SPECIES DIVERSITY AND ENVIRONMENTAL CORRELATES OF FARMLAND DEPENDENT BIRDS IN NAWALPUR, NEPAL

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Submitted to

Central Department of Zoology

Institute of Science and Technology

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Kirtipur, Nepal

April 2021

DECLARATION

I hereby declare that the work presented in this thesis entitled **"Species diversity and environmental correlates of farmland dependent birds in Nawalpur, Nepal"** has been done by myself, and has not been submitted elsewhere for the award of any other degree. All the sources of the information have been specifically acknowledged by references to the author(s) or institution(s).

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On the recommendation of the supervisor Assistant Professor Dr. Bishnu Prasad Bhattarai, this thesis submitted by Pabitra Regmi entitled **"Species diversity and environmental correlates of farmland dependent birds in Nawalpur, Nepal"** is approved for the examination in partial fulfillment of the requirement for the Master's Degree of Science in Zoology with special paper "Ecology and Environment".

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CERTIFICATE OF ACCEPTANCE

This thesis submitted by Pabitra Regmi entitled **"Species diversity and environmental correlates of farmland dependent birds in Nawalpur, Nepal"** has been approved as a partial fulfillment of the requirements of Master's Degree of Science in Zoology with special paper "Ecology and Environment".

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ACRONYMS AND ABBREVIATIONS

BCN	Bird Conservation Nepal
CBS	Central Bureau of Statistics
CCA	Canonical Correspondence Analysis
CITIES	Convention on International Trade in Endangered Species of Wild Fauna
CR	Critically Endangered
DHM	Department of Hydrology and Meteorology
DNPWC	Department of National Parks and Wildlife Conservation
EN	Endangered
GLM	Generalized Linear Model
GPS	Global Positioning System
IBA	Important Biodiversity and Bird Area
IUCN	International Union for Conservation of Nature and Natural Resources
LC	Least Concern
NRBD	National Redlist Bird Databook
NT	Near Threatened
VU	Vulnerable

ABSTRACT

The increase in change in farming practices, result in habitat destruction or alteration, the greatest threats to biodiversity. Birds found around or in the farm utilizing different crops for foraging and some nesting in the hedges near the farm area are known as farmland dependent birds. Bird richness in agricultural lands are considered to be a good indicator for good state of wildlife and healthy condition of plants and invertebrate on which they feed. This study aims to explore the species diversity and environmental factors affecting the diversity of farmland dependent birds. Data was collected from the centroid point of the randomly selected 72 grids of size 500m by 500m. The birds were recorded at the circle of 50m radius for 20 minutes by using visual encounter method. The environmental variables (distance to nearest forest, distance to nearest water body, distance to nearest tree, distance to nearest village distance and number of people presence) were also collected within the circle. The data was analyzed using standard statistical tools. Generalized linear model (GLM) was performed to examine the relation of birds with different environmental variables. A total of 123 bird species were recorded in the farmland of Nawalpur during this study, where eighty three species in summer season, seventy seven species in rainy season and sixty nine species in winter seasons were recorded. The species diversity was higher during summer than rainy and winter. The significant impact in species richness of birds with distance to nearest forest, distance to nearest water body, precipitation (mean) and temperature (mean) was found. Distance to nearest forest, distance to nearest water body, precipitation (mean) have negative correlation with species richness in all three season but temperature has positive association with species richness in all three season whereas distance to highway has positive correlation with species richness in winter seasons. Distance to village was not important compared to other factors for bird diversity. Thus farmland of Nawalpur supports higher species richness of farmland dependent birds.

1. INTRODUCTION

1.1 Background

Nepal represents about 9% of the world's known bird species (Grimmett *et al.*, 2016a). This high avian diversity is enhanced by the location of Nepal at the border of Palearctic and Oriental realm supporting tropical to alpine bio-climatic regions. At present 886 species of birds have been recorded in Nepal which is 9% of total birds species found worldwide (DNPWC, 2019; BCN, 2020). Among them 42 species of birds are globally threatened, 35 species are globally near threatened and 167 species are nationally threatened (Inskipp *et al.*, 2017).

Birds have been integral to human since prehistory. Birds and their diversity acts as a strong bio-indicator signal (Joshi and Bhatt, 2015) and represent the health of ecosystem and status of biodiversity as a whole (Gregory and van Strien, 2010). Birds occupy many levels of tropic webs from mid-level consumers to top predators. Diversity as a whole includes species richness, abundance, and evenness of a particular area. Understanding patterns of diversity in an area is important in conservation of species (Goddard *et al.*, 2010).

Farmland is now considered the world's widespread habitat (Bird International, 2008). The expansion of agriculture, results in habitat destruction, the greatest threats to the world's biodiversity (Bird International, 2008). Rise of farming practices, such as destruction of grasslands loss of crop diversity and excessive use of pesticides and chemical fertilizers, has led to the degradation of agricultural and semi-natural habitats. Agricultural intensification and expansion is regarded as the main threat to globally threated species, affecting 87% of these entire worldwide species (van der Weijden *et al.*, 2010).

Agri-ecosystem is consider as the important habitat for bird that provide foraging and breeding grounds (Flohre *et al.*, 2011). Birds are known as the key species in an agricultural ecosystem to maintain the ecological balance (Manning *et al.*, 2006). Farmland dependent birds are found in the farm for foraging and make nest in the hedges found near the farm area (Benton *et al.*, 2003). Farmland dependent bird populations decline have been principally attributed to the intensification of agriculture. Agricultural practices for "bird-friendly" include using more diverse crop rotation, stopping use of pesticides, and creating more heterogeneous landscape and are expected to create more food resources and nesting habitats for birds (Wilcox *et al.*, 2014). Farmlands plains are most important for farmlands dependent bird (Wretenberg *et al.*, 2010).

Bird richness in agricultural lands are considered to be a good indicator of the good state of wildlife and the countryside because they occupy a large range of habitats. A healthy condition of plants is signified by healthy bird population as well as healthy invertebrates on which they feed (Gregory and van Strien, 2010). As the farmland dependent birds are closely associated with human and human settlements but the farmers and local aren't aware about its importance (Tscharntke *et al.*, 2005). The birds are ecologically as well as economically important as they help in pollination, control of harmful pests, dispersal and make the matrix within which other wildlife habitats coexist (Whelan *et al.*, 2008). The main problems for farmland dependent birds are agricultural changes like growing cash crops for income with same expense of paddy which has been grown traditionally in Nepal. Over-use of chemical fertilizers for good production of crops, and the raise of agriculture by reducing uncultivated field changes and corners, which made valuable habitat for birds and other wildlife (Inskipp and Baral, 2010).

Farmland dependent bird species are highly susceptible to changes in farming practices that impact the farmland habitats (Ó hUallacháin *et al.*, 2015). Habitat loss, degradation and fragmentation are the most important threats followed chemical poisoning, over-exploitation, climate change, invasion of invasive or alien species, intensification of agriculture, disturbance and limited conservation measures and research are also responsible for decrease or extinction of the species (Inskipp *et al.*, 2017). To facilitate bird conservation and management Birdlife international has identified 27 Important Bird Areas (IBA) and 5 potential IBAs for Nepal (BCN, 2021).

1.2. Rationale of the study

The unique biodiversity found in the farmlands is nowhere present in the protected area system of Nepal (Grimmett *et al.,* 2016b). Over the years, the farmer's tolerance to existence of wildlife has been changed mainly due to market driven economy. In Nepal, considerable amount of work has been done on threatened birds, especially global threatened species in last 20 years (Thakuri, 2007). Differently, very little monitoring of common bird species or of those habitually frequenting agricultural lands has been done. The study of farmland birds has positive impact as well as the negative impact on the crop as well as has benefits and disadvantage for farmers. As the birds feed on the crop pests and increase the crop production whereas some birds feed on the crop or damage the crop that produce negative impression on the farmers towards the birds and their conservation. Realizing these facts and importance of study of avifauna on farmland this project is designed which will provide the baseline information about the status, diversity and seasonal variation of farmland dependent birds and their conservation status.

1.3. Objectives of the study

1.3.1. General objective

The general objective of this study was to determine species diversity, the environmental factors affecting diversity of farmland dependent birds in selected lowland areas of Nawalpur district, Nepal.

1.3.2. Specific objectives

The specific objectives were to:

1. Determine the diversity of farmlands dependent birds in Nawalpur

2. Understand the environmental factors affecting diversity of farmland dependent birds in the study area.

2. LITERATURE REVIEW

2.1. Bird richness and diversity

Bird species diversity and distribution along the landscape is not same (Hill *et al.*, 1992). Their pattern are related to different environmental variables (climatic condition, topography and habitats) and human disturbance or interventions for determining the bird diversity and abundance (Rodríguez-Estrella, 2007; Jankowski *et al.*, 2009).

Species richness of any area is related to its habitat, topography, latitude, climate, resources availability (da Silva *et al.*, 2014). Hawkins *et al.* (2007) studied that climate was responsible for species richness pattern. Mittelbach *et al.* (2001) lighten that factors like productivity, species area effect (Rahbek, 1997), vegetation type (MacArthur *et al.*, 1966), and temperature (McCain, 2009) as responsible for the pattern of diversity and richness. Bird distribution and abundance within a landscape are influenced by multiple factors that interact in space and time (Orians and Wittenberger, 1991).

The study avifaunal diversity of Khata corridor forest found 141 species belonging to 12 orders and 43 families (Chaudhari *et al.*, 2009). Adhikari *et al.* (2018) recorded 304 bird species belonging to 18 orders and 69 families including 59% residential, 8% summer visitors, 32% winter visitors and 1% vagrant in the Barandabhar Corridor Forest. Harisha and Hosetti (2009) studied the diversity of the birds in Lakkavali Range Forest, Bhadra Wildlife Sanctuary, Western Ghat, India and recorded a total of 132 species of birds of 34 families under 11 orders.

About 21% of bird species found in Nepal utilizes agricultural habitats for foraging at some season, also that the different method adapted for agricultural practices are having major and far-reaching impacts on natural habitats – wetlands, grasslands and forest along with the increase of pesticides use in Nepal mostly on vegetation cash crops, have serious impacts on birds and environments (Inskipp and Baral, 2010). Reino *et al.* (2009) during their found that forest plantation may increase overall bird diversity and abundance in adjacent farmland, at the expense of steppe birds of conservation concern. Increasing hedge length enhanced significantly the number of species, hedge length has a stronger effect on bird richness than management (Batáry *et al.*, 2010). The increase in the length of hedges enhanced the birds in conventional fields too. As hedges around the farm increase the bird species though there is crop rotation (Benton *et al.*, 2003).

Hedges provide important nesting, feeding and sheltering sites for birds in agricultural areas so that hedges are important in conserving avifaunal diversity as well as hedge length had strongest positive effect on bird diversity so, more hedgerows and carefully managing them, can contribute to the conservation of farmland birds (Batáry *et al.*, 2010). Sajjad *et al.* (2016) careful crop ecosystem analysis, can significantly improve species richness and functional diversity in agro-ecosystem by adopting four Better Management Practices (BMPs) i.e. i) use of farm yard manure and avoiding chemical fertilizers, ii) based on application of botanical insecticides and avoidance of chemical insecticides, iii) doing mulching of trash after harvest rather than burning it and iv) using base application of irrigation. Not only the hedge length crop ecosystem and rotation, environmental factors also play the significant role in species diversity. Climate affects diversity directly and indirectly, as it put restriction on the physiological tolerance of species and act as the species filter (Currie, 1991; Brown, 2001). Whereas the climatic factors (such as temperature and precipitation) indirectly affects species distribution (Currie, 1991; Hawkins *et al.*, 2003). Therefore, many study supported that climatic factors are considered as an important factor for the large patterns of biodiversity and their role in shaping the species richness (McCain, 2007; Rowe, 2009; Chen *et al.*, 2017) which reflect the complexity of energy and productivity, enhanced the vegetation index, could also be factors of bird diversity patterns (Hawkins *et al.*, 2005; Hawkins *et al.*, 2007; Pokharel, 2015).

2.2. Environmental factors affecting bird diversity

Several studied have analyzed species richness and environmental variation. Seasonal change highly influence the bird species richness. More number of species were recorded in winter season in Betana wetland of Belbari, Morang (Pokharel, 2015). Ríos-Muñoz and Navarro-Sigüenza (2012) found that the biogeographic patterns of avifauna associated with seasonally dry tropical forests in Mesoamerica are poorly understood despite their high levels of species richness and endemism. Parajuli (2018) found highest bird diversity during winter season than in summer season in the Karra River of the Hetauda, Makwanpur, Nepal. Highest bird diversity was found during spring and lowest in autumn season in coastal woodland of the reserve 'EI Destino', Buenos Aires Province, Argentina (Cueto and Lopez de Casenave, 2000). Avian population had the significant relation with variation of season. Thakuri (2007) discussed the highest species richness in summer followed by autumn and spring. The farmsteads are known to be of importances during winter, as species richness were observed in active farmsteads significantly more in winter season than other seasons (Šálek *et al.*, 2018).

Seasonal variation of food and rainfall brings changes in species occurrence and abundance of birds (Tonkin *et al.*, 2017). Change in weather patterns have direct impact upon several activities of birds and species richness of birds (Jenouvrier, 2013). The species richness showed pronounced seasonal changes with higher species richness number after monsoon (Katuwal *et al.*, 2016). Hence species richness of birds are influenced by the seasonal variation.

The study in Neo-tropical region showed the characteristics and complexity of vegetation is strong determining factors for bird species distribution pattern in ecotone (Antonelli and Sanmartín, 2011). Phytogeographic heterogeneity and presence of aquatic habitats in the Catimbau National Park of Brazil appear as the main ecological factors determining the species richness reported by (Sousa *et al.*, 2013) along with 179 bird species. During the study on seasonal diversity, status and habitat utilization of birds in Nawalparasi forest in Nepal species richness of birds was higher in agricultural farmland with wetland and lower in forest habitat (Khanal, 2008). Habitat structure, floristic composition such as canopy cover, tree species diversity and distribution of specific plant taxa have significant role in defining the occurrence of the species (Joshi *et al.*, 2012).

The human influenced activities like farming, cutting of forests, and urbanization, fragments the natural plant communities into smaller units affect not only the plant communities, but the animal communities also (Adams, 1994). Habitat loss and degradation can have direct and indirect adverse impact on birds. Anthropogenic activities like timber extraction, livestock grazing, hunting and trade of wild birds, infrastructure development, agricultural expansion or encroachment and introduction of invasive species have direct adverse impact (Johnson *et al.*, 2011). Use of excessive chemical compounds like pesticides and fertilizers, loss of crop diversity, intensification of farming practices, destruction of grassland and semi-natural habitat cause the decline of biodiversity including avian fauna (Emmerson *et al.*, 2016). The diversity and abundance of the threatened bird were found to be higher in wetlands, open wooded lands and grassland in Chitwan National Park whereas distance to road and village and livestock presence caused significantly negative impact (Adhikari *et al.*, 2019). In contrast to this, Møller and Díaz (2018) three small inlands in European cities and concluded that proximity to human habitation was a main factor of the birds distribution, with most individuals and species tightly linked to inhabited houses. Šálek *et al.* (2018) study found that active farmsteads are hotspots in agriculture landscape for local bird diversity and host species consrvation concern. Also, the farmsteads are known to be of importances during winter as species richness were observed in active farmsteads significantly more than other seasons. This study also provide recent conservation measures for farmland birds i.e. focusing on conservation within non-farmed habitats, such as actively used farmsteads

By understanding the factors that influence the distribution of organisms, it becomes possible to use conservation tools necessary for the survival of endangered species of the geographical areas (Guisan and Zimmermann, 2000). Availability of food, detectability and capture, location of nesting sites, availability of nesting materials, presence of predators and competitors are the major threats factors known to influence the population of birds (Khanal, 2008).

Most of the research of the birds are concentrated on the protected areas, forests ad landscape level. Farmland ecosystem isn't prioritized subject for the researchers and conservationist. Hence to fulfill this research gaps this study was designed to evaluate the importance of farmland dependent birds.

3. MATERIALS AND METHODS

3.1. Study area

This study was focused on the farmland of Nawalpur lowlands below 500 m asl. Nawalpur is an eastern part of Nawalparasi district which is located in Gandaki Province of Nepal. The study area encompasses the lowlands of Nawalpur district from Bhedabari in the east to Arunkhola in the west (DCCO, 2015). A large area of farmlands in Nawalpur district is excluded from the Nawalparasi forests (an Important Bird and Biodiversity Area-IBA-NP17) (Baral and Inskipp, 2005). However, this area is equally important for bird diversity as the Nawalparasi forests. The total area of Nawalpur District is 1,043.1 square kilometers and total population in 2011 was 310864 (CBS, 2012).

The forests of Nawalpur lowland located adjoining to the Chitwan National Park that supports high diversities of flora and fauna. The dominant forest in Nawalpur lowland are Sal (*Shorea robusta*) forest, Simal (*Bombax ceiba*) forest, riverine forest as well as tall and short grasslands (CNP 2019). Agriculture is the mainstay occupation of the people of Nawalpur where crop cultivation is done in two seasons. Main crop cultivated in Nawalpur agricultural land are paddy, maize, mustard, wheat, sugarcane, banana etc. Though both the cash crops and food crops are main crop cultivated in Nawalpur, during my field visit in my study area the most of the cultivated crops were food crops like paddy, wheat, maize and mustard.

Minimum and maximum annual temperature of Nawalpur district in 2020 was 18.4^{o}c and 28.553^{o}c. The temperature was maximum in the month of April and minimum in January. The average annual rainfall was 211.75mm and average annual percentage of humidity was 73.833 in 2020 (DHM, 2020).

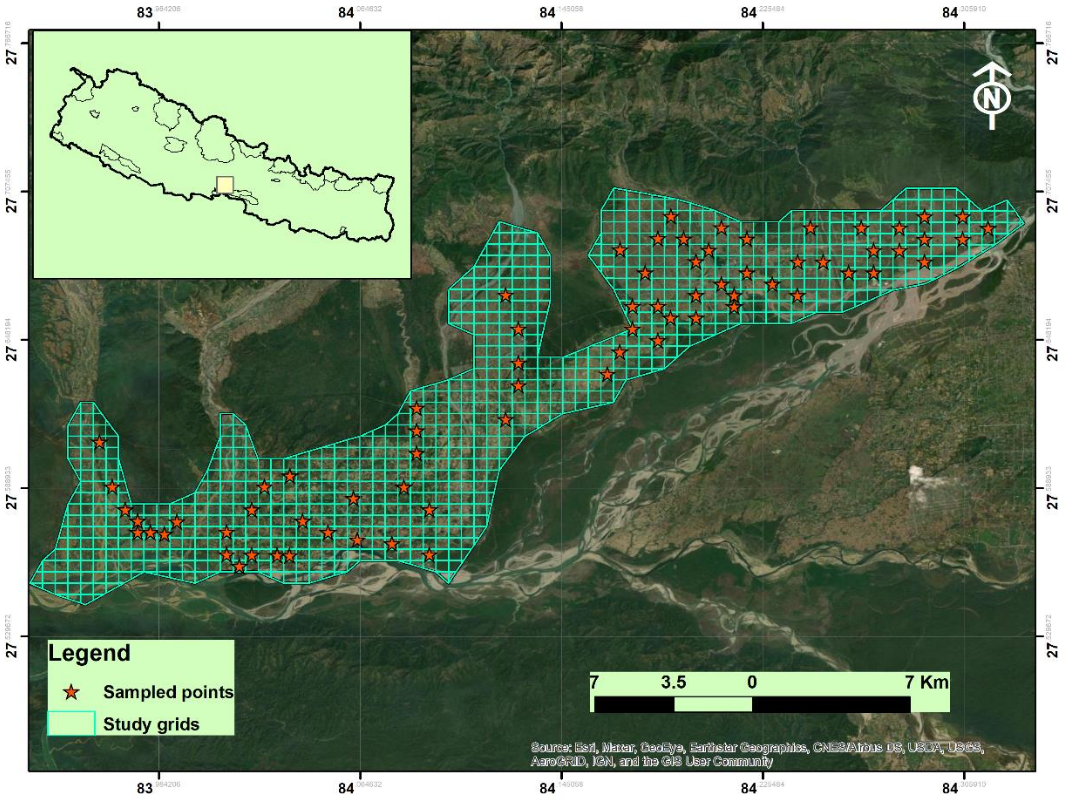

Figure 1. Map of the study area with grids and sampled points

3.2. Data collection

3.2.1. Preliminary survey

It was carried out before conducting the actual research by field visit for identifying the relevant farmlands and questioning the local people about the farmland dependent birds and crops that are cultivated in different seasons or mostly in their farmlands.

3.3.2. Bird survey

The study was conducted by dividing the entire study area into the grid of 500m × 500m. The grid was designed through fishnet tool using ArcGIS 10.7. A total of 72 grids were randomly selected for the study. The centroid points of the sample grids were taken from Google Earth and then taken uploaded into GPS (Garmin eTrex 10) for navigation. The points were also conformed during field by GPS. Point count method is used to estimate population densities, defining population trends, assessing habitat preference, mostly in avian fauna (Ralph *et al.*, 1995). Point count method was used for the survey of the birds recording all the individual birds in the farmlands (Gregory *et al.*, 2004) within the plot. In each point, species and number of individuals of birds including habitat and disturbance characteristics was recorded within 50m radius for 20 minutes by visual encounter method.

The birds were observed directly using binoculars (Bushnell 20×50) and photographs (Nikon Coolpix P900) was taken whenever possible. The birds were observed in the plot during the active time period of 7 am to 10 am in the morning and 3 pm to 6 pm in the evening during rainy and summer season while from 10 am to 4 pm in noon during winter season. Data was collected in July, 2019 (rainy season), in January, 2020 (winter season) and in May, 2020 (summer season). The field guide book- Birds of Nepal (Grimmett *et al.*, 2016a) was used to identify the birds.

3.3. Environmental Variables

3.3.1. Habitats variables

As a substitution of resources availability for species diversity and richness, presence of tree were recorded by direct observation and distance to nearest tree was noted by using range finder (Ailemon laser Hunting Range Finder 1200 yards 6x magnification) and distance to nearest forest and water body were measured using point data with the aid of Google Earth.

3.3.1. Disturbance variable

Distance to highway and presence of people on the grid was taken as the factor of human disturbance in the study area. Presence of people on the study grid were recorded by direct observation whereas highway were estimated in the field and confirmed by Google Earth.

3.3.3. Feeding guild classification

Feeding guild of recorded species were classified reviewing field guild book 'Birds of Nepal' (Grimmett *et al.*, 2016a) and categorized into five types on the basis of food insectivores (feeding on insects, larva, worms, spiders, crustaceans, mollusks etc.), omnivores (feeding on both plants and animals), carnivore (feeding on fishes, amphibians, reptiles, birds and mammals), granivorous (feeding on seeds, grains) and herbivore (feeding on plant leaves, grains, twig, fruits, berries, nectars, figs and drupes).

3.4. Data analysis

All the collected data from the field survey were entered in excel data sheet and then analyzed by using standard statistical tools.

3.4.1. Diversity index

For quantification of diversity and comparison of species diversities between different ecosystems in various ecological conditions, it is useful. Shannon-Wiener diversity index was used calculate the diversity of species (Shannon, 1948).

In Shannon's index, ratio of each component is multiplied by the loge of the ratio (ni/N) and summed it.

Mathematically,

$H' = -\sum Pi (\ln Pi)$

Where, $\sum$ represent sum of Pi (ln Pi)

H' = Shannon's index of diversity

Pi = the proportion of individuals in the i^{th} species, Pi= ni/N

ni = number of species in a community

N= total value for all species in a community.

Higher value of H' shows the higher diversity and the lower value shows the lower diversity. The maximum value of H' can be more than one.

3.4.2. Evenness index

Evenness is a measure of the relative abundance of different species making up the richness of an area. Evenness expresses how evenly the individuals in a community are distributed among the different species and is the important of the component of diversity indices. Evenness index was calculated to know whether the species are evenly distributed among the study area in different seasons. It is calculated as,

$E = H'/H'_{max}$

Where,

H'= Shannon's index of diversity

H'_{max} = maximum possible value of H', if every species is equally likely and equal to ln(S)

S = Species Richness is the total number of species.

If we have value near the 0, then the diversity is said to be uneven distribution and when the value is nearer to 1, the diversity is said to be even distribution.

3.3.3. Simpson's Index (D)

Measures the probability that bird species were randomly selected from a sample was belong to the same species (or some category other than species) (Simpson, 1949).

Index of dominance (D) = $\sum (ni/n)^2$

Where, ni= number or biomass or energy flow for each species

N= total value for all species.

The value of D lies between "0 to 1". If the value is nearer to 0, then there is less dominance but, if the value is closer to 1, then there is greater dominance. With this index, 0 represents infinite diversity and 1, no diversity. That is, the bigger the value of D, the lower the diversity. All the diversity indices calculated using "PAST".

Local status of bird was identified according to the category described by Bull (Bull, 1974). Status was classified as: very abundant (above 250 individuals), abundant (201-250), very common (101-200), common (51-100), fairly common (16-50) and rare (below 15 individuals). Results was be presented with the help of tables, charts and graphs.

3.3.4. Climatic data

Due to unavailability of the climatic data form on-field data loggers, all the climatic data were extracted from WorldClim (https://www.worldclim.org/) (Fick and Hijmans, 2017) database for the coordinates of the points to roughly describe climate condition (mean monthly precipitation and mean monthly temperature).

3.3.5. Environmental correlates of bird diversity

3.3.5.1. Generalized linear model

Generalized linear model was used to identify the relation between the bird species richness and diversity changes with different environmental and disturbance variables. GLM was done using R software (Team, 2020).

Table 1. Environmental variables and their codes used

S.N.	Environmental variables	Codes used
1.	Distance to nearest forest	NFD
2.	Distance to nearest tree	NTD
3.	Distance to nearest water body	NWD
4	Distance to nearest village	NVD
5.	Distance to highway	DH

4. RESULTS

4.1. Species diversity

4.1.1. Status of birds in farmland

The study recorded 123 species belonging 41 families and 14 orders and were recorded from 72 grids during our field visit on three different seasons. Highest number of species belongs to order Passeriformes (69 species and 25 families) followed by Pelecaniformes (9 species and 2 families), Accipitriformes (8 species and 1 family), Coraciiformes (7 species and 3 family) and Cuculiformes (5 species and 1 family) and least number of species belongs to Bucerotiformes and Galliformes (1 species and 1 family) (Table 2). A total of 8 species recorded were globally threatened (two Critically Endangered, three Vulnerable and three Near Threatened).

Table 2. Orders of birds recorded along with number of family and species recorded in Farmland

S.N	Orders	Number of family	Number of species
1	Passeriformes	25	69
2	Pelecaniformes	2	9
3	Acciptriformes	1	8
4	Coraciiformes	3	7
5	Psittaciformes	1	6
6	Cuculiformes	1	5
7	Camprimulgiformes	1	3
8	Ciconiiformes	1	3
9	Columbiformes	1	3
10	Gruiformes	1	3
11	Piciformes	1	3
12	Suliformes	1	2
13	Bucerotiformes	1	1
14	Galliformes	1	1

4.1.2. Seasonal status of birds in farmlands

A total of 77 species belonging 33 families and 12 orders were recorded in rainy season whereas 83 species belonging to 36 families and 13 orders were found in summer season and 69 species of 28 families and 10 orders were recorded in winter season. In all three season the highest number of species was recorded on order Passeriformes and least on order Bucerotiformes in rainy and summer but on order Cuculiformes in winter (Figure 2).

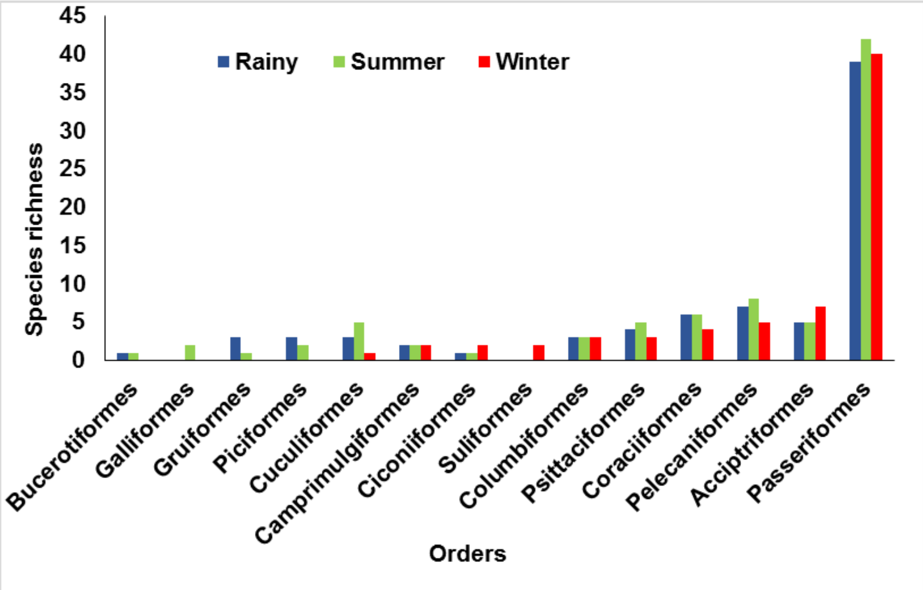

Figure 2. Seasonal species richness of the birds

4.1.3. Bird diversity

This study reported that the Shannon-Weiner index of diversity (H) was 4.47. The diversity of the bird was higher in the farmlands of Nawalpur. The evenness index was very lower (e=0.717), this value indicated that the birds diversity was said to be even distribution. Simpson's Index of dominance (D) of birds of farmland of Nawalpur was 0.01466. Hence, no one species control the study area. This result indicates the greater diversity of the bird in Farmlands (Table 3).

4.1.4. Seasonal bird diversity

The study found the Shannon-Weiner index of diversity (H) of the farmland birds was greater in summer saeson i.e.(H= 4.253) than in rainy (H= 4.113) and winter season (H=

4.129) while evenness was greater in winter season than rainy season and summer season. The dominance of the Farmlands birds was found to be greater in rainy season than other two seasons (Table 3).

Table 3. Diversity indices of birds in different Season

	Rainy	Summer	Winter	All
Taxa_S	77	83	69	123
Individuals	2714	3184	2615	8513
Dominance_D	0.01962	0.01608	0.01769	0.01466
Simpson_1-D	0.9804	0.9839	0.9823	0.9853
Shannon_H	4.113	4.253	4.129	4.479
Evenness_e^H/S	0.7936	0.8476	0.9	0.717

4.1.5 Feeding guild

High number of insectivores species were recorded during the study along with omnivore, carnivore and least recorded were herbivore and granivore (Figure 3).

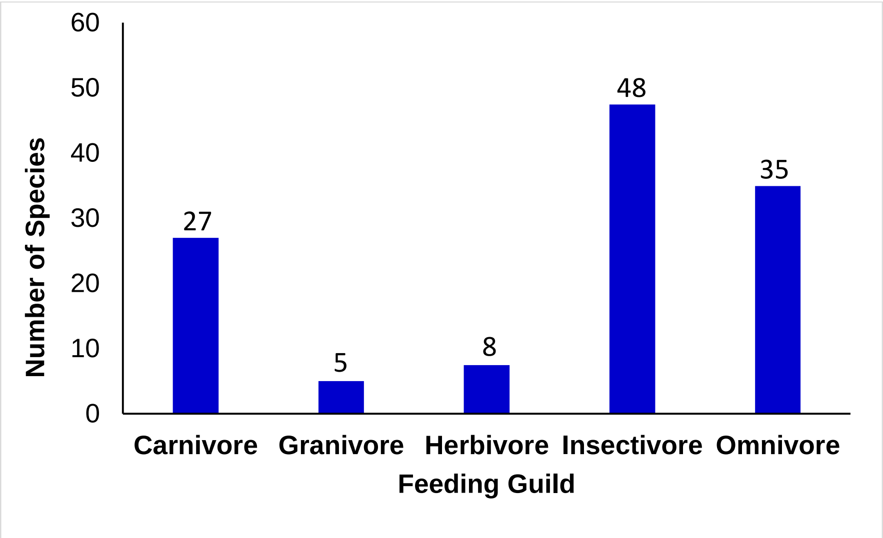

Figure 3. Species richness in different feeding guild

4.2. Environmental factors affecting the bird diversity.

Different environmental factors (habitat and disturbance) and parameters was taken for determining their effects on the farmland dependent bird diversity by using GLM.

4.2.1. Habitat and disturbance variable

There was positive and negative impact in species richness of birds with distance to nearest forest distance, distance to nearest water body, distance to nearest tree, number of people presence distance to highway and distance to nearest village. In rainy season, it was found that there was significantly negative association of species richness of birds with distance to nearest forest distance and distance to nearest water body (Table 4).

Table 4. Generalized linear model (GLM) with Poisson distribution and identity link function test showing the effects of environmental factors of different seasons on bird species richness in farmland of Nawalpur in rainy season

Rainy	**Intercept**	**z value**	**Pr(>|z|)**
Distance to highway (DH)	6.08E-06	0.504	0.614
Distance to nearest forest (NFD)	-0.00145	-1.768	0.057 *
Distance to nearest tree (NTD)	-0.02903	-1.642	0.101
Number of people	-0.4253	-1.023	0.306
Distance to nearest village (NVD)	0.007941	0.893	0.372
Distance to nearest water body (NWD)	-0.00191	-2.069	0.0385 *
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1			

In summer season, it was found that there was significantly negative correlation of species richness of birds with distance to nearest forest distance and distance to nearest water body (Table 5).

Table 5. Generalized linear model (GLM) with Poisson distribution and identity link function test showing the effects of environmental factors of different seasons on bird species richness in farmland of Nawalpur in summer season

Summer	**Intercept**	**z value**	**Pr(>|z|)**
Distance to highway (DH)	-3.20E-06	-0.272	0.786
Distance to nearest forest (NFD)	-0.00151	-1.798	0.0522 *
Distance to nearest tree (NTD)	-0.029	-1.596	0.11
Number of people	-0.5021	-1.181	0.237
Distance to nearest village (NVD)	0.009965	1.089	0.276
Distance to nearest water body (NWD)	-0.00162	-1.694	0.0502 *
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1			

In winter season, it was found that there was significantly negative correlation of species richness of birds with distance to nearest forest distance and distance to nearest water body and significantly positive association with distance to highway (Table 6).

Table 6. Generalized linear model (GLM) with Poisson distribution and identity link function test showing the effects of environmental factors of different seasons on bird species richness in farmland of Nawalpur in winter season

Winter	**Intercept**	**z value**	**Pr(>|z|)**
Distance to highway (DH)	5.082	1.818	0.0014**
Distance to nearest forest (NFD)	-0.00139	-1.758	0.0587*
Distance to nearest tree (NTD)	-0.02397	-1.4	0.161
Number of people	-0.4196	-1.049	0.294
Distance to nearest village (NVD)	0.005687	0.666	0.505
Distance to nearest water body (NWD)	-0.00162	-1.818	0.0591 *
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1			

4.2.2. Environmental parameters

Temperature and precipitation has significant impacts on the species richness. Temperature shows significantly positive association on the species richness whereas precipitation shows significantly negative correlated with species riches in all three seasons (Table 7).

Table 7. Generalized linear model (GLM) with Poisson distribution and identity link function test showing the effects of environmental parameters of different seasons on bird species richness in farmland of Nawalpur

Parameters	**Intercept**	**z value**	**Pr(>|Z|**
Rainy			
Temperature	11.541	2.67	0.00758**
Precipitation	-0.04543	-2.545	0.0109*
Summer			
Temperature	11.554	2.406	0.0161*
Precipitation	-0.2536	-2.234	0.0255*
Winter			
Temperature	6.437	2.094	0.0362*
Precipitation	-1.536	-2.042	0.041154*

4.3. Conservation priority

During the study, number of conservation priority species were found. A total of eight globally threatened species (two Critically Endangered, three Vulnerable and three Near Threatened) (IUCN, 2018), 18 nationally threatened (three Critically Endangered, one Endangered, six Vulnerable and eight Near Threatened) (Inskipp *et al.*, 2017) and 12 CITES (Appendix II) (CITES, 2021) enlisted bird species were recorded from study area. Globally threatened species like Red-Headed Vulture (*Sarcogyps calvus*), White-Rumped Vulture (*Gyps bengalensis*), Asian Woolly Neck (*Ciconia episcopus*), Alexandrine Parakeet and so on were recorded (Table 8).

Table 8. List of threatened bird species recorded on the farmland of Nawalpur

S.N.	**Common Name**	IUCN	NRDB	CITES
1	Alexandrine Parakeet	NT	NT	II
2	Asian Openbill		VU	
3	Asian Woollyneck	VU	NT	
4	Baya Weaver		NT	
5	Black-faced Bunting		VU	
6	Black-winged Kite			II
7	Blossom-headed Parakeet	NT	NT	II
8	Brahminy Kite		CR	II
9	Crested Serpent-eagle			II
10	Great Cormorant		NT	
11	Hume's Leaf-Warbler		VU	
12	Indian spotted Eagle	VU	VU	II
13	Lesser Adjutant	VU	VU	
14	Plain Martin		NT	
15	Plum-headed Parakeet			II
16	Red-breasted Parakeet	NT	VU	II
17	Red-headed Vulture	CR	EN	II
18	Rufous-necked Laughing thrush		CR	
19	Shikra			II
20	Vernal Hanging-parrot			II
21	Watercock		NT	
22	White-rumped Spine tail		NT	
23	White-rumped Vulture	CR	CR	II

4.4. Conservation status

The conservation status of the farmland dependent birds of the study was categorized according to the IUCN category in Least Concern (LC), Near Threatened (NT), Vulnerable (VU), Endangered (EN) and Critically Endangered (CR). Most of birds recorded during the field survey are of Least Concern under IUCN category (Figure 4).

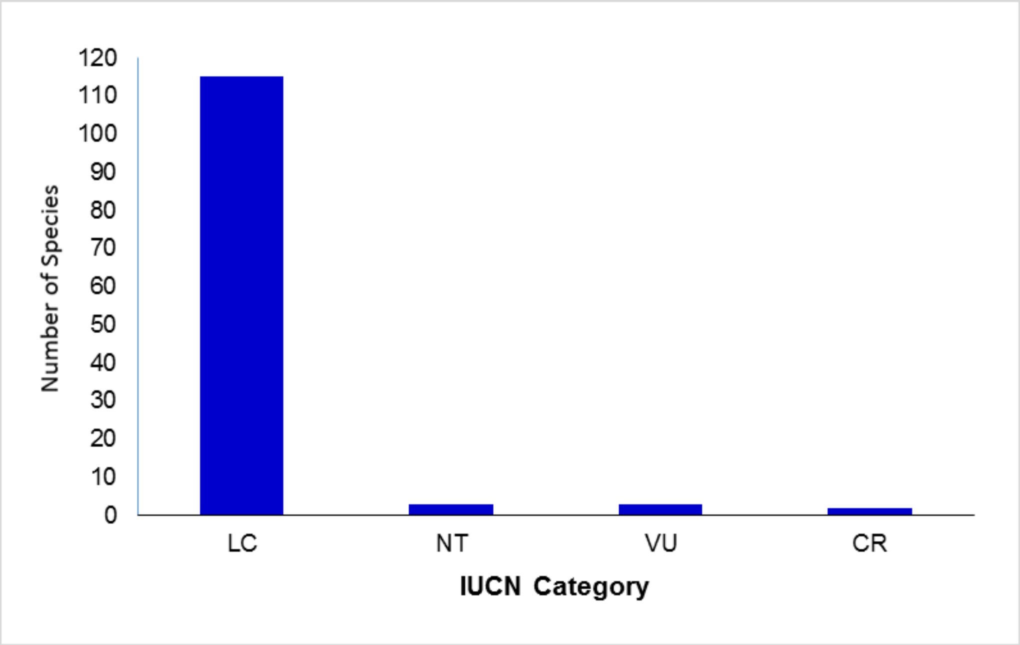

Figure 4. Conservation status according IUCN Category

Local status of the farmland dependent birds of the study was categorized according to the local category very abundant (above 250 individuals), abundant (201-250), very common (101-200), common (51-100), fairly common (16-50) and rare (below 15 individuals). The birds of fairly common category are recorded more followed by common, very common and least recorded were very abundant category (Figure 5).

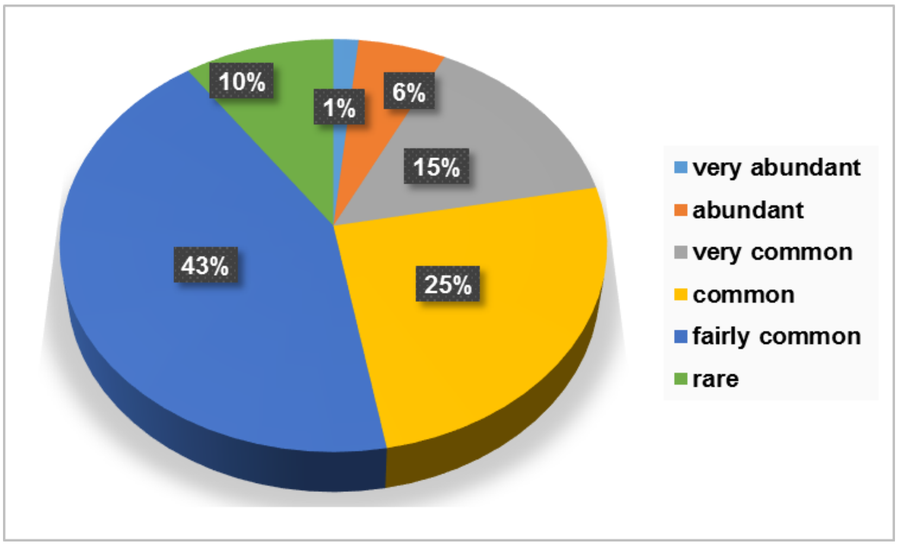

Figure 5. Local Status of birds according Local Category

5. DISCUSSION

5.1. Species richness and diversity

The farmland of Nepal supports 21% (~180) bird species among them 11% are globally threatened species (Inskipp and Baral, 2010; Inskipp *et al.*, 2017) among which 123 species of farmland dependent birds along with eight species which were globally threatened species were recorded in the farmland of Nawalpur. Higher richness of farmland dependent bird in these farmland were found as these farmlands are nearer foraging sites for the birds of the forests of CNP which are found in different habitat and easy availability of food for the species in the farmland. The diversity of the birds in farmland species is high as the agricultural land of this study area has seasonal variation in farming (Robinson *et al.*, 2001) also found similar result bird species diversity and abundance are likely to fall wherever agricultural landscapes become homogeneous and their richness depend to the arable habitats.

5.2. Factors affecting bird diversity

The bird community in any given habitat type is not static but changes seasonally (Avery and Riper III, 1989), so there might be the fluctuation in the diversity and richness of bird with change in seasons. During the study, higher species richness was found in summer season and rainy season in comparison to the winter season. Higher species in summer season among all three seasons might be due to the assemblage of migratory birds in summer and the favorable ecological and climatic condition as well as food availability in this season. Similar finding was made by Murgui (2007) during his study on the effect of seasonality on bird species in which due to the unfavorable climatic conditions, shortage of food and predation in winter season, the species richness was higher in summer and rainy season.

The difference in diversity of farmland dependent birds was found between two seasons. Shannon Weiner index shows that summer season was more diverse (H= 4.253) than rainy (H= 4.113) and winter (H= 4.129). All three seasons have almost similar number of individuals but higher species richness in summer is the reason for diverse assemblage of bird in summer season. The diversity and distribution of birds are affected due to the temperature and climatic condition which differs according to seasons (Shoo *et al.*, 2005).

One of the major determinants of species diversity, especially the richness is the amount of the energy available in a system (Bailey *et al.*, 2004) which is lower in winter season.

There are many environmental and disturbance factors affecting the species richness and diversity of the area. During this eight variables were taken for knowing the impact on bird diversity of the farmlands. Likewise forest, water body, precipitation and temperature have positive impact on the richness whereas road or highway has negative impact.

In accordance to the result of this study, the association of roads on the species richness is positively significant, as near the distance from the road lesser the species richness. Similar finding was discussed in threatened birds of Chitwan National Park that showed a negative impact of road in the species richness (Adhikari *et al.*, 2019). Species richness, occurrence and abundance of birds have shown negative relation on many studies, which shows birds are mostly declined near road, with high traffic on roads than lower traffic (Brotons and Herrando, 2001; Fuller *et al.*, 2001; Rheindt, 2003; Griffith *et al.*, 2010).

In this study, more species richness was found along with the increase temperature in all the three seasons we surveyed and also shows the positive correlation whereas negative correlation with precipitation in all rainy, summer and winter season. Climate limits species distribution on the basis of their physiological tolerance and indirectly influenced species distribution by gradients of climatic factors (temperature, precipitation) (Hurlbert and Haskell, 2003).

The species richness showed negative correlation with distance to nearest water body during this study which means bird richness or diversity increase in distance to nearest water body from the surveyed point/grid. Li *et al.* (2013) described that species richness was linear function of water availability and further concluded that water availability had strong effects on plant richness, and weaker effects on vertebrate richness.

A total of eight globally threatened species 18 nationally threatened and 12 CITES (Appendix II) bird species were recorded in this study likewise (Dangaura *et al*., 2020) recorded 15 globally threatened species, 53 nationally threatened and 58 CITES (Appendix II) bird species during 10 years of the study.

6. CONCLUSION AND RECOMMENDATION

Farmlands played the significant roles in supporting the bird species. Altogether of 123 species of birds were supported by the farmland of Nawalpur. Species richness as well as diversity of the farmland dependent birds was higher in summer season than in rainy and winter seasons. It was found that there was significant impact in species richness of birds with nearest forest distance, nearest water distance, precipitation (mean) and temperature (mean) in farmland dependent birds in all three surveyed seasons but distance to highway also shows positive significant in winter seasons. Distance to nearest forest, Distance to nearest water body and precipitation are negatively associated with the species richness whereas temperature is positively correlated with species richness of farmland dependent birds.

Farmland of Nawalpur supported eight globally threatened birds (two Critically Endangered, three Vulnerable and three Near Threatened). The farmland dependent birds were greatly affected by seasonal variation and environmental factors of the farmland.

Few recommendation from this study are:

- High diversity of birds in the study was found, so more research should be designed for the study of farmland dependent birds.

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APPENDICES

I. List of birds with scientific name, orders, family, and species code for CCA, migratory status, IUCN status and feeding guild.

S.N.	Common name	Zoological name	Spp_code	Orders	Family	IUCN	population trend	presence in rainy	in summer	in winter	feeding guild	migratory
1	Black-winged Kite	*Elanus caeruleus* (Desfontaines, 1789)	Ela.cae	Accipitriformes	Accipitridae	LC	stable	√	√	√	Carnivore	resident
2	White-rumped Vulture	*Gyps bengalensis* (Gmelin, 1788)	Gyp.ben	Accipitriformes	Accipitridae	CR	decreasing	√	√	√	Carnivore	resident
3	Brahminy Kite	*Haliastur indus* (Boddaert, 1783)	Hal.ind	Accipitriformes	Accipitridae	LC	decreasing	√	√	√	Carnivore	resident
4	Red-headed Vulture	*Sarcogyps calvus* (Scopoli, 1786)	Sar.cal	Accipitriformes	Accipitridae	CR	decreasing	√	√	√	Carnivore	resident
5	Shikra	*Accipiter badius* (Gmelin, 1788)	Acc.bad	Accipitriformes	Accipitridae	LC	stable			√	Carnivore	resident
6	Indian spotted eagle	*Clanga hastata (Lesson, 1831)*	Cla.has	Accipitriformes	Accipitridae	VU	decreasing		√	√	Carnivore	resident
7	Changeable Hawk-eagle	*Nisaetus cirrhatus (Gmelin, 1788)*	Nis.cir	Accipitriformes	Accipitridae	LC	decreasing	√			Carnivore	resident
8	Crested Serpent-eagle	*Spilornis cheela (Latham, 1790)*	Spi.che	Accipitriformes	Accipitridae	LC	stable			√	Carnivore	resident
9	Common Hoopoe	*Upupa epops Linnaeus, 1758*	Upu.epo	Bucerotiformes	Upupidae	LC	decreasing	√	√		Insectivore	resident
10	House swift	*Apus nipalensis (Hodgson, 1836)*	Apu.nip	Caprimulgiformes	Apodidae	LC	increasing	√		√	Insectivore	resident
11	Pacific Swift	*Apus pacificus* (Latham, 1802)	Apu.pac	Caprimulgiformes	Apodidae	LC	Stable		√	√	Insectivore	s. migratory

12	White-rumped Spinetail	*Zoonavena sylvatica (Tickell, 1846)*	Zoo.syl	Caprimulgiformes	Apodidae	LC	stable	√	√		Insectivore	resident
13	Asian Woollyneck	*Ciconia episcopus* (Boddaert, 1783)	Cic.epi	Ciconiiformes	Ciconiidae	VU	decreasing	√			Carnivore	resident
14	Lesser Adjutant	*Leptoptilos javanicus (Horsfield, 1821)*	Lep.jav	Ciconiiformes	Ciconiidae	VU	decreasing			√	Carnivore	resident
15	Asian Openbill	*Anastomus oscitans (Boddaert, 1783)*	Ana.osc	Ciconiiformes	Ciconiidae	LC	unknown		√	√	Carnivore	resident
16	Western Spotted Dove	*Spilopelia suratensis (Gmelin, 1789)*	Spi.sur	Columbiformes	Columbidae	LC	increasing	√	√	√	Granivorous	resident
17	Eurasian Collared-dove	*Streptopelia decaocto Frivaldszky, 1838*	Str.dec	Columbiformes	Columbidae	LC	increasing	√	√	√	Granivorous	resident
18	Rock Dove	*Columba livia Gmelin, 1789*	Col.liv	Columbiformes	Columbidae	LC	decreasing	√	√	√	Granivorous	resident
19	Common Kingfisher	*Alcedo atthis (Linnaeus, 1758)*	Alc.att	Coraciiformes	Alcedinidae	LC	unknown	√	√	√	Carnivore	resident
20	White breasted kingfisher	*Halcyon smyrnensis (Linnaeus, 1758)*	Hal.smy	Coraciiformes	Alcedinidae	LC	increasing	√	√	√	Carnivore	resident
21	Pied Kingfisher	*Ceryle rudis (Linnaeus, 1758)*	Cer.rud	Coraciiformes	Alcedinidae	LC	unknown	√			Carnivore	resident
22	Indian Roller	*Coracias benghalensis (Linnaeus, 1758)*	Cor.ben	Coraciiformes	Coraciidae	LC	increasing	√	√	√	Carnivore	resident
23	Oriental Dollarbird	*Eurystomus orientalis (Linnaeus, 1766)*	Eur.ori	Coraciiformes	Coraciidae	LC	decreasing	√	√		Insectivore	s.migratory
24	Green Bee-eater	*Merops orientalis Latham, 1802*	Mer.ori	Coraciiformes	Meropidae	LC	increasing	√	√		Insectivore	resident
25	Blue-tailed Bee-eater	*Merops philippinus* Linnaeus, 1766	Mer.phi	Coraciiformes	Meropidae	LC	Stable		√	√	Insectivore	S. migratory
26	Lesser Coucal	*Centropus bengalensis (Gmelin, 1788)*	Cen.ben	Cuculiformes	Cuculidae	LC	increasing	√	√		Omnivores	resident
27	Greater Coucal	*Centropus sinensis (Stephens, 1815)*	Cen.sin	Cuculiformes	Cuculidae	LC	stable	√	√	√	Omnivores	resident
28	European Cuckoo	*Cuculus canorus* Linnaeus, 1758	Cuc.can	Cuculiformes	Cuculidae	LC	Decreasing		√		Omnivores	S. migratory
29	Western Koel	*Eudynamys scolopaceus* (Linnaeus, 1758)	Eud.sco	Cuculiformes	Cuculidae	LC	Stable		√		Omnivores	s.migratory
30	Common Hawk-cuckoo	*Hierococcyx varius* (Vahl, 1797)	Hie.var	Cuculiformes	Cuculidae	LC	stable	√	√		Insectivore	resident

31	Black Francolin	*Francolinus francolinus* (Linnaeus, 1766)	Fra.fra	Galliformes	Phasianidae	LC	stable		√		Omnivores	resident
32	White-breasted Waterhen	*Amaurornis phoenicurus (Pennant, 1769)*	Ama.pho	Gruiformes	Rallidae	LC	unknown	√			Omnivores	resident
33	Watercock	*Gallicrex cinerea (Gmelin, 1789)*	Gal.cin	Gruiformes	Rallidae	LC	decreasing	√	√		Omnivores	s.migratory
34	Common Moorhen	Gallinula chloropus (Linnaeus, 1758)	Gal.chl	Gruiformes	Rallidae	LC	stable	√	√		Omnivores	resident
35	Black-throated Bushtit	*Aegithalos concinnus* (Gould, 1855)	Aeg.con	Passeriformes	Aegithalidae	LC	stable			√	Omnivores	resident
36	Bengal Bushlark	Mirafra assamica Horsfield, 1840	Mir.ass	Passeriformes	Alaudidae	LC	stable	√			Omnivores	resident
37	Large Cuckooshrike	*Coracina javensis* (Horsfield, 1821)	Cor.jav	Passeriformes	Campephagidae	LC	stable		√		Insectivore	resident
38	Small Minivet	*Pericrocotus cinnamomeus (Linnaeus, 1766)*	Per.cin	Passeriformes	Campephagidae	LC	stable	√	√		Insectivore	resident
39	Black-headed Cuckooshrike	*Lalage melanoptera (Rüppell, 1839)*	Lal.mel	Passeriformes	Campephagidae	LC	stable	√			Insectivore	s.migratory
40	Rosy Minivet	*Pericrocotus roseus (Vieillot, 1818)*	Per.ros	Passeriformes	Campephagidae	LC	decreasing	√	√		Insectivore	resident
41	Zitting Cisticola	*Cisticola juncidis (Rafinesque, 1810)*	Cis.jun	Passeriformes	Cisticolidae	LC	increasing	√	√	√	Insectivore	resident
42	Common Tailorbird	*Orthotomus sutorius (Pennant, 1769)*	Ort.sut	Passeriformes	Cisticolidae	LC	stable	√	√		Insectivore	resident
43	Grey-breasted Prinia	*Prinia hodgsonii* Blyth, 1844	Pri.hod	Passeriformes	Cisticolidae	LC	stable		√		Insectivore	resident
44	Plain Prinia	*Prinia inornata* Sykes, 1832	Pri.ino	Passeriformes	Cisticolidae	LC	stable		√		Insectivore	resident
45	IndianJungle Crow	*Corvus culminatus Sykes, 1832*	Cor.cul	Passeriformes	Corvidae	LC	stable	√		√	Omnivores	resident
46	House Crow	*Corvus splendens Vieillot, 1817*	Cor.spl	Passeriformes	Corvidae	LC	stable	√	√	√	Omnivores	resident
47	Rufous Treepie	*Dendrocitta vagabunda (Latham, 1790)*	Den.vag	Passeriformes	Corvidae	LC	decreasing	√	√	√	Omnivores	resident
48	Red-billed Blue Magpie	*Urocissa erythroryncha (Boddaert, 1783)*	Uro.ery	Passeriformes	Corvidae	LC	stable	√			Insectivore	resident
49	Black Drongo	*Dicrurus macrocercus Vieillot, 1817*	Dic.mac	Passeriformes	Dicruridae	LC	unknown	√	√	√	Insectivore	resident

50	White-bellied Drongo	*Dicrurus caerulescens (Linnaeus, 1758)*	Dic.cae	Passeriformes	Dicruridae	LC	unknown	√			Insectivore	resident
51	Ashy Drongo	*Dicrurus leucophaeus Vieillot, 1817*	Dic.leu	Passeriformes	Dicruridae	LC	unknown		√	√	Insectivore	W. migratory
52	Crested Bunting	*Emberiza lathami* Gray, 1831	Emb.lat	Passeriformes	Emberizidae	LC	stable			√	Frugivorous	W.migratory
53	Black-faced Bunting	*Emberiza spodocephala Pallas, 1776*	Emb.spo	Passeriformes	Emberizidae	LC	stable	√		√	Omnivores	w.migratory
54	Scaly-breasted Munia	*Lonchura punctulata (Linnaeus, 1758)*	Lon.pun	Passeriformes	Estrildidae	LC	stable	√	√	√	Granivorous	resident
55	Barn Swallow	*Hirundo rustica Linnaeus, 1758*	Hir.rus	Passeriformes	Hirundinidae	LC	decreasing	√	√	√	Insectivore	resident
56	Nepal House Martin	*Delichon nipalense Horsfield & Moore, 1854*	Del.nip	Passeriformes	Hirundinidae	LC	stable	√	√		Insectivore	resident
57	Plain Martin	*Riparia chinensis* (Gray, 1830)	Rip.chi	Passeriformes	Hirundinidae	LC	decreasing	√	√		Insectivore	resident
58	Long-tailed Shrike	*Lanius schach Linnaeus, 1758*	Lan.sch	Passeriformes	Laniidae	LC	unknown	√	√	√	Insectivore	resident
59	Brown Shrike	*Lanius cristatus Linnaeus, 1758*	Lan.cri	Passeriformes	Laniidae	LC	decreasing	√		√	Insectivore	w. migratory
60	Rufous-necked Laughingthrush	*Garrulax ruficollis* (Jardine & Selby, 1838)	Gar.ruf	Passeriformes	Leiotrichidae	LC	stable		√		Omnivores	resident
61	Jungle Babbler	*Turdoides striata* (Dumont, 1823)	Tur.str	Passeriformes	Leiotrichidae	LC	stable		√		Omnivores	resident
62	Indian Paradise-flycatcher	*Terpsiphone paradisi* (Linnaeus, 1758)	Ter.par	Passeriformes	Monarchidae	LC	stable		√		Insectivore	S. migratory
63	Rosy Pipit	*Anthus roseatus Blyth, 1847*	Ant.ros	Passeriformes	Motacillidae	LC	stable			√	Omnivores	w.migratory
64	White Wagtail	*Motacilla alba Linnaeus, 1758*	Mot.alb	Passeriformes	Motacillidae	LC	stable	√		√	Insectivore	W.migratory
65	Western Yellow Wagtail	*Motacilla flava* Linnaeus, 1758	Mot.fla	Passeriformes	Motacillidae	LC	decreasing			√	Insectivore	W.migratory
66	Olive-backed Pipit	*Anthus hodgsoni Richmond, 1907*	Ant.hod	Passeriformes	Motacillidae	LC	stable			√	Omnivores	w.migratory
67	Richard's Pipit	*Anthus richardi Vieillot, 1818*	Ant.ric	Passeriformes	Motacillidae	LC	stable			√	Omnivores	w.migratory
68	Paddyfield Pipit	*Anthus rufulus Vieillot, 1818*	Ant.ruf	Passeriformes	Motacillidae	LC	stable	√	√		Omnivores	resident
69	White-browed Wagtail	*Motacilla maderaspatensis Gmelin, 1789*	Mot.mad	Passeriformes	Motacillidae	LC	stable			√	Insectivore	resident
70	Siberian Rubythroat	*Calliope calliope* (Pallas, 1776)	Cal.cal	Passeriformes	Muscicapidae	LC	stable			√	Insectivore	W.migratory

71	Oriental Magpie Robin	*Copsychus saularis (Linnaeus, 1758)*	Cop.sau	Passeriformes	Muscicapidae	LC	stable	√	√	√	Insectivore	resident
72	Black-backed Forktail	*Enicurus immaculatus* (Hodgson, 1836)	Eni.imm	Passeriformes	Muscicapidae	LC	stable	√		√	Carnivore	resident
73	Little Forktail	*Enicurus scouleri* Vigors, 1832	Eni.sco	Passeriformes	Muscicapidae	LC	stable	√		√	Insectivore	resident
74	Little Pied Flycatcher	*Ficedula westermanni* (Sharpe, 1888)	Fic.wes	Passeriformes	Muscicapidae	LC	decreasing		√	√	Insectivore	resident
75	White-rumped Shama	*Kittacincla malabarica* (Scopoli, 1788)	Kit.mal	Passeriformes	Muscicapidae	LC	decreasing		√	√	Insectivore	resident
76	Indian Blue Robin	*Larvivora brunnea* Hodgson, 1837	Lar.bru	Passeriformes	Muscicapidae	LC	decreasing	√	√		Insectivore	s.migratory
77	Blue Whistling-thrush	*Myophonus caeruleus* (Scopoli, 1786)	Myo.cae	Passeriformes	Muscicapidae	LC	unknown			√	Omnivores	W.migratory
78	White-tailed Stonechat	*Saxicola leucurus* (Blyth, 1847)	Sax.leu	Passeriformes	Muscicapidae	LC	stable	√	√		Insectivore	resident
79	Pied Bushchat	*Saxicola caprata (Linnaeus, 1766)*	Sax.cap	Passeriformes	Muscicapidae	LC	stable	√	√	√	Insectivore	resident
80	Grey Bushchat	*Saxicola ferreus Gray, 1846*	Sax.fer	Passeriformes	Muscicapidae	LC	stable	√	√		Insectivore	resident
81	Common Stonechat	*Saxicola torquatus (Linnaeus, 1766)*	Sax.tor	Passeriformes	Muscicapidae	LC	stable		√	√	Insectivore	W. migratory
82	Indian Golden Oriole	*Oriolus kundoo Sykes, 1832*	Ori.kun	Passeriformes	Oriolidae	LC	unknown	√	√		Insectivore	s.migratory
83	Black-hooded Oriole	*Oriolus xanthornus (Linnaeus, 1758)*	Ori.xan	Passeriformes	Oriolidae	LC	stable	√	√		Insectivore	resident
84	House Sparrow	*Passer domesticus (Linnaeus, 1758)*	Pas.dom	Passeriformes	Passeridae	LC	decreasing	√	√	√	Granivorous	resident
85	Puff-throated Babbler	*Pellorneum ruficeps* Swainson, 1832	Pel.ruf	Passeriformes	Pellorneidae	LC	stable		√	√	Omnivores	resident
86	Common Chiffchaff	*Phylloscopus collybita* (Vieillot, 1817)	Phy.col	Passeriformes	Phylloscopidae	LC	increasing			√	Omnivores	W.migratory
87	Smoky Warbler	*Phylloscopus fuligiventer (Hodgson, 1845)*	Phy.ful	Passeriformes	Phylloscopidae	LC	stable		√	√	Insectivore	w. migratory
88	Dusky Warbler	*Phylloscopus fuscatus (Blyth, 1842)*	Phy.fus	Passeriformes	Phylloscopidae	LC	stable		√	√	Insectivore	w. migratory

89	Hume's Leaf-warbler	*Phylloscopus humei* (Brooks, 1878)	Phy.hum	Passeriformes	Phylloscopidae	LC	stable			√	Omnivores	W.migratory
90	Blyth's Leaf-warbler	*Phylloscopus reguloides* (Blyth, 1842)	Phy.reg	Passeriformes	Phylloscopidae	LC	stable			√	Omnivores	W.migratory
91	Greenish Warbler	*Phylloscopus trochiloides* (Sundevall, 1837)	Phy.tro	Passeriformes	Phylloscopidae	LC	increasing			√	Carnivore	w.migratory
92	Grey-hooded Warbler	*Phylloscopus xanthoschistos (Gray, 1846)*	Phy.xan	Passeriformes	Phylloscopidae	LC	stable	√			Insectivore	resident
93	Baya Weaver	*Ploceus philippinus (Linnaeus, 1766)*	Plo.phi	Passeriformes	Ploceidae	LC	stable	√	√		Omnivores	resident
94	Black Bulbul	*Hypsipetes leucocephalus* (Gmelin, 1789)	Hyp.leu	Passeriformes	Pycnonotidae	LC	stable		√		Omnivores	resident
95	Red-vented Bulbul	*Pycnonotus cafer (Linnaeus, 1766)*	Pyc.caf	Passeriformes	Pycnonotidae	LC	increasing	√	√	√	Omnivores	resident
96	White-throated Fantail	*Rhipidura albicollis (Vieillot, 1818)*	Rhi.alb	Passeriformes	Rhipiduridae	LC	stable			√	Insectivore	resident
97	Chestnut-bellied Nuthatch	*Sitta cinnamoventris* Blyth, 1842	Sit.cin	Passeriformes	Sittidae	LC	unknown		√		Omnivores	resident
98	Common Myna	*Acridotheres tristis (Linnaeus, 1766)*	Acr.tri	Passeriformes	Sturnidae	LC	stable	√	√	√	Omnivores	resident
99	Asian-pied Starling	*Gracupica contra (Linnaeus, 1758)*	Gra.con	Passeriformes	Sturnidae	LC	increasing	√	√	√	Omnivores	resident
100	Brahminy Starling	*Sturnia pagodarum (Gmelin, 1789)*	Stu.pag	Passeriformes	Sturnidae	LC	unknown	√			Omnivores	resident
101	Large Wood-shrike	*Tephrodornis virgatus* (Temminck, 1824)	Tep.vir	Passeriformes	Vangidae	LC	stable		√		Insectivore	resident
102	Common Wood-shrike	*Tephrodornis pondicerianus (Gmelin, 1789)*	Tep.pon	Passeriformes	Vangidae	LC	stable	√			Insectivore	resident
103	Indian White-eye	*Zosterops palpebrosus* (Temminck, 1824)	Zos.pal	Passeriformes	Zosteropidae	LC	decreasing	√	√		Omnivores	resident
104	Great White Egret	*Ardea alba* Linnaeus, 1758	Ard.alb	Pelecaniformes	Ardeidae	LC	unknown		√		Carnivore	resident
105	Intermediate Egret	*Ardea intermedia Wagler, 1829*	Ard.int	Pelecaniformes	Ardeidae	LC	decreasing	√	√	√	Carnivore	resident
106	Purple Heron	*Ardea purpurea* Linnaeus, 1766	Ard.pur	Pelecaniformes	Ardeidae	LC	decreasing	√			Carnivore	resident

107	Indian Pond Heron	*Ardeola grayii (Sykes, 1832)*	Ard.gra	Pelecaniformes	Ardeidae	LC	unknown	√	√	√	Carnivore	resident
108	Cattle Egret	*Bubulcus ibis (Linnaeus, 1758)*	Bub.ibi	Pelecaniformes	Ardeidae	LC	increasing	√	√	√	Carnivore	resident
109	Green-backed Heron	*Butorides striata* (Linnaeus, 1758)	But.str	Pelecaniformes	Ardeidae	LC	decreasing		√		Carnivore	resident
110	Little Egret	*Egretta garzetta (Linnaeus, 1766)*	Egr.gar	Pelecaniformes	Ardeidae	LC	decreasing	√	√	√	Carnivore	resident
111	Cinnamon Bittern	*Ixobrychus cinnamomeus (Gmelin, 1789)*	Ixo.cin	Pelecaniformes	Ardeidae	LC	stable	√	√		Carnivore	S.migratory
112	Red-naped Ibis	*Pseudibis papillosa (Temminck, 1824)*	Pse.pap	Pelecaniformes	Threskiornithidae	LC	decreasing	√	√	√	Omnivores	resident
113	Coppersmith Barbet	*Psilopogon haemacephalus (Müller, 1776)*	Psi.hae	Piciformes	Megalaimidae	LC	increasing	√	√		Frugivorous	resident
114	Great Barbet	*Psilopogon virens* (Boddaert, 1783)	Psi.vir	Piciformes	Megalaimidae	LC	decreasing	√	√		Omnivores	resident
115	Blue-throated Barbet	*Psilopogon asiaticus (Latham, 1790)*	Psi.asi	Piciformes	Megalaimidae	LC	stable	√			Insectivore	resident
116	Vernal Hanging-parrot	*Loriculus vernalis (Sparrman, 1787)*	Lor.ver	Psittaciformes	Psittacidae	LC	stable	√			Herbivore	resident
117	Red-breasted Parakeet	*Psittacula alexandri* (Linnaeus, 1758)	Psi.ale	Psittaciformes	Psittacidae	NT	decreasing		√		Herbivore	resident
118	Plum-headed Parakeet	*Psittacula cyanocephala* (Linnaeus, 1766)	Psi.cya	Psittaciformes	Psittacidae	LC	decreasing		√		Herbivore	resident
119	Blossom-headed Parakeet	*Psittacula roseata* Biswas, 1951	Psi.ros	Psittaciformes	Psittacidae	NT	stable	√	√	√	Herbivore	resident
120	Rose-ringed Parrakeet	*Psittacula krameri (Scopoli, 1769)*	Psi.kra	Psittaciformes	Psittacidae	LC	increasing	√	√	√	Herbivore	resident
121	Alexandrine Parakeet	*Psittacula eupatria (Linnaeus, 1766)*	Psi.eup	Psittaciformes	Psittacidae	NT	decreasing	√	√	√	Herbivore	resident
122	Little Cormorant	*Microcarbo niger (Vieillot, 1817)*	Mic.nig	Suliformes	Phalacrocoracidae	LC	unknown			√	Carnivore	resident
123	Great Cormorant	*Phalacrocorax carbo* (Linnaeus, 1758)	Pha.car	Suliformes	Phalacrocoracidae	LC	increasing			√	Carnivore	W.migratory

PHOTOGRAPHS

1. Black-winged Kite

2. Shikra

3. Asian Openbill

4. Common Moorhen

5. Pied Kingfisher

6. Lesser Adjutant

7. Blossom-headed Parakeet

8. White-browed Wagtail

9. Coppersmith Barbet

10. Scaly-breasted Munia

11. Bhraminy Starling

12. Pied Bushchat