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ORIGINAL ARTICLE

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Documentation and habitat association of birds of prey species in Hetauda, Central Nepal

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ABSTRACT

Birds of prey (raptors) are top predators and important indicators of ecosystem health, yet little is known about their ecology in unprotected landscapes of Nepal. Hetauda, a rapidly urbanizing region with forests, rivers, farmlands, and open spaces, provides a heterogeneous habitat for raptors but remains poorly studied. This study aimed to document raptor diversity and identify environmental, vegetation, and anthropogenic factors influencing their occurrence in Hetauda, Central Nepal. Raptor surveys were conducted at seven fixed point-count stations across major habitat types. Vegetation structure, including the number of large trees, canopy cover, and habitat openness, was measured using nested quadrats, while landscape variables such as elevation and distances to water sources, human settlements, and landfill sites were recorded in the field. Multiple linear regression was used to examine the effects of these variables on raptor species richness. A total of 24 raptor species from three orders and six families were recorded, including four globally threatened species. Species richness was higherin areas with more large trees, greater habitat openness, and proximity to water sources,whereas higher elevations and areas farther from landfill sites supported fewer species. Distance to human settlements did not significantly affect raptor richness. These findings indicate that habitat heterogeneity, mature trees, and selected human-modified features play critical roles in supporting raptor communities outside protected areas. The study provides essential baseline data for raptor conservation in mid-hill landscapes and highlights the need for long-term monitoring, broader spatial surveys, and management of anthropogenic habitats to maintain raptor diversity in human-dominated regions.

KEY WORDS

Birds of prey; Raptor diversity; Habitat association; Hetauda; Nepal; Conservation

ARTICLE HISTORY

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Introduction

Birds of prey (raptors) are a diverse and widely distributed group of predatory birds, encompassing species from the orders *Accipitriformes*, *Cathartiformes*, *Falconiformes*, and *Strigiformes* [1]. They exhibit considerable ecological and morphological diversity, reflected in their hunting strategies, feeding behavior, and habitat use [2]. Due to their sensitivity to environmental change and their position at the top of food webs, raptors are widely recognized as reliable indicators of ecosystem health and effective umbrella species for conservation planning [3,4]. By regulating prey populations and influencing trophic dynamics, raptors play an important role in maintaining ecosystem stability and resilience [5-7]. Nepal supports approximately 15% of the world's raptor species, with 84 species of birds of prey recorded nationwide [8]. These include eagles, vultures, hawks, kites, falcons, and owls, mainly belonging to the orders *Accipitriformes*, *Falconiformes*, and *Strigiformes*. The country's broad altitudinal range, extending from the lowland Terai to the high Himalaya, creates diverse habitats that strongly influence raptor diversity and distribution [9]. Despite their ecological importance, raptors are among the most threatened avian groups, with approximately 30.6% of species globally classified as threatened or near threatened [10].

In Nepal, most raptor research and conservation efforts have focused on protected areas, while unprotected and human-dominated landscapes remain poorly studied. Hetauda, located in central Nepal, represents one such understudied area despite its ecological importance and rapidly changing land use patterns.

Objectives

The present study aimed to (i) document the diversity and conservation status of raptor species in Hetauda, and (ii) identify key environmental, vegetation, and anthropogenic factors influencing their occurrence.

Study Limitations

The study is limited by seasonal sampling, a relatively small number of survey stations, and reliance on visually estimated anthropogenic variables, which may affect detectability and precision. Nonetheless, the findings provide essential baseline data for raptor conservation in unprotected mid-hill landscapes of Nepal.

Materials and Methods

Study area

This study was conducted in Hetauda (27.4284° N, 85.0322° E), as shown in Figure 1, the capital of Bagmati Province and administrative headquarters of Makwanpur District, Central Nepal. Hetauda lies in a transitional zone between the Mahabharat Range to the north and the Churia (Siwalik) Range to the south, forming an ecological corridor connecting the mid-hills and the lowland Terai. The area is around 450 m above sea level and has a subtropical climate with hot, humid summers and mild winters. The landscape of Hetauda is shaped by three major rivers the Rapti, Karra, and Samari creating a patchwork of habitats including riverine forests, mixed forests,

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open grasslands, farmland, and fishponds. These habitats provide important perching, nesting, and hunting grounds for different raptor species. Large trees in riverine and mixed forests offer roosting sites for migratory and resident eagles, kites, and hawks, while open grasslands and farmland support hunting by Steppe Eagle, Booted Eagle, and Black Kite. Fishponds and riverbanks serve as feeding areas for fish-eating species like Osprey and Grey-headed Fish Eagle. The vegetation is typical of tropical and subtropical forests, with over 150 plant species, and the area supports diverse wildlife, including 98 butterfly species and 91 bird species [11-13]. This ecological diversity creates rich foraging opportunities for raptors, making Hetauda an important but understudied area for their ecology. The survey covered all potential raptor habitats across roughly 644 ha, capturing both resident and migratory species throughout the year.

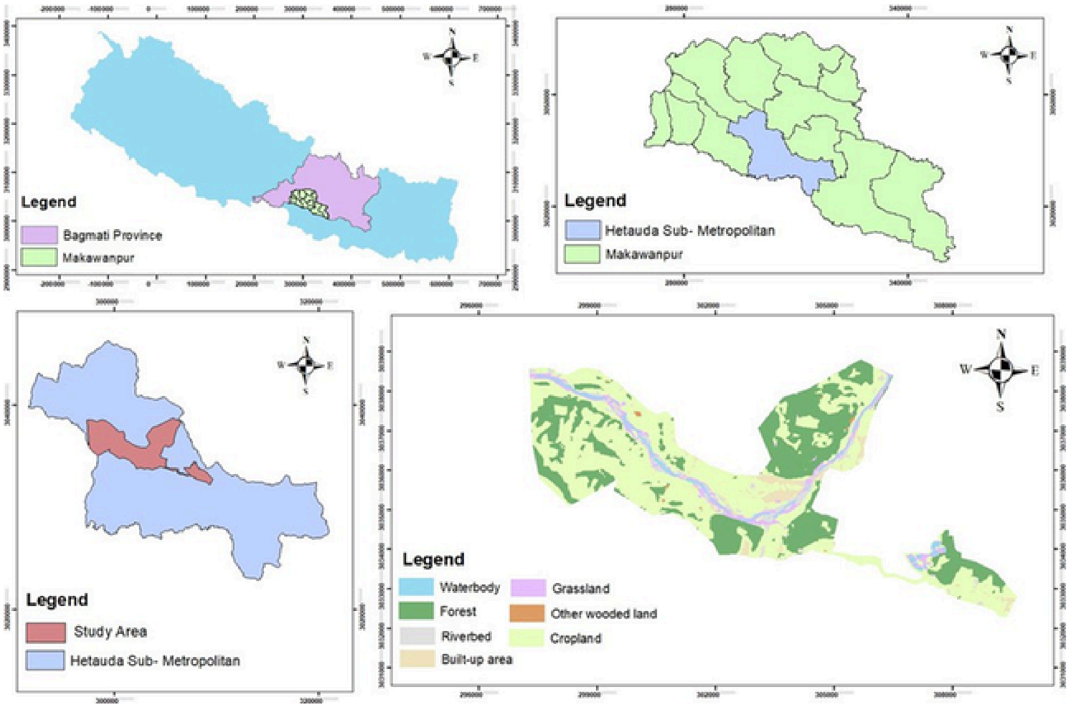

Figure 1. Map of study area.

Preliminary survey

A preliminary survey was carried out to determine the possible suitable habitat for raptors species documentations across the study area, and potential habitats were selected with guidance from birding experts and local community members. Following habitat selection, initial birding surveys, combined with consultations with local birders, forest officers, and community members, helped identify suitable sites for establishing point-count stations.

Sampling design

Bird survey methods

Raptor surveys were done using the fixed-point count method [14-16]. In this method, we observe birds from a fixed spot for a set time instead of walking along a transect [17].Count station points were placed every3 km so that we could cover all major habitats used by raptors, such as riverine forests, farmland, grasslands, and fishery areas as shown in Figure 2. At each point, we spent the first 10 minutes getting used to the surroundings and checking possible perching or feeding places. After this, we carried out a 15- minute count to identify and record the birds seen. Surveys were mainly done between 10:00a.m. and 5:00 p.m., the period when raptors are most active, especially in late morning and afternoon [18]. We used Olympus 10×50 binoculars to observe raptors and a Canon 100× zoom camera to take photos for confirming species and reducing mistakes. During each 15-minute count, we recorded the species and the number of individuals on a data sheet.

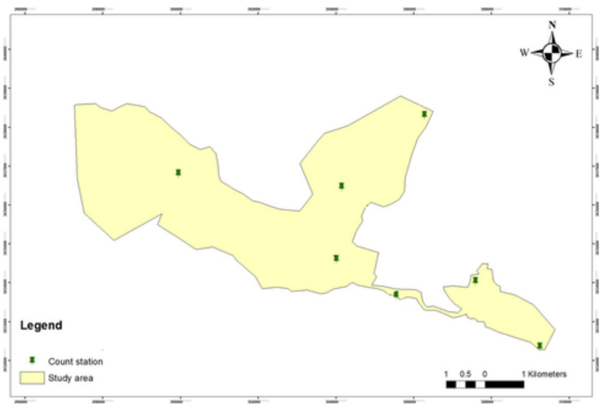

Figure 2. Distribution of count stations.

Vegetation survey

To thoroughly describe the habitats used by birds of prey, systematic field surveys were carried out across the study area. Fourteen concentric quadrat plots were established, with two placed at each of the seven point-count stations, to ensure that the vegetation data accurately represented the habitat where raptors were observed. Following Dhami et al., vegetation

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sampling was conducted using nested quadrats of three sizes: 10 × 10 m for trees, 4 × 4 m for shrubs, and 1 × 1 m for herbaceous plants [19]. Within each plot, all tree, shrub, and herb species were identified. For trees, species name, diameter at breast height (DBH), and total height were measured. A tree was classified as large if its DBH exceeded 40 cm and its height was greater than 15 m, based on widely used forest structure standards [20,21].Then each large tree with in plots are counted to determine the number of large trees nearby.

Crown cover (CC) was assessed in the field using a convex spherical densitometer following Lemmon's (1956) protocol [22]. The instrument contains a fixed grid of points, and the observer counts how many pointsare covered by canopy versus visible sky. Crown cover (%) was calculated using the formula:

CC (%) = (Number of canopy-covered grid points / Total grid points) × 100 Habitat openness was quantified using CC values [23].

Habitat Openness= 100%-CC%

Landscape variables such as elevation, slope, and aspect were derived from the GPS coordinates of each survey point. Other site-level factors including signs of human activity, distance to the landfill, distance to the nearest settlement, and distance to water sources were visually assessed in the field, as shown in Table 1.

Table 1. Environmental variables used for habitat assessment of birds of prey.

S.N	Variable Category	Variables	Unit	Data Source
1	Topography	Elevation	Meters (m)	GPS
2	Human	Distance to Settlement Proximity to Dumping site Distance to Human Settlement	Meters (m)	Visually estimated in the field
3	Habitat	Distance to Water Source	Meters (m)	Visually field
		Vegetation Structure (Tree, Shrub, Herb Cover) to determine Habitat Openness	Percent cover (%)	Field quadrats
		No of Large tree near by	Number	

Data Analysis

Data analysis was carried out manually and through the use of statistical tools in RStudio Desktop 2026.01.0-392 (https://posit.co/download/rstudio-desktop/), employing both descriptive and quantitative approaches. Results are presented through tables, bar graphs, and pie charts to ensure clear visualization and interpretation.

Documentation and listing of birds of prey

All field observations were collected to make a complete list of raptor species. The information was recorded in Microsoft Excel, including common name, scientific name, order, family, IUCN status, and whether the species is migratory. Bar charts were used to show the number of species in each family and to display the proportion of species among different raptor families.

Multiple linear regression model for habitat analysis

To assess the influence of environmental and habitat variables on raptor presence, a multiple linear regression model was developed. In this model, the number of Bird of Prey species recorded (Y) is considered the dependent variable, while topographic, habitat, and anthropogenic factors are the independent predictors. The model is expressed as:

Equation:

$Y = \beta_0 + \beta_1 + \beta_2 + \beta_3 + \beta_4 + \beta_5 + \beta_6 + \varepsilon$

Where:

Y = No of Bird of prey species recorded (Raptor species richness) [dependent variable]

β_0 = Intercept

β_1–β_6 = Regression coefficients for each predictor

- β_1 = Elevation
- β_2 = Number of Large tree near by
- β_3 = Distance to Settlement
- β_4 = Proximity to Dumping site
- β_5 = Distance to Water Source
- β_6 = Habitat openness:

ε = Error term representing unexplained variation

Together, these variables capture the key ecological and anthropogenic factors influencing raptor distribution and habitat suitability within the study area.

Results

Documentation and list of the birds of prey

A total of 24 raptor and owl species were observed in the study area (Table 2), representing three orders and six families, showing a high diversity of raptors. The order Accipitriformes had the most species with 15, followedby Strigiformes with seven species, and *Falconiformes* with three species. Among the families, Accipitridae had the largest number of species (14), followed by *Strigidae* (6), *Falconidae* (3), and *Tytonidae* and *Pandionidae* with one species each as Figure 3. The IUCN conservation status of the recorded raptors revealed that a majority of the species (20 species) were categorized as Least Concern (LC), reflecting relatively stable populations. However, the presence of four globally threatened species emphasizes the conservation significance of the area. These include two Endangered (EN) species Steppe Eagle (*Aquila nipalensis*) and Pallas's Fish Eagle (*Haliaeetus leucoryphus*), and two Near Threatened (NT) species Himalayan Griffon (*Gyps himalayensis*) and Grey-headed Fish Eagle (*Ichthyophaga ichthyaetus*).

Regarding migratory and residency status, resident species dominated the assemblage, accounting for more than half of the total records, indicating the area provides suitable nesting and foraging conditions year-round. Several winter visitors and passage migrants, such as Booted Eagle, Steppe Eagle, and Osprey, also utilized the area, highlighting its role as an important wintering and migratory stopover site.

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Table 2. List of bird of prey species recorded with common name, scientific name, family name, order, IUCN status and migratory/residency status.

Common Name	Scientific Name	Order	Family	IUCN	Migratory/ Residency Status
Osprey	*Pandion haliaetus*	Accipitriformes	Pandionidae	LC	WV
Black- winged Kite	*Elanus caeruleus*	Accipitriformes	Accipitridae	LC	R
Black Kite	*Milvus migrans*	Accipitriformes	Accipitridae	LC	R
Black Baza	*Aviceda leuphotes*	Accipitriformes	Accipitridae	LC	SV
Booted Eagle	*Hieraaetus pennatus*	Accipitriformes	Accipitridae	LC	WV
Crested Serpent Eagle	*Spilornis cheela*	Accipitriformes	Accipitridae	LC	R
Himalaya n Buzzard	*Buteo refectus*	Accipitriformes	Accipitridae	LC	WV
Himalaya n Griffon	*Gyps himalayensis*	Accipitriformes	Accipitridae	NT	WV
Long- legged Buzzard	*Buteo rufinus*	Accipitriformes	Accipitridae	LC	WV
Oriental Honey- buzzard	*Pernis ptilorhynchus*	Accipitriformes	Accipitridae	LC	R
Shikra	*Accipiter badius*	Accipitriformes	Accipitridae	LC	R
Steppe Eagle	*Aquila nipalensis*	Accipitriformes	Accipitridae	EN	WV
Pallas's Fish Eagle	*Haliaeetus leucoryphus*	Accipitriformes	Accipitridae	EN	WV
Black Eagle	*Ictinaetus malaiensis*	Accipitriformes	Accipitridae	LC	R
Common Kestrel	*Falco tinnunculus*	Falconiformes	Falconidae	LC	R
Peregrine Falcon	*Falco peregrinus*	Falconiformes	Falconidae	LC	WV
Barn Owl	*Tyto alba*	Strigiformes	Tytonidae	LC	R
Brown Fish Owl	*Ketupa zeylonensis*	Strigiformes	Strigidae	LC	R
Jungle Owlet	*Glaucidium radiatum*	Strigiformes	Strigidae	LC	R
Collared Owlet	*Glaucidium brodiei*	Strigiformes	Strigidae	LC	R
Asian Barred Owlet	*Glaucidium cuculoides*	Strigiformes	Strigidae	LC	R
Spotted Owlet	*Athene brama*	Strigiformes	Strigidae	LC	R
Grey- headed Fish Eagle	*Ichthyophaga ichthyaetus*	Strigiformes	Accipitridae	NT	WV

R: Resident WV: Winter Visitor SV: Summer Visitor

IUCN Red List: International Union for Conservation of Nature's Red List of Threatened Species LC: Least Concern NT: Near Threatened EN: Endangered

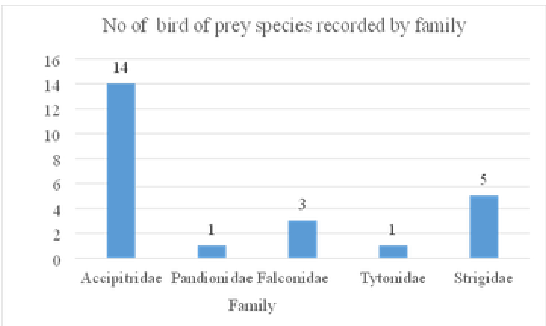

Figure 3. Bar graph showing the no of bird speciesrecorded by family.

Factors influencing raptor species occurrence

Multiple linear regression analysis identified several key factors affecting the number of raptor species observed at each point-count station (Table 3). Elevation had a significant negative effect on species richness (β = -0.0069, p = 0.018),indicating that fewer raptor species were recorded at higher altitudes. Proximity to dumping sites also negatively influenced species occurrence (β = - 0.0087, p < 0.001), suggesting that areas closer to these sites supported higher raptor richness. In contrast, the number of large trees nearby positively affected raptor species richness (β = 0.319, p= 0.008), highlighting the importance of mature trees for perching and hunting. Distance to water sources (β = -1.530,p = 0.036) showed a negative association, while habitat openness(β = 1.735, p = 0.041) was positively related to species richness, indicating that wider, more open habitats near water supported higher raptor diversity. Distance to human settlements did not have a significant effect (β = 0.251, p = 0.753).

Overall, these results indicate that proximity to dumping sites, availability of large trees, water sources, and habitat openness are the primary determinants of raptor species richness in the study area. The relationships between raptor species richness and environmental variables are illustrated in Figure 4.

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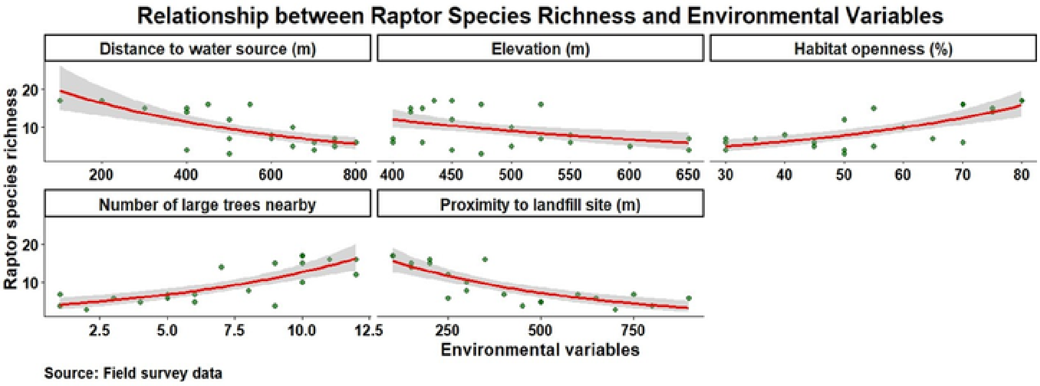

Figure 4. Scatter regression graphs showing the relationship between the numbers of species recorded (Raptor Species Richness) and Environmental variables.

Table 3. Multiple linear regression results showing the most significant factors influencing habitat association of bird of prey.

Coefficients:				
Estimate		Std. Error	t value	Pr(>|t|)
(Intercept)	15.449	2.497137	6.187	< 0.003 ***
Elevation	-0.0069	0.002568	-2.717	0.017617 *
Proximity to Landfill site	-0.008668	0.001588	-5.459	0.000109 ***
Distance to settlement	0.250772	0.778967	0.322	0.752624
Distance to water source	-1.529891	0.655178	-2.335	0.036219 *
No of Large tree Near By	0.31886	0.101256	3.149	0.007686 **
Habitat Openness (%)	1.735432	0.764423	2.27	0.040849 *

Discussion

Documentations of bird of prey in Hetauda & factors influencing raptor species occurrence in Hetauda:

Our study in Hetauda, Central Nepal highlights the key ecological drivers shaping raptor species richness and their habitat associations, providing insights critical for conservation planning. We recorded 24 raptor species across three orders and six families, accounting for nearly 30% of all raptor species reported from Nepal dominated by Accipitriformes (14 species) [8].

The present study identified several key habitat variables influencing the number of raptor species recorded in the study area which aligns with the previously done studies as shown in Table 4. Our finding shows Elevation as a significant negative relationship with raptor species richness, indicating fewer species at higher altitudes. This pattern aligns with Paudel et al., who reported that threatened species richness declines along Himalayan elevational gradients due to habitat constraints and reduced species ranges [24]. Similarly, in our study, distance to dumping sites was identified as an important factor influencing raptor species richness, with more species observed closer to these sites. This is consistent with the study by Kumar et al., in the northwestern Himalayas, India, which highlighted the role of human-modified landscapes and anthropogenic food sources in shaping raptor distribution [25]. Dumping sites provide reliable food for scavenging raptors, a pattern also documented by Oro et al [26]. Our Finding shows that the number of large trees near sampling points showed a strong positive association with raptor richness, supporting findings by Liu, who emphasized that mature trees provide critical perch, nesting, and roosting sites for forest and edge-dwelling raptors [27]. Open areas were associated with more raptor species, which agrees with Kumar et al., who noted that open and varied landscapes help raptors see prey more easily and improve their hunting success during the day [22]. Likewise, our study showed that habitat openness positively influenced the number of raptor species recorded. Although riparian zones are often linked to high biodiversity, Paudel et al., pointed out that local conditions, such as dense vegetation or human activity near water bodies, can change typical species–habitat relationships [24]. In our study area, dense vegetation or disturbance along water sources may make the habitat less suitable for aerial predators. Overall, our results emphasize the role of habitat heterogeneity including open areas, mature trees, and selected human-modified features in supporting diverse raptor communities. This agrees with global studies by Buechley & Şekercioğlu, which showed that a mix of forests, agricultural lands, and open habitats promotes higher raptor diversity [28].

From a conservation perspective, protecting large trees, maintaining open habitats, and managing anthropogenic food sources responsibly are essential. Although dumping sites currently support several species, reliance on artificial food sources may pose long-term risks if waste-management practices change abruptly [26].

Table 4. Comparison of present study findings with previous studies.

Variable / Finding	Present Study Result	Comparison With Previous Studies	Reference
Elevation	Significant negative effect on raptor species richness. Higher elevation = fewer species.	Elevational decline in raptor and threatened species richness aligns with studies showing habitat and geometric constraints along Himalayan gradients.	[24] [25]

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Distance to Dumping Site	Strong negative effect. Richness increases closer to dumping sites due to predictable food availability.	Similar studies report that anthropogenic food sources attract scavenger raptors, increasing local richness.	[25] [26]
Distance to Human Settlement	Not significant. Minimal direct effect on richness.	Mixed findings reported: some raptors tolerate humans while sensitive species avoid settlements.	[28]
Distance to Water Source	Positive effect. More species found farther from water.	May reflect local vegetation density or disturbances near water bodies.	[24]
Number of Large Trees	Significant positive effect. Large trees provide essential perching and nesting sites.	Consistent with studies showing forest structure strongly influences raptor habitat use.	[27]
Habitat Openness	Positive effect. Open areas support more raptors due to improved hunting visibility and prey detection.	Landscape heterogeneity and open habitats enhance raptor richness.	[25]
Overall Trend	Habitat heterogeneity (trees + openness + anthropogenic features) increases richness.	Global evidence shows mixed landscapes support diverse and abundant raptor communities.	[28]

Conclusions

This study provides the first comprehensive record of raptor and owl diversity in Hetauda, Central Nepal, documenting 24 species across three orders and six families, including four globally threatened species. Raptor richness was higher in areas with large trees, open habitats, and close to water sources, whereas higher elevations and locations farther from human-modified areas, such as landfill sites, supported fewer species. The findings highlight the importance of conserving mature trees, maintaining open and wetland habitats, and minimizing anthropogenic disturbances to support raptor populations outside protected areas. Future research should focus on long-term monitoring of population trends, breeding and migratory ecology, seasonal movements, and the impacts of urbanization. Such studies will provide stronger scientific guidance for effective raptor conservation and habitat management in unprotected mid-hill landscapes of Nepal.

Author Contribution

The research was conceptualized by Samik and Nilima. Fieldwork was carried out by Nilima, Ruchi, and Samik, while data analysis was completed by Dinesh and Nirvika. Manuscript was prepared by Nirvika and Samik.

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Competing Interest

There is no competing interest.

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