

Review article

Avian urban ecology in Nepal: A call for attention

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Abstract

Urbanization is increasing at an unprecedented rate, leading to changes in land use resulting in the loss of habitat for birds worldwide. Nevertheless, urban areas still support approximately 20% of the world's bird population. In Nepal, urbanization has been rapidly increasing in recent decades, yet little attention has been paid to urban biodiversity exacerbating the impact of urban expansion on threatened birds. In this perspective article, we explore studies on urban birds in Nepal to identify existing research patterns, discuss what has been known, outline gaps and pave immediate future interventions in studies of avian urban ecology in Nepal. There has been a significantly lower number of studies on urban birds in Nepal compared to neighbouring India and China in the last 10 years. Studies of urban birds in Nepal are at a very early stage focused on the diversity and richness in Kathmandu, Pokhara and Butwal with no baseline data for other major cities. Our understanding of bird homogenization or extinction as well as the effects of birds on cities, such as their rapid colonization and potential role as pests, may be limited by this dearth of knowledge about urban birds and biodiversity. Therefore, we have outlined future research opportunities in avian urban ecology in Nepal such as long-term bird surveys, interdisciplinary field of studies, diseases study, management of urban green spaces, avian adaptation to urban environments, colonization and extinction patterns in cities, and conflicts, challenges, and management strategies related to urban avian ecology. With this article, we call the immediate attention of scientists, urban planners, and related stakeholders to use birds as a model system to study urban environments which could be a good start in building a bird-friendly city.

Keywords: Biodiversity; Urban birds; Nepal; Urban ecology; Urbanization

1 | Introduction

Urbanization is increasing at a rapid pace around the world with 3.3 million hectares of land being converted to urban areas annually (UNCCD 2017). The urban area is expected to triple between 2000 and 2030 (CBD 2023). Change in land use comes with a cost to biodiversity. Today, urbanization is one of the most dramatic environmental changes, endangering biodiversity and ecological services that support human civilization (McDonald et al. 2013). Urbanization impacts species and communities in various ways such as habitat fragmentation and alteration of many plant, bird and animal species' native habitats, which pose a danger to biodiversity and present significant conservation concerns (Theodorou 2022). As urbanization accelerates, understanding its impact on urban species is essential, providing insights into the challenges they encounter in adapting to the changing urban environment. Therefore, it is a concern for biologists to understand how urbanization

affects global biodiversity so that effective strategies can be developed for urban management.

Birds are the key component of urban biodiversity. Out of the total 10,052 bird species known across the world, around 20% (2041 species) exist in urban environments (Aronson et al. 2014). About 36.9% of Key Biodiversity areas are in urban areas and the impact of urbanization is known to over 27% of globally threatened bird species (Birdlife International 2022). Most birds are easily detectable and relatively conspicuous and show a marked sensitivity to environmental alteration (Sepp et al. 2018) making them model organisms to assess urban ecosystem conditions. In response to urbanization, birds either avoid cities or adapt to the urban environment (Shochat et al. 2010; Sol et al. 2017). Urban birds face loss of natural habitat, alteration of available resources, increased stress leading to a change in hormone levels, and reduction in reproductive success (Slabbekoorn & Ripmeester 2008; Esquivé et al. 2020) along with changes in their physiology, behaviour, and morphology (Isaksson 2018).

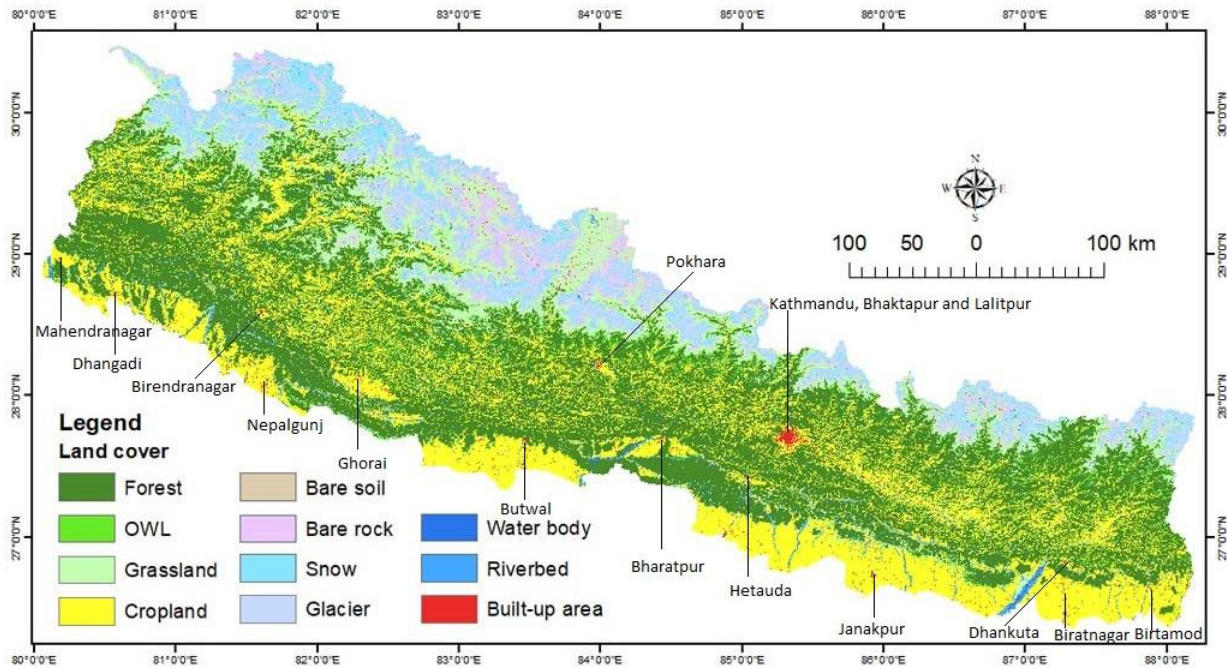


Figure 1. Land use system of Nepal showing different land use class and major cities (Modified from (FRTC 2022)). * OWL- Other Wooded Land. Kathmandu, Pokhara and Butwal are the cities that received attention for urban birds. Other cities with significant urbanization still lack checklists of the birds.

Urbanization induces hominization of the birds, favoring mostly generalists (Evans et al. 2011) and filtering species/population with specific traits (Leveau 2019).

The rate of urbanization in Nepal has been accelerating in recent years due to rural-urban migration, better economic opportunities, and infrastructure development (Timsina et al. 2020). Urban area in Nepal increased from 9% in 1990 to 21% in 2022, indicating a steady rise in urbanization (Figure 1) (FRTC 2022; World Bank 2023).

Over the past three decades, the Kathmandu Valley, the capital city of Nepal has experienced the highest growth in built-up areas, expanding by 206.88 km² followed by Hetauda, an increase of 24.77 km² and Pokhara with an expansion of 22.68 km² (Figure 2) (Devkota et al. 2023). Such a surge in urban expansion is driven by the escalating urban population, which has risen from 17.07% in 2011 to 66.08% in 2021 (Ghimire 2022).

Furthermore, ecologically sensitive areas like riverbanks, farmlands and forests have encroached limiting green space availability for birds (Devkota et al. 2023). This fragmentation disrupts ecological connectivity, leading to the alteration of avian habitat, behaviour, physiology, and breeding patterns (Heinen-Kay et al. 2021; Isaksson 2018), genetic isolation and decreased species diversity (Wan et al. 2018).

Studies on avian ecology in urban environments have received great attention in developed countries. For example, bird abundance and community composition in urban areas have been thoroughly studied in Europe (Morelli et al. 2021), Australia (Wooster et al. 2022), and the USA (Gil & Brumm 2014). However, concerns over

urban birds and their ecology have just begun in South Asia and negligible attention has been given in developing countries like Nepal. It is crucial to generate scientific evidence on urban birds (and biodiversity) to design sustainable urban management plans. Realizing the necessity and scant of information on diverse aspects of urban avifauna which need to be studied, we explore current efforts to study urban birds, highlight gaps and provide the potential areas of research.

2 | Materials and methods

In this perspective review, we used secondary sources of information to understand trends of research in Nepal and compare them with neighboring nations. We obtained published research articles from Google Scholar, ResearchGate, the National Center for Biotechnology Information and the Web of Science. We used keywords such as 'Urban birds', and 'Nepal' to explore peer-reviewed articles in above mentioned sources. Due to the lack of abundant literature on urban birds of Nepal, we also accessed annual reports (such as Bird Conservation Nepal) and grey literature such as undergraduate and graduate theses along with news articles. To understand trends of urban bird research in Nepal compared to neighbouring India, China, Bangladesh, and Pakistan, we extracted the trends of urban bird research from different search directories using keywords "Urban birds" and "India", "China", "Nepal" and respective countries dated from 2010-2022.

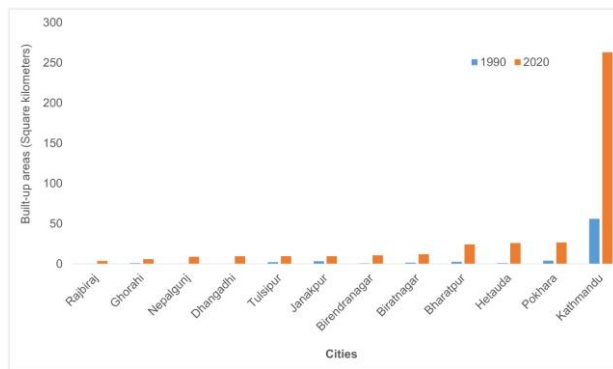


Figure 2. Change in built-up areas in major cities of Nepal (1990 and 2020); from Devkota et al. 2023. Built up areas have significantly increased in all major cities of Nepal with Kathmandu having almost quadruple increase.

3 | Results and discussion

Studies on urban birds of Nepal started very recently after the initiation of urban bird count in 2016. It is the first and only long-term study for urban bird avifauna in Nepal (BCN 2023). Apart from that, there are some short-term studies and anecdotal evidences that seek further validation. In this perspective article, we discuss such trends, and patterns and lay a foundation for future research on urban birds in Nepal.

3.1 | Limited urban bird research in Nepal

Only ten studies have been conducted in Nepal on urban birds which includes both published and grey literature. Although the exact number might be biased as grey literature is not easily accessible online, it is very clear that the least attention has been given to urban birds. Most of these studies were baseline surveys to explore the diversity and distribution of birds in three major cities, Kathmandu, Pokhara and Butwal.

Research on urban birds in Nepal lags behind that in neighbouring countries like India and China yet shows comparable levels to studies conducted in Pakistan and Bangladesh (Figure 3). China is leading urban bird research and substantive efforts have been made in India (Figure 3) which is an expected trend as shown in other life science research (Ghimire et al. 2021).

China has made significant contributions to urban bird research in Asia. Studies have focused on various aspects of urban bird ecology, including risks and opportunities for urban nesting (Liang et al. 2011), adaptation to disturbances (Lin et al. 2012), effects of plastic on nesting (Townsend & Barker 2014), role of urban park in urban biodiversity (Yang et al. 2020) species composition in urban parks (Tan et al. 2021), seasonal immigration response and fluctuations (Xie et al. 2021), contamination of organohalogenes and anthropogenic effects (Yu et al. 2014), and hormonal variations along urban gradients (Zhang et al. 2011). In India, urban research has been directed towards diverse facets of avian urban ecology

including distribution and status of birds (Rawat and Rao 2020; Vala et al. 2020), avian diversity along gradients (Sengupta et al. 2014), adaptation measures (Panda et al. 2021), impact of disturbance adaptation measures (Panda et al. 2021), on community structure (Verma & Murmu 2015), heavy metal bio-monitoring in urban bird feathers (Manjula et al. 2015), and the use of urban materials in nest construction (Pandian 2023). These studies have revealed declining House sparrow *Passer domesticus* populations, greater diversity in suburban areas, preference for native trees by urban nesters, nesting in trees rather than artificial features, and increased use of artificial materials in urban nests by house sparrows compared to rural areas (Radhamany et al. 2016; Rao & Koli 2017). In addition, there are similarities in research on urban birds in Nepal, Pakistan and Bangladesh which indicates these countries also lack sufficient research attention on urban birds.

The urban avifaunal research in Europe, North America and Australia has progressed to continent-scale genomics/epigenetics level studies (Salmón et al. 2021; Watson et al. 2020), urban tolerance and homogenization (Callaghan et al. 2023; Cooper et al. 2020) breeding ecology and the breeding success in urban region (Fritsch et al. 2019) as well as urban area acting as migration fuel over (Rondon et al. 2011) aiding the urban management strategies (for example: Urban Bird Treaty in United States (U.S. Fish and Wildlife Service 2020) and The Birds Directive in Europe (European Union 1979).

3.2 | Current urban bird research in Nepal is preliminary

Studies on urban birds of Nepal has mostly focused generating baseline data on diversity and composition of birds in rural-urban gradients. This is consistent with trends of overall biodiversity research in Nepal (Paudel et al. 2023).

One key literature on urban birds of Nepal is Katuwal et al. (2018) which studied seasonal differences as well as diversity gradients along urban, suburban, and rural areas

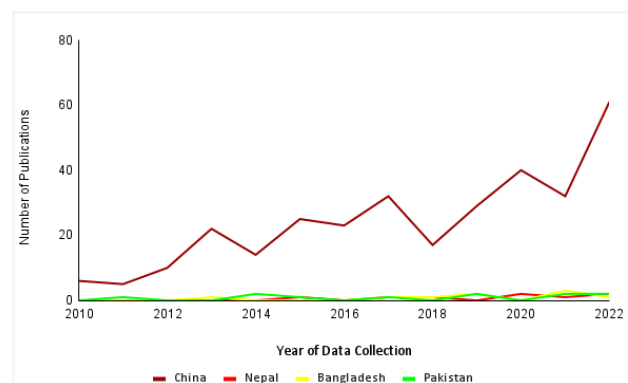


Figure 3. Studies on urban birds in India, China, Pakistan, Bangladesh and Nepal. Both neighboring India and China have significant increase in efforts to study urban birds (number of papers published) over the years while Nepal still struggles to publish a paper a year.

of Kathmandu Valley. They found a total of 102 species with decreasing rural to urban avifaunal richness and diversity with mostly resident birds (81.37%) followed by winter migrants (14.7%) and summer migrants (3.92%). Seasonal variation of feeding guild richness was observed significantly among insectivores and carnivores. This study is part of Bird Conservation Nepal's (BCN) initiation of urban bird count that started in 2016 where annual urban bird count surveys are conducted in 24 fixed transects of Kathmandu Valley in summer and winter (Katuwal et al. 2018). The total number of individuals counted in the winter season over the years in Kathmandu Valley shows an almost consistent status (Figure 4, (BCN 2017; BCN 2018; BCN 2019, BCN 2020; BCN 2021 Himalayan News Service 2022).

A similar study was conducted in Pokhara Valley in 2017 in 12 locations which found a total of 79 species and 3530 individuals of birds (BCN 2018). Although the urban bird count in Kathmandu has been long-term, Pokhara still lacks long-term systematic surveys.

Hill and Pawley (2018) studied the song complexity of Common Myna *Acridotheres tristis* including field observations/recordings from Chitre, Nepal and found founder population (a new colony initiated by a small group of individuals from the population) has lesser song complexity than their native population. Hansen and Huettmann (2020) published a compiled set of common urban animals and birds and their association in the urban environments of Kathmandu and Pokhara combining a field survey and the Open Street GIS map. They found that bird abundance and diversity increased closer to natural environments. Aryal et al. (2021) conducted an avian diversity study in Butwal and found a total of 69 species from 14 orders and 33 families with decreasing diversity from sub-urban to urban gradient. Similarly, a study along Bagmati Corridor discovered a total of 67 species of birds from 28 families and 11 orders with abundance positively related to the presence of trees, distance to sewage, distance to settlement, increasing distance to water and at low temperature while decreased at higher elevation and distance to open land (Mahata and Sharma 2023). Apart from published articles, academic theses revealed some interesting findings. For example: - a study on Oriental Magpie Robin *Copsychus saularis* revealed that the minimum frequency of birds is highly related to the level of anthropogenic noise recommending increasing vegetation cover in Kathmandu Valley to reduce man-made noise (Maharjan 2023). Another study on flight initiation distance (FID) – a proxy of disturbance, found shorter FID in urban birds meaning urban birds are adapted to human disturbance compared to rural ones (Nepali 2023). A study on barn owls in Kathmandu Valley depicted a positive association of artificial structures such as temples and other built-up areas (Gurung 2015).

Kathmandu and Pokhara are consistently surveyed locations, facilitated by a large number of birdwatchers and organizations such as Bird Conservation Nepal (BCN), Friends of Birds, and Pokhara Bird Society (Bhattarai 2020) whereas a single study has been done in Butwal

(Aryal et al. 2021). Other cities of Nepal are still lacking baseline bird data which is of grave concern as this will limit our understanding on birds of rapidly expanding cities of Nepal. The lack of systematic studies in cities has not only fostered rapid decline of species in lack of conservation intervention but also prevented us from appreciating urban biodiversity. Therefore, we here outline some key future research opportunities in avian urban ecology in Nepal.

3.2 | Future research opportunities

Apart from very few preliminary studies on urban birds of Nepal, there is huge gap on knowledge of urban birds. The lack of baseline data from major cities, virtually no data on urban breeders and their habitat, no long-term data on threatened species that utilize urban areas extensively, and inadequate attention on urban green space degradation indicate substantial threats to Nepal's urban birds and biodiversity. Such knowledge gaps also hinder sustainable urban management; therefore, it is critical time to start prioritizing urban avifauna before it's too late. We here highlight some key aspects of studies in Nepal's urban avifauna that need immediate attention for the conservation of birds and effective management of habitat amidst rapid urban expansion.

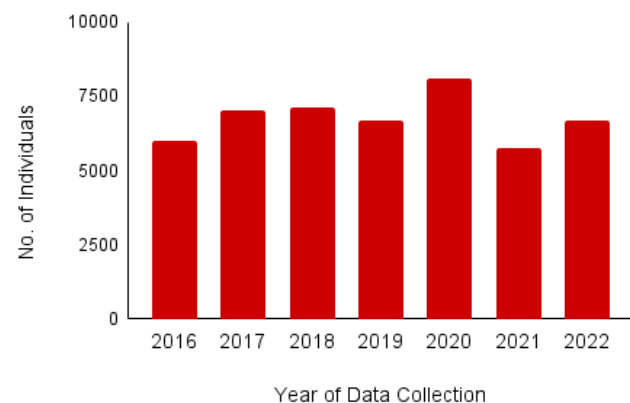


Figure 4. Abundance of birds in Kathmandu Valley (2016 to 2022) as reported by Bird Conservation Nepal. Note: Data has been extracted from BCN reports and News media (BCN 2017; BCN 2018; BCN 2019, BCN 2020; BCN 2021; Himalayan News Service 2022).

3.3.1 | Long-term bird surveys in urban areas

Long-term research offers distinct perspectives on how gradual and nuanced processes of urbanization, lasting effects of land use, delayed reactions over time, and intricate occurrences impact avian populations in urban environments (Gopalan & Radhakrishna 2022). For example: through long-term monitoring in India, the Indian Council of Agricultural Research has pointed to a rapid decline of house Sparrows up to 88% in Andhra Pradesh, up to 20% in Kerala and up to 70-80% in Gujrat and coastal areas (Maxmellion et al. 2020). This is not only important from avian conservation perspectives but also critical for species/pest management in cities. Anecdotal

evidence suggests that the number of feral pigeons has exploded in Kathmandu due to a decrease in a number of Peregrine Falcons (*Falco peregrinus*) in city (Joshi 2022). Similarly, various news sites have reported a drastic decrease in a number of sparrows and mynas in Kathmandu Valley (Awale 2018) and Kanchanpur district due to increased temperature which still needs scientific validation (Setopati 2018). Long-term systematic surveys are necessary to understand status and distribution of birds, nesting ecology, habitat, and adaptations in cities. Long-term studies in Nepal have been hindered by funding availabilities. In such cases, citizen science programs can be useful resources for cost-effective scientific monitoring of birds in cities.

Increased interest and participation in citizen science efforts have been observed in the last few years with an increase in citizen scientists reporting count data via eBird. For example, - there were 98 submissions with a total of 307 species from 7 provinces of Nepal in the Great Backyard Bird Count (eBird 2023a). Moreover, a Nepali user-friendly application *Chhimeki chara* has been developed by BCN which has received encouraging attention from citizen scientists and the public. In the first launch, this application had 432 submissions on around 160 species in 2022. BCN has been continuously expanding *Chhimeki chara* through outreach and training which has reached to around 70 districts engaging more than 900 users in 2023 (BCN 2023). We, reinforce that citizen science efforts integrated with scientific design (such as permanent count stations/transsects) could help to generate evidence on the status and ecology of urban birds in Nepal.

3.3.2 | Multidisciplinary study

The urban landscape, featuring tall buildings causing bird collisions, and dense residential areas with challenging waste management among many others, poses health and environmental risks in cities (Johnson & Munshi-South 2017). It is estimated that between 365 million to 998 million birds die annually due to collisions with urban buildings in the United States (Bowes 2020). This ongoing issue has resulted in a substantial 29% reduction in the North American bird population since 1970 (Rosenburg et al. 2019). Although bird strike in buildings is not prominent in Nepal yet, collision with high-tension power line has been a big concern (Hamal et al. 2023). For bird-friendly infrastructure design, engineering and related fields can play a pivotal role. Similarly, other fields of study such as veterinary, chemistry, environmental science and many more have a significant role to play in the management of avian populations through zoonotic disease monitoring, the rehabilitation of injured birds (Vogelnest & Woods 2008), conducting toxicological research, analyzing food chains, monitoring the environment, examining avian tissues such as feathers chemically, and developing medications and treatments.

Urban birds and biodiversity studies and their subsequent management require people from all walks of life. Therefore, an integrated multidisciplinary body including

environmentalists, chemists, engineers, landscape planners, veterinary doctors, medical doctors, policymakers and many others is needed for urban biodiversity management.

3.3.3 | Avian diseases and human health

The dynamics of avian diseases in urban settings are yet to be understood along with their prevalence, transmission, and impact of diseases on urban bird populations in Nepal. Potential research on avian diseases and human health could involve studying the interactions between birds, humans, and urban wildlife, and the role of environmental factors, including chemical pollutants, in disease transmission. Urban birds also suffer from infections such as beak and feather disease virus (BFDV) (Desingu & Nagarajan 2022).

Sometimes these infections are transferred to humans. For example: Chang et al. (2020) identified a diverse virome in several common wild birds found in urban environments, including Australian Ravens *Corvus coronoides*, Magpie Larks *Grallina cyanoleuca*, Pied Currawongs *Strepera graculina*, Rainbow Lorikeets *Trichoglossus moluccanus*, and Australian Magpies *Gymnorhina tibicen*, with viruses from families such as Paramyxoviridae, Circoviridae, Picornaviridae, Polyomaviridae, Astroviridae, Parvoviridae, and Adenoviridae. Jha (2017) reported about 90.83% of 120 samples of feral pigeon poop consisted of six gastrointestinal parasites with mixed infection more common than single infection endoparasites of feral pigeons in Pashupatinath and Krishna Temple of Kathmandu Valley. A higher abundance of pigeons is associated with holy sites in Kathmandu, Nepal which also indicates that these areas are vulnerable to disease contact and outbreaks (Hansen & Huettmann 2020). More studies related to the infections and diseases caused by increased stress, unmanaged landfill sites, food waste from restaurants and homes, polluted rivers, unmanaged solid waste in avifauna and their transmission to humans along with studies on impacts on urban structures must be conducted in Nepal.

3.3.4 | Urban green space management

Green space in urban areas is a major refuge for birds living in the chaos of cities (Carbó-Ramírez & Zuria 2011). An example is Central Park in the middle of New York is home to 280 species of bird (Central Park 2023). Urban green spaces help accommodate breeding birds (Spotswood et al. 2021) and aid overall biodiversity (Threlfall et al. 2017).

In Kathmandu, Nepal, urban green spaces such as Swayambhu and Ranibari Forests behold a huge diversity of birds. Ranibari Community Forest, the urban green patch, is home of 108 species of plants (Maharjan et al. 2006), and 149 species of birds (eBird 2023b). It is essential to keep track of the progress in such urban green spaces and create more regions in drastically urbanizing areas even outside Kathmandu Valley. Urban areas in

Nepal consist mostly of exotic trees with low tree diversity compared to rural regions (Shrestha et al. 2023). Enhancing the coverage of understory vegetation and incorporating native plantings in urban green areas positively impact biodiversity (Threlfall et al. 2017). Conserving the remanent degraded habitats patches and river corridors, promoting green roofs and size of green space has a key role in bird and biodiversity conservation (Lepczyk et al. 2017). Therefore, efforts must be made to survey urban green space and conserve such green space to provide refuge habitat to birds and other organisms.

3.3.5 | Adaptation to the urban environment

Urbanization alters the habitat of birds where birds either need to adapt to the city or shift their ranges escaping cities for their persistence. Many forms of adaptations have been observed in urban birds for example use of artificial materials for nesting (Suárez-Rodríguez et al. 2017), high-frequency songs (Cardoso & Atwell 2011), brighter plumage (Jones et al. 2010) and adapted to supplementary feeding (Seress et al. 2020). In general, urban-adapted bird species often exhibit traits like smaller body sizes, reduced territorial behaviour, enhanced dispersal capabilities, wider dietary and habitat preferences, larger clutch sizes, and longer lifespans (Neate-Clegg et al. 2023).

It is important to understand how urbanization impacts traits like morphology, foraging behaviour, vocalizations, genetic diversity, and population structure, including gene flow, genetic adaptation, and inbreeding risks. For example: - studying how Nepal's endemic Spiny babbler *Turdoides nipalensis* differs in sub/urban shrubland compared to rural one would also help to understand how they are adapting in expanding cities. Additional research endeavours should concentrate on examining the use of urban landscapes such as crows and kites, a phenomenon notably conspicuous in the city of Kathmandu. An example can be observed in the ring road of Kathmandu where birds are observed using artificial materials such as plastics, wires as well as cigarette butts (Fig. 5).

The use of plastic has also been observed in Black kite *Milvus migrans* in rural areas of Nepal (Ghimire et al. 2020). Studies should be made to understand if such use of anthropogenic materials in cities is due to a lack of natural substrate or due to their short-term fitness advantage (Bressler et al. 2020). Studies on avian adaptations in cities will help us understand their adaptive potential in ever-changing urban environments ultimately aiding to conserve urban birds.

3.3.6 | Colonization and extinction in cities

The urban environment is a cradle for some and a graveyard for many birds (Isaksson 2018). For generalist birds like crows, the city is a cradle with diverse resources whereas for specialist birds, cities turn into graveyards in lack of resources (Patankar et al. 2021). For example, migratory birds that pass-through cities have a higher extinction rate (Husté & Boulinier 2007).

In Nepal, anecdotal evidence suggests a rapid decline in the population of Kestrels and Peregrine falcons which used to breed in Kathmandu Valley (Joshi 2022). On the other hand, generalist bird-like Black Kite has higher relative abundance in cities compared to other areas of Nepal (eBird 2023). Nepalese cities are at various stages of urbanization. Kathmandu for example is highly populated and urbanized with little green space whereas cities like Butwal have more green spaces comparatively. There are other emerging cities in the mid-hills of Nepal with abundant green spaces. Therefore, these urban gradients offer huge opportunities to study colonization and extinction mechanisms in birds in Nepal.

3.3.7 | Conflicts, challenges, and management

Avian conflicts are prominent in cities (Schell et al. 2020). For example, bird strike is one of the serious issues throughout the world and so is the condition in Nepal. The major international airports Tribhuvan International Airport and Pokhara Regional International Airport are among those which are facing more problems due to bird strikes than other airports (CAAN 2023). Between 1990 and 2013, Nepal experienced the loss of a minimum of 66 aircraft and 26 lives in civil aviation incidents resulting from bird strikes (CAAN 2016). Even at a small domestic airport in Pokhara, there have been 22 reported bird strikes in the past decade, spanning from 2010 to 2020 (CAAN 2023). Bird colliding in power lines is another major threat to birds. The primary factors leading to collisions with electric power lines are bird abundance, the distance between these power lines and agricultural areas, and the proximity of these power lines to human settlements (Hamal et al. 2023). According to BCN's data,



Figure 5. Birds nesting in the Kathmandu Valley. Natural substrate, towers, and electric poles have been used for nesting utilizing anthropogenic materials such as plastic, cables, and cigarette butts as nesting materials.

there have been over 50 instances of vultures being electrocuted throughout the country from 2010 to 2021, resulting in the deaths of around 130 vultures (Gurung 2023). In addition to vultures, other large raptors, wading birds like storks and cranes are also at significant risk of electrocution (Chaudhary et al. 2019). Investigating how urban infrastructure, including buildings, power lines, and communication towers, influences bird behaviour and population dynamics is a key to designing linear infrastructures. This type of research could explore the interaction between birds and engineered structures, such as the risk of bird collisions, electrocution, or habitat modification caused by infrastructure development. In recent times, due to ongoing development and urbanization, concrete walls or pavements have been made near the shores of several lakes and rivers, such as Phewa Lake and the Dhobikhola River (Ojha 2021) but their impacts on biodiversity have not been analyzed yet. Greenery and beautification with most exotic plants eliminating bushes and shrubs have been practiced in cities like Kathmandu. This might impact food availability and act as an ecological trap which also needs further scientific interventions. Addressing these multifaceted challenges in urban management necessitates thorough evidence from systematic studies to effectively resolve conflicts involving birds.

Apart from the above opportunities, socio-economic research on how urban human population value birds, green space and biodiversity, their willingness to pay for such ecosystem services could be another avenue of research. For example: about 65% of the visitors in Kuala Lumpur, Malaysia expressed a willingness to pay an average entry fee of 0.66 USD per person to access regulating, cultural and supporting services of urban forest (Jamean & Abas 2023). Studies like such might help to make policies to implement green taxes from urban residents as well as entry permits in urban forests that can be used for urban biodiversity management.

4 | Conclusions

Today, the preservation of biodiversity cannot rely solely on protected areas, as every environment hosts diverse flora and fauna. While studies on birds and biodiversity in protected areas flourish, urban areas have been overlooked, reminiscent of the popular Nepali idiom, "the nearest pilgrimage is ignored". Despite Nepal's rapid urbanization, urban ecology remains a neglected area of research which has impeded effective planning and management of urban spaces. In the lack of scientific evidence from urban environments, the management of cities may contribute to the decline in species diversity and the disruption of urban ecosystems and promote the spread of pests and diseases harming both humans and birds.

Research from neighbouring countries like India and China has provided scientific evidence to assist urban planners, yet our understanding of bird richness and

diversity within Nepalese cities remains inadequate. To bridge these critical gaps and enhance decision-making processes, it is imperative to advocate for extensive research initiatives. We advocate for long-term surveys, interdisciplinary investigations, studies focused on diseases, management of urban green spaces, conflict resolution, avian adaptations within cities, as well as the exploration of colonization and extinction patterns. These diverse studies hold the potential to inform urban planners about the distinct habitat requirements of various species, aiding in the identification of potential green corridors and connectivity networks crucial for avian movement and genetic exchange enabling adaptation to changing environments. By delving into the intricate relationships among urban infrastructure, green spaces, and birds, we can formulate strategies aimed at augmenting urban biodiversity, fostering sustainable urban planning, and elevating the quality of life for city dwellers.

Finally, to prevent cities from becoming lifeless concrete jungles, comprehensive studies on urban birds and biodiversity are imperative. Therefore, urgent attention and scientific investigation are needed to fill this crucial knowledge gap and facilitate informed planning for urban biodiversity conservation in Nepal. By prioritizing the study of urban ecology, Nepal can foster sustainable urban development, preserve its unique biodiversity, and create harmonious living environments that benefit both humans and wildlife. Recognizing the critical significance of urban ecology research, it is high time to take proactive measures in Nepal to bridge existing knowledge disparities and elevate urban management practices. This proactive approach is imperative to pave the way for a scientific and ecologically conscious approach to urban development within the country.

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Authors' contributions

P.G. formulated the idea, D.B. collected and analyzed data, and both authors wrote the manuscript. Both authors contributed in the same manner to prepare the drafts and gave final approval for publication.

Conflicts of interest

The authors declare no conflict of interest.

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