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# Ecology, Distribution, and Conservation Drivers of the Pangolin (*Manis spp*) in the Churia Landscape of Eastern Nepal

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**Abstract**

Pangolins (*Manis* spp.) are among the most threatened mammals globally, yet their ecological patterns and conservation status in Nepal's Churia region remain poorly documented. This study examines habitat preferences, distribution, key threats, and community-based conservation practices of the Indian pangolin (*M. crassicaudata*) and Chinese pangolin (*M. pentadactyla*) across 57 community forests in the Koshi landscape. Field observations and community monitoring show that pangolins are closely associated with mixed *Shorea robusta* and riverine forests that provide moderate canopy cover, well-drained soils, gentle slopes, and abundant ant and termite populations. The Indian pangolin is mostly found in lower and middle elevations, while the Chinese pangolin is more common at higher altitudes. The estimated population of 149 individuals reflects a decline of about 38% in community forest occupancy over the last three decades. The main pressures on pangolins include poaching linked to traditional beliefs, habitat loss from deforestation and infrastructure development, invasive species, repeated forest fires, and illegal cross-border trade. In response, Community Forest User Groups have implemented various conservation actions such as regular forest patrolling, protection of burrow sites, fire control measures, and support for alternative livelihood options. These efforts have improved local awareness and encouraged greater stewardship among communities. However, conservation outcomes are still limited due to weak integration of pangolin-specific measures within the Forest Operational Plan, inadequate monitoring systems, and continuing socio-cultural drivers of exploitation. The study highlights the need to strengthen the integration of species-focused conservation into forest management, improve monitoring approaches, and link conservation efforts more effectively with local livelihoods to ensure the long-term survival of pangolins in Nepal's Churia landscape.

**Keywords:** Pangolin, *Manis crassicaudata*, *Manis pentadactyla*, habitat ecology, illegal trade, community-based conservation, Nepal

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## Introduction

Pangolins (order *Pholidota*) are among the most distinctive yet highly threatened mammals worldwide (International Union for Conservation of Nature (IUCN, 2020; International Fund for Animal Welfare (IFAW, 2019; Challender *et al*., 2019). Of the eight extant species, four occur in Asia and four in Africa. Nepal supports two species, the Chinese pangolin (*Manis pentadactyla*) and the Indian pangolin (*Manis crassicaudata*) (Department of National Parks and Wildlife Conservation [DNPWC], 2018; IUCN Species Survival Commission Pangolin Specialist Group [IUCN SSC PSG], 2016; Suwal et al., 2020). Recent molecular evidence suggests that Himalayan populations of *M. pentadactyla* form a distinct genetic clade, proposed as *Manis indoburmanica*, highlighting potential cryptic diversity and the need for further taxonomic and conservation research (Challender et al., 2019; Nash et al., 2018).

Globally, all pangolin species are listed under Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora, prohibiting commercial trade (CITES, 2016; IUCN, 2020). The Chinese pangolin is classified as Critically Endangered, while the Indian pangolin is listed as Endangered, largely due to poaching and habitat loss (IUCN, 2020; Challender et al., 2019; Heinrich et al., 2017). In Nepal, both species are protected under Schedule I of the National Parks and Wildlife Conservation Act 1973 and are categorized as Endangered in the National Red List of Mammals (Jnawali et al., 2011; Amin et al., 2018).

Within Nepal, pangolins are distributed across the mid-hills and Siwalik (Churia) ranges, occupying mixed *Shorea robusta* forests, grasslands, and agroforestry mosaics where ants and termites are abundant (DNPWC, 2018; Sharma et al., 2020; Suwal et al., 2020; Bhandari & Chalise, 2014). Despite legal protection, these species face increasing pressure from illegal hunting for scales and meat, along with habitat fragmentation driven by road expansion, forest degradation, and riverbed extraction in the fragile Churia system.

The Churia landscape, Nepal's youngest and most fragile geological formation, functions as a key ecological corridor linking the Terai plains with the mid-hills and supports diverse biodiversity, including pangolins. However, it has undergone rapid degradation due to both inherent fragility and growing human pressure (DNPWC, 2018; MoFE, 2019; ICIMOD, 2017). Deforestation, forest encroachment, and land conversion have accelerated habitat loss (MoFE, 2019; FAO, 2020), while recurrent human-induced forest fires further reduce vegetation cover and regeneration capacity (DoFSC & WWF, 2022; WWF, 2020). Combined with overgrazing and fuelwood extraction, these pressures intensify soil erosion and reduce ecosystem productivity (ICIMOD, 2017; MoFE, 2019).

Pangolins depend on stable soils for burrowing and adequate populations of ants and termites for feeding (Challender et al., 2019; IUCN, 2020). Habitat degradation disrupts these conditions by reducing soil stability, lowering prey availability, and fragmenting habitats, thereby limiting movement and increasing vulnerability (Heinrich et al., 2016; Challender et al., 2019). These combined effects significantly reduce habitat suitability and pose a serious threat to long-term conservation in the Churia landscape.

In response, the Government of Nepal developed the Pangolin Conservation Action Plan (2018–2022), emphasizing habitat management, law enforcement, and community engagement (DNPWC, 2018). However, implementation remains constrained by limited site-specific ecological evidence and insufficient integration of local knowledge into conservation planning (Challender et al., 2014; IUCN SSC PSG, 2020). This gap is particularly critical in the Churia landscape, where rapid environmental change and strong community dependence on forest resources demand context-specific, participatory approaches (MoFE, 2019; ICIMOD, 2019). Addressing these challenges requires a clearer understanding of habitat conditions, species ecology, and human–wildlife interactions (Heinrich et al., 2017; Nash et al., 2016).

This study addresses these gaps by integrating ecological assessment with community-based approaches to examine pangolin ecology, distribution patterns, and key threats in the Churia region. It also aims to strengthen local stewardship among Community Forest User Groups and Buffer Zone User Committees through participatory engagement and awareness. By linking ecological evidence with community knowledge, the study provides practical insights to inform future conservation planning, support evidence-based decision-making, and contribute to the long-term conservation of pangolins in this ecologically sensitive landscape (Danielsen et al., 2014; WWF, 2021; Sutherland et al., 2018; Newing et al., 2011).

## Materials and Methods

### *Study area*

The research was carried out across the Saptakoshi landscape, encompassing the Churia (Siwalik) range and adjoining Terai plains of Nepal. The study area extended from 26.8120° N, 87.2836° E in the east to 26.9833° N, 85.8333° E in the west, covering over 56 Community Forest User Groups (CFUGs) and Buffer Zone User Groups in Sunsari, Udaypur, Saptari, Siraha, Dhanusa, Mahottari, and Sarlahi districts (Fig 1). Altogether, the initiative spanned approximately 18,000 hectares and directly benefited more than 88,000 people from 15,000 households. This landscape is recognized as one of Nepal's most significant biodiversity zones, characterized by tropical *Shorea robusta* forests, grasslands, and riparian habitats along the Koshi River system (MoFE, 2021).

The Churia belt forms a critical ecological transition zone supporting a wide range of fauna, including pangolins (*Manis pentadactyla* and *M. crassicaudata*), sloth bears (*Melursus ursinus*), leopards (*Panthera pardus*), striped hyenas (*Hyaena hyaena*), and several reptiles and ungulates (DNPWC, 2018; IUCN, 2020). Forests managed under community forestry provide vital foraging and burrowing habitats for pangolins, while the protected core of Koshi Tappu Wildlife Reserve functions as a refuge and dispersal corridor (DNPWC, 2018; Sharma *et al*., 2020; Suwal *et al*., 2020).

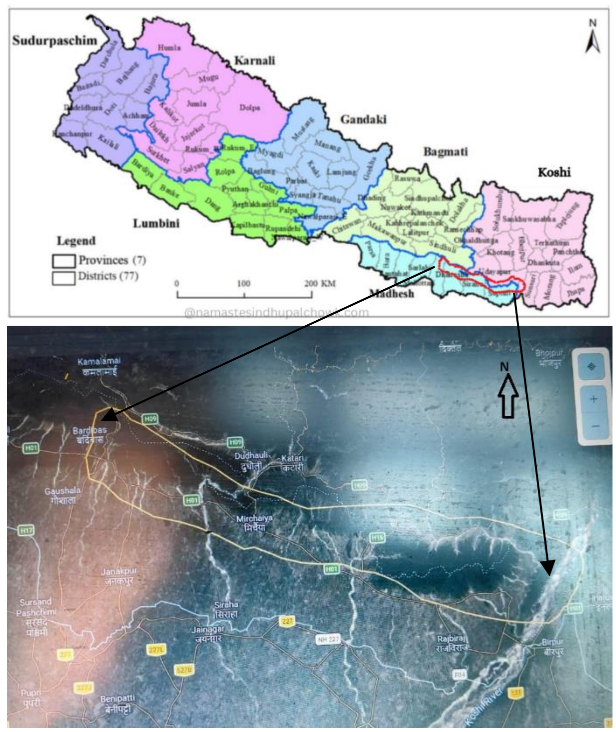


**Figure 1.** Study area of the Churia landscape in Nepal showing the distribution of surveyed Community Forest User Groups (CFUGs).

Participatory conservation in the Saptakoshi landscape emphasizes local stewardship of forests, integrating biodiversity protection with livelihood improvement. Active involvement of CFUGs and Buffer Zone User Groups (BZUGs) ensures community participation in habitat monitoring, anti-poaching measures, and ecosystem restoration

***Integrated Methods Paragraph***

A mixed-method approach was employed to assess pangolin ecology, habitat use, and associated threats in the Churia landscape by combining field-based observation with participatory techniques. Given the elusive and nocturnal nature of pangolins, species occurrence was inferred primarily through indirect indicators, particularly burrows and feeding signs, following established approaches for studying cryptic mammals under imperfect detection (MacKenzie et al., 2017; Kéry & Royle, 2016; Plumptre & Reynolds, 1996). Stratified random sampling was applied across forest patches, community forests, and adjacent agricultural lands, where sampling plots (100 m × 20 m) were georeferenced using handheld GPS and surveyed for burrows, feeding pits, scats, and tracks. Burrows were treated as ecologically meaningful indicators of habitat use, reflecting soil suitability, prey availability, and disturbance levels (Willcox et al., 2019; Tamang et al., 2022; Khadka et al., 2020; Heath & Coulson, 1997). To evaluate habitat associations, burrow abundance was compared across forest types using one way analysis of variance, while regression analysis was used to examine the relationship between pangolin presence and burrow density. These approaches are widely applied in ecological studies to test habitat differences and quantify species–environment relationships (Quinn & Keough, 2002; Guisan & Zimmermann, 2000). Prior to analysis, data exploration protocols were followed to ensure statistical robustness (Zuur et al., 2010). Field observations were complemented by Focus Group Discussions and Key Informant Interviews with Community Forest User Groups, Buffer Zone User Committees, and local stakeholders to document habitat knowledge, seasonal activity, and threat patterns. Participatory monitoring approaches have been shown to enhance detection and ecological understanding of rare species in data-limited contexts (Danielsen et al., 2014). Additional field visits were conducted to validate community reports and assess habitat conditions, while Forest Operational Plans were reviewed to examine the integration of pangolin-specific conservation measures.

## Results

***Habitat ecology***

The distribution and habitat ecology of the Indian pangolin (*Manis crassicaudata*) in the Koshi region are closely associated with the subtropical forest mosaics of the Churia foothills. Across 57 Community Forest User Groups, the mean burrow density was 1.02 with a standard deviation of 1.11 (Table 1). This pattern, with presence recorded in 49.1 percent of sites, indicates a fragmented distribution, which is commonly observed in the Siwalik range of Nepal. Habitat use appears selective rather than random and is influenced by local microclimatic conditions (Ghimire et al., 2020; Panta et al., 2023).

**Table 1.** Descriptive statistics of pangolin burrows

| Variable | Number of CFUGs (n) | Mean | SD | Min | Max |
|---|---|---|---|---|---|
| Number of Burrows | 57 | 1.02 | 1.11 | 0 | 4 |

The variation in burrow distribution suggests that *M. crassicaudata* tends to occupy specific habitat niches within community-managed forests, often associated with Shorea robusta dominated stands and riverine vegetation. Soil characteristics play a key role in this selection. The species shows a clear preference for red, well drained soils that support stable burrow structures and reduce the effort required for excavation (Mahmood et al., 2013; Acharya et al., 2021). Topography and vegetation cover further influence habitat suitability. Burrows were most frequently recorded on gentle slopes of about 15 to 20 degrees, with moderate canopy cover ranging from 51 percent to 75 percent. These conditions likely promote adequate drainage, reduce the risk of flooding, and maintain the humidity needed for sustaining ant and termite populations, which form the primary diet of pangolins (Sabin et al., 2024; Karawita et al., 2018).

Field identification of these individuals as *M. crassicaudata* is supported by their occurrence in the lower subtropical zone below 1000 meters and by morphological characteristics such as larger scale rows. This distinguishes them from the Chinese pangolin (*M. pentadactyla*), which is more commonly found at higher elevations and on steeper mid-hill slopes (Baral & Shah, 2008; Suwal et al., 2020). Accordingly, the analysis presented here primarily reflects Indian pangolin due to the dominance of lowland records.

Although the Churia landscape provides suitable ecological conditions, these habitats are increasingly affected by human activities. Livestock grazing and fuelwood collection are particularly influential, as they compact the soil and reduce leaf litter, thereby affecting both burrow construction and prey availability (Sharma et al., 2020; MoFE, 2021). As a result, the persistence of *M. crassicaudata* in the Koshi region depends largely on community-based conservation efforts that maintain and protect these critical microhabitats (Suwal et al., 2023).

***Burrow Abundance as a Predictor of Pangolin Presence***

The regression analysis shows a clear and statistically significant positive relationship between pangolin presence and burrow abundance ($\beta = 0.343$, $p < 0.001$), with the model explaining a large share of the variation ($R^2 = 0.713$) (Table 2). This level of explanatory power indicates a strong association between burrow density and species occurrence rather than a random pattern.

**Table 2.** Regression results

| Variable | Coefficient (β) | Std. Error | t-value | p-value |
|---|---|---|---|---|
| Intercept | 0.084 | 0.113 | 0.75 | 0.457 |
| Pangolin Number | 0.343 | 0.029 | 11.68 | <0.001 |

Ecologically, this relationship reflects the importance of burrows as both habitat features and indicators of behavior. Burrow construction is closely tied to feeding activity, shelter requirements, and microhabitat preferences, all of which depend on factors such as prey availability, soil conditions, and human disturbance. Areas with higher burrow densities are therefore likely to offer more suitable conditions for sustained occupancy.

The observed increase in burrow numbers alongside pangolin presence also points to repeated and active use of these habitats, not just occasional occurrence. This supports the use of burrow counts as a practical and dependable proxy for assessing habitat use, especially for a species that is difficult to detect directly. Overall, these findings highlight the value of burrow-based indicators in ecological monitoring and provide a sound basis for habitat assessment, conservation planning, and prioritizing management actions.

***Pangolin Habitat Preference Across Forest Types***

Field observations showed that pangolins were most frequently encountered in sal dominated forests, particularly in small gullies, along seasonal streams, and on ridges with dry, well drained soils. The animals were elusive, nocturnal, and non aggressive, and typically constructed burrows about 1 to 2 meters deep. Their diet consisted mainly of ants and termites, with occasional reports from local communities of feeding on tuberous plants.

To examine habitat association, a one-way ANOVA was conducted and showed a statistically significant difference in burrow abundance among forest types ($F = 3.87$, $p = 0.027$). Burrow density was highest in *Shorea robusta* forests (1.36 ± 1.21), followed by mixed forests (0.95 ± 1.02), and lowest in *Acacia catechu* forests (0.67 ± 0.82) (Table 3). This pattern indicates a clear and non random habitat preference, with forest composition playing an important role in shaping pangolin distribution.

**Table 3.** ***Comparison of pangolin burrow density across forest types and ANOVA results***

| Forest Type | n | Mean ± SD |
|---|---|---|
| *Shorea* Forest | 22 | 1.36 ± 1.21 |
| Mixed Forest | 20 | 0.95 ± 1.02 |
| *Acacia catechu* Forest | 15 | 0.67 ± 0.82 |

**ANOVA:** $F(2,54) = 3.87$, $p = 0.027$

Sal dominated forests appear to offer more suitable ecological conditions, including stable soils, better drainage, higher prey availability, and relatively lower levels of human disturbance. These factors together support burrow construction, efficient foraging, and continued habitat use. In contrast, mixed forests and *Acacia catechu* dominated areas provide less favourable conditions for both burrowing and feeding.

Taken together, the field observations and statistical results point to *Shorea robusta* forests as key habitats for pangolin conservation and emphasize the need to prioritize these areas in management and protection efforts.

### *Drivers of pangolin decline and illegal trade dynamics*

Pangolin populations in the Churia landscape show a clear and continuing decline over recent decades, based on both community reporting and field estimates. Local observations point to a steady reduction in sightings over time, with each decade showing a sharper drop than the one before (Fig. 2). This pattern suggests that pressures on the species are not only persistent but increasing. The estimated population of 149 individuals, with an average of about four per Community Forest User Group, indicates a low density and fragmented distribution. Such a structure makes the population more vulnerable to local disturbances and reduces its capacity to recover, increasing the risk of local extinction.

The decline is driven by four closely linked factors: subsistence hunting, habitat degradation, forest fire, and commercial poaching (Fig. 3). Subsistence hunting, accounting for 51 %, appears to be the most significant driver. This is largely associated with the use of pangolins for bushmeat and long standing beliefs in the medicinal and cultural value of their scales. Similar trends have been reported elsewhere in Nepal, where local use remains a persistent and socially rooted challenge (Suwal et al., 2020; Sharma et al., 2020; Suwal et al., 2023). Because of its embedded nature, this form of hunting is difficult to address through enforcement alone.

Habitat degradation, contributing 20% percent, acts as a widespread and ongoing pressure across the landscape. Factors such as rural road expansion, unmanaged grazing, invasive species, and soil compaction reduce habitat quality, disturb burrows, and limit prey availability, all of which are critical for pangolin survival (Khatiwada et al., 2022; Panta et al., 2023). This gradual deterioration lowers the carrying capacity of the habitat and increases exposure to other threats.

Forest fire, also accounting for 21%, represents an intermittent but highly damaging disturbance. Repeated fires destroy burrows and feeding areas and can directly cause mortality. However, the absence of systematic fire records means that its exact contribution is difficult to quantify, and these estimates should be interpreted with some caution, consistent with findings from similar settings (Shrestha et al., 2023; Suwal et al., 2020).

Commercial poaching, although reported at 8 percent, poses a serious risk due to its link with organized illegal trade.

Pangolins are targeted for international markets, with trafficking routes connecting Nepal to China and Southeast Asia through urban centers such as Kathmandu, Biratnagar, and Nepalgunj (DNPWC and WWF, 2022). Even low levels of extraction can have severe impacts on already small and fragmented populations.

These drivers do not act in isolation. Habitat degradation and forest fire reduce habitat quality and prey availability, which in turn makes pangolins more susceptible to hunting. At the same time, fragmented populations are more exposed to localized poaching. The combined effect of these pressures accelerates population decline and increases extinction risk.

Overall, the consistent decline in sightings (Fig. 2) together with the identified drivers (Fig. 3) presents a clear picture of a rapidly declining population in the Churia landscape. The findings point to the need for integrated conservation approaches that address local use, restore habitats, and control illegal trade, while also improving monitoring systems to better understand disturbances such as forest fire.

***Conservation Practices***

Conservation practices in the study area are largely driven by community engagement, with a strong focus on local stewardship, habitat protection, and livelihood support. Community Forest User Groups and local volunteers play a key role in forest patrolling, discouraging illegal hunting, and reducing trapping through organized watch systems and informal community-based protection. These locally led efforts reflect the broader success of community forestry in Nepal, where collective action and shared responsibility have helped limit forest degradation and wildlife exploitation (Suwal et al., 2020; Shrestha et al., 2023).

Awareness and education programs in schools and villages have contributed to gradual changes in local attitudes toward pangolins. There are indications of reduced consumption linked to traditional beliefs, along with a growing willingness among community members to report illegal activities. This shift suggests that behavior change efforts are beginning to show positive results. Similar observations have been reported by the Department of National Parks and Wildlife Conservation and the National Trust for Nature Conservation (2022), which highlight the importance of education and incentives in lowering poaching pressure.

At the institutional level, however, the inclusion of pangolin-focused measures in Forest Operational Plans remains limited. While some Community Forest User Groups have introduced actions such as no hunting areas, seasonal access control, and protection of known burrow sites, a review of 56 plans showed that only two explicitly mentioned pangolin conservation. This points to a gap between what is practiced on the ground and what is formally documented in management plans, indicating that species specific conservation is still not fully integrated into community forestry systems.

Habitat management activities such as fire control, controlled burning, and soil conservation are being implemented to reduce degradation and protect critical areas, especially during the dry season. Although these measures are not always designed specifically for pangolins, they contribute to improving habitat conditions and support species persistence. This reflects a broader pattern in Nepal, where ecosystem based management often provides indirect benefits for wildlife.

Community based monitoring further strengthens conservation efforts. Local reporting systems, designated focal persons, and informal communication networks allow for quick responses to pangolin sightings and illegal activities. Collaboration with Division Forest Offices, nongovernmental organizations, and wildlife rescue centers supports timely rescue and rehabilitation when needed. These linkages across community and institutional levels help improve overall conservation effectiveness.

Overall, conservation efforts in the study area are most effective where community participation, awareness, and institutional support come together. At the same time, the limited inclusion of pangolin specific strategies in Forest Operational Plans highlights the need for stronger integration into formal management frameworks. Strengthening this connection, while continuing to support community action, awareness, and livelihood options, will be essential for the long-term conservation of pangolins.

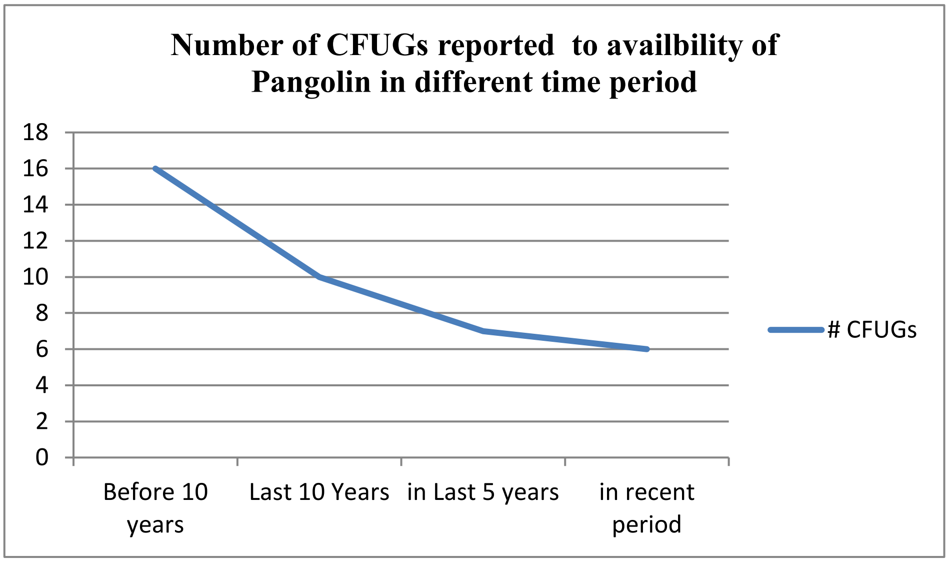


**Figure 2.** Temporal trend in pangolin sightings based on community responses across different time periods in the Churia landscape, indicating a progressive decline in occurrence

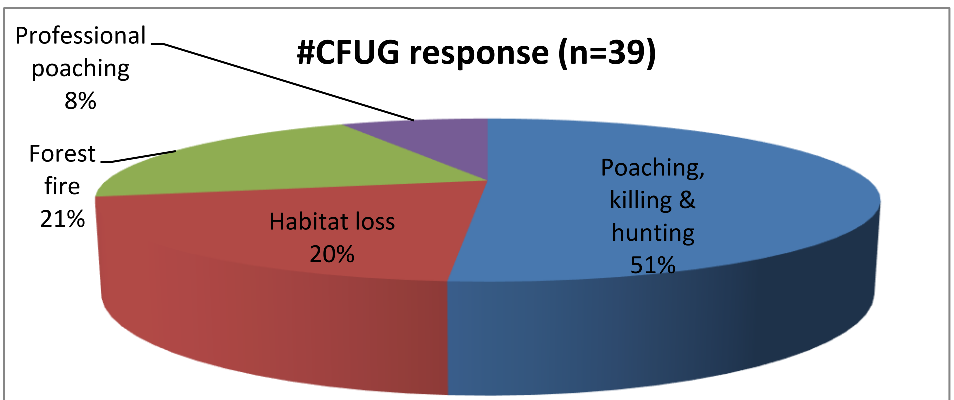


**Figure 3.** Perceived causes of pangolin population decline in the Churia landscape of Nepal, showing the relative contribution of subsistence hunting, habitat degradation, forest fire, and commercial poaching.

## Conclusion

Pangolin conservation in Nepal is influenced by a complex mix of social, ecological, and institutional factors. Community Forest User Groups are increasingly involved, and there are early efforts to include conservation actions in Forest Operational Plans. However, several challenges continue to limit progress. Cultural beliefs that support local use remain widespread, while species specific measures are still rarely included in formal plans. Monitoring systems are often weak, and illegal trade persists as a serious threat. The species' elusive and nocturnal nature makes reliable data collection difficult, and ongoing habitat degradation and forest fires further increase vulnerability. Although community based conservation provides a strong base, its impact remains limited without better integration of scientific methods, targeted planning, and effective enforcement.

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## Ethical Approval and Consent to Participate

This study adhered to recognized ethical standards in community-based research. All discussions and data collections were conducted in accordance with the principles of Free, Prior, and Informed Consent (FPIC**)**, ensuring voluntary participation, respect for confidentiality, and the protection of traditional knowledge. The research process fully respected local norms, community rights, and cultural values associated with biodiversity and natural resource management.

## Author Contributions and Funding

The author independently conceptualized, designed, and implemented the study; performed data collection and analysis; and prepared the manuscript. The research was funded by a small grant from the Crowder Mssrsmith Fund.

## Conflict of Interest

The author declares **no conflict of interest** related to this research.

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