Diversity and Seasonal Variation of Avifauna along the Eastern Rapti River, Hetauda, Nepal

Nikeet Pradhan

Received: 23 May 2024 Revised: 6 November 2025 Accepted: 23 November 2025 Published: 31 January 2026

Seasonal fluctuations significantly impact bird species diversity and community composition. This study was conducted in the eastern Rapti river, Nepal during winter and summer seasons to explore bird diversity in different seasons. The line transect method was adopted for this study. Altogether 21 transects were placed, and 110 bird species were recorded. According to the Shannon-Weiner diversity index, greater avian richness and diversity was recorded in the winter season than the summer season. In contrast, bird species were evenly distributed during the summer season than the winter season. The order passeriformes, and guild insectivorous had the highest number of bird species, and resident species were the most prominent. One of the notable sightings in this study was the record of Watercock (*Gallicrex cinerea)* for the Makwanpur District, Nepal. This study provided an overall checklist of bird species in the region, laying out baseline data on the area's avifauna to aid and guide future studies. The Eastern Rapti river provides a unique habitat for bird species and requires a conservation management plan to protect the birds and their habitat.

Keywords: Bird Migration; Feeding Guilds; Line Transect; Riparian Habitat; Riverscapes; Waterfowl.

Wetlands are natural resources that are crucial to the economy, culture, research, and education (Dudgeon et al., 2006); equally, a refuge for a significant portion of biodiversity. Birds and other wildlife populations rely heavily on wetlands, which are home to over 40% of avian species worldwide (Kumar, 2005). In the context of Asia, wetlands sustain more than 20% of endangered bird species, including migratory and resident (Paracuellos, 2006; Grimmett et al., 2014). Rivers are key dispersing paths, refuges, breeding, and nesting locations, and maintain a high variety of bird species (Sinha et al., 2019). Contrary to the fact, numerous human alterations and developmental processes in riverscapes in the present day influence the diversity, richness and seasonal variation of avifauna and their habitats, making these sites the world's most vulnerable ecosystems (Revenga et al., 2005; Bastola et al., 2022). Inadequate conservation management of these riverscapes is exacerbated by a lack of ornithological data, which makes it challenging to figure out how human activity is affecting bird diversity (Singh, 2022).

Nepal is rich in flora and fauna due to its varied geography despite its small territorial coverage in the world. A total of 892 bird species are recorded in Nepal, with 42 globally threatened, 172 nationally threatened, and 100 listed in the CITES Appendices (DNPWC & BCN, 2022), and new species records are still increasing.

The Eastern Rapti River in Hetauda has limited data on bird diversity, seasonal variation, abundance, and habitat preferences, which are crucial baseline information required to formulate conservation efforts. Several studies have been undertaken in several river landscapes of the country (Khadka et al., 2017; Neupane et al., 2020; Shrestha et al., 2021; Parajuli, 2022), revealing their relevance for ecosystem and biodiversity conservation; nevertheless, the Eastern Rapti River, as one of the major rivers, has not been studied for bird diversity and seasonal fluctuation. So, documenting birds in these areas is crucial for future evaluation of habitat kinds and conditions. The purpose of this research is to create a record of the bird species in

Faculty of Forestry, Agriculture and Forestry University, Makwanpur, Hetauda, Nepal
Email: nikeetpradhan13@gmail.com

the Eastern Rapti River basin, tracking how their populations change with the seasons and evaluating their current conservation status.

Materials and Methods

Study area

The study was conducted in the Eastern Rapti River within Hetauda Sub-metropolitan City, Bagmati Province, Nepal (27°27.159'N, 84°56.009'E). According CBS (2017), the site has an average annual temperature of 22.7°C and precipitation of 2474 mm, where elevation is 450 meters above Mean Sea Level (MSL). The Eastern Rapti River was associated with farmlands and settlements, which were dominant in the southwest part, and were relatively close to the urban areas. The northeast side of the river had an association with forest and reed habitats, with dominant tree species being *Dalbergia sissoo* and *Trewia nudiflora*, while the dominating perennial grass species was *Saccharum spontaneum* (Figure 1). Along the stretch of the river, there was excessive illegal extraction of the riverbed materials, predominantly in the northeast region.

Data collection

The line transect method was applied, which is an adaptive and effective way for surveying birds with low density, offshore seabirds, and water birds (Bibby et al., 2000; Sutherland, 2006). The total stretch of the Eastern Rapti River is 17.6 km, which was divided into 21 transects, each of which were 500 m in length from the riverbank and spaced at 250m apart, as shown in Figure 1. To avoid habitat overlap and double-counting birds, this strategy was used.

The 250-meter distance represented the normal visual range in plain terrain and provided appropriate spacing between transects. This technique successfully balances habitat representation, detection efficacy, and spatial coverage. The research was conducted for a total of 32 days, in the winter season (January to February 2023) for 16 days from 0700-1030 h and the summer season (June to July 2023) for 16 days from 0600-1000 h.

Bird watching was done using the Nikon Acculon binoculars of magnification 8×42, and the Nikon

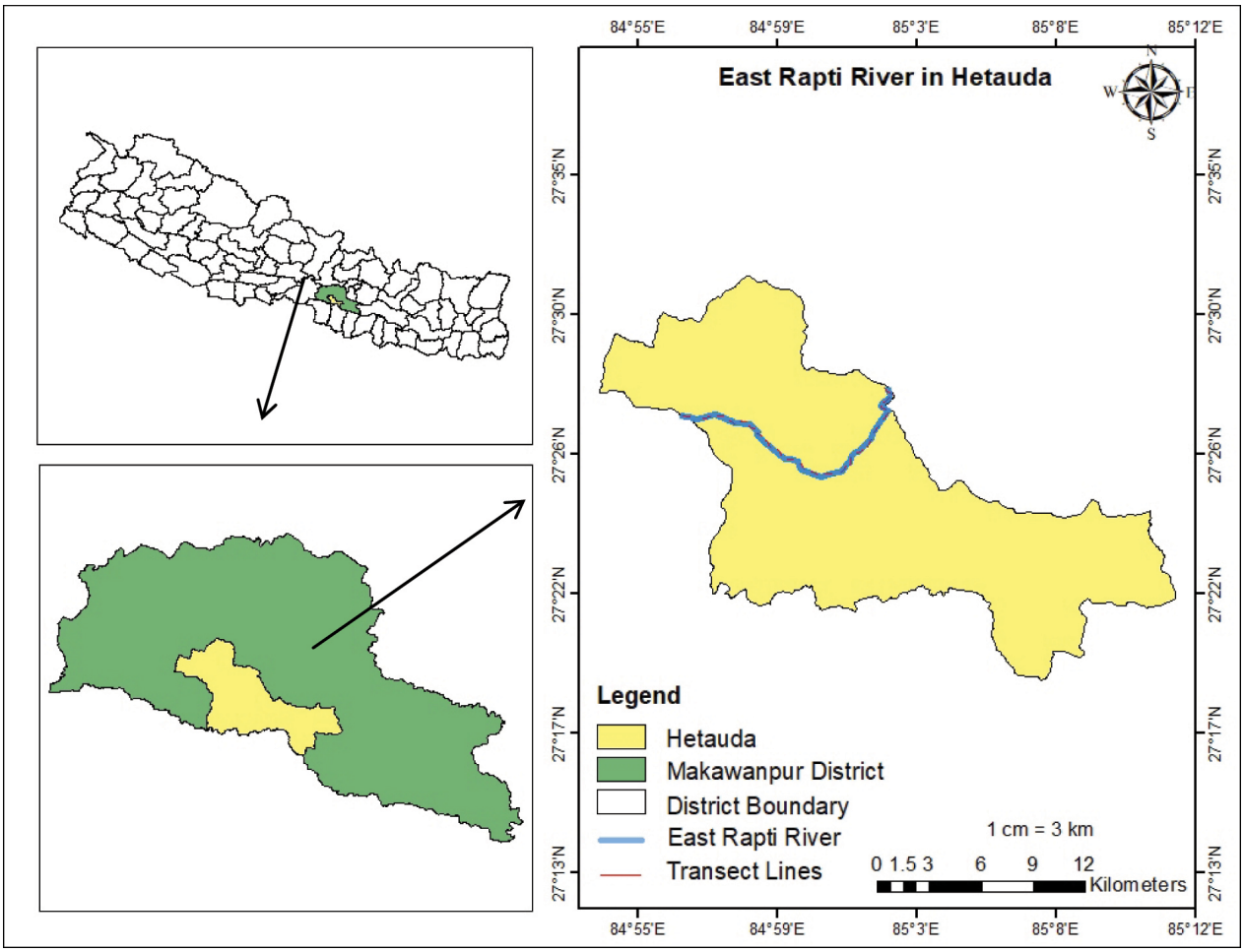

Figure 1: Study Area Map of Eastern Rapti River stretch in Hetauda Sub-Metropolitan City, Makwanpur District, Nepal

D7000 camera was used to photograph birds. Additionally, bird identification was done following the Birds of Nepal book (Grimmett et al., 2016). Geographical coordinates were marked in the Garmin eTrex10 Worldwide Handheld GPS navigator. Bird nomenclature and conservation status were assigned following the National Red List assessment (DNPWC & BCN, 2022) and Global assessment (IUCN, 2025).

Data analysis

The collected data were evaluated using MS Excel and examined using the following methods:

a) Shannon-Wiener diversity (Shannon-Wiener et al., 1949):

$$H = -\sum_{i=1}^{N} P_i ln P_i$$

b) Margalef's Richness Index (Margalef, 1958):

$$R = \frac{S-1}{lnN}$$

c) Pielou's species evenness (Pielou, 1966):

$$E = {}^{H}/_{lnS}$$

Where, H = Shannon's Index of Diversity, R = Margalef's Richness Index, E = Pielou's species evenness, S = Total number of species, ln = Logarithm of base e, N = Total number of individuals, i = Total number of species i, Pi = Proportion of total number Ni/N.

Furthermore, the estimate of relative bird species abundance was based on encounter rates, resulting in a categorical scale ranging from abundant to rare (Bibby et al., 2000).

Results

Species composition and conservation status of recorded bird species

Bird diversity of 110 species encompassing 16 orders and 41 families were documented. A notable finding was the seasonal fluctuation in abundance, where winter populations was found to be 1,180 individuals, which was higher than the 830 individuals recorded in summer. The passeriformes were the most prominent order in this study, with 52 species spanning across 19 families. However, orders Piciformes and Galliformes, were the least predominant orders, where each had only a single species.

Egyptian Vulture (*Neophron percnopterus*) and Steppe Eagle (*Aquila nipalensis*) (Figure 2) were two birds recorded with globally threatened status. Four nationally threatened bird species were Steppe Eagle, Egyptian Vulture, Asian Openbill (*Anastomus oscitans*) and Ibisbill (*Ibidorhyncha struthersii*) (Figure 3). The Peregrine Falcon (*Falco peregrinus*) was uniquely identified as the sole species falling under the CITES Appendix I. Furthermore, 12 species were recorded in the CITES Appendix II (Table 1).

Table 1: Conservation concern species recorded during the survey

S.N.	Common Name	Scientific Name	IUCN Global Red List	National Red List	CITES Appendix
1	Alexandrine Parakeet	*Psittacula eupatria*	NT	NT	II
2	Black Kite	*Milvus migrans*	LC	LC	II
3	Plum-headed Parakeet	*Psittacula cyanocephala*	LC	LC	II
4	Crested Serpent Eagle	*Spilornis cheela*	LC	LC	II
5	Egyptian Vulture	*Neophron percnopterus*	EN	VU	II
6	Eurasian Sparrowhawk	*Accipiter nisus*	LC	LC	II
7	Jungle Owlet	*Glaucidium radiatum*	LC	LC	II
8	Oriental Honey Buzzard	*Pernis ptilorhynchus*	LC	LC	II
9	Peregrine Falcon	*Falco peregrinus*	LC	LC	I
10	Shikra	*Accipiter badius*	LC	LC	II
11	Spotted Owlet	*Athene brama*	LC	LC	II
12	Steppe Eagle	*Aquila nipalensis*	EN	VU	II
13	Asian Openbill	*Anastomus oscitans*	LC	VU	
14	Ibisbill	*Ibidorhyncha struthersii*	LC	EN	
15	Common Kestrel	*Falco tinnunculus*	LC	LC	II
16	Watercock	*Gallicrex cinerea*	LC	NT	

Note: LC: Least Concern, NT: Near Threatened, VU: Vulnerable, EN: Endangered (IUCN, 2025)

Figure 2: Steppe Eagle *(Aquila nipalensis)*

Figure 3: Ibisbill *(Ibidorhyncha struthersii)*

Seasonal variation in diversity

Diversity indices of seasonal variation revealed distinct avian composition patterns in the Eastern Rapti River. While the winter season had higher species richness and diversity, species were more evenly distributed throughout the summer, as evidenced by a higher evenness index (Table 2). Therefore, the winter bird community was characterized by high diversity and species richness, whereas the summer community was less diversified but had a more balanced species composition.

Migratory status and abundance of birds

Among migratory status, 78 (71%) species were resident birds, 6 (5%) species were summer visitors, and 26 (24%) species were winter visitors. Bird abundance was skewed toward uncommon categories, with the majority of species (55%) classified as uncommon and nearly half (44%) as rare. Only one species (1%) was identified as frequent. Grey-throated Martin (*Riparia chinensis)* had the highest encounter rate (2.14).

Feeding guilds

Insectivorous birds dominated the foraging guild with 48 species, followed by carnivores with 37 species. The remaining 25 species were divided into omnivorous, granivorous, frugivorous, and herbivorous guilds (Figure 4).

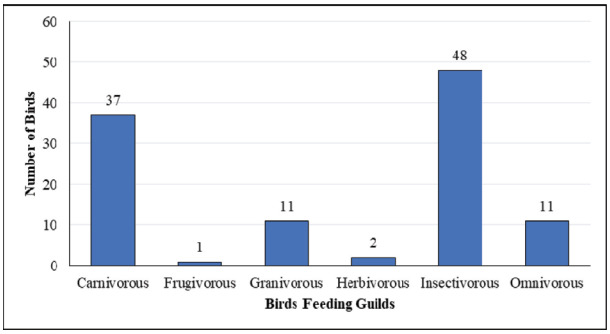

Figure 4: Feeding Guilds of Birds

Species distribution in different habitats

Altogether 21 transect lines were surveyed, in which 4 transects had reed areas (19.05%), 6 transects had forest areas (28.57%), and 11 transects had riverine areas (52.38%). The highest species of birds were found in the riverine habitat (34), followed by the reed habitat (26), and the least in the forest habitat (22) in the study area (Figure 5). 12 birds were recorded in mixed habitat with riverine and reed area which shows that birds prefer mixed habitats with river and reeds more than the mixed habitat with reed and forest area (5 species) as well as mixed habitat of river and forest area (1 species).

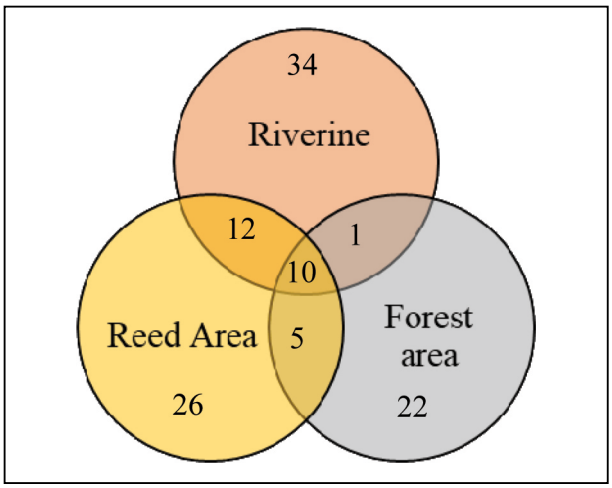

Figure 5: Venn diagram showing the number of birds in different habitat types

Figure 6: Watercock *Gallicrex cinerea* recorded in Eastern Rapti River during the study

Discussion

Species diversity and seasonal dynamics

The study found that the Eastern Rapti River has higher bird diversity (H = 4.03) than Sani Bheri

Table 2: Bird Species Diversity Index in different seasons

S.N.	Seasons	Shanon-Weiner Diversity Index (H)	Pielou's Eveness Index (E)	Margalef's Richness Index (R)	Total Taxa	Individuals
1.	Summer	3.82	0.69	9.67	66	830
2.	Winter	3.94	0.55	13.01	93	1180
3.	Total	4.03	0.51	14.33	110	2010

Figure 7: Illegal Sand & Gravel Mining

Figure 8: Illegal fishing by electrocution

River (Shrestha et al., 2021), and Bagmati River Corridor (Thapa et al., 2008) however lower than Karra River Basin (Parajuli, 2022) and Kaligandaki River Basin (Neupane et al., 2020). Anthropogenic impacts and continual habitat deterioration for many species (Shrestha & Lakhey, 2000) are present but also species are thriving. Bird diversity might have increased because of the mosaic of habitats that provide adequate food and water, as well as suitable nesting locations. The greater Margalef's Richness Index (14.34) shows the habitat's propensity towards community equilibrium, which is consistent with research in the same location with wetlands and grassland habitats (Bajagain et al., 2020) as well as other studies in Nepal (Baral et al., 2022).

Passeriformes was the most prominent order with 52 species, which supports other studies by Bajagain et al. (2020), Bhusal & Paudel (2021), Baral et al. (2022), Parajuli (2022), and Pradhan et al. (2023). The Muscicapidae family was the most dominant family, which contains old world flycatchers, and are mostly aerial insectivores. Water bodies are the primary source of aquatic emergent insects, which serve as the prey basis for flying insectivores (Manning & Sullivan, 2021). The richness of aerial insectivores increases with the increased availability of aquatic emergent insects, so the Eastern Rapti River has ideal conditions for both organisms, which play a greater role in wider ecosystem functioning. The high abundance of Grey-throated Martin (n = 154) in the study area is most likely attributed to its foraging ecology, habitat selection, and behavior, all of which revolve around an insect-based diet (Ali & Ripley, 1987).

Seasonal fluctuations are one of the most important elements influencing bird species richness, as well as individual bird species, which vary according to migratory type and feeding guild (Katuwal et al., 2016). In the study, the Shannon-Wienner diversity index revealed that the winter season (3.96) had more bird diversity than the summer season (3.82), which is consistent with other studies conducted in the same region (Nepali et al., 2021; Baral et al., 2022; Neupane et al., 2022; Parajuli, 2022). The surge in bird diversity during the winter could be attributed to shift in temporal community structure, as higher local movement and altitudinal migration among birds are dominant in this season. The study region had a larger concentration of altitudinal migrants migrating from the high Himalayas to the lowlands to avoid harsh climatic circumstances (Barcante et al., 2017; Delany et al., 2017; Shah & Sharma, 2022). This study observed a smaller number of summer visitors (5%), compared to winter visitors (71%), which might be attributed due to migration timing and reduced vocalization after the mating and breeding period (Desgranges et al., 2006; Katuwal et al., 2016).

Feeding guilds

Eastern Rapti River had distinct ecosystems, and six bird-feeding guilds were documented, with insectivores being the major guild, which is consistent with previous studies such as Pandey et al. (2020), Baral et al. (2022), Shah & Sharma (2022), and Pradhan et al. (2023).

Less than 3% of all species of insects have aquatic stages in life, which is a great source of nutrition for aquatic insectivorous birds. Due to the abundance of food materials for insectivorous birds, this might be the reason for the insectivorous guild to be the major feeding guild. In the study region, the Eastern Rapti River is contaminated by plastic waste, fishing by poisoning, and the use of pesticides such as Furadane and Thiodane (Shrestha & Lakhey, 2000). These harmful effects on insects negatively impact the area's most prominent insectivorous birds, posing a greater conservation threat.

Distribution record of Watercock (Gallicrex cinerea) for Makwanpur District

Watercock, which belongs to the family Rallidae, is listed as near threatened in the National Redlist and Least Concern in the IUCN Global Status (Inskipp et al., 2016). Two individuals of the species, one male and one female, were spotted around 1600h on June 28, 2023, in a marshy region of the river with extensive foliage of *Eichhornia crassipes*. Although the species distribution spans multiple districts in Nepal (Inskipp et al., 2016), it is particularly rare in the Makwanpur District, with only one reported sighting of a female in the Macchaplan area of Hetauda (eBird, 2025). So, the record of the species in the Eastern Rapti River is the second record in the Makwanpur district, making it a valuable insight into the Watercock distribution.

Watercock is an uncommon monsoon visitor in Nepal, with very few records from the protected area and outside protected areas of Nepal (Inskipp et al., 2016). Watercocks thrive in reedy swamps, streams, and flooded fields, feeding on seeds, green crop shoots, aquatic insects, larvae, and mollusks (Ali & Ripley, 1987; Inskipp & Inskipp, 1991). The study area habitat is ideal for foraging and nesting, which shows that it might be seeking appropriate nesting locations under various circumstances.

Wintering number, significance, and habitat of Ibisbill in the eastern Rapti River

Ibisbill is an uncommon altitudinal migrant in Nepal, wintering in the lowlands of Nepal (Inskipp et al., 2016), and in the Eastern Rapti River, it has been recorded every year with fluctuating numbers. This species feeds on water invertebrates and is consistently found near shingle banks. During the winter, it frequents riverbank habitats, but for breeding, it seeks out a network of interlaced channels within glacier valleys (Pierce, 1986). Shrestha & Lakhey (2000) recorded 18 individuals during their study; however, in this study, only 6 individuals were recorded. The Eastern Rapti River has a suitable wintering habitat for the species, but there is a population decline, which might be due to the rapid habitat destruction in the Eastern Rapti River being outside the protected area.

Conservation status and threats to avifauna

This research identified two species considered threatened at the global level, four facing threats at the national level, and thirteen species listed in CITES Appendices. During the survey, the following probable threats to birds were observed in the study area: illegal sand & gravel mining (Figure 7), illegal fishing by electrocution & poisoning, industrialization, water pollution, increasing human settlement, and hunting, causing negative impacts. These threats were similar to previous studies in the study region (Shrestha & Lakhey, 2000; Parajuli, 2022), which pose serious threats to birds and their habitat, affecting the ecosystem in the long run.

Conclusion

This research on the Eastern Rapti River highlights the vital role of river ecosystems as avian habitats and the urgent need for their conservation, demonstrating the high ecological significance of the region. The river supports a diverse avifauna and serves as both a winter and summer habitat for many threatened bird species, significantly increasing its importance. Illegal activities in the river have become the reasons for contamination of water and habitat destruction of the birds in the area. The conservation initiative focusing on environmental education, particularly the birds' ecological functions, is very crucial in the area. Simultaneously, reducing habitat degradation, wilderness exploitation, and other anthropogenic impacts is essential. To ensure the species' survival, these actions should be complemented by robust river management and habitat rehabilitation strategies.

Acknowledgements

This study was a part of Friends of Nature, Nepal (FON) internship field-based research project, and I would like to thank FON for providing this opportunity and support. I am grateful to Soniya Shrestha for providing assistance during the field survey. I want to acknowledge Mr. Raju Acharya, Mr. Krishna Prasad Bhusal, Dr. Anand Chaudhary, and Dr. Hem Sagar Baral for their guidance and motivation. I would like to remember my mentor, Dr. Oluwadunsin Adekola, for his help and advice.

Data Availability

The data collected for this research can be accessed in the Figshare repository. https://doi.org/10.6084/m9.figshare.26335294.v3

Conflict of Interest

The author reports no conflicts of interest or personal affiliations that could have influenced their work in this study.

References

Ali, S., & Ripley, S.D. (Eds.). (1987). *Compact handbook of the Birds of India and Pakistan.* (2nd ed.). Oxford University Press.

Bajagain, S., Pokhrel, S., Baniya, S., Pradhan, A., Paudel, S., & Joshi, I. D. (2020). Avifaunal Diversity of Institute of Forestry Complex, Hetauda Metropolis, Nepal. *Forestry: Journal of Institute of Forestry, Nepal, 17*, 83–101. https://doi.org/10.3126/forestry.v17i0.33624

Baral, M., Neupane, A., Ghimire, M., & Bhusal, K. P. (2022). Avian Diversity and Seasonal Abundance in Banpale Forest, Kaski District, Nepal. *Forestry: Journal of Institute of Forestry, Nepal, 19*(01), 1–15. https://doi.org/10.3126/forestry.v19i01.55699

Barcante, L., Vale, M., & Alves, M. A. (2017). Altitudinal migration by birds: A review of the literature and a comprehensive list of species. *Journal of Field Ornithology, 88*(4), 321-335. https://doi.org/10.1111/jofo.12234

Bastola, S. C., Adhikari, J. N., Dhakal, H., & Bhattarai, B. P. (2022). Influence of environmental factors on bird diversity in and around Kahundanda Hillscape, Pokhara, Nepal. *Nepalese Journal of Zoology*, *6*(2), 1-16.

Bhusal, N., & Paudel, S. (2021). Avian diversity and abundance in the Machhaplan complex, Hetauda, Nepal. *Forestry: Journal of Institute of Forestry, Nepal, 18*(01), 90-106.

Bibby, C., Jones, M., & Marsden, S. (2000). *Bird surveys*. London: Expedition Advisory Centre. BirdLife International, Cambridge, UK.

CBS. (2017). National climate change impact survey 2016: A statistical report. Central Bureau of Statistics, Kathmandu, Nepal.

Delany, S., Williams, C., Sulston, C., Norton, J., & Garbutt, D. (2017). Passerine migration across the Himalayas. In H. H. T. Prins, & T. Namgail (Eds.). Bird Migration Across the Himalayas: Wetland Functioning Amidst Mountains and Glaciers. Cambridge University Press, United Kingdom.

DNPWC & BCN. (2022). Birds of Nepal: An Official Checklist. Department of National Parks and Wildlife Conservation and Bird Conservation Nepal, Kathmandu, Nepal.

Desgranges, J., Ingram, J., Drolet, B., Morin, J., Savage, C., & Borcard, D. (2006). Modelling wetland bird response to water level changes in the Lake Ontario-St. Lawrence River hydro system. *Environmental Monitoring and Assessment, 113*, 329-365. https://doi.org/10.1007/s10661-005-9087-3.

Dudgeon, D., Arthington, A., Gessner, M., Kawabata, Z., Knowler, D., Leveque, C., Naiman, R., Prieur-Richard, A., Soto, D., Stiassny, M., & Sullivan, C. (2006). Freshwater biodiversity: importance, threats, status and conservation challenges. *Biological Reviews*, *81*(2), 163-182.

eBird (2025). eBird Checklist: https://ebird.org/checklist/S113549015. eBird: An online database of bird distribution and abundance. eBird, Ithaca, New York. Available: http://www.ebird.org. (Accessed: May 21, 2025).

Grimmett, R., Inskipp, C., & Inskipp, T. (2014). *Birds of the Indian Subcontinent: India, Pakistan, Sri Lanka, Nepal, Bhutan, Bangladesh and the Maldives*. Bloomsbury Publishing.

Grimmett, R., Inskipp, C., Inskipp, T., & Baral, H. S. (2016). *Field Guide to the Birds of Nepal*. Bloomsbury Publishing.

Inskipp, C., Baral H. S., Phuyal, S., Bhatta, T. R., Khatiwada, M., Inskipp, T., Khatiwada, A., Gurung, S., Singh, P. B., Murray, L., Poudyal, L., & Amin, R. (2016). *The status of Nepal's Birds: The National Red List Series*. Zoological Society of London. Downloaded on 01/3/2023; www.himalayannature.org

Inskipp, C., & Inskipp, T. (Eds.). (1991). *A guide to the birds of Nepal* (2nd ed.). Christopher Helm. http://archive.org/details/guidetobirdsofne85insk

IUCN. (2025). *IUCN Red List of Threatened Species*. http://www.iucnredlist.org/. Downloaded on 01 Mar 2025.

Katuwal, H. B., Basnet, K., Khanal, B., Devkota, S., Rai, S. K., Gajurel, J. P., Scheidegger, C., & Nobis, M. P. (2016). Seasonal Changes in Bird Species and Feeding Guilds along Elevational Gradients of the Central Himalayas, Nepal. *PLOS ONE, 11*(7), e0158362. https://doi.org/10.1371/journal.pone.0158362

Khadka, B. B., Acharya, P. M., & Rajbhandari, S. L. (2017). Population status and species diversity of wetland birds in the Rapti and Narayani rivers and associated wetlands of Chitwan National Park, Nepal. *Journal of Threatened Taxa, 9*(6), 10297-10306.

Kumar, A. (2005). *Handbook on Indian wetland birds and their conservation*. Zoological Survey of India, Ministry of Environment and Forests, Government of India.

Manning, D. W., & Sullivan, S. M. P. (2021). Conservation across aquatic-terrestrial boundaries: Linking continental-scale water quality to emergent aquatic insects and declining aerial insectivorous birds. *Frontiers in Ecology and Evolution, 9*, 633160.

Margalef, R. (1958). Temporal succession and spatial heterogeneity in phytoplankton. *Perspectives in Marine Biology,* 323-349.

Nepali, A., Khanal, S., Sapkota, S., & Nanda, B. S. (2021). Seasonal Variation of Bird Diversity in Dhaneshwor Baikiwa Community Forest, Kavrepalanchowk District, Nepal. *Journal of Biodiversity Management & Forestry 10*, 3.

Neupane, J., Khanal, L., & Chalise, M. K. (2020). Avian diversity in Kaligandaki River basin, Annapurna conservation area, Nepal. *International Journal of Ecology and Environmental Sciences, 46*(2), 99-110.

Neupane, B., Dhami, B., Panthee, S., Stewart, A. B., Silwal, T., & Katuwal, H. B. (2022). Forest management practice influences bird diversity in the Mid-Hills of Nepal. *Animals, 12*(19), 2681.

Pandey, N., Khanal, L., & 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), 31.

Paracuellos, M. (2006). Relationships of songbird occupation with habitat configuration and bird abundance in patchy reed beds. *ARDEA-WAGENINGEN-, 94*(1), 87.

Parajuli, K. (2022). Assessment of bird diversity and abundance in Karra River Basin, Hetauda, Makawanpur. *International Research Journal of MMC (IRJMMC), 3*(3), 18-33.

Pielou, E. C. (1966). The measurement of diversity in different types of biological collections. *Journal of theoretical biology, 13*, 131-144.

Pierce, R. J. (1986). Observations on behaviour and foraging of the Ibisbill Ibidorhyncha struthersii in Nepal. *Ibis, 128*(1), 37-47.

Pradhan, N., Rokka, P., & Bajagain, S. (2023). Diversity and status of birds in the Bimalnagar, Tanahun, Nepal. *Species, 24*(73), 1–11. https://doi.org/10.54905/disssi/v24i73/e23s1023

Revenga, C., Campbell, I., Abell, R., De Villiers, P., & Bryer, M. (2005). Prospects for monitoring freshwater ecosystems towards the 2010 targets. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *360*(1454), 397-413.

Shah, S. B., & Sharma, H. P. (2022). Bird diversity and factors affecting bird abundance at Dullu Municipality, Dailekh, Nepal. *Biodiversitas Journal of Biological Diversity, 23*(3). https://doi.org/10.13057/biodiv/d230343

Shannon, C. E., & Weaver, W. (1949). *The mathematical theory of communication*. University of illinois Press.

Shrestha, A. K., & Lakhey, S. P. (2000). A survey of Ibisbill (*Ibidorhyncha struthersii*) in the Rapti river. *Banko Janakari, 10*(1), 4-6. https://doi.org/10.3126/banko.v10i1.17645

Shrestha, G., Shrestha, M. B., Byanju, R. M., Reule, S., & Oli, S. (2021). A baseline study on diversity of birds in Sani Bheri River Valley, Nepal. *Nepal Journal of Environmental Science, 9*(2), 25-33.

Singh, M. (2022). Avifaunal diversity in unprotected wetlands of Ayodhya District, Uttar Pradesh, India. *Journal of Threatened Taxa, 14*(8), 21561-21578.

Sinha, A., Hariharan, H., Adhikari, B. S., & Krishnamurthy, R. (2019). Bird diversity along riverine areas in the Bhagirathi Valley, Uttarakhand, India. *Biodiversity Data Journal*, *7*, e31588.

Sutherland, W. J. (Ed.). (2006). *Ecological Census Techniques: A Handbook* (2nd ed.). Cambridge University Press, 324 p.

Thapa, S., Paudel, S., & Dipak, B.K. (2008). An assessment on bird's diversity in Bagmati River Corridor. *The Initiation, 2*(1), 34-40.