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Research Article

HUMAN- LEOPARD *Panthera pardus* (Linnaeus, 1758) CONFLICT IN GODAWARI MUNICIPALITY, LALITPUR, NEPAL

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ABSTRACT
Leopard (*Panthera pardus*) is a globally vulnerable large cat, widely distributed in Nepal. It occurs in different protected and outside protected areas in the human-dominated landscape. We used semi-structured questionnaires to know the Human-Leopard Conflict (HLC) and people's perception towards Leopard conservation in the conflict-prone areas of Godawari, Lalitpur. The signs survey was conducted to know the presence of Leopards in the study area. Households were sampled using the snowball sampling technique. The presence of signs such as scats, pugmarks, and scents marks in the forest and nearby settlement areas indicated that there was a frequent occurrence of leopards in the study area. The Leopard frequently attacked livestock and pets and sometimes humans. Local people believed that the major reasons behind HLC were insufficient prey species and human disturbances in the habitat of Leopards. The majority of the respondents were against the conservation of Leopards because of the frequent depredation of domestic animals in the study area. The research findings will be useful in making a conservation action plan for Leopards and conflict mitigation strategies in such human-dominated semi-urban and urban landscapes.

Keywords: Conservation, human-wildlife conflict, leopard, livestock depredation, people's perception

INTRODUCTION
Human-wildlife conflict (HWC) is an interaction between humans and wildlife that results in negative impacts on human social, economic or cultural life on the conservation of wildlife populations or the environment (Athreya *et al*., 2007). HWC is a serious emerging issue in conservation globally. Humans can be economically affected through destruction and damage to property and infrastructure, livestock depredation, and transmission of domestic animal diseases (Hoare *et al.,* 1992). Humans have competed with other species on the planet for habitat and resources and have innovated and adapted to become the dominant ecological force (Waters *et al.,* 2016). The human disturbances in the habitats of wildlife have led to greater conflict between people and wildlife (Thirgood & Redpath, 2008). Many wildlife species have received threats due to conflict, especially large carnivores (Qamar *et al*., 2010). Human carnivore conflict most commonly involves killing of livestock, and occasional attacks on human (Nowell & Jackson, 1996).

The Leopard (*Panthera pardus*) is one of the five "big cats" in the genus *Panthera* and is a member of the family Felidae. The Leopard has well-camouflaged fur, opportunistic hunting behavior, broad diet, and strength (which it uses to move heavy carcasses into trees) as well as its ability to adapt to various habitats ranging from dense tropical forests to open human-dominated landscapes (Nowell *et al.,* 1996). In the context of Nepal, Leopards (*Panthera pardus*) are common in the foothills of the Nepalese Himalayas, though densely populated by human settlements (Nowell & Jackson, 1996). Studies showed the declining trend of the Leopard population in many parts of Africa and south Asia due to habitat loss and depletion of prey (Kumar, 2011; Thapa *et al.,* 2021; Lamichhane *et al.,* 2021). Leopard is common in the forests across the Himalayas and its food consists of wild prey species such as Himalayan goral (*Naemorhedus goral)*, Barking deer or Northern red muntjac (*Muntiacus vaginalis*), Wild boar (*Sus scrofa*), Jungle fowl (*Gallus gallus*) and Langur (*Semnopithecus* sp.). An increase in the frequency of confrontation between Leopard and humans during the last decade may be due to accelerating trend in habitat fragmentation, scarcity of wild prey base and a high rate of livestock depredation and to some extent may be due to an increase in the local Leopard population (Kumar, 2011).

The leopard acts as a top predator in most of its home range and plays an important role in the continuation and conservation of biodiversity (Karanth, 2002). The Leopard's home range depends on prey availability, the size of territories decreases with the increase of the population density of Leopard but if the human disturbance occurs, their territories tend to expand (Dickman & Marker, 2005). Gunawan *et al.* (2012) stated that Leopards tend to keep a distance of approximately more than half a kilometer from human settlements. The home range of Leopard varies from 6 km^2 (Seidensticker *et al.,* 1990) to over 2000 km^2 (Bothma *et al*., 1997), generally, male territories ranged between 30 and 78 km^2, whereas 15– 16 km^2 for females (Nowell & Jackson, 1996). In Nepal's Bardia National Park, territories are 48 km^2 for males and 5–7 km^2 for females (Odden & Wegge, 2005). Leopards have widespread distribution across a range of altitude up to

4400 m (Henschel, 2008; Aryal & Kreigenhofer, 2009; Koirala *et al*., 2012).

Humans are also a part of the natural ecosystems of the park and therefore human behavior can cause a serious impact on any ecosystem where they exist (Thapa, 2011; Bhattarai & Kindlmann, 2012). There are several reasons for conflicts to take place among forest management, authority and local people residing around the forests. The present study is significant as it may fill the knowledge gap on Leopard occurrence and Human-Leopard conflict and provide practical solutions to address the conflict. This study may contribute information that may help government, wildlife managers and conservation biologists to develop harmonious relationships between people and wildlife.

MATERIALS AND METHODS

Study area

The study area Godawari is one of the municipalities of Lalitpur district situated in Bagmati Province, Central Nepal. It covers an area of 96.11 km² and elevation ranges from 457 m to 2831 m above sea level (Phulchowki). Godawari lies 11 km east of Lalitpur City (Fig. 1). It is one of the popular hiking destinations in Nepal for its wildlife and splendid environment. The climate is warm-temperate and subtropical, with a mean annual temperature of 17.2°C. The maximum summer temperature is 33.8°C, whereas the minimum winter temperature is -0.9°C. The relative humidity is 76%. Most of the precipitation occurs during the monsoon and the average annual rainfall is about 2000 mm (Godawari Municipality, 2021). The population in Godawari has increased over the years. Total population is 78301 and density 814.7/km² (CBS, 2011). The carnivore species in this area are Leopard (*Panthera pardus*), Leopard cat (*Prionailurus bengalensis),* Jungle cat (*Felis chaus*), and Golden Jackal (*Canis aureus).* The major wild prey species includes Rhesus Monkey (*Maccaca mulatta*), Northern-red Muntjac (*Muntiacus vaginalis*). Godawari lies in the deciduous monsoon forest zone with an altitude range of 1500 m to 3000 m. The major tree species are *Castanopsis indica, Schima wallichii, Pinus roxburghii.* Above 1800 m the forest is covered with *Quercus* spp. Phulchowki hills from 1800 m to 2000 m hills are dominated by *Quercus lantana.* Above the 2000m -2500 m mixed forest of *Quercus lamellosa* and *Quercus laurifolia. Quercus semicarpifolia* are above 2500 m.

Methods

A preliminary survey was carried out in April 2018 for the confirmation of the presence of Leopards in the field. Accessible trails were scanned for evidence of leopards in various regions and a sign survey (pugmarks, scats, scrape marks etc.) was carried out. The fieldwork was carried out from April 2018 to February 2019. The survey is based on primary and secondary data. The primary data was collected through the household questionnaire survey, interviews with forest authorities, forest user-group members and field observation. Secondary data related to HLC (e.g., Human causalities/injuries, Leopard killed) was collected from official records and reports of the municipality, and Department of Forest (DoF) to know the status of HLC in the study area.

We recorded the signs of Leopards using 16 transects of variable lengths (1.5 to 3 km). The signs of Leopard such as scat, pugmarks and scent marks were recorded along the transect walk. For the systematic survey, we collected environmental data in every 100 m distance (points) along the transect. At each point, we recorded water source distance, habitat types and cover and disturbance factors such as distance to human settlement and distance to the road in the study area.

At first, we performed key informant interviews (KII) to know the extent and causes of HLC in the study area and the local people's role in HLC mitigation. The forest department officials and members of community forests were considered the key informants of HLC in different places of the study area. With the help of these key informants, we identified the affected households (any kind of effect caused by Leopards- livestock depredation or human harassment/death/injury) and it also made it easier to ensure information regarding the extent of the conflict and its effect on people to be endorsed to reduce the increasing HLC situations of the study area. We found 75 affected households for interview from Godawari. A semi-structured questionnaire was prepared to collect data from the selected households. Most of the respondents were the senior or head member of the family and depended upon their availability during the household survey. Among 75 interviewed households, there were 40 male and 35 female respondents. Among the respondents 5 were of age group between 16 and 25 years occupying 7% of the total questionnaire, 12 were between 26 and 35 years stating 16%, from 36 to 45 years 34 showing 45%, Of 46 to 55 age group were 15 in number i.e., 20%, the experienced people were of age group 56-65 occupying 12%.

Most of the questions were in multiple-choice form. A questionnaire survey was used to find out the extent of HLC in the study area, availability of natural resources to the local community, livestock depredation and compensation facility, perception of local people on Leopard conservation and community awareness towards biodiversity conservation without hurting their sentiments.

Data Analysis

The starting point of the line transect was chosen from the human trail to the forest then every possible transect was used to find the signs of Leopard. The use of a human trail is the best option for transect layout and survey in the hilly regions. At every 100 m of line transect, the surrounding

was observed to record habitat type, the distance from the village, road, and water resources. Whenever a scat and other signs of Leopard were encountered in line transect, it was recorded as presence plot or Leopard sign plots. If not present a systematic plot was established online transect.

The collected data were analyzed by combining data from questionnaire surveys and personal communication with governmental officials. Every question and response of the respondents were coded in MS-Excel. MS-Excel was used to visualize the data in bar diagrams, and pie charts and summarized in the tables. R- studio was used to perform the linear regression between the presence of signs of Leopards with the presence signs of wild prey, distance to village and distance to the motorable roads. Similarly, Chi square test was also performed on R-Program (R Core Team, 2020) to know the significance of male and female attitude towards the conservation of Leopard. GPS points recorded from the field showed the distribution of the signs of Leopards in the study area using the ArcGIS program (ESRI, 2011).

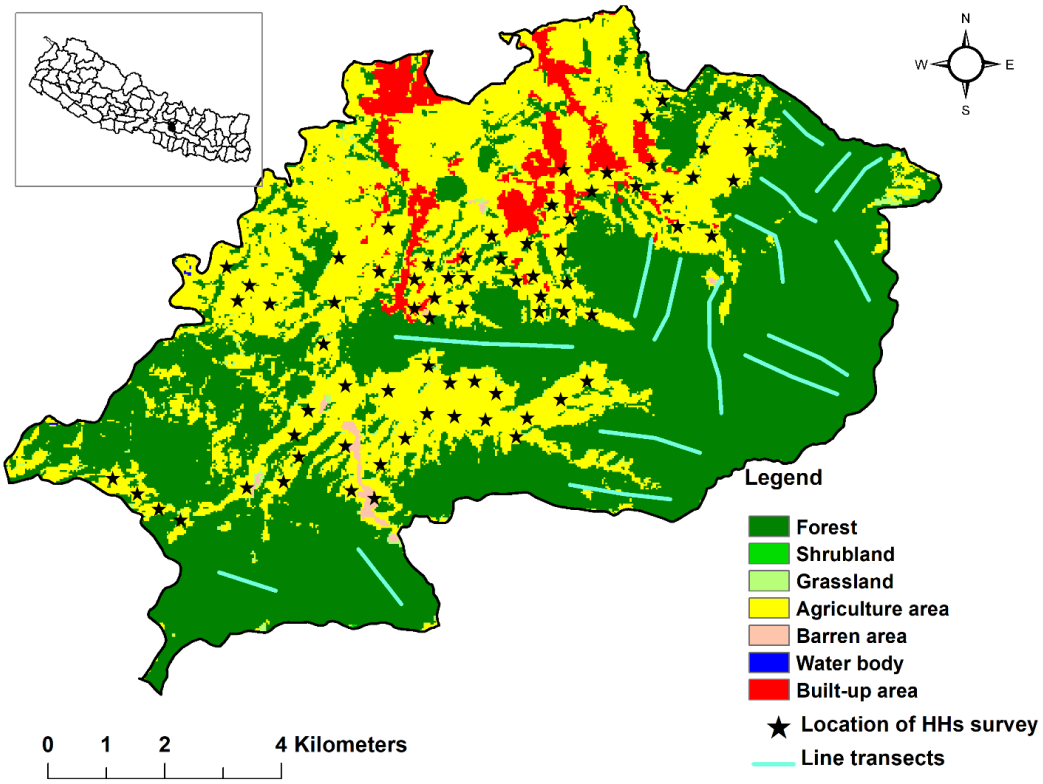

Figure 1. Map of Godawari Municipality showing different land covers, location of households (HHs) survey and line transects in the study area

RESULTS

Presence of Leopard

Signs (scat, pugmark, scratch, scrape, scent) survey was carried out in the study area to know the presence of Leopard (Fig. 2). We have recorded 34 signs of Leopard in various parts of the study area. Pugmarks were reported near the water resources and open areas such as walking trails, and roads. A higher number of signs of Leopard such as scat, scrape, scratches, and scent marks were recorded in the mixed dense forest areas. There were few signs of scrapes, scratches, and the scent of the Leopard in Pine forests (Fig. 3). Presence signs of Leopards highly positively correlated with the prey presence areas and marginally correlated with distance to the villages (Fig. 3). Negative relation between Leopard signs and distance to water showed that they usually reported nearby by the water sources (Table 1).

In the questionnaire survey, 57 people out of 75 had seen Leopards and 18 people had never seen Leopard. The people grazing their livestock have seen the Leopard. Their sound is usually heard at night near the forest areas. Leopard visits to settlements and roads in the areas near the forest are very common in Lalitpur, especially in Godawari and Bungamati (DFO, 2019).

Table 1. Linear regression between presence of signs of Leopards with presence signs of wild prey, distance to village and distance to the motorable roads

Env. variables	Estimate	Std. Error	t value	Pr(>|t|)
Presence of wild prey	0.59405	0.12235	5.804	0.0000003 ***
Distance to village	0.005368	0.000159	3.377	0.00133 **
Distance to water	-0.00179	0.00053	-3.373	0.00134 **

*Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*

Figure 2. Scat (the left Photo) and pugmark (the right photo) of Leopard in the study area

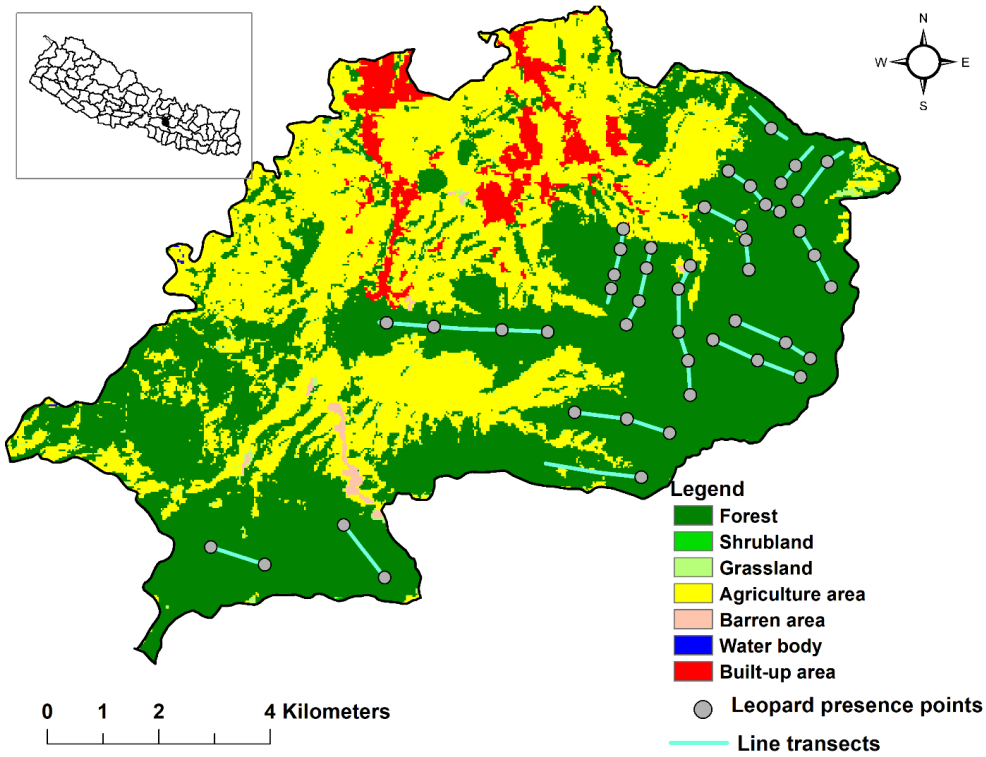

Figure 3. The presence locations of Leopard in forest patches of Godawari Municipality area, Lalitpur

Human- Leopard conflict

Forest resource collection

This study found that there were about 99% of people found to be dependent on the forest for products like firewood, and grass. More than 81% of the people collected grass and firewood for household purposes, 14% collected only firewood for cooking food, 4% collected only grass for feeding the livestock and 1% does not depend on the forest for the resource collection. The collection of forest products is one of the main reasons for HLC in Godawari (Table 2).

Table 2. Resource collection by local people in the forest

Forest products	Usage (%)
Grass, herbs, and fodder trees	81%
Firewood	14%
Grass	4%
None	1%
Total	100%

Livestock depredation

The families in the study area mainly depend upon the forest and agricultural products for their livelihood. Among them, more than 90% of households had goats (*Capra aegagrus hircus)*, chickens (*Gallus gallus domesticus*), buffalo (*Bubalus bubalis*), cow (*Bos taurus*), and pigs (*Sus scrofa domesticus)* as cattle. Livestock depredation occurs all time of the year because they take the livestock either to pastureland or to the forest for grazing. Leopards even enter the village and the house; attack all the livestock and eat all of them. The most affected time was during the earthquake because livestock herds are kept near the settlement, the settlements were scattered as most of the houses were affected and people were scared of the re-occurring of the earthquake. The guarding was not enough for the attack of the Leopard. The natural prey also decreased in the forest so the attack and killing of livestock was at the peak. From a questionnaire survey, study found the most affected wildlife was Leopard and Jungle cats (*Felis chaus*). There were 33 households affected with Leopard whereas both Jungle cats and Leopard affected 29 households. However, the remaining 13 households were affected by other unidentified animals (Fig. 4). This study reported that Leopard killed 2 cows, 16 goats and 28 chicken; and Jungle cats killed 21 chickens during the study period. Leopards can be seen or heard in almost every season in the forest of the Godawari. According to the respondent Leopard affected in all seasons. Most of the respondents agreed that the most affected season was winter (50.7%) followed by summer 49.3%.

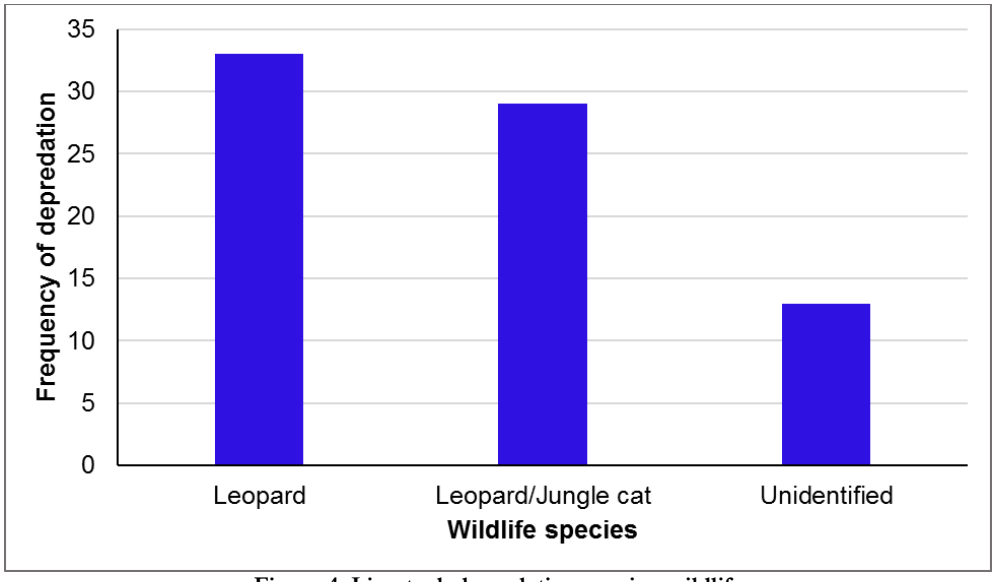

Figure 4. Livestock depredation causing wildlife

Attack on humans

This study reported that only 1 case of human casualty was at the study site and 2 cases were in nearby places. Children were saved from being injured or attacked. One person believed to come on a walking trail when Leopard attacked him. The retaliatory killing of Leopard or translocation to other areas or sending to the zoo is also in practice in the study area (2 cases during the study period) for the safety of locals.

Figure 5. Leopard killed by aggrieved people in the study area (Source: DFO, 2019)

Figure 6. Dislocation of problematic leopard from the study area (Source: DFO, 2019)

Causes of Human-Leopard conflict

Most of the respondents (33%) answered the reason for Leopard visit and attack on livestock in the village was the lack of natural prey in the forest and 23% thought it was due to a lack of conservation effort and the rest of the respondent said different reasons like the human disturbance in the forest, increased forest area and habitat loss of the Leopard.

People's perception towards Leopard conservation

In the study area, agriculture is the mainstay occupation of people and they mainly depended on forest products for firewood, fodder, and livestock grazing. The average family size in the study area was five. Few had 12 members in their family. Most of the respondents were farmers. They have production of maize, vegetables, wheat, soybeans, millet, rice, and fruits. The production of crops is sufficient for only 3 to 6 months (Fig. 8).

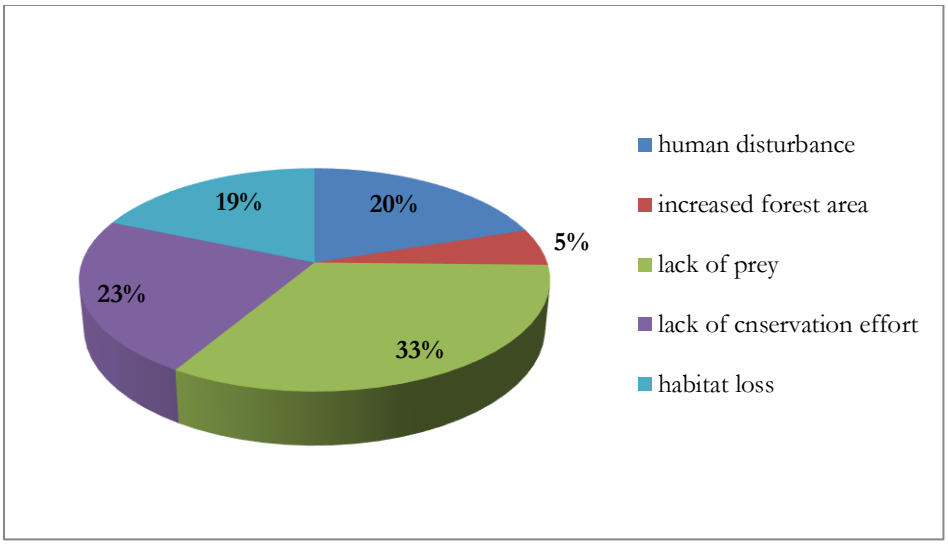

Figure 7. Reasons for Human-Leopard conflict

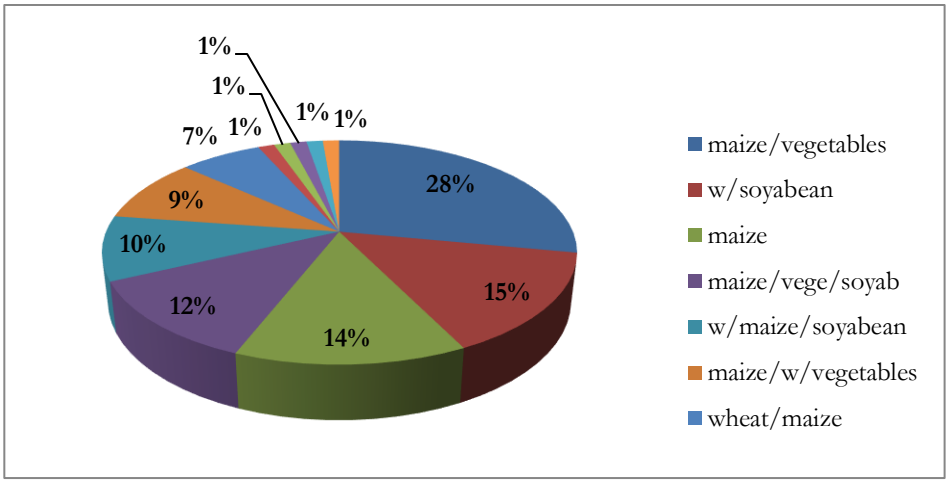

Figure 8. Crop production in study area

In the study area, 85% of the households involved in livestock rearing and 15% weren't engaged. Our results found that the most of respondents mainly reared goat (*Capra aegagrus hircus*) (37%), 32% reared chicken (*Gallus gallus domesticus*) and goat (*Capra aegagrus hircus*), 5% reared only chicken (*Gallus gallus domesticus*), 4% reared cow (*Bos taurus*) and goat (*Capra aegagrus hircus*) and 3% reared buffalo (*Bubalus bubalis*), goat (*Capra aegagrus hircus*) and chicken (*Gallus gallus domesticus*), and 3% reared pig (*Sus scrofa domesticus*) and goat (*Capra aegagrus hircus*) and 1% of respondents reared buffalo and goat (Fig. 9).

A questionnaire survey was conducted to know the perception of people towards the conservation of Leopard *(Panthera pardus)*. The overall response of people was negative. Most of the people 50% said we should not conserve it because Most of the Livestock were killed by wildlife. Very few people said that we should conserve it knowing the importance of the Leopard. Forty-one percent of respondents remained neutral and had no idea about the conservation of Leopard. These respondents had no livestock. About 9% of respondents were aware of the importance of Leopard.

Benefits of Leopard conservation

To know the people's point of view about the Leopard *(Panthera pardus)*, a question was designed what the benefits of Leopard conservation are; most of the respondents were negative about the conservation of the Leopard. Most of them have livestock, which is mostly attacked and killed by the Leopard. About 34% of the respondents said there is not any benefit of conserving the Leopard and 32% respondents were unaware of the benefits of conserving the Leopard and said I don't know. Few were aware of the fact that we have benefits of Leopard conservation, 17% of the respondent said environmental balance. Around 9%

of respondents were not interested in answering the question; there was no response from their side. However, the rest 5% and 3% said that the conservation of Leopards helps in biodiversity conservation and supports tourism (Fig. 10).

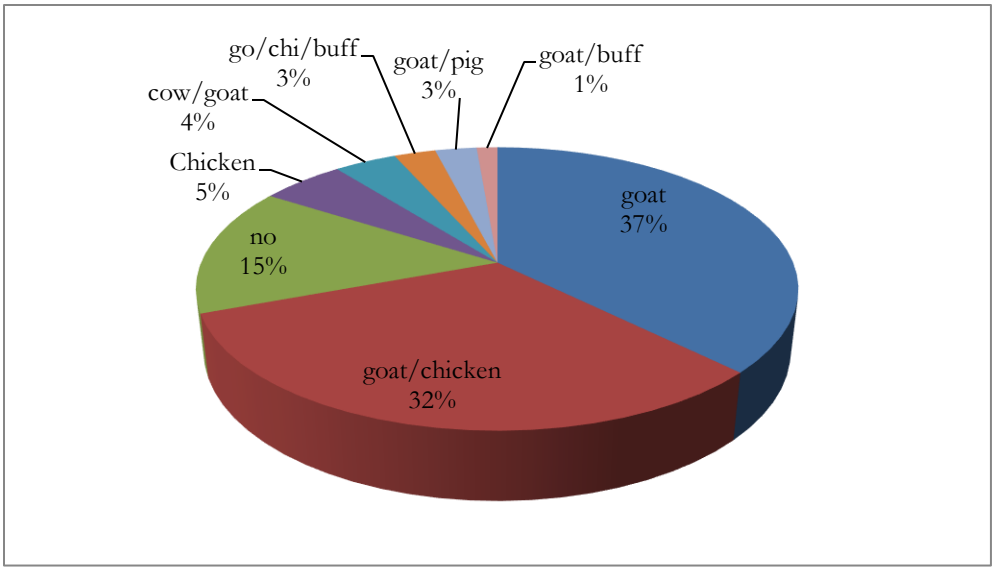

Figure 9. Number of respondents holding livestock

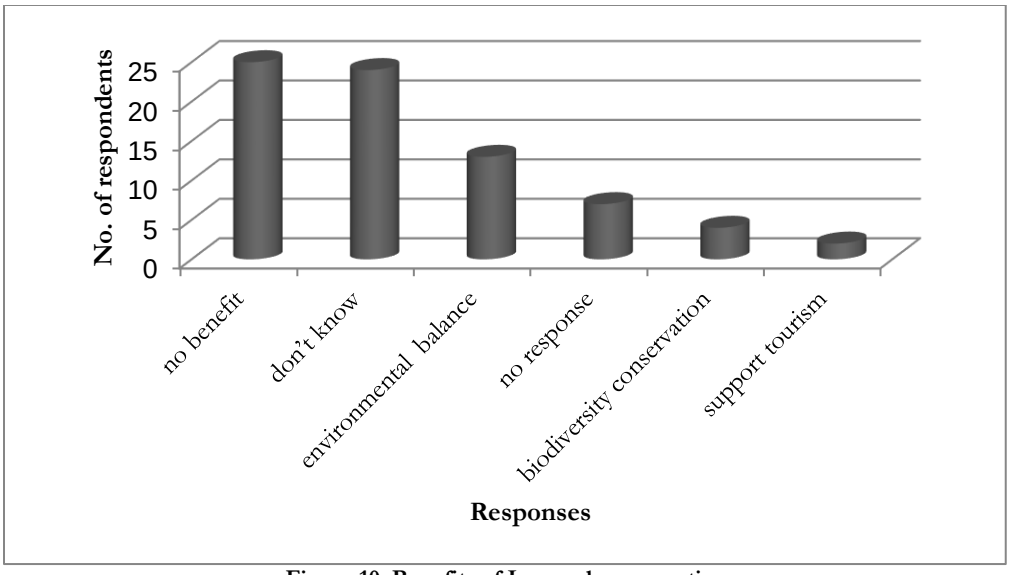

Figure 10. Benefits of Leopard conservation

The respondent's views were mapped to what suggestions they would like to give to the concerned authorities. About 23% of the total respondents said that they have no suggestions. People with no suggestions were locals that do not own livestock and do not visit the forest for the collection of forest products. Most of the people reared livestock. About 17% of the respondents suggested the availability of pastureland could help in the reduction of HLC. More than 16% of people were aware of the importance of Leopards and suggested the need for strict rules to minimize conflict. About 15% of respondents agreed public awareness program must be conducted to create a positive attitude towards Leopards. The respondents believed that conservation efforts (protection of prey, scientific research) along with a compensation scheme for the victims would be the best solution for such burdening issue of Human-Leopard conflict. Some people (4%) of them said there must be public participation for a

better result for conservation (Fig. 11). More than 85% of the households around the Godawari area have been experiencing problems from Leopard but still there is no scheme of compensation in the village. None of the victims received any compensation in the study area.

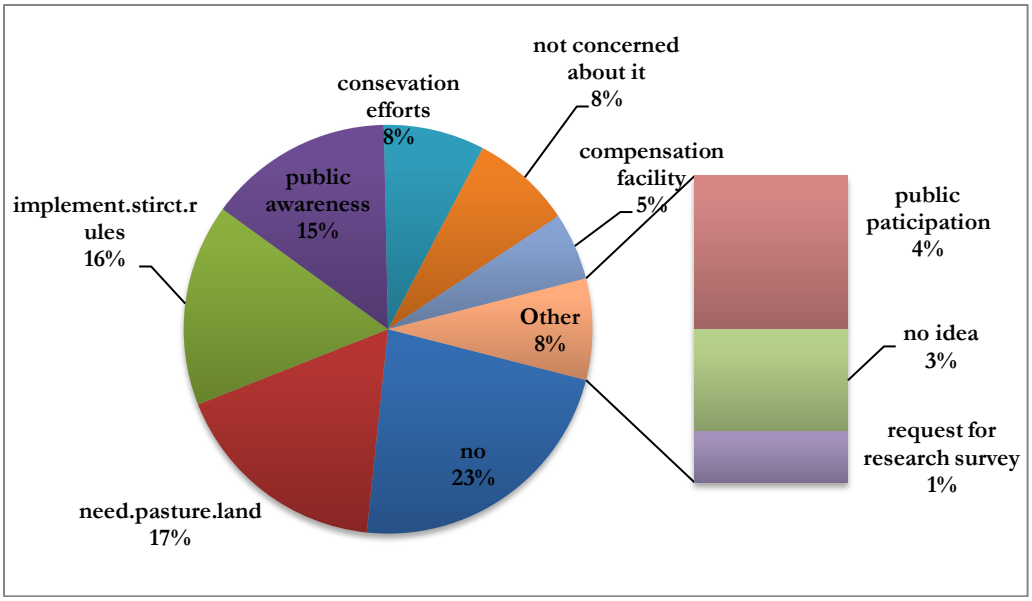

Figure 11. Responses of people towards Leopard conservation

There was no significance difference between male and female respondents about the perception that Leopard needs to be conserve or not. ($\chi^2 = 6$, df = 4, p = 0.1991). Likewise, no significant difference was obtained between male and female respondents about the perception on benefits of conservation of Leopard ($\chi^2 = 12$, df = 9, p = 0.2133).

DISCUSSION

Presence of Leopard

Human-wildlife conflict is an emerging issue for the survival of the threatened and endangered species of animals in the world. Not only Nepal, but it is also a challenge to the world in case of the severity of the conflict. In-depth study is the need to overcome the severity of the conflict and conserve threatened and potentially endangered species (Distefano, 2005). The present study showed Leopard is one of the potentially threatened animals not concerned towards its conservation. Every year Leopards have injured, killed, or have their body parts traded from Lalitpur (Division Forest Office, Lalitpur). This area is suitable for Leopards due to many factors such as climate, dense forest, and elevation range (Odden & Wegge, 2005; Henschel, 2008; Aryal & Kreigenhofer, 2009; Koirala *et al.*, 2012). Signs of Leopards are frequently reported along the walking trail, near the water sources in the forest, and around the marble factory. The area coverage, elevation and sign survey proved the availability of Leopard in the Godawari area.

Human- Leopard conflict

A study by Straede and Helles (2000) in the Chitwan National Park found that the causes of conflict were illegal transactions of forest products from the park, livestock grazing in the park, illegal hunting and fishing, crop damage, and threats to human and animal life caused by wild animals from the park. A study by Karki (2014) in Baitadi, said that due to the poor condition of the community forest and the lower number of natural preys the conflict increases in the area. Other studies stated that competition for shared and limited resources results in conflict between humans and predators (Aryal *et al.,* 2012; Thirgood *et al.,* 2000; Graham *et al.,* 2005). In this study, the village is near to the forest and people are dependent on the forest. About 99% of the villagers depend on the forest. The competition for limited resources resulted in livestock depredation in the study area. Tigers and Leopards killing livestock in Asia (Karantha, 2002), and Asian elephants' conflict in many parts of Asia have a consistent impact on the livelihoods of local populations of that place (Nyhus & Tilson, 2004). In the case of this study, Leopard prey on the animals of forest such as deer, cattle, feral dogs, goats, etc. Livestock-holding respondent (85%) are most affected in the study area. There are a few cases of dog depredation by the Leopards in the study area. Wasim *et al.* (2014) stated that in June 2005, a leopard killed six women in Gallies Forest located in the Western Himalayas of Pakistan. As a result, the conflict between

Leopard and humans increased, with fifteen Leopards were killed within three years from the area. Attacks by Himalayan black bears (*Ursus thibetanus*) and Leopards caused four injuries and one fatal to human beings in the Panchase area (Adhikari *et al.,* 2018). In this study, there were few cases of human injuries by the Leopard. Respondents believed that the cases had arisen probably after the earthquake in recent years.

Socio-economy and people's perception towards Leopard conservation

The local people are highly affected by the depredation of livestock and human harassment (Bhattarai & Kindlmann, 2012, 2013; Limbu & Karki, 2003). The people living outside the protected areas are negative towards wild animals. Leopard entered the houses and killed the livestock. The grazing of livestock was prohibited in the forest after the earthquake. Most of the people, 50%, said we should not conserve it whereas 41% did not have any idea about it. These respondents had no livestock. Local people living near the forest are negative towards wildlife. There has never been scientific research in Godawari about Leopard. Thus, a detailed scientific study of the home range and movement pattern of the Leopard is needed in the Godawari area. This could provide an estimation of the number of Leopard and natural prey in the forest.

CONCLUSIONS

The conflict between humans and wildlife increases when local people occupy and overutilize the forest area or their natural habitats of wildlife. The Leopard is usually present in the forest area and even in human settlements in search of food. The most affected time of conflict was during the earthquake. People guarded the village by lighting a fire at night to escape Leopard to the forest. The cases of human injuries were minimum in the study area, but cases of livestock depredation were reported high. Humans are not affected yet but the day is not far if the human disturbance increases to the same extent. Frequent depredation of domestic and pet animals, including a few cases of human injuries showed problems of HLC. The major reasons for HLC were insufficient prey species and human disturbances in the Leopard habitat. Most of the respondents were against conservation of Leopard because of frequent domestic animal depredation in the study area. According to the reports of DoF (2066-2075) yearly Leopard is killed and traded for their body parts and translocated to other areas such as forests in other districts and zoos. The negative interaction between humans and Leopard's impact created a negative attitude toward the conservation of this ecologically valuable species.

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AUTHOR CONTRIBUTIONS

AM: collected data and prepared the first draft of manuscript; BPB: analyzed the data and finalized the manuscript. Both authors contributed to the drafts and gave final approval for publication.

CONFLICT OF INTERESTS

The authors declare no conflict of interests.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

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