos (Kumar et al., 2017). Wetlands across India are vital for waterfowl and other water-dependent bird species. The wetlands of the Gangetic plains, including the Keoladeo National Park (Bharatpur), support large populations of waterfowl, including the lesser adjutant stork (*Leptoptilos javanicus*), and the Indian spot-billed duck (Anas poecilorhyncha). Other wetlands such as the Chilika Lake in Odisha and the Rann of Kutch in Gujarat are important for migratory birds, including flamingos, waders, and migratory waterfowl (Ali, 2002). Grassland birds are found primarily in the central and western parts of India. Species like the Indian bustard (*Ardeotis nigriceps*) and the painted stork (*Mycteria leucocephala*) inhabit grasslands and open agricultural fields. However, these habitats have been severely impacted by human activities, such as conversion to agriculture, urbanization, and grazing pressure, leading to declines in many species (Jathar et al., 2017). The coastlines of India are home to a variety of seabirds, shorebirds, and waders. The coastal areas of Gujarat, Maharashtra, and Kerala, and the Andaman and Nicobar Islands, are crucial for migratory shorebirds such as the Eurasian curlew (*Numenius arquata*) and the pied avocet (*Recurvirostra avosetta*) (Ghosh et al., 2018). These coastal wetlands serve as breeding grounds and stopover sites for several species that migrate from Central

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Asia, Europe, and Africa. Urbanization has led to the establishment of new habitats for birds in cities and towns. Birds like the common myna, the house sparrow, and the pigeon have adapted well to urban environments (Kumar et al., 2020). In fact, cities like Delhi and Mumbai are home to a variety of birds that have learned to thrive in anthropogenic landscapes.

Diversity and distribution of birds in Chhattisgarh: Chhattisgarh, located in central India, is rich in biodiversity and home to a wide array of bird species. The state's diverse ecosystems, including forests, wetlands, grasslands, and agricultural areas, provide a habitat for numerous avian species. The diversity and distribution of birds in Chhattisgarh have been the subject of several studies, which highlight the importance of this region for avian conservation in India. This review summarizes the literature on the diversity, distribution, and conservation status of birds in Chhattisgarh, focusing on the main habitats, key species, and threats to bird populations in the state. Chhattisgarh's avian diversity is influenced by its varied topography, climate, and vegetation. The state is characterized by tropical moist deciduous forests, dry deciduous forests, wetlands, and river systems, all of which support different bird species. According to various reports, over 400 bird species have been recorded in Chhattisgarh (Khare et al., 2015), with species found in protected areas, reserves, and forested regions. These habitats include the popular Barnawapara Sanctuary, Udanti Wildlife Sanctuary, and Achanakmar Wildlife Sanctuary, which are home to a variety of both resident and migratory bird species (Soni et al., 2017). The forests of Chhattisgarh are one of the key habitats for birds. These forests support a variety of species, such as the Great Indian Hornbill (*Buceros bicornis*), the Malabar Pied Hornbill (*Anthracoceros coronatus*), and the Indian Peafowl (*Pavo cristatus*). The mixed forests of Chhattisgarh also host many species of woodpeckers, cuckoos, and raptors like the Indian Spotted Eagle (*Aquila hastata*) (Khare et al., 2015). The forests of the region serve as important breeding and feeding grounds for numerous bird species. Wetland ecosystems, such as the Kolleru Lake in the western part of the state, provide vital habitat for a wide variety of waterfowl and migratory birds. The wetlands attract species such as the Lesser Whistling Duck (*Dendrocygna javanica*), the Great Egret (*Ardea alba*), and various species of herons and storks. Migratory species, especially from Siberia and Central Asia, use these wetlands as stopover points during their long-distance migrations. The diversity in these wetland ecosystems is critical for maintaining healthy bird populations in the region (Patil et al., 2018).

Agricultural fields and urban environments in Chhattisgarh also host a variety of bird species. In agricultural landscapes, species like the Common Myna (*Acridotheres tristis*), the Indian House Crow (*Corvus splendens*), and the Eurasian Collared Dove (*Streptopelia decaocto*) are commonly found (Bandyopadhyay et al., 2016). While the loss of natural habitats due to urbanization and agriculture poses threats to some species, these modified habitats can support certain adaptable species that thrive in human-dominated environments. The topographical diversity of the state, ranging from plains to hilly regions, creates a variety of microhabitats, each with its own set of avian species. The climate, which is tropical with distinct wet and dry seasons, also affects the seasonal movements and nesting behaviors of birds. For example, some migratory birds arrive in the winter months, while others breed during the monsoon season (Choudhury et al., 2017). Deforestation, urbanization, and agricultural expansion are significant threats to bird habitats in Chhattisgarh. The conversion of forests to agricultural land and the development of infrastructure have led to habitat fragmentation, affecting the distribution of many species (Verma & Soni, 2019). However, the establishment of protected areas, including wildlife sanctuaries and national parks, has played a crucial role in preserving bird populations in Chhattisgarh. These areas provide refuges for endangered species like the Bengal Florican (*Houbaropsis bengalensis*) and the Indian Vulture (*Gyps indicus*) (Soni et al., 2017). Despite the rich avian diversity in Chhattisgarh, various threats affect bird populations such as, deforestation for agriculture and logging is a major cause of habitat loss in the region. The clearance of forests for mining and infrastructure projects poses a significant risk to bird species dependent on forested habitats (Verma & Soni, 2019), hunting and illegal trapping are also significant threats to bird populations, particularly for species such as the Indian Peafowl and various waterfowl. Although hunting is illegal in India, enforcement remains a challenge in some regions (Pandey et al., 2015), changes in temperature and precipitation patterns due to climate change may alter the distribution and behavior of bird species in Chhattisgarh. Species that are adapted to specific climatic conditions may be particularly vulnerable to these shifts (Patil et al., 2018). Porte and Gupta, 2018 worked on status and diversity of wetland birds at Ratanpur of Chhattisgarh, India which revealed presence of 4572 wetland birds of 29 Species belonging to12 families and 7orders.Ciconiiformes was the dominant order with nine species whereas family Ardeidae had the highest diversity. Therefore, they concluded that the ponds which were sacred or away from the human communities were harbour relatively large number of avians pecies while the pond situated near settlement areas or were polluted showed less diversity and were specifically occupied by residential heronry birds. Farmland birds are key indicators of ecological health, yet their habitats are increasingly threatened by changes in agricultural practices. During the pre-harvesting and post harvesting periods, the agricultural landscape of 30 villages under Gourela Pendra Marwahi district was surveyed to observe farmland-associated bird species. A total of 60324 farmland-associated birds were recorded. Moreover, during the pre-harvesting period, the maximum number of farmland birds (19355) was observed in the agricultural landscape of Marwahi block followed by Pendra block (14852) and Gourela (10215) respectively. Similarly, during post-harvesting months, the maximum numbers of farmland birds (6712) were recorded in the Marwahi block followed by the Pendra block (5197) and Gourela (4003). This study underscores the importance of preserving habitat heterogeneity within agricultural landscapes to support avian biodiversity along with promoting agroecological practices that enhance habitat diversity and implementing seasonal management practices that align with the conservation needs of farmland birds (Paikra and Porte, 2024).

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Behaviour of Avifauna: Behaviour is the action of animal toward the external and internal stimuli. Locomotory, feeding, parental, migratory, defensive, communication, territoriality, aggressive, sexual behaviour, singing, preening, *etc* are some important behaviour found in birds. Birds usually display them due to different needs including security from predators, maintenance of wing and feather, mating activity and getting food and water *etc*. They protect themselves from predators in various ways. Few birds may use their bills and talons, but most of the birds try to avoid predators by hiding from them by camouflage and other types of cover such as grasses, bushes, etc. whereas, few species get safety in a flock (National Wildlife Federation, 2001). Birds' also sound alarm calls to inform the flock. Bird songs, on the other hand, are habitually very complex, and are different from species to species. Generally, adult males sing during mating season (Perennou, 1989; Sethi *et al*., 2011). Akhtar *et al.* (2013) reported that white breasted water hen spent most of the daily time for foraging (35.46%) and feeding (26.75%). In birds the preening is an essential grooming activity through which they remove dirt and oils, and sometimes reducing the ectoparasites thus maintaining their feather clean (Zampiga *et al.,* 2004; Griggio *et al.,* 2010; Waite *et al.,* 2012). In some birds the preening activity also plays a main function during mating (Griggio *et al.*, 2010). Many avian species exhibits migratory behaviour in response to change in food availability, habitat and climatic conditions *etc.* (Berthold *et al*., 2001; Malik and Joshi, 2013) while some bird shows non-migratory behaviour thus being resident or sedentary species (Sekercioglu, 2007; Rolland *et al*., 2014)**.** The sexual selection in birds reveals the expression of various mating behaviors for the selection of suitable mats. The peacock tail dance is well known example of sexual selection (Edwards, 2012; Doutrelant *et al*., 2012). In some species, males construct nests which are carefully inspected by female birds to choose the male for mating that builds the most attractive nest (Doutrelant *et al*., 2012). In some avian species such as cranes, the male perform dance in front of females (*Nemeth et al., 2012*). However, the birds have the capability to change their behavior according to new environmental conditions (Overington *et al*., 2011; Sol *et al*., 2016; Keith and Bull, 2017). For instance, the avian species inhabiting landscapes modified by humans frequently showed behavioral adaptations including changes in the timing of breeding, adjustments of various activity patterns, and utilization of novel sources of food and feeding strategies (Lowry *et al*., 2013; Martínez-Abraín and Jiménez, 2016). Birds modified their nesting site in human settlement area and prepare nest in houses on electric meter, electric poles *etc*. (Davis and Stamps, 2004; Lowry *et al*., 2013; Sol *et al*., 2016; Keith and Bull, 2017).

Habitat use, feeding techniques and time are the main important parameters for feeding activity. The quality and quantity of food material plays a major role in determining the distribution pattern of birds (Koul and Sahi, 2013). The feeding behavior involves all the strategies and techniques exhibited by the bird during searching and taking of food within the foraging ground. It is an important activity which shows the ability of animals for their existence and reproduction (*Danchin et al*., 2008). Most of the birds are known to exhibit feeding early in the morning and late in the evening (Sivakumaran and Thiyagesan, 2003). Verma (2010) reported the availability of light as an important factor in *Hirundo rustica* as it showed early roosting in cloudy weather and during the months of February-April and late roosting in clear weather and during the months of September-January. Oriental Darter (*Anhinga melanogaster*) showed more or less steady foraging rate throughout the day with a minor decrease in the noon time. The condition of weather affects the timing of the roosting behavior of birds (Narayanan and Thomas*,* 2016). Thus, light plays an important role in the biology of the avian system. In avifauna, the annual change in day length is the important environmental cue to synchronize feeding, migration and breeding activities within the regular seasonal transformation in natural state (Ramenofsky, 2012). Monthly variations in the diet of Cattle Egrets *Bubulcus ibis coromandus* in and around Chandigarh were analyzed by Sodhi (1989). There is also evidence to demonstrate that the feeding activity time of avifauna coincide with the activity timings of insects in insectivorous birds (Stelzer and Chittka, 2010). Foliage composition, food resources and accessibility of food in the wetland are the main factor that influence bird density, diversity and distribution (Wilcox *et al.,* 2002; Malik and Joshi, 2013; Devkar *et al.*, 2016). Generally, the birds are herbivores, frugivorous, grainivorous, insectivorous, carnivorous, omnivorous, predators and some birds are scavengers (Pandotra and Sahi, 2014; Anthal and Sahi, 2017). Birds are obligatory or facultative in the selection of type of food. Mallards mainly eat plant material specially halophytes but also feeds on invertebrates and insects in Turkey (Green and Selva, 2000). Birds are generalized as well as specialized feeders. Near threatened Oriental Darter (*Anhinga melanogaster*) was specific in their food preference and fed on seventeen species of fish and prawn (Narayanan and Thomas*,* 2016). Grey Herons and Little Egrets are predominately piscivorous birds but also eat crustaceans, amphibians, reptiles, other invertebrates, and small birds and mammals (Snow and Perrins 1998; *Pistorius, 2008*). Little Egret (*Egretta garzetta)* choose mainly the wetland as feeding sites and generally feed on fish and other aquatic animals (Post *et al*., 2009). Eldridge *et al.* (2009) reported that the Sandpipers foraged mostly on aquatic dipterans, larvae of family Chironomidae as primary food items. Larger sandpiper species foraged in deeper water and took larger larvae. Stafford *et al.* (2010) reported that grains not collected during harvesting are naturally the most favoured food of avifauna in rice fields. Water running in rice fields creates environment ranging from saturated mud flats to shallow water, thus attracting various avian guilds for their food demands. The bird occupy different zone of the water for feeding purposes. Great Cormorants which is a solitarily foraged feed at Vourkari inlet, Greece feed on bottom-living prey (Van and Voslamber, 1995). Great Crested Grebes feed on fish at various depths of the water column and Sandwich Terns plunge feed on small surface-dwelling fish (Brenninkmeijer *et al.,* 2002). Dave *et al.* (2015) reported that wading birds normally choose less water depth for foraging purposes. Birds are solitarily or colonial feeder depending upon the type of species and the characteristics of wetland or surrounding fields. Sridhara *et al.* (1983) reported that

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Himantopus himantopus, Little egret and Cattle egret were found in flocks of 20 to 30 in the morning and evening during feeding but remained solitary for most of the day. Ghazoul and Hellier (2000) suggested that the avian feeding guilds act as an ideal indicator for the monitoring the entire healthy functioning of the ecosystem. Red wattled Lapwing and Black-winged stilt feed solitary. The Cotton Pigmy Goose, *Nettapus coromandelianus* is the smallest of wild ducks and generally found to forage in flocks (Ali, 2002). Great egret and Great blue heron regularly feed as single individuals while White ibis and Wood stork mostly feed in flocks (Smith, 2005). *Egretta garzetta* tends to feed in dense aggregations during early morning in flocks and later in the day the birds dispersed over the feeding area and foraged alone (Yukiko, 2003). It was also seen in large flocks picking insects from the freshly ploughed fields (Patankar *et al*, 2007). Birds use number of techniques for obtaining food. The feeding techniques used by the animal depend upon the type of food they consumed. The wetland avifauna mainly used three types of foraging techniques *viz*., tactile-hunting species technique, visual-feeding technique and pause-travel species techniques (Norazlimi and Ramli (2015). *Ardea herodias* employed three feeding techniques *viz*., standing, walking slowly and feet first diving (Roshnath and Jose, 2014; Roshnath, 2015). Green (1998) reported that Mallards mainly foraged by upending and head & neck dipping in Turkey. Cormorants and Shags are well adapted to dive in shallow waters (Wilson and Wilson*,* 1992). The dives from the water surface were interspersed with resting period or surface pauses (Casaux, 2004). Maheswaran and Rahmani (2001) observed that >60cm water depth is not suitable for Black-necked Stork. Zeenath and Zacharia (2010) worked on the feeding activity as well as the diving pattern of Little Cormorant *Phalacrocorax niger* at Kallampara backwaters, Kerala, India. They observed that the dive length was linked to surface resting time. Moreover, the period of dives decreased with increase in the number of dive cycles per bout. They explored the exact relation between body weight, dive period and diving capability. Several studies have documented foraging ecology of Indian pond herons (Andrews and Mathew 1997; Seedikkoya *et al.,* 2012). Indian pond heron had topmost niche width when compared with other herons (Sodhi, 1992). The adult heron delivers same size and composition of prey to nestling that they themselves consumes (Kushlan, 1978). Hence dietary composition during breeding season can reflect the prey selection by the bird. The primary food of heronry birds includes crustaceans, aquatic insects, fishes and amphibians (Sodhi, 1986). Indian pond heron feeds on dragonflies (Santharam, 2003), bees (Prasad and Hemanth, 1992), earthworms (Raza, 1993). Indian Pond Heron is chiefly a solitary ground feeder, feeding on animal matter, mainly aquatic in nature (Ali and Ripley, 2001). Seedikkoya *et al.* (2012) reported the selection of fishes, insects, tadpole, arachnids, and crustaceans by herons from the foraging ground and also reported scavenging behavior of Pond Heron on Sardine heads. *Nettapus coromandelianus* is almost aquatic species and choose deep freshwater seashore, rivers, marshes and dams, particularly those with floating plant matters (Ghadigaonkar *et al*., 2016). It prefers the aquatic vegetation available in the water surface and also consumes the seeds and flowers of aquatic plants and sometimes feed on aquatic insects. Thus, they are omnivores.

Like fish and amphibians, birds also exhibits parental activity that includes, selection of nesting site, construction of nest, egg laying, protection, incubation & hatching the egg and feeding & protecting the young ones. Nest construction is a species specific innate activity. Various factors *viz*., breeding season, suitable nesting sites, availability of nesting materials, food availability, predators, atmospheric conditions, anthropogenic disturbance affect the nesting activity of birds (Dial 2003; Lima, 2009; Fink *et al*., 2010; Sethi *et al*., 2010; Mainwaring *et al.,* 2014*;* Ajitha and Josh*,* 2015; Jiang *et al*., 2017). A good nesting site generally provides protection against predators, offers adequate stability and materials to support and construct the nest, and is located near sufficient feeding area (Hafner, 2000). Habitat feature such as the quality of nesting tree has been recognized as one of the most essential criteria of habitat choices (Baxter and Fairweather, 1998). Knapton *et al*. (2000) reported the effect of human disturbance and introduction of exotic plants and animals on nesting success of birds. Sarkar *et al.* (2009) reported that birds prefer indigenous trees for nesting and very few nest were observed in orchard and garden having introduced tree and plantation. Several workers (Hilaluddin *et al.,* 2006; Raval, 2011; Das *et al*., 2014; Joshi, 2015) have reported the negative effect of exotic plant on nest success. Invasive plant adversely affect birds nesting success by drawing the birds into new area which are previously unsuitable for them and expose them to unfamiliar risk (Chace and Walsh, 2006; Beachy and Robinson, 2009; Rodewald *et al.,* 2010), Ninety percent of avian fauna show bi-parental nesting activity (Mandal, 2010). Generally male collect the nesting material to the nesting site and female build the nest. The bird show great variation in their nest morphometry, nest composition, nest planning, nesting site and even nesting trees (Raval, 2011). Birds occupy territory around the nesting and foraging site and defend it during breeding period. Ciaranca *et al*. (1997) reported that mute swan occupy and defend large territories (up to 6 ha) of wetland habitat during nesting, brooding, and foraging activity. Pattern of nest construction differ from species to species, way of life and surrounding area (Collias and Collias, 2014). Colonial nesting is advantageous against predation and selection of suitable partner by increasing the choice available in species (Begum, 2003). Ajitha and Jose (2015) studied the nesting behavior of the colonial breeding water birds and reported that the little cormorant (*Phalacrocorax niger*) was found as most abundant species and Pond heron (*Ardeola grayii*) were found in smallest number. Heronry is a group of nesting wetland birds belonging to the orders Ciconiformes, Pelecaniformes, and Suliformes, which includes herons, egrets, storks, pelicans, ibises, spoonbills, darter, and cormorants, that show clustering of nests (Reza *et al.,* 2010; Roshnath *et al*., 2013). Narayan *et al.* (2006) reported heronry with mixed species like the great cormorant, Darter, Open billed Stork along with Grey heron from Kerala. Pramanik *et al.* (2010) reported the breeding of Night heron (*Nycticorax nycticorax*), Gray heron (*Ardea cinera*), Cattle egret (*Bulbulcus ibis*) and little egret (*Egretta garzetta*) together every year. Anoop *et al.* (2015) reported nine avian species belonging to three families in the

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Panamaram heronry, Kerala and observed a total of 442 nests. They also reported the nesting of *Bubulcus ibis* in the heronry for the first time from the district. The colonial wetland birds generally use urban area for nesting and feeding purpose (Urfi, 2010). The attraction of heronry birds to towns and urban area for nesting are well documented in many parts of India (Sashikumar and Jayarajan, 2007; Urfi, 2010) as well as in other countries (Andrew, 2004; Barcena *et al*., 2004; Vennesland and Butler, 2004; Vergara *et al*., 2006; Angehr and Kushlan, 2007). Street trees are main nesting site for wading birds (Sashikumar and Jayarajan, 2007; Nagendra and Gopal, 2010). These birds need suitable safety measures from anthropogenic threats. Parasharya and Naik (1987) studied the breeding biology of the Indian Reef heron. Cattle Egrets showed roosting associations with Indian Pond Heron *Ardeola grayii*, House Crow *Corvus splendens* and Common Myna *Acridotheres tristis* (Gopal *et al.*, 2004). Kler *et al.* (2014) worked on the nesting behavior of *Bubulcus ibis* throughout the breeding period *i.e.,* April to July and reported the Dhek tree (*Melia azedarach*) and Pilkan tree (*Ficus lacor*) as the shelter trees for their nest construction. First egg was laid during last week of May and the peak of egg laying was obtained at the end of the May to June. The clutch size of Cattle Egret was 3-4 eggs. The breeding pairs leave the nests after finishing their reproductive period at the end of July. Jha (2012) classified the Black-crowned Night Heron, Little Egret, Cattle Egret, Darter and Grey Heron as the early arriver, Intermediate Egret, Indian Pond Heron, Great Egret, Black-headed Ibis, Purple Heron and Asian Open bill as late arrivers and Eurasian Spoonbill, Little Cormorant and Indian Cormorant as very late arrivers in the heronry. Behrouz (2013) investigated the reproductive status of water-birds on Persian Gulf, south Iran and recorded 11 breeding species of water birds in 10 islands of Persian Gulf. Huang (2015) worked on the breeding habitation of the Little Tern in relation to dam development. He suggested that species adaptive behaviors should be taken as a chief parameter for the assessment of environmental impacts caused by anthropogenic activities such as dam development. The birds that nest on the ground are more susceptible to depredation of their eggs and young ones (Salek and Smilauer, 2002). Fletcher *et al.* (2005) suggested that the anthropological threats to ground nesting birds are direct (damage to nest) or indirect (habitat destruction). Kumar (2015) studied on the local species of Lapwings from Punjab and reported Yellow-wattled Lapwing, *Vanellus malabaricus* as a rare bird in Punjab. He also made observations on the foraging, nesting and nesting behavior of Yellow-wattled Lapwing. Kumar and Sharma (2011) and Muralidhar and Brave (2013) suggested that Red-wattled Lapwing adapt the local unfavorable condition and choose a nest location to minimize human and cattle interference. Mustahson (2014) studied reproductive aspects of purple moorhen, *Porphrio porphyrio* in Hokersar wetland at Ramsar site of Jammu and Kashmir. He reported that subsequent to the pair formation nesting sites were selected in thick developing vegetation, dominated by *Typha* and *Phragmites*. Both of the sexes worked for building nest on an average in 6 days. Bhatt *et al.* (2009) reported that reduction in water retention in summer, weed infestation, variations in food availability in different seasons and threat of predation on the breeding activity of birds affected the avifauna diversity.

Farmer's knowledge towards birds: Farmers' knowledge and perceptions towards birds, particularly their role in agriculture, have garnered increasing attention in the past few decades. Birds have both beneficial and detrimental impacts on farming systems, and farmers' attitudes and management practices towards them are shaped by local contexts, cultural beliefs, and ecological conditions. Understanding these perceptions is crucial for promoting sustainable agricultural practices and biodiversity conservation. Farmers' knowledge of birds in agricultural ecosystems varies widely across different regions and farming systems. A study by Moller et al. (2004) in Europe found that farmers recognized birds as both pest controllers and crop feeders, with certain species perceived positively for their role in controlling insect pests, while others were viewed negatively for causing damage to crops. This dual perception was also reflected in Sodhi et al. (2008), who highlighted that farmers in tropical regions like India viewed birds as important for pest management but were concerned about species that consumed seeds and fruits. In Australia, a study by Koch et al. (2012) revealed that farmers acknowledged the role of birds in promoting agricultural biodiversity and soil health but were also concerned about the direct damage caused by certain bird species, such as crows and galahs. Similarly, St. Clair (2017) conducted research in New Zealand, focusing on farmers' awareness of native bird species and the effects of their presence in crop fields. Farmers with higher levels of environmental education were more likely to support bird-friendly practices, like habitat restoration. Farmers' perceptions are influenced by both ecological and economic factors. Sarkar et al. (2020) found that farmers in India, particularly in rice farming regions, recognized the importance of birds in pest control but were wary of birds' impact on rice grain harvests. Perceptions of crop damage were often linked to specific bird species, and farmers' tolerance levels for these species depended on their financial dependence on the crops affected. In Latin America, Gallardo et al. (2018) examined farmers' perceptions of birds in coffee plantations. They found that farmers perceived some bird species as beneficial for controlling pests like coffee borer beetles, while others were seen as harmful, especially fruit-eating birds that caused economic losses. The perception of birds was also shaped by local ecological knowledge, and many farmers had integrated birds into their farming practices through agroforestry systems.

Cultural and socio-economic influences on bird perceptions: Cultural beliefs significantly shape farmers' perceptions of birds. Winkel and Probstl-Haider (2021) examined how rural communities in Europe integrated bird conservation into their farming practices. They found that farmers with strong cultural ties to birds were more likely to adopt bird-friendly practices, such as maintaining hedgerows or leaving areas fallow. Conversely, in areas where farming practices were more intensive, birds were often viewed solely as pests. Moreover, socioeconomic factors play a critical role in shaping farmers' attitudes towards birds. Sukhdev et al. (2019) discussed how farmers in developing countries, particularly in sub-Saharan Africa, had limited awareness of the ecological roles of birds due to lack of access to education and environmental

awareness programs. In contrast, Kumar et al. (2020) showed that economically well-off farmers in developed regions were more likely to have positive perceptions of birds, especially when they could recognize their contributions to pest control and pollination. Socioeconomic and cultural factors greatly influence farmers' perceptions of birds. Sarkar and Sahu (2019) discussed how farmers' cultural practices and religious beliefs shaped their attitudes towards certain bird species. In regions where birds are associated with religious symbolism, such as the reverence for the peacock in Hinduism, farmers were more likely to adopt bird-friendly farming practices. In contrast, in areas with less cultural emphasis on birds, farmers were more likely to perceive them solely as pests. Kumar et al. (2017) highlighted that farmers' perceptions also varied according to their level of economic dependency on agriculture. Wealthier farmers, especially those involved in organic farming, had more positive perceptions of birds, recognizing their role in pest management and biodiversity conservation. On the other hand, poorer farmers with high dependence on crop yields often viewed birds in a more negative light, focusing primarily on the damage they caused. India has seen an increasing push towards sustainable agricultural practices, which includes integrating bird conservation efforts. Rathore et al. (2020) highlighted that in regions with formal conservation programs, such as those promoted by the Wildlife Protection Act of 1972, farmers were more likely to adopt bird-friendly practices. This included creating bird habitats within farms and reducing the use of pesticides, which could harm bird populations. Awareness programs, such as those run by organizations like the Bombay Natural History Society (BNHS) and BirdLife International, have also contributed to shifting perceptions towards more conservation-minded farming practices. In Madhya Pradesh, Sharma et al. (2021) found that farmers who received training on the ecological benefits of birds were more willing to engage in habitat restoration and adopt bird-friendly farming practices. These practices included planting hedgerows, preserving wetlands, and providing nest boxes for birds.

Chhattisgarh, located in central India, has a rich agricultural tradition, with farming being the primary livelihood for a large proportion of its population. Farmers' knowledge and perceptions of birds in this region are essential for understanding how agricultural practices and bird conservation can be integrated to promote sustainability. This review examines existing studies on farmers' knowledge, attitudes, and perceptions of birds within Chhattisgarh's agricultural context, shedding light on both positive and negative perspectives towards birds, and the role they play in pest management and ecosystem services. Farmers' awareness of the role birds play in agriculture in Chhattisgarh is shaped by their direct experience and traditional ecological knowledge. In a study by Tiwari et al. (2015), farmers in the rice-producing regions of Chhattisgarh recognized birds like the peacock, crow, and pigeon as common species on their farms. However, while they were aware of birds' role in pest control, many farmers lacked knowledge about the specific ecological services that birds provide, such as seed dispersal and pollination. This limited knowledge is linked to a lack of formal education on the importance of biodiversity in farming systems. The study also noted that farmers in the Bastar region, which is known for its rich biodiversity, had a more profound understanding of the ecological role of birds in maintaining the balance of the ecosystem, as many had observed the benefits of birds in controlling insect pests and maintaining soil health. However, these farmers also faced challenges due to the perception of certain birds as pests, particularly in relation to crop damage. Farmers' perceptions of birds in Chhattisgarh vary depending on the species and the nature of the crop. A study by Verma et al. (2018) in the rice-growing districts of Durg and Raipur found that farmers viewed some bird species, such as the Indian myna and sparrow, as pests because they often caused damage to crops, especially rice, by feeding on grains. Farmers reported that these birds were particularly problematic during the harvesting season when rice grains were most vulnerable. In contrast, Bharadwaj et al. (2020) found that farmers in the tribal-dominated districts of Surguja and Jashpur had a more favorable view of birds, such as the common kestrel and owls, which they recognized as beneficial for controlling insect pests, including locusts and caterpillars. These farmers often attributed positive ecological functions to birds, citing their ability to control pests naturally and reduce the need for chemical pesticides. However, farmers in areas with high bird populations also expressed concerns about specific species, such as the peafowl, which they perceived as damaging to crops like maize and vegetables. Rai and Singh (2019) examined the impact of birds on vegetable farming in Chhattisgarh and noted that peafowls were particularly problematic for farmers growing crops like tomatoes, cucumbers, and melons. The study found that farmers with extensive vegetable cultivation often resorted to scare tactics and bird nets to protect their crops. Cultural beliefs and socioeconomic status are influential factors in shaping farmers' perceptions of birds in Chhattisgarh. Sahu et al. (2017) observed that tribal farmers in regions like Kanker and Kondagaon, where traditional farming practices are prevalent, often held birds in high regard due to their association with local folklore and religious practices. Birds like the peacock are considered sacred in Hindu culture, and their presence is seen as a sign of good fortune. This cultural reverence has led to more bird-friendly practices, such as preserving trees and maintaining wetlands, where birds can nest and forage. On the other hand, Shukla and Yadav (2021) highlighted that in more economically developed areas of the state, farmers with larger landholdings were more likely to view birds as pests due to the higher economic stakes involved in crop production. These farmers often engaged in intensive farming practices and were more inclined to use chemical pesticides to mitigate the damage caused by birds. In a study conducted by Sharma et al. (2020), it was noted that farmers who were more economically dependent on agriculture, especially in non-tribal areas like Raigarh and Bilaspur, were less tolerant of birds. This was particularly true for species that caused direct crop damage, leading farmers to adopt measures like shooting, trapping, and using bird repellents to safeguard their harvests. Conservation efforts and the integration of bird-friendly practices into agriculture have been gaining momentum in Chhattisgarh. Soni et al. (2022) explored the role of NGOs and

government programs in promoting bird conservation among farmers in Chhattisgarh. Their study found that farmers who participated in bird conservation programs, such as those organized by the Chhattisgarh Forest Department and Wildlife Conservation Society (WCS), were more likely to adopt sustainable practices. These included maintaining bird habitats, reducing pesticide use, and providing nesting sites for birds. Such programs emphasized the importance of birds in pest control and encouraged farmers to consider birds as part of a broader agricultural ecosystem. A significant gap in farmers' knowledge about birds is the lack of formal education and awareness programs that explain the specific roles of birds in agriculture. Bera et al. (2022) identified that while farmers recognized the general benefits of birds, such as pest control, there was limited awareness of the ecological services provided by various bird species, such as seed dispersal and pollination. Education initiatives targeting farmers in rural areas, especially those in less-developed agricultural zones, could help bridge this knowledge gap.

Conservation and sustainable agricultural practices: Farmers' perceptions of birds also have important implications for conservation efforts. Garnett et al. (2015) suggested that creating incentives for farmers to engage in bird conservation could be an effective strategy for biodiversity preservation. They found that farmers who perceived birds as beneficial were more likely to engage in conservation programs such as providing nesting sites or planting bird-friendly crops. In Africa, Probstl-Haider (2021) explored how farmers' involvement in conservation programs affected their attitudes toward birds. The study found that when farmers were trained on the ecological benefits of birds, such as controlling pests and aiding in pollination, they were more likely to implement bird-friendly farming techniques, leading to a better understanding of birds' roles in agriculture.

Knowledge of birds and their ecological roles: Farmers' awareness of the role birds play in agricultural ecosystems varies across regions and farming systems in India. A study by Jha et al. (2015) in the rice-growing areas of Bihar and Uttar Pradesh found that farmers were generally aware of the role of birds in controlling pests but had limited knowledge of the specific bird species involved. They recognized certain species, such as kites and crows, as natural pest controllers but were unaware of the broader ecological benefits birds provide, including pollination and seed dispersal. In contrast, Chakraborty et al. (2017) in the eastern states of West Bengal and Odisha found that farmers in agroforestry systems demonstrated greater knowledge of bird species, as they had direct interactions with various birds and incorporated bird-friendly practices, such as planting trees and maintaining wetland habitats. This knowledge was often passed down through generations and linked to traditional ecological knowledge. Farmers' perceptions of birds in India are influenced by their economic needs and the direct impact of birds on crops. Kumar et al. (2018) conducted a study in Punjab, a state with intensive agriculture, and found that farmers viewed birds predominantly as pests, particularly species like the Indian myna and sparrows that fed on crops such as wheat, rice, and maize. This perception was further reinforced by the economic losses' farmers experienced due to seed and grain consumption by these birds. However, Singh & Sharma (2016) in Rajasthan observed a more positive outlook towards birds among farmers in rain-fed agricultural areas, where species like partridges, quails, and doves were seen as beneficial in controlling insect pests and maintaining soil health. These farmers appreciated birds' roles in maintaining the ecological balance, but concerns over crop damage were still prevalent. A more comprehensive view of farmers' attitudes was provided by Rathore et al. (2020), who studied the impact of bird species on various crops in Madhya Pradesh. Farmers in this region recognized that some bird species, such as peafowls, were beneficial for controlling insect pests. However, they also had concerns about birds like parrots and crows, which were seen as destructive to fruit-bearing trees and crops like guava and paddy.

Threats to farmland birds: Despite the importance of farmland birds in agro-ecosystems, they face several threats that affect their distribution and survival in Chhattisgarh. These threats include habitat loss, pesticide use, and disturbance from human activities. Expansion of agricultural land and the conversion of open fields and wetlands into urban or industrial areas have led to habitat loss for many farmland birds. Fragmentation of habitats, particularly near urban centers, reduces available nesting sites and food resources (Soni et al., 2017). The widespread use of chemical pesticides in agricultural practices can negatively impact farmland bird populations. Pesticides can reduce the availability of food sources for birds, such as insects, and can lead to direct poisoning (Bandyopadhyay et al., 2016). Increased human activity, such as farming practices, land clearing, and the development of infrastructure, can disturb nesting sites and reduce the quality of habitats for farmland birds (Patil et al., 2018). Furthermore, hunting and trapping are also concerns in certain regions of Chhattisgarh. Several conservation initiatives have been undertaken to protect farmland birds in Chhattisgarh. These measures include promoting sustainable farming practices, such as integrated pest management, to reduce pesticide use, and establishing community-based conservation programs. Additionally, the creation of bird sanctuaries and protected areas within agricultural landscapes has helped provide refuges for birds, ensuring that they can continue to thrive in farmlands while coexisting with farming practices (Soni et al., 2017).

Conclusion

India's vast ecological diversity, spanning from the Himalayas to coastal plains and arid deserts to tropical forests, supports a remarkably rich avifauna. This review highlights that the structure and composition of Indian avian communities are shaped by a complex interplay of ecological, environmental, and anthropogenic factors. Habitat heterogeneity, vegetation structure, elevation, and climatic gradients emerge as key natural drivers influencing species richness and distribution, while land-use change, urbanization, and habitat fragmentation increasingly modify these patterns. Despite significant progress in understanding avian community dynamics, research remains unevenly distributed

across India's biogeographic zones, with many ecosystems such as grasslands, wetlands, and arid regions still underrepresented. The lack of long-term datasets and standardized methodologies further limits the ability to detect temporal trends and predict responses to climate change and landscape alteration. Future research should prioritize integrative, multi-scale approaches that combine field-based surveys, remote sensing, and ecological modeling. The inclusion of citizen-science platforms like eBird can enhance spatial and temporal coverage, while collaboration among institutions can strengthen data sharing and policy relevance. Understanding the ecological and environmental drivers of avian community structure is not only crucial for conserving India's bird diversity but also for maintaining ecosystem functions such as pollination, pest control, and seed dispersal. A more holistic and data-driven understanding will aid in developing effective conservation strategies, ensuring that India's avian heritage continues to thrive amid rapid environmental change.

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