Spatio–temporal pattern of human leopard conflict and mitigation strategy in Baitadi district, mid–hills of Nepal

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Human–wildlife conflict is increasing globally, particularly in the areas, where wildlife and humans coexist and share resources. Large mammalian predators such as common leopards not only kill livestock but they are also killing humans. Baitadi is among the top ranked districts in Nepal in terms of number of human common leopard conflict events in last 10 years. The fieldwork for this study was carried out between January and June 2020 in the villages of *Bishalpur, Udayadev, Pancheshor* and *Aamchaura* of Baitadi district. Field observation, questionnaire survey, key informant interview and literature review were used for the data collection. Our study found that common leopards killed 23 and injured eight people between 2011 and 2019 in the district. In retaliation, people killed 26 common leopards in the same period, which must have spelt disaster for these rare cats. Despite the increasing number of conflict events, the local people, in general, were found to have positive attitude towards wildlife conservation. Therefore, improved prey species management, awareness raising among the local people and detailed study on habitat assessment, population status of leopards and their prey species are the urgent needs for the mitigation of human common leopard conflict in the district.

Keywords: Conservation, habitat management, human–wildlife conflict, mitigation strategy

Human–wildlife conflict (hereafter HWC) is an ongoing issue in many parts of the world and is creating significant problems in the parts where wildlife and human populations coexist and share limited resources (Bhandari *et al.,* 2019; Wang & Macdonald, 2006; Woodroffe, 2000). Conflicting situations arise when wildlife negatively affect the lives of humans or when the activities of humans negatively affect the needs of wildlife (Dickman & Hazzah, 2016; Wang & Macdonald 2005). Conflict between humans and wildlife is escalating due to the increased human population, loss of natural habitat, and in some areas, even increasing wildlife populations as a result of successful conservation programmes (Baral *et al.,* 2021; Laurance *et al*., 2000; Naha *et al.,* 2018; Syombua, 2013). HWC is not only an issue for humans and their livestock but when humans retaliate, this also has an impact on the survival of many endangered mammalian predators. As a consequence, large predator numbers are declining and at the same time people have concerns about their welfare, health and safety, economic existence and social costs (Aryal

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et al., 2016; Bhandari & Chalise, 2016; Le Bel *et al*., 2011). HWC may range from simple nuisance issues, such as crop damage, through to livestock depredation and potentially human life–threatening emergencies. Thus, HWC is a burgeoning problem in several parts of Nepal where people and wildlife share forest areas to fulfill their needs (Aryal *et al*., 2014a; Aryal *et al*., 2014b).

HWC has become quite a serious issue in and around the Protected Areas (PAs) of Nepal, (Adhikari *et al.,* 2018; Bhandari *et al.,* 2019; Neupane *et al.,* 2018; Sharma *et al.*, 2019). Due to the increased forest cover as a result of the successful Community Forestry (CF) programme, now a day, conflict has increased outside PAs as well (Baral *et al.,* 2021; Gurung *et al.,* 2008; Reddy et al. 2018). Over two thirds of the HWC incidences reported in last five years in Nepal occurred outside PAs (DNPWC, 2017). Previously, these incidents may have be underreported because there were no relief or compensation packages available from the government. The scheme to compensate the victims of human wildlife in PAs was started in 1996 following the endorsement of the Buffer Zone Regulation (DFO, 2018; 2019; DNPWC, 2017). However, this scheme for outside PAs was started only in 2012. So, people did not use to report HWC outside PAs before 2012 (DNPWC, 2017).

Out of the 77 districts in Nepal, 69 have reported human wildlife conflicts. Twenty–six species of animals were found to be involved in HWC (DNPWC, 2017). Among them, snow leopards (*Panthera uncia*), common leopards (*P. pardus*), tigers (*P. tigris*), Himalayan brown and black bears (*Ursus arctos isabellinus* and *U. thibetanus laniger*, respectively), elephants (*Elephas maximus*), rhino (*Rhinoceros unicornis*) and Rhesus monkeys (*Macaca mulata*) are the most common species involved in human wildlife conflict (DNPWC, 2017). Baitadi, a district in Far Western Province of Nepal, is among the most highly affected districts by HWC in Nepal (DNPWC, 2017)). During 2011 to 2019, common leopard killed 23 and injured eight people in the district. In retaliation, people killed 26 common leopards in the same period, in the district (DFO, 2019). Despite the increasing number of conflict events, limited number of scientific studies focusing on human common leopard conflict have been carried in the district. In this study, we investigated the spatial and temporal pattern of human common leopard conflict and assessed the causes and the potential strategies for mitigation of the ongoing conflict.

Materials and methods

Study area

Baitadi district (29^{o} 19' – 29^{o} 40' N and 80^{o} 22' – 80^{o} 50' E) is located in the Far Western Province of Nepal (Figure 1). Its elevation ranges between 390 and 2,950 meters above sea level (m a.s.l.). The total area of the district is 1,519 km^{2}. Sixty–two percent of the district is covered by forests. Of which, 69% are being managed under community forest system and the rest under the government management system (Kunwar *et al.,* 2016). Majority of the forests are dominated by *Pinus roxburghii* while the rest are dominated by mixed broadleaved species and Sal (*Shorea robusta*).

The total population of Baitadi district is 250,898 (DDC Baitadi, 2017). More than 80% of the population depends on agriculture for their livelihoods, followed by government jobs and businesses. Seasonal migration to India as laborers is also common in the district (Sharma, 2008).

The overall literacy rate of Baitadi district is well below the national literacy rate, with only 63% of the males and 49% of female can read and write (DDC 2018). Compounding this is the large number of people living in poverty. In the Baitadi district, 37% of the population lives in below poverty line compared to the national average of 18% in Nepal (NBS 2018).

The fieldwork for this study was carried out between January and June 2020 in the villages of *Bishalpur, Udayadev, Pancheshor and Aamchaura* as several common leopard attacks on villagers were reported from these villages (DFO, 2018). These are the remote villages with limited access to electricity and road facilities, where people are living in extreme poverty (Thapamagar *et al.,* 2019). The villagers have low literacy rate

and very low level of awareness about potential measures for mitigation of ongoing human common leopard conflict.

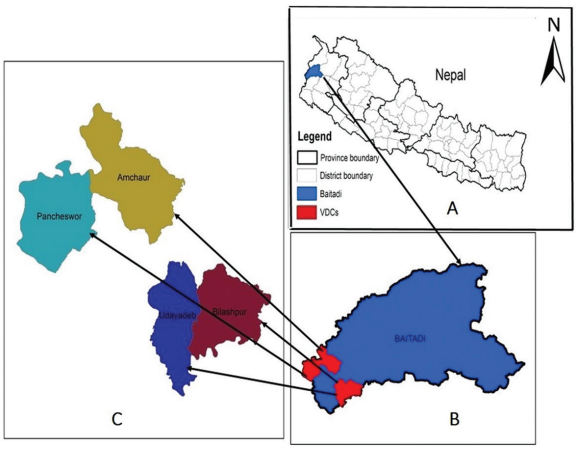

Figure 1: The study area map with (A) showing the location of Baitadi district within Nepal, (B) showing the location of four study villages within Baitadi district and (C) showing the four study villages

Data collection

Questionnaire survey

Questionnaire survey was used for the collection of information on HWC with victimized and non–victimized people. A total of 359 people (330 males and 29 females; Table 1) from *Bishalpur, Pancheshor, Aamchaura and Udayadev* were surveyed between May and June 2020. Most of the survey respondents were males because women in these villages rarely attended public gatherings and did not wish to be surveyed individually.

We collected information on the demography and socio–economy of the victims and their family (Table 2), the leopard attacks on humans and their consequence (death or injury), season of attack (autumn, winter, spring, rainy), time of attack (morning, day, evening, night), location of attack (forest, farmland, home).

Table 1: Details of the respondents of questionnaire survey. The respondents are disaggregated by village, sex and age

Villages	Sex		Age group (yr)			Total
	Male	Female	< 30	30–60	>60	
Amchaura	93	7	4	83	13	100
Bishalpur	78	10	9	71	8	88
Pancheshor	74	7	8	64	9	81
Udayadev	85	5	17	65	8	90
	330	29	38	283	38	359

Table 2: Socio–economic details of the respondents of questionnaire survey

Villages	Profession				Literacy				Economic status			Total
	Ag	J	B	O	I	P	S	U	L	M	H	
Amchaura	77	19	3	1	20	39	38	4	38	61	1	100
Bishalpur	81	3	3	1	27	16	43	2	46	42	0	88
Pancheshor	61	14	4	2	11	27	37	6	22	59	0	81
Udayadev	82	8	0	0	12	35	38	5	38	52	0	90
	301	44	10	4	70	117	156	17	144	214	1	359

Details on respondents' profession (Ag = agriculture, J = Government or private sector job, B = Business person, O = other), literacy or education (I = illiterate, P = primary, S = secondary, U = University), and economic status (L = low, M = medium, H = high) are shown.

Literature review

We reviewed Division Forest Office (DFO) Baitadi records to obtain information on number of HWC events. We used the HWC data between 2011 and 2019 because we couldn't find the records of HWC before 2011 at DFO Baitadi. We also obtained information on a range of other species involved in HWC from the records. Information about the victims (age group, gender, and ethnicity) were obtained from DFO Baitadi and Province Forest Directorate. In addition, the current policies related to the forest and wildlife conservation and the directives were also thoroughly reviewed.

Key informant interview

We interviewed DFO Baitadi staffs to obtain information on the current HWC policies, legal provisions, major interventions carried out to date and their effectiveness, and future strategies to combat HWC.

Perception survey

We surveyed perception of respondents to collect their impressions about need of wildlife conservation. Open–ended questionnaire was used and the people were asked whether they want to conserve wildlife or not and why. For the ease of analysis, the responses of people were broadly categorized into five categories namely, i) legal (punishment and imprisonment), ii) cultural importance, iii) identity, iv) ecosystem balance, and, v) tourism promotion (Table 3).

Table 3: Categorization of respondents' perceptions of wildlife conservation

We want to conserve wildlife and not kill them because :	Category
If we kill them, we will be punished.	Legal
Wildlife is protected by the law of Nepal and we respect our law.	
We worship nature (plants, wildlife, water, etc.) according to Hindu religion.	Cultural importance
Goddess Durga is believed to use leopard as her Vahana (vehicle) according to Hindu religion.	
Every wildlife has some religious value. If we disturb wildlife, our god will be angry with us and we will have to face different catastrophes like, heavy rain, landslide, hail stone, fire, epidemic, etc.	
Wildlife are the ornaments of our forests. Many of them helps to retain identity of our forests.	Identity
Wildlife are the gifts of god to us.	
Our livelihoods are closely connected to many wildlife. If we disturb them, our livelihoods will be disturbed.	Ecosystem balance
Snakes help us to control the mouse and birds help us in pollination of the crops.	
Wildlife help us promote tourism. Many local and foreign tourists come to Nepal to observe and to study wildlife.	Tourism promotion.
Wildlife support livelihoods of people.	

Data analysis

Data on HWC events between 2011 and 2019 obtained from DFO Baitadi records were tabulated based on year and species involved in the events. By examining the location of the incidents, and various characteristics of victims (age, gender, ethnicity, occupation, literacy etc), we performed an associative statistical analysis to identify whether correlated variables (positive/

negative) could help managers reduce wildlife attacks. The association between temporal variables (year, month, season, and time) and the HWC events were analyzed using Fisher's exact test. We classified the time of attack in four categories (Morning: 4.00 to 9.59, Day: 10.00 to 15.59, Evening: 16.00 to 21.59 and Night: 22.00 to 3.59) and seasons of attack also in four categories (Spring, Summer, Autumn and Winter) and tested whether time and season factor is significant in terms of occurrence of attack events. Similarly, we categorized the location of attacks i.e. home yard / settlement area, farm / cultivated land and forestland and tested the association of these variables with the attack events. Logistic regression was used to analyze the association between peoples' perception of wildlife conservation.

Results

Overall scenario of HWC in Baitadi district

During 2011 to 2019, 34 people were attacked by wildlife in Baitadi district. Of the 34 reported attacks, common leopard attacks accounted for 91% (n= 31), Himalayan black bear for 6% (n=2) and porcupine for 3% (n=1). The number of common leopard attacks are significantly higher than attacks by any other wildlife species (Fisher's exact test, p = 0.02). Of the 34 reported attacks, in 23 events, people (68%) were killed and in 11 events, people (32%) were injured. Common leopards were responsible for all human killings. They mainly attacked females (65%: n = 22) below 13 years. The age of humans attacked by wildlife ranges between 1.5 and 55 years. Since more children were attacked/killed, age is significantly associated with the wildlife attacks (Fisher's exact test; p = 0.0003). In contrast, wild bears attacked and injured 2 people resulting in no deaths and one person was injured from a porcupine attack (Table 4). Eighty–eight percent (n = 27) of all attacks occurred around the victim's home and/or backyard, while the rest occurred in farmland and forest area. Most of the leopard attacks occurred in 2012. Ten people were killed in 2012. Most of the victims were uneducated farmers or the children of uneducated farmers 65% (n = 22, Fisher's exact test, p = 0.0053).

DFO Baitadi records showed that 26 leopards were killed by people in retaliation in the same period. Thus, retaliatory killing appears to be a great challenge for the conservation of common leopards in the district.

Table 4: Human casualty and injury caused by wildlife in Baitadi district

Year	Wildlife	Number of human death	Number of human injured
2011	Leopard	5	0
2012	Leopard	10	0
2013	Leopard	3	0
2014	Leopard	1	0
2015	Leopard	2	0
2016	Leopard	2	0
2017	Leopard	0	3
2017	Bear	0	1
2018	Leopard	0	2
2018	Bear	0	1
2018	Porcupine	0	1
2019	Leopard	0	3
	Total	23	11

Of the 34 people attacked by wildlife, 20 (59%) were poor and 14 (41%) were medium class people. There is no significant difference in number of people killed or injured by wildlife by socio economic status (Fisher's exact test, p = 1). Among the victims, 35% (n = 12) were literate and 65% (n = 22) were illiterate. It shows that illiterate people are more often victimized by wildlife than literate people.

Human common leopard conflict situation in Baitadi district

Villages affected by human common leopard conflict

In total 13 villages (previously they were Village Development Committees–VDCs) namely, Amrhaura, Bishalpur, Dashrath Chand, Giregadha, Kulau, Mahakali, Melauli, Panchesor, Patan, Rhodidewl, Shrmali, Shivanath and Udayadev were found affected by human common leopard

conflict in Baitadi district. The village that suffered the greatest loss was *Bishalpur*, where nine people were killed by common leopards in last nine years.

Table 5: Number of human death in different villages

Villages	Bishalpur	Pancheshor	Aamchoura	Udayadev	Sharmali	Kulau	Giregada
Number of human death due to leopard attack	9	4	4	4	1	1	1

Time and season of leopard attacks

In 24 occasions, common leopards attacked their victims in the evening (16.00 to 21.59; Figure 2A). but leopards also attacked 5 people in the morning (4.00 to 9.59), 3 people during the day (10.00 to 15.59)and, two people at night (22.00 to 3.59) (Figure 2A). Further, most of the attacks of common leopard (n = 12) occurred during autumn followed by nine attacks in winter, eight in summer and, five in spring (Figure 2B). Our results show that common leopards attack people significantly more often in the evening (Fisher's exact test, p = 0.001) and in the autumn season (Fisher's exact test, p = 0.009).

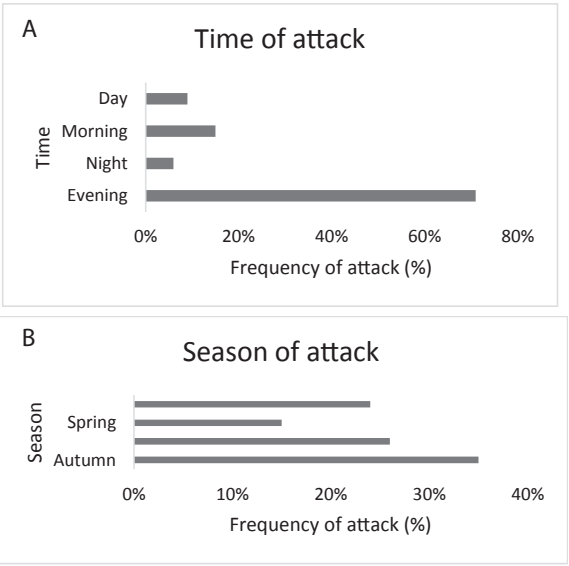

Figure 2: A) Time pattern of wildlife attack B.) Seasonal pattern of wildlife attack in Baitadi district

Spatial pattern of leopard attack

Out of 31 attacks of leopard 88% (n=27) were occurred close to the victims home and settlement area, 9% (n=3) in cultivated land and 3% (n=1) in forest area. As leopard attacks were significantly higher in home yard (Fisher's exact test; p = 0.0002), there were other common features of the attacks site i.e. absence of security lighting at village or around home in evening, presence of dense vegetation and unsupervised children playing at home yard in the evening. Eyewitnesses reported that the common leopards that attacked people were either old individuals or were females with cubs.

Possible causes of leopard attacks

From the questionnaire survey and the key informant interview, habitat modification and behavior of the villagers were identified to be the two key reasons of leopard attacks. Of the 359 people surveyed, 167 people thought prey scarcity inside the forests was the main reason of leopard attacks. Many of the interviewees freely admitted that illegal hunting of deer, wild boar (*Sus scrofa*), and other wildlife is common in the study villages. Other issues, such as, water scarcity (n = 97), forest fires (n = 59) and deforestation (n = 36) were also identified as possible reasons of leopard attacks. However, the perceptions were significantly different between the male and female respondents (χ^2 = 51.8; df = 3; p < 0.0001).

Lack of awareness about wildlife and leopard behavior among the villagers was identified to be a reason of leopard attacks by 209 respondents. Many respondents (n = 103) identified continual incursions and frequent entering to the forests to collect firewood and food were also major contributing factors. Habitat modification or land–use change i.e. encroachment of forest areas for agriculture and infrastructure, was identified as another reason of leopard attacks by 13% of the respondents. The perceptions of male and female respondents were not significantly different (χ^2 = 4.27; df = 2; p = 0.1181).

Perception on wildlife conservation

Despite the serious loss of lives inflicted by common leopards, 71% (n = 254) of the respondents showed positive perception towards wildlife conservation. They expressed the view that coexistence of human and wildlife is necessary so long as they do not cause harm to each other. We asked the respondents to rank the reasons why they think they should conserve wildlife and 50% of them ranked fine and imprisonment (i.e. if they kill the wildlife then they will be punished) the first. Cultural reasons were ranked second (34% (n = 124) of the respondents). Similarly other reasons identity, ecosystem balance and tourism promotion were stood in third, fourth and fifty ranks with the 40 (11%), 11(3%) and 2 (1%) respectively. The ANOVA test showed that the perception of the respondents were not significantly different ($F=0.000$; $df = 24$; $p > 0.005$) between male and female respondents.

Discussion

We found that common leopards killed 23 people in Baitadi district during period of 2011–2019. Most of the leopard victims were children and they were killed in close proximity to their homes. While other wildlife species have been reported to injure people, none of them has killed any humans. Habitat deterioration and decreased natural prey base within forests were identified to be the major causes for common leopards invading the human settlements, which is in line with the findings of Baral *et al.* (2021). Large predators like common leopards are more than capable of killing people and some have reported to switch their prey to specialize on humans (Brain, 1983; Sillero–Zubiri & Laurenson, 2001; Treves & Naughton–Treves, 1999; Woodroffe, 2000). Villagers are concerned that if common leopards are moving into villages because their natural prey is declining and their habitats are being modified, then the number of attacks are bound to increase in future further heightening the tension between people and leopard.

Most people killed by common leopards were children aged below 13 years. This is in line with the findings from Gharawal, India, where 41% of leopard victims were children aged under 10 years (Sathyakumar *et al.,* 2018). Majority of attacks occurring in the evening may has to do with the crepuscular or nocturnal nature of common leopards (Bailey, 1993; Grimbeek, 2006; Martins & Harris, 2013). Bhatia *et al.* (2017) have suggested that sickly or older leopards or female with cubs are more likely to attack vulnerable children because they would be easy to kill. Thus, organized efforts are required to raise awareness and to educate people about not leaving young children alone in the evening to prevent future leopard attacks.

In Nepal, autumn is the season of festivals and a large number of people travel during this time presenting an opportune time for leopards to attack people. Our data indeed showed that many attacks occurred in autumn in Baitadi district. Acharya *et al*. (2016) also found in their study from 2010 to 2014 that more people were killed in leopard attacks in autumn. On the other hand, spring is the dry season and most of the forests remain dry in this time. Though the lowest number of leopard attacks were recorded in spring in Baitadi district, leopards may still attack people because this is when a large number of forest fires erupt (Bhatia *et al*. 2017; Pitman *et al.,* 2012; Ritchie & Johnson, 2009) and the leopards may retreat to settlements in search for shelter and water.

The most highly affected villages in the Baitadi district lies in the western most border of Nepal that adjoins Pithauragadh district of India. The study villages are often scattered apart but most are situated near the patches of forests. This must be the reason most leopard attacks occurred within 1 km radius from the forest edges.

P. roxburghii is the dominant forest type in the study villages in Baitadi district. Fallen pine needles take long time to decompose on the forest floor and because of this, it prevents most grass species from growing well in the forests (Jackson, 1994). Consequently, the population of wild ungulates may be decreasing. This might be the major cause of prey scarcity of leopard within forest area. Unlike other ungulate species that live deep inside the forests, barking deer *(Muntiacus vaginalis*) depend on grasses on the forest edges

near village. In absence of deer deep inside the forests, common leopards prowl the forest margins looking for deer, rather than hunting deep inside the forests (Wang & Macdonald, 2006). Common leopards are opportunistic hunters (Balme *et al.,* 2007; DNPWC, 2017; Jenny & Zuberbuhler, 2005) and will attack any available prey when the occasion arises. With deer browsing close to the villages and common leopards seeking food, they may stray into villages seeking easy prey, which, in turn, may create situation for frequent encounter of leopard with people subsequent increase in number of attack events.

As few police and DFO staffs are present in these remotely scattered villages, poaching is rife. Villagers are poaching the species that are preferred by common leopards. Such competition for prey may intensify the problem of common leopards roaming in villages in search for food. Deforestation, agricultural encroachment and construction of rural roads are reported to cause habitat fragmentation and subsequent decline in prey numbers triggering behavior changes in wildlife (D'Angelo *et al.,* 2004; Laurance *et al.,* 2000; Laurance *et al.,* 2009; Syombua, 2013). This situation is being exacerbated by drying up of natural water sources in the forests. As a results of habitat modification and recent forest fires natural water sources are drying up in the forests. Indeed, the anthropogenic changes in forest structure has been highlighted as a key issue contributing to the increasing HWC (Bhandari & Chalise, 2016; Kshettry *et al.,* 2017; Treves & Naughton–Treves, 1999).

Most of the villagers depend on the natural resources in the forests for their livelihoods. For example, more than 80% of villagers rely on firewood from the nearby forests for cooking and heating. The villagers often visit forests for collection wild fruits and fodder (DFO, 2019). Such continual presence of the villagers in the forests is increasing the frequency of HWC in the study villages.

As result of out–migration of youths to the urban areas and abroad for education and employment, majority of agriculture lands in the villages are being left abandoned to be converted into bushy area in absence of work force in the villages for agriculture works (Childs *et al.,* 2014; Sharma, 2008). The situation is not different in the study villages. Such conversion of agriculture lands that used to function as buffer the forests and human settlements into bushy areas could be a cause that is facilitating common leopards to close to human settlements and subsequently increasing the human wildlife encounters.

It is promising to find that two third of the respondents are positive towards wildlife conservation despite the higher number of human casualties in the Baitadi district (Table 4). This is probably due to the religious belief of the people. Most of the people (> 92%) in the district are Hindus and in Hindu myth, common leopard is believed to be the vehicle (Vahan) of the goddess Durga (Dickstein, 2002; Miller, 2010; Mukul *et al.,* 2012). Regrettably, such beliefs are gradually eroding as people are becoming less religious (Adeola, 1992; Dickstein, 2002; Miller, 2010; Mukul *et al.,* 2012) and this is reflected in our results that 26 leopards were killed in retaliation in last nine years in Baitadi district.

In other regions with adequate skilled human resources and facilities, nuisance leopards are darted, captured in snares or traps and translocated (DFO, 2019; Viollaz, 2016). However, translocation is only a short–term solution to human common leopard conflict (DFO, 2019; Kshettry *et al.,* 2017). Conservation of their habitats and prey base are required so that there is little need for the leopards to stray into the villages. Unfortunately, there have been no studies on population of leopards and their prey species in Baitadi district. Provided insufficient prey are available because their habitats are constantly eroding, appropriate conservation/ management plans and actions are required to revive prey population. Population studies will be helpful to adopt the appropriate management strategies in future.

Conclusion

Human common leopard conflict is one of the major conservation issues in Baitadi district. During 2011 to 2019, common leopards killed 23

people and 26 leopards were killed in retaliation. *Bishalpur, Pancheshor, Aamchaura* and *Udayadev* are the highly affected village of leopard attack where female, illiterate, poor people and farmers / children of farmers are extremely victimized. Attacks were occurred significantly higher in evening time and autumn season. Similarly, 88 percent of the attacks were held close to or around home of the victims. Habitat modification and lower level of awareness on villagers regarding the habitat management of leopard were identified to be the two key reasons of leopard attacks.

There is no single solution to control HWC and promote coexistence. Therefore, there is a need to develop multilayer mitigation strategies (Dickman & Hazzah, 2016). To mitigate ongoing HWC and avoid future HWC, we recommend DFO Baitadi, concerned rural municipalities and CFUGs 1) to initiate habitat management activities such as construction/maintenance of water holes, grassland management for the ungulates/prey species of leopards, control forest fires, control poaching, and control forest fragmentation, 2) to carry out community awareness programmes to the villagers about leopards ecology and behavior and precautions to be taken to avoid HWC, and 3) to undertake detailed study on habitat assessment, population status of leopards and their prey species that will be helpful in prioritizing appropriate future management strategies.

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