

## Research Article

# Impacts of Livestock Grazing on Wild Ungulate Habitat in the Khata Corridor, Bardiya, Nepal

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The wildlife population is an important part of the forest ecosystem and plays a crucial role in maintaining ecosystem health and integrity. In many grassland ecosystems, wild herbivores face substantial competition for space and resource use from livestock over grazing resources. Livestock and ungulates have shared a large portion of the Terai forest resources for decades, but little information has been explored about the influence of livestock on the grassland ecosystems of the protected areas of the Terai region of Nepal. We assessed the impact of livestock grazing on wild ungulate habitat in the Khata Corridor, Bardiya, Nepal. We used direct field observation, key informant interview ( $n = 10$ ), focus group discussion ( $n = 5$ ), and a questionnaire survey with local households to study the seasonal occurrence of wild ungulates in multiple habitats, livestock rearing practices, stocking density, and resource use by domestic livestock in and around the forest land of villages located in the Khata Corridor, Bardiya, Nepal. We followed livestock herds from the early morning to their return for consecutive days in each sample village to estimate the grazing circuits. We individually recorded a total number of grazing cattle in five different habitats while following the cattle grazing path by direct and indirect observation. Morisita's index was used to evaluate the habitat overlap between domestic livestock and wild ungulates. The domestic cattle had a higher habitat overlap and effective stocking density in winter than wild ungulates in summer in the corridor forest. Lower availability of forage around the village led to the concerted effort of grazing in the forest, increasing the higher effective stocking density in winter, leading to the competition with wild ungulates. However, the carrying capacity is highly unevenly observed across the region, and overgrazing is found in many areas of the forest corridor. We recommend the development of comprehensive wildlife livestock grazing strategies for planning sustainable livestock farming and for important wildlife areas to maintain long-term landscape connectivity to protect migrating endangered wild species.

## 1. Introduction

Grazing by livestock has been an emerging threat to protected areas [1]. Forest lands are an important resource base for the livelihood of people living around the protected areas and wildlife corridors, as they are the sources of revenue for the state as well. Livestock shares food resources with wild ungulates in high-density forests [1–3]. Mainly, species diversity and productivity are maintained by livestock and wildlife grazing in many highland pastures

[4–6]. Rangeland species, diversity, and richness could be strongly influenced by grazing, but grazing impacts are totally variable and likely to be intricately by range management practices, individual species responses, and abiotic factors such as soil characteristics and light availability [7, 8]. Maintenance of biodiversity is strongly influenced by the maintenance of grasslands [9–13]. Ungulates play a vital role in the sustenance of higher trophic levels in an ecosystem. It was found that the quality and quantity of food as well as foraging opportunities greatly influence

habitat selection [11, 14–18]. Extensive livestock grazing poses a potential threat to the conservation of sensitive native species, which can cause their extinction and reduce species richness in native pasturelands [19–21]. Livestock grazing has reduced the available forage and important habitat qualities needed by wild ungulates by altering the structure and composition [18, 20]. Conflicts between wildlife and domestic livestock are increasing in many areas [18]. There has been an overlap in the dietary niche between wild and domestic ungulates [2, 18, 19] and consequent impact on wild ungulates [1, 3]. Species struggles occur when the amount of resource for a species gets reduced due to use by another [1, 18], rather than by directly averting each other from resources access. Research and findings on livestock grazing and the perception of livestock grazing practices by locals in the study area will help further conservation strategies and grassland management practices. Therefore, our study aimed to assess (a) livestock rearing practises, (b) cattle foraging paths and stocking densities, investigate livestock killed by wild animals, and (c) habitat overlap among wild and domestic ungulates in the Khata Corridor.

## 2. Materials and Methods

The study was carried out in three community forests (Shiva Community Forest (CF), Gauri Maila CF, and Ganesh Punersenia CF of the Khata Corridor) 28°18'30"N to 28°27'30"N and 81°10'30"E to 81°18'30"E, as well as an area 11–12 km long and 8 km wide [22, 23] is a forest of the Terai Arc Landscape (TAL), Bardiya district, Lumbini Province, Nepal (Figure 1). The area covered by the corridor is 9,250.32 hectares, which is almost 24.51% of the total area of Bardiya district (2,025 km<sup>2</sup>), with an effective forest area of 31.86 km<sup>2</sup> [23–25]. The corridor has a degraded buffer zone and community forest (65 km<sup>2</sup>) due to livestock grazing, excessive tree felling [23], land clearing, and human settlement degrading most of the forest, scrub grassland, and wildlife [23]. Due to the large biological diversity of the Khata Corridor forest, the growing density of the human population, increasing anthropogenic pressure on the natural habitats, and its relatively easy accessibility, it is a suitable area to study these problems. The corridor is habitat for different endangered animals such as tigers [23, 25–27], rhinos [27], and elephants, and provides connectivity between the Bardiya National Park (Nepal) and Katarniaghat Wildlife Sanctuary (India), along with many wild ungulates. The Khata Corridor forest has been degraded and deforested for settlement and agriculture, to obtain materials for building construction, and to collect firewood and fodder [28, 29]. In addition, the forest lands of Nepal are of two types of ownership, i.e., national forest and private forest. Government forests are of six types, i.e., government-managed forest, forest protection area, community forest, leasehold forest, religious forest, and partnership forest [30]. Khata Corridor is under the forest protection area that is managed by the local communities, and the forests have been opened for the grazing of livestock.

**2.1. Data Collection and Analysis.** Direct field observation and key informant interviews ( $n = 10$ ) were carried out with people related to community forest such as the president of CF and staff of national park. A focus group discussion ( $n = 5$ ) was conducted with mostly herders (female groups herding, old-aged people, and youths), and questionnaire surveys with local households were carried out to know the seasonal occurrence of wild ungulates in multiple habitats, livestock herding practices, stock density, and resource use by domestic livestock in and around forest land situated in the Khata Corridor. From the key informant survey, we selected three community forests (Shiva CF, Gauri Maila CF, and Ganesh Punersenia CF) that had high grazing areas for this study. Secondary data were collected from articles gathered through online portals [31, 32].

**2.2. Cattle Foraging Path and Stocking Density.** For the cattle foraging path, at least one herd was randomly selected in each selected CFUG per day to identify the foraging path of the respective CFUG, and the herd movement was mapped through the use of Global Positioning System (GPS) unit. The foraging paths of cattle were extracted and overlaid on high-resolution georectified images downloaded from Google Earth to look over the cattle's movements and activities in the intensive study area. The total distance travelled per day indicated the length of the foraging path. The stocking density of cattle was calculated based on the average foraging area and total forest-dwelling cattle. When following the cattle herd, their food preference was directly observed and recorded.

**2.3. Habitat Overlaps between Wild and Domestic Ungulates.** For habitat overlap assessment, the herd of cattle was traced from morning to evening and investigated the habitat use by cattle. Different parameters such as herd size, vegetation and habitat characteristics, and microhabitats were also recorded for habitat use analysis. Habitat use of wild ungulates was shaded by searching their evidence (direct/indirect). To confirm the presence of wild ungulates, animal sightings and signs such as pellets, footprints, and hair were recorded. In total, five herds were followed in five different habitats of each selected CFUG. The Morisita index was used to find the overlap between the different pair of species [33]. The index values ranged from 0 to 1. Zero represents no overlap, whereas 1 represents maximum overlap and three levels of overlap [34, 35] such as high overlap ( $\geq 0.80$ ), moderate overlap (0.40–0.80), and low overlap ( $< 0.40$ ) were used.

$$c = \frac{2 \sum_i^n p_{ij} \cdot p_{ik}}{\sum_i^n (n_{ij} - 1) / (N_j - 1) + \sum_i^n p_{ik} (n_{ij} - 1) / (N_j - 1)} \quad (1)$$

where  $c$  = Morisita index of niche overlap between species  $j$  and  $k$ ,  $p_{ij}$  = proportion resource  $i$  of the total resources used by species  $j$ ,  $p_{ik}$  = proportion resource  $i$  of the total resources used by species  $k$ ,  $n_{ij}$  = number of individuals of species  $j$  that use resource category  $i$ ,  $n_{ik}$  = number of individuals of species  $k$  that use resource category  $i$ , and  $N_j$  = total number of individuals of each species in sample.

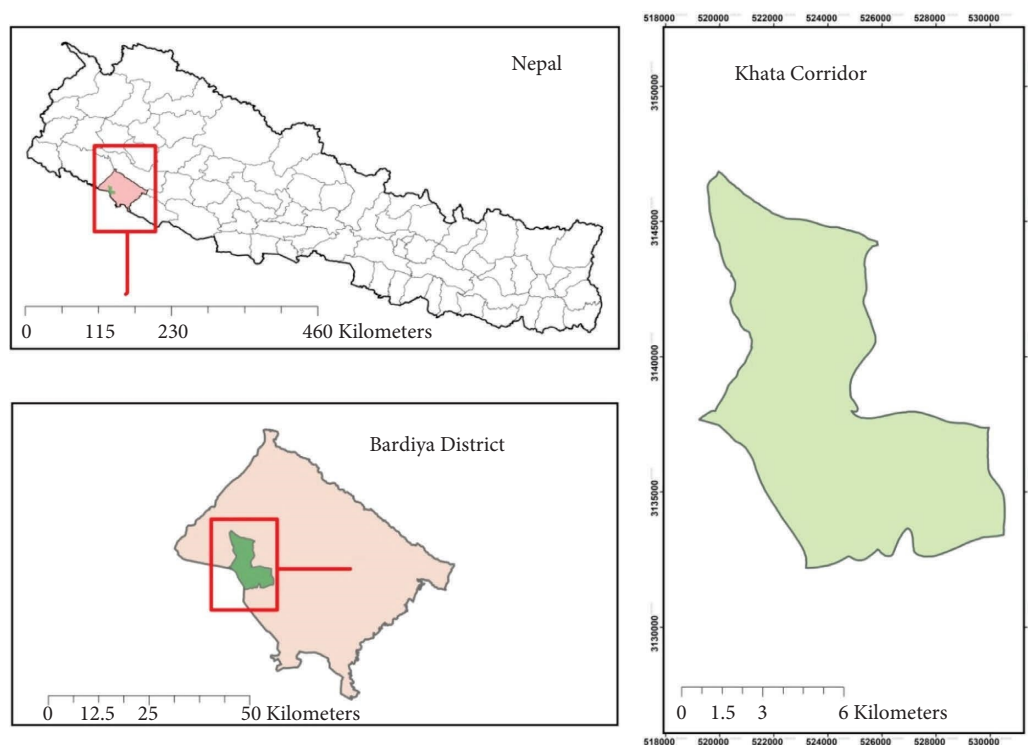


FIGURE 1: Map of Nepal showing the study location in Bardiya district.

### 3. Results

**3.1. Livestock Rearing Practices in Different Seasons.** Most of the households were found grazing their livestock during dry summer (60%) and winter (73.3%) than in monsoon (23.3%), whereas stall feeding was mostly practiced during monsoon (16.7%) than in dry summer (13.3%) and winter (6.7%) due to the adequate availability of agricultural residue, fodder, and grass from agriculture and forest land (Figure 2). Both grazing and stall feeding are highly practiced during the monsoon (60%). In the study site, major livestock reared by the households are goats (37.15%) followed by sheep (33.06%), cattle (17.84%), and buffalo (11.94%). Among these, livestock, goats, and sheep are mostly taken to forest land for grazing.

According to the interview with respondents, most people in three different seasons take their livestock to forest land than agriculture fallow land or communal land, since the respondent lacks private and communal land and the forest is a common resource with the availability of preferable food for livestock (Figure 3). In Gauri Maila CF study site, the forest area has been restricted to livestock grazing, so most of the people are found taking their livestock for agriculture fallow land. However, the other two CFs, i.e., Ganesh and Shiva, are opened, and cattle are freely allowed to graze inside the forest. Grazing is higher in the forest areas on the periphery of the village than inside the core forest area because of the risk of predation by tigers and leopards.

**3.2. Response of People towards Grazing inside the Corridor Forest.** Most people, 93.33%, responded by taking their cattle to graze in the forest, and 6.67% denied taking their cattle to the forest (Figure 4). Of the response from the people, most of them responded that they allowed free grazing of the livestock inside the forest during the dry winter and summer season (> eight months a year).

**3.3. Perception of People towards Major Conservation Issues and Livestock Grazing in Wildlife in the Corridor.** About 57% of the people interviewed mentioned grazing as the major problem of the Khata Corridor (Figure 5(a)). People do not have their own grazing land and depend on the forest areas for grazing their cattle. Of the people interviewed, 50% identified high disturbance as one of the major problems for the wildlife in the corridor. It shows that most of the respondents were aware of the effects of grazing on wildlife but still allowed their livestock to graze directly on forest land due to insufficient agricultural and private land. Disease transmission (17%) has also been one of the major problems for both wild and domestic ungulates coexisting in over-grazing conflict in the landscape (Figure 5(b)).

**3.4. Livestock Killed by Wild Animals.** Most of the livestock have been killed by wildlife while grazing in the forest area and are also attacked inside their sheds. As per the response of the respondent, the major number of goats (24) has been killed, followed by sheep (15), buffalo (2), and cattle (8) since the last two years (Figure 6).

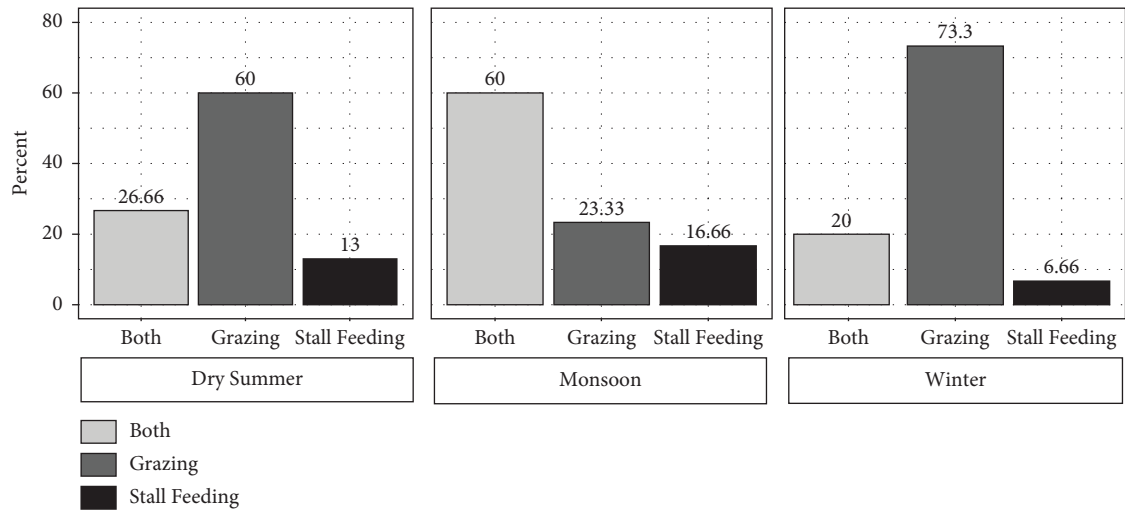


FIGURE 2: Rearing practice of livestock in different seasons in this study site.

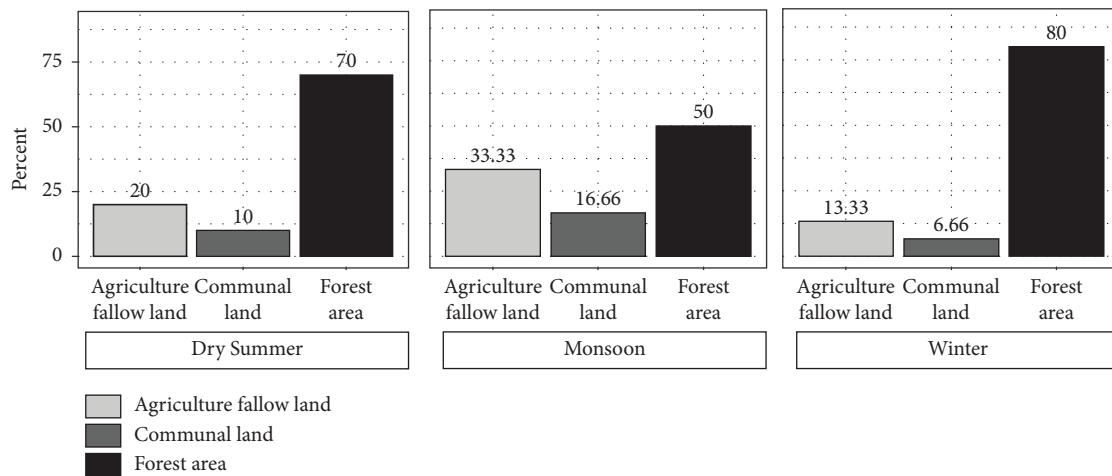


FIGURE 3: Grazing on different lands in different seasons in this study site.

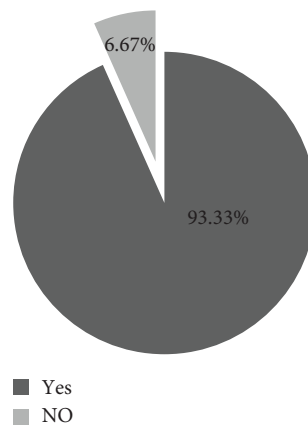


FIGURE 4: Status of grazing inside the corridor forest.

**3.5. Cattle Foraging Path and Effective Stocking Den.** A total of (winter:  $n = 412$ ; summer:  $n = 297$ ) individual cattle were found grazing largely in the forest land in three villages. The

maximum number of livestock entering the forest for grazing was from village Ganesh Punersenia (172 individuals) and the minimum was from Gauri (101 individuals) during

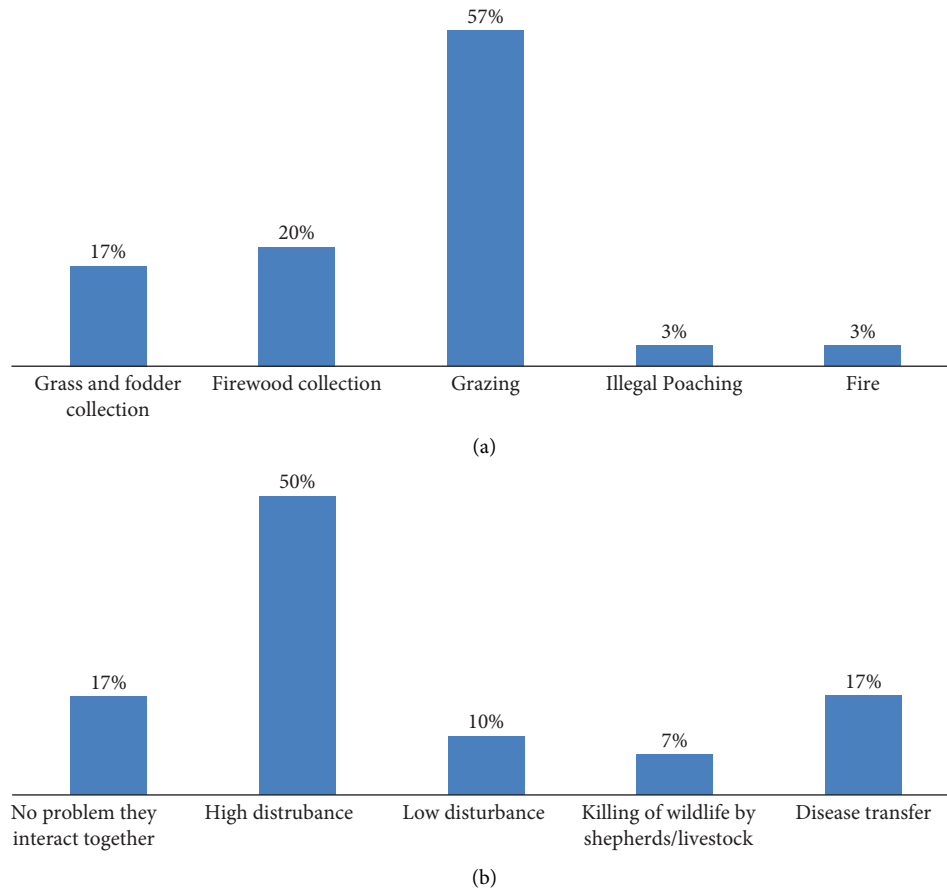


FIGURE 5: (a) Perception of people to the major conservation issues and (b) livestock grazing problems in wildlife in the corridor.

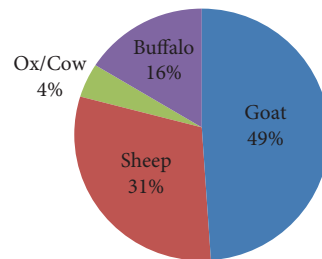


FIGURE 6: Livestock killed by wild animals in the study site.

winter. However, the maximum was from Shiva (125 individuals) and the minimum was from Gauri (81 individuals) during the summer season. The number of livestock grazing was found more in available agricultural and private land because of the adequate availability of foraging resources during the summer season. The effective stocking density of cattle during winter 2019 ranges from winter: min 34.58 to max 56.39 per ha.; summer: min 44.02 to max 54.49 per ha. in the sampled corridor forest. The effective stocking densities for both seasons were similar to each other, despite slight changes in effective grazing area. On the contrary, the effective area used by cattle for grazing during summer was significantly less than the number of cattle in the forest. Therefore, the resulting effective stocking density is very low. During winter, herders grazed their cattle on forest land from

early in the morning to late in the evening, leaving them there freely for the whole day. During winter, herders used to take their cattle for grazing on forest land from early morning to late evening, leaving the cattle to graze freely for the whole day. Unlike the winter season, herders take their cattle to directly graze on the forest land early in the morning, i.e., around 6:00 am, and return back to their shed at 10:00 am during the summer season. Again, take them in the evening at 4:30 pm when the temperature relatively falls and returns back at 7:00 pm.

An effective grazing area has been selected where the maximum number of cattle can be found, that is, the periphery of the village, the habitat where the maximum amount of preferable food resources for cattle is present, around the water hole, the wetland, and the place where the

fear of predators is least. During summer, two grazing routes were formed in Shiva CF (Figure 7), where herders grazed their cattle in both riverine and mixed forest in the morning and evening, respectively; however, only one route in mixed forest was used for grazing in winter, while herders used two grazing routes (i.e., riverine forest and woody grassland) during both summer and winter seasons in Ganesh Punersenia CF. The cattle were taken to both short grassland and agricultural fallow land during winter due to the insufficient availability of palatable grass species in agricultural fallow land.

During our field visit in Gauri Maila CF, we also observed a high number of wild ungulate signs in the restricted areas of the CF. Similarly, we observed during summer that herders in Gauri Maila CF used only one route to agricultural fallow land due to the availability of adequate grass species which was comparatively higher than that of winter and cattle were not grazed on short grassland, since the number of cattle grazing directly in forest land was lower (Figure 8). Unlike in winter, herders take their cattle to graze directly on forest land early in the morning between 6:00–10:00 and 16:30–19:00 in the evening.

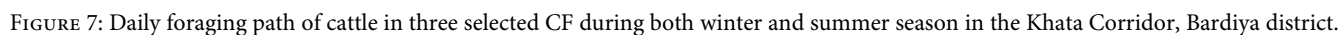
**3.6. Habitat Overlap Using Morisita's Index.** The study site is primarily a human-dominated landscape with mosaics of agricultural fields, habitation, roads, forests, and rivers. We observed maximum habitat usage by wild herbivores (spotted deer, wild boar, one-horned rhinoceros, Asian elephants, and other herbivores) in short grassland and riverine forests, where direct/indirect evidence of wild ungulates was recorded, following the cattle foraging path during winter. The study showed that the wild ungulates in short grassland and riverine forests; however, livestock was most abundant in mixed forests. Comparison between habitats used by cattle and wild ungulates showed that wild ungulates were most frequently encountered in short grassland and riverine forests (29.63%) and least in mixed forest (7.41%). However, the habitat used by livestock was maximum in mixed forest (27.20%) and minimum in short grassland (8.27%) (Figure 9). Likewise, the wild ungulates were maximum encountered in riverine forest A (36.84%) and minimum in riverine forest B (5.26%) during the summer season. However, the habitat used by livestock was maximum in riverine forest B (28.62%) and minimum in riverine forest A (11.45%).

The observation on the food habits of cattle included varieties of grasses, herbs, shrubs, leaves, flowers, and fruits of trees. However, due to the intense food scarcity, we observed cattle feeding on some weeds such as *Lantana camera* and *Parthenium* spp.

**3.7. Discussion.** Our study suggests that during summer, the number of livestock grazing directly in forest land is comparatively less than during winter, where most of them were found to be grazing on agricultural and private land available due to adequate availability of food resources during summer. Firewood, fire, grass, and fodder collection have been recognized as the major conservation problems,

and grazing has been recognized as the highest disturbing factor in the Khata Corridor. Overgrazing was recognized as one of the potential threats for wild ungulates in the corridor forest. This could be attributed to the high forest dependency of people and livestock rearing as their major subsistence of living. Uncontrolled and heavy grazing by cattle causes deterioration, decreases preferred plant availability [1, 3, 5, 7, 17, 36], increases food overlap in winter and early spring, and has undesirable effects on native herbivores [2, 36, 37]. The effective stocking density for winter is higher than that of the summer season due to the large number of cattle-dwelling in forest land. There has been a low availability of forage around the villages, leading to a concerted effort to graze in the forest, increasing the higher effective stocking density. An increase in stock density results in more grazing pressure on land, affecting the carrying capacity of forest land [18]. Here, the question that remains to be answered is whether the resource available in the study area of the Khata Corridor is adequate or in limited condition for sympatric wild ungulates. Our research pinpoints the moderate level of habitat overlap between domestic livestock and wild ungulates during winter (0.8) and summer season (0.79). An increased overlap was found during winter as all livestock were taken only in the forest corridor, putting substantial pressure on their wild counterparts. However, the villagers took cattle on agricultural and private land as there was availability of forage during the summer season reducing cattle grazing directly into forest. Thill [38] also found that white-tailed deer and cattle foraged materials at forest sites with the greatest overlap during the winter and spring seasons. The authors in [39] found the greatest overlap (60%) in winter and spring under inadequate forage conditions, resulting from rapid heavy stocking treatment. Our research study also showed that there were 49 cases of livestock killed inside forests of which goats (24) and sheep (15) were the highest in the past two years, contributing to the diet of predators in the corridor and reducing the pressure on the wild ungulates to some extent. Li et al. [40] emphasized that the competition between domestic livestock and wild ungulates was the reason for the limited population growth of predators, hence advocating strict grazing controls. The existing levels of grazing by livestock appear to limit the resources for wild herbivores; the reduction and exclusion of their density from grazed areas put them at risk of stochastic extinction [18, 41, 42]. Wild ungulates were found to use the community forest, which is restricted for open grazing; however, they avoided community forest use, where livestock has a fair share of grazing. According to [43, 44], the negative responses of cervids are due to overgrazing, heavy cattle intensity, particularly at high stocking rates and with low rainfall, and A/C interference competition, where deer respond with the presence of livestock rather immediate changes in forage quantity or quality a/c social intolerance. Wild ungulates were found more in short grassland and riverine forest, with the least in mixed forest, which was used maximum by domestic livestock. Previous study conducted by [9] in Barandabhar corridor of Chitwan National Park explored that species





on sympatric medium and large-sized herbivores. The observation on the food habits of cattle includes a wide variety of grasses, herbs, shrubs, leaves, flowers, and fruit of trees. However, due to intense food scarcity, we observed them feeding on some weeds like *Lantana camera* and *Parthenium* spp. However, it is not possible to draw a definitive conclusion about the interspecific competition between livestock and wild ungulates from these few data. To protect forest land with an abundance of wild ungulates, overgrazing of livestock is needed to be reduced by establishing a public fodder land area for the villagers.

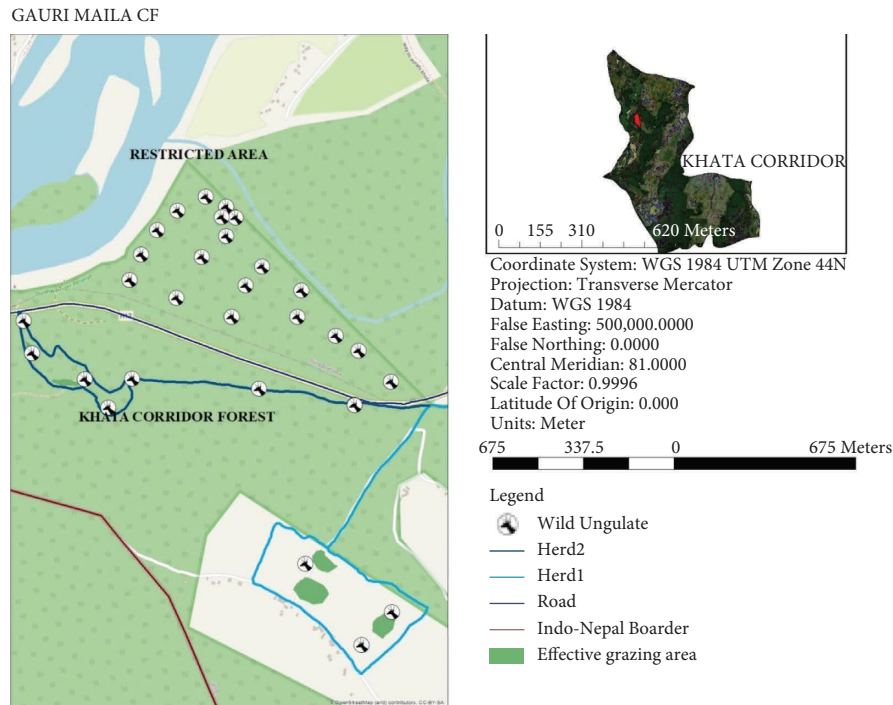


FIGURE 8: Presence of wild ungulates in a restricted area of Gauri Maila CF in Khata Corridor, Bardiya district.

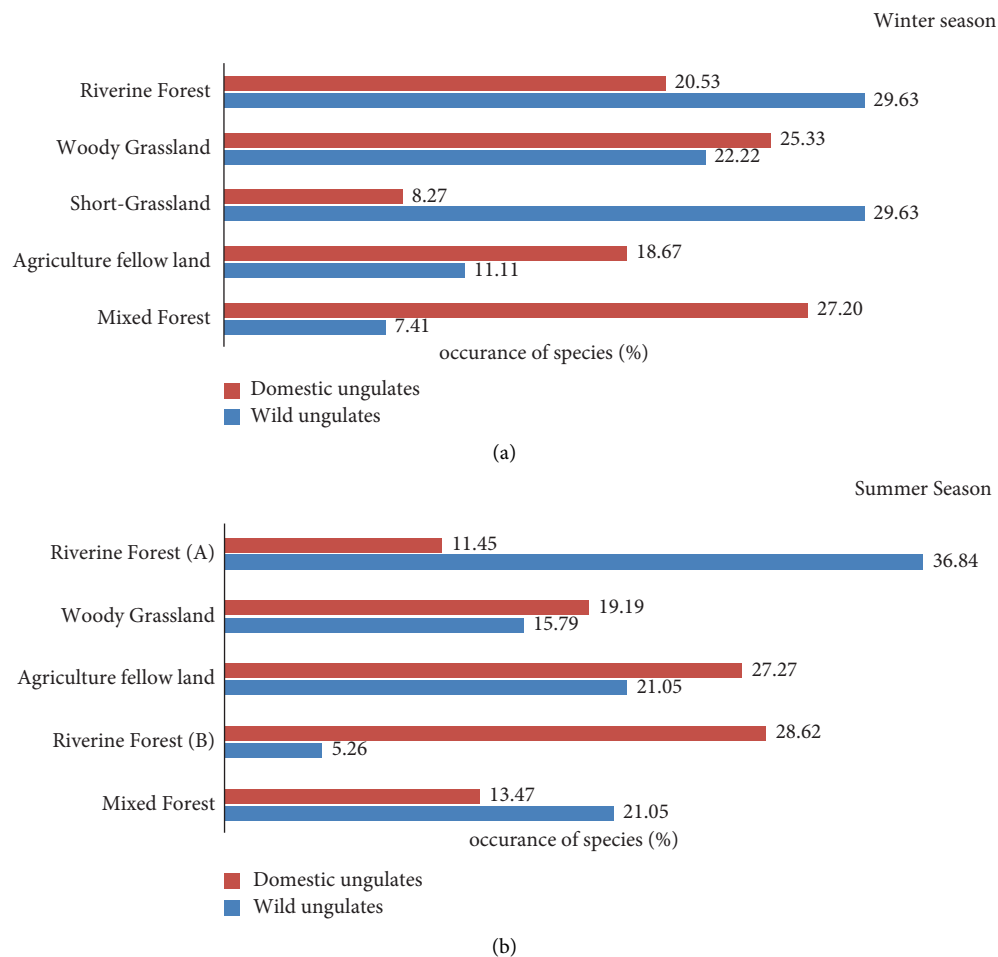


FIGURE 9: Proportion of wild and domestic ungulates occurrences in different habitat types: (a) winter and (b) summer seasons.



## 4. Conclusion

Our research suggests the severe impact of domestic livestock in the Khata Corridor forest on the wild ungulates. We observed wild ungulates avoiding the area grazed by domestic livestock, as evidenced by from field observations, and we need to advocate for the development of more standard methods that can be repeated and compared across studies. The possibility of high spatial habitat overlap was found in the month of winter when forage availability was scarce. The management of grasslands through moderate grazing practices is also a major topic of controversy due to inadequate knowledge and information. The increasing level of grazing inside forest land has resulted in the decreasing of palatable species of wild ungulates and gradual replacement of their habitat by livestock. The biodiversity of the Khata Corridor forest must be maintained to sustain the ecological balance. The overgrazing of livestock must be reduced to protect forest land against abundant wild herbivores by establishing public pasturelands for the villagers. Development of a comprehensive wildlife livestock grazing framework for planning sustainable livestock farming and for important wildlife areas to maintain long-term landscape connectivity is to protect migrating endangered wild species.

## Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

## Ethical Approval

This research has been conducted by following all the Mammalia guidelines on ethical standards, followed the standards of the Social Research Association, and was reviewed and approved by the Ethics Committee of the Kathmandu Forestry College, Tribhuvan University, Nepal. The Ministry of the Forest and Environment, DNPWC, and the Bardia National Park authorities in Nepal granted permission to conduct this research, which complied with all legal requirements for research within the country. Researchers harmonized and conducted the data collection in collaboration with herders. This study does not involve any animal experiments or operations.

## Conflicts of Interest

The authors declare that they have no conflicts of interest.

## Acknowledgments

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