

HUMAN-LEOPARD CONFLICT IN THE KATHMANDU VALLEY, NEPAL



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NEPAL**

APRIL 2015

DECLARATION

I hereby declare that the work presented in this thesis entitled **Human-Leopard Conflict in the Kathmandu Valley, Nepal** has been done by myself, and has not been submitted anywhere for the award of any other degree. All sources of the information have been specifically acknowledged by references to the author(s) or institution(s).

Date: 9 April 2015

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RECOMMENDATIONS

It is my pleasure to mention that Ms. Monsoon Pokharel has carried out the research on **Human-Leopard Conflict in the Kathmandu Valley, Nepal** for the partial fulfillment of the Degree of Master of Science in Zoology with special paper Ecology and Environment. This is her original work and has been carried out under my supervision. To the best of my knowledge, this thesis work has not been submitted for any other degree in any institutions. I recommend that the thesis be accepted for the Degree of Master of Science in Zoology with special paper Ecology and Environment.

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LETTER OF APPROVAL

On the recommendation of the supervisor Prof. Dr. Khadga Basnet, this thesis submitted by Ms. Monsoon Pokharel entitled **Human-Leopard Conflict in the Kathmandu Valley, Nepal** is approved for the examination and submitted to Tribhuvan University in partial fulfillment of the requirements for the Degree of Master of Science in Zoology with special paper Ecology and Environment.

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ABSTRACT

The common leopard (*Panthera pardus*) is widely distributed large cat included in near threatened category of IUCN red list. In Nepal, common leopards are distributed widely in different protected areas and human dominated landscape. Human-leopard conflict is a major issue in the Kathmandu valley with death of leopards, injuries to human beings, and livestock losses. The main objective of this study was to assess the trend and causes of human-leopard conflict in the Kathmandu valley. Specific objectives were to find out frequency of leopard encounters and rescues, to explore the causes of conflict, to examine the change in forest cover change (2003-2013) with its appropriate mitigation measures in the Kathmandu valley. I collected data on leopard deaths/rescues, conducted questionnaire survey (n = 110) and analyzed satellite imagery of 2003 and 2013 using ArcGIS. Thirty eight human leopards encounter cases were recorded in 2010-2013 of which 50% leopards were found dead and the remaining 50% were rescued and released back to natural habitat. Seven leopards were found dead in the border area of Shivapuri National Park (SNP). Out of three districts in the valley, Kathmandu had the most human-leopard conflicts, and most of the dead and rescued leopards. Forest cover change into settlements, limited prey species in forest and insufficient awareness level of local communities were the major causes of human leopard conflict in the Kathmandu valley. During the period of 2003-2013 an area of 4011 hectare was converted from forest to barren land in the Kathmandu valley. Most of the human-leopard conflict cases occurred in forest cover change area. During encounters with leopards, human provocations have often resulted in aggressive nature of leopards. Afforestation, local education campaigns, and enhancement of wild prey populations hold much promise for reducing and better managing conflicts.

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ABBREVIATIONS AND ACRONYMS

DFO	District Forest Office
DNPWC	Department of National Parks and Wildlife Conservation
DoF	Department of Forests
ENVI	The Environment for Visualizing Images
GIS	Geographic Information System
GPS	Global Positioning System
HLC	Human- Leopard Conflict
HWC	Human- Wildlife Conflict
IUCN	International Union for Conservation of Nature
NDVI	Normalized Difference Vegetation Index
NP	National Park
NT	Near Threatened
NTNC	National Trust for Nature Conservation
SNNP	Shivapuri-Nagarjun National Park
UNESCO	United Nations Educational, Scientific and Cultural Organization
VDC	Village Development Committee
WWF	World Wildlife Fund

1. INTRODUCTION

1.1. Background

Human-Wildlife Conflict (HWC) is an interaction between people and wildlife that results in negative impacts on human's social or economic life on the conservation of wildlife populations or on the environment (Madden 2004). Human-wildlife conflicts most commonly involve killing of livestock, occasional attacks on human and animal persecution in retaliation (Nowell and Jackson 1996, Woodroffe 2000, Treves and Karanth 2003 and Gurung 2008). Human population growth and associated increase in rates of resources use, habitat modification and fragmentation is forcing wild animals to live in increasing proximity to humans (Inskip and Zimmerman 2009). In such circumstances, competition between animals and people is inevitable for space and food resources, often leading to severe conflicts. According to World Wildlife Fund (WWF), human-wildlife conflict is one of the main challenges to the survival of many species. HWC is a growing global problem not only restricted to particular geographical region but is common in all areas where humans and wildlife co-exist and share limited resources.

Particularly, large cats are predisposed to conflicts with human because of their large home range and dietary requirements which often overlap with people (Macdonald and Sillero-Zubiri 2002). In Nepal, three species of large cats- tiger, common leopard and snow leopard have been reported as notorious livestock killer (Oli 1994, Tamang and Baral 2008, and Bhattarai 2009) causing financial losses to rural communities. Affected communities may retaliate and destroy wildlife or their habitats.

The Common Leopard, *Panthera pardus* Linnaeus, 1758 is a widely distributed large cat found in Asia, Africa, Middle East and South Eastern Europe (Nowell and Jackson 1996, Sunquist and Sunquist 2002). International Union for Conservation of Nature (IUCN) categorized common leopard (here after called as leopard) as Near Threatened (NT) species (IUCN 2014). Leopards are graceful and powerful big cats found in variety of habitats, from deserts to rainforest to high mountains. In Nepal, out of seventy-five districts, leopards are widely distributed in seventy-three districts, up to 3,000 m where it shares its habitat with snow leopard (*Panthera uncia*) (Jnawali et al. 2011). Leopards are opportunistic animals with very flexible diet. Unlike the tiger (*Panthera tigris*) which lives primarily inside protected areas, leopards may be in greater numbers outside park,

on the periphery of human settlements (Prater 1948, Santiapillai et al. 1982, Tikader 1983 and Johnsingh 1992). This is because leopards are highly adaptable species, competent of eating wide variety of prey (Prater 1948, Bertram 1982, Edgaonkar and Ravi 1997, Stander et al. 1997, Mukherjee and Mishra 2001 and Kulkarni et al. 2004). Leopards are known to inhabit croplands in human dominated landscapes (Athreya et al. 2004). This close proximity to humans often results in conflict. Leopard is particularly one of the most problematic wildlife species because of its secretive nature and increasing population size (Ghimirey 2006).

Human-Leopard Conflict (HLC) is the most escalating problem for conservation of cats globally. Conflict with leopards in the Kathmandu valley and its surroundings is a critical issue as people encounter leopards, which turn into conflict with humans. For last 10 to 15 years people have encountered leopards which have attacked them especially in settlement areas at the edge of forest, in several regions of Nepal, including the Kathmandu valley (Wildlife extra 2013). These encounters turn into tragedy either for the local people, who lose their livestock or for the leopards.

The conflict has intensified with the loss of habitat and natural food which force the wildlife to enter the human-populated areas, where herbivores target crops and predators target livestock. Due to lack of prey in natural habitats, leopards enter the human inhabitation in search of easy prey, which often lures the leopard to make repeated visits to nearby human settlements resulting to conflict. People residing in the valley and its surroundings occasionally suffer from the threat of leopard, its attack and its aggressiveness. Human-leopard conflict has proven to be the main threat for continual survival of leopards in and around the valley. The cause of the conflict has yet not been addressed thoroughly. This study hypothesized, increasing urbanization and deforestation resulted leopard habitat degradation which has grown human-leopard conflict.

1.2. Objectives

The main objective of this study was to assess the trend and causes of human-leopard conflict in the Kathmandu valley.

Specific objectives were to:

- i. identify the frequently conflicted areas and explore frequency of leopard encounter and rescues in the Kathmandu valley
- ii. find out the causes of conflict
- iii. examine the change in forest cover change since 2003 to 2013
- iv. explore the mitigating measures of the conflicts

1.3. Rational

Human-leopard conflict in the Kathmandu valley was recorded since last 10 to 15 years. Leopard attack to humans and people kill leopard were common news in Nepali media. Proper documentation of conflict cases and underlying causes of conflicts were poorly known. The Kathmandu valley is crowded with population density of 19,250 per km² (CBS 2011) is also accompanied by the Shivapuri National Park (SNP) with patches of forest cover in and around the valley. Human settlements are encroaching forests and wildlife habitats which are inducing wildlife to be on the settlement land.

Why are leopards using human settlements, are they repeatedly making encroachment in and around the same area, what lures them for frequent visits resulting in conflict are some of the unanswered questions in the study of human-leopard conflict. Hence, this research collects information about the source of human-leopard conflict and their mitigation measures needed by conservation officials to frame strategy and to alleviate emerging problems. Maskey et al. (2001) reported that the rate of leopard predation on humans in Nepal is 16 times higher than anywhere else globally. It reflects that human-leopard conflict is serious issue which demands for better understanding of conflicts and suitable mitigation measures in Nepal. More human population was migrated to the Kathmandu valley from other parts of the country in last decade due to insurgency and political movement, which caused decrease in forest area. This study was designed to understand whether the forest cover change stimulated human-leopard conflict or that does not have any role in the conflict.

1.4. Limitations of the study

- Only those field sites, where the cases of HLC were recorded, were visited for the study of HLC in the Kathmandu valley.
- This study has focused only on the causes of HLC and mitigation measures so that the concerned authorities will have baseline information for the conservation of the common leopard.

2. LITERATURE REVIEW

2.1. Conflict

Human-Wildlife Conflict is an interaction between people and wildlife that results in negative impacts on human's social, economic or cultural life on the conservation of wildlife populations or on the environment (Madden 2004). According to World Wildlife Fund (WWF), human-wildlife conflict is one of the main challenges to the survival of many species. Human-animal conflicts often occur when human beings and animals clash as a result of encroachment on territory, limited resources as habitat and adverse activities of man like deforestation and poaching. This conflict has led to the endangerment, and even extinction of several animal species.

Human-leopard conflict is a complex issue influenced by social attitudes of people, biology of the species, and management action. Leopard attacks on humans are generally rare occurrences but the cases of leopard attacks are regularly reported in India and Nepal. Leopards are very adaptable, and can live close to human habitations. Leopards generally avoid human, they tolerate proximity to humans better than lions and tigers and often come into conflict with humans when raiding livestock (Quammen 2003). In Nepal, most attacks occur in the midland regions (the terai, mid hills, and lesser Himalaya) (Maskey et al. 2001).

Reducing human-leopard conflict has proven difficult. Conflict tends to increase during periods of drought or when the leopard's natural prey becomes scarce. Shrinking leopard habitat and growing human populations also increase conflict. Couple of years ago only one or two leopards entered the settlements of the valley, but the numbers of leopards lurking about the human settlements has gradually been rising. This frequent confrontation between humans and leopards is resulting grave risk of both human's and leopard's lives (My Republica 2013). Human-leopard encounters have become increasingly common in valley as both the outskirts and the cities are frequently encountering leopards. But most encounters result in tragedy, either for the farmers who lose goats or chicken, or for the leopard (Nepali Times 2010).

Across Nepal, the success of community forests has led to a revival of wild animals, which enter inhabited areas in search of easy livestock prey (Nepali Times 2010). A ferocious common leopard may have killed 15 people in the span of 15 month in Baitidi district of western Nepal (CNN Asia 2012). A study conducted by Koirala et al. (2012) on

human-leopard conflict in Annapurna Conservation Area of Nepal concluded that leopard killed more livestock than any other predators. For the families living in subsistence economy, per household monetary loss due to livestock depredation was significant. The highest financial impact was associated with predation on goats, with leopard accounting for 95% of total monetary loss over the two years (2009 and 2010) study period. The majority of the local people expressed strongly negative views towards conservation of the leopard. The authors recommended improving livestock husbandry practices, implementation of a livestock depredation compensation program, and programs for improving the conservation of wild prey as mitigation measures for minimizing human-leopard conflict in Annapurna area.

The presence of a species like leopard in a human dominated landscape will invariably lead to some predation on domestic animals. Carnivore density is known to be dependent on prey density (Karanth et al. 2004) and the leopard is no exception. Various studies across India have confirmed the important role of domestic dog in the leopard's diet. It is likely that the abundance of feral animal populations helps sustain leopard populations in human dominated areas in India (Athreya and Belsare 2007). Leopards can live near humans with low levels of conflict (McDougal 1991, Seidensticker 1990, Athreya and Belsare 2006).

In the past decade, parts of many Indian states have reported an increase in leopard populations outside forests accompanied by large numbers of attacks on people. This high density was attributed to declining natural habitats and prey species, and the increased survival of leopards in croplands where they preyed on tended and feral domestic animals. That leopard cubs were frequently found in agricultural fields was thought to also indicate rising leopard populations (Athreya et al. 2007). Increase in leopard population and conflict is related to the sustained translocations of problem leopards into nearby forests. That sustained releases could lead to population increases was never considered before, even though translocation is known to be a procedure aimed at increasing populations of species at or close to the site of release. Although, scientists do not recommend translocations as a management strategy used in response to problem carnivores, it is currently the legally recommended method of dealing with problem large cats in India (Athreya et al. 2007).

In June 2005, leopard killed six women in Gallies forest located in the Western Himalaya of Pakistan. As a result, the retaliatory killings of the leopards increased (a total of 15

leopards killed within three years from the area), attacks on human beings increased (17 human beings were attacked and badly injured by the leopard), rate of livestock depredation also increased. In order to manage human-leopard conflict a community based livestock insurance scheme was launched in the area to reduce the economic losses to farmers due to leopard, and an environmental education and awareness program was initiated in the local schools to normalize the existing situation (Waseem and Khan 2014). Serious cases of human casualties occurred in different countries due to leopard attacks (Annex II).

2.2. Conflict Management

Effective management of conflict will have to strike a balance between minimizing serious conflict (attacks on people) and the long-term conservation of the leopard species (Athreya et al. 2004). The challenge of addressing the conflict is in understanding the human dimension with its social, cultural, political, economic, and legal complexities. Perhaps the common report often heard from local communities is that the government and conservation agencies cares more for wildlife and forest than the people- is an indication of the misconception that conservation is purely a matter of biological science (Madden 2004).

The academic literature distinguishes between conflict management, conflict resolution, and conflict transformation. Each term suggests a progressively larger and more ambitious scope of action. Conflict management aims to regulate and contain conflict, but not necessarily to end it. Conflict resolution aims to resolve the issue or incompatibility that divides the parties. Conflict transformation goes further in aiming for a change in the fundamental relationships, social structures and contextual conditions that gave rise to the conflict in the first place (Miall 2007).

2.3. Review on Normalized Difference Vegetation Index (NDVI)

Normalized Difference Vegetation Index (NDVI) is a simple numerical indicator that uses the visible and near-infrared bands of electromagnetic spectrum. It is used to analyze remote sensing measurements, from a space platform, and assess whether the target being observed contains live green vegetation or not. NDVI attempts to simply and quickly identify vegetated areas and their conditions. It is an index used to detect live green plant canopies in multispectral remote sensing data.

NDVI was first used by Rouse et al. (1973) from the Remote Sensing Centre of Texas A&M University. Since, then it has been widely applied in vegetative studies such as estimating crop yields, pasture performance, and rangeland carrying capacities.

Healthy vegetation absorbs most of the visible light that falls on it, and reflects a large portion of the near-infrared light. Unhealthy or sparse vegetation reflects more visible light and less near-infrared light. Bare soils on the other hand reflect moderately in both the red and infrared portion of the electromagnetic spectrum (Holme et al. 1987). With this basic behavior of plants across the electromagnetic spectrum NDVI is derived by focusing on the satellite bands that are most sensitive to vegetation information (near-infrared and red). NDVI algorithm subtracts the red reflectance values from the near-infrared and divides it by the sum of near-infrared and red bands.

$$\text{NDVI} = (\text{NIR} - \text{RED}) / (\text{NIR} + \text{RED})$$

Negative values of NDVI correspond to water. Values close to generally correspond to barren areas. Low, positive values represent shrub and grassland while high values indicate temperate and tropical rainforests (Wikipedia 2014).

3. STUDY AREA

3.1. The Kathmandu Valley

The Kathmandu valley (900 km²), is an urban agglomerate standing at an elevation of 1,300 masl, is formed of three districts namely Kathmandu, Lalitpur, and Bhaktapur. It extends along the coordinates of 27°32'13" to 27°49'10" north latitude and 85°11'31" to 85°31'38" east longitude. The valley is bowl shaped and surrounded by the Mahabharat mountain range on all sides. There are four hills acting as forts of the valley, Phulchowki in the South East, Chandragiri/ Champa Devi in the South West, Shivapuri in the North West, and Nagarkot in the North East. The highest altitudes are 2,166m (in Bhaktapur), 2,732m (in Kathmandu), and 2,831m (in Lalitpur). Shivapuri and Nagarjun hills form the ninth National Park of the country, Shivapuri-Nagarjun National Park. It was established in 2002 locating in the northern fringes of Kathmandu valley covering an area of 159 km² (Bhujy et al. 2007). As Shivapuri-Nagarjun National Park is located in between the transitional zone of sub-tropical and temperate climate, it is rich in faunal and floral diversity. National, private, community forests and the national park of the valley are the habitat of diverse fauna and flora.

Study of human-leopard conflict in the Kathmandu valley was conducted in different places of the valley. Village Development Committees (VDCs) of all three districts where, the leopard encounter or the conflicts were common were taken into consideration. The study was conducted in Kavresthali, Dahachowk, Baluwa, Arubari, Swechatar (Durga colony), Sitapaila (Ramkot), Gothatar and Mrigasthali- Bankali of Pasupati area, Chobar and Chalnakhel in Kathmandu district. In Bhaktapur district, the study was conducted in Changunarayan and Balkot. Likewise, in Lalitpur district, the study was conducted in Tikathali, Sirutar, Lubhu and Lamatar (Figure 1). These locations were selected as suggested by District Forest Offices (DFO) of the valley, Department of Forests (DoF) and the Central Zoo. This was also supported by the news about leopard encounters and conflicts published in local and national newspapers.

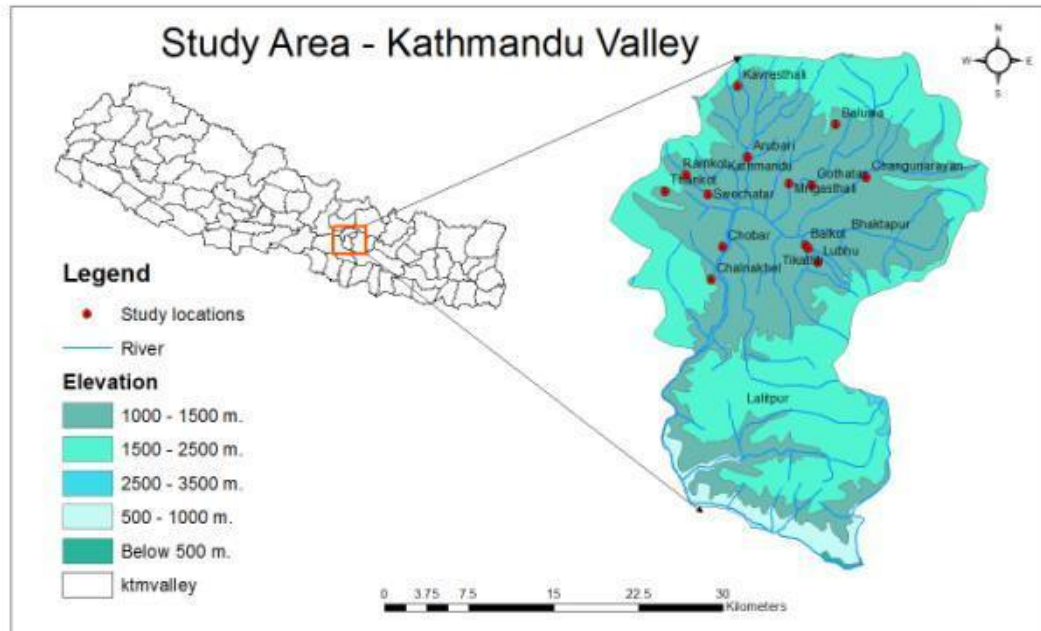


Figure 1. Study area - the Kathmandu valley

There are several major river systems flowing through valley of which Baghmāti, Bishnumāti, Dhobikhola, Hanumante and Manohara are the predominant rivers. These rivers system originates from the mountain elevation of 1500m to 3000m.

The Kathmandu valley is developed, populated and important industrial/commercial center of Nepal. According to a census conducted in 2011, Kathmandu metropolitan alone has 1.7 million inhabitants and the valley has a population of more than 2.5 million inhabitants. The valley is cultural and political hub of Nepal. The Kathmandu valley was accorded with the status of a World Heritage Site by UNESCO in the year 1979.

3.2. Fauna

The bowl-shaped Kathmandu valley is also rich in its faunal diversity. It comprises of different wild lives as the common leopard (*Panthera pardus*), Wild boar (*Sus scrofa*), Deer (*Cervus sps*), Jungle cat (*Felis chaus*), Squirrel (*Sciurus carolinensis*), Porcupine (*Hystrix indica*), Rabbit (*Oryctolagus cuniculus*), Jackal (*Canis aureus*), Lokharke (*Rautufa indica*), Yellow-throated martin (*Martes flabigula*) etc. Several surveys carried out in the Shivapuri National Park situated in the valley have identified different faunal species as Himalayan black bear (*Ursus thibetanus*), Himalayan goral (*Naemorhedus goral*), Barking deer (*Muntiacus muntjak*), Rhesus macaque (*Macaca mulatta*), Chinese pangolin (*Manis pentadactyla*), Clouded leopard (*Neofelis nebulosa*), leopard cat (*Prionailurus bengalensis*) etc.

3.3. Flora

Of the five vegetation zones of Nepal, the Kathmandu valley lie in the deciduous monsoon forest zone with an altitude range of 1500m to 3000m. The major vegetation type of valley are *Schima castanopsis* on the ground of the valley and at hill slopes, *Pinus roxburghii* on lower drier hill slopes, *Quercus lanata* and *Q. semicarpifolia* dominating upper hill slopes with *Rhododendron arboreum* on the reaches of surrounding mountains. Oak, Laurel are found at middle elevation, *Quercu slanata* and *Pinus wallichiana* at higher elevation. Altogether 1500 vascular plant species are reported from Kathmandu valley.

3.4. Climate

The Kathmandu valley falls on warm temperate zone ranging from 1,200 to 2,300 m where the climate is fairly temperate. The valley has a climate with warm days followed by cool nights and mornings. Rainfall is mostly monsoon-based from June to August receiving approximately 80% of rainfall with dry winters. During summer, temperature reaches to 35⁰c and in winter it drops to 3⁰c and average humidity is 75% (DHM 2010).

3.5. Socio-economy

Over the years, the Kathmandu valley has been home to people of various ethnicities, resulting in a range of different traditions and cultural practices. The Kathmandu valley is major hub of a country. Population of the valley was 1,645,091 in 2001 which increased to 2,510,788 in 2011 (CBS 2011).The largest ethnic groups are Newars followed by Brahmins, Chetri and Tamangs. Different ethnic groups from Terai have also become part of valley.

The location and terrain of the Kathmandu valley have played a significant role in the development of a stable economy. The economic output of the metropolitan area of the valley is worth more than 170 billion rupees per year. Other economic sectors include agriculture, education, transport and hotels and restaurants.

4. MATERIALS AND METHODS

4.1. Collection of data on leopards encounters and rescues

Primary data - Government officials of DFO and DoF along with the officers of the Central zoo were consulted for the information about HLC of the valley. Following their suggestions, a semi-structured set of questionnaires were prepared (Annex V). Primary data were collected using these questionnaires. The questionnaire was set-up to understand the following three general concepts of the villagers, often being troubled with leopard.

- General information on leopard
- Frequency and causes of leopard visit in human settlements
- Mitigation measures to be taken

The questionnaire was pre-tested on the subject (n=7) with the local respondent of Chobar and Chalnakhel VDCs of Kirtipur to understand the communicative quality of the questionnaire.

Secondary data - Secondary data were collected from the records and registrations from DFO of Kathmandu, Lalitpur and Bhaktapur districts, DoF and NTNC- Central zoo. Data were collected from other sources such as libraries, review of related literature, newspapers and various websites.

4.2. Exploring causes of conflicts and mitigation measures

Snowball sampling-Snowball sampling method was used to conduct the questionnaire/interview survey to find out the cause of conflict and suitable mitigation measures for HLC in the valley. Through this method, key informants of the HLC were identified in different places of the study site. With the help of these key informants it got easier to ensure information regarding causes of conflict and its mitigation measures to be endorsed to reduce the increasing HLC situations of the valley.

Questionnaire/Interview Survey- Altogether 110 individuals were questioned/interviewed from different sites of Kathmandu, Bhaktapur and Lalitpur district. These individuals included equal number of males and females. Snow ball sampling method was used to identify the key informants of HLC. The respondents include six victims of HLC, security personnel, HLC rescue member of Central zoo and local people often being troubled by leopards.

4.3. Analysis of Satellite Imagery of the Kathmandu valley

Landsat images using space craft ID Landsat 7 and sensor ID ETM () of 2003 (2003-03-04) and 2013 (2013-02-27) were downloaded using glovis website.

To see the changes in green biomass in between 2003 and 2013, NDVI process was employed. It is calculated from the red and near-infrared light reflected by the vegetation. The red and near infrared lights are represented by band 3 and band 4 of satellite images respectively. Digital number (DN) value of both images (2003 and 2013) was converted to Reflectance (R) value using ENVI 4.7. Further, NDVI of each year was calculated in Arc GIS 10 using the formula:

$$\text{NDVI} = (\text{NIR} - \text{R}) / (\text{NIR} + \text{R})$$

Where, NIR is near-infrared light represented by band 4 and R is red light represented by band 3 of landsat system respectively.

To find out change in land cover (green biomass) in the last ten years of the Kathmandu valley, difference between the NDVI of 2013 and 2003 respectively were calculated using Arc GIS 10.

$$\text{Output/Difference} = \text{NDVI}_{(2013)} - \text{NDVI}_{(2003)}$$

Where, the difference in NDVI value ranges from -1 to +1. Then the final map was reclassified using spatial analyst tool in Arc GIS 10 (Figure 7).

4.4. Data analysis

The collected data were analyzed by combining data of questionnaire/interview survey and personal communication with governmental officials. Every questions and responses of the respondent were coded in SPSS 16.0 software for analysis of responses statistically. The results obtained from different set of questions were calculated in terms of percentage. Line chart and bar chart were produced to represent the responses of respondent with the help of SPSS and MS-Excel. ENVI 4.7 and Arc GIS 10 software were used to create a field map and to find vegetation change over the last ten years of the Kathmandu valley. Leopard death and rescue data were collected during field visit and overlaid on the map (Figure 8).

5. RESULTS

5.1. Leopards encounters and rescues

Out of 38 leopards encounter cases, 19 leopards were found dead and 19 leopards were rescued from different places of the Kathmandu valley (Annex IV). Major conflicted sites of the valley were identified by analyzing the data collected from the DFO of Kathmandu, Lalitpur and Bhaktapur districts and Central Zoo. These sites included villages residing nearby forests as well as the residential areas (Annex IV). Villages near by forests were Chobar, Chalnakhel, Kavresthali, Thankot, Baluwa, Changunarayan, Ramkot, Vimdhunga, Pharping, Budhanilkantha, Gagalphedi, Jitpurphedi, Dahachowk, Sipadol, Chhaling, Godawari, Sesnarayan and Pataldhonse. Arubari, Balkot, Tikathali, Lubhu, Gothatar, Mrigasthali, Kirtipur, Gorkarna, Danchi, Maharajgunj, Banasthali, Balaju, Sallaghari, Jhaukhel, Jharuwarasi and Swechatar were the residential areas.

Out of 107 respondents, 35% noted the increase of leopards in their surroundings, 15% indicated a decrease in number of leopards while the remaining 50% of the total respondents claimed on constant population of leopards in their area as they see at least two leopards annually near their settlement (Figure 2).

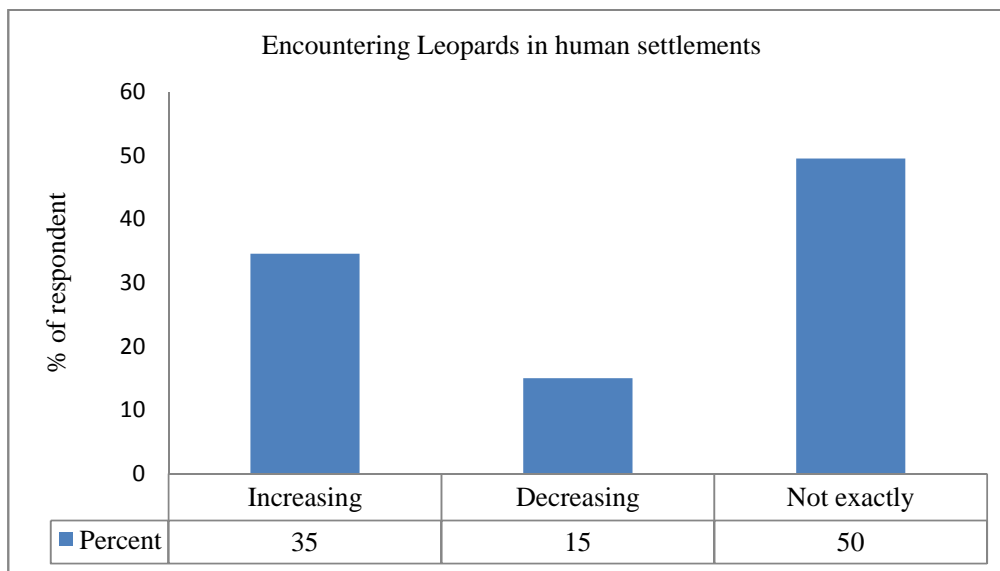


Figure 2. Encountering leopards in human settlements

Leopards were encountered at any time, day and night but the highest encounter was during the morning (Figure 3).

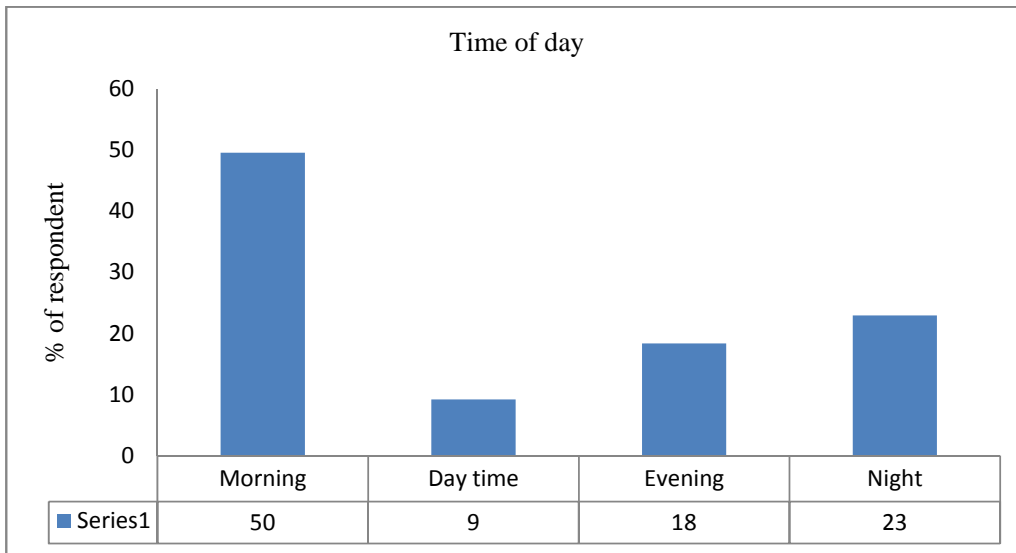


Figure 3. Time of a day of leopard’s movement towards village

According to 60% of the total respondents, summer from March to September was the major period of encountering leopards. The remaining 40% noted the presence of leopards in nearby settlement in the period of winter from October to February (Figure 4).

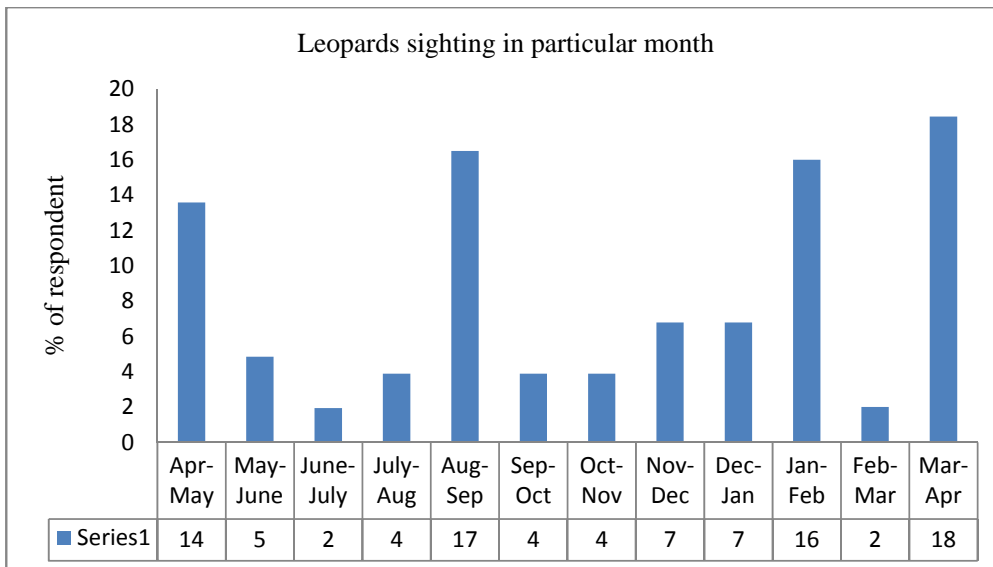


Figure 4. Leopards sighting in particular months

Of 38 leopard encounter cases in different places of the Kathmandu valley from 2010-2013, 19 leopards were found dead. Five leopards were dead in 2010, six leopards in 2011, and the number decreased to four in 2012 and 2013 (Figure 5).

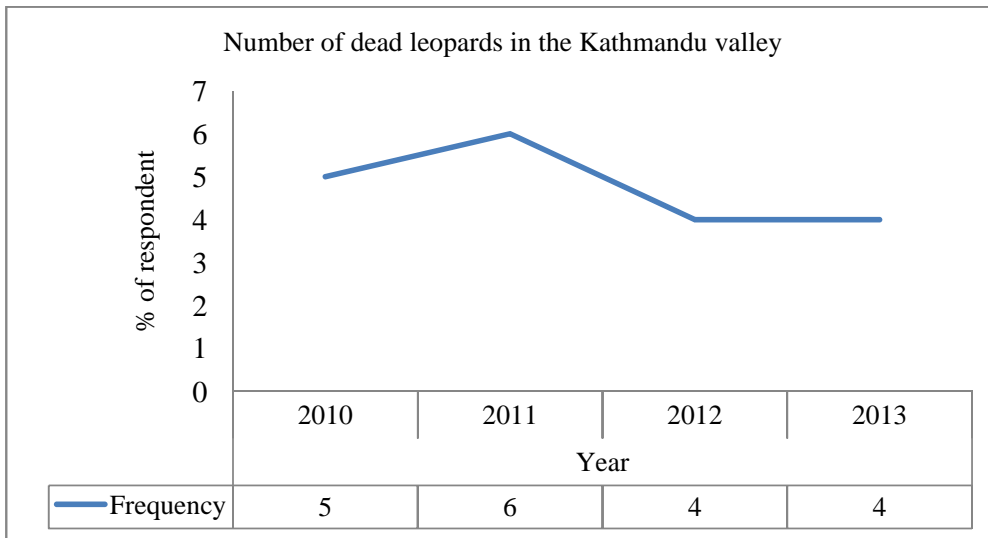


Figure 5. Number of dead leopards in the Kathmandu valley

5.2. Causes of human-leopard conflict

Most of the respondents (65%) answered the causes of leopards visiting the human settlements was due to lack of prey species in forests and 28% thought it was due to deforestation and the rest of respondents said different causes like fetch for water and forest fire (Figure 6).

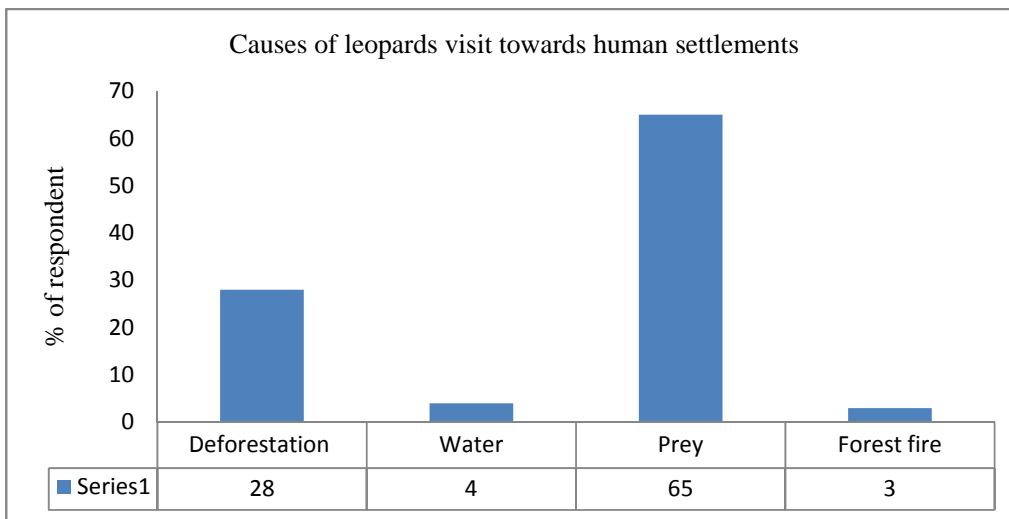


Figure 6. Causes of leopards visit towards human settlements

5.3. Habitat change analysis of the Kathmandu valley (2003 - 2013)

During the period of 2003 to 2013, an area of 4011 hectare (ha) of forest was converted to barren land in the Kathmandu valley (Figure 7). Most of the human-leopard conflict cases

occurred in forest cover change area i.e., forest cover converted into settlements or agriculture or barren land and the area where change is occurring gradually (Figure 8).

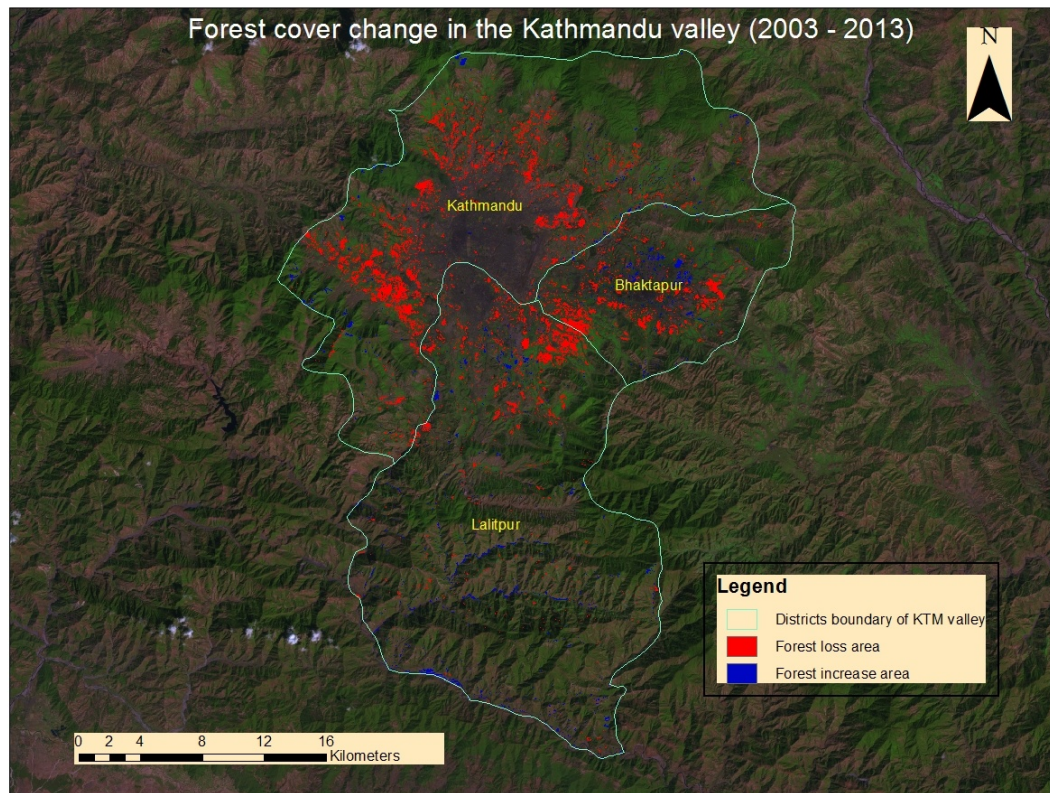


Figure 7. Forest cover change in the Kathmandu valley

Out of 38 leopards encounter cases, 19 leopards were found dead and the remaining 19 leopards were rescued from different places of the Kathmandu valley. Seven leopards were found dead in boarder area of SNP (Figure 8). Out of three districts in the valley, Kathmandu district was the most human-leopard conflicted district as most of the dead and rescued leopards were found in Kathmandu (Figure 8). Dead leopards were found in Sesnarayan, Pharping, Chobar, Pataldhonse, Vimdhunga, Ramkot, Jitpurphedi, Kavresthali, Budanilkantha, Baluwa, Gagalphedi, Gothatar and Gokarna. The leopards were rescued from Pharping, Chalnakhel, Kirtipur, Dahachowk, Thankot, Swechatar, Arubari, Balaju, Banasthali, Maharajung, Mrigasthali and Danchi (Figure 8).

A total of 28 human leopard encountered cases were recorded during the period of 2010 to 2013 in Kathmandu district of which 16 leopards were found dead. Six leopards were encountered in Bhaktapur district of which three leopards were killed. One leopard was killed in Changunarayan area where the forest cover has changed into barren land and the

remaining two in Jhaukhel and Chhaling respectively. Three leopards were safely rescued from Balkot, Sallaghari and Sipadol. Similarly four leopards were encountered in Lalitpur district (Lubhu, Tikathali, Godawari and Jharuwarasi) but they were all safely rescued (Figure 8).

Baluwa, Kavresthali and Sesnarayan areas were found to be most conflicted areas in Kathmandu where leopard killing was repeated. In Gothatar of Kathmandu, 15 people were injured in a conflict with leopard in April 2013. Tikathali, Lubhu, Lamatar, Sirutar and Godawari were the most leopard sighting places in Lalitpur district but conflict was recorded in Lubhu and Godawari (Figure 8).

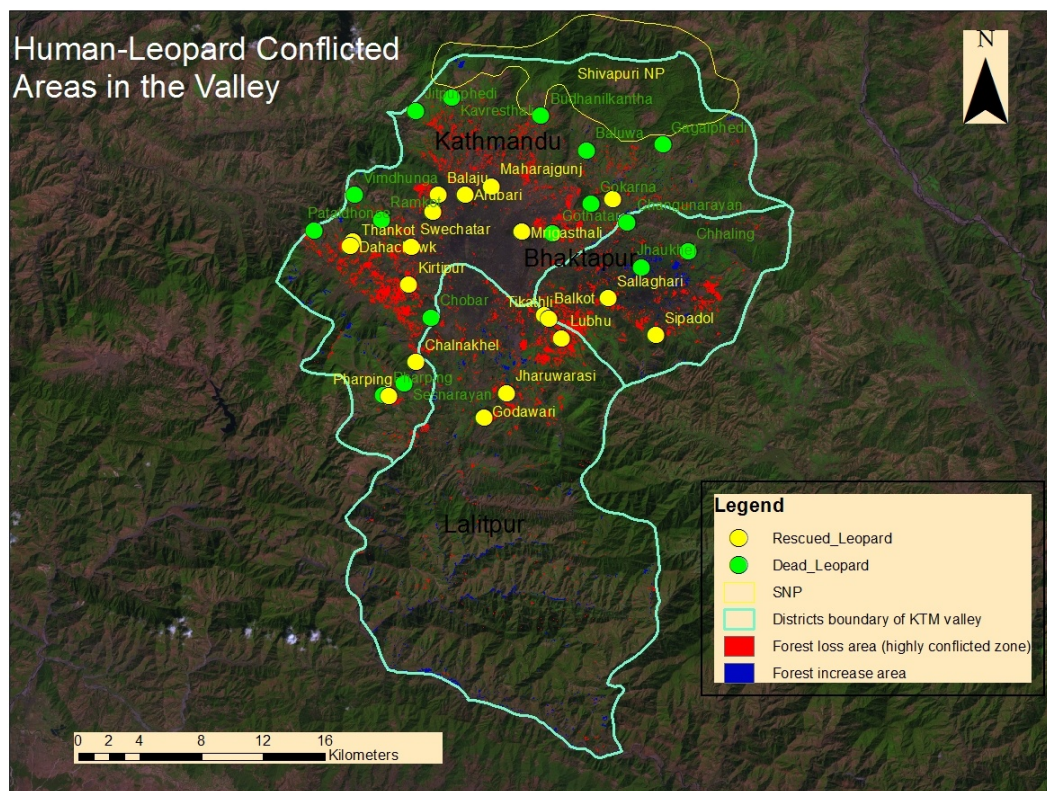


Figure 8. Human-leopard conflicted areas in the valley

5.4. Mitigation measures for human-leopard conflict

There was a mixed response of respondents to conflict management strategy to be applied for reduction of increasing HLC in the Kathmandu valley. Out of 105 respondents, 29% suggested for the restoration of leopard habitat through afforestation, 23% for managing preys in their native habitat, 19% suggested for fencing around SNP, 18% suggested for

awareness raising activities for local community and the rest 11% suggested keeping problem animal in zoo as conflict management tool.

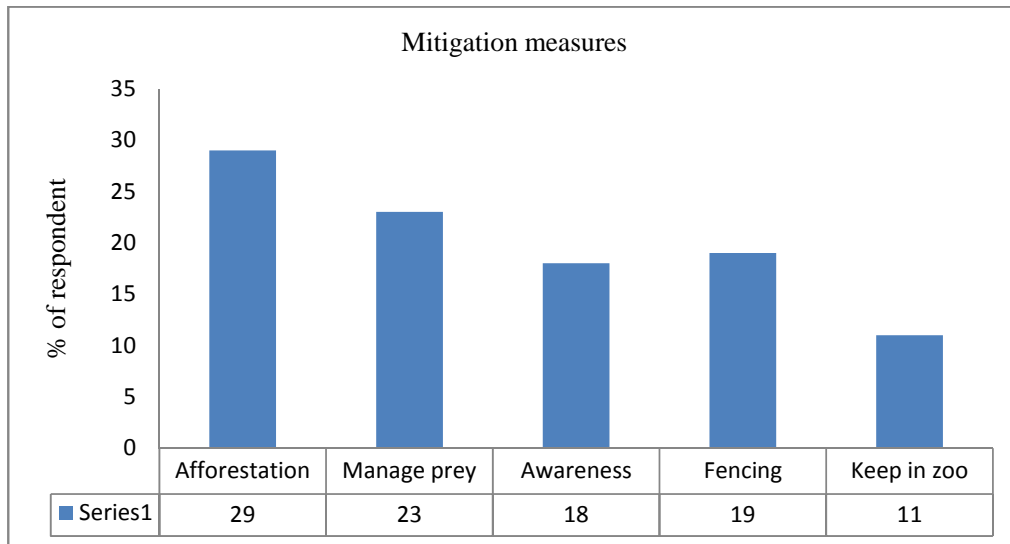


Figure 9. Mitigation measures to control human-leopard conflict

6. DISCUSSION

6.1. Leopards encounters and rescues

With the current rate of expansion and growth of human population, conflicts with carnivores are becoming more and more unavoidable. Study of Koirala et al. (2012) in the lower belt of Annapurna Conservation Area showed the loss due to leopard was higher in winter season. Thapa (2011) observed seasonality in livestock depredation by leopards was more prevalent in the monsoon and summer. Current study showed more encounter with leopards during summer as 60% of the respondents claimed of encounter with leopards during the summer. Also the study showed that leopards and humans come across each other at morning time. 50% of the respondents claimed leopard encounter during morning and 23% during end of the day. These timings coincide with the findings of Rahalkar (2008) in Maharashtra, India, where the livestock are either herded back inside the cow shed at the evening or relieved from their shed at morning. Similarly, study conducted by Balme et al. 2007 in Phinda private game reserve, South Africa found morning and evening as active time for leopards.

Out of 12 leopards rescued from different places of Kathmandu district six were released to SNNP and remaining six were released to their own locations from where they were rescued. Most of dead leopards were found in villages nearby forests and rescue cases were in town. This may be due to lack of awareness among villagers for wildlife conservation. People in the town comparatively seem to be more aware as they timely inform concerned authority to rescue leopards when encountered.

6.2. Causes of human-leopard conflict

Leopards are highly territorial animals and when displaced, they have a tendency to seek out their original territory, which may be hundreds of kilometers away (Athreya 2006). In the Kathmandu valley the translocation of leopards from their original place to another may be one of the causes of conflict. Out of 38 human-leopards encounter cases recorded from 2010 to 2013, 50% (19 leopards) found dead in the Kathmandu valley. Increasing encounter of leopards in the settlements nearby forest is due to the declining state of forest with loss in its natural prey (Athreya et al. 2007). When leopards enter the village area it may get habituated there due to accessible prey and may not to return back to their natural habitats. Stray dogs and some domesticated animals are the easy preys for leopards (Athreya et al. 2007). During my study some respondents from Lubhu and

Sirutar VDCs also reported about the leopards visiting settlement areas in search of easy preys like domestic livestock that do not have anti-predatory behavior (Linnell et al. 1999). Interview survey and satellite imagery of this study showed that deforestation is the cause of HLC in the valley. As deforestation results in lack of prey, leopards lurk towards settlements in search of easy prey.

6.3. Habitat change analysis of the Kathmandu valley (2003 - 2013)

Vegetation change map shows that HLC was observed at areas where forest cover has converted into settlements. This indicates one major cause of HLC is deforestation but from the questionnaire/interview survey I found lack of prey is major driver to bring leopards out from the forest which is partly due to deforestation, related with the loss of prey species of leopards. The satellite image analysis result and local people perception regarding leopard occurrence in the village seems to be different. This may be because local people do not want to take the responsibility of habitat change as a major cause of HLC and blame leopards as they come out from forest to prey their livestock.

6.4. Mitigation measures for human-leopard conflict

Human-carnivore conflict is a delicate issue to be resolved in the field of conservation. It becomes complex issue when the predators and mankind share the same habitat. So the issue needs to be managed properly to achieve the goal of wildlife management and well-being of local people (Thapa 2011). In this study I found, releasing problem leopard to its natural habitat or translocation to other leopard habitat is generally followed to mitigate HLC. But the process of translocation is not recommended for problem carnivores due to reasons rooted in their biology such as very strong territoriality, movement of the conflict with the individual, social disturbance of existing leopard populations at site of capture as well as release, etc. (Linnell et al.1996, Linnell et al. 1997, Treves and Karanth 2003 and Athreya et al. 2004).

Also when encounter with leopards, human provocation have often result in aggressive nature of leopards. To minimize conflict, it is important to aware local communities on the merits of afforestation, techniques to tackle leopards when sighted in villages where leopard share space in human dominated landscape like settlements nearby SNNP and forest areas. Enhancement of the number of wild prey populations in its natural habitat hold much promise for reducing and better managing conflicts.

7. CONCLUSIONS AND RECOMMENDATIONS

7.1. Conclusions

- Human-leopard conflict is an escalating problem in the Kathmandu valley. 38 leopards encounter cases were recorded of which 50% (19) leopards were found dead in four year period (2010-2013). Kathmandu district was the most human leopard conflicted district.
- Forest cover change into settlements, limited prey species in forest and insufficient awareness level of local communities were found to be the major causes of HLC in the Kathmandu valley.
- With the increase in population of the valley, forest cover is changing into settlements/agricultural and barren land. NDVI change showed that an area of 4011 ha of forest cover was changed to barren, settlement or agricultural land from 2003 to 2013.
- Local education awareness campaigns, habitat restoration, and enhancement of wild prey populations hold much promise for reducing and better managing conflicts.

7.2. Recommendations

- Further research on the availability of natural prey species in the leopard habitat is essential.
- Establish a problem leopard rescue center as problem leopards are not recommended to display at the zoo and translocate in another habitat.
- Maintain the data /records of number of leopards trapped and rescued and the proximity of these sites where the conflict occurred in order to analyze human-leopard conflict patterns in the Kathmandu valley.
- Raise public awareness with sufficient information on leopard behavior and rescue techniques in conflict prone areas in the Kathmandu valley.
- Develop a problem leopard rescue team with full government authority in the Kathmandu valley to rescue problem leopard on time.

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9. ANNEXES

Annex I. Some case studies from the field site

During study period, visiting different conflicted areas of the Kathmandu valley, I found that many people have to say many things regarding the encounter with leopards. All the stories regarding the onset of conflict situation are summarized below.

Kavresthali

Two leopards were encountered in this area of which one was found dead in paddy field due to electric current. Another leopard caused havoc in village attacking Mr. Nawaraj Chapagain (Annex III) a local resident of the village.

According to Mr. Hari Bahadur Phuyal, a key informant of Kavresthali, if a leopard is encountered in village, villagers inform concerned authorities and if the concerned personnel are late to reach the site, locals set up a trap for leopard and chase leopard into the trap and kill.

Baluwa

People of this village primarily rely on agriculture and poultry. Leopards preyed chicken several times in the village. Pawan kumar Bista, owner of one poultry farm, shared his experience. A leopard, with her cubs, came and resides nearby the poultry farm at the evening hiding behind farm bushes. Later at night, she entered the farm keeping cubs outside and started to take out chickens which were passed outside to her cubs. In one attempt approximately thirty chickens were taken out. In this way, in three to four attempts, the leopard with her cubs preyed the whole chickens of the poultry farm in a single night. This type of leopard attack was not happened to Pawan's farm only in the village. According to Mr. Bista, poultry farm owners keep poison on the carcasses of chickens to kill leopards on retaliation. Two adult leopards were retaliated in this village by poisoning.

Changunarayan

Deforestation in private forest for agriculture and real estate resulted loss of leopard habitat in Budathoki Gaun of Changunarayan VDC, Bhaktapur. Private forest of this area was supposed to be home for the leopards since history of the time where leopards used to be sighted occasionally in the past. A leopard was shot dead when it attacked two persons in 2013 at the village.

Gothatar

According to police record 15 people were injured in HLC in Gothatar. Keshav Pd. Lamichhane (Annex III) local resident of Gothatar was attacked by leopard and the remaining 14 people met an accident fracturing their legs and hands during runaway situation of the conflict. Four to five round of police firing was made to kill the leopard but in vain, at last people beat it to death, says Keshav Pd. Lamichhane.

Lubhu and Sirutar

Leopard was sighted in Lubhu VDC of Lalitpur district which later turned into conflict in 2012. Leopard attacked Laxmi Bajracharya (Annex III) of the village. Conflicted leopard was tranquilized by zoo officials and taken to central zoo. Sunil Rana Magar, local resident of Lubhu claimed that two leopards are sometimes seen in the nearby Bamboo bushes of the village.

According to Sunil Rana Magar and Sobha Poudel of Sirutar VDC, stray dogs from major cities of the valley are collected and released in Lubhu and Sirutar villages of Lalitpur. Leopards often visit these places to prey on these dogs giving rise to conflict.

Annex II. Cases of human casualties in different countries due to leopard attack

Country	Region	Deaths	Year(s)	References
Nepal	Pokhara valley, Gandaki zone	12	1987-1989	Leopards attack in Nepal. Cat news (IUCN) 1989.
	Parwat district, Gandaki zone	1	2009	http://www.ekantipur.com/np/2066/9/2/full-story/303627.html
	Baitadi district, Mahakali zone	15	2010-2012	www.cnn.com/ASIA/
	Kavrepalanchok district, Bagmati zone	1	2013	http://khabarsansani.com/?p=1346
	Lalitpur district, Bagmati zone	1	2014	DFO, Lalitpur
	Argakhanchi district, Lumbini zone	4	2014	http://hankweekly.com/index.php?action=news&id=5851
	India	Sanjay Ghandi National National Park, Maharashtra	16	1986-1996
Mandi district, Himanchal Pradesh		13	1987-2007	Kumar, D., N. P. S. Chauhan 2011. Human-leopard conflict in Mandi district, Himachal Pradesh, India. Julius-Kühn-Archiv 432: 180–181
Uttar Pradesh		95	1988-1998	Hart, D. L. R. W. Sussman 2005. Man the hunted: Primates, predators, and human evolution. Page 1–11, 60–62. MA: Westview Press, Cambridge.
Pauri garhwal district, Uttarakhand		140	1988-2000	Goyal, S. P., D. S., Chauhan, M. K., Agrawal, R. Thapa, 2000. A study on distribution, relative abundance and food habits of leopard (<i>Panthera</i>

				<i>pardus</i>) in Garhwal Himalayas. Report submitted to Wildlife Institute of India, Dehradun.
	North bengal	15	1990-2008	Leopard study report. A report submitted to World Wide Fund for Nature 1997. New Delhi, India.
	Junagadh district, Gujrat	29	1990-2012	Shastri, P 2013. "Leopards kill 12 in Junagadh, injure 48 in one year". The Times of India.
	Himanchal Pradesh	6	2000-2007	Marker, L., S. Sivamani, 2009. "Policy for human-leopard conflict management in India". Cat News 50: 23–26.
	Pune district, Maharashtra	18	2001-2003	Athreya, V.R., S.S. Thakur, S. Chaudhuri and A.V. Belsare 2004. A study of the man-leopard conflict in the Junnar Forest Division, Pune District, Maharashtra. Unpublished report Submitted to the Office of the Chief Wildlife Warden, Nagpur. India.
	Jammu and Kashmir	17	2004-2007	Nabi, D. G., S. R., Tak, K. A., Kangoo, M. A. Halwai, 2009. "Injuries from leopard attacks in Kashmir". <i>Injury</i> 40: 90–92
	Erode area, Tamil Nadu,	2	2015	http://www.deccanherald.com/content/463344/deaths-due-animal-attacks-rise.html
Pakistan	Ayubia National Park, Khyber Pakhnhwa	12	1989-2006	Lodhi, A 2007. Conservation of leopard in Ayubia National Park, Pakistan. University of Montana.
	Machiara National Park, Azad Kashmir	2	2004-2007	Dar, N. I., R. A., Minhas, Q., Zaman, M. Linkie, 2009. Predicting the patterns, perceptions and causes of human–carnivore conflict in and around Machiara National Park, Pakistan. <i>Biological Conservation</i> 142: 2076–2082
Srilanka	Yala National Park	1	2011	http://www.sundaytimes.lk/110717/Plus/plus_11.html

No complete database of fatal leopard attack exists as many countries do not keep official records.

Annex III. Victims of different leopard conflict situation in the Kathmandu valley

S. No.	Name of the victim	Sex	Age	Address	Situation of attack	Condition of leopard
1.	Nawaraj Chapagain	Male	40	Kavresthali-3	Encountering leopard in paddy field, victim chased the leopard which in turn attacked the victim.	Tranquillized by zoo personal which died after 4 days of the incident.
2.	Hari Kaji Bhadel	Male	63	Changunarayan-2	On sighting leopard villagers gathered around, leopard entered into nearby home pipe. Villagers closed one side of the pipe and lit fire on other side. With extinguishing fire victim peeped into the home pipe to see if leopard was present there or not, leopard from inside the pipe attacked victim.	On running out from the home pipe leopard further attack Sita Ram Neupane. It was shot dead by police.
3.	Keshav Prasad Lamichanne	Male	50	Gothatar-1	After assuring the crowd of people to make a way for leopard to let go its way, victim was returning back to home. But at the meantime leopard attack victim from back.	Leopard was killed by villagers.
4.	Laxmi	Female	38	Lubhu-4	Victim was	Handed to

	Bajracharya				conducting her household work inside home premises. A leopard being chased by the villagers attacked the victim.	central zoo.
5.	Dev Narayan Shrestha	Male	50	Gothatar-1	Fell down from rice field while running away from leopard during Gothatar conflict, he broke an ankle. Victim still cannot walk properly.	Killed by villagers.

Annex IV. Locations of HLC in the Kathmandu valley

S.No.	X-cordinates	Y-cordinates	Elevation	Place	Condition
1	331514	3060606	1287	Chobar	Dead
2	330517	3057705	1330	Chalnakhel	Rescued
3	332851	3074859	1419	Kavresthali	Dead
4	326413	3065554	1403	Thankot	Rescued
5	341584	3071453	1349	Baluwa	Dead
6	333729	3068581	1372	Arubari	Rescued
7	344238	3066776	1332	Changunarayan	Dead
8	338883	3060757	1332	Balkot	Rescued
9	339160	3060509	1300	Tikathli	Rescued
10	339953	3059255	1328	Lubhu	Rescued
11	339405	3066081	1334	Gothatar	Dead
12	337409	3066216	1335	Mrigasthali	Rescued
13	330228	3065213	1302	Swechatar	Rescued
14	328325	3066955	1384	Ramkot	Dead
15	330069	3062726	1401	Kirtipur	Rescued
16	326525	3068576	1426	Vimdhunga	Dead
17	328738	3055514	1576	Pharping	Rescued
18	341907	3067999	1360	Gokarna	Dead
19	338628	3073691	1484	Budhanilkantha	Dead
20	346538	3071826	1752	Gagalphedi	Dead
21	343267	3068305	1375	Danchhi	Rescued
22	335431	3069127	1343	Maharajgunj	Rescued
23	330528	3074018	1577	Jitpurphedi	Dead
24	331649	3067496	1302	Banasthali	Rescued
25	331983	3068557	1326	Balaju	Rescued
26	329753	3056359	1581	Sesnarayan	Dead
27	323929	3066256	1510	Pataldhonse	Dead
28	328436	3055576	1623	Pharping	Dead
29	326264	3065232	1391	Dahachowk	Rescued
30	342976	3061856	1317	Sallaghari	Rescued
31	346096	3059477	1406	Sipadol	Rescued
32	345174	3063885	1370	Jhaukhel	Dead
33	348164	3064914	1376	Chhaling	Dead
34	336397	3055699	1439	Jharuwarasi	Rescued
35	334921	3054133	1485	Godawari	Rescued

(Locations plotted in figure 8)

Source: DFO of the valley, Central Zoo records and field survey 2013.

Annex V. Questionnaire

घर धुरी सर्वेक्षण

१. नाम ठेगाना उमेर
लिङ्ग शिक्षा पेशा
२. तपाईंको क्षेत्रमा कुनकुन जंगली जनावरहरु पाईन्छ?
३. तपाईंलाई चितुवाको बारेमा केहि थाह छ ?
यदिथाहा छ भने केहि जानकारी दिन सक्नुहुन्छ?
४. तपाईंको घर बस्तीमा कहिल्यै चितुवा बाहिर निस्किएको छ ?
छ भने कहिले महिना
कुन समयमा बिहान दिउँसो साँझ रातमा
५. तपाईंको घर बस्तीमा बिगत पाँच बर्षमा कतिचोटि चितुवा निस्किएको छ होला?
६. चितुवाले गरेको क्षतिवाआक्रमणको बारेमा यहाँलाई केहि जानकारी छ ?
छ भने तपाईंहरुको घर बस्तीमा बितेको ५ बर्षमा कतिचोटि चितुवाले आक्रमण गरेको छ होला?
७. तपाईंको बिचारमा चितुवा किन घर बस्तीमा निस्कन्छ होला?
क. जङ्गलको बिनाश (बास स्थानको कमी) ख. पानी खान
ग. शहरीकरणले गर्दा घ. आहारको खोजीमा
८. तपाईंको बिचारमा चितुवाले किन मानिसलाई आक्रमण गरेको होला?
क. मानिसले जिस्काएर ख. चितुवाको बास स्थानमा कमी भएर ग. अन्य
९. आक्रमणगर्ने चितुवाको शैली कस्तो भेट्नु भएको छ ?
क. लुकेर ख. अगाडिबाटै
१०. तपाईंको घर बस्तीमा आक्रमणगर्न निस्किएको चितुवाको जीवित नै उद्धार भएको छ कि मृत अवस्थामा?
११. तपाईंहरु गाउँलेनै मिलेर चितुवाको उद्धार गनुभएको हो कि अरु कोहि अनुभवी व्यक्तिद्वारा
जस्तै : विभागका मानिसहरु चिडियाखानाका अनुभवी व्यक्तिहरु
१२. कस्तो ठाउँमा चितुवाले अलिबढि आक्रमण गर्छ होला?
क. जङ्गल नजिकको बस्तीमा

- ख. बढि शहरीकरण भएको ठाउँमा
ग. सुनसान बस्तीमा
१३. बिगत ५-१० बर्षमा तपाईंको क्षेत्रमा जङ्गलको विनाश/फडानीभएको छ कि छैन ?
छ भने अनुमान गर्न सक्नुहुन्छ?
जङ्गल विनाश हुनुको कारण के होला?
१४. कसैले चितुवाको आक्रमणबाट बच्न वा आफ्नो रिसिवि साधन चितुवा निस्कने खोला,
खोल्सावा अरु कतै विषको उपयोग गरेको थाहापाउनु भएको छ ?
१५. चितुवा देखेमा सबैभन्दा शुरुमा के गर्नुहुन्छ?
क. आत्तिएर चिच्याउने
ख. शान्त रहेर सम्बन्धित निकाय लाई खबर गर्ने
१६. तपाईंको विचारमा तपाईंको घर बस्तीमा चितुवाको संख्या बढेको छ की घटेको छ ?
क. बढेको छ
ख. घटेको छ
ग. यसै भन्न सकिन्न
१७. चितुवाले गर्नेहानि नोक्सानीको रोकथाम के कसरी गर्न सकिएला?
क. वन संरक्षण गर्ने
ख. वन जङ्गल भएको क्षेत्रमातार बार गर्ने
ग. प्राकृतिक आहाराको व्यवस्था मिलाउने
घ. जनचतेन ।जगाउने
ङ. समस्या पुऱ्याउने चितुवालाई चिडियाखानामा राख्ने

Annex VI. Some photos from the field site



Interaction with leopard victim at Kavresthali



Questionnaire survey with security personnel at Changunarayan



Discussion about HLC with local people of Gothatar



Leopard encounter news in Bode, Bhaktapur



Human settlements in outskirts of the Kathmandu Valley



Photo by: KiranPanday

Leopard resting in tree found in private compound at Dhapasi of Kathmandu

Annex VII. Some photos of Gothatar conflict

(Published on mail online, June 9, 2013)



Chasing and capturing a leopard between houses in Gothatar



Local people dragged the dead leopard which attacked 15 people in Gothatar