DIVERSITY AND HABITAT UTILIZATION OF BIRDS IN LUMBINI, NEPAL

Asmita Gyawali

T.U Registration No.: 5-2-50-194-2013

T.U. Examination Roll No.: Zoo 557/074

Batch: 2074/2075

A dissertation submitted in the partial fulfillment of the requirements for the award of the Degree of Masters of Science in Zoology with special paper Ecology and Environment

Submitted to

Central Department of Zoology

Institute of Science and Technology

Tribhuvan University

Kirtipur, Kathmandu, Nepal

August, 2021

DECLARATION

I hereby declare that the work presented in this thesis has been done by myself, and has not been submitted elsewhere for the award of any degree. All sources of information have been specifically acknowledged by reference to the author(s) or institution(s).

Date: 16 August, 2021

.....

Asmita Gyawali

TRIBHUVAN UNIVERSITY
01-4331896
CENTRAL DEPARTMENT OF ZOOLOGY
Kirtipur, Kathmandu, Nepal.

Ref.No.:

RECOMMENDATIONS

This is to recommend that the thesis entitled "Diversity and habitat utilization of birds in Lumbini, Nepal" has been carried out by Asmita Gyawali for the partial fulfillment of Master's Degree of Science in Zoology with special paper Ecology and Environment. This is her original work and has been carried out under my supervision. To the best of my knowledge, this thesis work has not been submitted for any other degree in any institutions.

Date: 16 August, 2021

Bishnu Prasad Bhattarai, PhD
Assistant Professor and Supervisor
Central Department of Zoology
Tribhuvan University
Kirtipur, Kathmandu, Nepal

TRIBHUVAN UNIVERSITY
01-4331896
CENTRAL DEPARTMENT OF ZOOLOGY
Kirtipur, Kathmandu, Nepal.

Ref.No.:

Central Department of Zoology T.U., Kirtipur

LETTER OF APPROVAL

On the recommendation of supervisor Asst. Prof. Dr. Bishnu Prasad Bhattarai, Central Department of Zoology, Tribhuvan University, the thesis submitted by Asmita Gyawali entitled "Diversity and habitat utilization of birds in Lumbini, Nepal" is approved for the examination in partial fulfillment of the requirements for Master's Degree of Science in Zoology with special paper Ecology and Environment.

Date: 16 August, 2021

Tej Bahadur Thapa, PhD
Professor and Head of Department
Central Department of Zoology
Tribhuvan University
Kirtipur, Kathmandu, Nepal

TRIBHUVAN UNIVERSITY
01-4331896
CENTRAL DEPARTMENT OF ZOOLOGY
Kirtipur, Kathmandu, Nepal.

Ref.No.:

CERTIFICATE OF ACCEPTANCE

This thesis work submitted by Asmita Gyawali entitled "Diversity and habitat utilization of birds in Lumbini, Nepal" has been accepted as a partial fulfillment for the requirements of Master's Degree of Science in Zoology with special paper Ecology and Environment.

EVALUATION COMMITTEE

Supervisor
Bishnu Prasad Bhattarai, PhD
Assistant Professor
Central Department of Zoology
Tribhuvan University
Kirtipur, Kathmandu, Nepal

Head of Department
Tej Bahadur Thapa, PhD
Professor
Central Department of Zoology
Tribhuvan University
Kirtipur, Kathmandu, Nepal

Internal Examiner
Laxman Khanal, PhD
Assistant Professor
Central Department of Zoology
Tribhuvan University

External Examiner
Ramesh Prasad Sapkota, PhD
Assistant Professor
Central Department of Environment Science
Tribhuvan University

Date of Examination: 13 September, 2021

ACKNOWLEDGEMENTS

First of all, I would like to express my deep gratitude to my academic supervisor, Asst. Prof. Dr. Bishnu Prasad Bhattarai, Central Department of Zoology for his Continuous guidance and encouragement in carrying out this thesis work.

I am very grateful to Prof. Dr. Tej Bahadur Thapa, Head of Central Department of Zoology, T.U, for his kind support and encouragement.

My sincere thank goes to Dr. Hem Sagar Baral for his kind suggestions and support to carry out this thesis work. I would like to thank Mr. Bibek Aryal and Laxman Timalsina for helping me in the field work. I am thankful to Mr. Naresh Pandey for helping in data analysis. I am grateful to Mr. Sanjeev Acharya for helping in identifying some photographs of birds.

I would like to express my appreciation to all the teaching and non- teaching staffs of Central Department of Zoology.

Finally, I would like to express my sincere thanks to my parents, family members and my almighty, for their continuous help and encouragement to carry out this thesis work.

Asmita Gyawali

Examination Roll No: 557

Batch: 2074/2075

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

Abbreviated form	Details of Abbreviations
°C	Degree Celsius
BCN	Bird Conservation Nepal
BMFD	Bhairahawa Meteorological Forecasting Division
CCA	Canonical Correspondence Analysis
CITES	Convention on International Trades in Endangered Species of Flora and Fauna
DNPWC	Department of National Parks and Wildlife Conservation
E	East
GLM	Generalized Linear Model
GPS	Global Positioning System
LMPA	Lumbini Master Plan Area
m.a.s.l	meter above sea level
mm	millimeter
N	North
UNESCO	United Nations, Educational Scientific and Cultural Organization

ABSTRACT

The study was conducted in Lumbini Master Plan Area of Rupandehi District, Nepal with the main objective to explore the bird diversity and habitat utilization of birds. Point count method was used for bird survey. Altogether, 994 individuals of 111 species representing 15 orders and 41 families were recorded in which 79 species were resident and 32 species were winter migratory. Passeriformes (48 species) was found dominant order. Shannon diversity index in LMPA was 3.686, whereas Simpson diversity index is 0.9721 and the evenness value is 0.8867. The habitat utilization rate was higher in forest with the utilization rate 0.46. Carnivores didn't show significant relationship with habitat types whereas frugivores were associated with forest, herbivores were strongly associated with wetlands, insectivores and omnivores showed significant relationship with forest and grassland habitat. Feeding guild of the species also drives the habitat utilization pattern of the avifauna. Presence of people and livestock had a significant effect on diversity and abundance of birds. This study suggested that human is the key factor for degrading the habitat that negatively impacts on the distribution, diversity and abundance of birds in LMPA.

1. INTRODUCTION

1.1 General background

Nepal's rich biodiversity is a reflection of its unique geographic position, diverse climatic conditions, complex topography, altitudinal range, and great habitat variation. Biodiversity of Nepal is well reflected with high number of bird species so far, 886 species of birds have been recorded in Nepal, which is about 8.87% of the total bird species found worldwide (BCN 2020, DNPWC 2019). Among them 42 species are globally threatened and 35 globally near threatened and one endemic species (Grimmett et al. 2016, Inskipp et al. 2017). Further, 168 species are nationally threatened in which 68 Critically Endangered species, 38 Endangered species and 62 Vulnerable species (Inskipp et al. 2017). Nine species of birds are Nationally Protected according to NPWC Act 1973 (DNPWC 1973) and 113 birds are enlisted in CITES category (DNPWC 2018).

Birds prefer different habitat types for various purposes. In the context of Nepal, 53% of Nepal's nationally threatened birds inhabits in forests, 27% in wetlands, 15% in grasslands, 8% in cultivated land, 5% in shrub, nine percent in open canopy, 3% near human habitation, and 1% in semi-desert areas (Inskipp et al. 2013). On the basis of the protection, different arrays of foraging opportunities and nesting sites, birds select different habitats. The availability of food, suitable cover and nesting sites, adaptation and tolerance level of the species, degree of threats or prey vulnerability are the factors influencing prefer in habits by birds (Girma et al. 2017). Vegetation structure, floristic composition as well as vegetation cover for nesting or shelter are also the determinants for habitat selection for birds (Jones 2001)

Among all the species present on this earth, birds are one of the sensitive species that shows the quick response towards the habitat change. The diversity of birds and their presence provide strong bio-indication signals (Urfi 2011, Bregman et al. 2014). They are the good indicators of ecological status of any given ecosystem and are good indicator for studying the structure and composition of habitat (Bilgrami 1995, Burel et al. 1998), habitat changes and agricultural intensification (Robledano et al. 2010). Birds that are encountered in the various habitat types indicate their tolerance to a wide range of ecological condition (Sekercioglu 2006). They are the indicators of pollution, seed dispersal, scavenging and as predators of insect pests (Aynalem and Bekele 2008), wetland habitat quality, productivity and stability (Seymour and Simmons 2008) as well

as for changes related to global warming as a result of their rapid response to temperature changes.

Habitat loss, fragmentation and degradation are the major threats to avifauna (Inskipp et al. 2017). Illegal trade, water poisoning, over fishing, food scarcity, over grazing and use of pesticides, pollution from households and industrial discharges and agricultural run-off is seriously degrading the habitat of birds which are posing serious threats to birds of Nepal (Inskipp et al. 2016). Intensification of farming practices, such as the loss of crop diversity, destruction of grasslands and excessive use of pesticides and fertilizers, has led to the degradation of agricultural and semi-natural habitats, and is also causing declines in biodiversity across huge areas (Inskipp et al. 2013). Livestock grazing, human disturbances (Adhikari et al. 2019), urbanization (Matuoka et al. 2020), Pollution, land use, land cover changes, urbanization, encroachment, climate change, introduction of exotic species are the threats to avifauna (Dar et al. 2020).

1.2 Objectives of the study

1.2.1 General objective

The main objective of the study was to explore the diversity and habitat utilization of birds in Lumbini, Nepal.

1.2.2 Specific objectives

The specific objectives were:

i. To determine the diversity of birds in Lumbini, Nepal

ii. To evaluate the factors affecting habitat utilization of birds in Lumbini, Nepal

1.3 Rationale of the study

Lumbini Master Plan Area (Lumbini Sacred Garden) is the area consisting different land types like; wetlands, forest as well as grassland. This study helps to identify the current status of the birds as well as habitat utilization by different species.

As Lumbini is one of the famous tourist areas, construction works and human disturbances are putting pressure on the natural environment (Lafortune-Bernard and Weise 2020). The impacts of human disturbances on diversity of birds can be assessed. The assessment of bird community is important to determine the health status of local ecosystem and regional landscapes (Sethy et al. 2015). The studies in Lumbini are

focused mostly on Sarus Crane only (Paudel 2009). So, this study will help as a baseline for further study on birds as well as it could help to make better management and conservation of bird species in the study area.

2. LITERATURE REVIEW

2.1 Diversity of birds

Avifaunal diversity varies with spatiotemporal distribution of environmental resources. The study conducted by (Tanalgo et al. 2015) in Phillipines in different habitats, highest percentage in agroforest followed by ricefields and disturbed roads due to the vegetation diversity and heterogeneity of the habitat. Dangaura et al. (2020) explored avifaunal diversity in far western Nepal, in which 381 species of 19 orders and 78 families were recorded and concluded that the high diverse avifaunal community was due to the greater habitat complexity. Khatri et al. (2019) conducted study in Phewa wetlands of Nepal and reported 148 species belonging to 11 orders and 44 families and water level was the influencing factor for the avian diversity. Jacoboski et al. (2017) explored the grassland bird communities in Southern Brazil reporting 36 bird species in both protected and non-protected areas and concluded habitat heterogeneity is the necessary to ensure species coexistence and maintaining the diversity of grassland birds. Green lawn, the peripheral waterlogged areas, habitat heterogeneity supported the rich diversity of birds (Dangaura et al. 2020, Singh et al. 2020).

Bird diversity is sensitive to environmental changes especially habitat changes due to various factors. Human disturbance has major negative impact on diversity, distribution and abundance of various species of birds. Presence of livestock and people caused significantly negative effects on species richness and abundance of threatened birds (Adhikari et al. 2019). Changes in the vegetation composition and structure caused by the human disturbance had led to change in the bird richness, abundance and assemblage composition. Anthropogenic pressure causes decline in the number of species of birds (MacGregor-Fors and Schondube 2011, Menon and Rangaswamy 2016). Habitat loss, degradation as well as fragmentation due to urbanization had potential negative impacts on different bird communities (Xu et al. 2018). Despite of abiotic gradients, competition, predation and state of succession were some of the biotic factors that affect the diversity of birds in the particular area (Sheta et al. 2011).

2.2 Habitat utilization

Birds utilize different types of habitats like; forest, grassland or wetlands differently either for various purposes. On the basis of the habitat use, birds are categorized as lowland grassland specialist, wetland specialist and forest specialist. Habitat selection of

wintering birds is influenced by the prey availability and accessibility (Nagarajan and Thiyagesan 1996). Availability of microhabitats and various food resources was the determining factor for habitat utilization by birds (Tanalgo et al. 2015, Mishra et al. 2020) . Habitat preferences is related to the food availability as well as habitat composition is most important in habitat selection by individual species (Gillies and St. Clair 2010).

Birds in the different habitat are fluctuated with the difference in environmental variables. Birds in the forest use dense vegetation structure (Tarbox et al. 2018) with average canopy height for their own safety due to predation (Vitz and Rodewald 2007). Forest specialists strongly prefer dense canopy cover (Gillies and St. Clair 2010). Coverage of the bare ground, height and density of vegetation, dead vegetation and grass were the important predictors for the habitat use by grassland birds (Fisher and Davis 2010, Azpiroz and Blake 2016). Landscape structural features influence the grassland bird communities (Coppedge et al. 2008, Codesido et al. 2013). Intermediate tall grasslands are necessary to maintain grassland specialists and avian diversity whereas short open grasslands are important for the obligate grassland species (Baral 2001). Mostly grassland birds rely on the habitat for feeding (Batáry et al. 2006)and also for the nesting requirements (Fletcher Jr and Koford 2002) as well as for both purposes (Nocera et al. 2007, Codesido et al. 2013, Dias et al. 2014). Many grassland birds require a mosaic with different habitat patches for their reproductive requirements (Dias et al. 2014). Land cove type is most important factor for wetland birds that provides food resources and different habitat for use (Wu et al. 2020). Open water body, meadows and vegetation type (Talbi et al. 2020) are the attraction for wetland birds (Elafri et al. 2017).

Bird's functional diversity responds negatively to disturbances (Matuoka et al. 2020). A substantial proportion of the threats to birds results from anthropogenic sources. Habitat fragmentation, degradation and loss are the major threats to avian species. Invasion of introduced birds is also the threat to native birds (Baker et al. 2014). Climate change (Garnett et al. 2019, Grand et al. 2019, Woo-Durand et al. 2020) is becoming the threats to biodiversity from which avifauna cannot be excluded. Land use change is widely accepted threats to avian communities (Guo et al. 2018, Grand et al. 2019). Most of the agricultural lands, forests, grasslands are being overexploited and being changed into urban areas that creates pressure to avian loss. Agriculture intensification creates negative impacts on birds with the use of chemicals, different farming operations, reduced nesting sites and increase in the predation after harvesting of crops (Altaf et al. 2018). Illegal

trade is also one of the threats to birds (Uprety et al. 2021). Road expansion, eutrophication, poaching and encroachment is also increasing that causes serious decline in avifauna (Dangaura et al. 2020).

3. MATERIALS AND METHODS

3.1 Study area

3.1.1 Location and climate

The study was conducted in Lumbini Master Plan Area (27.462°N, 83.276°E to 27.506°N, 83.277°E), Lumbini Sanskritik Municipality of Rupandehi District of Lumbini Province, Nepal (Figure 1). It lies in an elevation of 100 m a.s.l. (Rupakheti et al. 2017). The Master Plan Area of Lumbini consists of an area of 770 hectares. It was made a world heritage site by UNESCO in 1997. The climate of this region is tropical type. The temperature is highest on average in May, at around 36.4 minimum temperature on average in January is around 8.8ºC in cold winter. The most precipitation falls in July with an average of 545.6 mm. The least rainfall occurs in November with an average rainfall of 8.2 mm (BMFD 2020).

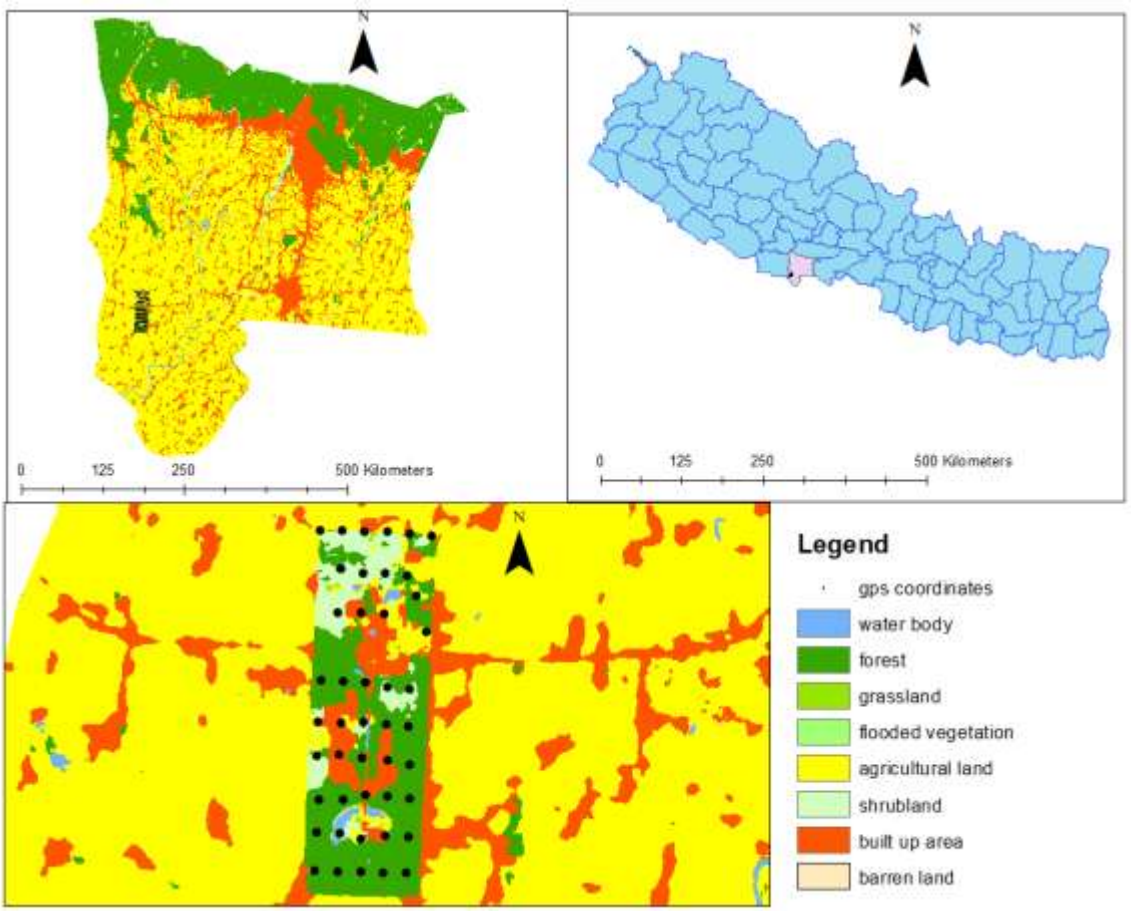

Figure 1. Location map of study area (LMPA)

3.1.2 Flora and fauna

The area consists of different types of habitats like; forest, grassland and wetlands. Three hundred fifty five species belonging to 75 families and 245 genera of plants were documented from Lumbini Sacred Garden and its adjoining area. It includes the tropical forest. Among above mentioned vegetation, the major vegetation are Sal (*Shorea robusta*), Sisoo (*Dalbergia sisso*), Teak (*Tectona grandis*) and Khayir (*Acacia catechu*) including some fruiting trees like; Kadam (*Neolamarckia cadamba*), Bayar (*Zigyphus maurititiana*). Grassland of this region comprises of Babiyo (*Eulaliopsis binate*) and Siru (*Imperata cylindrica*) (Siwakoti 2008).Fauna like Nilgai (*Boselaphus tragocamelus*), Wild boar (*Sus scrofa*), Python snake, Jungle cat (*Felis chaus*) and more than 100 species of birds. Sarus crane (*Antigone antigone*) is one of the protected breeding species in Lumbini Master Plan Area (Baral 2018).

3.1.3 Culture and ethnicity

The study area is surrounded by villages inhabited by Tharus and Madhesi along with other ethnic group such as Brahmin and Chhetri. Islam and Buddhism are the major religion followed by the people around study area (Baral 2018). Agriculture is the primary occupation and major source for income generation. Rice (*Oryza sativa*), Wheat (*Triticum* spp.) are major crops whereas Potato (*Solanum tuberosum*) and Sugarcane are the cash crops grown here. Livestock farming is also the important component of agriculture system of the people residing around study area.

3.2 Avian survey

The study was initiated by conducting preliminary survey during December, 2019 visiting three days to gather information about the study area. Bird sampling was done at three different habitats including forest, grassland and wetlands. Habitat was categorized on the basis of vegetation present in the study area. The field survey was conducted in the month of January, 2021. Point count method between two points were widely used for surveying birds in different landuse types (Waltert et al. 2004) and to study the species- habitat relationship (Alldredge et al. 2007). Point count method (Bibby et al. 2000) was used to survey bird diversity and abundance. A 1.5 km long transect was first deployed at the edge with point stations at an interval of every 300 m which was recorded by Garmin Etrex 10 GPS. A total of nine transects were deployed with 45 sampling points. The interval between transect was 500 m. In each point station, birds heard and seen within the radius of 50 m were noted for 20 minutes. Area was scanned with the help of

binoculars (Bushnell 8*10) to observe, count and identify bird species. Photographs were taken with Camera (Nikon P900). Bird observation was done from 7:00-11:00 in the morning and 15:00-17:00 in the evening. The field guide book 'Birds of Nepal' (Grimmett et al. 2016) was used for identification of birds. Photographs of unidentified species were identified with the help of bird experts. Status of residential and migratory birds was assessed.

3.3 Data analysis

Data obtained from field was arranged, organized and entered into Microsoft Excel 2010 for analysis. Birds were categorized according to their feeding guilds (Katuwal et al. 2018, Dangaura et al. 2020). Diversity indices was calculated for the avian diversity using PAST V3.18 (Hammer et al. 2001).

The habitat utilization rates of birds of all habitat types were calculated as (Zhao et al. 2013)

$$Ui=Ni/N$$

Where, Ui is the utilization rate of the specific habitat type by birds.

Ni is the number of individuals of birds in the specific habitat type.

N is the total number individuals of birds in all habitat types.

Generalized Linear Model (GLM) was used to show the response between habitat variables and species abundance.

The relationship between bird species and different habitat types and disturbance variables were analyzed using the ordination method Canonical Correspondence Analysis (CCA). Before conducting canonical analysis (CCA), the Detrended Correspondance Analysis (DCA) was used to evaluate the appropriate test (Correa-Metrio et al. 2014). While analyzing, the gradient length was more than three (3.886), hence, we chose CCA for analysis. Habitat type data where birds were recorded was considered as independent variable whereas species data with different feeding guilds were considered as dependent variable. Disturbance variables were considered as predictor variables and species data as response variables. Ordination plots were drawn using CANOCO v4.5 (Ter Braak and Smilauer 1998). Monte-Carlo permutation Test by using 499 permutations was done and the result was presented in form of biplot.

In the analysis, the guild is excluded if there was less than three species because of the lower statistical power (Weiher et al. 1998).

4. RESULTS

4.1 Diversity of birds

4.1.1 Species composition of birds

A total of 994 individuals of 111 species representing 15 orders and 41 families were recorded in which 79 species were resident and 32 species were winter migratory. Order Passeriformes was found dominant over others representing 48 species (Figure 2). Lesser Whistling-duck (83) was the dominant species followed by Jungle babbler (74).

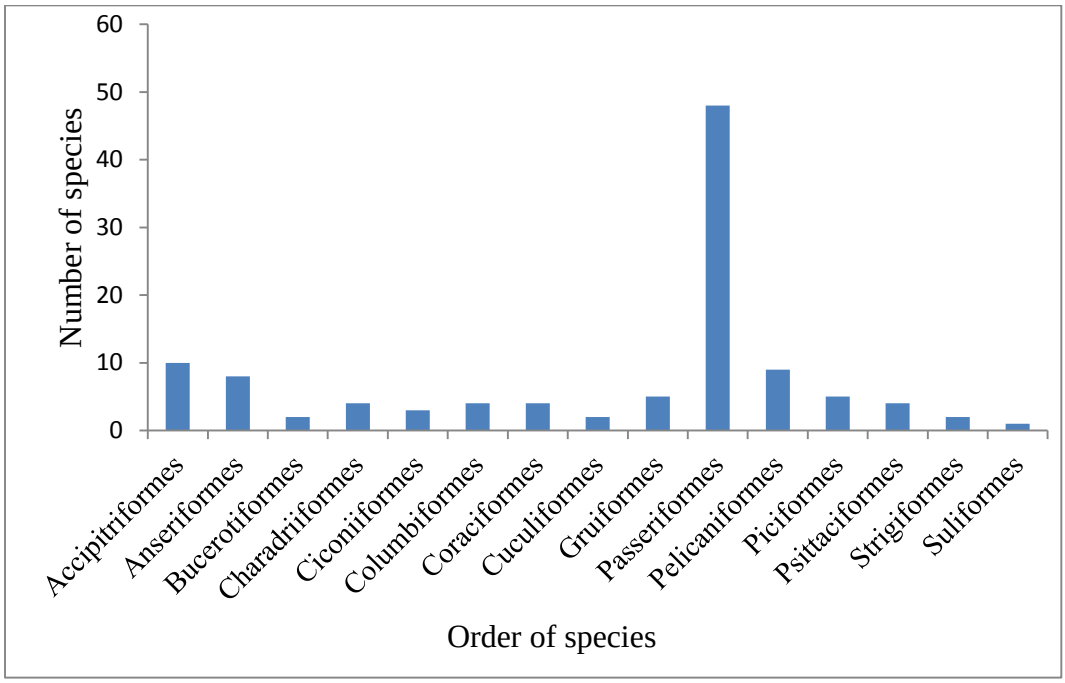

Figure 2. Order-wise species richness of birds

A total of 10 species were globally threatened species which consists of 9% of the total species found in the study area. Alexandrine Parakeet (*Palaeornis eupatria*), Ferruginous Duck (*Aythya nyroca*) and Himalayan Griffon (*Gyps himalayensis*) were Near Threatened whereas, Indian Spotted Eagle (*Clanga hastata*), Asian Openbill (*Anastomus oscitans*), Lesser Adjutant (*Leptoptilos javanicus*), Sarus Crane (*Antigone Antigone*) and Common Pochard (*Aythya ferina*) were listed as Vulnerable species, Steppe Eagle (*Aquila nipalensis*) was listed in Endangered species and White-rumped Vulture (*Gyps bengalensis*) was categorized as Critically Endangered species (Appendix 2).

On the context of feeding guild, highest numbers of insectivores (34) were recorded followed by carnivores (33) and least number of nectarivores (1) (Figure 3).

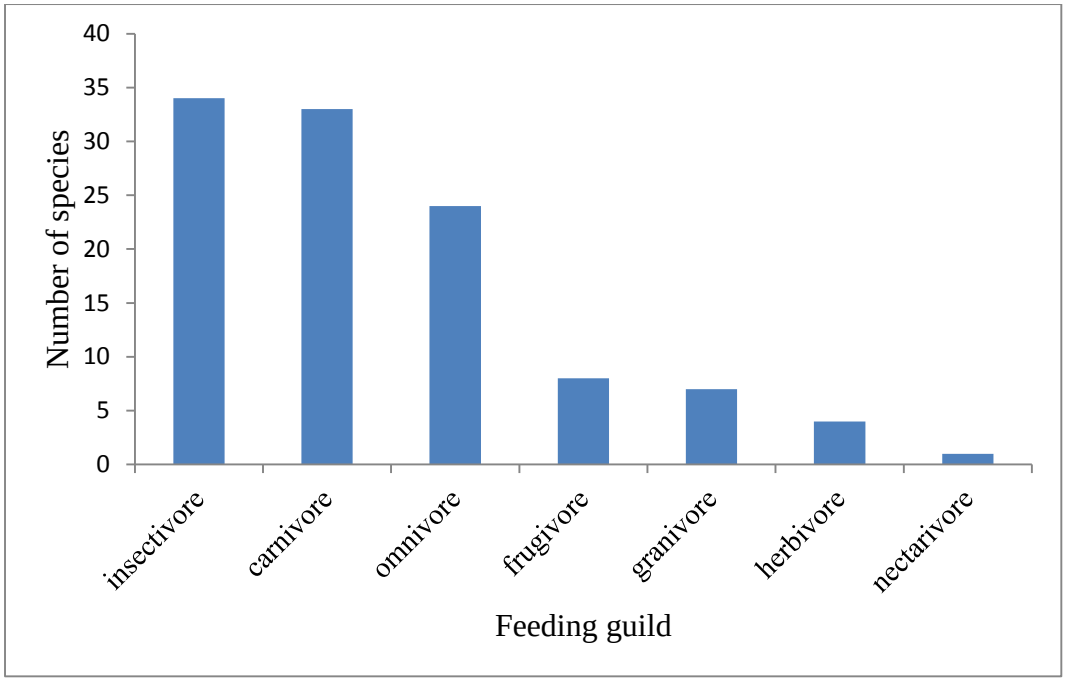

Figure 3. Feeding guild-wise species richness of birds

4.1.2 Avian diversity in different habitats

Habitat types were classified by visual estimation. The comparative diversity indices of Avifauna were noted in different habitats. The Shannon diversity indices show the highest diversity in grassland on the context of richness and abundance is also higher in grassland. The Simpson index is slightly higher in grassland than forest and least is in wetlands (Table 1). All over, Shannon diversity index in LMPA was 3.686, whereas Simpson diversity index is 0.9721 and the evenness value is 0.8867.

Table 1. Diversity indices in different habitat types

	Species richness		
Diversity indices	**Forest**	**Grassland**	**Wetland**
Dominance_D	0.05826	0.05671	0.3488
Simpson_1-D	0.9417	0.9433	0.6512
Shannon_H	2.935	2.949	1.074
Evenness_e^H/S	0.8962	0.9087	0.9756

4.2 Habitat utilization

The habitat utilization rate was higher in forest (0.46) having 21 sampling points followed by grassland (0.30) having 21 sampling points and the least were in wetland (0.24) within 3 sampling points.

4.2.1 Species richness in relation to different habitats

The generalized linear modeling (GLM) shows the significant difference ($p<0.05$) in species richness in response to grassland habitat ($p<0.05$) and wetland ($p<0.05$) whereas no significant difference was shown in species richness with forest habitat ($p>0.05$) (Table 2).

Table 2. Generalized Linear Model showing the species response to different habitat types.

Model parameters	**Estimate(β)**	**Std. Error(SE)**	**t value**	**Pr(>|t|)**	**Significance**
Forest	0.1964	1.1019	0.178	0.859	
Grassland	-2.1250	1.0536	-2.017	0.05	*
Wetland	7.7143	1.8645	4.137	0.00016	***

Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

On the basis of habitat use, 24 species were found in forest, 31 species using open wooded grassland as well as forest, 28 species were using open wooded grassland only, 23 species were using wetlands, 4 species were using open wooded grassland as well as wetland and only one species was found using forest and wetland. Since a single species can found in many types of habitat so these habitat are selected in which it depends on.

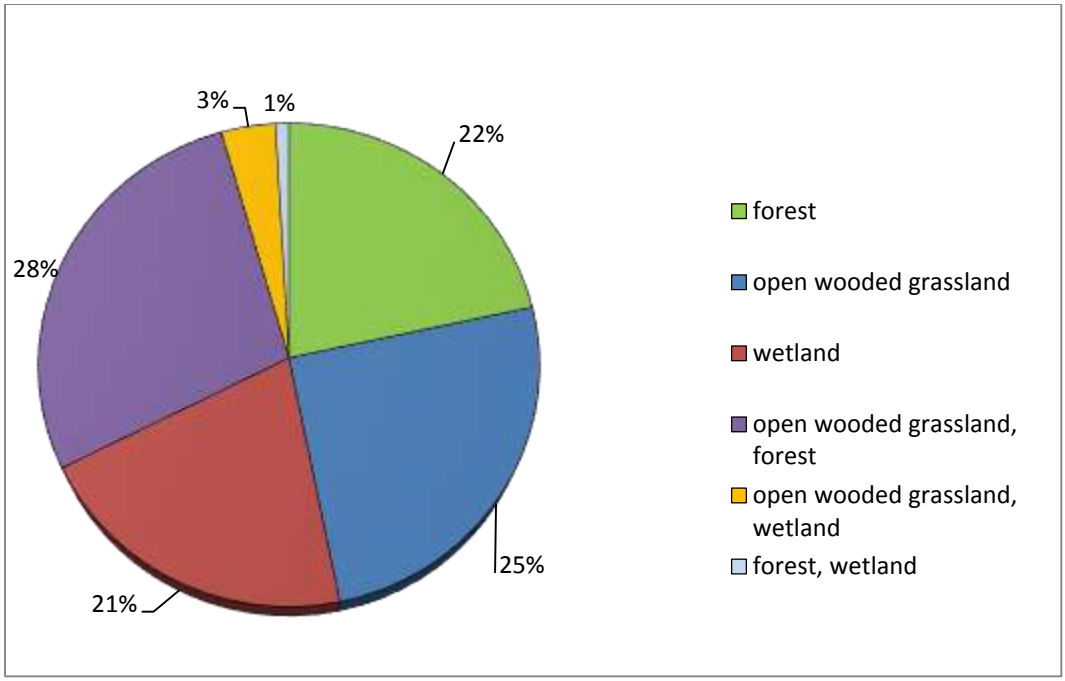

Figure 4. Different habitat used by bird species

4.2.3 Feeding guild composition relation with habitat types

The feeding guild composition of the species were tested for selected habitat types; forest, grassland and wetland. The Monte- Carlo permutation test of significance of all the canonical axes revealed significant preference of the herbivorous species (Trace=1.134, F-ratio=2.194, P=0.010) to different habitat types (Figure 5). Herbivores were associated with wetlands. Similarly, frugivorous species also showed significant preference (Trace=0.589, F-ratio=2.592, P=0.0080) to different habitat types (Figure 6). Frugivores were mostly associated with forests. Insectivore species (Trace=0.259, F-ratio=1.649, P=0.05) and omnivorous species (Trace=1.313, F-ratio=3.228, P=0.0020) (Figure 8) showed significant association to different habitat types. Insectivores and omnivores were associated with forest and grasslands. However, the Monte-Carlo permutation test of significance of all the canonical axes showed no any significant relationship of carnivorous species (Trace=0.265, F-ratio=1.886, P=0.096) to habitat types (Figure 9). Nectarivore was excluded as it consists of only one species which is not sufficient for statistical analysis.

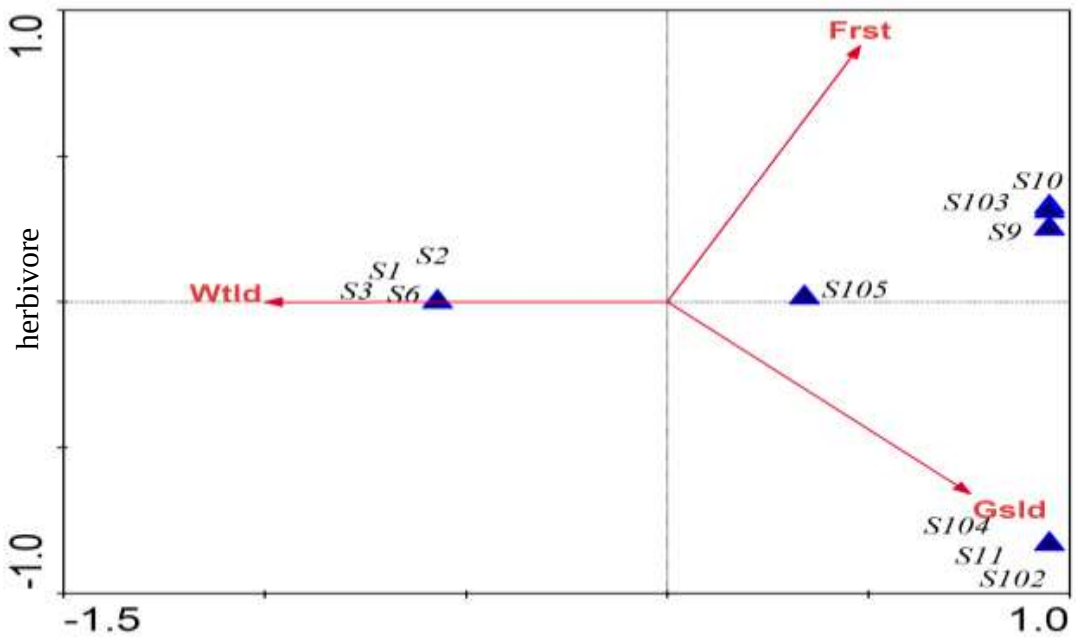

Figure 5. CCA diagram (biplot) showing herbivore species response to different habitat types (Frst= Forest, Gsld= Grassland, Wtld=Wetland).

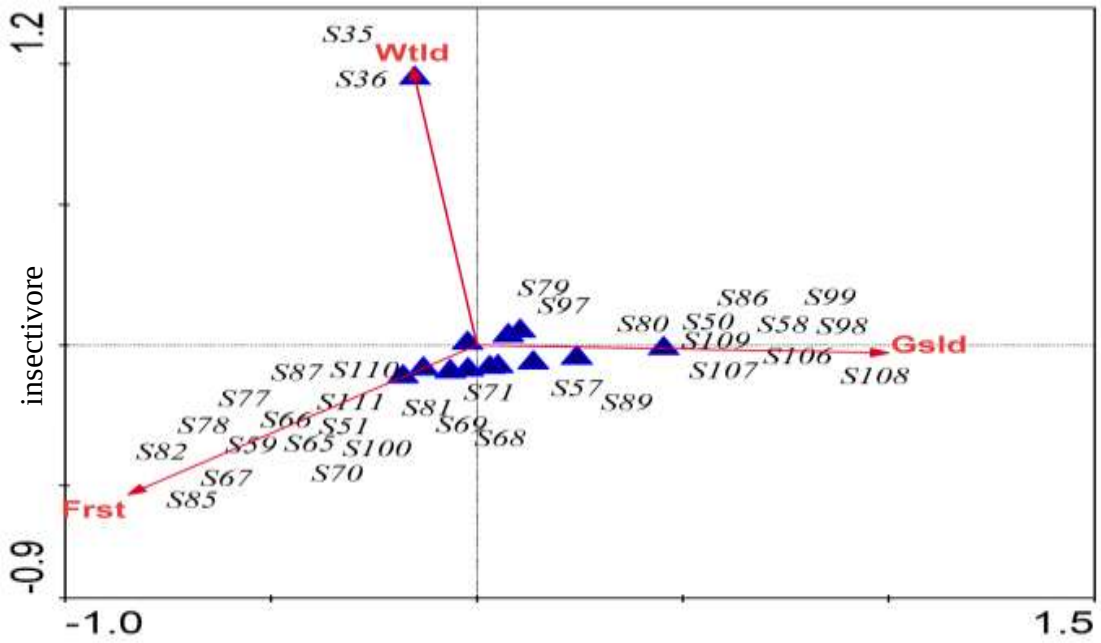

Figure 6. CCA diagram (biplot) showing insectivorous species response to habitat types (Frst=Forest, Gsld=Grassland, Wtld=Wetland).

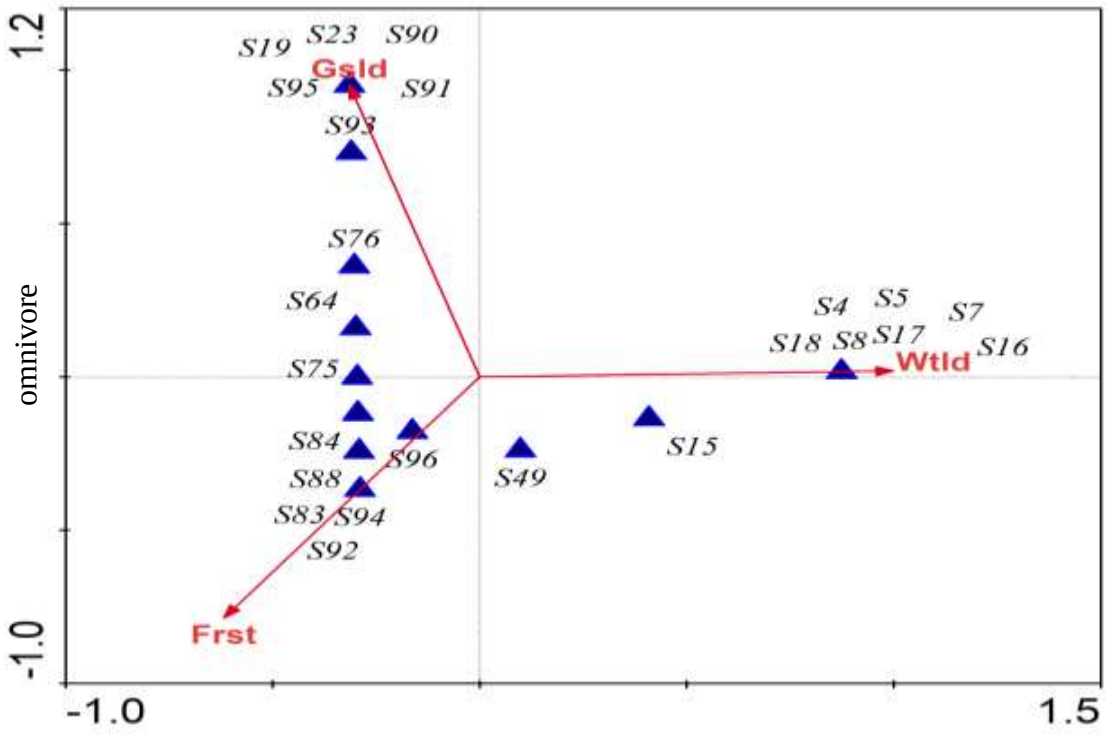

Figure 7. CCA diagram (biplot) showing response of omnivorous species to habitat types (Frst= Forest, Gsld= Grassland, Wtld= Wetland)

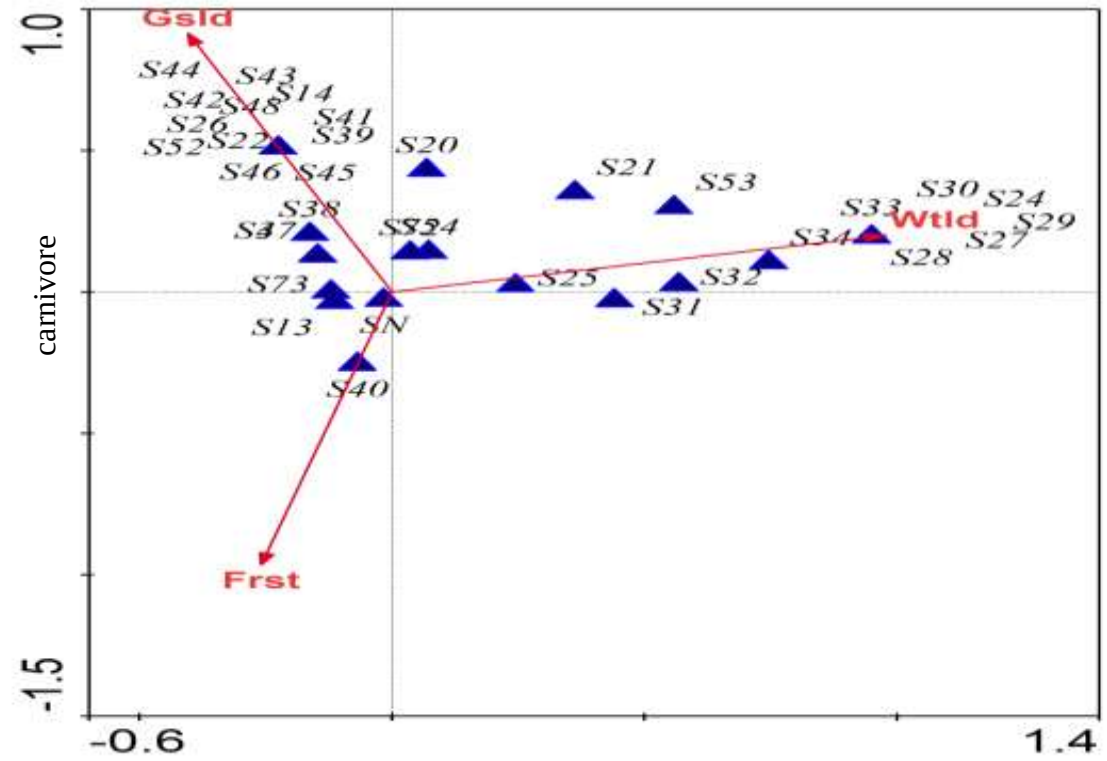

Figure 8. CCA diagram (biplot) showing carnivorous species response to habitat types (Frst=Forest, Gsld=Grassland, Wtld=Wetland)

CCA diagram showed that the bird diversity was more influenced by the Number of livestock grazing (NoL) and Number of people presence (NoP) and less influenced by the Distance to nearest road (DR). There was strong correlation between the species-disturbance variables. The Monte- Carlo permutation test of significance of all the canonical axes showed the negative significant relation between species-disturbances variables (Trace=1.310, F-ratio=1.364, P=0.0240). The species such as Black-throated Thrush (*Turdus atrogularis*), Indian Cuckoo-shrike (*Coracina macei*) showed more tolerant to distance to human trials whereas less tolerant towards number of people. The maximum abundance of species such as Cattle Egret (*Bubulcus ibis*), White-throated Kingfisher (*Halcyon smyrnensis*) and Common Pigeon (*Columba livia*) showed more tolerant to number of livestock grazing whereas White Wagtail (*Motacilla alba*) and White-browed Wagtail (*Motacilla maderaspatensis*) showed more tolerance to number of people. Among all the variables, the association of maximum abundance of species was higher with distance to human trial.

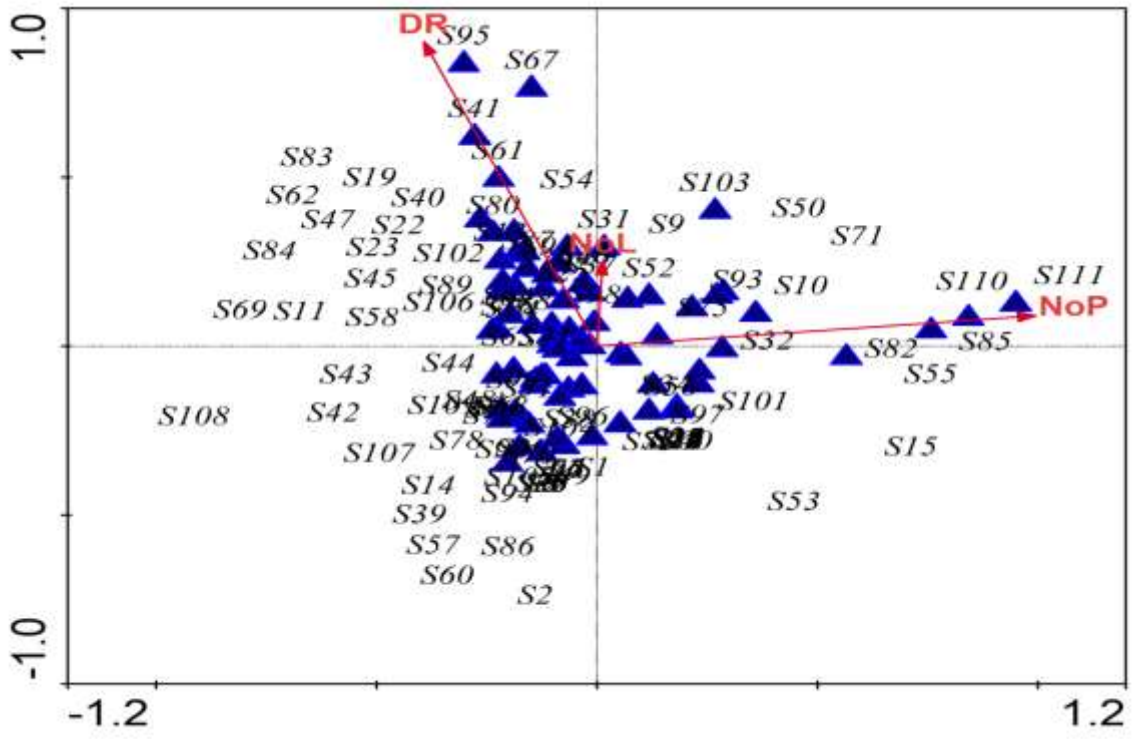

Figure 9. CCA diagram (biplot) showing species response to different disturbance variables (NoP= Number of people, NoL= Number of livestock grazing, DR= Distance to nearest road).

5. DISCUSSION

5.1 Bird diversity

In the present study, higher number of bird diversity was found within the small area. The Shannon index value (3.686) indicates that LMPA has rich avifaunal diversity. This index value is normally noted between 1.5 and 3.5 and rarely exceed above 4.5 (Gaines 1999). The Shannon index is influenced by the species richness and evenness value (Supriatna 2018). This could be due to the habitat heterogeneity that can provide different arrays of foraging opportunities and nesting sites as well as resting sites (Basnet et al. 2016, Issa 2019). The higher number of species was recorded from the Passeriformes order of the total identified species that aligns with (Kiros et al. 2018, Neupane et al. 2020, Pandey et al. 2020). The present study found the highest number of species from family Accipitridae (10). The presence of carcass and dead animals facilitate the presence of the family Accipitridae. The study area comprises the highest diversity but low abundance due to the lesser availability of the food resources as well as cutting and harvesting of tall grasses (Baral 2001), fire in the study area. Lesser Whistling-duck was highly abundant species (8.35%) across the study area due to its gregarious and sedentary nature occurred in groups (Zakaria et al. 2020) followed by Jungle Babbler (7.44%) due to its grouping behavior and generalist nature (Anthal and Sahi 2013). There are comparatively few species that are common and comparatively large number of species that are rare that is one of the characteristics feature of animal and plant communities (Gaston 1994).

The presented study showed Large Billed Crow (*Corvus culminates*)**,** Jungle Babbler (*Turdoides striata*) and Red-vented Bulbul (*Pycnonotus cafer*) were very commonly seen species. This might be due to the adaptation of the species in diverse habitat condition. Jungle Owlet (*Glaucidium cuculoides*) and Spotted Owlet (*Athene brama*) were sighted during day time as they were resting in their shelter and hence recorded in the study.

Insectivore was the dominant feeding guild which was consistent with the study carried out by (Jamil et al. 2020, Kumar and Sahu 2020). Presence of varieties of insect groups facilitates the food resources for insectivorous bird species The least number of species were nectarivores which matches the findings of (Chatterjee et al. 2018, Katuwal et al. 2018).

Present study found 10 globally threatened species (3 Near Threatened, 5 Vulnerable, 1 Critically Endangered, 1 Endangered). Alexandrine parakeet, Ferruginous Duck and Himalayan Griffon were near threatened whereas Indian spotted eagle, Asian Openbill, Lesser Adjutant, Sarus Crane and Common Pochard were listed as vulnerable species. Steppe Eagle was listed as Endangered species. White-rumped Vulture was categorized as Critically Endangered species.

5.2 Habitat utilization

The bird's population also showed fluctuation within the habitat type. Mixed forest harbored maximum bird population (45.57%). The species diversity of birds was different among the habitat types although some species share the same habitat type. At stopover and staging sites in between, wetlands with high productivity provide critical feeding and resting habitat necessary to complete migration successfully (Ma et al. 2013). Some of the species utilize bush area in the forest like; *Phylloscopus* spp. Some species of *Psittacula* and *Pericrocotus* utilize mixed forest habitat. Habitat use pattern differs with the food resources aviability and their feeding behavior.

Jungle Babbler, Large-billed Crow, Red-vented Bulbul, Ashy Drongo utilize all type of habitat. Due to the resource partitioning, inter specific competition as well as adaptation capacity, some species become generalist and have ability to use different habitat types (Wesolowski and Fuller 2012). The least number of birds were recorded from wetlands as there was limited number of wetlands. Similar result was noted by other studies (Pradhan et al. 2016, Bajagain et al. 2020). Many bird species also have multiple habitat requirements on much smaller spatiotemporal scales (Jackson et al. 2019).

The feeding guild of the species also drives the habitat utilization in bird species. There was no significant association of carnivores with habitat types but with the resource availability. The ordination analysis revealed the significant relationship of frugivore, insectivore, herbivore and omnivore to specific habitats. Grassland supports granivores and carnivores. Granivores are non-forest species and non-opportunistic to food resources, rely on grassalands for food (Gray et al. 2007). Frugivores and nectarivores highly rely on forest for their food resources. Fruit abundance is directly related to frugivore species richness and abundance (Mulwa et al. 2013). Omnivore and herbivore species depend much on wetlands. Insectivore species are the generalist species which

prefer different habitats. Availability of food resources in response to the feeding guild directly affects the patterns of habitat utilization in bird species.

The GLM between the habitat types and species richness shows the significant difference with grassland habitat and wetlands. Grass height, grass cover and density of grasses are strongly associated for the grassland species with the food accessibility (Macías- Duarte et al. 2017). In case of the wetland birds, emergent vegetation cover, open water bodies and combined habitat supports the wetland species (Elliott et al. 2020).

Livestock pressure and human disturbances are the major threats to the bird species in the study area. Number of people present in the study area causes the significant difference in the species richness of birds. It shows when the number of people (both local and tourist) in the habitat decreases there is increase in the species richness. The presence of livestock in the habitat causes the significant decrease in the richness of birds. Adhikari et al. (2019) also described livestock presence and human disturbance were the major threats to birds in CNP. Species richness decreased due to the human disturbance factors like habitat loss, land use change, alien invasion (Murphy and Romanuk 2014). Collection of fodder, forest products and habitat destruction were the major activities of people causing disturbances to bird species.

6. CONCLUSIONS

Lumbini Master Plan Area is one of the areas with habitat heterogeneity consisting grassland, forest, wetlands that facilitates many bird species. This study revealed that 12.5% of the total avian species of Nepal were found in LMPA.

The bird diversity in LMPA showed that there were altogether 994 individuals of 111 species belonging to 15 orders and 41 families during study period in which 79 species were resident and 32 species were winter migratory. Order Passeriformes represent the highest species composition (43.24%) and least was from Suliformes (0.9%). Altogether, 3 species were Near Threatened, 5 were Vulnerable, 1 Endangered, 1 Critically Endangered and 101 species were Least Concerned.

The most utilized habitat was forest with utilization rate of 0.46. Feeding guild of the species also drives the habitat utilization pattern of the avifauna. Carnivores didn't show any significant relationship with habitat types whereas frugivores, herbivores, insectivores and omnivores showed significant relationship with the habitat types. Availability of food resources as well as heterogeneous habitat supports high bird diversity. The study area is composed of heterogeneous habitat that can occupy high bird diversity.

Livestock and human disturbances are the major factors significantly negative effects on species richness as well as abundance. Human related activities like; livestock grazing, collection of fodder, deforestation, collection of forest products, road construction as well as cutting grasses were the major threats to bird's species composition. It is concluded that presence of people is the key factor for degrading the habitat that negatively impacts on the ecological condition of Lumbini Master Plan Area.

7. RECOMMENDATIONS

Since the study was conducted in only one season, complete seasonal variation could not be explored. So, further research should be conducted in all seasons to understand seasonal variation of birds in detail. As the study area is focused only in conservation of Sarus Crane, so management practices should be conducted integrating with other birds with Sarus Crane. There is unmanaged plantation, deforestation, threat from fire as well as rampant waste disposal in the area. So, there is a need for ecological restoration as well as wetland restoration that facilitates wetland bird species too. Strict rules and regulations by Lumbini Development Trust should also be implemented to protect the area from deforestation and habitat destruction of birds.

REFERENCES

Adhikari, J. N., Bhattarai, B. P. and Thapa, T. B. 2019. Factors affecting diversity and distribution of threatened birds in Chitwan National Park, Nepal. Journal of Threatened Taxa **11**:13511-13522.

Alldredge, M. W., Simons, T. R. and Pollock, K. H. 2007. A field evaluation of distance measurement error in auditory avian point count surveys. The Journal of Wildlife Management **71**:2759-2766.

Altaf, M., Javid, A., Khan, A. M., Khan, M., Umair, M. and Ali, Z. 2018. Anthropogenic impact on the distribution of the birds in the tropical thorn forest, Punjab, Pakistan. Journal of Asia-Pacific Biodiversity **11**:229-236.

Anthal, A. and Sahi, D. 2013. Food and feeding ecology of jungle babbler, Turdoides striatus sindianus (Ticehurst) in District Jammu (J&K), India. International Research Journal of Environment Sciences **2**:54-57.

Aynalem, S. and Bekele, A. 2008. Species composition, relative abundance and distribution of bird fauna of riverine and wetland habitats of Infranz and Yiganda at southern tip of Lake Tana, Ethiopia. Tropical Ecology **49**:199.

Azpiroz, A. B. and Blake, J. G. 2016. Associations of grassland birds with vegetation structure in the Northern Campos of Uruguay. The Condor: Ornithological Applications **118**:12-23.

Bajagain, S., Pokhrel, S., Baniya, S., Pradhan, A., Paudel, S. and Joshi, I. D. 2020. Avifaunal diversity of Institute of Forestry Complex, Hetauda Metropolis, Nepal. Forestry: Journal of Institute of Forestry, Nepal **17**:83-101.

Baker, J., Harvey, K. J. and French, K. 2014. Threats from introduced birds to native birds. Emu-Austral Ornithology **114**:1-12.

Baral, H. S.2001. Community structure and habitat associations of lowland grassland birds in Nepal. Universiteit van Amsterdam.

Baral, H. S. 2018. Natural history of Lumbini farmscape: Central lowland Nepal. Himalayan Nature.

Basnet, T. B., Rokaya, M. B., Bhattarai, B. P. and Münzbergová, Z. 2016. Heterogeneous landscapes on steep slopes at low altitudes as hotspots of bird diversity in a Hilly Region of Nepal in the Central Himalayas. Plos One **11**:e0150498.

Batáry, P., Báldi, A. and Erdős, S. 2006. Grassland versus non-grassland bird abundance and diversity in managed grasslands: local, landscape and regional scale effects. Vertebrate Conservation and Biodiversity, Springer: 45-55.

Bibby, C. J., Burgess, N. D., Hill, D. A., Hillis, D. M. and Mustoe, S. 2000. Bird census techniques. Elsevier.

Bilgrami, K.1995. Concept and conservation of biodiversity. CBS Publishers and Distributors, New Delhi. Botanical Survey of India (www …: 1-8.

Bregman, T. P., Sekercioglu, C. H. and Tobias, J. A. 2014. Global patterns and predictors of bird species responses to forest fragmentation: implications for ecosystem function and conservation. Biological Conservation **169**:372-383.

Burel, F., Baudry, J., Butet, A., Clergeau, P., Delettre, Y., Le Coeur, D., Dubs, F., Morvan, N., Paillat, G. and Petit, S. 1998. Comparative biodiversity along a gradient of agricultural landscapes. Acta Oecologica **19**:47-60.

Chatterjee, A., Ghoshal, S., Chowdhury, S. and Chakrabarti, P. 2018. Report of the early winter migrants and resident birds in an inland wetland near Tundi Camp, Bajana, Gujarat. Journal of Threatened Taxa **10**:11652-11658.

Codesido, M., González-Fischer, C. M. and Bilenca, D. N. 2013. Landbird assemblages in different agricultural landscapes: A case study in the pampas of Central argentina: ensambles de aves terrestres en diferentes paisajes rurales: Un Estudio de Caso en las Pampas del Centro de Argentina. The Condor **115**:8-16.

Coppedge, B. R., Fuhlendorf, S. D., Harrell, W. C. and Engle, . M. 2008. Avian community response to vegetation and structural features in grasslands managed with fire and grazing. Biological Conservation **141**:1196-1203.

Correa-Metrio, A., Dechnik, Y., Lozano-Garcia, S. and Caballero, M. 2014. Detrended corresponding analysis: A useful tool to quantify ecological changes from data sets. Boletin de la Sociedad Geologica Mexican **66**:135-143.

Dangaura, H. L., Pandey, N., Chand, D. B. and Bhusal, K. P. 2020. Avian richness of the Basanta Protected Forest, far-western lowland Nepal: Implication for conservation. Nepalese Journal of Zoology **4**:68-84.

Dar, S. A., Bhat, S. U., Rashid, I. and Dar, S. A. 2020. Current status of wetlands in Srinagar City: threats, management strategies, and future perspectives. Frontiers in Environmental Science **7**:199.

Dias, R. A., Bastazini, V. A. and Gianuca, A. T. 2014. Bird-habitat associations in coastal rangelands of southern Brazil. Iheringia. Série Zoologia **104**:200-208.

Elafri, A., Belhamra, M. and Houhamdi, M. 2017. Comparing habitat preferences of a set of waterbird species wintering in the coastal wetlands of North Africa: implication for management. Ekológia (Bratislava) **36**:158-171.

Elliott, L. H., Igl, L. D. and Johnson, D. H. 2020. The relative importance of wetland area versus habitat heterogeneity for promoting species richness and abundance of wetland birds in the Prairie Pothole Region, USA. The Condor **122**:duz060.

Fisher, R. J. and Davis, S. K. 2010. From Wiens to Robel: a review of grassland- bird habitat selection. The Journal of Wildlife Management **74**:265-273.

Fletcher Jr, R. J. and Koford, R. R. 2002. Habitat and landscape associations of breeding birds in native and restored grasslands. The Journal of Wildlife Management 1011-1022.

Gaines, W. L. 1999. Monitoring biodiversity: quantification and interpretation. US Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Garnett, S. T., Butchart, S. H., Baker, G., Bayraktarov, E., Buchanan, K. L., Burbidge, A. A., Chauvenet, A., Christidis, L., Ehmke, G. and Grace, M. 2019. Metrics of progress in the understanding and management of threats to Australian birds. Conservation Biology **33**:456-468.

Gaston, K. J. 1994. What is rarity? Rarity, Springer: 1-21.

Gillies, C. S. and St. Clair, C. C. 2010. Functional responses in habitat selection by tropical birds moving through fragmented forest. Journal of Applied Ecology **47**:182-190.

Girma, Z., Mamo, Y., Mengesha, G., Verma, A. and Asfaw, T. 2017. Seasonal abundance and habitat use of bird species in and around Wondo Genet Forest, south- central Ethiopia. Ecology and evolution **7**:3397-3405.

Grand, J., Wilsey, C., Wu, J. X. and Michel, N. L. 2019. The future of North American grassland birds: Incorporating persistent and emergent threats into full annual cycle conservation priorities. Conservation Science and Practice **1**:e20.

Gray, M. A., Baldauf, S. L., Mayhew, P. J. and Hill, J. K. 2007. The response of avian feeding guilds to tropical forest disturbance. Conservation Biology **21**:133-141.

Grimmett, R., Inskipp, C., Inskipp, T. and Baral, H. 2016. Birds of Nepal, Revised edn. Christopher Helm, London

Grimmett, R., Inskipp, C., Inskipp, T. and Baral, H. S. 2016. Birds of Nepal. Bloomsbury Publishing.

Guo, F., Lenoir, J. and Bonebrake, T. C. 2018. Land-use change interacts with climate to determine elevational species redistribution. Nature communications **9**:1-7.

Hammer, Ø., Harper, D. A. and Ryan, P. D. 2001. PAST: Paleontological statistics software package for education and data analysis. Palaeontologia electronica **4**:9.

Inskipp, C., Baral, H., Phuyal, S., Bhatt, T., Khatiwada, M., Inskipp, T., Khatiwada, A., Gurung, S., Singh, P. and Murray, L. 2016. The status of Nepal's birds: the national red list series. Zoological Society of London, UK **628**:

Inskipp, C., Baral, H. S., Inskipp, T., Khatiwada, A. P., Khatiwada, M. P., Poudyal, L. P. and Amin, R. 2017. Nepalâ€™s National Red List of Birds. Journal of Threatened Taxa **9**:9700-9722.

Inskipp, C., Baral, H. S., Inskipp, T. and Stattersfield, A. 2013. The state of Nepal birds 2010. Journal of Threatened Taxa **5**:3473-3503.

Issa, M. A. A. 2019. Diversity and abundance of wild birds species' in two different habitats at Sharkia Governorate, Egypt. The Journal of Basic and Applied Zoology **80**:1-7.

Jackson, M. V., Carrasco, L. R., Choi, C. Y., Li, J., Ma, Z., Melville, D. S., Mu, T., Peng, H. B., Woodworth, B. K. and Yang, Z. 2019. Multiple habitat use by declining migratory birds necessitates joined- up conservation. Ecology and evolution **9**:2505-2515.

Jacoboski, L. I., Paulsen, R. K. and Hartz, S. M. 2017. Bird-grassland associations in protected and non-protected areas in southern Brazil. Perspectives in Ecology and Conservation **15**:109-114.

Jamil, N. N. M., Ibrahim, H., Zain, H. H. M. and Musa, N. H. C. 2020. Species diversity and feeding guilds of birds in Malaysian agarwood plantations. Journal of Threatened Taxa **12**:16954-16961.

Jones, J. 2001. Habitat selection studies in avian ecology: a critical review. The Auk **118**:557-562.

Katuwal, H. B., Pradhan, N. M. B., Thakuri, J. J., Bhusal, K. P., Aryal, P. C. and Thapa, I. 2018. Effect of urbanization and seasonality in bird communities of Kathmandu Valley, Nepal. Proceedings of the Zoological Society, Springer.

Khatri, N. D., Neupane, B., Timilsina, Y. P. and Ghimire, S. 2019. Assessment of avifaunal diversity and threats to them in Phewa Wetland, Nepal. Forestry: Journal of Institute of Forestry, Nepal **16**:31-47.

Kiros, S., Afework, B. and Legese, K. 2018. A preliminary study on bird diversity and abundance from Wabe fragmented forests around Gubre subcity and Wolkite town, Southwestern Ethiopia. International Journal of Avian & Wildlife Biology **3**:333-340.

Kumar, P. and Sahu, S. 2020. Composition, diversity and foraging guilds of avifauna in agricultural landscapes In Panipat, Haryana, India. Journal of Threatened Taxa **12**:15140-15153.

Lafortune-Bernard, A. and Weise, K. 2020. Religious tourism and environmental conservation in Lumbini, the birthplace of Lord Buddha, world heritage site, Nepal. Religious Tourism and the Environment 83-94.

Ma, Z., Hua, N., Peng, H., Choi, C., Battley, P. F., Zhou, Q., Chen, Y., Ma, Q., Jia, N. and Xue, W. 2013. Differentiating between stopover and staging sites: functions of the southern and northern Yellow Sea for long- distance migratory shorebirds. Journal of Avian Biology **44**:504-512.

MacGregor-Fors, I. and Schondube, J. E. 2011. Gray vs. green urbanization: relative importance of urban features for urban bird communities. Basic and Applied Ecology **12**:372-381.

Macías- Duarte, A., Panjabi, A. O., Strasser, E. H., Levandoski, G. J., Ruvalcaba-Ortega, I., Doherty, P. F. and Ortega- Rosas, C. I. 2017. Winter survival of North American grassland birds is driven by weather and grassland condition in the Chihuahuan Desert. Journal of Field Ornithology **88**:374-386.

Matuoka, M. A., Benchimol, M., de Almeida-Rocha, J. M. and Morante-Filho, J. C. 2020. Effects of anthropogenic disturbances on bird functional diversity: A global meta-analysis. Ecological Indicators **116**:106471.

Menon, M. and Rangaswamy, M. 2016. Avifaunal richness and abundance along an urban rural gradient with emphasis on vegetative and anthropogenic attributes in Tiruchirappalli, India. Landscape Research **41**:131-148.

Mishra, H., Kumar, V. and Kumar, A. 2020. Population structure and habitat utilization of migratory birds at Bakhira bird sanctuary, Uttar Pradesh, India. Pakistan Journal of Zoology **52**:247.

Mulwa, R. K., Neuschulz, E. L., Böhning- Gaese, K. and Schleuning, M. 2013. Seasonal fluctuations of resource abundance and avian feeding guilds across forest–farmland boundaries in tropical Africa. Oikos **122**:524-532.

Murphy, G. E. and Romanuk, T. N. 2014. A meta- analysis of declines in local species richness from human disturbances. Ecology and evolution **4**:91-103.

Nagarajan, R. and Thiyagesan, K. 1996. Waterbirds and substrate quality of the Pichavaram wetlands, southern India. Ibis **138**:710-721.

Neupane, J., Khanal, L., Gyawali, B. and Chalise, M. K. 2020. Elevational pattern and seasonality of avian diversity in Kaligandaki River Basin, central Himalaya. Journal of Threatened Taxa **12**:16927-16943.

Nocera, J., Forbes, G. and Milton, G. R. 2007. Habitat relationships of three grassland breeding bird species: broadscale comparisons and hayfield management implications. Avian Conservation and Ecology **2**:

Pandey, N., Khanal, L. and Chalise, M. K. 2020. Correlates of avifaunal diversity along the elevational gradient of Mardi Himal in Annapurna Conservation Area, Central Nepal. Avian Research **11**:1-14.

Paudel, S. 2009. Study on threats to Sarus Crane Grus antigone antigone in farmlands in Lumbini, an Important Bird Area of Nepal–AEC/OBC Award 2007. BirdingASIA **12**:9-10.

Pradhan, A., Mishra, S. and Behera, N. 2016. Avian diversity in a sacred natural forest site in Odisha. The Ecoscan **10**:91-95.

Robledano, F., Esteve, M. A., Farinós, P., Carreño, M. F. and Martínez-Fernández, J. 2010. Terrestrial birds as indicators of agricultural-induced changes and associated loss in conservation value of Mediterranean wetlands. Ecological Indicators **10**:274-286.

Rupakheti, D., Adhikary, B., Praveen, P. S., Rupakheti, M., Kang, S., Mahata, K. S., Naja, M., Zhang, Q., Panday, A. K. and Lawrence, M. G. 2017. Pre-monsoon air quality over Lumbini, a world heritage site along the Himalayan foothills. Atmospheric Chemistry and Physics **17**:11041-11063.

Sekercioglu, C. H. 2006. Handbook of Birds of the World. Old World Flycatchers to Old World Warblers. Barcelona: Lynx Edicions **11**:84-9655306.

Sethy, J., Samal, D., Sethi, S., Baral, B., Jena, S., Payra, A., Das, G., Boruah, B. and Sahu, H. 2015. Species diversity and abundance of birds in and around North Orissa University, Takatpur, Baripada, Mayurbhanj, Odisha. Species Diversity **4**:

Seymour, C. and Simmons, R. 2008. Can severely fragmented patches of riparian vegetation still be important for arid-land bird diversity? Journal of Arid Environments **72**:2275-2281.

Sheta, B., Orabi, G., Bedir, M., El-bokl, M. and Habbk, L. 2011. Impact of some anthropogenic activities on the diversity of resident bird species at Damietta Region, Egypt. Catrina: The International Journal of Environmental Sciences **6**:59-74.

Singh, J., Antil, S., Goyal, V. and Malik, V. 2020. Avifaunal diversity of Tilyar Lake, Rohtak, Haryana, India. Journal of Threatened Taxa **12**:15909-15915.

Siwakoti, M. 2008. A checklist of angiospermic flora in and around the Lumbini Sacred Garden, Nepal. Journal of Natural History Museum **23**:27-44.

Supriatna, J. 2018. Biodiversity Indexes: Value and Evaluation Purposes. E3S Web of Conferences, EDP Sciences.

Talbi, A., Samraoui, F., Samraoui, B., Zullo, F. and Battisti, C. 2020. Habitat selection of Coot (Fulica atra) and Moorhen (Gallinula chloropus) in a remnant Mediterranean wetland (Italy): Implications for conservation. Lakes & Reservoirs: Research & Management

Tanalgo, K. C., Pineda, J. A. F., Agravante, M. E. and Amerol, Z. M. 2015. Bird diversity and structure in different land-use types in lowland south-central Mindanao, Philippines. Tropical life sciences research **26**:85.

Tarbox, B. C., Robinson, S. K., Loiselle, B. and Flory, S. L. 2018. Foraging ecology and flocking behavior of insectivorous forest birds inform management of Andean

silvopastures for conservation. The Condor: Ornithological Applications **120**:787-802.

Ter Braak, C. t. and Smilauer, P. 1998. CANOCO reference manual and user's guide to Canoco for Windows: software for canonical community ordination (version 4).

Uprety, Y., Chettri, N., Dhakal, M., Asselin, H., Chand, R. and Chaudhary, R. P. 2021. Illegal wildlife trade is threatening conservation in the transboundary landscape of Western Himalaya. Journal for Nature Conservation **59**:125952.

Urfi, A. 2011. Climate change and its impacts on Indian birds: monsoon phenology and monitoring heronry birds. Current Science **101**:1140-1142.

Vitz, A. C. and Rodewald, A. D. 2007. Vegetative and fruit resources as determinants of habitat use by mature-forest birds during the postbreeding period. The Auk **124**:494-507.

Waltert, M., Mardiastuti, A. and Mühlenberg, M. 2004. Effects of land use on bird species richness in Sulawesi, Indonesia. Conservation Biology **18**:1339-1346.

Weiher, E., Clarke, G. P. and Keddy, P. A. 1998. Community assembly rules, morphological dispersion, and the coexistence of plant species. Oikos 309-322.

Wesolowski, T. and Fuller, R. J. 2012. Spatial variation and temporal shifts in habitat use by birds at the European scale. Birds and habitat: relationships in changing landscapes 63.

Woo-Durand, C., Matte, J.-M., Cuddihy, G., McGourdji, C. L., Venter, O. and Grant, J. W. 2020. Increasing importance of climate change and other threats to at-risk species in Canada. Environmental Reviews **28**:449-456.

Wu, H., Chen, J., Zeng, G., Xu, J., Sang, L., Liu, Q., Dai, J., Xiong, W., Yuan, Z. and Wang, Y. 2020. Effects of early dry season on habitat suitability for migratory birds in China's two largest freshwater lake wetlands after the impoundment of Three Gorges Dam. Journal of Environmental Informatics **36**:

Xu, X., Xie, Y., Qi, K., Luo, Z. and Wang, X. 2018. Detecting the response of bird communities and biodiversity to habitat loss and fragmentation due to urbanization. Science of the Total Environment **624**:1561-1576.

Zakaria, M., Martins, C., Rajpar, N. and Olaniyi, E. 2020. Comparison of interrelationship with site occupancy, population structure and foraging ecology of lesser whistling duck. Dendrocygna javanica 79-84.

Zhao, F., Zhou, L., Xu, W., Zhao, F., Zhou, L. and Xu, W. 2013. Habitat utilization and resource partitioning of wintering Hooded Cranes and three goose species at Shengjin Lake. Chinese Birds **4**:281-290.

APPENDICES

1. Checklist of birds in study area with their family and order

English name	Scientific name	Order	Family
Lesser Whistling Duck	*Dendrocygna javanica*	Anseriformes	Anatidae
Ruddy Shelduck	*Tadorna ferruginea*	Anseriformes	Anatidae
Red-crested Pochard	*Netta rufina*	Anseriformes	Anatidae
Common Pochard	*Aythya ferina*	Anseriformes	Anatidae
Ferruginous Duck	*Aythya nyroca*	Anseriformes	Anatidae
Gadwall	*Mareca strepera*	Anseriformes	Anatidae
Mallard	*Anas poecilorhyncha*	Anseriformes	Anatidae
Common Teal	*Anas crecca*	Anseriformes	Anatidae
Common Pigeon	*Columba livia*	Columbiformes	Columbidae
Spotted Dove	*Stigmatopelia chinensis*	Columbiformes	Columbidae
Eurasian-collared Dove	*Streptopelia decaocto*	Columbiformes	Columbidae
Yellow-footed Green Pegion	*Treron apcauda*	Columbiformes	Columbidae
Greater Coucal	*Centropus sinensis*	Cuculiformes	Cuculidae
Lesser Coucal	*Centropus bengalensis*	Cuculiformes	Cuculidae
White-breasted Waterhen	*Amaurornis phoenicurus*	Gruiformes	Rallidae
Purple Swamphen	*Porphyrio porphyria*	Gruiformes	Rallidae
Common Moorhen	*Gallinula chloropus*	Gruiformes	Rallidae
Common Coot	*Fulica atra*	Gruiformes	Rallidae
Sarus Crane	*Antigone Antigone*	Gruiformes	Gruidae
Lesser Adjutant	*Leptoptilos javanicus*	Ciconiformes	Ciconiidae
Asian Openbill	*Anastomus oscitans*	Ciconiformes	Ciconiidae
Black Stork	*Ciconia ciconia*	Ciconiformes	Ciconiidae
Red-naped Ibis	*Pseudibis papillosa*	Pelicaniformes	Threskiornithidae
Black-crowned Night-heron	Nycticorax nycticorax	Pelicaniformes	Ardeidae
Indian Pond-heron	*Ardeola grayii*	Pelicaniformes	Ardeidae
Cattle Egret	*Bubulcus ibis*	Pelicaniformes	Ardeidae
Grey Heron	*Ardea cineria*	Pelicaniformes	Ardeidae
Purple Heron	*Ardea purpurea*	Pelicaniformes	Ardeidae
Great White Egret	*Ardea alba*	Pelicaniformes	Ardeidae
Intermediate Egret	*Ardea intermedia*	Pelicaniformes	Ardeidae
Little Egret	*Egretta garzetta*	Pelicaniformes	Ardeidae
Little Cormorant	*Microcarbo niger*	Suliformes	Phalacrocoracidae
Grey-headed Lapwing	*Vanellus cinereus*	Charadriiformes	Charadiidae
Red-wattled Lapwing	*Vanellus indicus*	Charadriiformes	Charadiidae
Bronze-winged Jacana	*Metopidius indicus*	Charadriiformes	Jacanidae
Common Greenshank	*Tringa nebularia*	Charadriiformes	Scolopacidae

Jungle Owlet	*Glaucidium radiatum*	Strigiformes	Strigidae
Spotted Owlet	*Athrene brama*	Strigiformes	Strigidae
Black-winged Kite	*Elanus caeruleus*	Accipitriformes	Accipitridae
Crested Serpent Eagle	*Spilornis cheela*	Accipitriformes	Accipitridae
Himalayan Griffon	*Gyps himalayensis*	Accipitriformes	Accipitridae
White-rumped Vulture	*Gyps bengalensis*	Accipitriformes	Accipitridae
Indian Spotted Eagle	*Clanga hastata*	Accipitriformes	Accipitridae
Steppe Eagle	*Aquila nipalensis*	Accipitriformes	Accipitridae
Pied Harrier	*Circus melanoleucos*	Accipitriformes	Accipitridae
Black Kite	*Milvus migrans*	Accipitriformes	Accipitridae
White-eyed Buzzard	*Butastur teesa*	Accipitriformes	Accipitridae
Himalayan Buzzard	*Buteo refectus*	Accipitriformes	Accipitridae
Common Hoopoe	*Upupa epops*	Bucerotiformes	Upupidae
Indian Grey Hornbill	*Ocyceros birostris*	Bucerotiformes	Bucerotidae
Asian Green-beeeater	*Merops orientalis*	Coraciformes	Meropidae
Indian Roller	*Coracius bengalensis*	Coraciformes	Coraciidae
Common Kingfisher	*Alcedo atthis*	Coraciformes	Alcedinidae
White-throated Kingfisher	*Halcyon smyrnensis*	Coraciformes	Alcedinidae
Brown-headed Barbet	*Psilopogon zeylanicus*	Piciformes	Megalaimidae
Copper Smithbarbet	*Psilopogon haemacephalus*	Piciformes	Megalaimidae
Black-rumped Flameback	*Dinopium benghalense*	Piciformes	Picidae
Yellow-crowned Woodpeacker	*Dendrocopus mahrattensis*	Piciformes	Picidae
Brown Capped Pygmy Woodpeacker	*Dendrocopus nanus*	Piciformes	Picidae
Slaty-headed Parakeet	*Psittacula himalayana*	Psittaciformes	Psittacidae
Plum-headed Parakeet	*Psittacula cyanocephala*	Psittaciformes	Psittacidae
Rose-ringed Parakeet	*Psittacula krameri*	Psittaciformes	Psittacidae
Alexandrine Parakeet	*Psittacula eupatria*	Psittaciformes	Psittacidae
Black-hooded Oriole	*Oriolus xanthornus*	Passeriformes	Oroilidae
Long-tailed Minivet	*Pericrocotus ethologus*	Passeriformes	Campephagidae
Scarlet Minivet	*Pericrocotus flammeus*	Passeriformes	Campephagidae
Indian Cuckoo-shrike	*Coracina macei*	Passeriformes	Campephagidae
Black Drongo	*Dicrurus macrocerus*	Passeriformes	Dicruridae
Ashy Drongo	*Dicrurus leucophaeus*	Passeriformes	Dicruridae
White-bellied Drongo	*Dicrurus caerulescens*	Passeriformes	Dicruridae
Brown Shrike	*Lanius cristatus*	Passeriformes	Laniidae
Long-tailed Shrike	*Lanius schach*	Passeriformes	Laniidae
Grey-backed Shrike	*Lanius tephronotus*	Passeriformes	Laniidae
Rufous Treepie	*Dendrocitta vagabunda*	Passeriformes	Corvidae
House Crow	*Corvus splendens*	Passeriformes	Corvidae
Large-billed Crow	*Corvus culminatus*	Passeriformes	Corvidae

Great Tit	*Parus major*	Passeriformes	Paridae
Yellow-bellied Prinia	*Prinia flaviventris*	Passeriformes	Cristicolidae
Ashy Prinia	*Prinia socialis*	Passeriformes	Cristicolidae
Plain Prinia	*Prinia inornata*	Passeriformes	Cristicolidae
Common Tailorbird	*Orthotomus sutorius*	Passeriformes	Cristicolidae
Blyth's-reed Warbler	*Acrocephalus dumetorum*	Passeriformes	Acrocephalidae
Red-whiskered Bulbul	*Pycnonotus jocosus*	Passeriformes	Pycnonotidae
Red-vented Bulbul	*Pycnonotus cafer*	Passeriformes	Pycnonotidae
Common Chiffchaff	*phylloscopus collybita*	Passeriformes	Phylloscopidae
Tickell's Leaf-warbler	*Phylloscopus affinis*	Passeriformes	Phylloscopidae
Greenish Warbler	*Phylloscopus trochiloides*	Passeriformes	Phylloscopidae
Jungle Babbler	*Turdoides striata*	Passeriformes	leiotrichidae
Chestnut-bellied Nuthatch	*Sitta cinnamoventris*	Passeriformes	Sittidae
Asian-pied Starling	*Gracupica contra*	Passeriformes	Sturnidae
Brahminy Starling	*Sturnia pagodarum*	Passeriformes	Sturnidae
Chestnut-tailed Starling	*Sturnia malabarica*	Passeriformes	Sturnidae
Common Myna	*Acridotheres tristis*	Passeriformes	Sturnidae
Jungle Myna	*Acridotheres fuscus*	Passeriformes	Sturnidae
Black-throated Thrush	*Turdus atrogularis*	Passeriformes	Turdidae
Oriental-magpie Robin	*Copsychus saularis*	Passeriformes	Muscipidae
Taiga Flycatcher	*Ficedula albicilla*	Passeriformes	Muscipidae
Pied Bushchat	*Saxicola caprata*	Passeriformes	Muscipidae
Common Stonechat	*Saxicola torquatus*	Passeriformes	Muscipidae
Brown Rockchat	*Oenanthe fusca*	Passeriformes	Muscipidae
Purple Sunbird	*Cinnyris asiaticus*	Passeriformes	Nectariniidae
Red Avadavat	*Amandava amandava*	Passeriformes	Estrildidae
Scaly-breasted Munia	*Lonchura punctulata*	Passeriformes	Estrildidae
House Sparrow	*Passer domesticus*	Passeriformes	Passeridae
Eurasian-tree Sparrow	*Passer montanus*	Passeriformes	Passeridae
Tree Pipit	*Anthus trivialis*	Passeriformes	Motacillidae
Olive-backed Pipit	*Anthus hodgsoni*	Passeriformes	Motacillidae
Paddy Field Pipit	*Anthus rufulus*	Passeriformes	Motacillidae
Grey Wagtail	*Montacilla cinerea*	Passeriformes	Motacillidae
White-browed Wagtail	*Montacilla maderaspatensis*	Passeriformes	Motacillidae
White Wagtail	*Montacilla alba*	Passeriformes	Motacillidae

2. Species code of birds with status, feeding guild and IUCN category

English name	Species code	Status	Feeding guild	IUCN Status
Lesser Whistling Duck	S1	R	Herbivore	LC
Ruddy Shelduck	S2	W	Herbivore	LC
Red-crested Pochard	S3	W	Herbivore	LC
Common Pochard	S4	W	Omnivore	VU
Ferruginous Duck	S5	W	Omnivore	VU
Gadwall	S6	W	Herbivore	LC
Mallard	S7	W	Omnivore	LC
Common Teal	S8	W	Omnivore	LC
Common Pigeon	S9	R	Granivores	LC
Spotted dove	S10	R	Granivores	LC
Eurasian-collared Dove	S11	R	Granivores	LC
Yellow-footed Green Pegion	S12	R	Frugivore	LC
Greater Coucal	S13	R	Carnivore	LC
Lesser Coucal	S14	R	Carnivore	LC
White-breasted Waterhen	S15	R	Omnivore	LC
Purple Swamphen	S16	R	Omnivore	LC
Common Moorhen	S17	W	Omnivore	LC
Common Coot	S18	W	Omnivore	LC
Sarus Crane	S19	R	Omnivore	VU
Lesser Adjutant	S20	R	Carnivore	VU
Asian Openbill	S21	R	Carnivore	VU
Black Stork	S22	W	Carnivore	LC
Red-naped Ibis	S23	R	Omnivore	LC
Black-crowned Night-heron	S24	R	Carnivore	LC
Indian Pond Heron	S25	R	Carnivore	LC
Cattle Egret	S26	R	Carnivore	LC
Grey Heron	S27	W	Carnivore	LC
Purple Heron	S28	R	Carnivore	LC
Great White Egret	S29	R	Carnivore	LC
Intermediate Egret	S30	R	Carnivore	LC
Little Egret	S31	R	Carnivore	LC
Little Cormorant	S32	R	Carnivore	LC
Grey-headed Lapwing	S33	W	Carnivore	LC
Red-wattled Lapwing	S34	R	Carnivore	LC
Bronze-winged Jacana	S35	R	Insectivore	LC
Common Greenshank	S36	W	Insectivore	LC
Jungle Owlet	S37	R	Carnivore	LC
Spotted Owlet	S38	R	Carnivore	LC
Black-winged Kite	S39	R	Carnivore	LC

Crested-serpent Eagle	S40	R	carnivore	LC
Himalayan Griffon	S41	W	Carnivore	VU
White-rumped Vulture	S42	R	Carnivore	CR
Indian Spotted Eagle	S43	R	Carnivore	VU
Steppe Eagle	S44	W	Carnivore	EN
Pied Harrier	S45	W	Carnivore	VU
Black Kite	S46	R	Carnivore	LC
White-eyed Buzzard	S47	R	Carnivore	LC
Himalayan Buzzard	S48	W	Carnivore	LC
Common Hoopoe	S49	R	Insectivore	LC
Indian Grey Hornbill	S50	R	Omnivore	LC
Asian Green-beeeater	S51	R	Insectivore	LC
Indian Roller	S52	R	Carnivore	LC
Common Kingfisher	S53	R	Carnivore	LC
White-throated Kingfisher	S54	R	Carnivore	LC
Brown-headed Barbet	S55	R	Frugivore	LC
Copper Smithbarbet	S56	R	Frugivore	LC
Black-rumped Flameback	S57	R	Insectivore	LC
Yellow-crowned Woodpeacker	S58	R	Insectivore	LC
Brown-capped Pygmy Woodpeacker	S59	R	Insectivore	LC
Slaty-headed Parakeet	S60	R	Frugivore	LC
Plum-headed Parakeet	S61	R	Frugivore	LC
Rose-ringed Parakeet	S62	R	Frugivore	LC
Alexandrine Parakeet	S63	R	Frugivore	NT
Black-hooded Oriole	S64	R	Omnivore	LC
Long-tailed Minivet	S65	W	Insectivore	LC
Scarlet Minivet	S66	R	Insectivore	LC
Indian Cuckoo-shrike	S67	R	Insectivore	LC
Black Drongo	S68	R	Insectivore	LC
Ashy Drongo	S69	W	Insectivore	LC
White-bellied Drongo	S70	R	Insectivore	LC
Brown Shrike	S71	W	Insectivore	LC
Long-tailed Shrike	S72	R	Carnivore	LC
Grey-backed Shrike	S73	W	Carnivore	LC
Rufous Treepie	S74	R	Frugivore	LC
House Crow	S75	R	Omnivore	LC
Large-billed Crow	S76	R	Omnivore	LC
Great Tit	S77	R	Insectivore	LC
Yellow-bellied Prinia	S78	R	Insectivore	LC
Ashy Prinia	S79	R	Insectivore	LC
Plain Prinia	S80	R	Insectivore	LC
Common Tailorbird	S81	R	Insectivore	LC
Blyth's Reed-warbler	S82	W	Insectivore	LC

Red-whiskered Bulbul	S83	R	Omnivores	LC
Red-vented Bulbul	S84	R	Omnivores	LC
Common Chiffchaff	S85	W	Insectivore	LC
Tickell's Leaf-warbler	S86	W	Insectivore	LC
Greenish Warbler	S87	W	Insectivore	LC
Jungle Babbler	S88	R	Omnivore	LC
Chestnut-bellied Nuthatch	S89	R	Insectivore	LC
Asian-pied Starling	S90	R	Omnivore	LC
Brahminy Starling	S91	R	Omnivore	LC
Chestnut-tailed Starling	S92	R	Omnivore	LC
Common Myna	S93	R	Omnivore	LC
Jungle Myna	S94	R	Omnivore	LC
Black-throated Thrush	S95	W	Omnivore	LC
Oriental-magpie Robin	S96	R	Omnivore	LC
Taiga Flycatcher	S97	W	Insectivore	LC
Pied Bushchat	S98	R	Insectivore	LC
Common Stonechat	S99	W	Insectivore	LC
Brown Rockchat	S100	R	Insectivore	LC
Purple Sunbird	S101	R	Nectarivores	LC
Red Avadavat	S102	R	Granivores	LC
Scaly-breasted Munia	S103	R	Granivores	LC
House Sparrow	S104	R	Granivores	LC
Eurasian-tree Sparrow	S105	R	Granivores	LC
Tree Pipit	S106	W	Insectivore	LC
Olive-backed Pipit	S107	W	Insectivore	LC
Paddy Field Pipit	S108	R	Insectivore	LC
Grey Wagtail	S109	W	Insectivore	LC
White-browed Wagtail	S110	R	Insectivore	LC
White Wagtail	S111	W	Insectivore	LC

R=Resident, W=Winter visitor, LC=Least Concern, NT= Near Threatened, VU= Vulnerable, CR= Critically Endangered.

PHOTOPLATES

Asian Openbill

Ashy Prinia

Alexandrine Parakeet

Black Crowned Night Heron

Black Kite

Black- rumped Flameback

Black-throated Thrush

Black Winged Kite

Blyth's Reed Warbler

Brown-capped Pygmy Woodpecker

Brown Headed Barbet

Brown Shrike

Common Greenshank

Common Kingfisher

Common Stonechat

Crested Serpent Eagle

Indian Spotted Eagle

Ferruginous Duck

Grey Heron

Himalayan Buzzard

Himalayan Griffon

Jungle Owlet

Lesser Adjutant

Olive-backed Pipit

Plum-headed Parakeet

Purple Heron

Purple Sunbird

Red-crested Pochard

Sarus Crane

Yellow-footed Green Pigeon