Report on

Socio-Economic Impacts and Control Mechanisms of Problematic Wildlife Species in Mid-hill Regions of Nepal

(Monkey, Wild boar, and Porcupine)

2026

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CHAIR'S MESSAGE

It is our pleasure to present this report on **"Socio-Economic Impacts and Control Mechanisms of Problematic Wildlife Species in Mid-hill Regions of Nepal (Monkey, Wild boar and Porcupine)"**. This study comes at a critical time when human-wildlife conflict is at increasing level across Nepal, particularly in the mid-hill regions where agriculture-based livelihoods are increasingly under pressure.

The findings of this report clearly demonstrate the scale and complexity of the challenges posed by problematic wildlife species. Crop depredation by macaques, wild boars, and porcupines has not only caused substantial economic losses but has also contributed to social stress and declining motivation towards wildlife conservation among farming communities. These emerging patterns highlight the urgent need for evidence-based, context-specific, and socially acceptable management strategies

This study provides valuable baseline data, integrates local knowledge, and evaluates existing mitigation measures. Such efforts are essential for informing policy and strengthening responses to human-wildlife conflict. The report emphasizes necessity of combination of habitat management, community engagement, improved compensation systems, and strategic population management for long-term coexistence. Strengthened coordination among government bodies, researchers, and communities is equally important.

As Nepal advances its conservation and development goals, addressing human-wildlife conflict remains vital for protecting both biodiversity and rural livelihoods. The National Trust for Nature Conservation (NTNC) remains committed to supporting practical, ethical, and sustainable solutions that promote harmony between people and nature.

I would like to extend my sincere appreciation to the research team, collaborating institutions, local governments, and communities who contributed to this important work. On behalf of NTNC, I express my gratitude to all partners and stakeholders for their continued support. Together, we must continue to work towards sustainable and resilient solutions that ensure harmony between people and nature in Nepal.

Honorable Minister Gita Chaudhary
Ministry of Agriculture, Forests and Environment
Chairperson of the National Trust for Nature Conservation

Acknowledgements

National Trust for Nature Conservation (NTNC) extends its sincere appreciation to the individuals and institutions whose contributions were vital to the completion of this report. We are grateful to the Central Department of Zoology, Tribhuvan University, specifically Principal Investigator Prof. Dr. Hari Prasad Sharma and Co-Investigator Dr. Bishnu Prasad Bhattarai, for their dedicated research and technical expertise. Similarly, acknowledgment goes to Head of Central Departement of Zoology, Prof. Dr. Kumar Sapkota, for his leadership in this study. We also thank the Department of National Parks and Wildlife Conservation (DNPWC) and the Department of Forest and Soil Conservation (DoFSC) for providing the necessary regulatory permissions and cooperation throughout the study.

Our gratitude is further extended to the parliamentary and governmental leaders who provided oversight and guidance, including then Honorable Kushum Devi Thapa, President of the Agriculture, Cooperative and Natural Resources Parliamentary Committee, and then Honorable Juddha Bahadur Gurung, President of the National Natural Resource and Finance Commission. We acknowledge the valuable technical reviews provided by all experts and the insights shared by participants during our national workshops.

Finally, NTNC recognizes the essential role played by local governments, including the Mayors, Deputy-Mayors, and Ward members of the forty-four participating municipalities and rural municipalities. We are especially thankful to the local community members and farmers who shared their experiences through questionnaire surveys, as well as the research assistants who conducted the rigorous fieldwork. We are thankful to Ms. Rachana Shah, Head of the Species, Research and Academic Wing, and Ms. Astha Joshi, Research Officer, for their coordination and leadership throughout the process. Similarly, we would like to thank Dr. Madhu Chetri, Program Manager, Mr. Ashok Subedi, Senior Conservation Officer, Mr. Bishnu Singh Thakuri, Senior Conservation Officer, and Mr. Gobinda Prasad Pokharel, Conservation Officer for reviewing the report and providing valuable support from NTNC. This collaborative effort has provided the baseline data and evidence-based strategies necessary to address human-wildlife conflict and support the livelihoods of those living in the conflict prone regions of Nepal.

Chiranjibi Prasad Pokheral, PhD
Member Secretary

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Executive Summary

Human-wildlife conflict (HWC) is a growing issue in Nepal, particularly in rural and semi-urban areas, where species such as rhesus macaques (*Macaca mulatta*), wild boars (*Sus scrofa*) porcupines (Himalayan crestless porcupine: *Hystrix brachyura*; Indian crested porcupine: *H. indica*) are frequent and cause significant damage to crop and makes troubled to local livelihoods. The study focused on estimating the population of rhesus macaques, identifying the presence of porcupines and wild boars and analyzing the economic impact of crop damage caused by these animals. Data were collected through literature review, field visits, stakeholder consultations, and questionnaire surveys. Conflict hotspot maps were created using Geographic Information Systems (GIS) to visualize the areas most affected by wildlife-related crop damage. Additionally, the study also evaluated the effectiveness of existing mitigation practices and propose site-specific solutions. The study recorded rhesus macaque populations across 44 Local level bodies (Municipality = 18) and Rural Municipality = 26) in mid-hill regions of Nepal, with an estimated 20,395 individuals observed directly and a projected a minimum of 104,137 individuals in the wider mid-hill region. In a troop, the number of rhesus macaque were upto 198 individuals. Average troop size was 42.66 individuals with troop density of 0.119/km², with higher aggregation near agricultural land, settlements, and roads, demonstrating the strong influence of food availability and proximity to cropland.

Wild boar and porcupine were also widely distributed, with suitable habitats covering 69,353 km² and 64,081 km², respectively, across Nepal's mid-hills and lowlands. Their occurrence was strongly associated with lower elevations, rivers, and forest proximity. Both species were reported as major crop pests, with hunting suggested as sport hunting, as found in other countries.

The household survey (n = 1,846) revealed demographic patterns consistent with Nepal's census data 2021 but showed limited available manpower for working in the agricultural field or guarding crop fields. Nearly all respondents (98%) mentioned monkeys as the most problematic animal, followed by porcupines (67%) and wild boars (31%). Key informants emphasized these concerns, also reporting barking deer (*Muntiacus vaginalis*) as secondary crop raiders and leopards (*Panthera pardus*) as major livestock depredators. Conflict was most severe in Bagmati, Gandaki and Sudurpashchim Provinces, with co-occurrence of multiple pest species especially high in Sudurpashchim.

Crop loss was extensively high in most parts of the study area, and the economy loss per year was around NPR 5 crore among 1,846 household from rhesus macaque. Corn was the most widely cultivated crop and the most heavily raided, with an average household loss of 312 kg/year (50.3% of production) and an economic loss of NPR 2.5 crore across the respondents. Rice, wheat, millet, potato, mustard, orange, and cardamom were also significantly affected, with loss proportions ranging from 18–52%. Province-wise, the highest relative losses were reported for corn in Gandaki (90%) and Karnali (88%), rice in Sudurpashchim (85%), and wheat in Sudurpashchim (90%), respectively.

Overall, the study identified that rhesus macaques, wild boars, and porcupines are the major drivers of conflict in Nepal's mid-hill regions, with monkeys alone affecting nearly all households. The study suggests the urgent need for rhesus macaque population management through integrated management strategies, including habitat management, crop protection measures, government support programs, and community involvement to mitigate the growing human–wildlife conflict.

It further suggests the need for regulated, science-based population management of wild boar and porcupine, including targeted control in high-conflict areas, strengthened farm and habitat interface management, improved crop protection, and community-based mitigation along with effective compensation mechanisms to reduce agricultural losses and sustain rural livelihoods.

Majority of respondents (68%) and key informants (60%) suggested killing monkeys as the most effective strategy, while a significant minority stressed their ecological and religious importance, recommending alternative measures. Farmers currently use deterrents such as shouting, stone-throwing, guarding, and dogs, but these methods remain largely ineffective. Awareness of compensation schemes is low, and relief mechanisms are underutilized due to poor communication and bureaucratic hurdles.

Despite clear legal restrictions under the National Parks and Wildlife Conservation Act, 1973, harmful practices including illegal electrocution, drowning in poorly or deliberately designed lethal ponds, and unauthorized trapping and relocation are widespread. These actions not only violate the law but also threaten human lives, cause unnecessary animal suffering, and fail to reduce long-term conflict.

International experiences highlight both potential and limitations of management options. Sterilization and contraception can work if coverage is high, funding is sustained, and complementary measures are enforced, as seen in Hong Kong. However, isolated or underfunded efforts, like those in India and Thailand, have proven costly and largely ineffective. Culling has been practiced in India, Japan, and Gibraltar, but it remains controversial, requiring strict legal frameworks, humane methods, and public acceptance.

Alternative management options for Nepal include forest management to improve natural food availability in the forest and create buffer zones, though these risks increasing monkey populations. Compensation schemes, which can reduce farmer resentment but face challenges of cost, fairness, and sustainability. Sterilization, which is resource-intensive and logistically difficult in Nepal's context but could be piloted in high-conflict zones. Use in biomedical research, which could generate revenue under ethical and legal frameworks might be another option for monkey management. Culling, as a last resort, when non-lethal options fail and damage is demonstrably severe, implemented transparently and scientifically.

Overall, the evidence shows that no single approach is sufficient. Nepal requires an integrated management strategy combining habitat management, community education, deterrence, selective sterilization, strengthened compensation, and, where unavoidable, tightly regulated lethal control. Without such a multi-pronged framework, reliance on harmful or illegal practices is likely to persist, with negative consequences for both people and wildlife.

1.BACKGROUND

Nepal, situated in the central part of the greater Himalayan range, is a remarkable example of the earth's rich biological diversity. Its topographical diversity, ranging from the subtropical forests of the Tarai to the snow-clad heights of the Himalayas, gives shelter to a globally outstanding biodiversity hotspot, harbors a wealth of flora and fauna, including some of the world's most charismatic and endangered species, including red panda (*Ailurus fulgens*), snow leopard (*Panthera uncia*), and tiger (*P. tigris*) (Jnawali et al. 2011). This ecological richness, however, has given rise to a complex web of interactions between humans and wildlife, leading to Human-Wildlife Conflicts (HWCs) (Acharya et al. 2016). HWCs encompass a spectrum of encounters, from the subtle but persistent damage wrought by herbivores on crops to the more dramatic and potentially dangerous interactions between humans and carnivores (Goodrich 2011; Pandey et al. 2016). Nepal is home to four species of non-human primates: rhesus macaque (*Macaca mulatta*), Assam macaque (*M. assamensis),* Tarai gray langur (*Semnopithecus hector*), and Nepal gray langur (*S. schistaceus*) (Jnawali et al. 2011; IUCN 2026). Rhesus macaque is one of the most-conflict creating primates in Nepal (Koirala et al. 2022). In addition, the country has two species of porcupines: Himalayan crestless porcupine (*Hystrix brachyura*) and Indian crested porcupine (*H. indica*) (Jnawali et al. 2011; IUCN 2026). In this report, both species are collectively considered as porcupine. The HWC is rapidly increasing both inside and outside the protected

Photo: Rhesus macaque (upper left), Nepal gray langur (upper right), Assam macaque (lower left), Tarai gray langur (lower right) areas, probably due to increased number of these mammals, such as rhesus macaques, wild boars, and porcupines, habitat shrinkage due to land use and land cover change, change in vegetation dynamics and lack of corridors (Acharya et al. 2016; Koirala et al. 2022).

Monkeys, porcupines, and wild boars frequently raid crops, and effects on livelihoods of local people, leading to economic losses (Pandey et al. 2016; Regmi et al. 2013). In Nepal, the problem is particularly severe in rural and semi-urban areas, where monkeys' incursions into agricultural fields lead to substantial crop loss, estimated to affect nearly half of the agricultural households in some regions. In Nepal, many people depend on subsistence farming, and in areas that are badly affected, farmers can lose up to 20–30% of their crops each year (Pandey et al. 2016; Baral et al. 2021). This not only threatens food security but also places financial strain on already vulnerable communities, highlighting the need for effective management strategies to mitigate these losses.

Distribution mapping of mammal species plays a pivotal role in mitigating HWC by providing crucial spatial information for effective conflict management strategies (Snijders et al. 2019; Pant et al. 2023; KC et al. 2023). By delineating the habitats and movement patterns of conflict causing mammals, conservationists and policymakers can identify areas of potential overlap with human settlements and agricultural lands (Pressey et al. 2003). This knowledge empowers them to implement targeted measures such as habitat restoration, monitoring species movement, managing buffer zones, and early warning systems (Nagendra et al. 2004). Human-monkey conflict has emerged as a significant issue in many regions, leading to loss of crops, property damage, and sometimes injuries. This conflict affects the local communities and poses challenges to both human and wildlife welfare. The growing urbanization, habitat loss, and food scarcity for monkeys in the wild have intensified these encounters. However, detailed information at site specific areas on these problematic animals is little known, and it creates difficulties for developing mitigation policy.

2. OBJECTIVES

The main objective of the study was to assess the economy loss and implement sustainable strategies to mitigate human-monkey-porcupine-wild boar conflicts, ensuring the safety and well-being of both humans and wildlife. The specific objectives are:

I. To identify the population of monkeys mainly rhesus macaque.

II. To identify the presence locations of wild boar and porcupine.

III. To assess the economic loss from rhesus macaque.

IV. To understand the distribution of rhesus macaque, wild boar and porcupine, and develop hotspot maps with regards to economic loss.

V. To recommend mitigation measures for problematic rhesus macaque.

3. METHODS

3.1 Approach and Intervention

Detailed information on problematic wildlife species, rhesus macaques, porcupine, and wild boar, and the extent of crop damage they cause in mid-hill regions of Nepal was collected through a combination of comprehensive literature review, stakeholder consultations, and field investigations.

Approach I: Desk Review

A systematic desk review was conducted to synthesize existing knowledge on the distribution, behavior, and management of rhesus macaques, porcupines, and wild boars. This approach involved an iterative and comprehensive assessment of diverse information sources. The research team, including research assistants, carried out an extensive review of available literature, including:

- Reports from governmental and non-governmental organizations (national and international)
- Peer-reviewed journal articles
- Graduate and undergraduate theses
- Community Forest User Group (CFUG) documents
- Records from Division Forest Offices and protected area authorities

Additionally, insights were gathered from stakeholder engagement, including consultations with Division Forest Offices, park authorities, and CFUGs. These interactions helped document ongoing management practices, mitigation measures, and local experiences related to human–wildlife conflict.

Approach II: Consultation Meetings

Initial assessments of species presence and conflict severity were conducted through communication with local government representatives, including Mayors, Deputy Mayors, and Ward Chairpersons across all 753 local administrative units in Nepal via email and WhatsApp. Out of these, 493 local units (339 rural municipalities and 146 municipalities, including sub-metropolitan and metropolitan cities) are

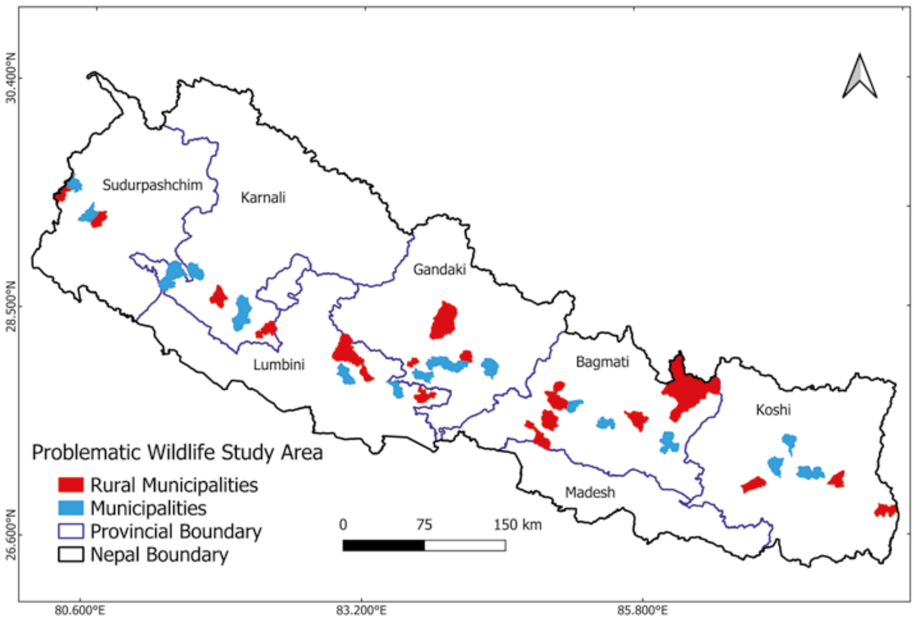

Figure 1 The Rural Municipalities and Municipalities in the mid-hill regions of Nepal selected for human-rhesus macaque, wild boar and porcupine conflict.

located in the mid-hill region. Responses were received from 188 units (62 municipalities and 123 rural municipalities), reporting issues with problematic wildlife.

Based on these responses, supplemented by recommendations from Members of Parliament and wildlife experts, 44 highly affected local units (18 municipalities and 26 rural municipalities) were selected for detailed study. The sample size exceeded the minimum requirement of 40 units, calculated at a 95% confidence level and 15% margin of error. The selection was further validated through consultations with the Agriculture, Cooperative, and Natural Resource Parliamentary Committee and expert input during an inception workshop.

Prior to field data collection, consultation meetings were conducted in each selected municipality with local leaders, key informants and affected community members. These meetings helped identify specific hotspots of wildlife conflict.

Approach III: Field Visits

Field surveys were conducted between April and July 2025 in the selected municipalities to confirm species presence. collect spatial data using GPS and document crop damage and human casualties. Data collection involved snowball sampling, where local residents provided information on wildlife encounters, crop losses, and incidents.

3.2 Activities Conducted

Objective	Description of Activities
Objective I	Forty-four municipalities were selected, followed by consultation with local authorities to verify wildlife presence. Community members near forest–agriculture interfaces were engaged through mobile communication and local leadership networks to report monkey sightings. Field teams (1–3 researchers per ward) conducted synchronized counts of rhesus macaques between 06:00 and 07:00 hrs. Individuals were classified into adult males, adult females, juveniles, and infants based on physical characteristics. In dense forest areas, where it is difficult to distinguish between adult males and females, individuals were categorized simply as adults. Additional data on habitat type, fruit tree presence, and land use/land cover (LULC) were recorded.
Objective II	The presence of wild boar and porcupine Himalayan crestless porcupine and Indian crested porcupine was documented using field-based sign surveys, camera trap records, and secondary datasets, including GBIF. Indirect evidence such as footprints, feces, scratches, and crop damage was recorded. A total of 1,400 wild boar and 1,609 porcupine occurrence records were recorded. Nineteen bioclimatic variables from WorldClim (30 arc-second resolution) were used for modelling, and relevant predictors were selected using correlation analysis and Jackknife testing. Species distribution models were developed using Maxent. Model performance was evaluated using AUC, and habitat suitability was classified into low (0.00–0.50) and high (0.50–1.00) categories. Spatial analyses were conducted in QGIS.
Objective III	Economic losses over the past five years were compiled from government reports, NGO publications, and academic literature. Primary data were collected through a semi-structured questionnaire survey involving 1,846 respondents from affected municipalities during Chaitra 2081–Ashad 2082. The demographic information, agricultural practices, and experiences of wildlife-induced crop damage were recorded during the survey. Crop losses were monetized using prevailing market prices for 2024–2025 to ensure standardized economic assessment.
Objective IV	Human–wildlife conflict hotspot maps were developed using GIS-based methods by integrating spatial data on rhesus macaque population density, troop size, and economic losses. These variables were analyzed to identify high-intensity conflict areas and spatial patterns, supporting the prioritization of vulnerable regions and targeted mitigation planning.
Objective V	Existing mitigation practices were evaluated through household surveys and Key Informant Interviews (KII), documenting current strategies, perceived effectiveness, and recommendations. Landscape analysis was conducted using Sentinel-2 (10 m resolution) LULC data processed in R. Key metrics, including adjacency index (AI), edge density (ED), and forest cover percentage, were calculated at the ward level to assess landscape fragmentation and human–wildlife interface intensity.

Photo: Questionnaire surver with farmers

3.3 Data Analysis

The collected data were summarized using descriptive statistics, including frequencies and percentages. The population density of rhesus macaques was calculated per square kilometer using the formula

$$\text{Population density of rhesus macaque} = \frac{\text{Total population}}{\text{Study area}}$$

$$\text{Troop density} = \frac{\text{Number of troops}}{\text{Study area}}$$

The economic impact of crop damage caused by problematic wildlife species was quantified by estimating the monetary value of losses based on the annual market prices of each crop for the most recent year at site-specific locations. Forest area coverage within the study area was quantified by applying a threshold of 100 m² at each sampling location. Additionally, forest cover within the affected local administrative units was estimated at the ward level to capture spatial variation across administrative boundaries.

Forest area coverage within the study area was quantified by applying a threshold of 100 m² at each sampling location. Additionally, forest cover within the affected local administrative units was estimated at the ward level to capture spatial variation across administrative boundaries.
To identify the factors influencing crop loss, a Generalized Linear Model (GLM) was applied. The GLM was used to examine the key determinants of crop damage caused by rhesus macaques and to assess factors affecting monkey abundance in the mid-hill regions of Nepal. Additionally, GLM was used to identify the factors affecting on the occurrence of wild boar and porcupine. Highly correlated variables ($r = 0.7$) were excluded to avoid the over prediction in the analysis. All statistical analyses were conducted using the R Program.

4. RESULTS AND DISCUSSION

4.1 Population Status of Rhesus Macaque

Rhesus macaques were recorded across all study areas (Figure 1). In addition, 585 langurs (min = 1, max = 95) and 514 Assam macaques (min = 5, max = 80) were observed. A total of 20,395 rhesus macaques were documented, comprising 14,626 adults, 3,706 juveniles, and 2,063 infants.

The mean troop size was 42.66 ± 1.87 (SE) individuals (range: 5-198). A total of 478 troops were recorded within 4,023 km², resulting in a troop density of 0.119/km² and a population density of 5.07 individuals/km². The male-to-female ratio was 17:25 (68 males per 100 females). The forest area in the affected mid-hill regions is 16,517.57 km², and that area might have >104,137 individuals of rhesus macaques.

Compared to India (Seth & Seth 1986), and Bangladesh (Hasan et al. 2013), troop sizes in Nepal are slightly higher. Reported troop sizes are also higher than earlier studies from other countries, likely due to the availability of food in both natural and semi-urban habitats in Nepal's mid-hill regions.

In Bagmati Province, females constituted the largest proportion (38%), followed by juveniles (27%), males (24%), and infants (21%). In Gandaki, females (32%) and juveniles (30%) dominated. In Koshi, Karnali, and Lumbini provinces, juveniles were the most abundant group (52%, 33%, and 27%, respectively) (Figure 2).

Majority of rhesus macaques (84%, n = 17,079) were recorded in forest areas, while 16% (n = 3,316) were found near agricultural lands and forest edges (Figure 3).

Agricultural land was the most significant factor influencing troop size (β = -2.7006; p = 0.016), with larger troops occurring near croplands. Proximity to roads and human provisioning also contributed to the increased troop sizes. Although macaques were also observed near water sources and settlements, these factors were not statistically significant (Table 1).

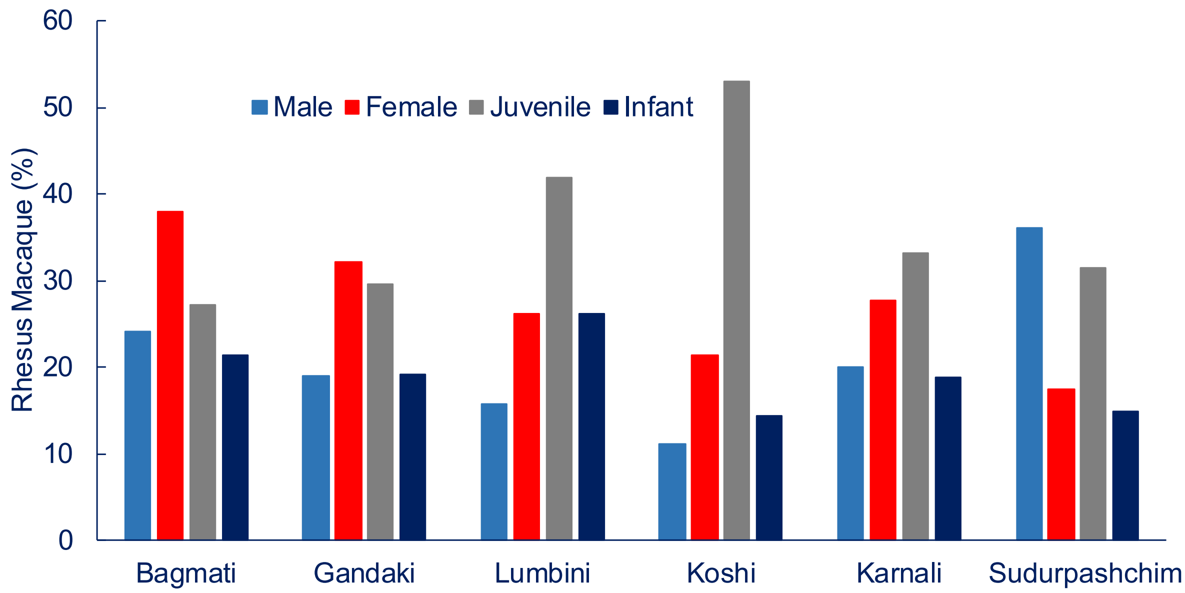

Figure 2 Percentage occurrence of rhesus macaque in six provinces in the mid-hill regions of Nepal in 2025.

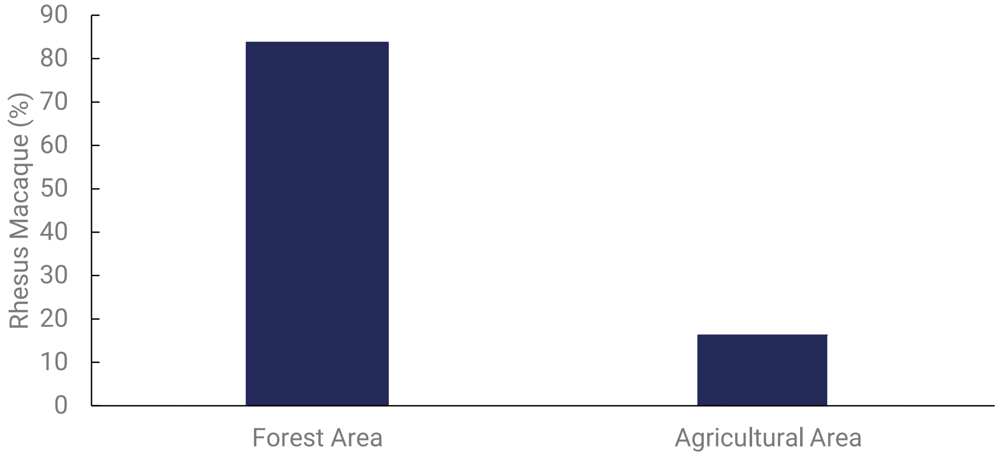

Figure 3 Rhesus macaques sighted habitats during study period.

Table 1 Results of the Generalized Linear Model (GLM) examining factors influencing the population of rhesus macaques. The response variable was the number of individuals recorded, while explanatory variables included habitat type (forest or agricultural land), distance to nearest water source (m), nearest distance to forest (m), farmland (m), settlement (m), and road (m), as well as the presence or absence of fruiting trees within monkey-inhabited areas. Model outputs are presented as estimated coefficients with corresponding standard errors (SE), lower confidence intervals (LCI), and upper confidence intervals (UCI).

Variables	**Estimates**	**SE**	**LCI**	**UCI**	**Z**	**p**
(Intercept)	3.6307	0.1140	3.4092	3.8640	31.852	**<0.001**
Agricultural land	-2.7006	1.1197	-4.7357	0.1132	-2.412	**0.016**
Forest	0.0689	0.1166	-0.1690	0.2973	0.591	0.555
Nearest distance to river	0.0521	0.0493	-0.0433	0.1557	1.056	0.291
Nearest distance to settlement	0.0725	0.0447	-0.0111	0.1599	1.624	0.105
Nearest distance to road	-0.0388	0.0469	-0.1275	0.0545	-0.827	0.408
Nearest distance to forest	-0.0303	0.0532	-0.1335	0.0768	-0.570	0.569
Nearest distance to farmland	-0.0330	0.0563	-0.1414	0.0776	-0.587	0.557
Fruit tree presence	0.1551	0.0955	-0.0296	0.3417	1.625	0.104

Higher aggregation of macaques near agricultural areas is likely driven by the availability of high-energy and predictable food resources. Forest-agriculture interfaces allow macaques to exploit both natural and cultivated food sources, leading to increased troop size and density.

4.2 Presence Locations of Wild boar and Porcupine

Distribution of Wild Boar

The model showed good predictive performance (AUC = 0.78). Suitable habitat for wild boar was identified across all mid-hill and lowland regions of Nepal, covering approximately 69,353.27 km² (Figure 4). Wild boar occurrence was increased at proximity to water bodies and forests (positive relationship) and negatively by elevation(Table 2). Other variables showed no significant effects.

The wide distribution of wild boar contributes to increasing crop damage, as reported in previous studies (Pandey et al. 2016; Magar et al. 2024). Management interventions, including controlled hunting, may be necessary to regulate populations, as practiced in countries such as India (The Hindu 2025) and Hong Kong (China Daily 2025).

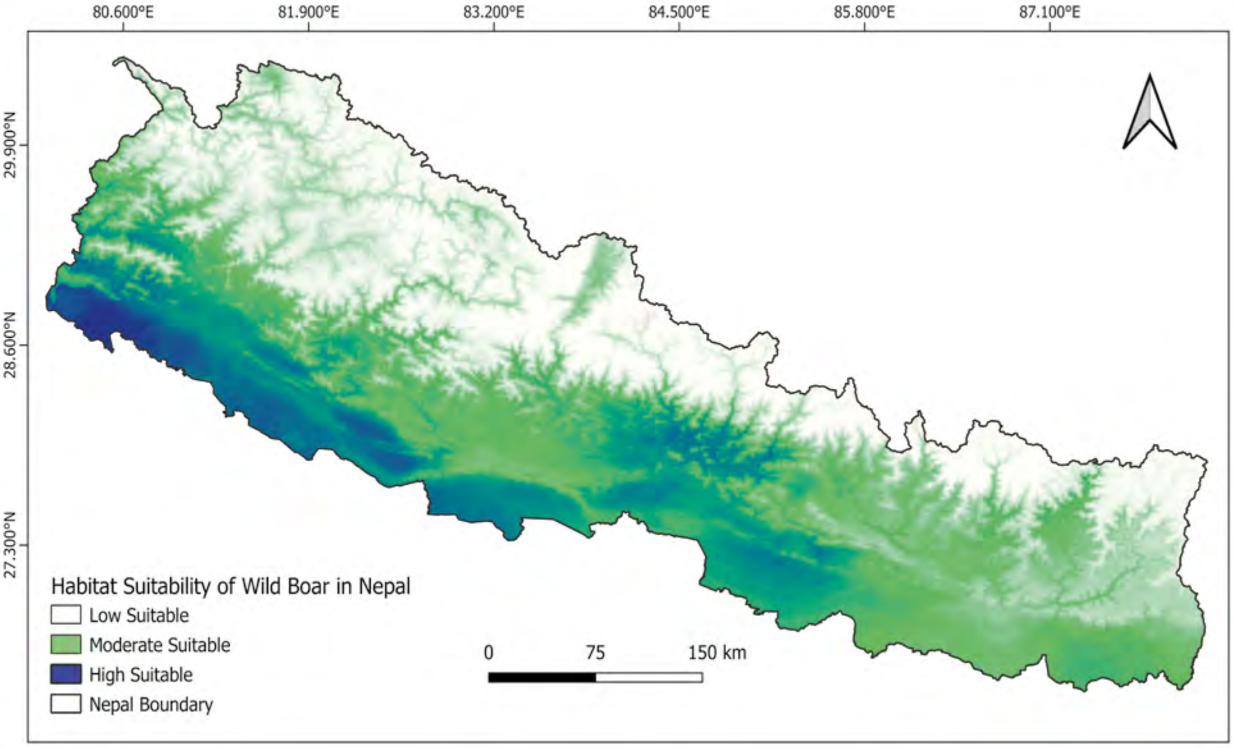

Figure 4 Potential distribution of suitable habitats of Wild boar in Nepal

Table 2 Results of the Generalized Linear Model (GLM) assessing factors influencing the occurrence of wild boar. The response variable was the occurrence of wild boar, while explanatory variables included distance to the nearest water source (m), forest (m), agricultural land (m), settlement (m), and road (m), as well as elevation (m) and slope (°). Model outputs are presented as estimated coefficients with corresponding standard errors (SE), lower confidence intervals (LCI), and upper confidence intervals (UCI).

Variables	**Estimate**	**SE**	**LCI**	**UCI**	**Z**	**P**
(Intercept)	185.0025	185.2041	-9.7839	556.5885	0.999	0.318
Nearest distance to river	0.1643	0.0426	0.0811	0.2484	3.853	**<0.001**
Nearest distance to settlement	-0.0517	0.0575	-0.1651	0.0607	-0.899	0.369
Nearest distance to road	0.0142	0.0524	-0.0892	0.1171	0.271	0.787
Elevation	-0.1425	0.0502	-0.2418	-0.0448	-2.839	**0.005**
Slope	-2.0586	2.0580	-6.1878	0.1060	-1.000	0.317
Nearest distance to forest	0.1138	0.0483	0.0194	0.2090	2.355	**0.019**
Nearest distance to agricultural land	0.0828	0.0523	-0.0195	0.1855	1.585	0.113

Distribution of Porcupine

The model also performed well for porcupine (AUC = 0.77). Suitable habitat was predicted across mid-hill regions of Nepal, covering approximately 64,080.95 km² (Figure 5). Similar to wild boar, porcupine occurrence was positively associated with proximity to rivers and forests and negatively with elevation (Table 3).

The widespread distribution of porcupine has implications for agricultural damage (Jnawali et al. 2011; Pandey et al. 2016; Baral et al. 2022). Effective management strategies, such as controlled hunting or classification as an agricultural pest, may be required.

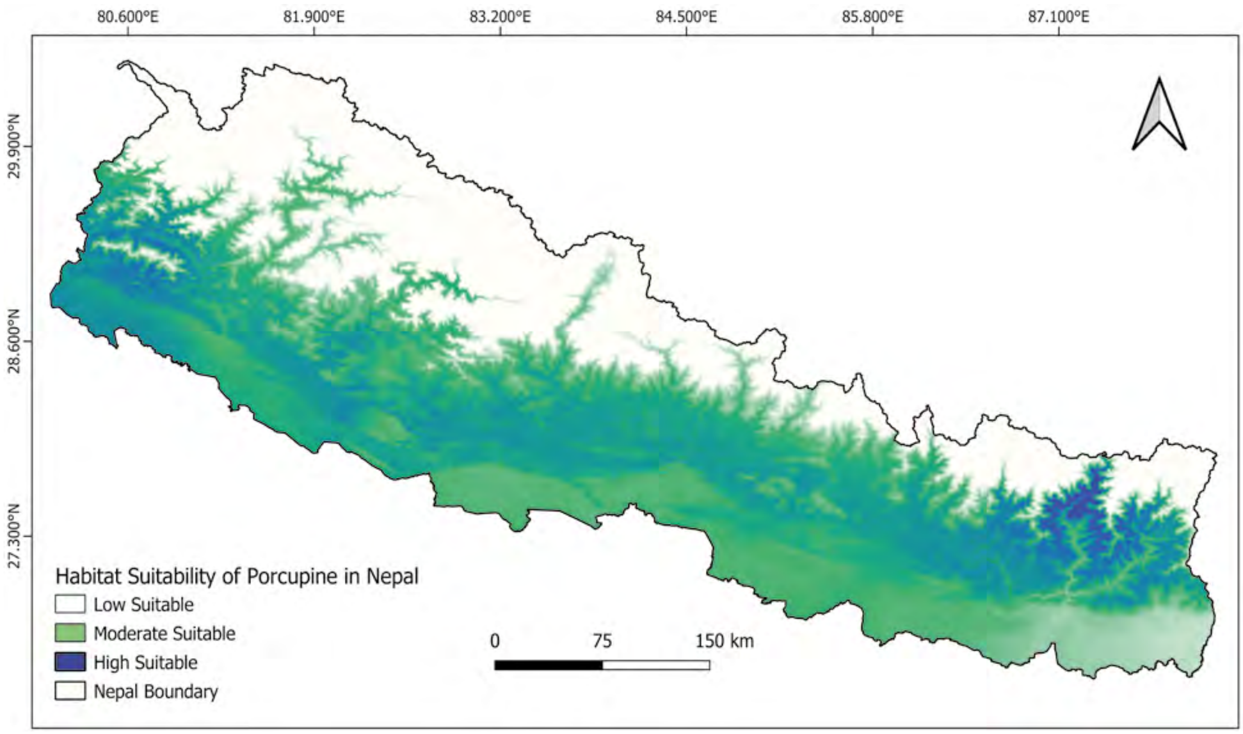

Figure 5 Potential distribution of suitable habitats of Porcupine in Nepal

Table 3 Results of the Generalized Linear Model (GLM) identifying factors affecting the occurrence of porcupine. The response variable was porcupine occurrence, while explanatory variables included distance to the nearest water source (m), forest (m), agricultural land (m), settlement (m), and road (m), as well as elevation (m) and slope (°). Model outputs are presented as estimated coefficients with corresponding standard errors (SE), lower confidence intervals (LCI), and upper confidence intervals (UCI).

Variables	Estimate	SE	LCI	UCI	Z	p
(Intercept)	185.0025	185.2041	-9.7839	556.5885	0.999	0.318
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Elevation	-0.1425	0.0502	-0.2418	-0.0448	-2.839	**0.005**
Slope	-2.0586	2.0580	-6.1878	0.1060	-1.000	0.317
Nearest distance to forest	0.1138	0.0483	0.0194	0.2090	2.355	**0.019**
Nearest distance to farmland	0.0828	0.0523	-0.0195	0.1855	1.585	0.113

4.3 Economic Losses from Rhesus macaque

Crop Production

All 1,846 respondents practiced year-round multi-cropping. Corn was the most widely cultivated crop (85%), followed by rice (53%), wheat (34%), millet (32%), potato (21%), and mustard (18%). A small number of respondents cultivated orange and cardamom. The average annual production per household was highest for corn (620 kg), followed by rice (561 kg), potato (284 kg), wheat (239 kg), millet (149 kg), and mustard (58 kg) (Figure 6). Among cash crops, orange production averaged 862 kg/household, while cardamom averaged 328 kg /household. In monetary terms, cardamom generated the highest average income per household (NPR 820,606), followed by orange (NPR 77,593). Among staple crops, corn contributed the highest income (NPR 30,304), followed by rice, potato, wheat, millet, and mustard (Figure 7, Annex 2).

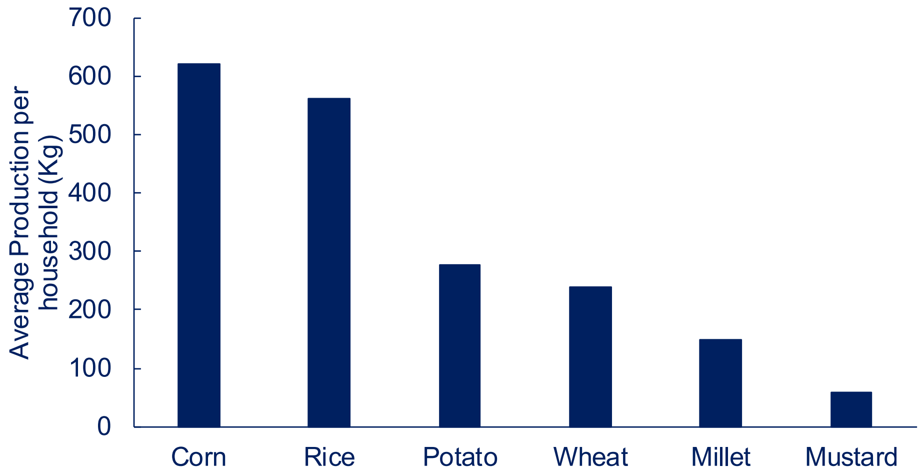


Figure 6 Average annual crop production per household among respondents in the study area

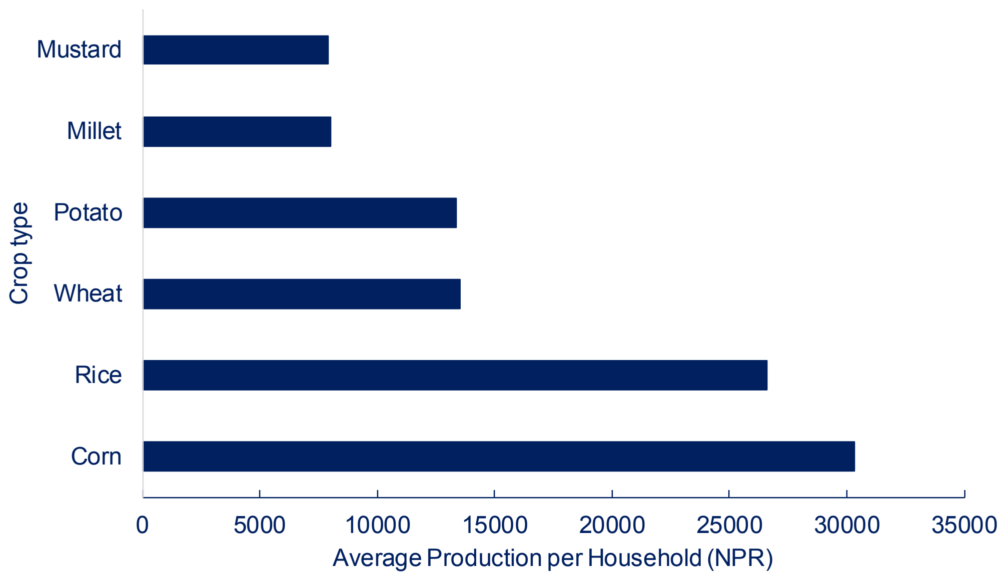


Figure 7 Average annual crop production per household in Nepalese Rupees (NPR) among the respondents in the study area

Species Identified as Problematic

Among respondents, 98% identified monkeys as the most problematic species, followed by porcupines (67%) and wild boars (31%) (Figure 8). Key informants reported similar trends, also highlighting leopard and barking deer as additional concerns (Figure 9). Most respondents indicated that wildlife-related problems have increased over the past 5-10 years (Figure 10).

Crop Loss from Wildlife

Crop damage was widespread, with 98% of respondents reporting losses from monkeys, 67% from porcupines, and 31% from wild boars. Combined impacts were common: 44% reported damage from both monkeys and porcupines, and 22% from all three species (Figure 11).

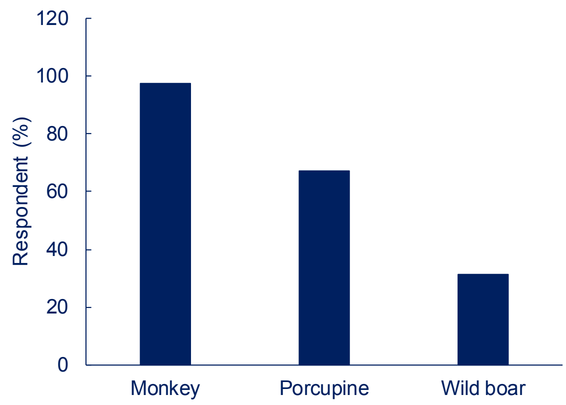


Figure 8 People confirming the presence of major problematic wildlife in the study area.

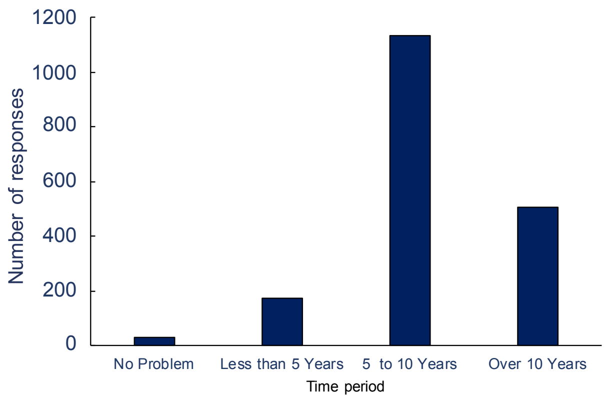


Figure 10 Respondents' knowledge about the sever time when the problems developed from problematic animals

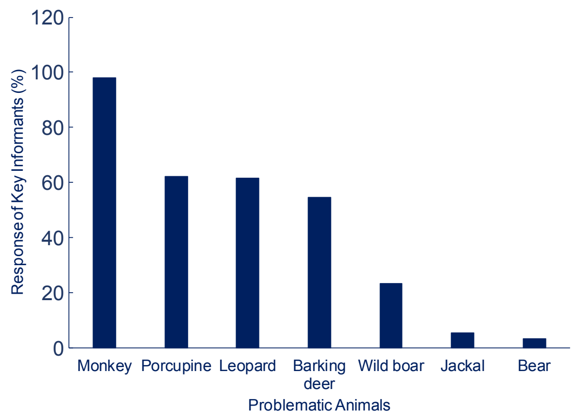


Figure 9 Key Informants confirming the presence of problematic wildlife in the study area

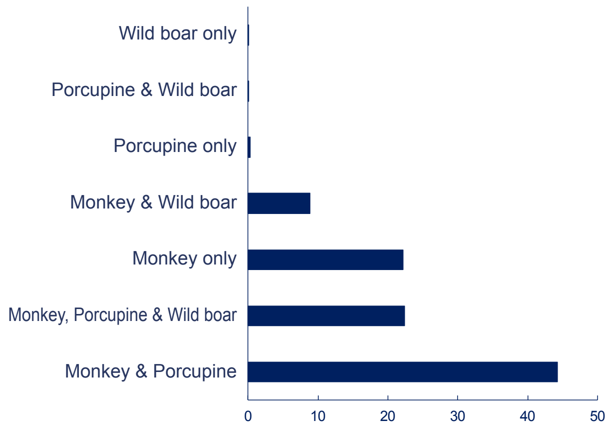


Figure 11 Problematic wildlife species alone and their combination occurrence at spatial scale

Across provinces, monkeys were consistently the most problematic species. Porcupines were the second most important in most regions, while wild boar impacts were more pronounced in Karnali and Sudurpashchim (Figure 12). The co-occurrence of all three species was highest in Sudurpashchim (70%), followed by Lumbini, Karnali, and Bagmati, and minimum in Gandaki and Koshi (Figure 13).

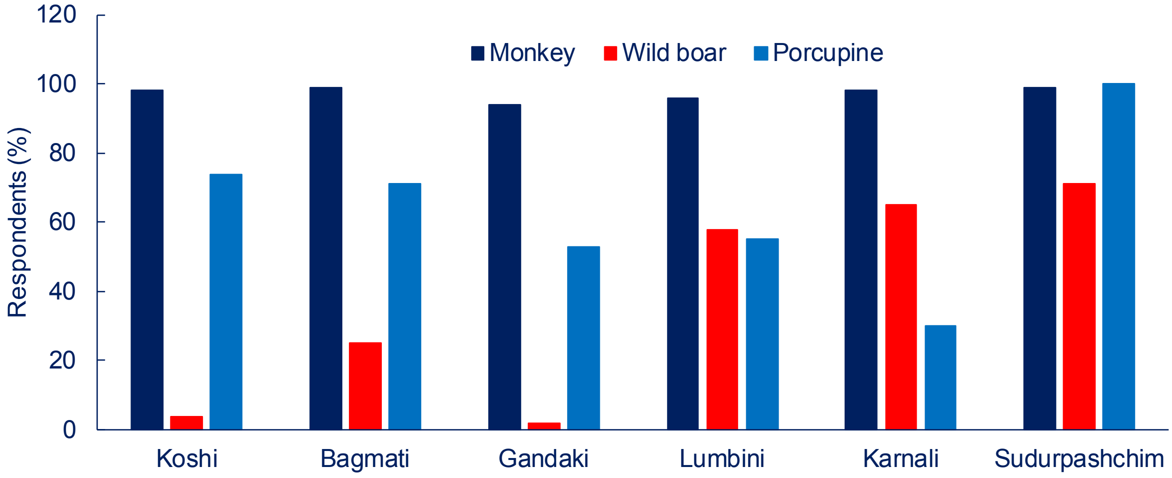


Figure 12 Occurrence problematic wildlife species at spatial scale in different provinces.

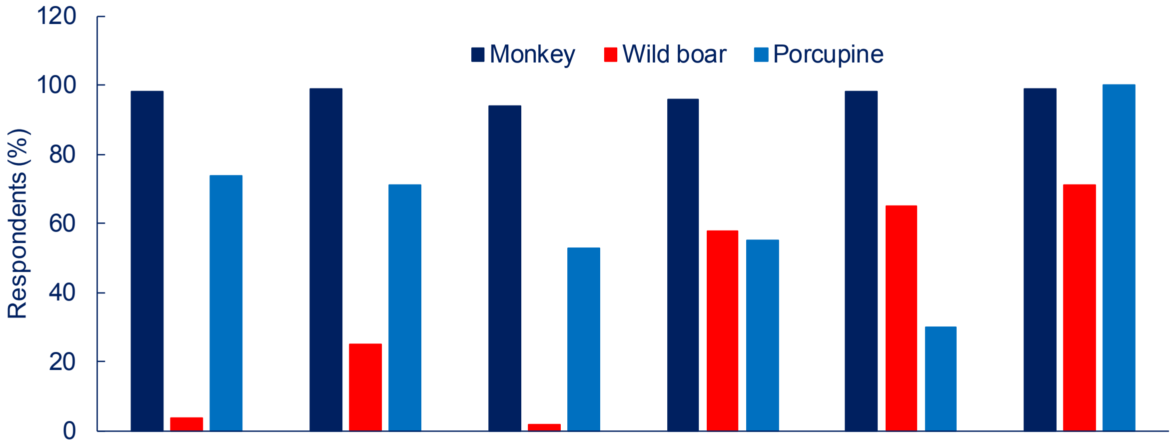


Figure 13 Occurrence of problematic wildlife species at same locations in different provinces.

Crop Production and Loss

Corn was found to be the most widely cultivated and most affected crop among cultivated crops. Households produced an average of 620 kg/ corn per year, with an average loss of 312 kg, resulting in a loss proportion of 50.3%. Rice had a loss proportion of 25.3%, while wheat showed a relative loss of 31.6% (Figure 14).

Total production and losses were substantial: corn (970,682 kg production; 488,390 kg loss), rice (546,909 kg production; 138,143 kg loss), and wheat (150,169 kg production; 47,466 kg loss) (Figures 15).

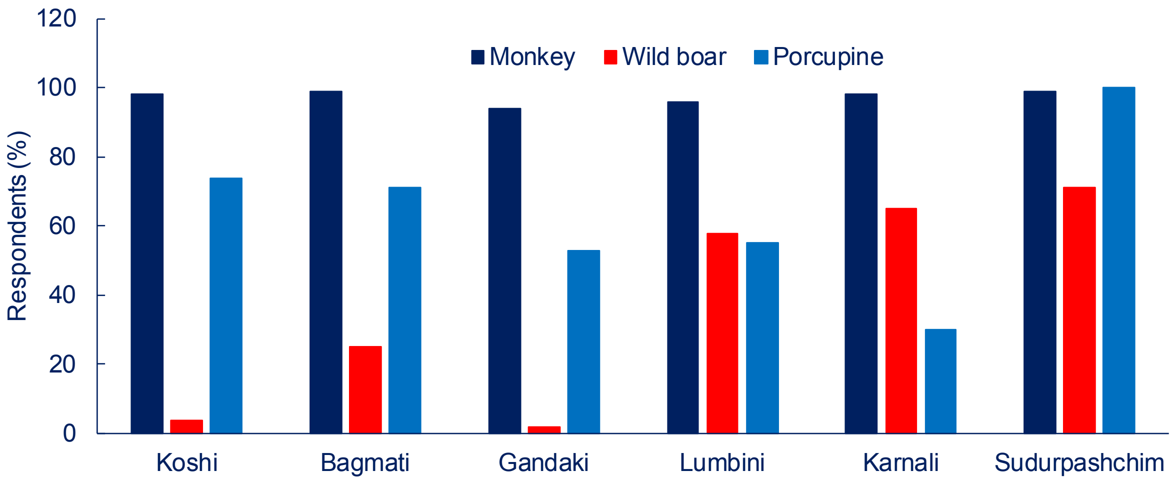


Figure 14 Average crop production per household (kg) and crop loss per household (kg) among the respondents

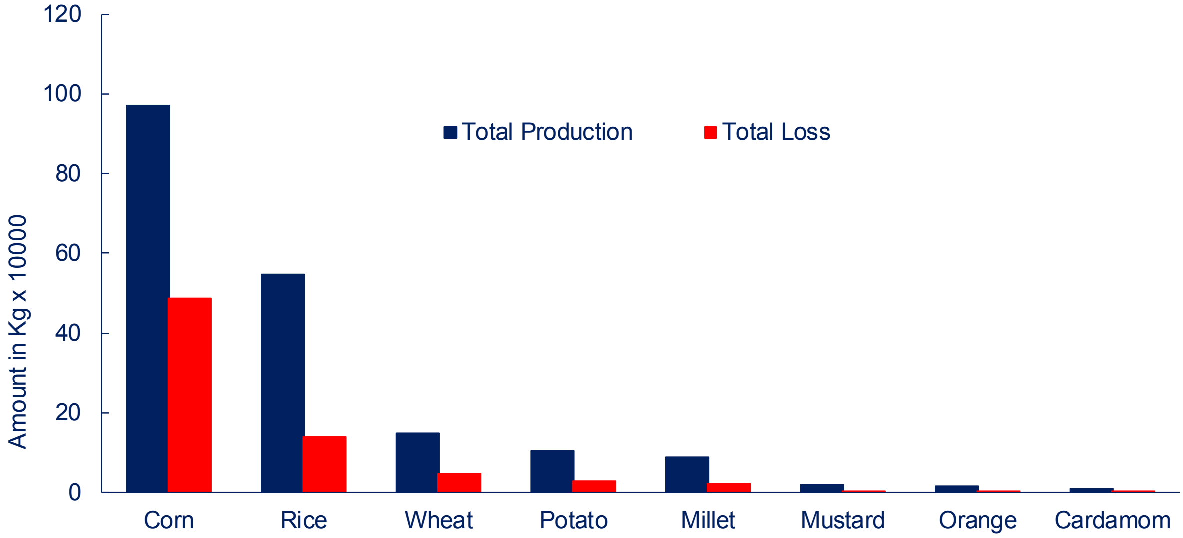


Figure 15 Total crop production and loss among the respondents

Province Wise Crop Production and Crop Loss

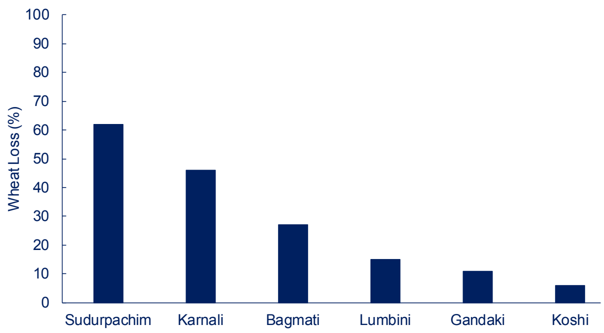
Crop production and losses varied across provinces. Corn production was highest in Bagmati (832 kg/hh) and lowest in Karnali (333 kg/hh), while losses were highest in Gandaki (369 kg/hh) and lowest in Koshi (195 kg/hh). Rice production was highest in Koshi (797 kg/hh) and was lowest in Sudurpashchim (207 kg/hh), which also experienced the highest rice and wheat loss percentages.

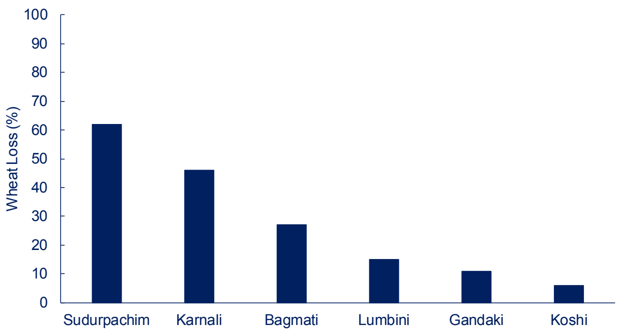
Loss proportions were particularly high for corn in Gandaki (90%) and Karnali (88%), while rice and wheat losses were highest in Sudurpashchim. Losses for other crops varied across regions (Figure 16).

Economic Loss

In terms of monetary value, corn was the most severely affected crop. The corn production's annual economy value was NPR 4,74,25,262, and the loss was NPR 2,50,31,240 (Figure 17), with a loss proportion of 52.78% (Figure 18), and an average loss per household of NPR 15,994.4. Wheat, millet, rice, potato, and mustard also experienced significant economic losses, with loss proportions ranging from ~18% to 29%.

Cardamom, cultivated only in Koshi and Sudurpashchim Provinces, recorded a loss proportion of 20.13%, with a remarkably high average loss of NPR 165,151.52 per household. Similarly, orange was reported to have loss proportions of 18.72%, with corresponding average household losses of NPR 13,800.





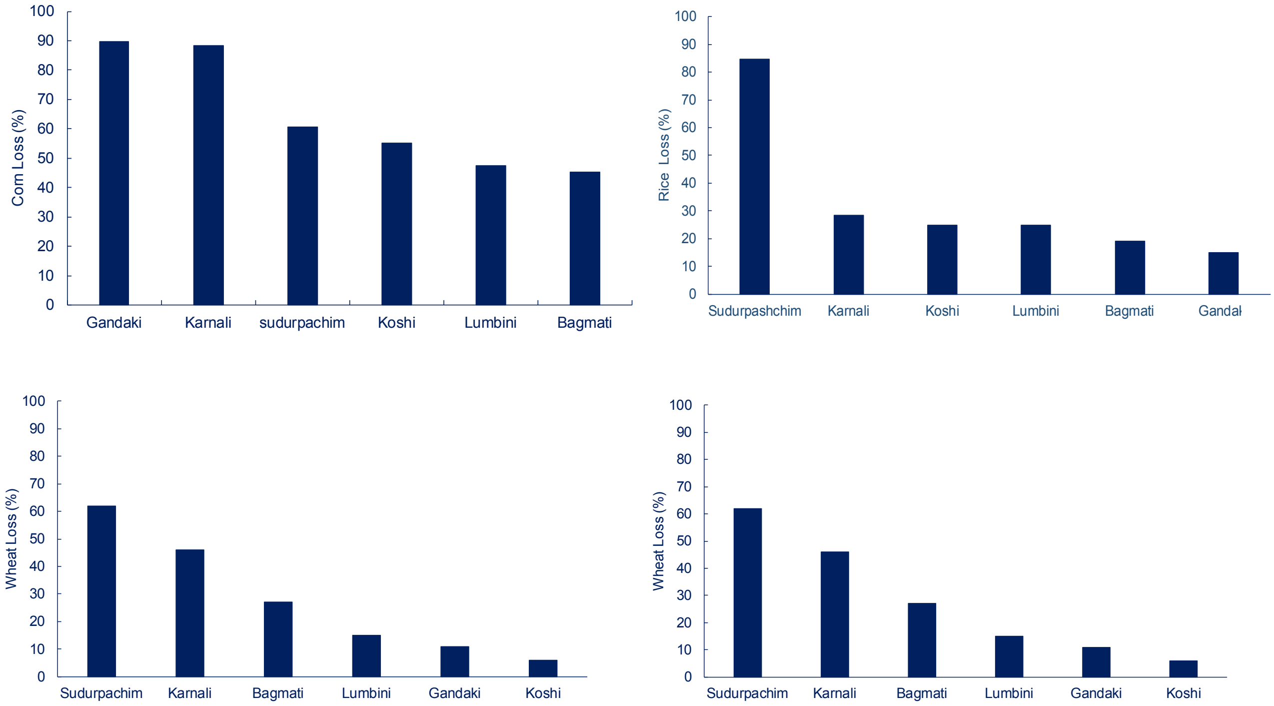


Figure 16 Crop loss percentage at different provinces

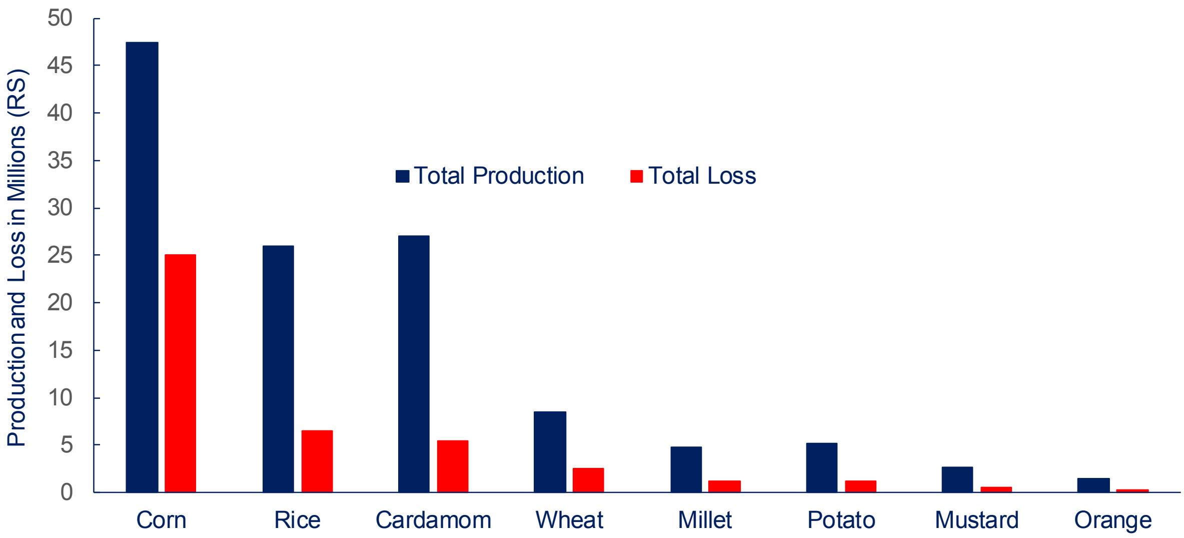


Figure 17 In terms of monetary value, the total crop production and loss among the respondents in Nepalese Rupees.

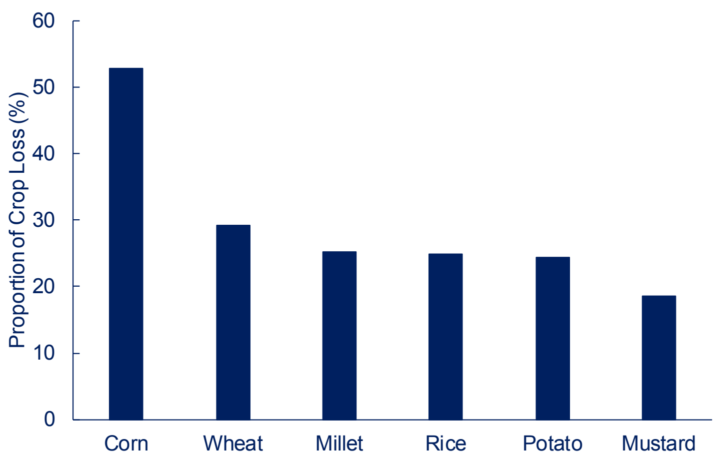


Figure 18 Proportion of cop loss in terms of monetary value in Nepalese Rupees.

Crop loss from rhesus macaque, wild boar and porcupine between1998–2024

A review of 53 studies (1998–2024) identified that corn experienced the highest average loss (27.1%), followed by vegetables (16.7%), rice (13.1%), wheat (10.6%), and millet (8.1%). The mustard, fruits, lentils, oats, cardamom, ginger, and buck wheat experienced minimal losses. These estimates are lower than the present study, likely due to methodological differences (Figure 19).

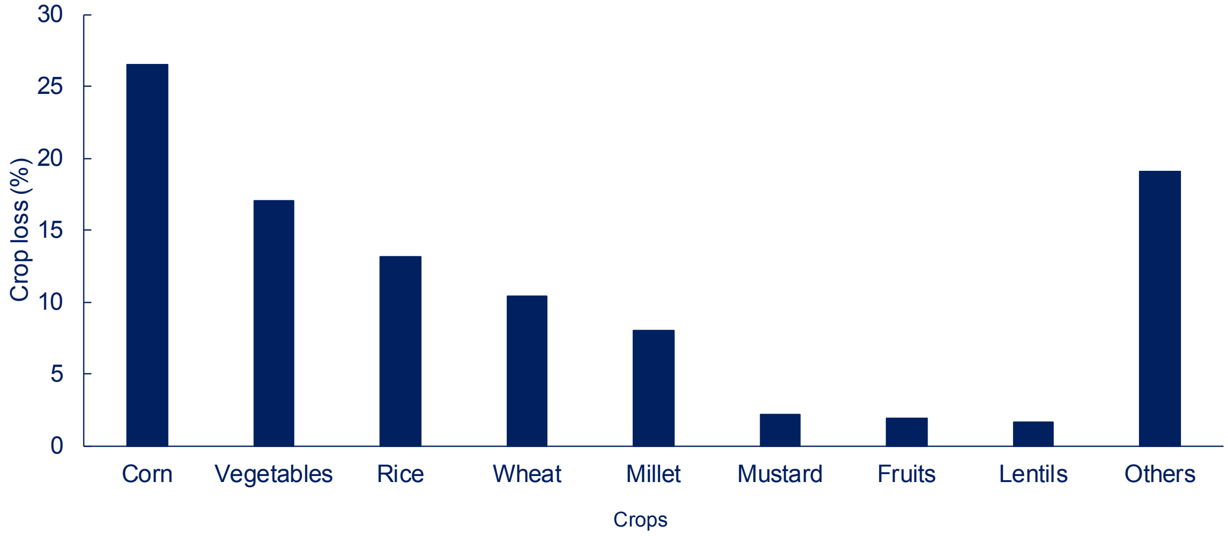


Figure 19 Crop loss proportion from rhesus macaque, wild boar and porcupine between 1998 and 2024.

Photo: Rhesus macaque in agricultural land (upper left and lower left) corn damages (upper right and lower right)

4.4 Distribution and Hotspot Map of Rhesus Macaque

The species distribution model showed good performance (AUC = 0.796). Suitable habitat was predicted across mid-hill and lowland regions of Nepal, covering approximately 53,255.06 km², including 44,606.95 km² in mid-hills (Figure 20).

The hotspot map of rhesus macaque showed that its problem is high in mid hill regions (Figure 21) with varied individual numbers in different locations (Figure 22).

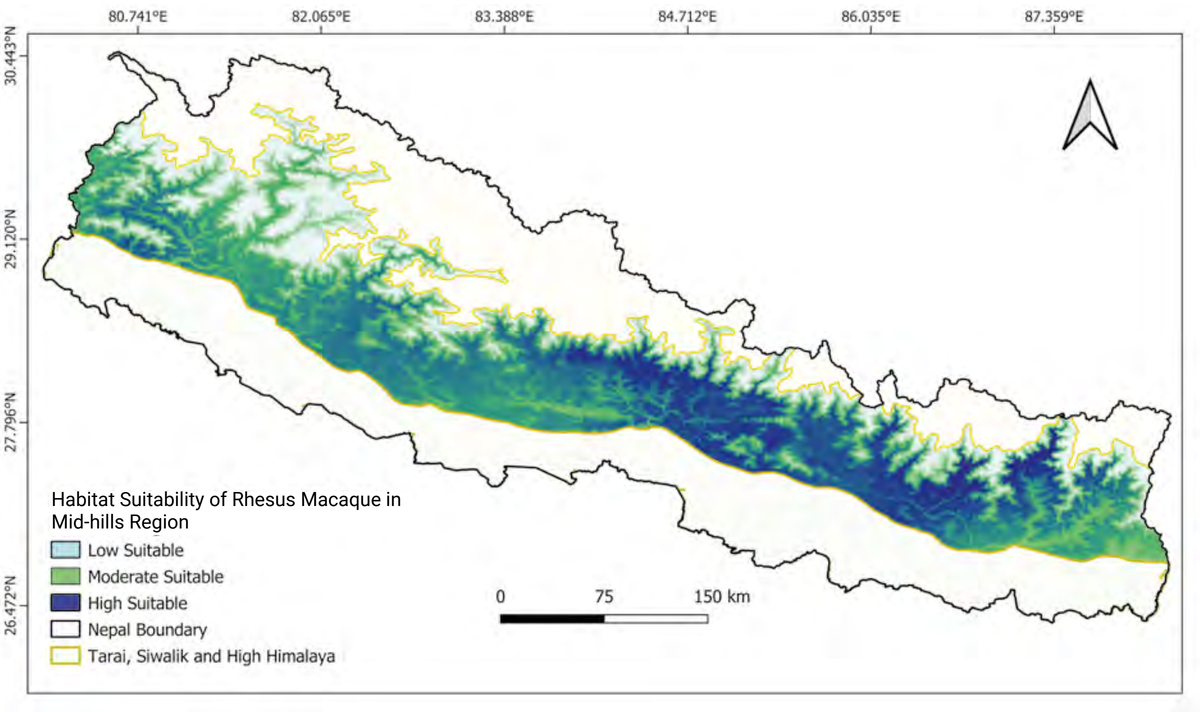


Figure 20 Potential distribution of rhesus macaque in Nepal

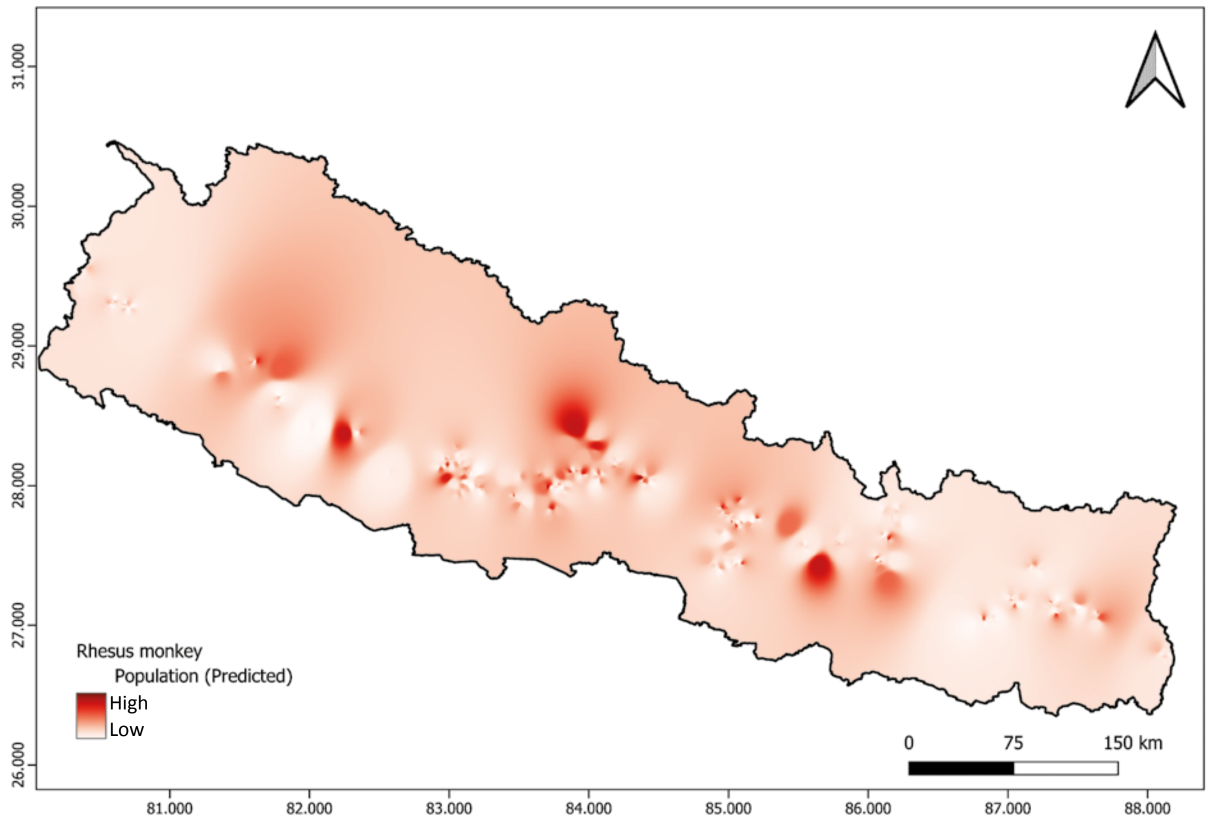


Figure 21 Hot spot map of potential human-monkey conflict areas

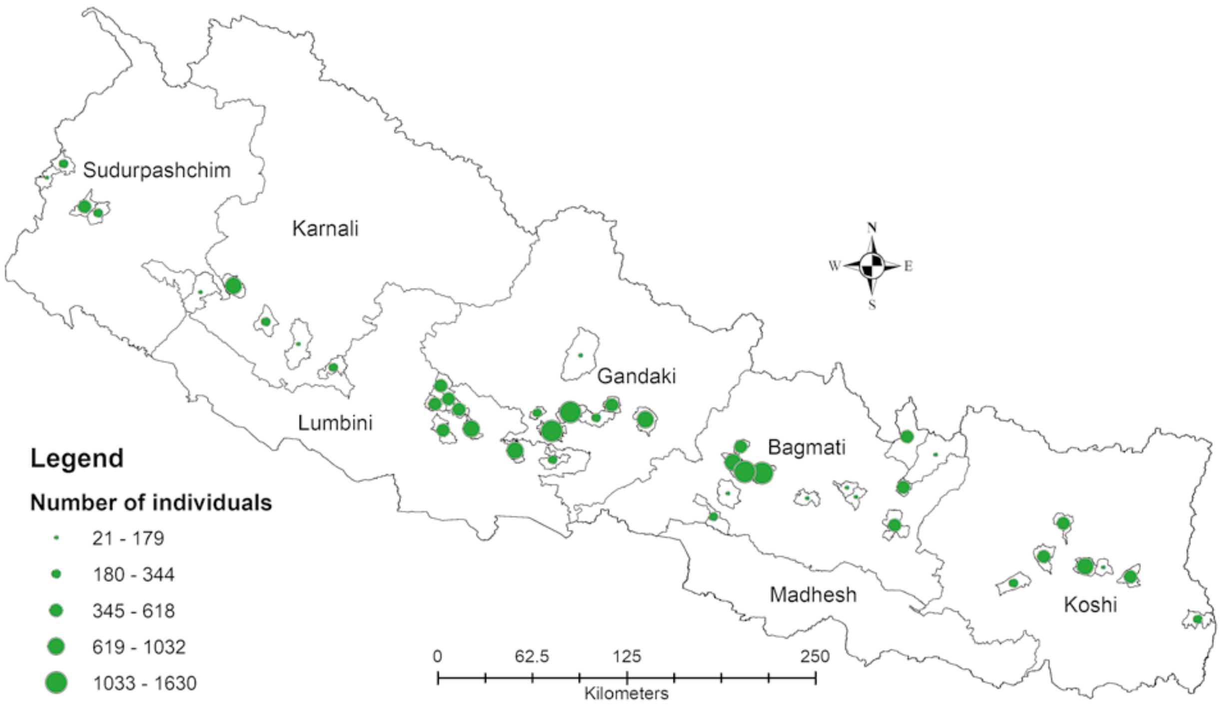


Figure 22 Number of rhesus macaque in Rural Municipality and Municipality in Mid-hill regions of Nepal

Crop loss in mid-hill regions increased with a higher number of monkeys, proximity of crops to forests, greater forest cover, and higher crop edge density (Figure 23).

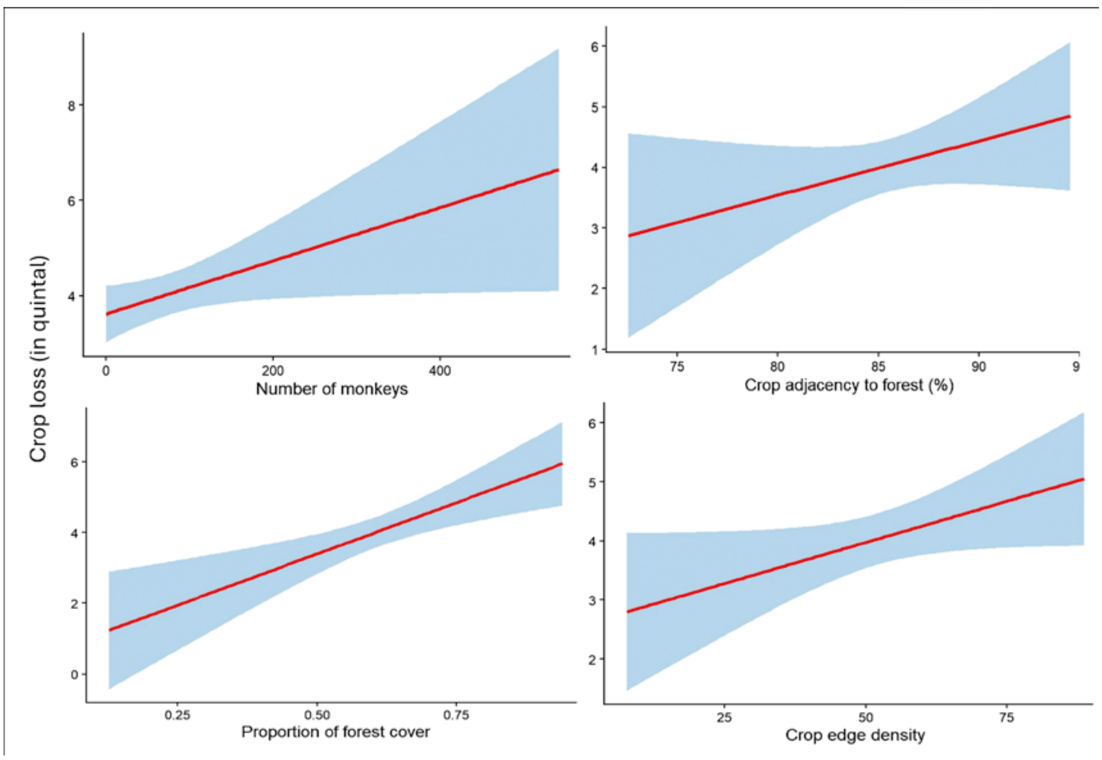


Figure 23 Factor affecting the crop loss in mid-hill regions of Nepal

Photo : Interaction with local people and ward representatives

4.5 Mitigation Measures for Problematic Rhesus Macaque

People's Perception on Rhesus Macaque Management

A total of 68% respondents suggested killing monkeys as the most effective way to reduce nuisance (Figure 24). However, 32% opposed this approach, emphasizing the ecological and cultural importance of monkeys and recommending alternative management strategies.

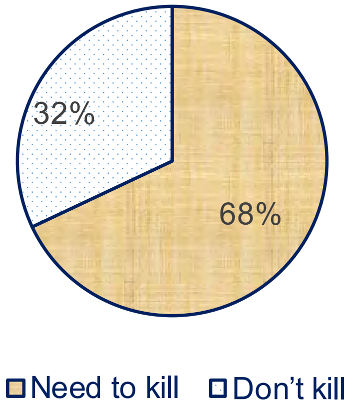


Figure 24 Respondent's suggestion about management of monkeys

Photo: A local person showing handheld devices including bell and gun designed to produce a loud sound, for the purpose of repelling monkeys or other problematic animals.

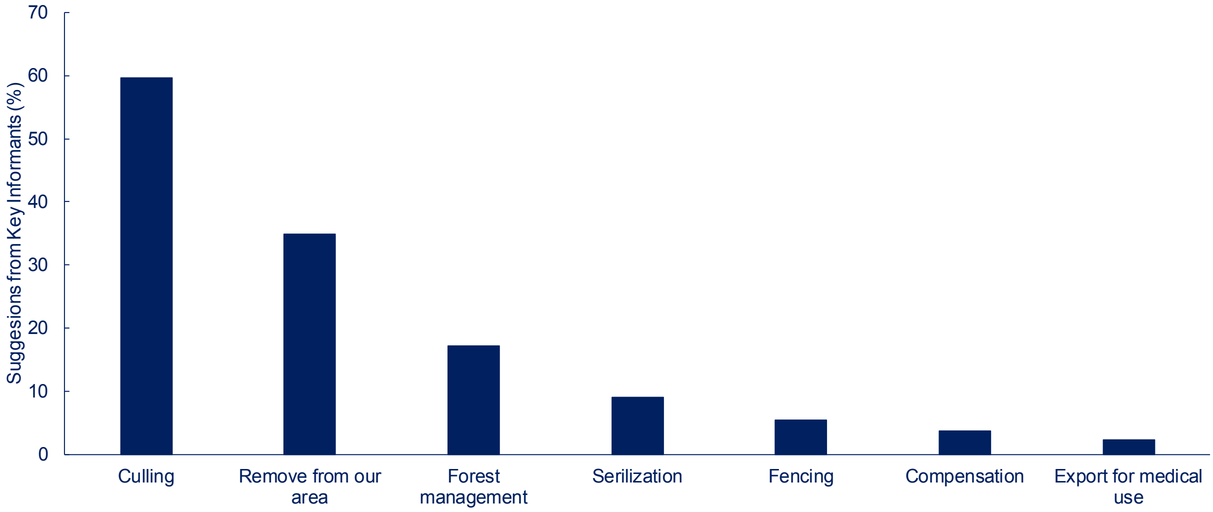


Figure 25 Key informants suggest mitigating the human-monkey conflict.

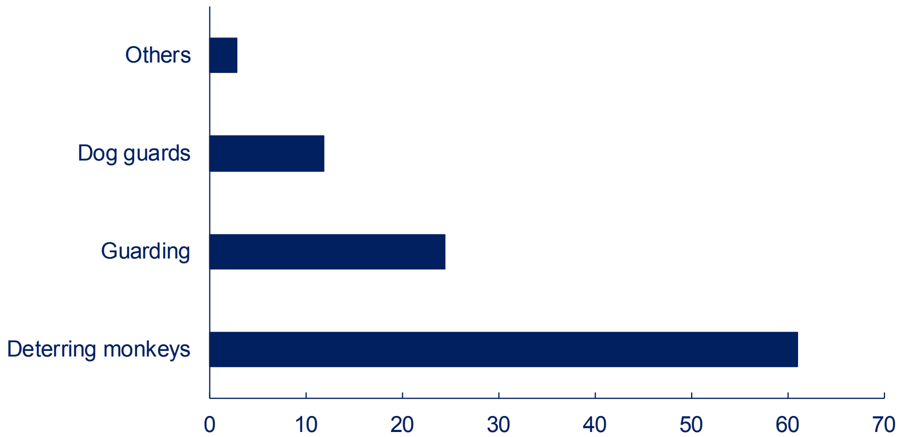


Figure 26 People's existing activities to prevent crop damage from problematic animals

Similarly, 60% of key informants supported culling, while 35% suggested relocation. Other proposed measures included forest management (17%), sterilization (9%), and interventions such as fencing, compensation, and translocation (Figure 25).

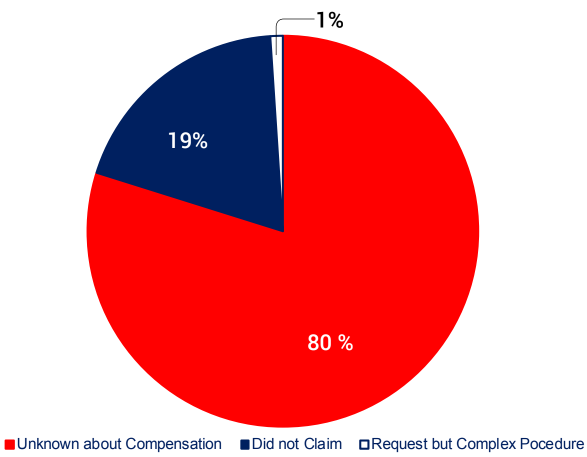


Figure 27 People's knowledge about compensation which was provided by government.

Existing Preventive Measures

The existing practices to prevent crop losses from monkeys, wild boar and porcupine have not been effective to date. About 61% of respondents used deterrent methods such as shouting, stone-throwing, and catapults. Guarding (24%) and use of dogs (12%) were also reported (Figure 26).

Awareness of government compensation schemes was low, with 80% of respondents lacking knowledge and only 19% having claimed compensation (Figure 27).

Photo: Rhesus macaque killed by human at Dhurkot Rural Municipality, Gulmi districts.

Photo: People have developed traps by placing food inside them, which attract monkeys, when the animals attempt to feed, they are killed using high-voltage electric shocks @Baiteshor Rural Municipality, Dolakha (right) and Ilam (Left) district.

Ongoing Practices and Challenges

Nepal's policy framework allows limited wildlife farming and population control under regulated conditions. The amendment of the National Parks and Wildlife Conservation Act permits commercial farming and breeding of selected species, although concerns remain regarding ethical issues and weak regulatory oversight (DNPWC 2017). Earlier policies also promoted wildlife farming and provision of "seed" animals; however, these provisions do not clearly address the management of problematic species such as rhesus macaques (GoN 2023).

Recent amendments to the National Parks and Wildlife Conservation Act (1973) temporarily designated rhesus macaques and wild boars as agriculturally harmfull species, allowing controlled removal under specific conditions (GoN 2023). However, long-term, species-specific management policies are still lacking.

Despite legal restrictions, various unsafe and illegal practices are being used at the community level:

a) Electric shock and high-voltage traps

Farmers in several areas use live electric wires to deter or kill monkeys. These unregulated measures have resulted in wildlife mortality and human fatalities, highlighting serious safety risks and legal violations. For example, in Musikot

Photo: Man-made ponds near forested areas, especially focusing to trap monkeys in Manthali Municipality, Ramechhap.

Municipality-7, Paltar, Gulmi, a 60-year-old woman was electrocuted after she touched an electric wire that had been installed in the field specifically to repel monkeys (Kathmandu Post 2025).

b) Drowning in artificial ponds

Multiple cases of monkey deaths in artificial ponds have been documented, often due to poor design or suspected intentional trapping. Incidents in Arghakhanchi (27 monkeys were found dead after drowning in a forested area) as reported by Khabarhub (2022) and Sindhupalchok (16 rhesus macaques were found dead in a pond constructed by local villagers) reported mass mortality events linked to such structures (Nature Khabar 2019). These practices reflect serious concerns regarding environmental planning and animal welfare.

c) Trapping and relocation

Unauthorized trapping and relocation of monkeys by local authorities have been reported in several municipalities. One such incidence was recorded in Rupa Rural Municipality in Kaski (Personal Communication, Nawaraj Ojha, Mayor), Mahashila in Parbat (Personal Communication, Ishori Bhusal, Mayor), and Bateshwar in Dhanusha had practiced in monkey-trapping and relocation operations (Rising Nepal 2024). These practices often bypass legal procedures and have proven ineffective, as conflicts persist or shift to new areas. Additionally, trapping can cause injury, stress, and safety risks for both animals and humans.

Overall, these practices are ineffective and violate wildlife protection laws, while posing risks to human safety and ecological balance. Without improved policy clarity, enforcement, and community engagement, such harmful practices are likely to continue and escalate.

5. MANAGEMENT PRACTICES IN OTHER COUNTRIES

5.1 Population Management

Culling and sterilization are widely used to manage wildlife populations when they exceed carrying capacity, cause human-wildlife conflict, or threaten agriculture and biodiversity. Several countries, including India, China, Japan, and Hong Kong, have implemented these measures for species such as rhesus macaques, wild boars, and nilgai (Annex 4).

Historically, rhesus macaques have also been captured and transported for research purposes since the 1940s (Frontera 1958; Sade et al. 1985). For instance, population control through removal has been practiced in Cayo Santiago, where 1,744 monkeys were removed between 2000 and 2012 to regulate population size (Hernandez-Pacheco et al. 2016).

In India, large-scale sterilization and culling programs have been implemented in response to increasing human–monkey conflict. For example, in Himachal Pradesh, over 186,000 monkeys were sterilized between 2007 and 2024, and financial incentives for culling were increased after other measures proved ineffective (Reuters 2016). Similarly, wild boar culling programs have been carried out in different regions of India to reduce agricultural damage.

In Japan, more than 20,000 Japanese macaques are culled annually, reflecting long-term population control strategies (Watanabe & Mitani 2019). In Hong Kong, integrated management approaches combining sterilization and culling have been applied to control wild boar populations (China Daily 2025).

These examples demonstrate that, where non-lethal methods are insufficient, countries often adopt a combination of sterilization, culling, and regulated removal to manage problematic wildlife populations. However, such interventions are typically implemented under strict regulatory frameworks and monitoring systems.

5.2 Possibilities for the Use of Rhesus Macaques in Biomedical Research

Rhesus macaques are widely regarded as indispensable models in biomedical research due to their close genetic and physiological similarities to humans (Gardner & Luciw 2008). They have been extensively used in studies on aging, cardiovascular and metabolic disorders, neurological diseases such as Huntington's disease, and infectious diseases including HIV and COVID-19 (Kwon 2024). Major scientific breakthroughs, such as the development of the polio vaccine and the discovery of the Rh blood factor, were achieved through research on rhesus macaques. Their similarity to human brain function and motor systems has also supported advances in treatments for macular degeneration and spinal cord injuries (Mansfield et al. 1995).

Rhesus macaques are naturally susceptible to a wide range of viral, bacterial and vector-borne diseases, making them ideal for studying disease progression, vaccine development, and therapeutic interventions (Dudley et al. 2016). They have been used in research on diseases such as Zika, dengue, yellow fever, West Nile virus, and tuberculosis (Wertheimer et al. 2010; Marchevsky et al. 2003; Foreman et al. 2017; Maximova et al. 2008; Trindade et al. 2008), as well as in the development and testing of COVID-19 vaccines and treatments (Yu et al. 2020; McMahan et al. 2021).

Beyond infectious diseases, rhesus macaques are used in studies of addiction, metabolic disorders, radiation biology, cardiovascular diseases, reproduction, anesthesia, and organ transplantation (Wang & Quan 1986; Doxiadis et al. 2003; Gibbs et al. 2007; Furlan et al. 2009; Fox et al. 2015; Foreman et al. 2017; Yang et al. 2008). Approximately 67% of non-human primates used in the European Union are involved in mandatory safety testing of pharmaceuticals and medical products, with rhesus macaques playing a central role in such studies.

International Practices

India:

India has historically used rhesus macaques for biomedical research, particularly in reproductive biology, immunology, and vaccine development (Rao 2003). Although large-scale breeding programs have declined, macaques are maintained in major research institutions such as All-India Institute of Medical Sciences (AIIMS, New Delhi), the National Institute of Immunology (New Delhi), the Post Graduate Institute of Medical Education and Research (Chandigarh), the National Institute of Virology (Pune), and the National Institute of Nutrition (Hyderabad). These institutions only maintain monkeys without running breeding programs and depend on wild animals (Rao 2003). Obtaining non-human primates (NHP)s for biomedical research, however, is severely restricted by the Indian Committee for the Purpose of Control and Supervision of Experiments on Animals, which is the regulatory body concerning the use of animals in research in India.

China:

China has emerged as a major global hub for primate research, supported by large populations and established breeding facilities. It exports approximately 20,000 monkeys annually and hosts major research centers such as the Kunming Primate Research Center housing around 1,500 rhesus macaques (Hao 2007). However, concerns have been raised about declining wild populations and the need for stronger conservation measures. While some scientists have proposed recognizing rhesus macaques as a "national strategic resource" and restricting exports, others emphasize the importance of conservation and sustainable management to support both research and biodiversity goals (Hao 2007).

The use of rhesus macaques in biomedical research is more restricted and costly in most part of the world. Currently, China, India, and the USA maintain large research populations and have more flexible regulatory systems (Rao 2003; Hao 2007). Records indicate that research laboratories of India, China and USA have more than 7,00,48,088, and 1,22,500 individuals of monkeys for biomedical research use (Annex 8).

Given the relatively high population of rhesus macaques in Nepal and increasing human–wildlife conflict, there is potential to explore regulated use in biomedical research or controlled export. Such initiatives could generate revenue for conservation and support local livelihoods. However, this would require strong legal and ethical frameworks, strict regulation and monitoring, clear policies on capture, breeding, and export and safeguards to prevent illegal trade and population decline. Although preliminary initiatives were attempted in Nepal in the past, they were discontinued (Fan & Song 2003).

5.3 Potential Management Strategies in Nepal

a. Forest management as a strategy to reduce monkey-induced crop loss

Minimizing crop-raiding by rhesus macaques has become a major challenge in many parts of Nepal, particularly in mid-hill regions. One frequently discussed strategy is forest management, which involves manipulating forest structure, composition, and resource availability (e.g., planting, promoting, or restoring fruiting trees) to reduce monkey movement into agricultural land. However, the effectiveness of this approach depends strongly on ecological and socio-economic contexts.

Forest management can help mitigate crop loss when it improves habitat quality and food availability within forested areas, thereby reducing the incentive for monkeys to raid farms. In Nepal, deforestation, forest degradation, settlement expansion, and infrastructure development (e.g., roads) have fragmented monkey habitats. As natural food sources decline, monkeys increasingly rely on agricultural crops, which are energy-rich and predictable. Restoring degraded forests, promoting fruit- and fodder-bearing species, and maintaining continuous forest cover can help retain monkey troops within forest interiors. For example, macaques are less likely to depend on crops when natural food resources are abundant (Yamada & Muroyama 2010). Similarly, restoring broadleaf forests and improving habitat quality near settlements can reduce crop-raiding behavior (Enari & Sakamaki-Enari 2013).

Forest management may also support the creation of buffer zones. Establishing community forests or mixed-use buffer plantations around agricultural land can function as ecological barriers between monkeys and croplands. However, if such plantations are located too close to settlements or fields, they may instead attract monkeys and exacerbate crop damage (Rudran et al. 2021). Therefore, careful spatial planning is essential.

Despite its potential, forest management alone is insufficient. Improved habitat quality may increase monkey population size due to higher survival and reproduction rates (Chapman et al. 2018; Chapman et al. 2025). Moreover, rhesus macaques are highly adaptable and opportunistic; even when natural food in the forest is adequate, they may continue to raid crops because of their higher nutritional value and accessibility.

Additionally, forest management requires long-term investment, strong governance, and sustained community participation. In Nepal's community forestry systems, priorities vary (e.g., timber, fuelwood, grazing), which may limit the effectiveness of interventions aimed at reducing wildlife conflict. Furthermore, macaques can travel long distances (up to 4 km per day), making it difficult to keep them within forested areas (Khatiwada et al. 2020).

Human behavior also plays a critical role. Activities such as forest fires, waste disposal, and deliberate feeding increase monkey presence near settlements. Therefore, reducing human-induced attractants, such as unmanaged garbage and provisioning, is essential alongside forest-based interventions.

b. Compensation for monkey-caused crop loss

Human-wildlife conflict is a major conservation and livelihood issue in Nepal, and compensation is often proposed as a strategy to offset economic losses from crop-raiding. Compensation schemes can reduce financial stress for farmers and discourage retaliatory killing of wildlife. In Nepal, revised relief distribution guidelines (GoN 2023) have expanded compensation coverage to include rhesus macaques and other species. Such measures can help maintain tolerance toward wildlife by addressing immediate economic losses.

However, compensation programs face several challenges. Administrative hurdles, such as damage verification and delayed payments, often reduce trust in the system. In remote areas, these processes are especially difficult to implement effectively. Compensation may also create dependency, reducing incentives for farmers to adopt preventive measures such as fencing or guarding.

Financial sustainability is another major limitation. Crop damage by monkeys is frequent and widespread, making compensation costly and difficult to maintain over time. Unequal access to compensation may also create social tensions, as better-connected farmers may benefit more.

Experiences from other regions show mixed outcomes. Compensation schemes in Sri Lanka and Africa have often failed due to delays, corruption, and insufficient funding (Bandara & Tisdell 2002; Baishya et al. 2025). In contrast, Nepal has had more success with compensation for livestock predation (e.g., tiger and snow leopard cases), where incidents are less frequent and easier to verify. However, such models may not translate well to monkey-related crop loss, which is chronic and diffuse.

c. Sterilization

Sterilization is often considered a non-lethal alternative to population control. However, evidence suggests that sterilization alone is insufficient to control rhesus macaque populations. Effective sterilization programs require a high proportion of reproductive individuals to be treated, along with sustained funding, long-term monitoring, adequate veterinary infrastructure, and technical expertise. Moreover, such programs are most successful when integrated with additional measures such as improved waste management, habitat modification, and public awareness initiatives.

In India, despite sterilizing 186,448 monkeys between 2006 and 2024, efforts at population control achieved only limited success (Reuters 2016; Forest Department 2025). Although population declines were reported, conflict persisted due to incomplete coverage and lack of complementary measures. Experiences from regions like Hong Kong demonstrate that consistent, science-based approaches can yield positive outcomes, whereas efforts in Thailand and parts of India have struggled due to high costs, logistical difficulties, and animal welfare concerns.

In Nepal, implementing sterilization at a large scale is likely impractical under current economic and institutional constraints, as the approach is resource-intensive and demands long-term commitment. Without reliable funding and coordination, partial implementation may not only fail but could potentially exacerbate conflict. Nevertheless, targeted pilot programs in high-conflict areas such as Bagmati, Gandaki, and Koshi may still be feasible if sufficient resources and technical capacity are ensured.

d. Use of monkeys for biomedical purposes

Utilizing rhesus macaques for biomedical research under strict ethical and legal frameworks may provide a value-based management approach. Given their importance in medical research (Gardner & Luciw 2008; Kwon 2024), Nepal could explore partnerships with national and international institutions. Such an approach has the potential to reduce waste associated with culling, generate revenue, and contribute to scientific progress. However, this strategy requires robust regulatory oversight to prevent illegal trade, unethical treatment, and overexploitation of wildlife populations. Any implementation must strictly adhere to international ethical standards and national wildlife protection laws, ensuring that conservation priorities and animal welfare are not compromised.

e. Culling of problematic populations

Culling, the deliberate removal of animals, is a controversial but sometimes necessary management tool. In this study, a majority of respondents (68%) and key informants (60%) supported culling. However, culling should only be considered as a last resort, after non-lethal measures (habitat management, community behavior change, serialization, translocation where suitable and feasible) have been thoroughly evaluated. If culling is adopted, it must be legally authorized, narrowly targeted (time/place/groups), scientifically designed to achieve measurable reduction of harm, carried out humanely by trained personnel following recognized euthanasia/depopulation standards, integrated with monitoring and adaptive management, and accompanied by community engagement and compensation schemes.

I. When (and when Not) to consider culling

Justification for culling

Rhesus macaques have demonstrated a clear and significant impact on human livelihoods in Nepal, particularly through crop damage and resource competition. In situations where non-lethal interventions fail to reduce conflict to acceptable levels, population reduction through culling may be considered. Evidence suggests that reducing local populations by up to 80% of adults and subadults can stabilize population growth and potentially decrease crop losses, provided that outcomes are measurable and monitored.

Ecological limitations of culling

Rhesus macaque populations exhibits strong demographic resilience. Removal of individuals without addressing underlying ecological drivers—such as human provisioning, habitat structure, proximity to forest edges, and access to garbage or other food sources—often results in rapid population recovery or immigration from surrounding areas. Mass removal in isolation is therefore unlikely to achieve long-term effectiveness. Integration of ecological management measures is essential for sustainable outcomes.

Social and Governance Considerations

Culling remains a socially and politically sensitive issue, with public attitudes varying significantly across regions. Implementation requires a clear legal mandate, well-defined permit systems, and transparent stakeholder consultation processes. Lack of social acceptance may result in public opposition, legal disputes, and negative impacts on broader conservation objectives. Careful consideration of ethical, cultural, and political dimensions is therefore critical.

Ii. First-line alternatives (to be implemented prior to culling)

Reduction of food availability

Elimination of intentional feeding, improved waste management, secure storage of food resources, modification of cropping patterns, and the use of deterrents are essential measures. Human provisioning has been identified as a primary driver of high macaque densities; reducing access to anthropogenic food sources is fundamental to population control.

Physical protection measures

Implementation of electric fencing, livestock and crop guarding, reinforced storage facilities, and community-based crop protection systems has shown effectiveness when properly managed. Incentive-based community participation can enhance the success of these interventions.

Fertility control (sterilization)

Surgical sterilization has been applied in several countries, including India and Japan. Effectiveness depends on achieving high and sustained coverage, particularly among females, which directly influence population growth rates. While promising, sterilization programs are resource-intensive, logistically complex, and require long-term financial and institutional commitment.

Translocation and monkey parks

Translocation and the establishment of designated monkey parks represent alternative strategies; however, such approaches frequently face challenges. Translocated individuals may reproduce, disperse, or create conflict in new areas. These measures should only be considered where release sites are secure and supported by animal welfare protocols and post-release monitoring. Establishment of monkey parks may offer localized solutions but is often constrained by land availability, resource requirements, and the need for sustained management.

Compensation and livelihood support

Strengthening compensation mechanisms, promoting alternative livelihoods, and introducing collective agricultural insurance schemes can reduce the immediate economic burden on affected communities. Updated national compensation guidelines should be effectively integrated into broader management strategies to enhance community support for non-lethal interventions.

6. RECOMMENDATIONS

No single solution is sufficient; therefore, Nepal must adopt a multi-pronged, adaptive, and participatory approach that balances farmer livelihoods, animal welfare, and cultural values.

Policy recommendations for Monkey

1. Establish a national integrated management framework

Establish a National Rhesus Macaque Management Task Force under the Ministry of Agriculture, Forests and Environment. The task force needs to develop a national strategy with ensuring coordination among federal, provincial, and local governments, academia, conservation organizations, and community forest user groups. So that a priority area for monkey management will be developed after combining habitat management, community-based deterrence, selective sterilization, compensation mechanisms, and regulated culling.

2. Prioritize conflict mapping and evidence-based planning

Classify conflict hotspots using crop loss, farmer complaints, and local government records, and population of monkey in the area. Focused initial interventions can be started in Koshi, Bagmati, Gandaki, and Sudurpashchim Provinces, where conflicts are most severe.

3. Strengthen habitat and forest management

Promote plantation of monkey-preferred fruit species within forests and away from farmlands. Establish buffer zones and green corridors between forests and agricultural areas. Regulate waste disposal and strictly discourage deliberate feeding near settlements, roads, and religious sites.

4. Enhance community-based crop protection

Promote effective non-lethal deterrents, including improved fencing and bio-acoustic devices. Encouraging cooperative guarding systems and community watch groups. Pilot crop diversification programs using less monkey-preferred crops (e.g., turmeric *Curcuma* spp.) along farm edges.

5. Implement targeted sterilization pilots

Conduct small-scale sterilization or contraception programs only in high-conflict areas with stable macaque troops. Integrate sterilization with feeding bans, habitat management, and continuous monitoring. Avoid large-scale sterilization programs where immigration rates are high and effectiveness is low.

6. Reform compensation and livelihood support

Simplify procedures for getting relief funds of crop loss. Increase awareness to ensure equitable access to government relief schemes. Explore community-based insurance or co-financing mechanisms for long-term sustainability.

7. Explore regulated research and revenue opportunities

Assess the feasibility of using rhesus macaques for biomedical research under strict ethical, legal, and institutional oversight. Ensure transparency, animal welfare compliance, and national benefit-sharing mechanisms.

8. Regulated culling as a Last Resort

Currently, farmers are suffering from rhesus macaque, and almost all practices for deterring monkey are not working. Evidence from South Asia suggests that sterilization alone is costly and often ineffective at reducing conflict. Forest improvement without population control risks further population growth. The National Parks and Wildlife Conservation Act, 1973 permits lethal control when wildlife causes substantial harm to livelihoods. Therefore, culling should be immediate management practice. For that, we need to identify target specific troops causing the highest damage, apply culling only in chronic, high-conflict zones where non-lethal measures have failed, aim for up to 80% reduction in local troop density, where scientifically justified. Conduct operations only by trained personnel under strict government authorization, following international animal welfare standards. Integrate culling with habitat management, waste control, and strengthened compensation schemes.

Short-term management recommendations (1–3 years)

1. Declare rhesus macaque conflict a priority management issue

Recognize rhesus macaque–human conflict in mid-hill agricultural landscapes as an urgent national livelihood and food security concern requiring immediate, coordinated intervention. Continue the legal provision of rhesus macaque as an agricultural pest until other appropriate measures are not implemented.

2. Conduct rapid conflict mapping and troop assessment

Identify and rank conflict hotspots based on crop loss magnitude, farmer complaints, and macaque troop size, with priority action in Koshi, Bagmati, Gandaki, and Sudurpashchim Provinces.

3. Strengthen immediate crop protection measures

Support farmers with effective non-lethal deterrents, including improved fencing, bio-acoustic devices, and cooperative guarding systems, while enforcing strict bans on feeding and improving waste management near settlements and religious sites.

4. Reform and fast-track compensation mechanisms

Simplify compensation procedures, ensure timely payments, and improve awareness to reduce farmer resentment and discourage illegal retaliatory actions.

5. Control illegal and unsafe practices

Strictly enforce existing wildlife laws to prevent illegal electrocution, drowning, and unauthorized trapping or relocation, thereby safeguarding human safety and animal welfare.

6. Implement regulated culling in chronic conflict zones as a last resort

Authorize targeted, scientifically justified culling of high-damage troops only where non-lethal measures have failed, conducted by trained personnel under strict legal and ethical oversight to rapidly reduce severe economic losses.

Long-term management recommendations (5–15 years)

1. Establish a national integrated management framework

Form a National Rhesus Macaque Management Task Force under the Ministry of Forests and Environment to develop and implement a coordinated national strategy across federal, provincial, and local levels.

2. Adopt science-based population regulation

Combine long-term monitoring with selective sterilization or contraception in stable, high-conflict troops, avoiding large-scale programs where immigration rates undermine effectiveness.

3. Strengthen habitat and forest management

Restore natural food availability within forests through plantation of preferred fruit species, establish buffer zones and ecological corridors, and reduce human-derived food subsidies that encourage macaque population growth.

4. Promote community-based coexistence strategies

Institutionalize farmer participation through community forest user groups, crop planning, cooperative insurance schemes, and promotion of less macaque-preferred crops along farm boundaries.

5. Integrate livelihood diversification and rural resilience

Support alternative livelihood options and agricultural diversification to reduce dependency on highly vulnerable crops and limit conflict-driven rural out-migration.

6. Explore regulated research and national benefit-sharing opportunities

Assess the controlled use of rhesus macaques in biomedical research under strict ethical, legal, and institutional oversight, ensuring transparency, animal welfare, and national benefit-sharing mechanisms.

7. Embed adaptive management and policy review

Establish long-term monitoring and periodic policy review to adapt management strategies based on ecological outcomes, social acceptance, and economic effectiveness, ensuring alignment with the Sustainable Development Goals.

8. Improve socio-economic condition of rural communities

Create economic opportunities in rural villages, so that out migration of youth will be reduced. Likewise, land use planning in the landscape is necessary to separate settlement, agricultural lands and other areas.

Policy recommendations for Wild boar

1. Implement regulated, science-based population control programs

Regular population surveys and mapping of conflict hotspots should be conducted, with controlled hunting allowed only in high-conflict areas during specific seasons. Local governments can manage these programs under the guidance of forest authorities. Continuous monitoring should be ensured to prevent overharvesting and maintain ecological balance.

2. Use community-based conflict mitigation measures

Farmers should be supported with subsidized fencing, trenches, and barriers, along with the promotion of less palatable buffer crops such as chili and turmeric. Community patrols, watchtowers, and early-warning systems should be strengthened to deter wildlife. Efficient compensation or insurance schemes should also be implemented to reduce financial losses and retaliatory actions.

Policy recommendations for Porcupine

1. Promote farm protection measures

Farmers should receive support for fencing, protection of root crops, and habitat management such as clearing nearby shelters. The cultivation of less preferred crops like ginger or chili should also be encouraged to reduce crop damage.

2. Establish compensation, monitoring, and community-based management programs

Timely compensation and insurance schemes should be prioritized to support farmers facing repeated crop losses. Transparent and fast processes should be established to reduce frustration and retaliatory killing of wildlife. Training programs should be provided on effective deterrent methods and alternative cropping strategies. Community-based monitoring and management should be strengthened to ensure more sustainable and locally adapted solutions.

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ANNEXES

Annex 1 Rhesus macaque population status and group characteristics.

Table: Population status, number of troop's size, its range and mean group size of rhesus monkey in studied local administrative units.

Province	District	Municipalities population	Population size	No. of groups	Range
		Dasharathchand Municipality	212	9	12-70
	Baitadi	Pancheswor Rural Municipality	170	5	15-60
		Amargadhi Municipality	450	14	6-60
Sudurpashchim	Dadeldhura	Ganyapdhura Rural Municipality	273	10	5-60
		Chingad Rural Municipality	239	6	12-108
	Surkhet	Panchapuri Municipality	120	3	31-88
	Dailekh	Dullu Municipality	745	9	8-198
		Chhatreshwori Rural Municipality	302	4	9-160
Karnali	Salyan	Bangad Kupinde Municipality	21	3	5-14
		Bhumikasthan Municipality	469	9	23-148
	Arghakhanchi	Chatradevi Rural Municipality	736	18	5-86
		Dhurkot Rural Municipality	388	10	11-110
	Gulmi	Madane Rural Municipality	273	9	6-72
		Gaumukhi Rural Municipality	465	10	5-86
	Pyuthan	Jhimruk Rural Municipality	389	9	10-138
		Purbakhola Rural Municipality	293	4	35-139
Lumbini	Palpa	Tansen Municipality	690	14	7-167

Province	District	Municipalities population	Population size	No. of groups	Range
		Putalibazzar Municipality	1310	18	5-161
	Syangja	Waling Municipality	1103	25	5-162
	Parbat	Mahashila Rural Municipality	293	5	30-113
		Bhanu Municipality	861	14	5-190
	Tanahun	Shuklagandaki Municipality	288	8	11-78
		Rupa Rural Municipality	497	10	7-100
Gandaki	Kaski	Machhapuchhre Rural Municipality	126	3	59-66
		Galchhi Rural Municipality	1032	17	10-148
		Thakre Rural Municipality	1630	35	5-160
	Dhading	Dhunibeshi Municipality	1178	25	5-150
		Kailash Rural Municipality	171	5	25-66
	Makwanpur	Manahari Rural Municipality	333	9	5-70
		Bigu Rural Municipality	499	20	8-62
		Gaurishankar Rural Municipality	145	6	10-39
		Kalinchok Rural Municipality	18	1	18
	Dolakha	Baiteshwor Rural Municipality	373	8	7-158
	Nuwakot	Tarakeshwor Rural Municiality	499	8	30-138
		Chaurideurali Rural Municipality	179	5	18-56
		Bhumlu Rural Municipality	61	2	23-38
	Kavrepalanchok	Panauti Municipality	116	5	10-48
Bagmati	Ramechhap	Manthali Municipality	484	7	7-120
	Khotang	Khotehang Rural Municipality	344	16	6-137
	Sankhuwasabha	Khandbari Municipality	474	17	5-86
	Dhankuta	Mahalaxmi Municipality	789	22	6-133
	Tehrathum	Laligurans Municipality	67	4	16-47
	Bhojpur	Bhojpur Municipality	618	21	6-117
	Ilam	Rong Rural Municipality	247	9	9-57
Koshi	Panchthar	Kummayak Rural Municipality	425	7	14-112

Annex 2 Average annual crop and fruit production

Table: Average annual crop and fruit production per household in Nepalese Rupees (NPR). The cost was calculated based on the local price rate at the time of questionnaire survey in 2025.

Province	Average crop and fruit production per household in Nepalese Rupees (NPR)							
	Corn	Rice	Wheat	Mustard	Potato	Millet	Orange	Cardamom
Koshi	24925.48	32767.86	10464.87	5718.18	6050.94	7126.31	40433.09	915689.70
Bagmati	36217.22	21069.02	8738.88	6435.86	19050.8	8778.60	12230.77	-
Gandaki	30610.26	56860.81	44124.91	32605.67	8848.14	8950.97	95497.40	-
Karnali	21416.39	33198.66	12271.19	17163.18	3912.04	7812.00	-	-
Lumbini	27779.57	30587.3	16853.13	6685.31	4079.649	7535.49	240000	-
Sudurpashchim	15077.8	11411.13	13887.99	-	16927.38	6387.36	-	131250

Annex 3 Household crop production and losses (kg) in mid-hill regions.

Table: Average crop production per household (kg) and average crop loss per household (kg) in mid-hill regions of six provinces.

Average crop production per household (Kg)								
	Rice	Wheat	Corn	Mustard	Potato	Millet	Orange	Cardamom
Koshi	797	230	353	48	111	113	578	366
Bagmati	469	175	832	52	417	174	122	-
Gandaki	728	535	411	163	166	117	955	-
Karnali	660	265	333	128	74	52	-	-
Lumbini	624	253	626	46	65	146	3000	-
Sudurpashchim	207	278	377	-	308	142	-	53
Average crop loss per household (Kg)								
Loss	**Rice**	**Wheat**	**Corn**	**Mustard**	**Potato**	**Millet**	**Orange**	**Cardamom**
Koshi	201	24	195	21	20	22	260	75
Bagmati	89	47	377	4	85	47	63	-
Gandaki	107	31	368	22	92	38	-	-
Karnali	185	122	294	72	42	15	-	-
Lumbini	159	38	298	2	30	42	1000	-
Sudurpashchim	176	174	229	-	120	25	-	-

Annex 4 Culling, sterilization and export records of problematic wildlife.

Country	Species	Number	Year	Source
India	Nilgai	200 (culled)	2016	https://www.telegraphindia.com/bihar/nilgai-killing-fight-escalates/cid/1358881
	Wild boar	4700 (culled)	2025	https://timesofindia.indiatimes.com/city/thiruvananthapuram/4700-wild-boars-killed-in-3-yrs-as-man-animal-conflicts-rise/articleshow/123571509.cms
	Rhesus monkey	100s (culled) 186448 (sterilized male: 96939, female: 89509)	2007-2024	https://hpforest.gov.in/monkey-sterilization-programme
China	Killed annually	Reptiles: 1.48–4.31 billion Birds: 2.69–5.52 billion Mammals: 3.61–9.80 billion	Estimate of 2021	https://www.sciencedirect.com/science/article/abs/pii/S0006320720309873
Hong Kong	Wild boar	1,937 (sterilized) 1,231 (culled)	2017-2021	https://www.chinadailyhk.com/hk/article/591839
Japan	Japanese macaques	Over 20,000 culled annually, in some years around 30,000	Since 2010	Watanabe & Mitani (2019)
	Rhesus macaque is designated as an "invasive alien species" in Japan	Unknown figure but since 2005 Rhesus macaque are culled annually		https://pmc.ncbi.nlm.nih.gov/articles/PMC11939813/
Bangladesh	Rhesus macaque	Estimated population 500 to 5000 individuals in 2013)	No official records of culling and sterilization	

Annex 5 Use of macaque in biomedical research

Country	Species	Number	Year	Research Center/Lab	Sources
India	*Macaca radiata*	350	2003	Indian Institute of Science, Bangalore	https://iisc.ac.in/ : Rao (2003), https://www.ncbi.nlm.nih.gov/books/NBK221767/
	Macaca mulatta	300	2003	Indian Institute of Science, Bangalore	https://iisc.ac.in/ : Rao (2003), https://www.ncbi.nlm.nih.gov/books/NBK221767/
	Semnopithecus entellus	50	2003	Indian Institute of Science, Bangalore	https://iisc.ac.in/ : Rao (2003), https://www.ncbi.nlm.nih.gov/books/NBK221767/
Subtotal		***700***			
China	*Macaca mulatta*	1,500	2021	Kunming Primate Research Center (KPRC)	http://english.kiz.cas.cn/ns/es/201111/t20111129_79485.html ; https://www.ncbi.nlm.nih.gov/books/NBK221790/, Fan and Song (2003)
	Macaca fascicularis and *Macaca mulatta*	2,500	2021	Yunnan Key Laboratory	https://www.kmmu.edu.cn/pages_2631_45142.aspx ; https://www.ncbi.nlm.nih.gov/books/NBK221790/, Fan and Song (2003)
	Macaca mulatta	3,040	2016	Yunnan National Laboratorial Primate Center	https://www.lpbr.cn/eng-page?utm_source=chatgpt.com ; https://www.ncbi.nlm.nih.gov/books/NBK221790/, Fan and Song (2003)
	Macaca fascicularis	7,200	2016	Yunnan National Laboratorial Primate Center	https://www.lpbr.cn/eng-page?utm_source=chatgpt.com ; https://www.ncbi.nlm.nih.gov/books/NBK221790/, Fan and Song (2003)

Country	Species	Number	Year	Research Center/Lab	Sources
	Macaca mulatta	*4,161*	2001	Guangxi Laboratorial Primate Research Center	https://www.gxu.edu.cn/en/info/1152/1716.htm ; https://www.ncbi.nlm.nih.gov/books/NBK221790/ , Fan and Song (2003)
	Macaca fascicularis	*29,687*		Guangxi Laboratorial Primate Research Center	https://www.gxu.edu.cn/en/info/1152/1716.htm
Sub-total		***48,088***			
USA	Mainly *Macaca mulatta*	5,000	2025	Oregon National Primate Research Center (ONPRC)	https://www.ohsu.edu/onprc : https://orip.nih.gov/division-comparative-medicine/research-resources-directory/oregon-national-primate-research-center https://en.wikipedia.org/wiki/Oregon_National_Primate_Research_Center
	Mainly *Macaca mulatta*	6,000	2025	California National Primate Research Center (CNPRC)	https://cnprc.ucdavis.edu/ ; https://cnprc.ucdavis.edu/our-animals
	Mainly *Macaca mulatta*	4,500	2025	Tulane National Primate Research Center (TNPRC)	https://tnprc.tulane.edu/home
	Non-human primates mainly *Macaca mulatta*	1,07,000	2025	Based on the data of Animal Welfare Institute	https://awionline.org/ ; https://en.wikipedia.org/wiki/Tulane_National_Biomedical_Research_Center https://awionline.org/awi-quarterly/spring-2025/primates-in-context-an-outsized-demand-for-monkeys-reshapes-the-research-landscape/

Country	Species	Number	Year	Research Center/Lab	Sources
Sub-total		***1,22,500***			
Netherlands	Non-human primates	950		Biomedical Primate Research Centre (BPRC) in Rijswijk	https://www.bprc.nl/en/
Sweden	Non-human primates	*		Karolinska Institutet (KI)	https://ki.se/en
France	Non-human primates	*		Simian Laboratory Europe (SILABE)	https://www.silabe.com/en/
Total		***1,72,238***			

**Note: A large number but does not disclose the number of individuals of monkeys*