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**Effects of Urban Forest Patch Characteristics on Bird  
Community Assemblage in Kathmandu Valley**

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Nepal**

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**A dissertation submitted  
In partial fulfilment of the requirements for the award of the degree  
of Master of Science in Zoology with special paper Ecology and  
Environment**

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**March 2025**



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**Dissertation submitted in partial fulfilment of the requirements for the  
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**March2025**

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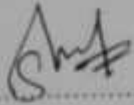
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## Declaration

I hereby declare that the work presented in this dissertation "**Effects of urban forest patch characteristics on bird community assemblage in Kathmandu Valley**" 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).



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**Recommendation**

This is to recommend that the dissertation entitled "Effects of urban forest patch characteristics on bird community assemblage in Kathmandu Valley" has been carried out by **Sabina Osthi** for the partial fulfilment 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 dissertation work has not been submitted for any other degree in any institution.

  
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**Letter of approval**

On the recommendation of supervisor "Laxman Khanal, PhD" this dissertation submitted by Sabina Osthie entitled "**Effects of urban forest patch characteristics on bird community assemblage in Kathmandu Valley**" is approved for the examination in partial fulfilment of the requirements for Master's Degree of Science in Zoology with special paper Ecology and Environment.



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**Certificate of acceptance**

This dissertation work submitted by Sabina Osthì entitled "**Effects of urban forest patch characteristics on bird community assemblage in Kathmandu Valley**" has been accepted as a partial fulfilment for the requirements of Master's Degree of Science in Zoology with special paper Ecology and Environment.

**Evaluation committee**

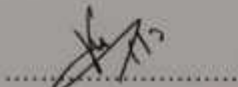
  
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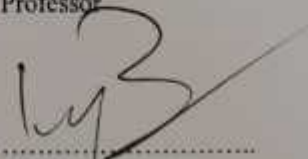


  
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## Abstract

Urbanization poses a significant threat to biodiversity, leading to habitat fragmentation and ecological imbalance. In fast growing cities like Kathmandu, the effect of rapid urbanization had serious impact on biodiversity. In this study the effect of urban forest patch characteristics on bird community structure of Kathmandu Valley, Nepal was investigated. A total of 92 of point counts in 15 patches were surveyed for birds using the point count method. Bird species richness and abundance as the response variable were analyzed using 23 explanatory variables (distance to source forest, area, perimeter, round, Shape Index, interior to edge (IE) ratio, urban strata, monkey presence (high, low, medium), place (15 forest patch), habitat (edge or not), season (summer and winter), cloud cover, wind, humid, precipitation, canopy cover, percentage of pine, and vegetation ground attributes (percentage of tree, bush, soil, grass, and litter; tree height). Generalized linear model was used to analyze the relationship among forest patch characteristics and bird species richness and abundance. Winter season showed negative relations to both bird species richness and abundance. Vegetation covers such as tree percentage, bare soil, litter have significant relation to both species' richness and abundance. Forest patch area showed a positive relation to species richness, with larger patches supporting higher species numbers. However, the patch shape index showed a negative impact on species richness suggested by a lower species richness in irregular shaped patch containing higher shape index. Patches closer to the source forest support higher individuals of birds while the patches far from source have low species abundance as they are more isolated. This study found that within the urban green patches in Kathmandu Valley, the forest patches that are closest to the city center and that are most disturbed have the lowest Shannon diversity index. The results suggested that urban forest patches that were far from the disturbed city center and with diverse habitat supported higher species richness of birds. Within the context of conservation, promoting these urban green patches in a fast-growing city should be a priority for urban planners and conservationists.

## शोध सारांश

शहरीकरणले जैविकविविधतालाईनकरात्मकप्रभाव पार्छ र शहरीकरणको कारणले सिर्जना हुने खण्डीकरणले पारिस्थितिकअसन्तुलन ल्याउँछ । काठमाडौं जस्ता तीव्रगतिले बिस्तार भईरहेकाशहरहरूमा, सहरीकरणको प्रभावले जैविकविविधतालाइगम्भीर असर पुऱ्याउँछ । यस अध्ययनले नेपालको काठमाडौंउपत्यकामा स्थानीय र आप्रवासी चराहरूको विविधतामाशहरी वनकाप्याचहरूकोअवस्था र आकारको प्रभावजाँचगरिएको छ । क्षेत्रफलकाआधारमा छनौट गरिएकाकुल १५ वटा वनकाप्याचहरूमा ९२ वटाविभिन्नविन्दुहरूमा चराहरूको गणना गरिएको थियो । चराकाप्रजातिहरूको विविधता र जनसंख्यालाई प्रतिक्रियात्मकभेरिएबल मानेर, ती भेरिएबलहरूलाई २३ व्याख्यात्मकभेरिएबलहरूको प्रयोग गरेर विश्लेषण गरिएको छ। अध्ययनको क्रममाचार पटकसर्वेक्षणगरिएको हुँदा हरेक पटकको सर्वेक्षणमा आउन सक्ने भिन्नतालाईमध्यनजर गरेर राउन्ड (हरेक पटक को सर्वेक्षण - जम्मा ४) लाई पनि भेरिएबल मानिएको छ ।त्यसैगरी सहरी वनका टुक्राका विशेषताहरू (स्रोतवनको दूरी, क्षेत्रफल, परिधि, शेप इन्डेक्स,IEअनुपात, वर्गीकरणको तह, बादरको उपस्थिति (उच्च, मध्यम, न्यून), स्थान (१५ वटा वनको प्याच), आवास (वन र वन किनारा), मौसम (जाडो र गर्मी), बादलआवरण, हावा, आर्द्रता, वर्षा, क्यानोपी कभर, सल्लाको प्रतीशत, र वनस्पतिविशेषताहरू(रुखको प्रतीशत, भारको प्रतीशत, खुल्लाजमिनको प्रतीशत, घाँसको प्रतीशत, पतभरको प्रतीशत, रुखको उचाई)सँग चराको प्रजातिहरूको विविधता र जनसंख्याविचको सम्बन्धविश्लेषण गर्न लिनिएर मिक्स्ड एफेक्ट मोडल प्रयोग गरिएको छ। यस अध्ययनमा जाडो मौसममाप्रजातिहरूको विविधता र जनसंख्यामानकारात्मक सम्बन्ध देखाएको छ। वनस्पतिविशेषताहरू, जस्तै रुखको प्रतिशत, खुल्ला माटो, र पतभरहरूको प्रजातिहरूको विविधता र जनसंख्यामा महत्वपूर्ण सम्बन्ध देखाएको छ भने वनको टुक्राको क्षेत्रफलले प्रजातिहरूको विविधतासँग सकारात्मक सम्बन्ध देखाएको छ, ठुलो टुकामा धेरै चराको प्रजातिहरू भेटिएको छ। वनकाटुक्राको आकारले प्रजातिहरूको विविधतामाप्रभाव गरेको पाइएको छ,किनभने उच्चआकार सूचकांकभएकाअसमानआकारका वनकाटुक्राहरूमा प्रजातिहरूको विविधतान्यून देखिएको थियो ।उपत्यकाआसपासका ठुला श्रोतवनको नजिकै भएकावनका टुक्राहरूमा धेरै प्रजातिका चराहरू पाइएको छभने, श्रोतवनभन्दा टाढारहेका वनका टुक्राहरूमा थोरै प्रजातिका चराहरू पाइएको छ। काठमाडौंउपत्यकाकासहरी हरियालीवनका टुक्राहरूको विचमा, शहर केन्द्रको नजिक रहेका र बढी विक्षितभएकाप्याचहरूमाशयानन डाइभर्सिटी इन्डेक्स न्यूनभएको र कमप्रजातिहरूको विविधता देखाएको छ ।यस अध्ययनबाट के देखिन्छभने शहरी वनका टुक्राहरू जुनउच्च जनघनत्व भएका सहर केन्द्रबाट टाढा छन् र जुनवनका टुक्राहरूमा विभिन्नआवासीयअवस्थाहरू उपलब्धछन्, तीवनका टुक्राहरूमा चरा प्रजातिहरूको विविधताउच्च हुन्छ । संरक्षणको सन्दर्भमाभन्नु पर्दातिब्र रूपमा बढिरहेका शहरहरूमा जैविकविविधताकायम राख्न हरियो वनका टुक्राहरूलाई जोगाउनप्राथमिकतादिएर व्यवस्थितसहरी योजनासम्बन्धीको नीतितर्जुमागनुपर्ने देखिन्छ।

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## List of abbreviations

<b>Abbreviated form</b>	<b>Details of abbreviations</b>
AIC	Akaike Information Criterion
ASL	Above Sea level
GIS	Geographic information system
GLMM	Generalized linear mixed effect model
GPS	Global Positioningsystem
IE-ratio	Interior to edge ratio
IUCN	International Union for Conservation of Nature
LULC	Land use/ Land cover
VIF	Variation Inflation Factor

# 1. Introduction

## 1.1 Background

Urbanization possesses a significant threat to biodiversity, leading to habitat loss and fragmentation (Wang et al., 2021). It is a prominent aspect of the ongoing global shift that has a serious impact on various aspects of biodiversity, ultimately resulting in changes in the ecological landscape (Aronson et al., 2014). However, amid rapid urbanization, urban forest patches act as “green islands,” which are crucial in maintaining biodiversity and offering vital ecosystem benefits (Niu et al., 2023). The rate of urbanization directly impacts the urban forest patches as the urbanization increases the green spaces become smaller, isolated, and more fragmented (Fujita & Koike, 2009; Uchida et al., 2021). The fragmentation and isolation impact the ecological function of the patches (Fahrig, 2017; Fujita & Koike, 2009; Palacio et al., 2018) as well as the biodiversity of the particular patch (Liu et al., 2019; Pradhan, 2004). The relation between these green patches and wildlife is important in avian communities, whereas birds also aid in ecological processes such as seed dispersal, pollination, pest control (Gaston, 2022), and elevate the biodiversity, aesthetic and recreational charm of urban areas (Chace & Walsh, 2006). For example, green spaces in and around Kathmandu Valley, spanning from compact patches to larger wooded areas, provide habitats for local and migratory bird species (Katuwal et al., 2016b; Upadhyaya et al., 2022). However, comprehensive analysis and the impact of urbanization on bird communities in Kathmandu Valley have yet to be thoroughly conducted till date (Katuwal et al., 2018).

Kathmandu Valley is characterized by its unique sociocultural and biological diversity, but in recent decades, it has undergone significant urban expansion (Ishtiaque et al., 2017). Kathmandu has become one of the fast-growing cities of South Asia, with a four percent increase in population every year (Acharya et al., 2015). As a result, the human influx brought a significant change in land use patterns, accelerating the urbanization process (Ishtiaque et al., 2017). To fulfill demand for housing, infrastructure, and other humanitarian uses, the natural habitats were converted into residential, commercial and industrial hubs (Thapa & Murayama, 2010). Once self-sustaining agricultural society with fertile land with temperate climate supporting variety of biodiversity starts to shift during latter half of 20<sup>th</sup> century (Ishtiaque et al., 2017; Thapa & Murayama, 2010). The surrounding foothills have still retained the forest cover. However, the urban forest decreased due to land clearing for urban expansion (Ishtiaque et al., 2017; Katuwal et al., 2018; Thapa &

Murayama, 2010). In the process of urbanization, during the 1980s, forest areas decreased dramatically, resulting the continuous fragmentation and a heterogenous landscape throughout the 1990s (Thapa & Murayama, 2009).

The fragmentation of forests disrupts the natural ecosystem and biodiversity sustaining in those areas(Chace & Walsh, 2006; Fahrig, 2017). The urban matrix, combined with degraded habitat, reduces the connectivity among the green spaces, making it difficult for the survival and movement of wildlife(Chang et al., 2023; Chen et al., 2024). Connectivity between the forest patches acts as a crucial factor in maintaining the diversity; the degree of connectedness determines the dispersal, foraging, and breeding success(Han et al., 2022; Jin & Song, 2023). A well-connected patch facilitates the interaction and gene flow of any biological community(Vandewoestijne et al., 2008), enhancing the resilience against environmental changes(Anderson et al., 2023; Tiang et al., 2021). In other hands, isolated patches lead to less species diversity and more vulnerability to extinction, particularly for species with specific habitat requirements (Dale, 2019; Fahrig, 2013).

Being small and scattered (Katuwal et al., 2016b), the fragmented forest still have great potential in conserving bird diversity and providing suitable habitats for birds (Katuwal et al., 2016b; Maseko et al., 2020). Even a small forest patch of less than 20ha can host a significant level of functional diversity of birds within the highly urbanized and densely populated area (Kang et al., 2015). The green spaces including parks, forest patches, gardens, and grasslands, play a crucial role in minimizing the impact of urbanization on bird diversity as well as overall biodiversity (Katuwal et al., 2016b; Upadhyaya et al., 2022). Not only to those species adapted to urban areas (common city birds), forest patches can provide a suitable habitat for many species of birds (Upadhyaya et al., 2022) and other animals (Liu et al., 2019). The vegetation structure of forests is a key determinant of habitat quality. The forest patch characteristics such as tree composition, canopy cover, native vegetation, and understory density, influence the food availability, shelter, and nesting sites of bird diversity. With the decrease in forest patches, species that are forest dwellers (excluding urban exploiters) cannot handle the human-induced disturbances very well (BirdLife International, 2017). Birds of different species have different unique ecological requirements. Generalists are adapted to urban environments and exhibit a tolerance to urbanization, whereas specialist those who rely on specific niche, have lesser resilience toward rapid urbanization. As a result, sudden population crashes could take place in such groups as they reach the stress resistance threshold (Watson et al., 2015). Interestingly, substantial loss in the bird diversity is not only

due to anthropogenic factors (human developments), however, urban features have the great impact on the loss of bird species(Aronson et al., 2014). Factors such as pollution, human disturbance, and climate change worsen the challenges faced by the urban avian population. As urbanization increases, managing and preserving the urban green spaces sustainably becomes important for developing effective conservation strategies as the urban green spaces serve as a vital refuge for the bird community in urban areas.

## **1.2 Statement of the problem**

Rapid and unsystematic urbanization in Kathmandu Valley(Pradhan, 2004; Thapa & Murayama, 2009, 2010) is leading the significant impact on biodiversity and green space. The urban green space of Kathmandu Valley holds a significant amount of residential as well as migratory birds. However, the threat of urbanization affects the ecological integrity of the urban forest patches altering their characteristics and spatial configuration inside the valley. Although, these green patches have the major role in sustaining the diversity and maintaining the ecosystem balance(Maseko et al., 2020), there is lack of comprehensive research on how patch characteristics influence the bird community assemblance. With the rapid change of landscape inside the Kathmandu Valley it still remains unclear how the green spaces inside the valley impact the diversity, and composition of the avian species. Understanding the relationship between green space and bird diversity is still lacking and creating the gap in the biodiversity research. This gap restricts effective urban planning and biodiversity conservation strategy in the face of ongoing urban expansion. With the study of green spaces and long-term monitoring it might help to create an effective conservation design and mitigate the negative effect of urbanization on the bird communities.

## **1.3 Objectives**

The general objective of this study was to assess the bird diversity on the different forest patches inside the Kathmandu Valley and the relationship between forest patches characteristics and bird community structure.

The specific objectives of the study are:

- i. To explore bird diversity in urban forest patches of Kathmandu Valley.
- ii. To understand the relationship between urban forest patch characteristics and bird community assemblage.

#### **1.4 Research hypothesis**

The research hypotheses for my study are as follows:

- i. Bird diversity among different forest patches inside the Kathmandu Valley varies significantly.
- ii. The patch characteristics highly correlates with the richness and abundance of birds in the Kathmandu Valley.

#### **1.5 Significance of the study**

In the context of the avian study in Kathmandu Valley, birds in the urban ecosystem are understudied. As urban areas are expanding and reshaping the landscape worldwide, it become necessary to understand and study the ecological importance of green space for sustainable urban growth. With rapid growth of urban areas in Kathmandu it is relevant to study about the relationship between remaining forest patches and bird community. Therefore, study of avian diversity in Kathmandu would help to understand the biodiversity in urban green patches. Bird species are the key indicators of ecological health of any green spaces as they play crucial role in various ecosystem functions. By analyzing the bird diversity and its relationship with urban forest patch characteristics might provide broader insights into the impacts of urbanization on bird diversity. The purpose of this study is crucial for developing strategies and managing the green space in the big cities, ensuring the conservation of bird community. Ultimately the findings of this study is anticipated to promote practical implications for urban planning and conservation strategies in Kathmandu Valley.

#### **1.6 Limitations of the study**

Surveying all the forest patches inside the Kathmandu metropolitan city was not feasible because of limited budget and time as the research needs to be fulfilled within the time frame of MSc program. Only the major patches that fall under the criteria of research methodology were surveyed. Also, the study has been designed to provide relative comparisons, but the total species richness of the whole valley is likely to be underestimated.

## 2. Literature review

### 2.1 Urbanization and bird diversity

Urbanization possesses profound impact on global biodiversity including avian diversity (Aronson et al., 2014; Ehlers Smith et al., 2018; Oliveira Hagen et al., 2017; Sol et al., 2020). Compared with the sub-urbs, cities worldwide have the lower diversity of birds as the impact of urbanization is higher in city areas (Aronson et al., 2014; Katuwal et al., 2018; Seress & Liker, 2015; Xu et al., 2018). As the cities increase, the natural ecosystem is converted into humanized structures and farmlands leading to habitat loss and fragmentation (Morelli et al., 2013; Peng et al., 2024; Thapa & Murayama, 2010). Such changes in the habitat directly or indirectly disrupts the breeding, foraging, and many other behaviors of birds' species which can have high impact on specific species that need specific habitat preferences (Richard et al., 2021; Wong & Candolin, 2015). For example, Taudahalake in Kathmandu was surrounded by concrete structures. The lake was once a thriving habitat for many water bird species, but in recent years it has faced significant challenges due to habitat degradation due human encroachment and high level of pollution (Khatri et al., 2023; Paudel et al., 2022; Shrestha et al., 2023). Pollution has challenged the bird species in major cities around the world. Increase in population and to fulfill its demand there is an increase in traffic all around leading to an increase in sound pollution. Sound pollution interferes with the communication and vocalization of many bird species, forcing them to adapt to high urban noise (Halfwerk et al., 2018; Klingbeil et al., 2020; Richard et al., 2021; Sordello et al., 2020).

Impact of urbanization has direct impact on habit and avian population, recent research shows both negative as well as positive influence of urbanization on avian species richness and abundance (Silva et al., 2015). For instance, the species that requires dense forest and low level of disturbance would struggle to survive in urban settlements leading to population decline or even extinction (Betts et al., 2017; Hensley et al., 2019; Seress & Liker, 2015). On the other hand, with the increase in urbanization, the generalist that takes advantage of human food/waste (such as crows, kites, pigeons) will thrive in the urban areas and their population will increase and dominate the area (Buxton et al., 2018; Ordóñez-Delgado et al., 2022; Wong & Candolin, 2015). In Kathmandu Valley significant number of kites and crows (Bhusal et al., 2025; Hansen & Huettmann, 2020; Katuwal et al., 2016b) can be observed within small range, in South Korea, Oriental Magpie dominates the city area (Chen et al., 2022; Kim et al., 2021; Lee, 2023). Despite the challenges, urban environments are not entirely bad news for bird diversity. Urban green spaces, such as parks and gardens, can serve

as important refuges sites for birds(Chiron et al., 2024; Kohout & Kopp, 2020). Some bird species have also developed remarkable adaptability to urban environments(Chiron et al., 2024; Staude et al., 2021; Xu et al., 2018). They have modified their behaviors to cope with urban challenges, such as changing their diets (include human-provided food) or adjusting their nesting sites to urban architectures (Bowes, 2020; Chatelain et al., 2025; Fehlmann et al., 2024).

## **2.2 Bird diversity and urban green patches**

Urban forest patch serves as fundamental ecological zones for avian species within the urban hubs, offering the shelter and resources amid urban expansion (Kang et al., 2015; Katuwal et al., 2016b; Morelli et al., 2017; Niu et al., 2023; Upadhyaya et al., 2022). Niu et al. (2023) described the urban green spaces as “green islands” and those green islands plays the vital role in maintaining the biodiversity in the urban settings. Likewise, in the Kathmandu Valley the remaining forest patches, green parks, gardens supports the high diversity of bird species(Katuwal et al., 2016b; Upadhyaya et al., 2022). Maseko et al. (2020) also concluded that the forest patches played a significant role in the survival of diverse species of birds in the urbanized landscape of Durban, South Africa. Green spaces not only hold the immense amount of biodiversity including bird diversity, it provides the aesthetic value too(Chace & Walsh, 2006). The forest patches have the great role in conserving the bird community and other biodiversity, however, rapid and unsystematic urbanization in Kathmandu Valley(Pradhan, 2004; Thapa & Murayama, 2009, 2010) cause the significant amount of impact on bird communities(Katuwal et al., 2018). Several studies (Aronson et al., 2014; Liu et al., 2019; Sol et al., 2020) have also highlighted the global impact of urbanization on the bird community. Compared with the sub-urbs cities worldwide have the lower diversity of birds as the impact of urbanization is higher in city areas(Aronson et al., 2014). Ecological dynamics of the fragmented landscape shape the diversity. Urban green patches and its characteristics such as; patch size, shape and its index substantially influence the bird community(Zhu et al., 2024).

Larger areas support greater diversity and patch area determines the ecological value of the patch(Maseko et al., 2020; Uchida et al., 2021).Whereas smaller patches are more prone to edge effect, reduced food availability, higher competition and increased predation risk (Jones et al., 2023; Liordos et al., 2021; Soifer et al., 2021). For example; the study of Kang et al.

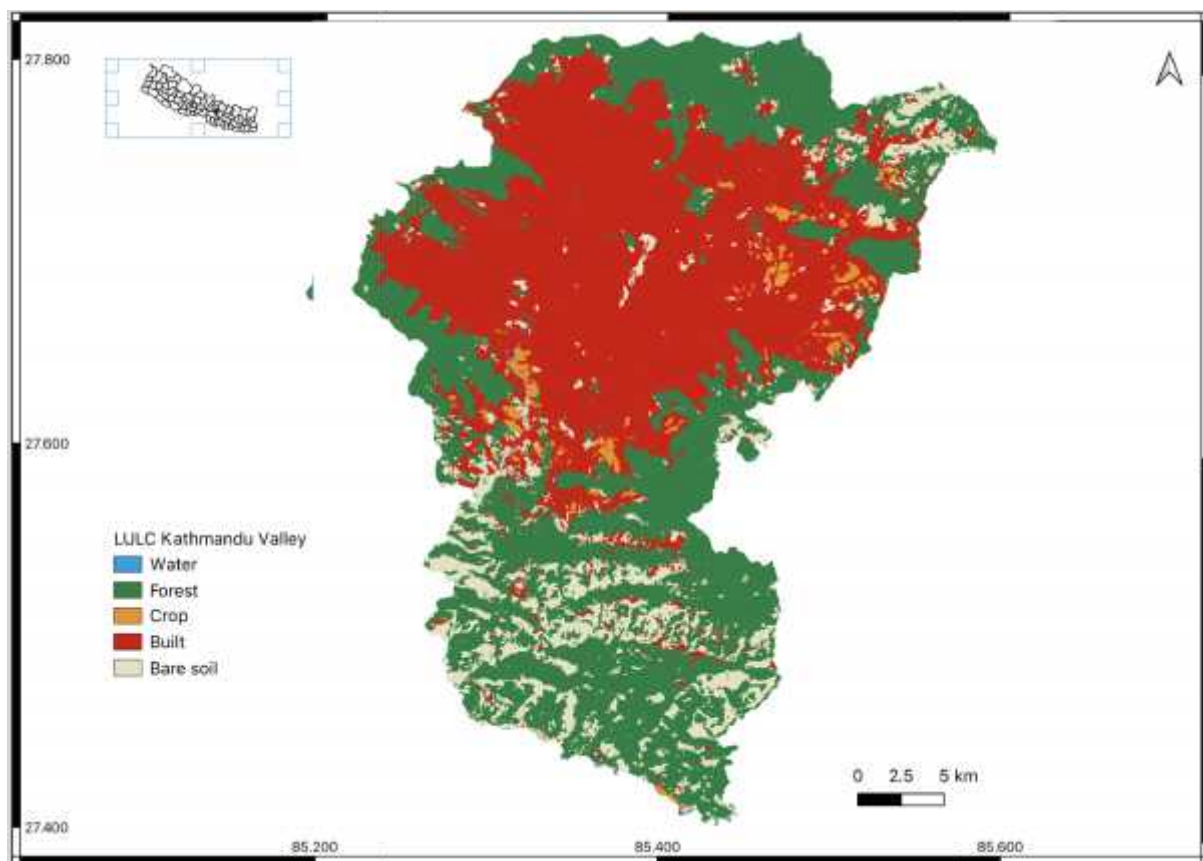
(2015) emphasize the positive influence of patch area on overall bird diversity. Similarly, Maseko et al. (2020) also have resembling data, that the bird species richness increased with increase in size of forest patches (Maseko et al., 2020; Wang et al., 2021; Zhu et al., 2024). Many studies support that large patches have increased habitat availability and can sustain the specialized bird species sensitive to habitat size. In the Gyeonggi Province, South Korea, the research done by Kang et al. (2015) also reflects the positive correlation between patch area and total species richness, total bird abundance, except for the ground-foraging species and granivore bird guilds. Their study also found the positive relationship between vegetation complexity and species richness and abundance of migrant and ground-nesting birds. Larger the area, the greater the habitat heterogeneity and more resources. Forest patch and its total area and land cover heterogeneity at the landscape level correlates positively with avian species richness in the urban areas across Europe (Chiron et al., 2024).

Perimeter and shape of urban forest patch plays an important role in determining habitat quality and bird diversity (Zhu et al., 2024). It influences the edge to core ratio and determines the extent of edge effect. Patch with relatively larger perimeter and irregular shapes increases the edge effect resulting in edge related impacts which then influence bird communities (increase in generalist and edge adapted species and decrease in specialist species. For example, study done by Zhu et al. (2024) showed that patches with lower perimeter complexity had higher bird richness. The patch with higher edge exposure supporting lesser diversity (Garizabal-Carmona & Mancera-Rodríguez, 2021; Guillaumet & Russell, 2022). This is due to reduced habitat, increased competition, higher nest predation rate (Paris & Studds, 2025). The balance between the edge and core habitat definitely supports the different bird's species highlighting that lower perimeter complexity and compact patch shape is important for enhancing ecological integrity of urban forest patch. A study on Hawaiian island have highlighted multiple features of forest dynamics that influence the arrangement of avian diversity (Flaspohler et al., 2010). Katuwal et al. (2016) and Upadhyaya et al. (2022) have specifically focused on the Kathmandu Valley, observing the diversity of bird and migratory bird within its urban forest patches. These studies state that there is need for a comprehensive analysis of how urban settlements impact bird communities in these unique ecological settings. So, this study will contribute to the understanding of the relationship between urban forest patches and its relationship with bird community's assemblages.

### 3. Materials and methods

#### 3.1 Study area

This study was conducted in the Kathmandu Valley, including the Kathmandu, Bhaktapur, and Lalitpur districts. It lies in the mid-hill region of central Nepal and elevation ranges between 1100 m and 2700m asl. The area falls under the sub-tropical climate zone with the summer temperature ranging between 20°C and 30°C and winter temperature ranging between 9°C to 12°C. Kathmandu Valley comprises various urban and sub-urban ecosystems with remaining forest patches (Katuwal et al., 2018). The most common and dominant tree species inside the Kathmandu Valley (for lower elevations) are *Pinus roxburghii*, *Castanopsis indica*, *Alnus nepalensis*, *Schima wallichii*, *Ficus religiosa*, *Myrsine capitellata*, *Salix babylonica*, whereas the dominant tree species in higher elevations surrounding the valley are *Rhododendron arboreum* and *Quercus semecarpifolia* (Bhujju et al., 2007; Ghimire et al., 2005). An estimate of 550 species of birds species are found in the Kathmandu Valley (Bhujju et al., 2007).



**Figure 1.** Map of study area showing forest patches in Kathmandu, Bhaktapur and Lalitpur districts, Land Cover data (Karra et al., 2021)

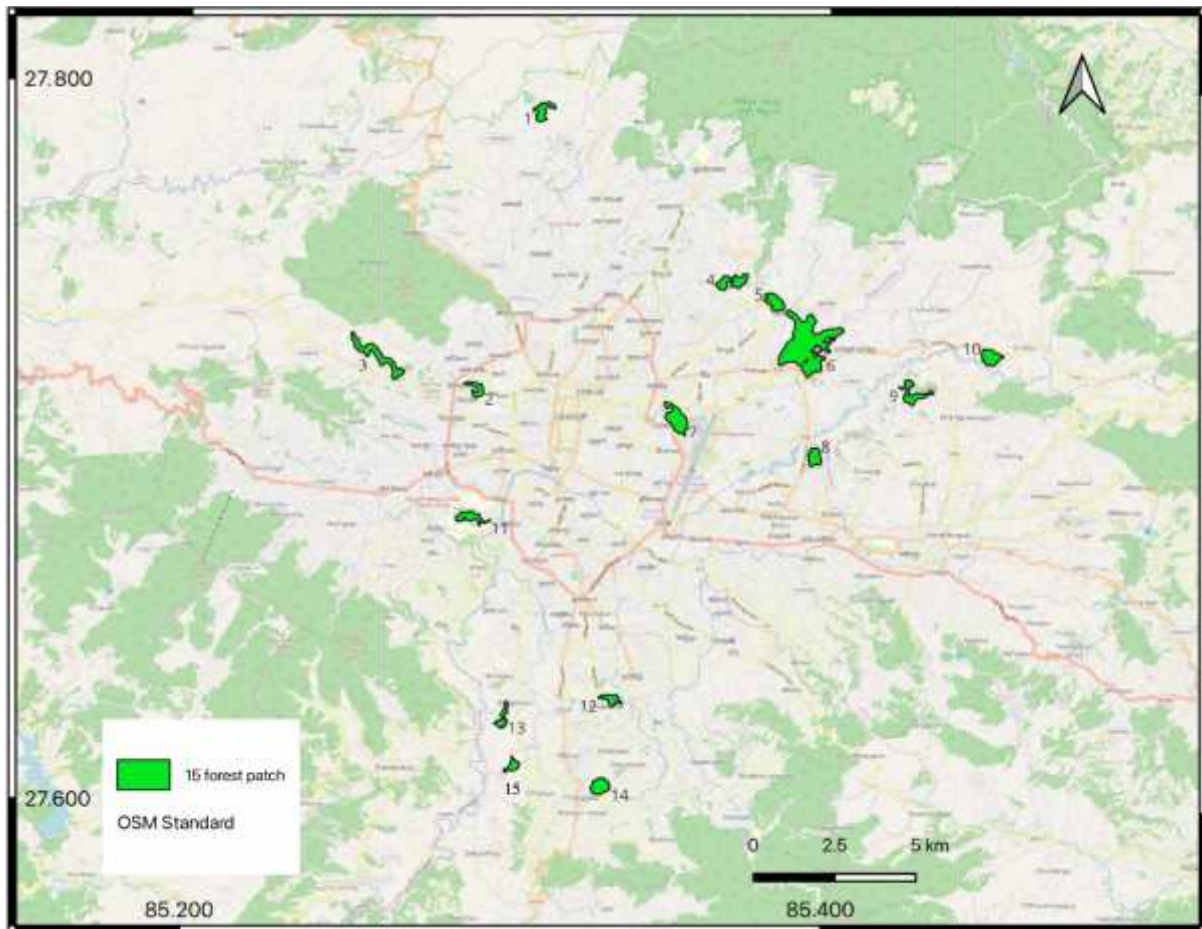
## **3.2 Methods**

### **3.2.1 Field survey**

#### **i. Forest patch characterization**

The study sites were selected using the Geographic information system (GIS) software (QGIS Development Team, 2023). First, the three districts inside the Kathmandu Valley were selected (Kathmandu, Bhaktapur, and Lalitpur). Then inside the valley, all the green forest and patches were isolated using the Land Use Land Cover data (Karra et al., 2021). The raster data was reclassified to select only forest cover. After that, the resulting raster file including forest cover was converted to vector format by using the Polygonize tool. This study only focused on the remaining forest patches inside the Kathmandu Valley, for that the continuous forests and patches that connect to those continuous forest surrounding the Kathmandu Valley were removed by creating a new shape file by drawing the line excluding all the major forest surrounding valley. Forest patches were then filtered and selected based on area. Only the biggest 15 patches (all the green patches above 1,00,000 m<sup>2</sup> in area) were selected for the study (Peng et al., 2024). This study aimed to study the bird community assemblages, areas less than 10ha do not support the forest specialist birds (Ferraz et al., 2007) and many migratory birds (according to Grimmett et al. (2016) migratory birds made up of one third of total birds of Nepal) needing special habitat for breeding (Robinson et al., 1995). After that inside all the patches, a grid of points spaced 200 meters apart was generated using the Create Grid tool. The points inside the patch boundaries are selected only the points inside the forested areas were clipped and rest are excluded. All the points generated with 200m apart were selected for field data collection except inside the Gokarna Forest and Pashupatinath forest, there were some restricted zones which were not accessible to do the bird survey. Those restricted areas were owned by Nepal Army and the permission was not granted to do the survey. Finally, 92 points inside the 15 forest patches were selected for bird survey and data collection. Coordinates were also calculated for each point using the Field Calculator so that the coordinates points could be used in GPS (Global positioning system) to find the point in the field. Kathmandu Valley was then again classified into city center (highly urban areas), periphery (sub-urban areas) and rural areas (Katuwal et al., 2018), and the patches were also classed accordingly. The degree of urban to rural was determined on the basis of human settlement density, infrastructure and facilities available (Katuwal et al., 2018). Area, perimeter, shape index, and Interior-Edge ratio of each patch were calculated in QGIS field calculator and added to the attribute table. Distance to nearest source (continuous

forest that is surrounding the Kathmandu Valley) was scaled for each point using the scale feature on QGIS.



**Figure 2.** Selected 15 forest patches inside Kathmandu Valley (including Kathmandu Lalitpur and Bhaktapur districts).

## ii. Field survey and data collection

Standard point count method (Bibby, 2000) was used to survey bird communities within selected forest patches. Binocular “Vortex Viper” 8×42 and field guide book “Birds of Nepal” (Grimmett et al., 2016) was used to identify birds and “Panasonic FZ82” digital camera (60x) and “Nikon D-500” (200–500) was used to take the photographs. The migration status (residential, summer migrant, and winter migrant) and six feeding guilds (insectivore, granivore, carnivore, frugivore, omnivore, and nectivore) were classified based on Grimmett et al. (2016) and Katuwal et al. (2018). Order, family and scientific name and IUCN status of bird species were classified according to the IUCN Red List of Threatened Species (IUCN, 2025). For the bird surveys, five minutes of settling time was given to minimize disturbances, and birds seen and heard were recorded for another 10 minutes. The radius of each fixed-

pointcount was 30m for accounting reduced visibility within the dense vegetation. Surveys were conducted during the summer (June–July 2024) and winter (December 2024 and January 2025) seasons to observe the seasonal variation. Time of survey was 6 AM – 11AM during summer and 7 AM -12 PM during winter season. For better detectability of birds, surveys were conducted when there was no rain and wind speed of less than 10km/hr(Bibby, 2000). The canopy cover was measured using the CanopyCapture APK mobile application. Google weather data such as precipitation, humidity, wind, cloud cover was recorded for each point at the starting time of bird survey. Percentage pine was measured by counting the number of pine trees/ total number of trees within the 30m radius. The amount of monkey presence was categorized into three parts high, medium and low. Patches where the monkey was seen almost in all the points and actively showing its presence was kept in high category, the monkey showing less activity and presence only on certain points were categorized to medium and for patches where there was almost no monkey or only occasional sightings of monkey was kept on low category. For characterizing the urban forest patch of Kathmandu Valley six vegetation structures attributes (VGS) were described within 30m radius point (Morelli et al., 2017). Visually estimated percentage cover of grass, leaf litter, barren soil (including rock, path cover area), bush, and tree data was noted (Morelli et al., 2017). Tree height was also estimated visually (Morelli et al., 2017).

### **3.2.2 Data analysis**

Bird species richness and abundance as the response variable were analyzed using 23 explanatory variables (distance to source, area, perimeter, round, Shape Index, IE ratio, urban strata, monkey presence (high, low, medium), place (15 forest patch), habitat (edge or not), season (summer and winter), cloud cover, wind, humid, precipitation, canopy cover, %pine, and vegetation structure attributes (%tree, %bush, % bare soil, %grass, %litter, tree height). Prior to the analysis the normality of the data was checked to see whether the data is normally distributed or not. A histogram showed close to normal distribution with slightly left skewedness. So, Shapiro-Wilk test confirmed the non-normality of the data ( $p=0.0035$ ). The data was then log-transformed, and the Shapiro-Wilk test was carried out again, however, the data remained non-normal. Since it was not normal, the original data set was used for analysis and generalized linear mixed effect models (GLMM) were used to analyze the dataset. To investigate the factors influencing the species richness and abundance, GLMM was used. Initial model included all the explanatory variables. As the data dealt with repeated measures,

to account for the random effect of location a random intercept for place was included. Also, the data was collected from the same place for four rounds and the round was also used as random effect. Multicollinearity among the predictor variables was checked using the Variance Inflation Factor (VIF). Variables with VIF values less than 5 were selected because VIF values greater than 5 considered highly collinear. Such collinearity among the explanatory variables lead to unreliable estimates by influencing the variance of regression coefficients so, variables with VIF value greater than 5 were removed. Post VIF, model was refined through backward elimination based on Akaike Information criterion (AIC). The model with the least AIC value was considered the best fitted model.

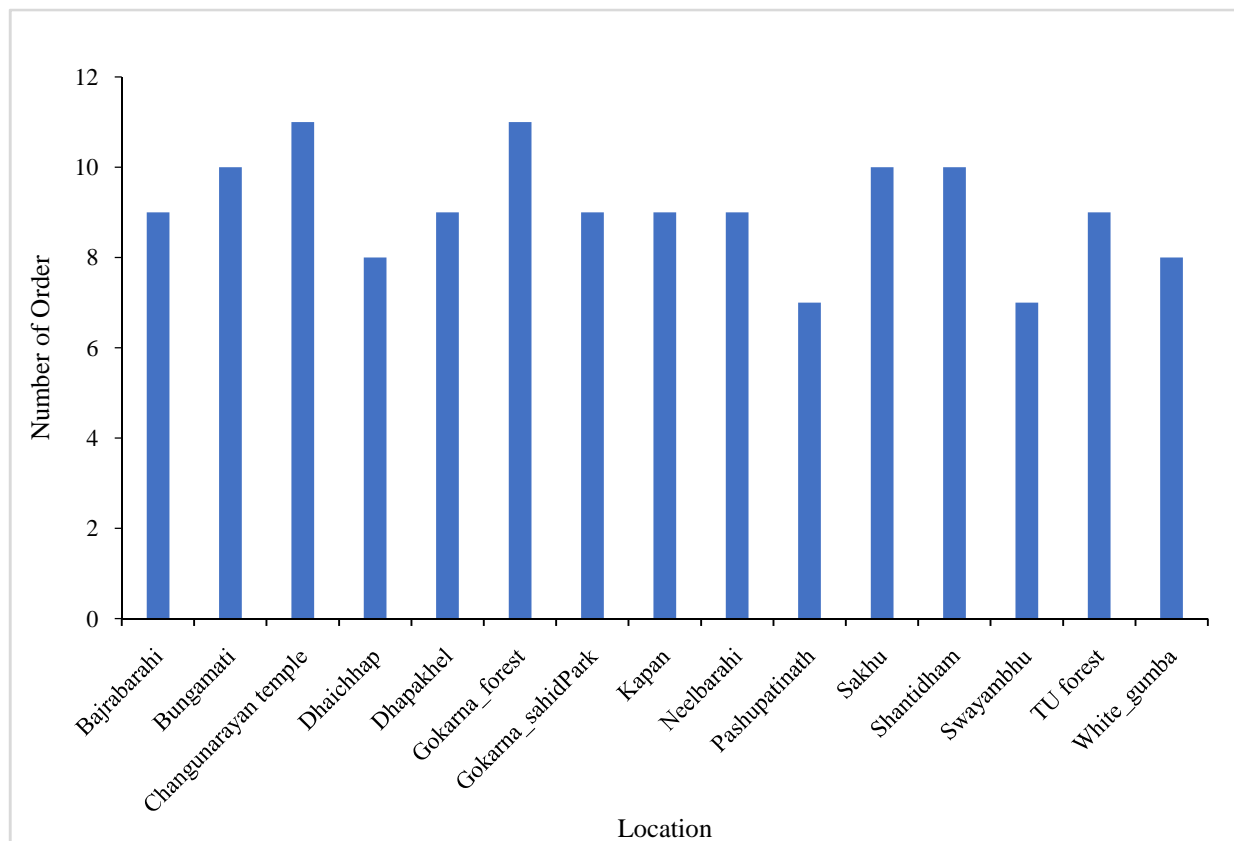
Diversity indices (Shannon-Wiener function) were calculated to compare the diversity of different forest patches. All statistical analyses was done in the R software using various R packages (R Core Team, 2021).

## 4. Results

### 4.1 Bird diversity in different forest patches of Kathmandu

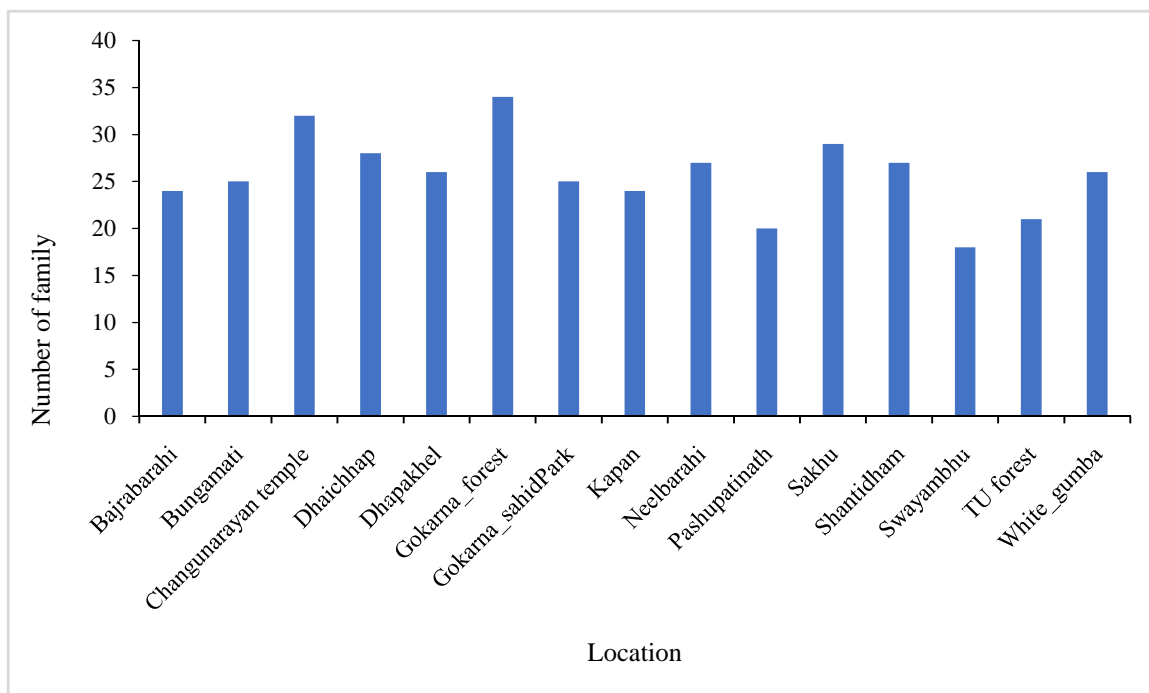
A total of 10,651 individuals of 118 species belonging to 11 orders and 44 different families were recorded during the whole survey. Among 118 species only one species, steppe eagle falls under the Endangered category of IUCN red list and one species, Alexandrine parakeet falls under Near Threatened category of IUCN red list (Appendix 2). All the other 116 species belonged to Least concern (Appendix 2). In summer 5,603 individuals of 78 species were recorded and in winter 5,048 individuals of 91 species were recorded. The abundant bird species among them were house crow (n=1317).

All the 11 orders of bird species were found in Gokarna Forest patch and Changunarayan temple forest making them the patches with highest number of orders and Pashupatinath and Swayambhu Forest patch has lowest no of order with 7 order (Figure 3).



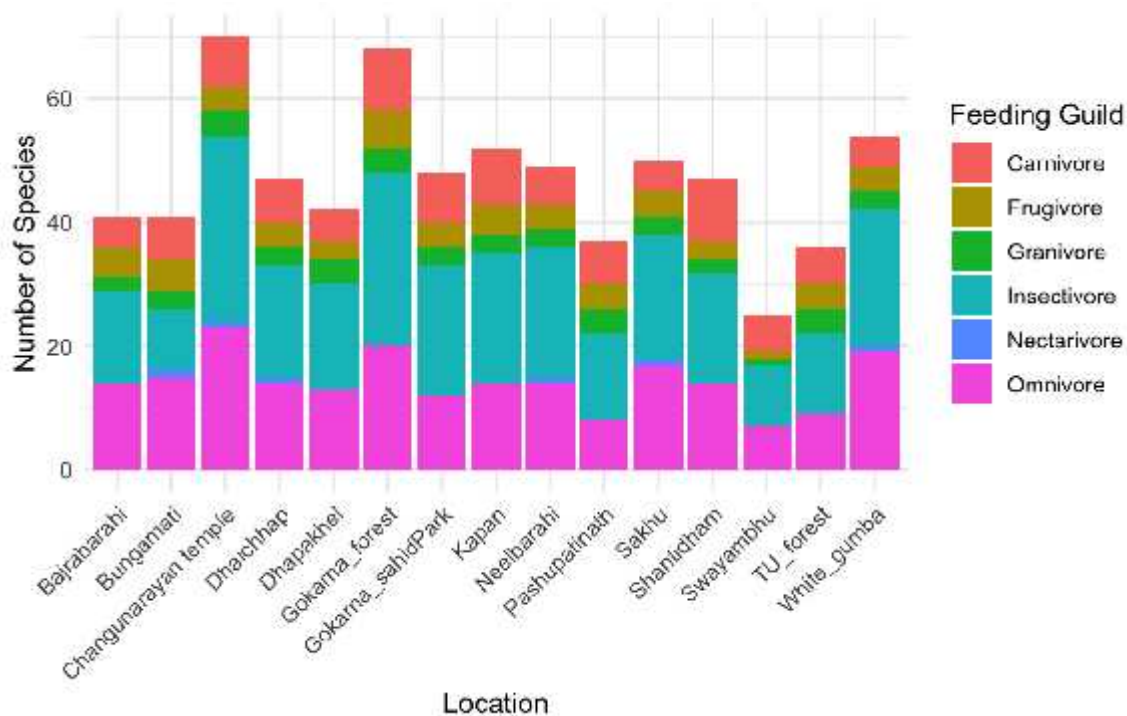
**Figure 3.** Number of different order of birds on different location of Kathmandu Valley.

The highest number of bird families was seen on Changunarayan with 34 families and lowest on Swayambhunath with 18 families (Figure 4).



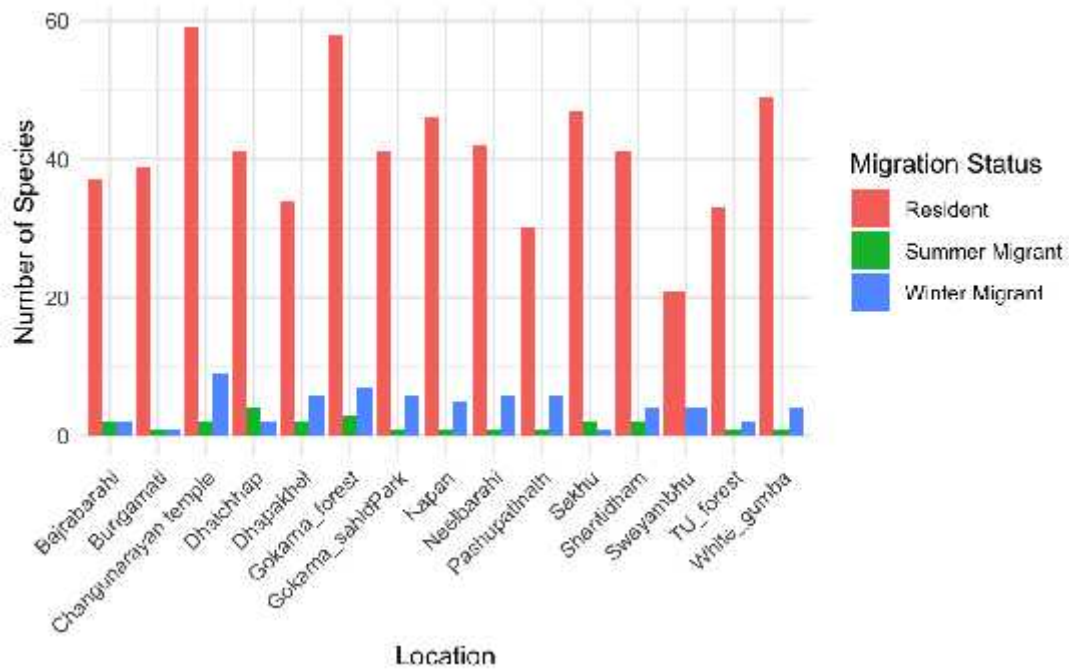
**Figure 4.** Number of different family of birds on different location of Kathmandu Valley.

Birds were categorized according to feeding guild, migration status and IUCN status. There were six different types of feeding guild and Insectivore was the most abundant and nectivore was the least in number across different locations (Figure 5).



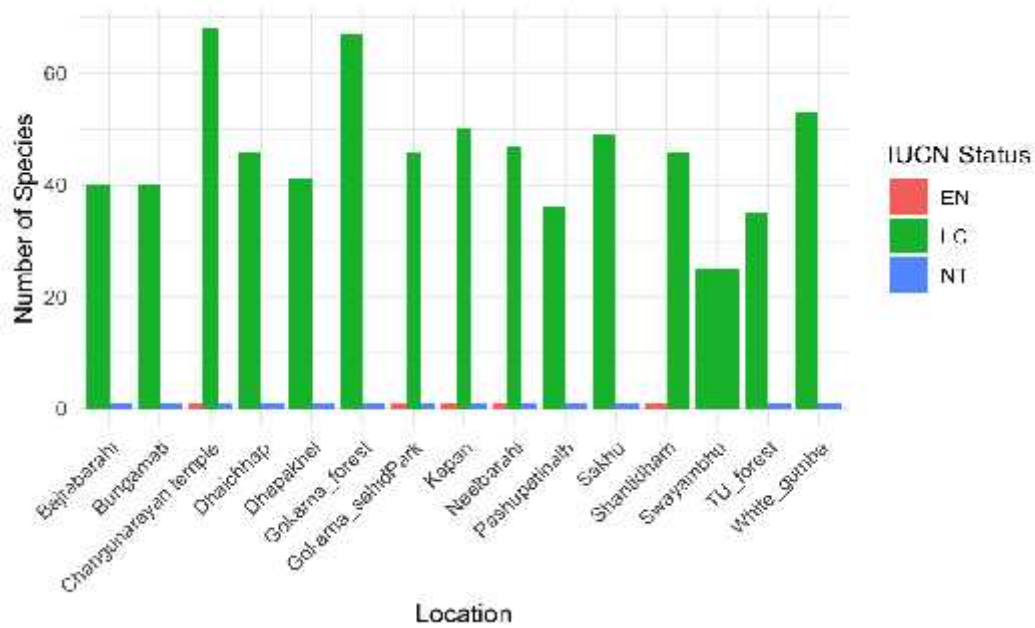
**Figure 5.** Feeding guilds of birds in different forest patches.

Also, among three migration status (Residential, Summer visitor, Winter visitor) Residential birds were highest among all and summer migrants the lowest (Figure 6).



**Figure 6.** Migration status of bird species in different forest patches.

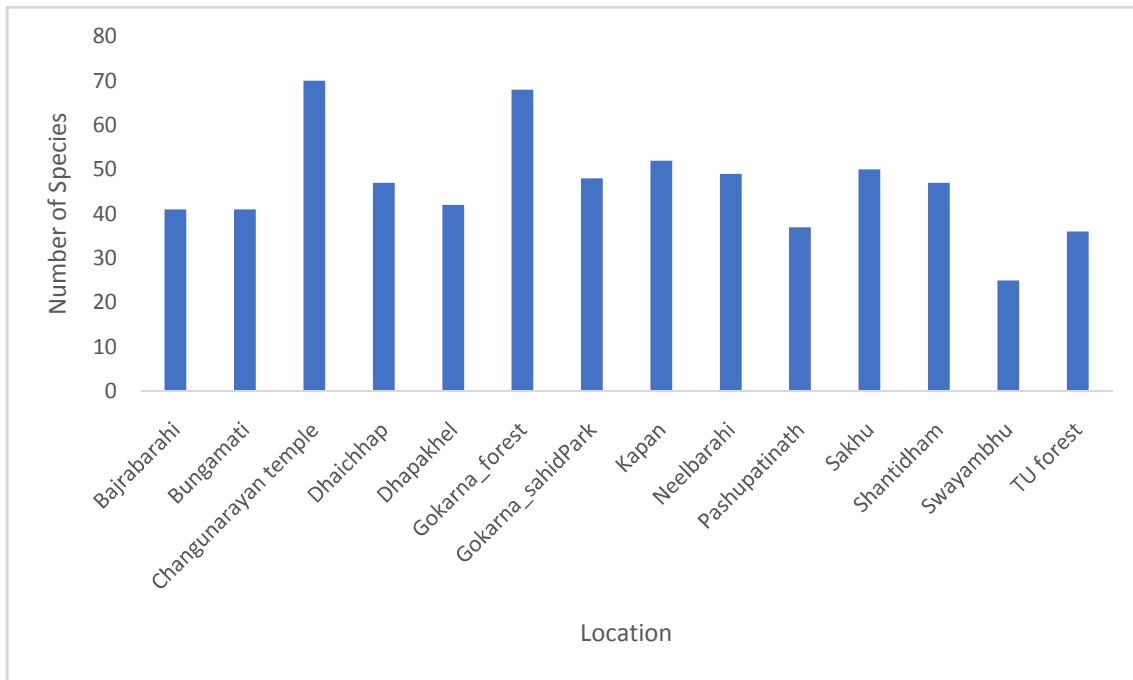
The Endangered and Near Threatened category of IUCN red list species were low in number while the least concerned species were very high (Figure 7).



**Figure 7.** IUCN status of bird species in different forest patches.

#### 4.1.1 Species richness of birds in the forest patches

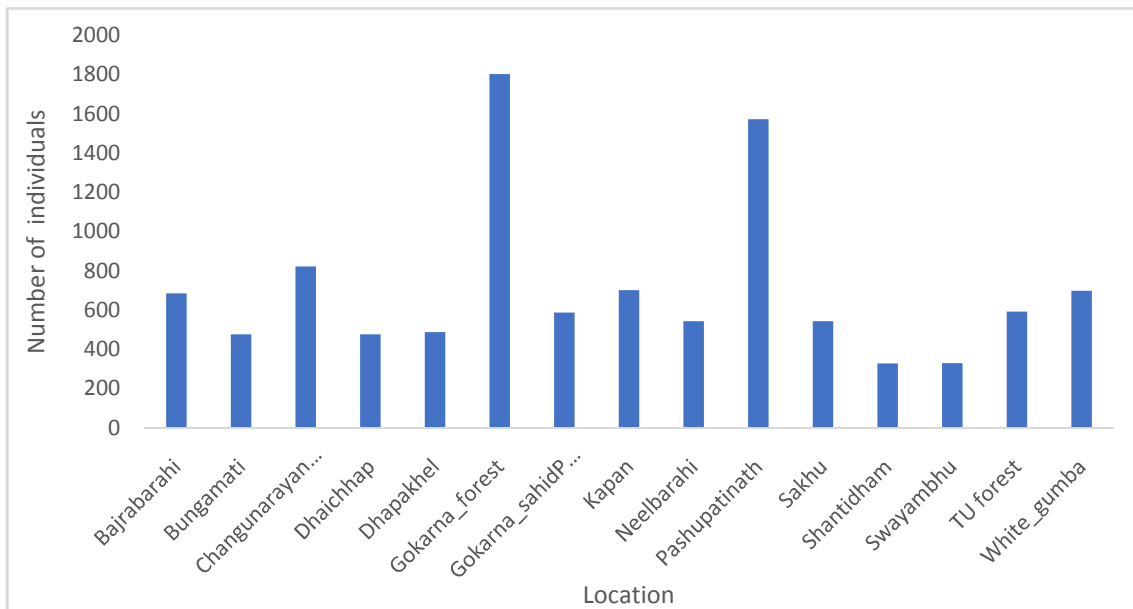
The highest number of species was found in Changunarayan with 70 species and lowest was on Swayambhu forest with 25 species (Figure 8).



**Figure 8.** Number of bird species on different forest patches of Kathmandu Valley.

#### 4.1.2 Bird abundance in the forest patches

The highest number of birds were found in GokarnaForest with 1802 individuals and lowest was on Shantidham patchwith 328 individuals (Figure 9).



**Figure 9.** Number of bird individuals on different forest patches of Kathmandu Valley.

#### 4.1.3 Bird diversity indices in the forest patches

Interestingly, forest patches close to the city center and most disturbed had the lowest Shannon diversity index and parks that are peripheral or away from the city center had higher

diversity and higher species richness (Table 1). The lowest Shannon diversity index was 2.3692 for Swayambhu Forest and highest was 3.5955 for Changunarayan.

**Table 1.** Shannon diversity index of different forest patch

<b>Location</b>	<b>Shannon diversity index</b>
<b>Bajrabarahi</b>	2.9447
<b>Bungamati</b>	3.3156
<b>Changunarayan</b>	<b>3.5955</b>
<b>Dhaichhap</b>	3.2081
<b>Dhapakhel</b>	3.0536
<b>Gokarna_forest</b>	3.1714
<b>Gokarna_sahidPark</b>	2.9512
<b>Kapan</b>	3.3211
<b>Neelbarahi</b>	3.2156
<b>Pashupatinath</b>	2.4545
<b>Sakhu</b>	3.2451
<b>Shantidham</b>	3.4885
<b>Swayambhu</b>	<b>2.3692</b>
<b>TU forest</b>	2.9066
<b>White_gumba</b>	3.3749

## **4.2 Factors affecting bird community structure in the forest patches of Kathmandu**

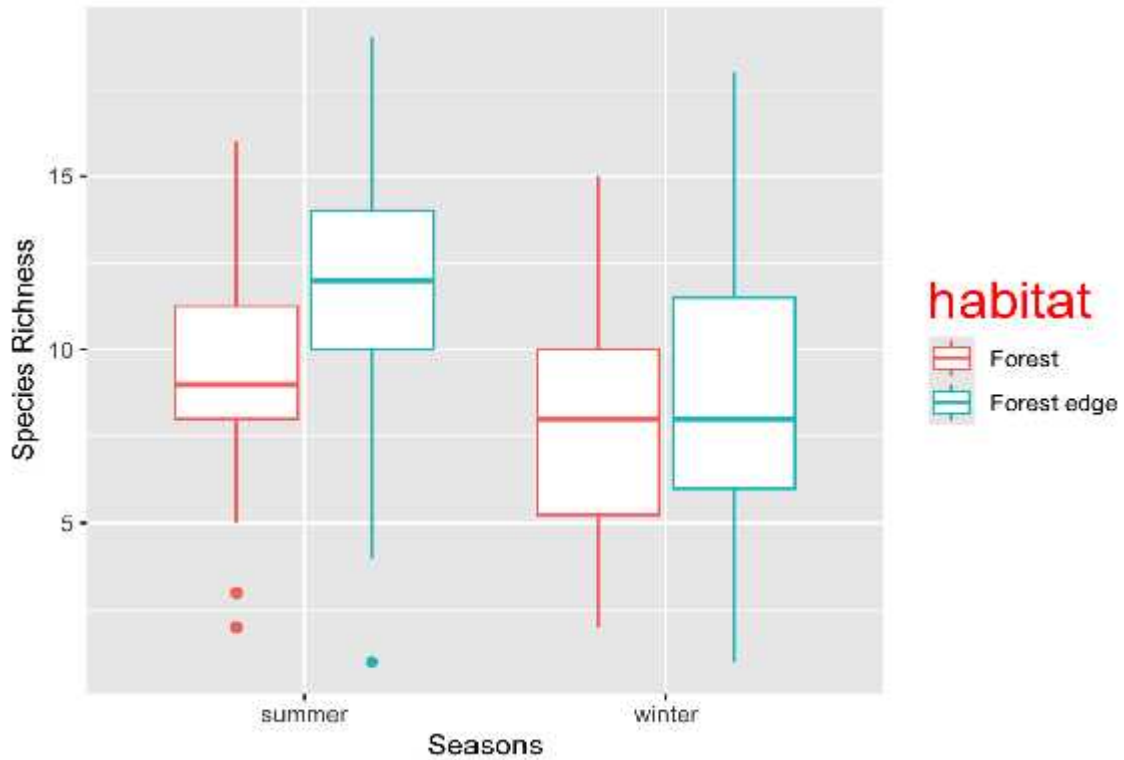
### **4.2.1 Factors affecting species richness**

The generalized linear mixed effect model showed significant effects of season, forest edge, monkey presence (low), cloud cover, humidity, percentage tree, bare soil, leaf litter, combined effect of season and habitat, patch area, and shape index on the species richness (Table 2).

**Table 2.** Summary of Generalized Linear Mixed-Effects Model for species richness

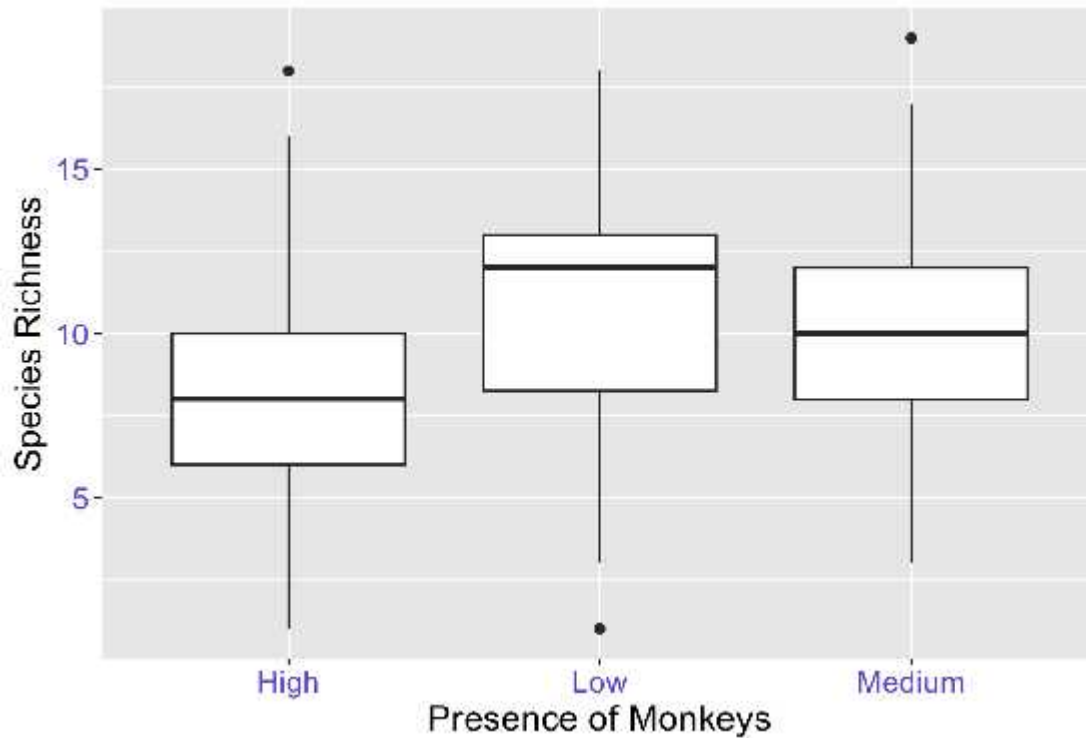
	<b>Estimate</b>	<b>Std. Error</b>	<b>z value</b>	<b>Pr(&gt; z )</b>	
<b>seasonwinter</b>	-0.4271	0.1128	-3.785	0.000	***
<b>habitatForestedge</b>	0.0327	0.0660	0.495	0.6207	
<b>monkey_prlow</b>	0.2087	0.0585	3.565	0.0004	***
<b>monkey_prmedium</b>	-0.0495	0.0665	-0.744	0.4569	
<b>scale(area)</b>	0.1472	0.0370	3.983	<0.0001	***
<b>Shp_Index</b>	-0.2410	0.0478	-5.042	<0.0001	***
<b>canopy</b>	-0.0012	0.0008	-1.428	0.1532	
<b>cloudMostlycloudy</b>	-0.0821	0.1201	-0.684	0.4941	
<b>cloudMostlysunny</b>	0.0618	0.1413	0.437	0.6617	
<b>cloudPartlycloudy</b>	-0.1329	0.1158	-1.147	0.2514	
<b>cloudPartlysunny</b>	-0.0334	0.1809	-0.185	0.8531	
<b>cloudSunny</b>	0.1868	0.0792	2.358	0.0183	*
<b>humid</b>	0.0034	0.0016	2.168	0.0301	*
<b>tree</b>	-0.0186	0.0050	-3.726	0.0002	***
<b>soil</b>	-0.0062	0.0018	-3.465	0.0005	***
<b>grass</b>	-0.0038	0.0022	-1.735	0.0827	
<b>litter</b>	-0.0053	0.0016	-3.254	0.0011	**
<b>seasonwinter:habitatForestedge</b>	-0.1687	0.0734	-2.297	0.0216	*

Winter season showed significant negative effect on the Species richness (-3.785,  $p=0.0001$ ). Cloud coverage also has some effect on richness, during the sunny days the species richness was high. Also, humidity has positive relation (2.168,  $p=0.0301$ ) to species richness. During winter season on the forest edge the species richness was significantly (-2.297  $p=0.0216$ ) low showing the combined effect of season and habitat type (Figure 10).



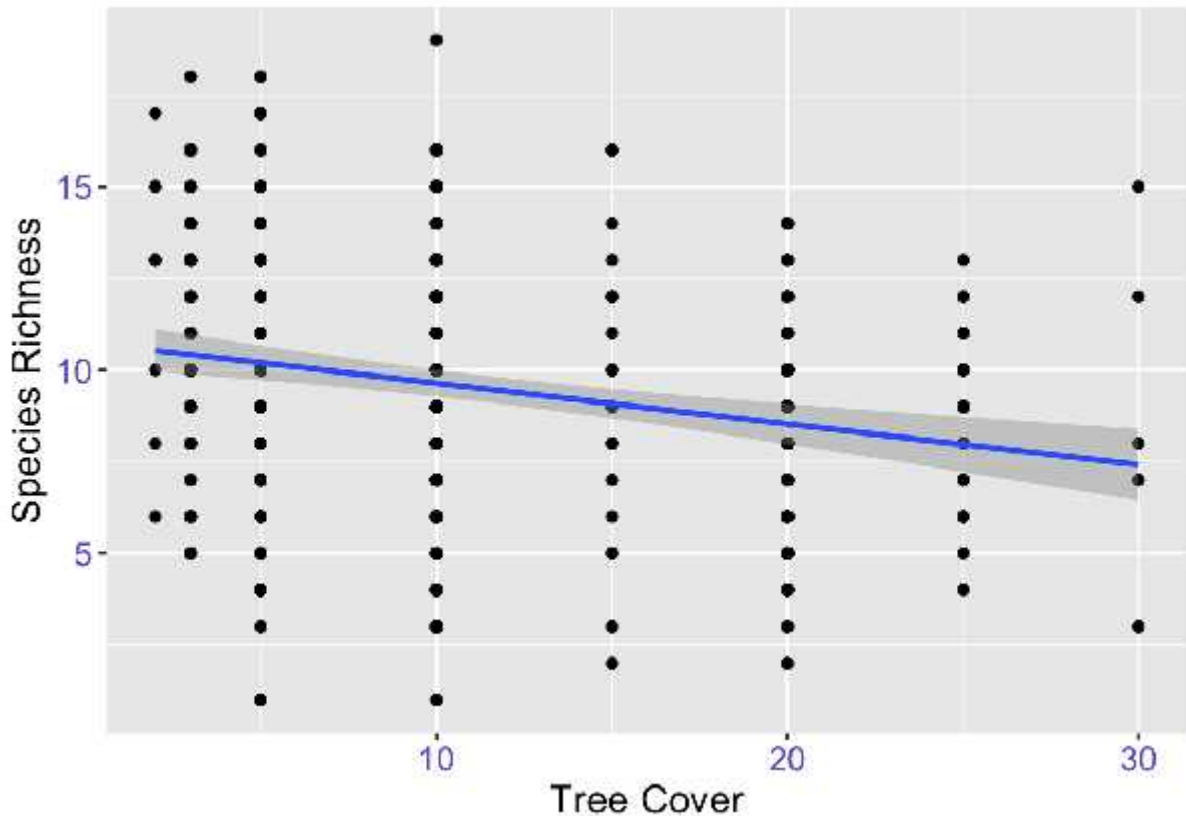
**Figure 10.** Species richness of different habitat (forest and forest edge) during summer and winter.

The presence of monkeys also affected the species richness of birds in the forest patches (Figure 11). Species richness was significantly high (3.565,  $p= 0.0004$ ) when the monkey presence was low.



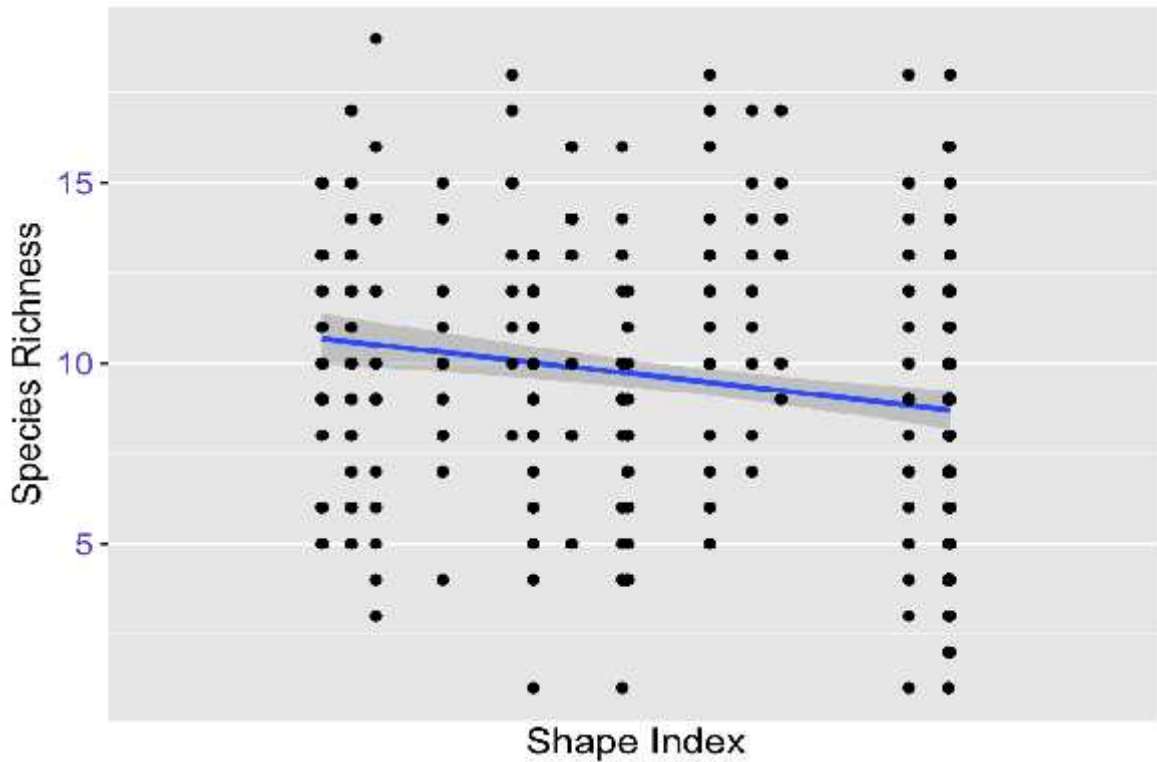
**Figure 11.** Presence of monkey and its effect on species richness.

The percentage tree (-3.726,  $p= 0.0002$ ), showed the negative relationship with the species richness i.e as the number of trees increases the species richness decreases (Figure 12). Percentage leaf litter (-3.254,  $p= 0.0011$ ), and percentage bare soil (-3.465,  $p=0.0005$ ) are negatively significant to species richness.



**Figure 12.** Species richness and its relationship with percentage tree cover.

Richness increases with the increase in patch size showing positive relationship (3.983,  $p < 0.0001$ ). Large patch size had the high species richness and as the area of patch decreased the number of species also decreased. The shape index on the other hand showed the negative relationship to the species richness (Figure 13). The value of shape index 1 means the patch is perfectly circular patch. As the value increases (shape index  $> 1$ ), it means the patch becomes more irregular in shape. From the GLMM model run for species richness, the patch shape showed negative relationship (-5.042,  $p = < 0.0001$ ) i.e species richness was low when the patch boundaries were more irregular. Interior to edge ratio and distance to source showed no specific relation to species richness and were removed on final model (AIC backward elimination process).



**Figure 13.** Species richness and its relation to shape index of forest patch of Kathmandu Valley.

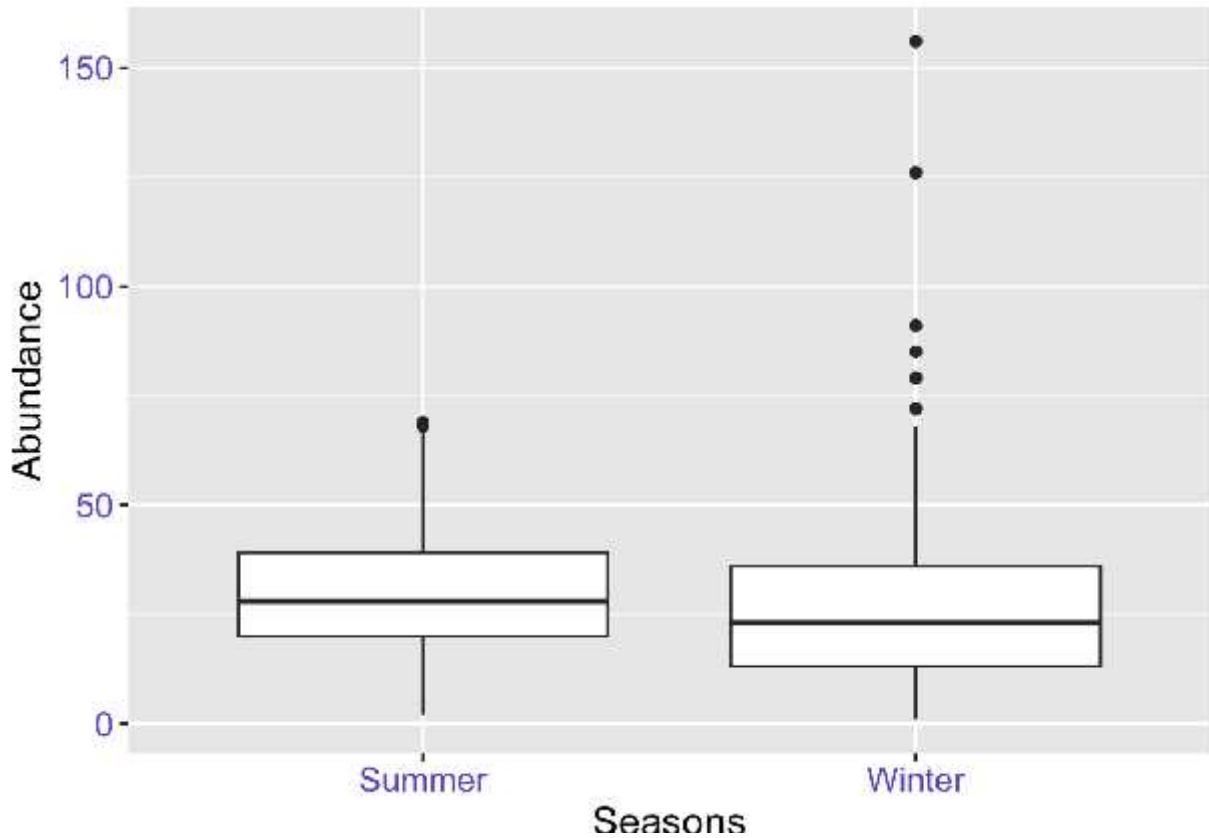
#### 4.2.2 Factors affecting bird abundance in the forest patches

Species abundance was significantly affected by season (winter), monkey presence (low), strata (periphery and rural), cloud cover, humidity, wind, percentage tree, bare soil, percentage grass, distance to source, and IE ratio (Table 3).

**Table 3.** Summary of Generalized Linear Mixed-Effects Model for species abundance

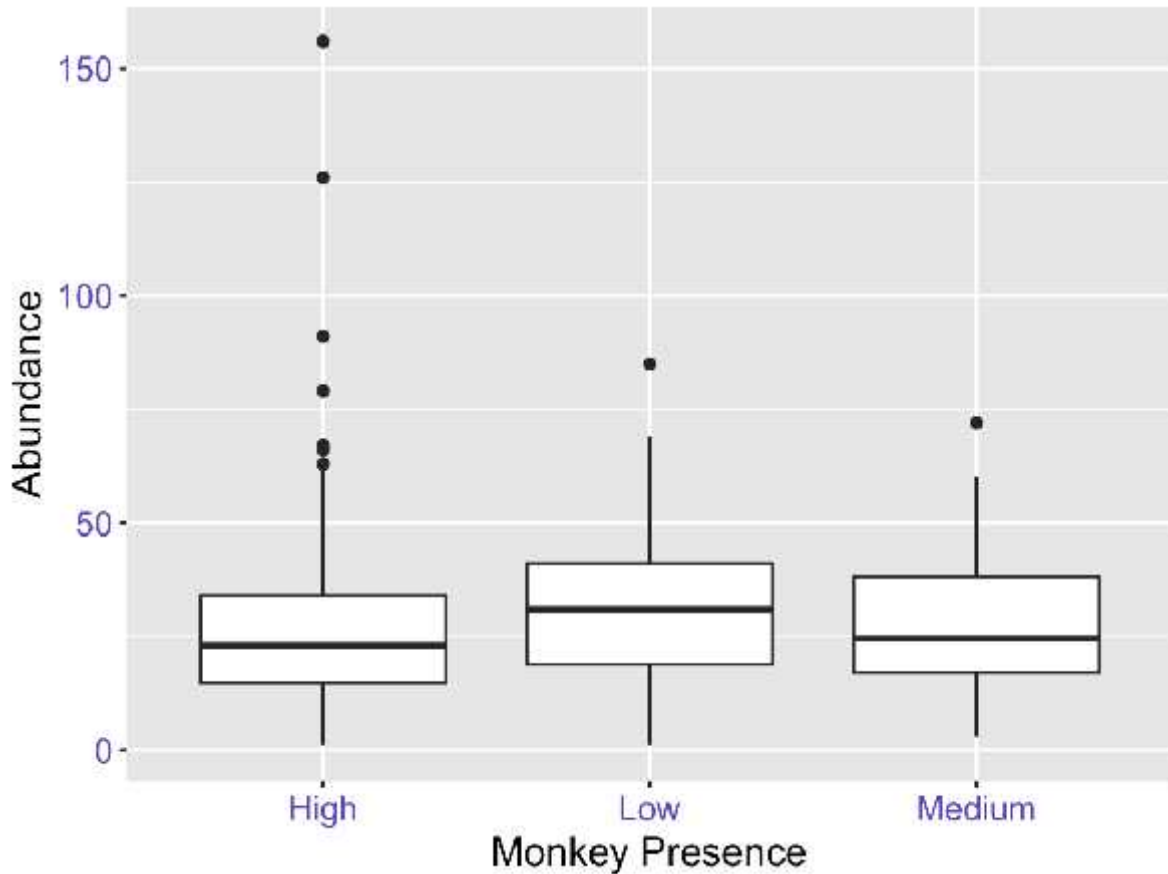
	<b>Estimate</b>	<b>Std. Error</b>	<b>z value</b>	<b>Pr(&gt; z )</b>	
seasonwinter	-0.385	0.0744	-5.168	<0.0001	***
habitatForestedge	-0.0708	0.0429	-1.65	0.0989	
monkey_prlow	0.722	0.291	2.478	0.0132	*
monkey_prmedium	-0.311	0.245	-1.272	0.2033	
scale(dist_source)	-0.363	0.0749	-4.844	<0.0001	***
Shp_Index	-0.228	0.160	-1.426	0.1537	
IE_ratio	-7.11	2.44	-2.917	0.0035	**
strataperiphery	-6.95	0.224	-3.108	0.0019	**
stratarural	-1.29	0.3	-4.289	<0.0001	***
canopy	-0.0024	0.0001	-4.362	<0.0001	***
cloudMostlycloudy	0.0551	0.0752	0.732	0.4640	
cloudMostlysunny	0.189	0.0925	2.049	0.0405	*
cloudPartlycloudy	-0.103	0.0746	-1.377	0.1684	
cloudPartlysunny	0.0821	0.117	0.704	0.4817	
cloudSunny	0.394	0.0511	7.716	<0.0001	***
wind	0.0216	0.0058	3.743	0.0002	***
humid	0.0046	0.0009	4.895	<0.0001	***
pine	0.0011	0.0007	1.637	0.1017	
tree	-0.0293	0.0033	-8.812	<0.0001	***
soil	-0.0035	0.0012	-2.96	0.0031	**
grass	0.0036	0.0013	2.834	0.0046	**
seasonwinter:habitatForestedge	0.0614	0.0428	1.434	0.1515	

During winter season the number of birds were low compared to summer showing seasonal variation (Figure 14). Winter season showed significant negative effect on species abundance (-5.168,  $p=0.0006$ ).



**Figure 14.** Season and its effect on abundance of birds.

Similarly, canopy coverage ( $-4.362$ ,  $p < 0.0001$ ), tree percent cover ( $-8.82$ ,  $p < 0.0001$ ), and bare soil percentage ( $-2.96$ ,  $p = 0.0031$ ) had a negative effect on the species abundance as well (Table 2). The numbers of individuals were high when the canopy cover was low meaning that dense canopy cover did not favor species abundance. Similarly, abundance was lower where the forest cover was high, it means high number of birds were seen where the number of trees was low. Barren areas (without plants or leaf litter) did not support the abundance meaning as the barren area increased the number of individuals decreased. Peripheral patch ( $-3.08$ ,  $p = 0.001885$ ) and rural patch ( $-4.2289$ ,  $p < 0.0001$ ) has lower species abundance, shown by the model. Wind ( $3.743$ ,  $p = 0.0002$ ) and humidity ( $4.895$ ,  $p < 0.0001$ ) also showed significant positive relation with species abundance. Low monkey presence ( $2.478$ ,  $p = 0.0132$ ) and sunny weather ( $7.716$ ,  $p < 0.0001$ ) favors the abundance just like the species richness (Figure 15).



**Figure 15.** Presence of monkey and its effect on abundance of birds

The species abundance was negatively significant ( $-4.844$ ,  $p = <0.0001$ ) to distance from source i.e as the distance to source forest increases the number of individuals decreases. Also, the shape index showed negative relation but was not significant. Interior to edge ratio has negative relationship ( $-22.97$ ,  $p = 0.0035$ ) to species abundance. Species abundance was higher on the patches that has more edge area (\*\*Higher IE- ratio means more core area and less edge and lower IE-ratio means the patch has more edgy area). Area of patch didn't have any specific relation to the species abundance and was removed from main model during AIC backward elimination process.

## 5. Discussion

### 5.1. Bird diversity in urban forest patches of Kathmandu

A total of 10,651 individuals birds belonging to 118 species were observed across both winter and summer seasons. In summer 5,603 individuals of 78 species were recorded and in winter 5,048 individuals of 91 species were recorded. House crows(*Corvus splendens*) were the most abundant species indicating that house crows are well suited to the urban environment and thrive on human disturbed landscape. Many studies found that generalist species are more likely to thrive on the urban settlements (Ferenc et al., 2014; Isaksson, 2018; Upadhyaya et al., 2022). In Kathmandu Valley previous studies done by Bhusal et al. (2025); Katuwal et al. (2018); Upadhyaya et al. (2022) also reported that the generalist species were more in number and house crow being one of the most abundant species. Species richness and abundance were varied across the different urban forest patches of Kathmandu Valley. Changunarayan had the highest number of species and Swayambhu had the lowest. That could be due to different factors such as size, habitat heterogeneity, and disturbance related factor (MacArthur, 1964). Changunarayan patch was the fifth largest patch with higher Interior-edge ratio while Swayambhu was one of the smallest patches with lower interior to edge ratio (appendix 3). Also, Changunarayan was in the rural part of valley with less human disturbance and lower monkey presence makes it suitable for higher diversity and Swayambhu being the opposite thus making it less suitable for lesser number of birds. Large area with low edge ratio supports the higher species richness (Garizabal-Carmona & Mancera-Rodríguez, 2021). Greater interior area means more stable microhabitat, with variety of ecological niche, making the heterogenous habitat which eventually aids in higher number of species (Garizabal-Carmona & Mancera-Rodríguez, 2021; Marzluff, 2008). Changunarayantemple forest supports edge dwelling generalists as well as forest specialists making it the ideal place to higher bird species.

In this study, interaction between edge and winter have also significant impact on species richness of bird. Lower species richness at edge during winter could be due to various ecological reason such as stronger winds, reduced shelter (Bernaschini et al., 2019; Zellweger et al., 2016). In contrast, interior forest may provide better protection from extreme condition and offers thermal insulation and stable microclimate to support bird population and survive in the winter (De Frenne et al., 2021).

In spite of the higher total number of species in winter the Mixed-Effect Model showed species richness was lower on average in winter. This suggested that although the species number was high during the winter, the number of species present at any specific patch was lower, this might be due to seasonal variation, habitat use and species distribution. Distribution of bird species are determined by many environmental factors (MacArthur, 1964; Shabani et al., 2009) such as vegetation, habitat structure, climate, food availability, and season (Cody, 1981; Crampton et al., 2011; Cumming et al., 2014; Ferger et al., 2014; García et al., 2011). Seasonal change influences the species richness in Nepal (Grimmett et al., 2016; Katuwal et al., 2016a; Katuwal et al., 2018) and it is considered an important factor that shape the bird diversity in many mountain valleys of Nepal. In Nepal, the migratory birds (both winter and summer migrants) are about one third of total bird species recorded in Nepal (Grimmett et al., 2016). Summer visitors in Nepal arrives around April to May and most of them stays up to September and winter visitors came around October and some species stays up to March (Grimmett et al., 2016; Katuwal et al., 2016a). Most of the birds are altitudinal migration and Nepal has less number of summer migrants than winter migrants (Grimmett et al., 2016), and this study aligns with the findings of Katuwal et al. (2018) which finds the less number of summer migrants compared to winter migrant in Kathmandu Valley. The seasonality observed in this study might be attributed to migration pattern in Nepal (Grimmett et al., 2016; Katuwal et al., 2016b) as the migratory bird species were of significant amount.

Monkeys' presence can directly or indirectly impact the bird species richness. They are competitors of birds in terms of food source and nesting site (Fleming, 1979; Terborgh, 1990). A study done by Jover (2001) found that in the shared habitat primate presence and their activities such as territorial behavior, and foraging could lead to reduced bird species and their activities. Many studies said that non-human primates (monkeys) feeding on bird eggs occasionally (Kaisin et al., 2018; Lima & Bicca-Marques, 2024). Particularly in small habitats such as Swayambhu and Pashupatinath, monkeys could alter the habitat structure due to their behavioral activities disrupting nesting sites driving the bird species away from such habitat. Many studies found that birds avoid patches with high monkey activities supporting the finding of this research (Cristóbal-Azkarate et al., 2015; Fleming, 1979; Zaluar et al., 2022).

The tree percentage also showed negative impact on bird species richness. Similar patterns have been observed by many other studies where dense forest with high canopy cover and support fewer species compared to open or heterogenous habitat structure. Lewandowski et al. (2021) in his study found that the small canopy gap could affect the bird assemblage in broadleaved forest and species richness and abundance of ground nester and cavity nesters were higher when there is a canopy gap. Similarly, Roll et al. (2015) also found that total no of species were significantly higher in less canopy than in closed-canopy forest. Also, dense forest support less diversity, study done by Czeszczewik et al. (2015) found that species richness and diversity were lower where the tree density was high, similar to the above finding.

On sunny days the activities of birds become high compared to cloud and rain (Sharp et al., 2021). This study found that bird species richness was higher when the weather was clear. This might be due to, during clear weather the foraging activities increases (Mainwaring et al., 2021) and availability of food such as insects are more visible (Sparks et al., 2002). Also, there was a positive relationship of humidity on bird species richness. The high humidity means higher production i.e insect abundance increases during humid weather which eventually improve bird abundance (Craig & Roberts, 2001). The percentage of leaf litter and percentage bare soil showed a negative impact on species richness. Both the factors are related to the micro habitat diversity, as the amount of litter and bare soil increases the species richness decreases. Study done by Morelli et al. (2017) suggested that the ground cover determines the food availability and shelter to many species of birds and their cover determines the species richness. Soil and other grounds can play an important role in foraging and birds could respond to composition of soil and leaf litter (Fonderflick et al., 2010; Morelli et al., 2013; Myers et al., 2015).

Winter season had a significant negative effect on species abundance. Like the species richness the number of individuals was also impacted by the seasonality. During winter temperature lowers, food availability decreases and harsh environmental factors may contribute to low bird abundance (Correia et al., 2015; MacArthur, 1964, 1984; Shabani et al., 2009). Higher number of bird individuals in Gokarna Forest and lower number of birds in Shantidham could be attributed to many factors such as area, vegetation, resource, shelter etc.

Similar to species richness the bare soil has negative relation to species abundance as well. This suggests, barren areas without ground cover support lesser number of birds. This might be due to less availability of food, nesting sites and shelter attributed to vegetation ground

cover (Fonderflick et al., 2010; Myers et al., 2015). Bare soil indicates the disturbance, which can negatively impact bird populations (Myers et al., 2015). Also, the presence of monkey has negative effect on bird abundance. This cause could be similar to above reasons, i.e. lower species richness when the monkey presence was high.

Similarly, canopy coverage and tree percent cover had a negative effect on the species abundance. Forest provides shelter and nesting sites for many species however; dense canopies may limit the undergrowth vegetation and insect communities serving as a crucial food source for bird species (Lewandowski et al., 2021; Santamaria-Rivero et al., 2016). Also, inside dense forest light penetration is low which also aids in low primary production (Czeszczewik et al., 2015; Roll et al., 2015). Some studies suggest that species richness and abundance are higher in open or mixed habitats compared to densely forested habitat (Basile et al., 2021; Hedwall et al., 2019; Tu et al., 2020). This is because the spaces and gaps in the forest allows for better foraging opportunities and open space (Cumming et al., 2014; Lewandowski et al., 2021; Roll et al., 2015).

The difference in Shannon diversity index across different forest patches was observed. This suggested that human disturbance, urbanization, habitat quality influence the bird diversity. The patches located to city center having lower species richness and diversity could be due to pollution, disturbance, human activities impacting the birds around the area. This finding aligned with global findings where heavy and rapid urbanization lead to habitat and biodiversity loss (Aronson et al., 2014; Camacho-Cervantes et al., 2018; Marzluff, 2008; Morelli et al., 2017; Palacio et al., 2018; Peng et al., 2024; Silva et al., 2015; Uchida et al., 2021; Wang et al., 2021; Xie et al., 2016). Similar result was demonstrated by Maseko et al. (2020) and Wang et al. (2021) and concluded that large forest fragment are important to maintain ecosystem functioning and conservation of bird species in urban areas. Dominance of generalist could be other factor (this study showed that House crow was the most abundant species) as they could adapt in all the habitat and could have wide range of food sources (Chace & Walsh, 2006; Katuwal et al., 2016a). Peripheral region supported both urban tolerant species as well as forest dependent species and might be the reason of higher diversity in the periphery than in city centers (Jokimäki et al., 2018; Otieno & Mutati, 2021).

## **5.2 Forest patch characteristics and bird community structure**

Forest patch characteristics (shape, size, connectivity) play fundamental role in shaping bird community. Patch area determines the species richness with larger patch supporting more

species supporting species-area relationship. Larger areas support more numbers of species due to greater habitat heterogeneity and lower extinction risks (MacArthur & Wilson, 2001). This phenomenon of species-area relationship, explains large forest patches avian communities than smaller fragments because larger areas provide better resources such as varied microhabitats, nesting sites, and food resources to sustain diverse guilds (Ferraz et al., 2007). Moreover, smaller patches have more edge effects, affecting sensitive forest-interior species from external disturbances like extreme weather and invasive predators (Flaspohler et al., 2010; Fujita & Koike, 2009). These small fragments often experience homogenization, where only generalist species with broad niches thrive (Fahrig, 2013). In contrast, larger patches maintain ecological complexity by supporting species with specialized foraging strategies (Haas et al., 2020). However, area alone cannot guarantee diversity if patches are degraded or isolated. Larger area provide heterogeneity in habitat with high food availability, more space, less competition and many more. Study from the city of North Andes by Garizabal-Carmona and Mancera-Rodríguez (2021) showed that larger and more regular shaped urban patches supported higher species richness. Regular shaped (round) patches not only support more species (Hawrot & Niemi, 1996; Helzer & Jelinski, 1999), but also support a wider range of ecological guilds, by providing diverse microhabitats (Yamaura et al., 2008). Conversely, irregular shaped patches (linear or fragmented) often support only generalist species, reducing overall ecosystem resilience (Helzer & Jelinski, 1999; Shake et al., 2012). Similar findings were found on many other research (Chiron et al., 2024; Morelli et al., 2013; Peng et al., 2024; Sol et al., 2020) supporting the result of this study which also showed positive significance of area and negative to shape index.

The distance from the source showed a negative significant relationship to bird abundance i.e as the patches becomes more isolated the bird abundance decreases. This pattern could be explained by the theory of Island Biogeography (MacArthur & Wilson, 2001), which states that “Island closer to the mainland (in our case source forest are main land and urban forest patches are island) have higher immigration rate, therefore increases the number of species.” Forest dependent species of birds are more likely to inhabit the birds close to the source forest as they have increased availability of food, nesting sites and shelter (Thompson et al., 2022). Also, the patches close to source have better connectivity and dispersal with the source forest which facilitates the better resource access and species movement (Liordos et al., 2021). While on the other hand, more isolated patches acts as ecological sinks due to limited

resource availability which negatively impacts the number of species in such patch (MacArthur, 1964).

The negative interaction between species abundance and IE ratio suggested that generalist surviving on edges of the urban forest patch dominates the urban forest suppressing the specialist number residing on the core habitat (Buxton et al., 2018; Morelli et al., 2017). Higher edge habitat often experiences invasion by secondary vegetation shifting resource availability. For example, edge-affiliated birds may outcompete forest-interior species for fruits, indirectly reducing plant dispersal services (Czeszczewik et al., 2015; Hawrot & Niemi, 1996; Palacio et al., 2018). Additionally, around the edge, raptors and large-bodied birds hovers and their dominance and predation increase there (Bernaschini et al., 2019). IE-ratio affects bird abundance by determining the proportion of habitat exposed to edge effects, normally the forest patch with more core areas supports numbers of forest specialist but in urban landscape the core- specialists might be less abundant due to high amount of habitat fragmentation and disturbance (Chiron et al., 2024; Kang et al., 2015; Maseko et al., 2020).

This study forest patch characteristics, particularly size, shape, and edge-to-interior ratio, distance to source forest fundamentally shape bird community assemblages thereby validating the hypothesis “the patch characteristics highly correlates with the richness and abundance of birds in the Kathmandu Valley”.

## 6. Conclusions and recommendations

### 6.1. Conclusions

This study highlighted the influence of habitat features, environmental variables, and seasonal fluctuations, and patch matrices on bird species richness and abundance in various Kathmandu Valley Forest patches. Although there were slightly more species recorded in the winter than in the summer, the mixed effect model revealed that species richness was lower in the winter.

Vegetation attributes such as tree percentage and ground cover were some environmental factors that had a significant impact on species richness and abundance. Furthermore, higher tree densities showed lower species richness and abundance indicating that dense forests would be less appropriate habitats for a wider variety of bird species compared to open or heterogeneous habitats. From the combined factor forest edge and the winter season, there was a significant result on species richness, with species richness being lower at the edges in the winter. The presence of monkeys showed a negative impact on both species richness and abundance, which might be due to competitive interaction between primates and bird species for resource and shelter. The increase in species richness and abundance during sunny weather is due to increased foraging activities as insect activities might be high in number during sunny weather.

Higher numbers of birds were found on patches that are close to continuous forest source and abundance of birds decreased as the patches are farther from the source. This supported the theory of island biogeography explaining that patches close to mainland support more numbers of species whereas isolation creates ecological sinks supporting less bird abundance. Interior to edge ratio and its relation to abundance suggested that the urban patches of Kathmandu Valley supported a high number of edge birds, and the patches are more likely to be dominated by generalists.

Species richness was positively related to patch size, suggesting that large areas support more species, confirming the Species-Area relationship. Large patches are more heterogeneous and have high resource availability, less competition, and shelter availability to support birds of different species. This emphasizes the importance of large forest patches to maintain biodiversity in urban areas. Patch shape, on the other hand, represented by shape index has a negative association to species richness. Irregular shaped patches seem to support less bird

species as such patches have an increased edge effect leading to disturbance and habitat degradation from the edge.

The Shannon diversity index revealed that forest patches near urban centers had reduced diversity relative to outlying areas, highlighting the influence of urbanization on avian groups. Because of variations in habitat quality and human disturbances, Changuarayan had the highest species diversity while Swayambhu Forest had the lowest. The insectivores were found to be higher across the urban forest patches in Kathmandu Valley. Also, the residential bird species were high, and summer migrants were lower. Majority of birds were of the Least Concern category of IUCN red list.

## **6.2. Recommendations**

It is recommended that habitat management and protection strategies need to be implemented to support avian biodiversity in the Kathmandu Valley. Maintaining and protecting interior forest areas from fragmentation and promoting afforestation with native tree species can enhance habitat quality and support the various biodiversity. Seasonal conservation strategies should focus on monitoring migratory species and improving habitat conditions suitable for migratory as well as residential birds. Community involvement and awareness through education, ecotourism, and collaboration with officials is essential for long-term conservation efforts. Furthermore, long term monitoring of bird populations, along with studies on climate change impacts and habitat, will provide insights for conservation of biodiversity.

## 7. References

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## Appendices

### Appendix 1. Forest patches and their area, perimeter, shape index, IE-ratio

S.N.	Place	Area	Perimeter	Shape_Index	IE_ratio
1	Shantidham	182021.066	3260	2.156	0.018
2	Swayambhu	126812.519	2740	2.171	0.022
3	White gumba	440632.181	7220	3.068	0.016
4	Kapan	262442.722	4360	2.401	0.017
5	Gokarnasahid park	212336.763	2700	1.653	0.013
6	Gokarna forest	<b>1737214.23</b>	14360	3.073	0.008
7	Pashupatinath	385857.512	4200	1.907	0.011
8	Neelbarahi	172831.581	2060	1.398	0.012
9	Changunarayan	238449.143	5120	2.958	0.021
10	Sakhu	224150.301	2460	1.466	0.011
11	TU forest	186918.129	3860	2.519	0.021
12	Dhapakhel	124516.545	2520	2.015	0.02
13	Bungmati	128213.513	3300	2.6	0.026
14	Bajrabarahi	222528.926	2200	1.316	0.01
15	Dhaichhap	<b>102811.093</b>	2100	1.848	0.02

**Appendix 2.** Common name, scientific name, order and family of bird species recorded from forest patches of Kathmandu Valley.

Common Name	Scientific Name	Order	Family
Alexandrine Parakeet	<i>Palaeorniseupatria</i>	Psittaciformes	Psittacidae
Ashy Drongo	<i>Dicrurusleucophaeus</i>	Passeriformes	Dicruridae
Ashy Wood-Pigeon	<i>Columba pulchricollis</i>	Columbiformes	Columbidae
Asian Barred Owlet	<i>Glaucidiumcuculoides</i>	Strigiformes	Strigidae
Asian Koel	<i>Eudynamysscolopaceus</i>	Cuculiformes	Cuculidae
Barn Swallow	<i>Hirundorustica</i>	Passeriformes	Hirundinidae
Black Bulbul	<i>Hypsipetesleucocephalus</i>	Passeriformes	Pycnonotidae
Black Drongo	<i>Dicrurusmacrocerus</i>	Passeriformes	Dicruridae
Black Kite	<i>Milvus migrans</i>	Accipitriformes	Accipitridae
Black Redstart	<i>Phoenicurusochruros</i>	Passeriformes	Muscicapidae
Black-throated Tit	<i>Aegithalosconcinnus</i>	Passeriformes	Aegithalidae
Black-winged Cuckooshrike	<i>Lalage melaschistos</i>	Passeriformes	Campephagidae
Blue Whistling-Thrush	<i>Myophonuscaeruleus</i>	Passeriformes	Muscicapidae
Blue-fronted Redstart	<i>Phoenicurus frontalis</i>	Passeriformes	Muscicapidae
Blue-throated Barbet	<i>Psilopogonasiaticus</i>	Piciformes	Megalaimidae
Blue-throated Flycatcher	<i>Cyornisrubeculoides</i>	Passeriformes	Muscicapidae
Booted Eagle	<i>Hieraaetuspennatus</i>	Accipitriformes	Accipitridae
Bronzed Drongo	<i>Dicrurusaeneus</i>	Passeriformes	Dicruridae
Brown Shrike	<i>Laniuscristatus</i>	Passeriformes	Laniidae
Brown-fronted Woodpecker	<i>Leiopicusauriceps</i>	Piciformes	Picidae
Buff-barred Warbler	<i>Phylloscopuspulcher</i>	Passeriformes	Phylloscopidae
Cattle Egret	<i>Bubulcus ibis</i>	Pelecaniformes	Ardeidae
Chestnut-bellied Nuthatch	<i>Sittacinnamoventris</i>	Passeriformes	Sittidae
Chestnut-bellied Rock-Thrush	<i>Monticola rufiventris</i>	Passeriformes	Muscicapidae
Chestnut-crowned Laughingthrush	<i>Trochalopteronerythrocephalum</i>	Passeriformes	Muscicapidae
Chestnut-headed Bee-eater	<i>Meropsleschenaulti</i>	Coraciiformes	Meropidae
Chestnut-tailed Starling	<i>Sturniamalabarica</i>	Passeriformes	Sturnidae
Cinereous Tit	<i>Paruscinereus</i>	Passeriformes	Paridae
Common Cuckoo	<i>Cuculuscanorus</i>	Cuculiformes	Cuculidae
Common Iora	<i>Aegithinatiphia</i>	Passeriformes	Aegithinidae
Common Myna	<i>Acridotherestrictis</i>	Passeriformes	Sturnidae
Common Rosefinch	<i>Carpodacuserythrinus</i>	Passeriformes	Fringillidae
Common Tailorbird	<i>Orthotomussutorius</i>	Passeriformes	Cisticolidae
Coppersmith Barbet	<i>Psilopogonhaemacephalus</i>	Piciformes	Megalaimidae
Crested Serpent-Eagle	<i>Spilornischeela</i>	Accipitriformes	Accipitridae
Crimson Sunbird	<i>Aethopygasiparaja</i>	Passeriformes	Nectariniidae

Eurasian Collared-Dove	<i>Streptopeliadecaocto</i>	Columbiformes	Columbidae
Eurasian Hobby	<i>Falco subbuteo</i>	Falconiformes	Falconidae
Eurasian Sparrowhawk	<i>Accipiter nisus</i>	Accipitriformes	Accipitridae
Fire-breasted Flowerpecker	<i>Dicaeumignipectus</i>	Passeriformes	Dicaeidae
Fulvous-breasted Woodpecker	<i>Dendrocoposmacei</i>	Piciformes	Picidae
Gray Treepie	<i>Dendrocittaformosae</i>	Passeriformes	Corvidae
Gray-backed Shrike	<i>Laniustephronotus</i>	Passeriformes	Laniidae
Gray-bellied Tesia	<i>Tesiacyaniventer</i>	Passeriformes	Scotocercidae
Gray-headed Canary-Flycatcher	<i>Culicicapaceylonensis</i>	Passeriformes	Stenostiridae
Gray-headed Woodpecker	<i>Dendropicospodocephalus</i>	Piciformes	Picidae
Gray-hooded Warbler	<i>Phylloscopusxanthoschistos</i>	Passeriformes	Phylloscopidae
Great Barbet	<i>Psilopogonvirens</i>	Piciformes	Megalaimidae
Greater Coucal	<i>Centropussinensis</i>	Cuculiformes	Cuculidae
Greater Yellownape	<i>Chrysophlegmaflavinucha</i>	Piciformes	Picidae
Green-backed Tit	<i>Parusmonticolus</i>	Passeriformes	Paridae
Green-billed Malkoha	<i>Phaenicophaeustristis</i>	Cuculiformes	Cuculidae
Greenish Warbler	<i>Phylloscopustrochiloides</i>	Passeriformes	Phylloscopidae
Hair-Crested Drongo	<i>Dicrurushottentottus</i>	Passeriformes	Dicruridae
Himalayan Black-lored Tit	<i>Machlolophusxanthogenys</i>	Passeriformes	Paridae
Himalayan Bulbul	<i>Pycnonotusleucogenys</i>	Passeriformes	Pycnonotidae
Himalayan Buzzard	<i>Buteorefectus</i>	Accipitriformes	Accipitridae
Hodgson's Redstart	<i>Phoenicurushodgsoni</i>	Passeriformes	Muscicapidae
House Crow	<i>Corvussplendens</i>	Passeriformes	Corvidae
House Sparrow	<i>Passer domesticus</i>	Passeriformes	Passeridae
Hume's Warbler	<i>Phylloscopushumei</i>	Passeriformes	Phylloscopidae
Indian Cuckoo	<i>Cuculusmicropterus</i>	Cuculiformes	Cuculidae
Indian Golden Oriole	<i>Orioluskundoo</i>	Passeriformes	Oriolidae
Indian Paradise-Flycatcher	<i>Terpsiphoneparadisi</i>	Passeriformes	Monarchidae
Indian Pond-Heron	<i>Ardeolagravii</i>	Pelecaniformes	Ardeidae
Indian White-eye	<i>Zosterospalpebrosus</i>	Passeriformes	Zosteropidae
Jungle Myna	<i>Acridotheresfuscus</i>	Passeriformes	Sturnidae
Kalij Pheasant	<i>Lophuraleucomelanos</i>	Galliformes	Phasianidae
Large Cuckooshrike	<i>Coracinamacei</i>	Passeriformes	Campephagidae
Large-billed Crow	<i>Corvusmacrorhynchos</i>	Passeriformes	Corvidae
Lemon-rumped Warbler	<i>Phylloscopuschloronotus</i>	Passeriformes	Phylloscopidae
Lesser Yellownape	<i>Picuschlorolophus</i>	Piciformes	Picidae
Little Bunting	<i>Emberizapusilla</i>	Passeriformes	Emberizidae
Long-tailed Broadbill	<i>Psarisomusdalhousiae</i>	Passeriformes	Eurylaimidae
Long-tailed Minivet	<i>Pericrocotusethologus</i>	Passeriformes	Campephagidae
Long-tailed Shrike	<i>Laniusschach</i>	Passeriformes	Laniidae
Olive-backed pipit	<i>Anthushodgsoni</i>	Passeriformes	Motacillidae
Oriental Honey-buzzard	<i>Pernisptilorhynchus</i>	Accipitriformes	Accipitridae

Oriental Magpie-Robin	<i>Copsychussaularis</i>	Passeriformes	Muscicapidae
Oriental Turtle-Dove	<i>Streptopeliaorientalis</i>	Columbiformes	Columbidae
Peregrine Falcon	<i>Falco peregrinus</i>	Falconiformes	Falconidae
Pied Bushchat	<i>Saxicolacaprata</i>	Passeriformes	Muscicapidae
Puff-throated Babbler	<i>Pellorneumruficeps</i>	Passeriformes	Pellorneidae
Red-billed Blue-Magpie	<i>Urocissaerythroryncha</i>	Passeriformes	Corvidae
Red-vented Bulbul	<i>Pycnonotuscafer</i>	Passeriformes	Pycnonotidae
Rock Dove	<i>Columba livia</i>	Columbiformes	Columbidae
Rose-ringed Parakeet	<i>Alexandrinuskrameri</i>	Psittaciformes	Psittacidae
Rufous Sibia	<i>Heterophasiacapistrata</i>	Passeriformes	Leiotrichidae
Rufous Treepie	<i>Dendrocittavagabunda</i>	Passeriformes	Corvidae
Rufous Woodpecker	<i>Micropternusbrachyurus</i>	Piciformes	Picidae
Rufous-gorgeted Flycatcher	<i>Ficedulastrophiata</i>	Passeriformes	Muscicapidae
Rusty-cheeked Scimitar-Babbler	<i>Erythrogyenyerythrogyenis</i>	Passeriformes	Timaliidae
Scaly Thrush	<i>Zootheradauma</i>	Passeriformes	Turdidae
Scarlet Minivet	<i>Pericrocotusflammeus</i>	Passeriformes	Campephagidae
Shikra	<i>Accipiter badius</i>	Accipitriformes	Accipitridae
Slaty-blue Flycatcher	<i>Ficedula tricolor</i>	Passeriformes	Muscicapidae
Slaty-headed Parakeet	<i>Himalayapsittahimalayana</i>	Psittaciformes	Psittacidae
Slender-billed Scimitar-Babbler	<i>Pomatorhinussuperciliaris</i>	Passeriformes	Timaliidae
Small Niltava	<i>Niltavamacgrigoriae</i>	Passeriformes	Muscicapidae
Speckled Piculet	<i>Picumnusinnominatus</i>	Piciformes	Picidae
Spotted Dove	<i>Spilopeliachinensis</i>	Columbiformes	Columbidae
Spotted Owlet	<i>Athene brama</i>	Strigiformes	Strigidae
Steppe Eagle	<i>Aquila nipalensis</i>	Accipitriformes	Accipitridae
Streaked Laughingthrush	<i>Trochalopteronlineatum</i>	Passeriformes	Leiotrichidae
Taiga Flycatcher	<i>Ficedulaalbicilla</i>	Passeriformes	Muscicapidae
Tree Pipit	<i>Anthustrivialis</i>	Passeriformes	Motacillidae
Velvet-fronted Nuthatch	<i>Sitta frontalis</i>	Passeriformes	Sittidae
Verditer Flycatcher	<i>Eumyiasthalassinus</i>	Passeriformes	Muscicapidae
Whistler's Warbler	<i>Phylloscopuswhistleri</i>	Passeriformes	Phylloscopidae
White-crested Laughingthrush	<i>Garrulaxleucolophus</i>	Passeriformes	Leiotrichidae
White-rumped Munia	<i>Lonchurastrata</i>	Passeriformes	Estrildidae
White-throated Fantail	<i>Rhipiduraalbicollis</i>	Passeriformes	Rhipiduridae
White-throated Kingfisher	<i>Halcyon smyrnensis</i>	Coraciiformes	Alcedinidae
White-throated Laughingthrush	<i>Pterorhinusalbogularis</i>	Passeriformes	Leiotrichidae
Yellow-bellied Fairy-Fantail	<i>Chelidorhynchypoxanthus</i>	Passeriformes	Stenostiridae
Yellow-bellied Flowerpecker	<i>Dicaeummelanozanthum</i>	Passeriformes	Dicaeidae
Yellow-breasted Greenfinch	<i>Chloris spinoides</i>	Passeriformes	Fringillidae
Yellow-browed Warbler	<i>Phylloscopusinornatus</i>	Passeriformes	Phylloscopidae


**Appendix 3.** Common name, feeding guild migration status and IUCN status of bird species recorded from forest patches of Kathmandu Valley.

<b>Common Name</b>	<b>feeding_guild</b>	<b>migration_status</b>	<b>IUCN_status</b>
Alexandrine Parakeet	Frugivore	Resident	NT
Ashy Drongo	Insectivore	Resident	LC
Ashy Wood-Pigeon	Frugivore	Resident	LC
Asian Barred Owlet	Carnivore	Resident	LC
Asian Koel	Omnivore	Resident	LC
Barn Swallow	Insectivore	Resident	LC
Black Bulbul	Omnivore	Resident	LC
Black Drongo	Insectivore	Resident	LC
Black Kite	Carnivore	Resident	LC
Black Redstart	Insectivore	Winter Migrant	LC
Black-throated Tit	Omnivore	Resident	LC
Black-winged Cuckooshrike	Insectivore	Resident	LC
Blue Whistling-Thrush	Omnivore	Resident	LC
Blue-fronted Redstart	Insectivore	Resident	LC
Blue-throated Barbet	Frugivore	Resident	LC
Blue-throated Flycatcher	Insectivore	Summer Migrant	LC
Booted Eagle	Carnivore	Winter Migrant	LC
Bronzed Drongo	Insectivore	Resident	LC
Brown Shrike	Insectivore	Winter Migrant	LC
Brown-fronted Woodpecker	Omnivore	Resident	LC
Buff-barred Warbler	Insectivore	Winter Migrant	LC
Cattle Egret	Carnivore	Resident	LC
Chestnut-bellied Nuthatch	Omnivore	Resident	LC
Chestnut-bellied Rock-Thrush	Insectivore	Resident	LC
Chestnut-crowned Laughingthrush	Omnivore	Resident	LC
Chestnut-headed Bee-eater	Insectivore	Summer Migrant	LC
Chestnut-tailed Starling	Omnivore	Resident	LC
Cinereous Tit	Insectivore	Resident	LC
Common Cuckoo	Insectivore	Summer Migrant	LC
Common Iora	Insectivore	Summer Migrant	LC
Common Myna	Omnivore	Resident	LC
Common Rosefinch	Omnivore	Winter Migrant	LC
Common Tailorbird	Insectivore	Resident	LC
Coppersmith Barbet	Frugivore	Resident	LC
Crested Serpent-Eagle	Carnivore	Resident	LC
Crimson Sunbird	Nectarivore	Resident	LC
Eurasian Collared-Dove	Granivore	Resident	LC
Eurasian Hobby	Carnivore	Resident	LC

Eurasian Sparrowhawk	Carnivore	Winter Migrant	LC
Fire-breasted Flowerpecker	Omnivore	Resident	LC
Fulvous-breasted Woodpecker	Insectivore	Resident	LC
Gray Treepie	Omnivore	Resident	LC
Gray-backed Shrike	Carnivore	Winter Migrant	LC
Gray-bellied Tesia	Insectivore	Resident	LC
Gray-headed Canary-Flycatcher	Insectivore	Resident	LC
Gray-headed Woodpecker	Insectivore	Resident	LC
Gray-hooded Warbler	Insectivore	Resident	LC
Great Barbet	Frugivore	Resident	LC
Greater Coucal	Carnivore	Resident	LC
Greater Yellownappe	Insectivore	Resident	LC
Green-backed Tit	Omnivore	Resident	LC
Green-billed Malkoha	Insectivore	Resident	LC
Greenish Warbler	Insectivore	Winter Migrant	LC
Hair-Crested Drongo	Insectivore	Resident	LC
Himalayan Black-lored Tit	Insectivore	Resident	LC
Himalayan Bulbul	Omnivore	Resident	LC
Himalayan Buzzard	Carnivore	Winter Migrant	LC
Hodgson's Redstart	Omnivore	Winter Migrant	LC
House Crow	Omnivore	Resident	LC
House Sparrow	Granivore	Resident	LC
Hume's Warbler	Insectivore	Resident	LC
Indian Cuckoo	Insectivore	Summer Migrant	LC
Indian Golden Oriole	Omnivore	Summer Migrant	LC
Indian Paradise-Flycatcher	Insectivore	Summer Migrant	LC
Indian Pond-Heron	Carnivore	Resident	LC
Indian White-eye	Omnivore	Resident	LC
Jungle Myna	Omnivore	Resident	LC
Kalij Pheasant	Omnivore	Resident	LC
Large Cuckooshrike	Insectivore	Resident	LC
Large-billed Crow	Omnivore	Resident	LC
Lemon-rumped Warbler	Insectivore	Winter Migrant	LC
Lesser Yellownappe	Insectivore	Resident	LC
Little Bunting	Omnivore	Winter Migrant	LC
Long-tailed Broadbill	Insectivore	Resident	LC
Long-tailed Minivet	Insectivore	Resident	LC
Long-tailed Shrike	Carnivore	Resident	LC
Olive-backed pipit	Insectivore	Resident	LC
Oriental Honey-buzzard	Carnivore	Resident	LC
Oriental Magpie-Robin	Insectivore	Resident	LC
Oriental Turtle-Dove	Granivore	Resident	LC


Peregrine Falcon	Carnivore	Resident	LC
Pied Bushchat	Insectivore	Resident	LC
Puff-throated Babbler	Insectivore	Resident	LC
Red-billed Blue-Magpie	Omnivore	Resident	LC
Red-vented Bulbul	Omnivore	Resident	LC
Rock Pigeon (Feral Pigeon)	Granivore	Resident	LC
Rose-ringed Parakeet	Frugivore	Resident	LC
Rufous Sibia	Omnivore	Resident	LC
Rufous Treepie	Omnivore	Resident	LC
Rufous Woodpecker	Insectivore	Resident	LC
Rufous-gorgeted Flycatcher	Insectivore	Resident	LC
Rusty-cheeked Scimitar-Babbler	Omnivore	Resident	LC
Scaly Thrush	Omnivore	Winter Migrant	LC
Scarlet Minivet	Insectivore	Resident	LC
Shikra	Carnivore	Resident	LC
Slaty-blue Flycatcher	Insectivore	Resident	LC
Slaty-headed Parakeet	Frugivore	Resident	LC
Slender-billed Scimitar-Babbler	Omnivore	Resident	LC
Small Niltava	Insectivore	Resident	LC
Speckled Piculet	Insectivore	Resident	LC
Spotted Dove	Granivore	Resident	LC
Spotted Owlet	Carnivore	Resident	LC
Steppe Eagle	Carnivore	Winter Migrant	EN
Streaked Laughingthrush	Omnivore	Resident	LC
Taiga Flycatcher	Insectivore	Winter Migrant	LC
Tree Pipit	Insectivore	Winter Migrant	LC
Velvet-fronted Nuthatch	Insectivore	Resident	LC
Verditer Flycatcher	Insectivore	Resident	LC
Whistler's Warbler	Insectivore	Resident	LC
White-crested Laughingthrush	Omnivore	Resident	LC
White-rumped Munia	Granivore	Resident	LC
White-throated Fantail	Insectivore	Resident	LC
White-throated Kingfisher	Carnivore	Resident	LC
White-throated Laughingthrush	Omnivore	Resident	LC
Yellow-bellied Fairy-Fantail	Insectivore	Resident	LC
Yellow-bellied Flowerpecker	Omnivore	Resident	LC
Yellow-breasted Greenfinch	Granivore	Resident	LC
Yellow-browed Warbler	Insectivore	Winter Migrant	LC

**Appendix 4.** Research permission for conducting research on forest patches of Kathmandu Valley from Department of Forest and Soil Conservation, Babarmahal-Kathmandu.



नेपाल सरकार  
वन तथा वातावरण मन्त्रालय  
**वन तथा भू-संरक्षण विभाग**

फोन नं. { १-२२७७७४  
१-२२७७७५ }  
फ्याक्स: १-२२७७७६



प्रान्त वन संख्या र मिति:-  
वन संख्या:- ०००/६१  
न. नं.- १४३६

मिति: २०८१/०२/१७

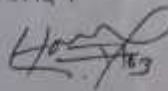
विषय: अनुसन्धान अनुमति सम्बन्धमा ।

श्री सोनिया ओस्ती,  
नुवाकोट, नेपाल ।

प्रस्तुत विषयमा Central Department of Zoology, Tribhuvan University, Kirtipur Kathmandu मा M.Sc. 3<sup>rd</sup> Semester मा अध्ययनरत तपाईंले "Effects of Urban Forest Patch Characteristics on Bird Community Assemblage in Kathmandu Valley" को विषयमा अध्ययन अनुसन्धानका लागि अध्ययन अनुमति उपलब्ध गराउनु हुन भनी मिति २०८१/०२/०८ गते यस विभागमा दिनु भएको निवेदन साध प्रयोग्य ज्ञान भएको । सो सम्बन्धमा कारवाही हुँदा उक्त अध्ययन अनुसन्धानबाट अध्ययन क्षेत्रमा bird diversity in urban forest patches of Kathmandu Valley and relationship between urban forest patch characteristics and bird diversity बारे जानकारी प्राप्त हुने बाटोको उक्त प्रयोग्यता उल्लेखित Methodology (Field survey, Standard point count method, Shannon-Weaner function and Simpson's index Method) अनुसार तर्फसितको शर्तहरूको अधिनमा रही डिभिजन वन कार्यालयसँग सम्न्धन गर्न सन् २०२४, जुन वैशि सन् २०२४, नोभेम्बर सम्मका लागि अनुसन्धान गर्न तन निदेशानुसार अनुसोध छ ।

**शर्तहरू**


१. अनुसन्धानकर्ताले वन ऐन २०७६ तथा वन नियमावली २०७९, राष्ट्रिय निकुञ्ज तथा वन्यजन्तु संरक्षण ऐन, २०२९, र नियमावली २०३० तथा यस मातहतका नियमावलीहरूको पूर्ण पालना गर्नुपर्नेछ ।
२. अनुसन्धान कार्य डिभिजन वन कार्यालयसँगको सम्न्धनमा गर्नुपर्नेछ ।
३. नयाँ संकलन गर्न पाइने छैन ।
४. अनुसन्धानको क्रममा प्राप्त भएको बैबिक विविधता सार्वजनिक सम्बन्धित संवेदनशील सूचनाहरू गोप्य राख्नु पर्नेछ, अनावधिकृत रूपमा त्यस्ता सूचनाहरू कसैलाई पनि उपलब्ध गराउन पाइने छैन ।
५. अनुसन्धान कार्य समाप्त भए पश्चात एक प्रति रिपोर्ट/प्रतिवेदन (कागजी तथा विद्युतीय) यस विभागमा अनिवार्य रूपमा बुझाउनु पर्नेछ ।
६. तोकिएका शर्तहरूको पालना नगर्नेमा विभागले कुनै पनि समयमा अनुसन्धान अनुमति रद्द गर्न सक्नेछ ।



(सबनम पाठक)  
सहायक वन अधिकृत

**सोपार्थ**  
श्री डिभिजन वन कार्यालय, काठमाडौं । ज्ञानसम्पन्न सहयोग तथा अनुसन्धानको लागि अनुसोध छ ।

**Appendix 5.** Research permission extension from Department of Forest and Soil Conservation, Babarmahal-Kathmandu.

  
नेपाल सरकार  
वन तथा वातावरण मन्त्रालय  
वन तथा भू-संरक्षण विभाग  
संकेत नं. { ४-२२२२२४  
४-२२२२२४  
संख्या: ४-२२२२२४


कृपया परोक्षरमा प्राप्त पत्र संख्या र मिति उल्लेख गर्नुहोला ।  
बबरमहल, काठमाडौं, नेपाल  
मिति: २०८१।०९।०३

प्राप्त पत्र संख्या र मिति:-  
पत्र संख्या - ०८१/०८२  
च नं. - ५४७

विषय: अध्ययन अनुसन्धान अनुमतिको म्याद थप सम्बन्धमा ।


श्री सविना ओस्ती,  
नुवाकोट, नेपाल ।

प्रस्तुत विषयमा Tribhuvan University, Central Department of Zoology, Kirtipur, Kathmandu मा M. Sc. मा अध्ययनरत तपाईंले "Effects of Urban Forest Patch Characteristics on Bird Community Assemblage in Kathmandu Valley" विषयमा यस विभागको प.सं. २०८०।०८।१ च.नं. १४२६ मिति २०८१।०२।१७ को पत्रबाट अध्ययन अनुसन्धान गर्न अनुमति प्रदान गरिएकोमा उक्त अध्ययन अनुसन्धान कार्य तोकिएको समयभित्र सम्पन्न गर्न नसकिएको भनी म्याद थप गर्न अनुरोध भई आएको हुँदा यस विभागको मिति २०८१।०२।१७ को अनुमति पत्रमा उल्लेखित शर्तहरूको अधिनमा रही अध्ययन अनुसन्धान गर्न अनुसन्धानको म्याद १८ डिसेम्बर, २०२४ देखि २८ फेब्रुअरी, २०२५ सम्म थप गरिएको व्यहोरा निर्देशानुसार अनुरोध छ ।

  
(सचनम पाठक)  
वन अधिकृत

बोधार्थ  
श्री डिभिजन वन कार्यालय, काठमाण्डौं, प्रत्यक्ष निगरानीमा उल्लेखित कार्य गर्न आवश्यक सहयोग गर्नु हुन ।

**Appendix 6.** Research permission for conducting research on Mrighasthali, Pashupati Development Trust, Gaushala Kathmandu .

**पशुपति क्षेत्र विकास कोष**  
**संचालक परिषद**  
देवपत्तन, काठमाडौं ।

फोन नं. ४४७१८२८  
फ्याक्स : ४४७२९६२  
प्यान नं. ३०४०९९१३४  
अडियो नोटिस बोर्ड: १६९८०९४४७०२७२  
वि.स २०८१/०४/०३  
मिति- त.स. १९४४ वि.सं. १२ वि.सी.कार

प.सं. - २०८१/०८२  
च.सं. - १२

श्री सविना ओस्ती  
विदुर ३, नुवाकोट  
९८४९०८२९७५ ।

विषय :- अनुमति दिइएको बारे ।

उपरोक्त सम्बन्धमा, तल्लो श्री विभुवन विश्वविद्यालय प्राणी शास्त्र केन्द्रीय विभाग कीर्तिपुरको पत्र संख्या ६२९/०८०/०८९ मिति २०८१/०३/१६ मार्फत कोषको द.न ३३१५, मिति २०८१/०३/३० को निवेदन अनुसार तपाईं श्री सविना ओस्तीलाई पशुपति क्षेत्र भित्र Effects of Urban Forest Patch Characteristics on Bird Community Assemblage in Kathmandu Valley विषयको अध्ययन अनुसन्धानको कार्य गर्न आदेशानुसार अनुमति दिइएको व्यक्तिय जानकारी गराइन्छ । साथै अध्ययन अनुसन्धान प्रतिवेदनको एक प्रति कोष कार्यालयलाई उपलब्ध गराउन समेत जानकारी गराइएको छ ।

अवगतार्थः  
श्रीमान् सदस्य सचिवज्यू  
श्रीमान् कार्यकारी निर्देशकज्यू

बोधार्थः  
श्री विभुवन विश्वविद्यालय प्राणी शास्त्र केन्द्रीय विभाग कीर्तिपुर  
श्री संस्कृति संरक्षण महाशाखा, प.क्षे.वि.कोष  
श्री मानव संसाधन तथा वातावरण संरक्षण शाखा, प.क्षे.वि.कोष  
श्री सुरक्षा इकाई, प.क्षे.वि.कोष - मापदण्ड विपरित नहुने गरी अनुमति एवं नियन्त्रणका लागि ।

  
रेवति रमण अधिकारी)  
नि. प्रमुख  
सार्वजनिक खरिद तथा सेवा सुविधा महाशाखा