Research Article Volume 18 Issue 1

ISSN NO. 2091-1742

SCITECH NEPAL Journal of Scientific and Technical Studies

Nepal Engineering College, Pokhara University

Received: May 27, 2025

DOI: https://doi.org/10.3126/scitech.v18i1.90819

Accepted: January 30, 2026

Distribution, Habitat Preference and Conservation Threats of Porcupine (*Hystrix* Spp.) in Mahankal Rural Municipality, Lalitpur Center for Postgraduate Studies, Nepal Engineering College, Pokhara University, Nepal

Parbati Adhikari

Department of Forest and Soil Conservation, Ministry of Forest and Environment

Email: adhikari.parbati2@gmail.com

Abstract

Porcupines play important ecological roles as ecosystem engineers, yet their distribution, habitat preference, and conservation challenges remain poorly documented in Nepal. This study assessed the distribution of porcupine burrows, habitat characteristics, human–porcupine conflict, and conservation threats in Mahankal Rural Municipality, Lalitpur. Primary data were collected through field surveys, burrow counts, household questionnaires (n = 85), key informant interviews, and focus group discussions. A total of 55 porcupine burrows were recorded across 12 randomly selected quadrats (500 m × 500 m), yielding an average burrow density of 18.33 burrows km^{-2}. Burrow distribution was strongly associated with proximity to cropland and forest edges, while fewer burrows occurred near roads and permanent water sources. Crop depredation emerged as the principal source of human–porcupine conflict, with a mean annual economic loss of NRs 9,488.24 per household, primarily affecting maize and potato. Despite economic losses, local attitudes toward porcupines were predominantly positive and significantly influenced by occupation, age, and gender. Habitat loss, land-use change, and infrastructure development were identified as major conservation threats. The study highlights the need for site-specific mitigation measures and landscape-level planning to reduce conflict while maintaining suitable porcupine habitat.

Keywords: Porcupine, burrow density, habitat preference, human–porcupine conflict, crop damage

1. Introduction

Porcupines (Family: Hystricidae) are among the largest rodents in the world and are widely distributed across Asia and Africa. They are nocturnal, burrowing mammals characterized by modified hairs forming defensive quills (Prater, 1980; Nair & Jayson, 2019). In South Asia, three species are commonly recognized: *Hystrix indica*, *Hystrix brachyura*, and *Atherurus macrourus* (Molur et al., 2005). In Nepal, two species occur—the Indian crested porcupine (*Hystrix indica*) and the Himalayan porcupine (*Hystrix brachyura*)—both currently listed as Least Concern on the IUCN Red List, although regional declines have been reported due to habitat loss and exploitation (Amori et al., 2016; Lunde et al., 2016; Molur et al., 2005).

Porcupines exhibit broad habitat tolerance, occupying rocky hillsides, forests, shrublands, grasslands, plantations, and agricultural landscapes (Amori et al., 2016). They typically inhabit natural caves or excavated burrows and prefer well-drained soils for denning (Marina & Zubaid, 2015; Mukherjee et al., 2017). As ecosystem engineers, porcupines influence soil structure and plant community composition through burrowing and selective herbivory (Sweitzer & Berger, 1992, 1997). Their diet consists mainly of roots, tubers, bark, fruits, grains, and cultivated crops, reflecting their generalist feeding strategy (Gutterman, 1982; Prater, 1980; Pervez et al., 2009).

Despite their ecological importance, porcupines are frequently regarded as agricultural pests because of crop raiding behavior. Studies across South Asia have documented significant economic losses due to depredation of maize, potato, wheat, and vegetables (Hussain, 2004; Khan, 2013; Ashraf et al., 2021). Human–porcupine conflict tends to intensify in forest–agriculture interfaces where suitable shelter and abundant food resources coexist (Lovari et al., 2017; Mukherjee et al., 2018). In Nepal, increasing human–wildlife conflict has been linked to habitat fragmentation, land-use change, and expansion of agricultural land into forest margins (GoN, 2014; Shrestha, 2007).

Urbanization and infrastructure development are widely recognized as major drivers of biodiversity loss globally (McKinney, 2006; Grimm et al., 2008). Habitat degradation, fragmentation, poaching, and retaliatory killing have been identified as key threats to porcupine populations across their range (Molur et al., 2005; Brooks et al., 2010; Heinrich et al., 2020). In human-dominated landscapes, porcupines often adapt to modified habitats; however, such adaptation frequently increases conflict with local communities.

In the southern part of Kathmandu Valley, particularly in Mahankal Rural Municipality, recent expansion of private and family forests—especially plantations of *Taxus mairei*—has altered habitat structure and food availability. These landscape changes may influence porcupine distribution, burrow site selection, and conflict patterns. However, empirical information on porcupine ecology and human–porcupine conflict in this region remains limited.

Therefore, this study aimed to: (i) assess the distribution and density of porcupine burrows; (ii) examine habitat characteristics influencing burrow site selection; (iii) quantify the extent of human–porcupine conflict and associated crop losses; and (iv) identify major conservation threats in Mahankal Rural Municipality, Lalitpur.

2. Study Area

2.1 Geographic Location

The study was conducted in Mahankal Rural Municipality (RM), located in the southern part of Lalitpur District within the Kathmandu Valley, Nepal. The municipality lies approximately 40 km from Lalitpur Metropolitan City and ranges in elevation from 1,500 to 2,300 m above sea level. Geographically, the area extends between approximately 27°25′–27°35′ N latitude and 85°20′–85°26′ E longitude. Administratively, Mahankal RM comprises six wards. The present study focused on the former Village Development Committees (VDCs) of Gotikhel and Kaleshwor, which together cover approximately 24.02 km² and include 698 households (Figure 1).

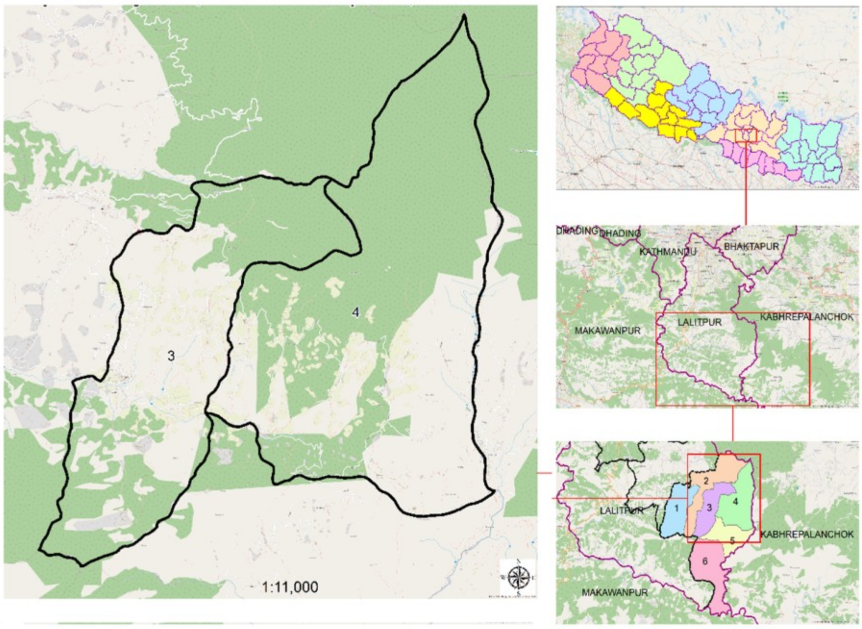

Figure 1: Study area showing Gotikhel and Kaleshwor in Mahankal RM

2.2 Topography and Climate

The study area is characterized by rugged topography with steep forested slopes (approximately 25°–40°) and moderately sloping agricultural land (15°–25°). Settlements are typically distributed along road corridors following ridge lines and ghat roads. The climate ranges from warm temperate to cool temperate. Mean annual temperatures vary from approximately 2.3 °C in winter to 23.4 °C in summer, while annual rainfall ranges between 1,400 and 2,000 mm. The monsoon season contributes the majority of annual precipitation, influencing vegetation growth and agricultural productivity.

2.3 Vegetation and Land Use

The area supports mixed temperate forests dominated by *Shorea robusta*, *Schima wallichii*, *Castanopsis indica*, *Pinus* spp., and *Taxus mairei*. Non-timber forest products (NTFPs) such as *Lokta*, *Pasanbed*, *Sugandhawal*, *Jatamasi*, and *Nagbeli* are also present. Mahankal RM is particularly recognized for private and family forest plantations of *Taxus mairei* (locally known as Lauth salla), which have expanded in recent years (Koirala, 2022). This expansion has altered habitat structure and vegetation composition in forest–agriculture interfaces.

Land use is primarily divided into forestland and agricultural fields. Agricultural practices include cultivation of maize, wheat, potato, vegetables, and fodder crops. The close proximity of cropland to forest edges creates a mosaic landscape that potentially provides both shelter and foraging opportunities for wildlife, including porcupines.

2.4 Socioeconomic Characteristics

Agriculture and livestock rearing constitute the main livelihoods of local residents. A significant proportion of households are engaged in commercial vegetable farming, milk production, green tea cultivation, and processing of dairy products such as *khuwa*. In recent years, many households have increasingly invested in *Taxus mairei* cultivation as a high-value medicinal plant species (Koirala, 2022). Such land-use transitions may influence wildlife distribution and patterns of human–wildlife interaction.

At the national level, habitat loss, land-use change, and infrastructure expansion have been recognized as major drivers of biodiversity decline in Nepal (GoN, 2014). These broader landscape-level dynamics provide an important context for understanding porcupine distribution and conservation challenges within Mahankal RM.

3. Data Collection Methods

3.1 Field Survey and Burrow Assessment

A field survey was conducted to record porcupine burrows and associated indirect signs. Twelve quadrats (500 m × 500 m; 25 ha each) were randomly selected using GIS. Each quadrat was systematically searched for active burrows, identified based on the presence of quills, footprints, fecal matter, and feeding signs. Geographic coordinates of burrows were recorded using GPS. Distances from burrows to cropland, forest edges, roads, households, and water sources were calculated for habitat analysis.

3.2 Socioeconomic Survey

A total of 85 households were surveyed using semi-structured questionnaires, following Arkin and Colton's sampling formula at a 95% confidence level. Additionally, four focus group discussions and five key informant interviews were conducted to gather qualitative information on crop damage, mitigation practices, and conservation threats.

4. Results and Discussion

4.1 Burrow Density in the Study Area

A total of 55 porcupine burrows were recorded across 12 quadrats (500 m × 500 m each), covering 3 km^2. The average burrow density was 0.183 burrows ha^{-1}, equivalent to 18.33 burrows km^{-2} (Figure 4.2). Considering that porcupines are generally solitary except during breeding (Van Aarde, 1985; Olson & Lewis, 1999), and that 1–4 individuals may occupy a burrow during the reproductive season (Mustikasari et al., 2019), the study area likely supports a substantial local population.

The recorded density is higher than estimates from Keoladeo National Park, India (3.21 ± 1.32 individuals km^{-2}; Mukherjee et al., 2018), Pakistan (6 km^{-2}; Siddique, 2004), and South Africa (2.6 burrows km^{-2}; Bragg et al., 2005), but comparable to higher estimates reported from semi-arid India (Sharma, 2001). Variations in density may reflect differences in habitat quality, food availability, predation pressure, and anthropogenic disturbance (Woods, 1973; Alkon, 1999). The mosaic of cropland and private forest in Mahankal RM likely provides abundant forage and shelter, supporting higher burrow densities.

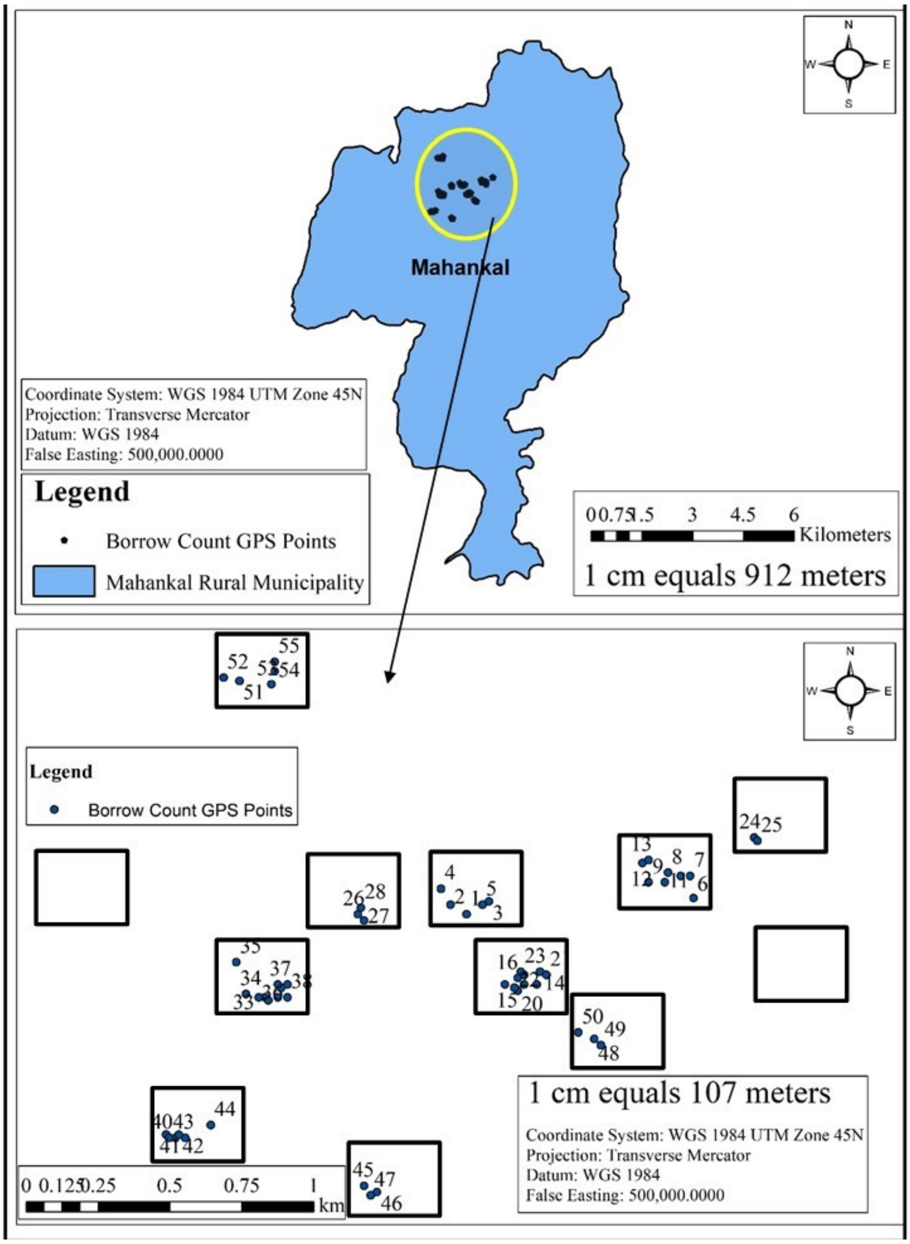

Figure 2 Distribution of burrows of Porcupine in study area

4.2 Distribution of Burrows Across Quadrats

Burrows were recorded in 10 out of 12 quadrats, indicating widespread distribution across the landscape. Most burrows were located near forest–agriculture interfaces, suggesting that porcupines exploit cultivated areas for food while relying on adjacent forest patches for denning and refuge. Such edge-associated distribution has been documented in suburban and agricultural landscapes (Lovari et al., 2017; Mukherjee et al., 2017).

4.3 Habitat Characteristics Influencing Burrow Distribution

4.3.1 Distance from Water Sources

Burrow distribution showed a weak relationship with proximity to water sources, with the highest proportion (38.2%) recorded at 600–800 m from water (Figure 3). Fewer burrows were observed in close proximity to permanent water. Porcupines are known to tolerate relatively dry environments and do not require frequent access to open water (Shapiro, 1949; Zeiner et al., 1988). Preference for well-drained soils has been reported in Malaysia and India (Marina & Zubaid, 2015; Mukherjee et al., 2017), supporting the present findings that waterlogged areas are less suitable for burrowing.

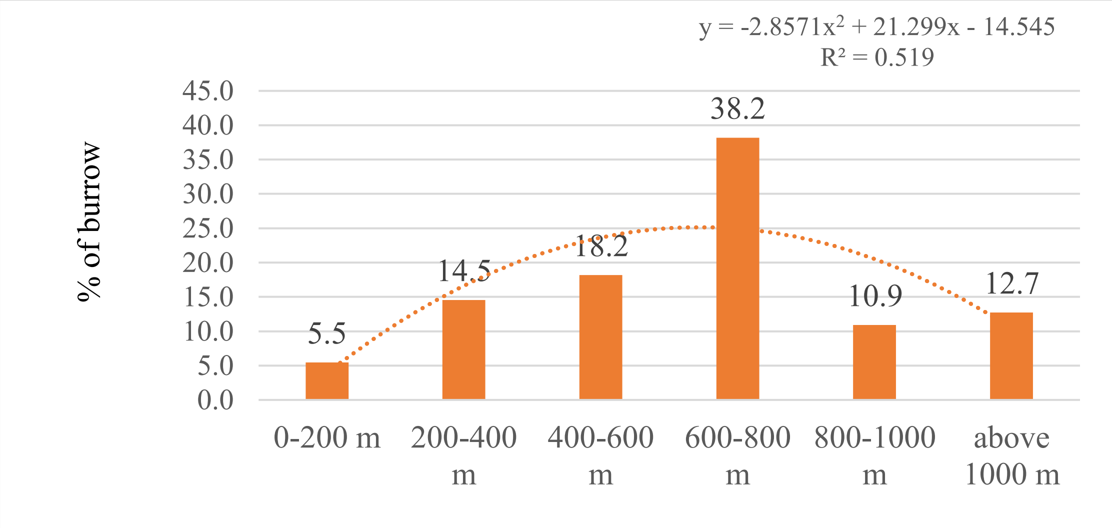

Figure 3 Distance from burrow to water resources

4.3.2 Distance from Households

Burrow occurrence increased with distance from households up to 400–600 m and declined beyond 800 m (Figure 4). Although porcupines can persist near human settlements, they tend to select den sites with reduced direct disturbance (Tinelli & Tinelli, 1980; Monetti et al., 2005). The hilly terrain and linear settlement pattern along roads may influence this spatial pattern, as increasing distance from one settlement may simultaneously decrease distance to another.

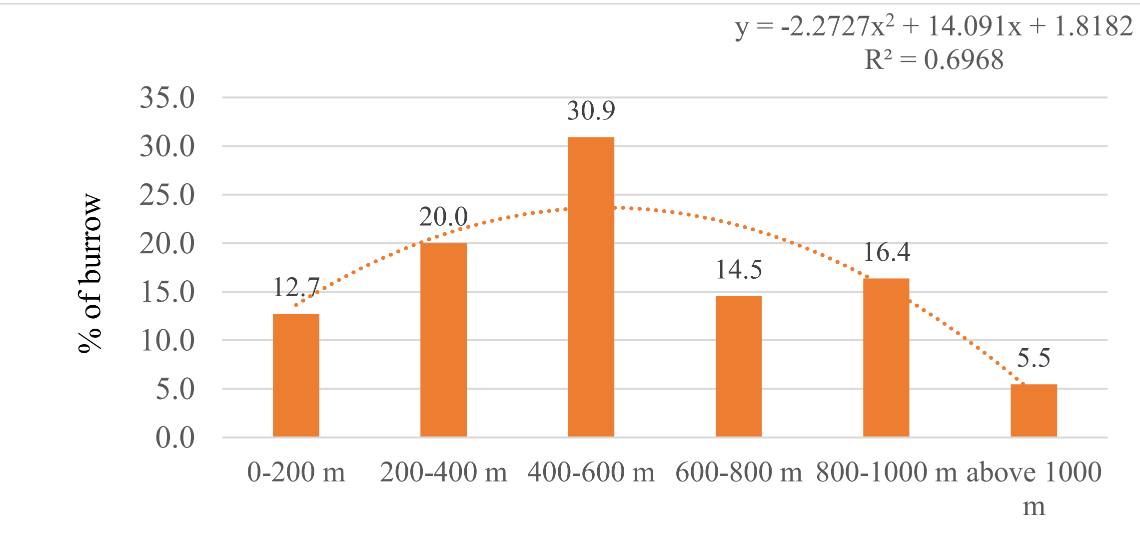

Figure 4: Distance from burrow to households

4.3.3 Distance from Cropland

Approximately 38.2% of burrows were located within 200 m of cropland boundaries. A strong positive trend ($R^2 \approx 0.85$) indicated that burrow density was highest near cultivated land (Figure 5). Similar patterns have been reported where Indian crested porcupines exploit agricultural crops while maintaining burrows in nearby non-cultivated areas (Lovari et al., 2017; Mukherjee et al., 2017). Agricultural fields provide high-energy food resources such as maize and potato, reducing foraging costs and increasing habitat suitability (Alkon, 1999).

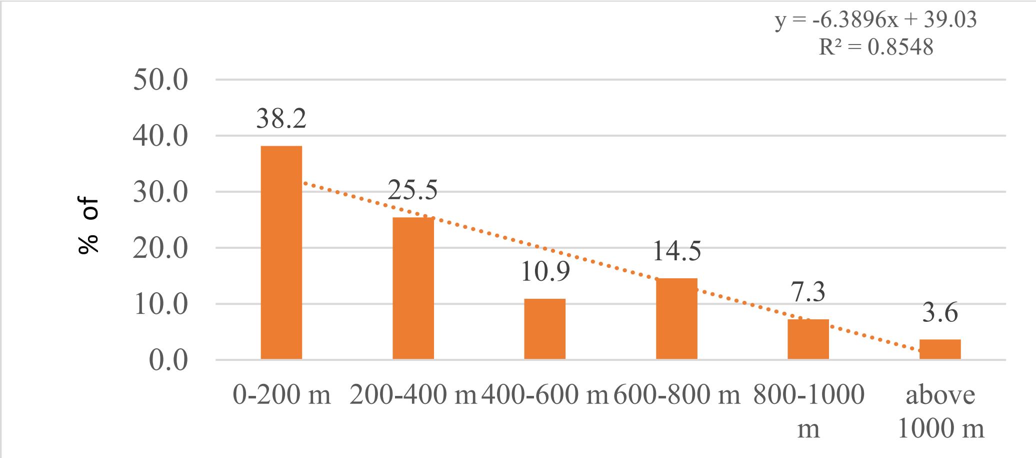

Figure 5: Distance of burrow from crop land

4.3.4 Distance from Forest Edges

Nearly 80% of burrows were located within 0–400 m of forest areas, indicating strong dependence on forest cover for shelter. The distribution trend ($R^2 \approx 0.82$) suggests that optimal sites occur where cropland and forest patches intersect (Figure 6). Forests provide protective cover, stable microclimatic conditions, and denning sites (Woods, 1973; Amjad et al., 1990). Thus, porcupines appear to rely on a forest–farm mosaic rather than exclusively forested habitats.

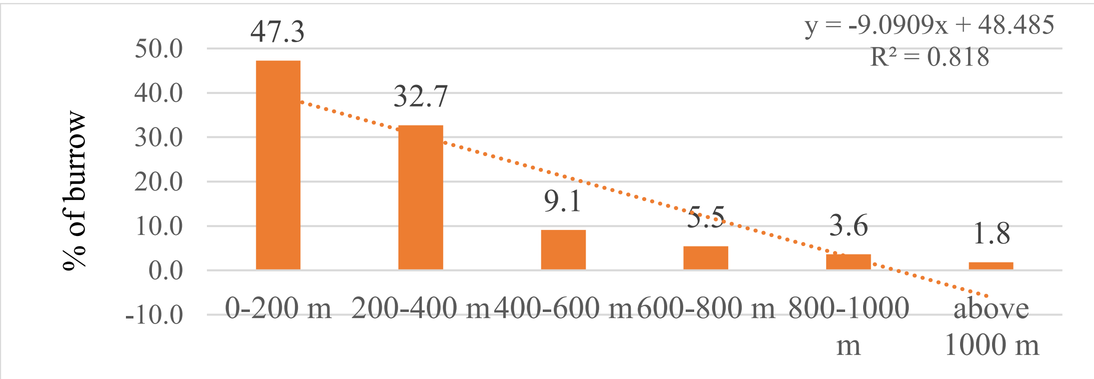

Figure 6 : Burrow distribution along forest

4.3.5 Distance from Roads

Most burrows (81.9%) were recorded 600–800 m away from roads. Burrow frequency declined in areas closer to roads, indicating avoidance of vehicular disturbance and noise (Figure 7). Roads are known to alter wildlife movement and behavior (Forman & Alexander, 1998; Seidler et al., 2015), and hunting with dogs can increase stress and spatial displacement in porcupines (Mori, 2017). Reduced disturbance at intermediate distances likely explains higher burrow densities in those zones.

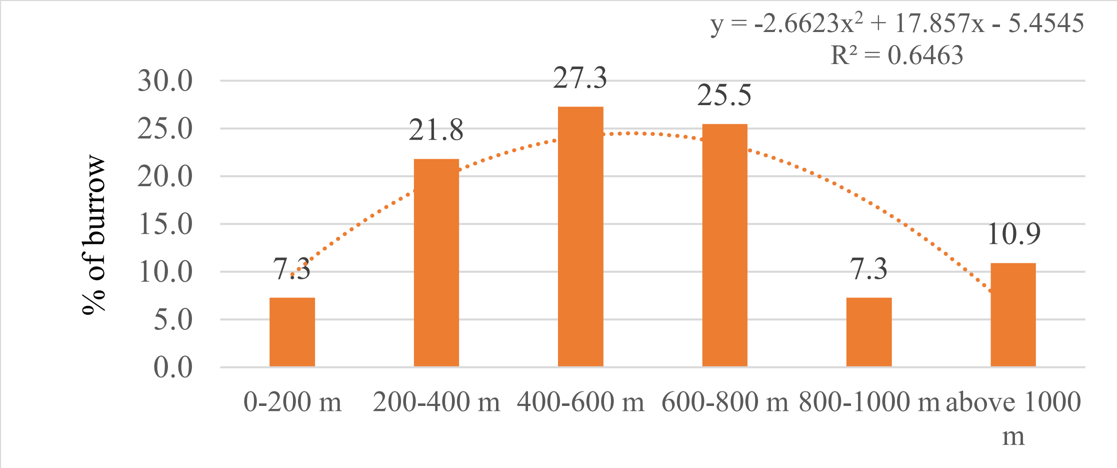

Figure 7: Burrows along roadside

4.4 Human–Porcupine Conflict and Crop Damage

Porcupine was identified as a major nocturnal crop raider, alongside wild boar. Mean annual crop loss was estimated at NRs 9,488.24 per household, with maize accounting for 39% of total loss, followed by potato (26%) and vegetables (14%) (Table 1). Damage to *Taxus mairei* seedlings was also reported. Similar patterns of maize-dominated crop loss have been documented in Nepal and Pakistan (Kaway, 2011; Ashraf et al., 2021).

Table 1: Total Crop loss per year per households

Crops	Total loss per year (NRS)	Total loss in %
Wheat	93000	12%
Maize	311000	39%
Potato	208000	26%
Lauth salla *(Taxus mairei)*	51500	6%
Vegetables (cauliflowers, cabbage, etc.)	116000	14%
Others (Jai grass, Amriso)	27000	3%
Total crop loss per year	806500	100%
total crop loss per year per HHs	9488.24	

Crop raiding represents a significant component of human–wildlife conflict, directly affecting livelihoods and shaping local perceptions of wildlife (Priston, 2008; GoN, 2014). Although economic loss in Mahankal RM is moderate compared to some protected areas, repeated seasonal damage may intensify retaliatory behavior.

4.5 Mitigation Measures Adopted by Farmers

Farmers reported multiple mitigation strategies, including night guarding, shouting, chasing with fire, throwing stones, and use of dogs (Table 2). The use of dogs received the highest satisfaction ranking (mean score 8.9/10), either alone or combined with guarding. Similar community-based deterrence methods have been reported in Nepal (Ghimire et al., 2022; Sherchan & Bhandari, 2017).

Despite the effectiveness of dogs, guarding is labor-intensive and increasingly constrained by labor shortages due to migration. Electric fencing and reinforced barriers have been recommended elsewhere as effective deterrents (Schemnitz, 1994), but such measures were not widely implemented in the study area.

Table 2: Response of respondents on strategies used to cope crop raiding

Techniques used to chase porcupine	No of respondent	% of respondents	Average Satisfaction rank out of 10
Guarding	14	16.5	7.8
Using Dogs	15	17.6	8.9
Both Guarding using dogs	30	35.3	8.7
Chasing and shouting	15	17.6	6.2
chasing with fire and shouting	20	23.5	6.4
Shouting, chasing, throwing stones	25	29.4	6.48
All of above	8	9.4	9
Don't use any techniques	20	23.5	
	147	172.9	

Note: The total percentage is higher than 100 since respondents choose more than one options.

4.6 Community Attitudes and Trends of Conflict

Among respondents, 64.7% expressed positive attitudes toward porcupines, particularly those engaged in *Taxus mairei* cultivation, whereas 28.2% (primarily cash crop farmers) held negative perceptions. Chi-square analysis revealed significant associations between occupation and attitudes toward porcupines ($\chi^2 = 48.325$, df = 10, $p < 0.001$), and between occupation and perceived trend of crop damage ($\chi^2 = 57.237$, df = 10, $p < 0.001$). Age was significantly associated with perceived crop damage trends ($\chi^2 = 56.96$, df = 6, $p < 0.001$), while gender showed significance only in relation to crop damage perception ($\chi^2 = 6.699$, df = 2, $p = 0.04$). Education, income, and landholding size were not significantly associated with attitudes (Table 3).

Table 3: Result of chi square test between different category with attitude towards porcupine

SN	Category	P value	χ2	d f	CV
1	Occupation with. Perception towards porcupine	**0.00**	48.325	10	18.307
	Occupation with trend of crop damage	**0.00**	57.237	10	18.307
2	Gender with perception towards porcupine	0.76	0.55	2	5.99
	Gender with trend of crop damage	0.04	6.699	2	5.99
3	Education with perception towards porcupine	0.76	3.499	6	12.59
	Educations with trend of crop damage	0.74	3.373	6	12.59
4	Age with perception towards porcupine	0.23	8.098	6	12.59
	Age with trend of crop damage	**0.00**	56.96	6	12.59
5	Land property with perception towards porcupine	0.11	5.05	4	9.48
	Land property with trend of crop damage	0.57	7.65	4	9.48
6	Income with perception towards porcupine	0.28	10.384	6	12.59
	Income with trend of crop damage	0.11	4.7756	6	12.59

These findings indicate that livelihood dependence strongly shapes perceptions of wildlife, consistent with broader patterns observed in human–wildlife conflict studies in Nepal (Shrestha, 2007; Pradhan et al., 2011). Positive attitudes among *Taxus* cultivators may reflect lower relative crop loss compared to vegetable farmers.

4.7 Conservation Threats to Porcupines

Respondents identified infrastructure development and habitat loss as the most significant threats (>90%), followed by crop alteration (70%), habitat fragmentation (66%), poaching (64%), and interspecific competition (58%) (Figure 8). Habitat loss and fragmentation are widely recognized as primary drivers of porcupine decline (Molur et al., 2005; Brooks et al., 2010). National assessments in Nepal similarly highlight land-use change and human–wildlife conflict as major biodiversity threats (GoN, 2014).

Expansion of roads, settlement areas, and agricultural intensification in Mahankal RM may further fragment habitats and increase human–porcupine interactions. Although porcupines demonstrate adaptive capacity in modified landscapes, sustained habitat degradation and retaliatory killing could negatively affect long-term population stability.

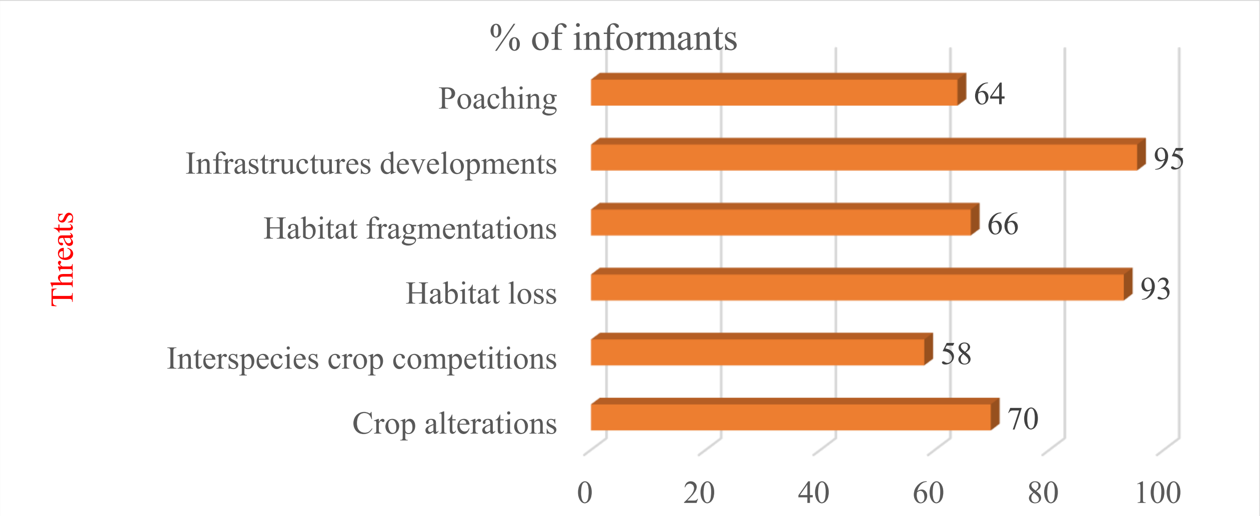

Figure 8: Main causes of threats to the porcupine

5. Conclusion

Mahankal Rural Municipality supports a relatively high density of porcupines, reflecting the availability of suitable habitat at the forest–agriculture interface. Porcupines preferentially establish burrows near cropland and forest edges while avoiding roads and waterlogged areas. Human–porcupine conflict, primarily through crop depredation, imposes notable economic losses on households, although community attitudes toward porcupines remain largely positive. Habitat loss and infrastructure development pose major conservation challenges. Effective conflict mitigation, awareness programs, and habitat-sensitive development planning are essential to ensure the long-term coexistence of porcupines and local communities.

References

Alkon, P.U. 1999 'Microhabitat to landscape impacts: crested porcupine digs in the Negev Desert highlands', *Journal of Arid Environments*, 412, pp. 183–202.

Amjad, R.K., Aslam, H.M., Beg, M.A. and Khan, A.A. 1990 'External characteristics and density of the crested porcupine burrows in forest plantations', *Pakistan Journal of Agricultural Sciences*, 271, pp. 1–6.

Amori, G., Hutterer, R., Kryštufek, B., Yigit, N., Mitsain, G. and Palomo, L. 2016 *Hystrix indica*. The IUCN Red List of Threatened Species 2016.

Ashraf, R.Z., Ahmad, B., Shafique, F., Hassan, M.U., Asim, N., Muhammad, M.W. and Sheikh, N. 2021 'Evaluation of economic loss caused by Indian crested porcupine *Hystrix indica* in agricultural land of Muzaffarabad, Pakistan', *Brazilian Journal of Biology*, 83, e247395.

Bragg, C.J., Donaldson, J.D. and Ryan, P.G. 2005 'Density of Cape porcupines in a semi-arid environment and their impact on soil turnover', *Journal of Arid Environments*, 612, pp. 261–275.

Brooks, E.G., Roberton, S.I. and Bell, D.J. 2010 'The conservation impact of commercial wildlife farming of porcupines in Vietnam', *Biological Conservation*, 143, pp. 2808–2814.

Forman, R.T.T. and Alexander, L.E. 1998 'Roads and their major ecological effects', *Annual Review of Ecology and Systematics*, 29, pp. 207–231.

Ghimire, S., Devkota, D., Dhakal, S.C. and Upreti, B.R. 2022 'Effectiveness of crop and livestock protection methods against wildlife damage', *Journal of Agriculture and Forestry University*, pp. 165–175.

GoN 2014 *Nepal National Biodiversity Strategy and Action Plan 2014–2020*. Kathmandu: Government of Nepal.

Grimm, N.B., Faeth, S.H., Golubiewski, N.E., Redman, C.L., Wu, J., Bai, X. and Briggs, J.M. 2008 'Global change and the ecology of cities', *Science*, 3195864, pp. 756–760.

Heinrich, S., Toomes, A. and Gomez, L. 2020 'Valuable stones: the trade in porcupine bezoars', *Global Ecology and Conservation*, 24, e01204.

Kaway, C. 2011 *Crop depredation by small mammals: a case study of porcupine Hystrix indica in Shivapuri National Park*. MSc thesis. Tribhuvan University, Nepal.

Khan, A.A. 2013 'Bio-economic impacts of vertebrate pests on crops', *Proceedings of Pakistan Congress of Zoology*, 33, pp. 75–108.

Koirala, T.P. 2022 *Status, growth and regeneration pattern of yews Taxus mairei in Lalitpur District*. Pokhara University, Nepal.

Lovari, S., Corsini, M.T., Guazzini, B., Romeo, G. and Mori, E. 2017 'Suburban ecology of the crested porcupine', *European Journal of Wildlife Research*, 63, 1–10.

Lunde, D., Aplin, K. and Molur, S. 2016 *Hystrix brachyura*. The IUCN Red List of Threatened Species 2016.

Marina, M. and Zubaid, A. 2015 'Porcupine burrow distribution in relation to soil types', *Malayan Nature Journal*, 671, pp. 24–32.

McKinney, M.L. 2006 'Urbanization as a major cause of biotic homogenization', *Biological Conservation*, 127, pp. 247–260.

Molur, S., Srinivasulu, C., Srinivasulu, B., Walker, S., Nameer, P.O. and Ravikumar, L. 2005 *Status of South Asian non-volant small mammals*. Coimbatore: Zoo Outreach Organization.

Monetti, L., Massolo, A., Sforzi, A. and Lovari, S. 2005 'Site selection and fidelity by crested porcupines for denning', *Ethology Ecology & Evolution*, 172, pp. 149–159.

Mukherjee, A., Kumara, H.N. and Bhupathy, S. 2017 'Determinants of occupancy and burrow site selection by Indian crested porcupine', *Current Science*, 113, pp. 2440–2448.

Mukherjee, A., Kumara, H.N. and Bhupathy, S. 2018 'Environmental determinants of activity variation of Indian crested porcupine', *Mammalia*, 825, pp. 449–459.

Mustikasari, I.A., Withaningsih, S., Megantara, E.N., Husodo, T. and Parikesit 2019 'Population and distribution of Sunda porcupine', *Biodiversitas*, 203, pp. 762–769.

Olson, R.A. and Lewis, A.M. 1999 *Porcupine ecology and damage management techniques*. University of Wyoming Extension.

Pervez, A., Ahmad, S.M., Lathiya, S.B. and Khadijah, E. 2009 'Food habits of Indian crested porcupine', *Pakistan Journal of Zoology*, 414, pp. 287–294.

Prater, S.H. 1980 *The book of Indian animals*. Mumbai: Bombay Natural History Society.

Pradhan, N.M., Williams, A.C. and Dhakal, M. 2011 'Current status of Asian elephants in Nepal', *Gajah*, 35, pp. 87–92.

Priston, N. 2008 *Modelling primate crop-raiding*. PhD thesis. University College London.

Schemnitz, S.D. 1994 *Porcupines*. Denver: Colorado State University Extension.

Seidler, R.G., Long, R.A., Berger, J., Bergen, S. and Beckmann, J.P. 2015 'Identifying impediments to long-distance mammal migrations', *Conservation Biology*, 291, pp. 99–109.

Shapiro, J. 1949 'Ecological and life history notes on the porcupine', *Journal of Mammalogy*, 303, pp. 247–257.

Shrestha, R. 2007 *A case study on human–wildlife conflict in Nepal*. WWF Nepal.

Siddique, M.M. 2004 'Relative density of porcupine *Hystrix indica* population', *Pakistan Journal of Biological Sciences*, 7, pp. 671–675.

Sweitzer, R.A. and Berger, J. 1992 'Size-related effects of predation on habitat use and behavior of porcupines', *Ecology*, 73, pp. 567–875.

Sweitzer, R.A. and Berger, J. 1997 'Sexual dimorphism and intrasexual selection in porcupines', *Canadian Journal of Zoology*, 756, pp. 847–854.

Tinelli, A. and Tinelli, P. 1980 *Le tane di istrice e di tasso*. Rome: Presidenza della Repubblica.

Van Aarde, R.J. 1985 'Reproduction in captive female Cape porcupines', *Journal of Reproduction and Fertility*, 752, pp. 577–582.

Woods, C.A. 1973 'Erethizon dorsatum', *Mammalian Species*, 29, pp. 1–6.

Zeiner, D.C., Laudenslayer, W.F., Mayer, K.E. and White, M. 1988 *California's wildlife*. Sacramento: California Department of Fish and Game.