Human-bear conflict in the Lahaul valley, Himachal Pradesh

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Certificate of Examination

This is to certify that the dissertation titled "**Human-bear conflict in the Lahaul valley, Himachal Pradesh"** submitted by Ms. Swastika Anand (Reg. No. MS16115) for the partial fulfillment of BS-MS dual degree programme of the Institute, has been examined by the thesis committee duly appointed by the Institute. The committee finds the work done by the candidate satisfactory and recommends that the report be accepted.

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Declaration

The work presented in this dissertation has been carried out by me under the guidance of Professor N.G. Prasad at the Indian Institute of Science Education and Research Mohali. This work has not been submitted in part or in full for a degree, a diploma, or a fellowship to any other university or institute. Whenever contributions of others are involved, every effort is made to indicate this clearly, with due acknowledgement of collaborative research and discussions. This thesis is a bonafide record of original work done by me and all sources listed within have been detailed in the bibliography.

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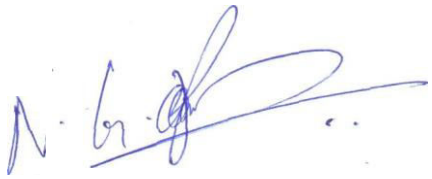
In my capacity as the supervisor of the candidate's project work, I certify that the above statements by the candidate are true to the best of my knowledge.



Professor N.G. Prasad

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As my intensive five years tenure at IISER Mohali is coming to an end, I would like to take this opportunity to write this note of thanks as a capstone to my thesis. Working on this thesis project has influenced me, not only in the scientific domain, but also on a personal level. I would like to thank IISER Mohali for providing me the opportunity to pursue my MSc project and Dr. N.G. Prasad for supporting me as my institutional guide. I would like to thank Dr. Yash Veer Bhatnagar and Dr. Rishi Kumar Sharma for providing me with this wonderful opportunity. Their support and guidance was crucial in the completion of this project. It was a golden opportunity for me to learn from their experiences and expertise in this field. I would also like to thank the Himachal Pradesh Forest Department for providing me with the permission to carry out this project. I am extremely grateful to WWF-India for the financial support for the project. Furthermore, I would like to express my deepest gratitude to my family, especially my father who was there with me throughout the project. Lastly, I would also like to thank my friends who have assisted me as field assistants during my fieldwork and the respondents for being a vital part of the project.

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Notation

Abbreviations:

HWC	Human-Wildlife Conflict
HBC	Human- Bear Conflict
F.D.	Forest Department
INR	Indian Rupee
USD	United States Dollar
NBA	National Biodiversity Authority
IUCN	International Union for Conservation of Nature
SSC HWCTF	Species Survival Commission Human-Wildlife Conflict Task Force
IDW	Inverse Distance Weighted Interpolation

Content:

ABSTRACT:

The Himalayan region has a history of people and wildlife sharing space. Less than 10 percent of the region is designated as protected areas, but wildlife populations occur across the region and are not restricted to protected areas alone. The region is witnessing an unprecedented socio-economic change due to, improved connectivity and integration with domestic and international markets, rapid growth in tourism, development of linear infrastructure and a growing human population with new aspirations. The region is facing increasing pressures to support a multitude of human enterprise and as human footprint and interface increases, so does the conflicts with the wildlife in the region. Loss of livestock due to predation by carnivores such as snow leopard, wolves and bears often causes severe economic losses to the local communities, imposes hidden costs, and increases vulnerability. Similarly, loss of crops to bears and wild ungulates also imposes cost on people sharing space with wildlife.

The Lahaul valley of Himachal Pradesh is a transition zone between the Trans-Himalayas and the Greater Himalayas and that endows it with rich floral and faunal diversity from both the regions. The resident agro-pastoral community primarily practice agriculture while the transhumant Gaddi community rears livestock, primarily sheep and goats. Earlier studies indicate a growing human-wildlife conflict with bear being reported as the species most often in conflict with people. This conflict ranged from losses to crops including recently introduced and valuable exotic vegetables such as broccoli and iceberg lettuce, apple as well as livestock depredation. I focused on understanding the nuances of human-bear relationships, the nature and extent of conflict and mitigation strategies the local communities use.

I administered a structured questionnaire to 197 respondents from 26 villages in Lahaul. Other than the village people, the Gaddi formed a major part of our study. My results show that the resident community lost 83 heads of livestock while the Gaddi community lost 165 heads of livestock amounting to a total economic loss of 46,50,000 INR between 2019 and 2020 (twenty months). The economic loss due to crop loss in 2019-2020 due to bears alone was INR 6,41,170 for 71 households. While people overall exhibited a positive attitude towards bears despite losing crops and livestock to bears, their tolerance towards bears was low. An ordinal logistic regression analysis showed that crop damage by bears was the

primary determinant of reduced tolerance of people to bears. The people reported deploying a range of interventions to deal with bears but most of these interventions lacked effectiveness. I present a nuanced understanding of the relationship between people and bears and suggest potential steps to mitigate human bear conflict in the region.

Chapter 1.
Introduction

1.1 Origin of study- Causes and problems of Human Wildlife Conflict HWC

Humans and wildlife have co-existed since ancient times, and a glimpse into the anthropological accounts give us the vast diversity of interactions between them (Saunders, 1998; Peterson et al., 2008; Newman, 2012; Athreya et al., 2013; Aiyadurai, 2016; Dhee et al., 2019). Such interactions range from appreciation, reverence, acceptance, utilization, to extreme conflict in the form of retaliation (Treves and Naughton-Treves, 1999; Ingold, 2000; Hunt, 2008; Lescureux and Linnell, 2010; Ghosal and Kjosavik, 2015; Bhatia et al., 2019). Management of the negative impacts of human wildlife interactions is vital for conservation because retaliatory killing of wildlife can threaten their populations and lack of support to communities to mitigate conflicts can further increase negative attitudes towards wildlife and conservation (Madden, 2004; Woodroffe et al., 2005; Bhatia et al., 2019). The negative interactions between the wildlife and the people are termed as human- wildlife conflict, and are an increasing conservation problem in India (IUCN SSC HWCTF, 2020).

Human-wildlife conflicts (HWC) are widespread, occurring when the wildlife's requirements overlap with the needs of the human populations (IUCN World Park Congress, 2003; Artelle et al., 2016). It particularly includes cases where wildlife threatens, charges, hurts or kills humans, or their livestock or crops or property. It also includes cases when humans deliberately abuse, injure, or kill wildlife due to a real or perceived threat to their livelihood, property, person or family (Madden, 2008). An ancient and widespread example of HWC is crop raiding (Hill, 1997; Naughton-Treves, 2001; Osborn and Hill, 2005) whereby a variety of birds, mammals, and insects utilize cultivated crops as food resources (Webber et al., 2007). Due to HWC, humans can be economically affected via destruction and harm to property and infrastructure (e.g. crops, orchards, grain stores, houses, water installation, fencing, and pipes), livestock depredation, and exposure to zoonotic diseases. Negative social influences include missed school and work, extra labour costs, lack of sleep, fear, etc. (Hoare, 1992; Human-Elephant Conflict Working Group, 2007). The affected individuals deal with such losses differently; some have high tolerance for losses whereas others might

retaliate against the wildlife species (Dickman, 2010; Goswami and Vasudev, 2017; Inskip and Zimmermann, 2009; McManus et al., 2014; Karanth and Kudalkar, 2017). Worldwide amongst the large carnivores, conflicts between humans and bears appear to have drawn much less attention than others, which includes felids (Macdonald et al., 2011) and canids (Macdonald and Sillero-Zubiri, 2004; Can et al., 2014). These massive omnivores are important for the ecosystem. Large carnivores act as keystone species, because as top predators they play an important role in regulating prey species, which in turn potentially impacts habitats and other species via trophic cascades (Terborgh, 2010; Ripple and Beschta, 2012; Ahmad et al., 2016). Due to HWC many large carnivores have become threatened. (Qamar et al., 2010; Ahmad et al., 2016). Moreover, such conflicts are likely to escalate in places where effective conservation measures help in increasing the number of wildlife (Namgail et al., 2007; Aryal et al., 2014).

Causes of HWC:

In recent years, with the increase in the human population, human settlements have encroached into new areas (Dickman, 2010), often inhabited by wildlife (Madden, 1999). The increased population has increased demands for raw material, land, energy, and food production. This leads to the transformation of the forests, savannah, grasslands and other ecosystems into fragmented agrarian areas or city agglomerates and is a critical driver for biodiversity loss and HWC (Madden, 1999; Madden, 2008). Growing livestock densities can deplete forage for wild herbivores, leading to forage competition. The overgrazing by the livestock leads to decline or even local extinction in wild herbivore populations (Mishra et al., 2003), thus increasing the proportion of livestock in carnivore diets. While many studies suggest that when wild prey is abundant, predators prefer it over domestic livestock and that impoverishment of prey populations is one of the foremost causes of carnivores shifting their diets to livestock (Mishra, 1997; Butler, 2000; Mishra et al., 2003), others have found that greater prey availability can lead to greater predator density which in turn can lead to greater predation of livestock (Abrams and Matsuda, 1996; Gascoigne et al., 2004; Suryawanshi et al., 2017). Thus, the effect of increase in density of wild prey can lead to either increase or decrease in livestock depredation by predator.

Another important cause of HWC is the formation of protected areas where human activities are prohibited or strictly limited, however, as human settlements encroach into and around protected areas, the levels of conflicts can increase (Preventing and Mitigating Human–Wildlife Conflicts: World Parks Congress Recommendation, 2004). The protected areas are often insufficient in size for the needs of wildlife which leads to them venturing in human settlements outside the protected areas in order to survive, thereby initiating conflicts (Madden, 2008). Retaliatory persecution as a result of HWC is one of the most significant threats that is pushing species to declines and extinction (Dickman, 2010). Additionally, other endangered wildlife species that are not commonly associated with HWC may incidentally or purposely be harmed because of retaliatory poaching or habitat loss (Madden, 2008). Although there have been many efforts from non-governmental organizations, governments, and academics, species declines have continued unabated in the past decades (St John et al., 2010). Factors such as the lack of co-ownership and co-management opportunities for the local residents, the costs of living with the wild neighbours being higher than the benefits, contribute to negative attitudes and retaliation (Madden, 2008).
It is widely accepted that human-wildlife conflicts are inevitable when humans and wildlife share the same habitat with limited resources (Le Bel et al., 2016). But a failure in identifying the conflict can lead to resistance of people in environmental initiatives, and a negative attitude towards wildlife, and reduced support for conservation efforts (Newmark et al., 1993; De Boer and Baquete, 1998; Naughton-Treves, 2001; Madhusudan, 2003; Webber et al., 2007). However, a better understanding of the patterns and drivers of conflicts coupled with an understanding of the socio-psychological response of people to such situations can greatly help manage the conflicts.

1.2 Study Species:

Bears are distributed all across the globe except Africa, Australia, and Antarctica (Nowak and Paradiso, 1983). In the world, there are eight species of bears, out of which four are found in India. They are versatile feeders and scavengers and play an important role in seed dispersal and providing nutrients to their habitat. They are also an indicator species of habitat quality and are pivotal for maintaining ecological balance (Sathyakumar and Vishwanath, 2003; Koike et al. 2008).

The brown bear has a varied habitat from arctic tundra and boreal forests and coastal forests, to the mountain forest of Russia and America in the north and grassland ecotone of the Himalayas in the south (Servheen, 1990). Since the agglomerate population of Brown bear is large and widely spread, globally they are of Least concern. However, the small, isolated population in India are threatened and placed under Schedule 1 protection (IUCN Red List of Threatened Species, 2012; National Biodiversity Authority, 2008). In the Indian Himalayas the subspecies, *Ursus arctos isabellinus* (The Himalayan brown bear or the red bear) is found. Based on a 2005 estimate, in India, the promising Himalayan brown bear distribution range is about 36,800 km^2, of which more than 10 % is protected under the existing network of protected areas in India (Sathyakumar, 2006a). The Himalayan brown bear is found in very low densities in the sub-alpine and alpine regions of the Greater Himalayas, and some regions of the Trans-Himalaya (Sathyakumar, 2001 and 2006a). The Brown bears' distribution is restricted to the northwestern and western Himalayan ranges in Jammu and Kashmir, Himachal Pradesh and Uttarakhand. In contrast, the Asiatic black bear is found in Jammu and Kashmir, Himachal Pradesh, Uttarakhand, West Bengal, Sikkim, Arunachal Pradesh, Assam, Meghalaya, Mizoram, Tripura, Manipur and Nagaland (Sathyakumar, 2006a). The Himalayan region and the hills of northeast India probably holds one of the largest populations of black bears in Asia (Sathyakumar, 2001, Sathyakumar and Choudhury, 2007; Charoo et al., 2011). But due to threats like habitat loss due to logging, growing human settlements, roadway networks, and hydro-power stations, along with hunting for skins, paws and gall bladders, this species has been listed as vulnerable under IUCN list (IUCN Red List of Threatened Species, 2012).

In the Asian landscape, only a few studies are available on the feeding ecology, phylogeography, and the distribution of the Brown Bears (Lan et al., 2017; Rathore, 2008; Sathyakumar, 2006a; Su et al., 2018). Many areas outside of the protected areas with suitable bear habitats have not been surveyed yet. The existing assessment of the species distribution was based on a questionnaire-based survey of key informants from academia and the forest departments. Their study shows that the Himalayan brown bear primarily occurs in alpine and sub-alpine regions of northwestern Himalayas (Sathyakumar, 2001; Sathyakumar, 2006a). A study from Pakistan on habitat selection of the Himalayan brown bear reported that brown bear prefer marshy vegetation with high forage production (Nawaz et al., 2014).

A recent study by ZSI on detection probability and occupancy assessment of the Brown bears in the Lahaul Valley has concluded a positive association between the agricultural land and alpine grassland with brown bear occupancy (Sharief et al., 2020). The findings by ZSI corroborates with other studies on the species (Nawaz, 2008; Rathore, 2008; Sharief et al., 2020). While the study in Pakistan showed that the bears tolerated human presence (Nawaz et al., 2014), the ZSI study found a negative association between brown bear occupancy and human settlement (Sharief et al., 2020). This might be because in the former study the resource rich areas were present near human settlements with little competition with humans (Nawaz et al., 2014). Thus, we can conclude that the species adapts to its surroundings based on the resource distribution and availability. This can also be inferred from the garbage raiding incidents in Alaska (Hanlon, 2017) and other areas, such as Kargil (Dasal, 2020), where there is poor management. Their ability to adapt by this omnivore can be attributed to their physiological ability to digest a vast range of food (Get Bear Smart Society, 2015).

Causes of Human-Bear conflict:

The maximum (75-90%) of bears' diet comprises of plant items. They select calorie rich food such as insects, fish, and meat when available. During late summer, they enter into a phase called hyperphagia in which they eat as many as 20,000 calories/ day in order to increase their fat reserves for the winter hibernation. Conflicts usually increase during this time (Hatler, 1967; Gunther et al., 2004; Get Bear Smart Society, 2015) due to bears' urge to travel large distances to seek calorie rich food. The nutrition they gain not only helps them to survive the winter but also affects their size, age of first reproduction, and litter size. For the females, if fat reserves are insufficient, the eggs will not implant and abortion takes place or she might not be able to nurse her cubs in the den (Get Bear Smart Society, 2015).

Since, human food, garbage, crops, orchards and livestock are rich in calories; bears might get tempted to enter human inhabited areas. In the long term, since bear population is proportional to food availability, there can be an unnaturally large bear population around human settlements (Ciarniello, 1997; Get Bear Smart Society, 2015). Bears' navigational ability and excellent memory allows them to return to the same place where they found food. Their ability to remember what they have learned (Rogers, 1993; get Bear Smart Society, 2015) leads to their forming association of people with food availability. An example of such

case can be the house break-ins by brown bears in Tibet. The Brown bears not only cause damage to doors, windows, furniture, and daily supplies (Dai, Li, et al., 2019; Dai, Xue, et al., 2019; Han et al., 2018; Wu, 2014) but also threaten the local herders' physical safety (Aryal et al., 2014; Aryal et al., 2012; Dai, Li, et al., 2019; Dai, Xue, et al., 2019; Han et al., 2018; Wu, 2014; Dai et al., 2019). While all sexes and ages of bears have been reported from human areas, particular age groups like subordinate males, subadults (particularly dispersing males), and female with cubs might utilize the human settlement areas more (Mattson, 1990). Various studies that include one in Spain, where predation by 50-60 Cantabrian brown bears (*Ursus arctos arctos*) were attributed with depredation resulting in 1,076 claims for damage compensation between 1973 and 1990 (Garcia-Gaona et al., 1993; Goldstein et al., 2006) and second in Norway, where a small population of 20-25 bears was estimated to kill about 2,000 sheep annually (Kaczensky, 1999), suggest that even small populations of bears can lead to significant damage to livestock. In Asia, the brown and black bears suffer extensive retaliatory killing as they are often responsible for the predation of the livestock of the herders (Sathyakumar, 2006a). They are also killed for the demand of body parts, especially their gall bladder, that are commonly used for the preparation of medicines, and there may be a nexus between retaliatory killing and illegal wildlife trade (WWF-India handbook, 1998; Charoo et al., 2011).

Chapter 2.

Objectives and Research questions

Objective:1 To quantify the spatiotemporal **patterns, extent and nature** of human-bear conflict in Lahaul

Background: HWC conflicts might not be consistent, as the activities of the conflict animal may also have spatiotemporal patterns associated with it. An animal might decide its activities in line with seasons, time of the day, reproductive status, etc. The changes within the surroundings of the animal might also impact its behaviour. In high altitude ecosystems, the climate conditions result in limited resources due to highly variable abiotic and biotic factors (Scherrer and Korner, 2010; Graham et al., 2012; Bashir et al., 2020**).** Wildlife in the region has to undergo different physiological and behavioral changes to cope with the scarcity of resources (Scholander 1955; Frappell and Cummings 2008; Bashir et al., 2020). Bears' diet and habitat use also varies throughout the year (Reid et al., 1991; Izumiyama and Shiraishi, 2004; Hashimoto and Anrui, 2013; Takahata et al., 2013; Bashir et al., 2018; Bashir et al., 2020). The movement patterns of bears are associated with changes in quantity, quality, and distribution of food in their environment (Oka et al., 2004; Koike et al., 2008; Nakajima et al., 2012; Sathyakumar et al., 2013**;** Bashir et al., 2020**).** During conditions of shortage of natural food, especially in pre-hibernation stages, bears can venture close to human settlements in search of alternative sources of food (Arimoto et al., 2011; Takahata et al., 2013; Malcolm et al., 2014), thus increasing chances of conflicts.

Research questions:

a. **Types and amount of losses:** What are the kind of losses faced by resident villages and the seasonally migrant Gaddis due to human-bear interactions?
   What is the amount of losses (numbers and economic loss) vis a vis crops, orchards and livestock losses?
b. **Circumstances of the conflict:** For livestock as well as crops, answering where, when, and what time of the day are more vulnerable to losses.

c. **Trends of losses:** Have the conflicts increased, decreased, or remained the same over years, and the reasons for any change
d. **Drivers of conflict:** If there is a pattern to conflicts and they aren't random occurrences, what are the drivers related to habitat, land use and cropping or livestock husbandry that cause vulnerabilities.

Objective: 2

To examine determinants of people's attitudes, tolerance and behaviour towards bears, using a socio-psychological framework

Background For long term survival of the conflict species, it is crucial to understand the perception of the people towards the species. This determines the tolerance of the people for the losses suffered by them due to conflict (Behdarvand et al., 2014; Behr et al., 2017; Karanth et al., 2012; Suryawanshi et al., 2014; Karanth and Kudalkar, 2017). Level of economic losses may not be the primary reason for negative perceptions but other cultural and socioecological parameters, including fear may govern attitudes and thus the behaviour towards conservation (Bagchi and Mishra, 2006; Suryawanshi et al., 2014; Bhatia et al., 2017; Nilsson et al., 2019; Hughes et al., 2020). Understanding the predictors of behaviour can help design interventions to change the behaviour as required (Parker, 2002; St. John et al., 2010). This allows for the usage of socio-psychological models like the 'theory of reasoned action' and its extension, the 'theory of planned behaviour', in conservation studies (St. John et al., 2010). Conservation of massive carnivores depends on the extent to which the local residents accept the animal. Attitudes toward carnivores are influenced by numerous and complex factors—from personal human attributes and socio-economic indices to appearance and conduct of the carnivore—which makes it challenging to recognize their drivers (Suryawanshi et al., 2014).

Research Questions:

a. **Measure Tolerance** (capacity for people to accept bears): What is the acceptance level of the people to bears? Do they want any changes in the bear population?

b. **Understand/quantify motivation to co-exist/retaliate:** What are the socio-psychological factors that play key roles in deciding the perception of the local and Gaddi people towards the bears**?**

Objective: 3

To examine the prevalent human-bear conflict mitigation strategies and role of traditional ecological knowledge in conflict mitigation

Background: The investments of the local communities on mitigation methods can be financially straining and even increase the vulnerability and stress of the weaker sections of the society (Barua et al., 2013; Naughton-Treves, 1998; Sitati et al., 2005; Karanth and Kudalkar, 2017). Such financial losses are especially straining for the underdeveloped economic regions (Mishra et al., 2003; Manral et al., 2016). But the negative social influences such as extra labour cost, lack of sleep, fear, etc. is often the same for each section of society. The affected individuals try to find solutions according to their traditional knowledge and experience. The state governments also play a role in dealing with such conflicts by providing monetary compensations to balance the losses. However, the compensation amount, which is very often delayed or insufficient, along with cumbersome application procedure leads to anti-wildlife department and anti-wildlife sentiments (Madhusudan, 2003; Mishra et al., 2003; Ogra and Badola, 2008; Gubbi, 2012). Due to these and some other social factors such as wealth, gender, and pre-existing expectations people do not apply for compensations (Ogra and Badola, 2008; Mishra et al., 2003). In recent years the amount of compensation amount has been substantially increased across the country but the processes remain complicated and there also seems to be poor awareness among beneficiary communitie about this.

Research Questions:

a) Is there any role of traditional ecological knowledge in managing conflicts with bears?
b) What are the current techniques used by the people to reduce conflict with bears? What is their effectiveness? Why some methods are used more commonly than the others? What can be done to have more effective management for protection and offsetting losses?

Chapter 3.

Research Methods

3.1 Study area:

The study was undertaken in the Lahaul and Udaipur Subdivisions of the Lahaul and Spiti District of Himachal Pradesh. Sandwiched between the Pir Panjal and the Zanskar ranges of the Greater Himalaya, the Lahaul valley exhibits a transition zone between the Greater and the Trans- Himalayan Range. People here are mostly agro-pastoralists. Due to difficult terrain and extreme climate, the local communities are present in very low densities (2/km^2) compared to other parts of the state (123/km^2). The local communities are primarily Hindus, while the uppermost villages on the right bank of the Chenab River are mostly followers of Buddhism (Ghoshal et al., 2017). These people have been dependent on natural sources for various purposes that vary across the landscape, and include food, livestock-grazing, fuel, fodder, medicinal plants, and construction materials (Mishra, 2001). Non-native labourers have been attracted to the place due to opportunities provided by the intensification of agriculture and emigration of a large portion of the local population for education and employment. Gaddis graze their large herds of livestock in this region during summer (Ghoshal et al., 2017). The region is rich in wildlife including the Snow leopard (*Panthera uncia*), the Wolf (*Canis lupus*), the Himalayan brown bear, the Himalayan Black bear, the Himalayan marmot (*Marmota himalayana*), Asiatic ibex, the Chukar partridge (*Alectoris chukar*), the Snowcock (*Tetraogallus himalayensis*).

For selecting the study villages, I obtained a list of all villages of Lahaul and Udaipur sub-divisions (total 69 from Panchayat-wise Census data of the year 2011). In order to obtain representative samling of conflicts, I then classed them based on their size, (low number of households (1-20), medium number of households (21-30), high number of households (>30); road access (Low proximity to highway (>500m), medium proximity (<500m), high proximity (on the road)); area under agriculture (low area (<100 sq km), medium area (101-200 sq km), high area (> 200 sq km)) and area under orchards (low orchard area (1-9 bigha), medium orchard area (10-20 bigha), and high orchard area (>20 bigha)). Of these 26 villages

were randomly selected such that there is almost equal proportion of representation in each category **(Table 1**).

	Number of Households	**Proximity to highway (m)**	**Agricultural area (square meter).**	**Area of Orchards (bigha)**
No. of villages in Low Category	10	8	9	12
No. of villages in Medium Category	6	7	8	7
No. of villages in High Category	10	11	9	7
Total	26	26	26	26

Table 1. The number of villages under different categories according to the number of households, village population, proximity of village to highway, size of the village and area of the orchard in the village (please see text for details of the categories).

From each village 30% of randomly selected households were interviewed. The chosen households represent the particular village.

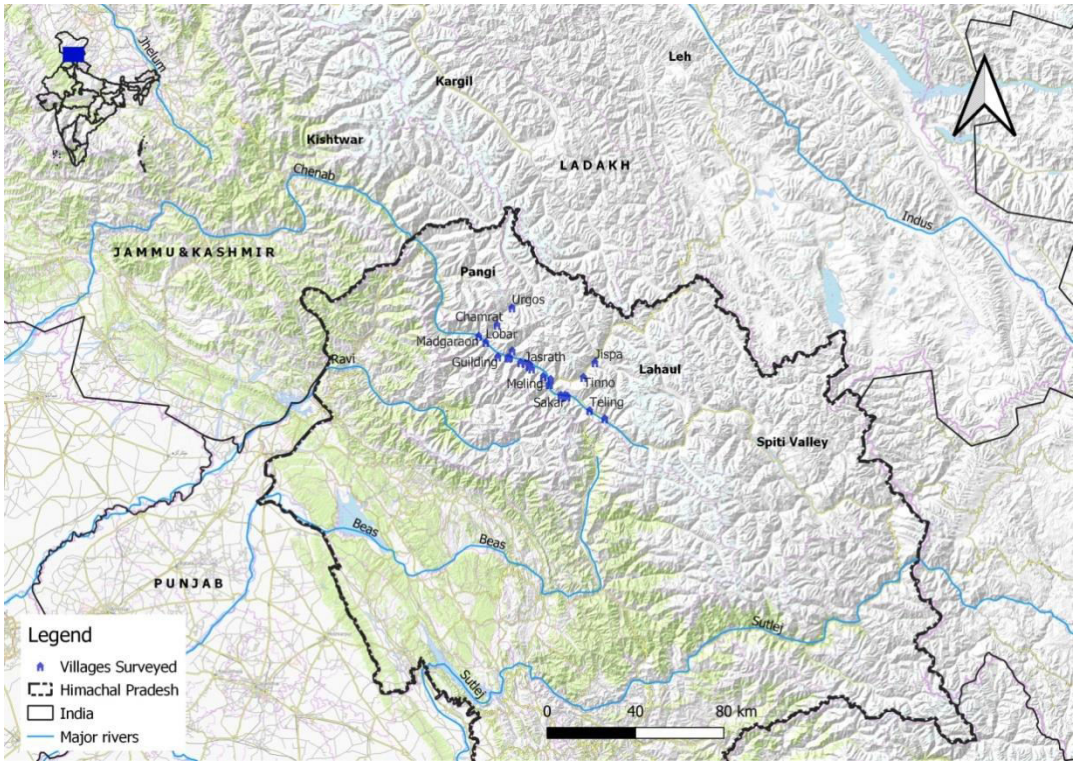

Image 1. Map of the study area showing the 26 study villages in Lahaul. The map inset shows the location of study area in India.

3.2 Gaddi people:

"*Nomadism is an extreme case of a human society's adaptation to an unfriendly natural environment*"- Krader (1959)

Transhumance is the seasonal back and forth migration of livestock and humans from one agro-ecological zone to the other, from a traditional permanent home base with subsistence level agriculture (Rota and Sperandini, 2009; Waters-Bayer and Bayer, 1992; Namgay et al., 2013). It has been practiced in the higher Himalayas since early human settlement. Like in other mountainous areas, it is attended with the cyclic vertical movements of the livestock from cool highland valleys in summer to warmer lowland valleys in winter (Aryal et al., 2014). Through 'vertical' migration the shepherds can exploit the alternative climates, altitudes and geographies of the regions which allow them to maintain larger collections of animals (Alexby, 2007). These movements might cover tens to hundreds of kilometers, and

allow the animals to cope up the seasonality of forage availability (Namgay et al., 2013). Around 10% of the world's population resides in the mountains, with livestock contributing significantly to their economy (Pun and Mares, 2000; Bagchi et al., 2003).

An Indian indigenous tribe, Gaddis, practices transhumance. With a population of approximately 181,000 (Ethnologue: Languages of the World, 2021) this tribe inhabits the slopes of the Dhaula Dhar and Pir Panjal ranges in the state of Himachal Pradesh. The interplay between the climate, altitude and the soil fertility limits the types of crops that can be grown by the Gaddis (Bhasin, 2011). This allows them to give more importance to their livestock and even adjust their life practices to the requirements of the animal's access to pastures, water, salt as required, and protection from predators (Bhasin, 2011). For the Gaddi population that is adapted to ecological and economic constrains of the Himalayas, the pastoralism is a sustainable system (Moudgil et al., 2017, Moudgil et al., 2019). It promotes sustainable land use by the transfer of low quality plant resources into portable, high quality animal foods (Bhasin, 2011). The animals need low input and investment, support the livelihood of the marginal farmers (Moudgil et al., 2017, Moudgil et al., 2019) by providing better "continuing" (calves, lambs, and kids; milk, butter and cheese; transport and traction; manure; hair and wool; and occasionally blood) and "final" (meat; hides and skins) products (Bhasin, 2011). It is the sole method of putting the pastures to economic use without a huge expenditure of capital (Janzen, 1993; Bhasin, 2011). They even trade their animals and animal products in town markets for grains and other necessities of life (Bhasin, 2011).

However, mobility is not an easy task. It requires family labour and investment in building social capital that is necessary to access vital resources (Namgay et al., 2013). The pastoralists are also put to face disasters and are subject to changing social and political conditions (Boone et al., 2008; Namgay et al., 2013). A lot of pastoralists look for jobs in other sectors due to increased competition over land use, the privatization of lands, commercialization process and other pressures (Sharma et al., 2003; Bhasin, 2011; Singh and Reija Hietala-Koivu, 2016). Climate change adds to the vulnerability of the transhumant people who depend on timing of forage production, agricultural seasons, and persistence of snow in rangelands and availability of water near grazing areas (Ayanda et al., 2013; Dong et al., 2011; Paavola, 2008; Tyler et al., 2007; Aryal et al., 2014). It is expected that due to

climate change, in higher elevations where snowfall is the current norm, rainfall will be the increased form of precipitation (Kumar, 2007) and this can have implications on pasture quality, erosion, extreme events, health and access to pastures.

Image 2. A young Gaddi with his livestock. Gaddis are transhumant pastoral communities who use the Lahaul mountains in the short summer season.

Tracking Gaddis

I visited two pasture areas of Gaddis i.e. Akulthang and Bhrend thaj. Since our my fieldwork was delayed due to COVID pandemic I reached Lahaul when most of Gaddis were preparing to leave the high pasture grounds. We spent 4-5 days in Marhi, Kullu district, which is a halt in the route of the Gaddis from the foothills of Mandi to interview them.

3.3 Questionnaires:

I used structured questionnaires to seek information from the local people and the Gaddis regarding the human-bear conflicts prevailing in the region. The questionnaires are

comprised of four sections: Socio-economic details of the interviewee, the nature and extent of conflict, the different factors underlying the human behaviour towards bears, and the potential mitigation strategies **(Appendix 1).**

Objective 1:

We designed a set of questions (Section 1 of the questionnaire; **Appendix 1**) to examine the extent of crop loss (including fruits and vegetables), livestock loss, seasonal patterns of loss, spatial patterns of loss and species causing the loss. We also include a set of open-ended questions to gain an in-depth understanding of affected people's perceptions of the losses they incur.

Objective 2:

The questions in this section (section 2 of the questionnaire; **Appendix 1**) are based on the theory of planned behaviour which is an extension of theory of reasoned action. In the theory of reasoned action, subjective norms i.e. the pressure faced by individuals to act in a certain way, and the individual's attitude i.e. the social-psychological characteristics of the decision-maker, influence decision making (Willock et al., 1999; Rounsevell et al., 2003; St. John et al., 2010). The theory of planned behaviour extends this model by including perceived control as a predictor of behaviour (Ajzen, 2002; St. John et al., 2010). Social psychologists, while measuring perceived behaviour control, are quantifying the extent that people feel they have the ability to carry out the behaviour under study. This measure includes the availability of resources, required skills, and other prerequisites needed for that behaviour. It also measures the power people perceive in each of these factors while performing the behaviour (St. John et al., 2010). From one behaviour to another, the relative importance of the three predictors, i.e. attitudes, subjective norms, and perceived behavioural control differs (Ajzen, 1991; St John et al., 2010). By investigating the reasons for carrying out behaviour, it will be possible to know the relative importance of predictors of that behaviour and target those predictors for making necessary behavioural interventions (St. John et al., 2010).

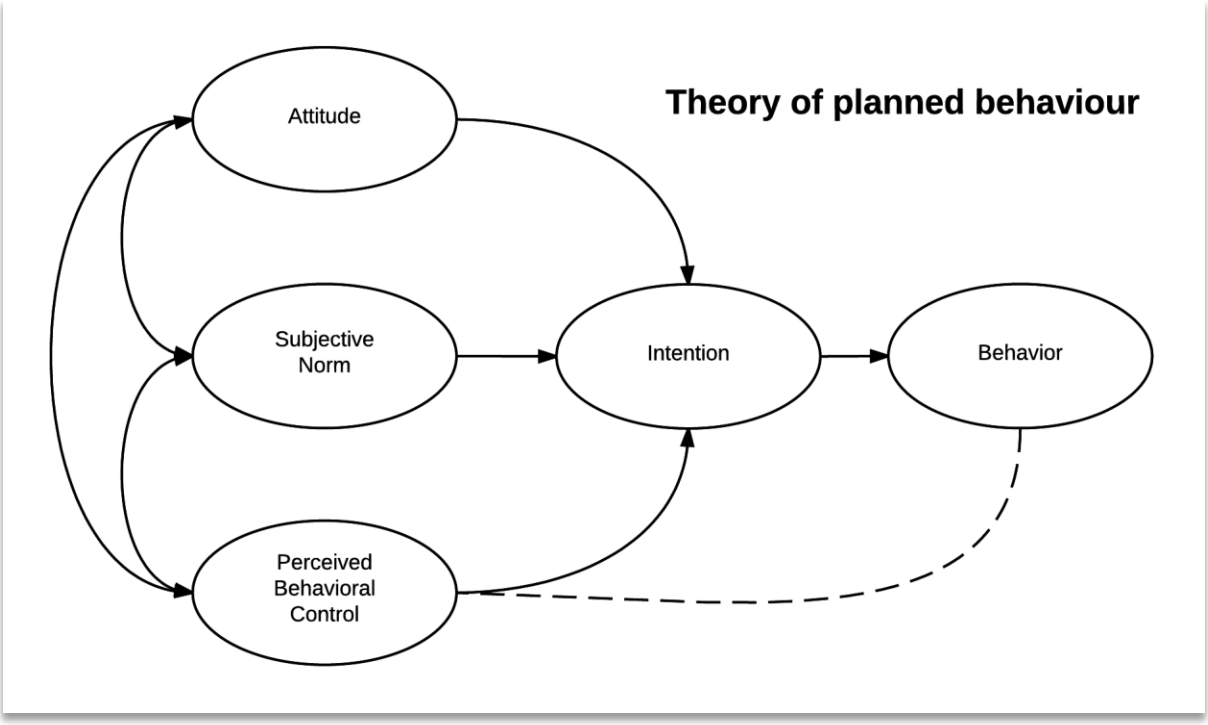

Image 3. Diagrammatic representation of theory of planned behavior (Diagram source: Wikipedia). Ajzen, Icek. "The Theory of Planned Behavior." ***Organizational Behavior and Human Decision Processes*****, Theories of Cognitive Self-Regulation, 50, no. 2 (December 1, 1991): 179–211. https://doi.org/10.1016/0749-5978(91)90020-T.**

To understand the factors driving the human behaviour towards bears, we divided the section into: Attitude, Subjective norms, Perceived behaviour control, and Political-economic cost/benefit. Statements were graded according to the 5 points Likert scale (*1-Strongly disagree, 2- Disagree, 3- neutral, 4- Agree, 5-Strongly agree*) to know the respondents level of agreement towards statements. Statement scores within sections were added together, giving overall attitude scores for bears and conservation efforts.

Objective 3:

The section 3 of the questionnaire (**Appendix: 1**) is designed to examine the current mitigation strategies used by the local people and the Gaddis to deal with the wildlife conflict. The role of authorities was also examined.

3.4 Current Patterns and Trends of Conflicts Based on Official Forest Department Records:

The forest department records (regarding conflict cases, location, losses, compensation provided) for the past twenty years were used to help document any changes in patterns of reporting of human-bear conflict and also in finding out the reasons behind these. The Forest Department officials were also asked about the ex-gratia policy of the state and any changes regarding the same. It may, however, be noted that the records may not accurately depict the annual losses due to multiple reasons. Primary reason being that people often do not report losses due to the remoteness of sites of the incidents, low compensation rates and cumbersome process of filing compensation claims. I however, collected this information to understand the patterns, with an assumption that the biases may have remained constant through the time period.

3.5 Calculating economic loss:

The economic loss for livestock was calculated from the estimated market prices mentioned by key informants which were as follows: Horse- 30,000 INR, Cow-Yak Hybrid- 25,000 INR, Jersey cow- 17,000 INR, Sheep and Goat- 10,000 INR. The economic loss for crops was calculated from the amount (in kg) of each crop lost to any species and the market price of the crop (price/kg). Unfortunately, people found it difficult to respond about losses in terms of production (kilograms) but were more comfortable estimating the proportion of the crop field that was affected. I thus used this information on percent of crop area lost, average production of the particular crop per hectare, average price of the crop production per kilogram to estimate the approximate price of economic loss per household. This was compiled for all sampled households to obtain larger losses in the sampled households.

3.6 Statistical analysis:

We used descriptive and exploratory and data analysis to summarize data on extent of human wildlife conflict, the primary causes of livestock and crop loss and the response of people towards bears as measured through different aspects of theory of planned behaviour. The causes reported for crop and livestock loss were expressed as frequency with which they were ranked (1- least damaging, 2-moderately damaging, 3-highly damaging 4- severely damaging). The mitigation methods used and their efficiency were also expressed in the same manner (1- most effective, 2- effective, 3- not effective). Contingency tables were used to express the relationship between categorical variables. For finding the determinants of tolerance ordinal logistic regression was run with tolerance as the response variable that had three categories (1- bear population increased, 2- bear population remain the same, 3- bear population decreased). Various explanatory variables were used in the models to find the best fit.

3.7 Heat map

A heat map for the villages with bear conflict using Inverse Distance Weighting (IWD) interpolation method in ArcGIS software was developed. Inverse Distance Weighting is a form of interpolation that has spatial autocorrelation as its underlying principle. Spatial autocorrelation is the principle of things that are closer to one another being more alike than those that are farther apart. IDW uses the known values surrounding an unknown value to predict the unknown value of the given location. The influence or weightage of the known values decreases with distance from the unknown value in making the prediction. Hence, given the name inverse distance weighted. I used the aggregate of livestock loss and incidents of crop loss per village as model weight for the Inverse Distance Weighing. The heat-map produced indicates the probability of conflict with bears in the study region through colour coded categorization of the probability values.

Chapter 4

Results

1) HWC local people

4.1.1. Livelihood profile

I surveyed 197 households (124 male and 73 female respondents) from 26 villages, all of whom were predominantly agro-pastoralists. Out of the 197 households all but one owned agricultural land, while 171 also reared livestock. These 171 households reared a total of 1591 livestock with an average herd size of 8.1 (0-56) per household. Sheep (69%) accounted for the largest proportion of livestock, followed by cattle (27.3%), goat (2%), and others (cow-yak hybrid, horse, donkey) (1.7%). Total agricultural land owned by the 196 households was around 591 acres with an average of 3 Acres (range: 0.2- 12). Out of the 124 male respondents, 45 (36%) had secondary occupation in fields like teaching (8%), business (7%), army (7%), banking (2%), pradhan/village head (2%), and others (IPH, peon, watchman, etc.) (10%). Among the 73 female respondents, 19 had secondary occupations like teaching (11%), handicraft (8%), anganwadi worker (4%), shopkeeper (2%), and pradhan/village head (2%). Most housholds take advantage of the Government's MNREGA (Mahatma Gandhi National Rural Employment Guarantee Act) program.

4.1.2. Livestock losses by agropastoral people from Lahaul:

a. Causes of livestock mortality

The perceived causes of livestock loss as mentioned by the agropastoral Lahaulis varies from accidents, depredation by bears, disease, depredation by snow leopard and wolf, and climate, in this order **(Table 2)**. The 'other' perceived causes of livestock losses include consuming poisonous forage, landslide and depredation by fox. Bear was the second most importance perceived cause of livestock losses as reported by respondents (18.8%). For those who responded about bear as a cause of livestock loss, most (73%) reported this to be 'highly damaging'. Interestingly, the major perceived cause of loss reported was accident. The

perception of free-ranging dogs as a cause of loss was higher among the people than for Snow leopard or wolf.

	Accidents	Bear	Disease	Feral dogs	Wolf	Snow leopard	Climate	Others
% people mentioning the cause	27.9	18.8	15.7	9.6	9.1	8.1	3.0	5.1
Highly damaging (%)	98.2	73.0	80.6	52.6	77.8	93.8	66.7	60.0
Damaging (%)	1.8	5.4	9.7	31.6	0.0	6.3	16.7	30.0
Less damaging (%)	0.0	21.6	9.7	15.8	22.2	0.0	16.7	10.0
Least damaging (%)	0	0	0	0	0	0	0	0

Table 2. Causes of livestock loss and their relative importance as mentioned by Lahaul agropastoralists (n=197). The level of perceived importance of the cause is also given. Please note that respondents reported multiple causes and thus the row total of the percent people mentioning a cause needn't total to 100. The level of damage (highly damaging, etc) is calculated for only those respondents who highlighted the respective cause.

b. Livestock losses in 2019-20

Thirty eight out of 197 respondents (19 %) reported 83 livestock losses in the years 2019 and 2020 due to depredation by wildlife, accidents and other causes (**Table 3**). The livestock losses of the agropastoral Lauhalis in the year 2019-20 were attributed to causes such as bear depredation, accidents, diseases, severe cold, and feral dogs. Bear was the primary cause of livestock losses (48%) followed by accidents (23%). Feral dogs caused higher losses (10%) than snow leopard (5%) or wolf (0%). Wildlife was responsible for close to half (53%) of the losses, feral dogs not included.

	Bear	Lost/fell	Disease	Snow andcold	Dog	Snow leopard	Wolf	Total
Donkey Adult	0	0	0	0	1	2	0	**3**
Goat Adult	0	2	0	0	1	0	0	**3**
Cow Juvenile	0	0	1	0	0	0	0	**1**
Hybrid Adult	1	0	0	1	1	1	0	**4**
Cow Adult	3	14	6	4	0	1	0	**28**
Sheep Adult	36	3	0	0	5	0	0	**44**
Total:	**40**	**19**	**7**	**5**	**8**	**4**	**0**	**83**

Table 3. Livestock losses during 2019-2020 for 26 survey villages. A total of 83 livestock were lost to 38 households 44 livestock were lost to wildlife, 8 to feral dogs, and 37 to other causes (n = 197)

The livestock most preyed upon by was sheep (78.9%), with cow (7.7%), hybrid cattle (5.8%), donkey (5.8%) and goat (1.2%), also suffering some losses. The losses of 83 livestock represent an economic loss of around INR 14,03,000 from 38 households (36,921 INR/HH). Among this the economic loss due to wildlife amounts to INR 4,15,000 or 5,701USD. The losses due to bears alone are INR 2,05,000 or 2,816 USD.

Bear (92%) losses primarily occurred at night, while feral dogs and snow leopards didn't show a clear diurnal pattern. Bears cause most damage during summers (88%) while for snow leopard losses were spread throughout the year.

4.1.3. Agricultural losses:

a. Causes of agricultural losses:

The perceived causes of agricultural losses as mentioned by the agropastoral Lahaulis include bears, monkey, birds, weather, and disease **(Table 4).** Bear was the most important perceived cause of agricultural losses as reported by respondents (49.2%). For those who responded about bear as a cause of agricultural loss, most (39.2%) reported this to be 'damaging'. Weather came out as an equally important perceived cause of loss for people (48.7%). The 'other wildlife' causes of crop loss include fox, marmots, vole and bats. The 'other' causes of loss include water shortage, seed quality, weed, and livestock.

	Bear	Macaque	Birds	Other wildlife	Weather	Disease	Pests	Others
% Respondents who mentioned the given cause	49.2	26.4	12.7	20.3	48.7	22.3	21.3	15.2
Most damaging (%)	18.6	71.2	72.0	35.0	12.5	36.4	35.7	33.3
Damaging (%)	39.2	9.6	24.0	32.5	38.5	36.4	38.1	26.7
Less damaging (%)	28.9	9.6	32.0	32.5	39.6	27.3	19.0	33.3
Least damaging (%)	13.4	9.6	8.0	0.0	9.4	0.0	7.1	6.7

Table 4. Causes of agricultural loss and their relative importance as mentioned by Lahaul agropastoralists (n=197). The level of perceived importance of the cause is also given. Please note that respondents reported multiple causes and thus the row total of the percent people mentioning a cause doesn't total to 100. The level of damage (highly damaging, etc) is calculated for only those respondents who highlighted the cause

b. **Agricultural losses in 2019-20**

Of the 197 households interviewed, the 101 households that suffered agricultural losses in 2019-2020 due to wildlife, maximum (64%) people reported losses by bear (64%) and macaque (22%). Vole, birds, fox and marmots cumulatively were reported by few people (14%) **(Figure 1)**. Most damage was reported for apple orchards (36%) in the study area, followed by peas (31%), and small amounts of losses to potato (11%), cabbage (11%), carrot (5%), iceberg lettuce (4%), jaw (2%), and plum (1%). Bears cause most damage at night (92%) while macaques are active during the daytime. The total economic loss in the year 2019 and 2020 due to crop losses by Bears alone for 71 respondents was 6,41,170.6 INR or 8,809 USD (9,030.6 INR/HH). Apart from agricultural losses, people also reported damage to their uncultivated areas by bear which dig the area in search of wild roots.

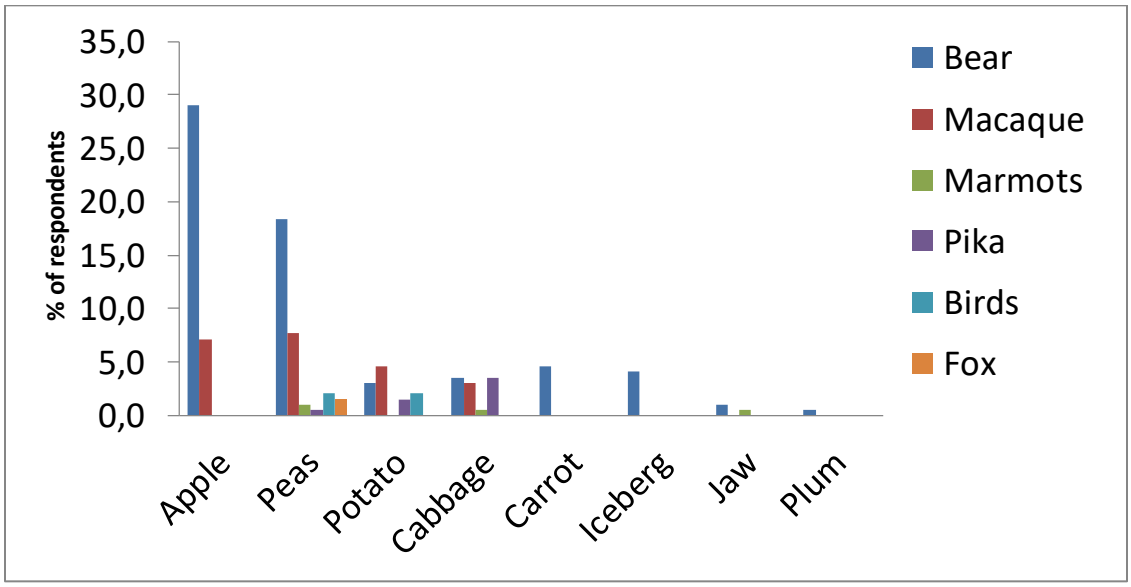

Figure 1. The distribution of agricultural losses reported (2019-20). Out of 197 respondents 101 reported agricultural losses due to wildlife in 2019-20. The distribution of frequency of losses is: bear (64%), macaque (22%), voles (6%), birds (4%), fox (2%), and marmots (2%) [n= 196; a person was allowed to mention >1 causes of loss].

Image 4. Apple tree branch broken by Bear **Image 5. Bear scat in the same field**

4.1.4. Attitude and tolerance:

For the complete set of questions asked under this section see **Section 2** in **Appendix 1.**
In order to measure attitudes of the Lahaul agro-pastoralists, I asked a set of five questions (**Figure 2**). Interestingly, a majority of them showed positive attitudes by 'agreeing' or even 'strongly agreeing' that they were 'ok with the depredations' (77%), 'bears play an important role in Nature' (48%), 'we need to know more about them' (72%), 'we need to protect them' (90%), and importantly, that 'they have an equal right to live' (87%).

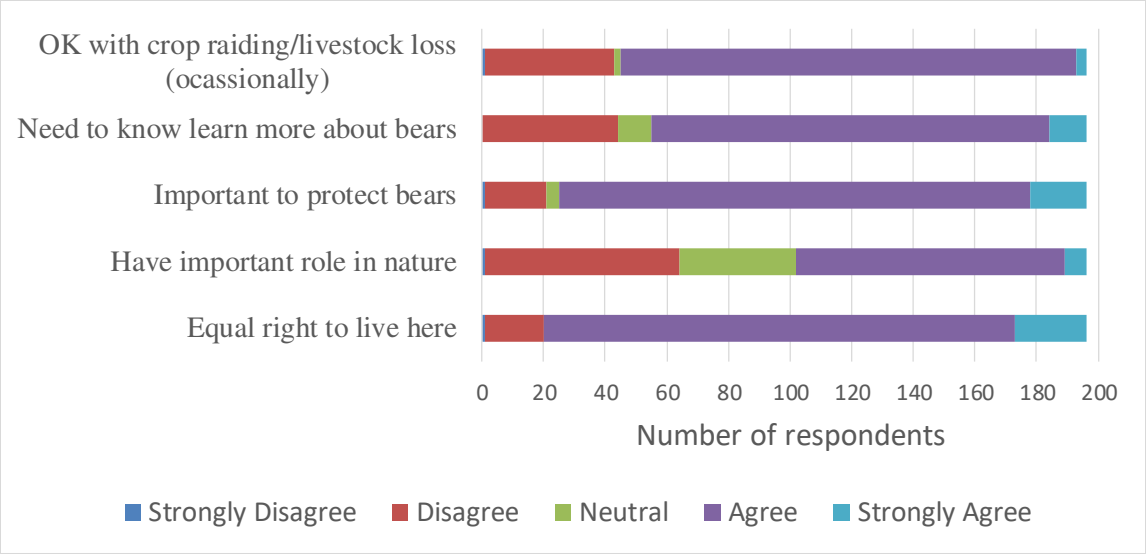

Figure 2. Attitude of respondents towards bear. Respondents were asked 5 questions to measure their attitude using a 5-point Likert scale. Overall the attitudes of the respondents are positive as 'agree' or 'strongly agree' were reported by majority (n= 196)

People had mixed attitude towards willingness to co-exist with bear (**Figure 3**). Majority of people (95%) were willing to share their resources with bear and majority (88%) responded that they will not harm a bear even if it damages crops or livestock. On the other hand, many respondents (62%) want bear to be translocated and over a half (53%) believed that bear and people can't co-exist.

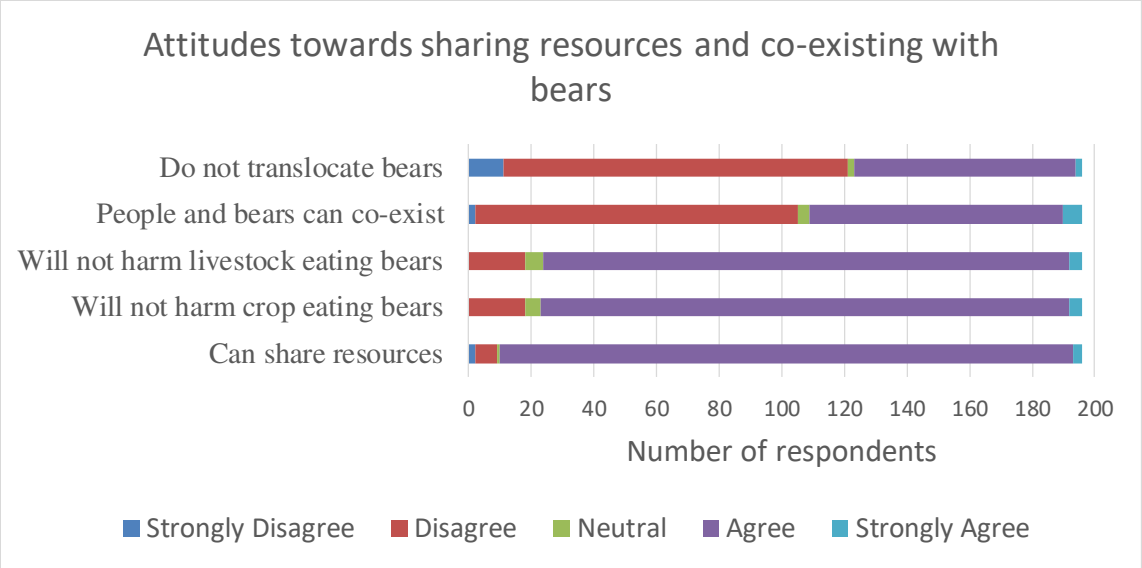

Figure 3. The attitude towards co-existing with bear. The respondents were asked 5 questions to measure their attitude towards sharing resources with bear using a 5-point Likert scale. Most are willing to share resources and will not harm a conflict bear but would like the bears to be translocated (n= 196)

Views by peers were important for the respondents. Many respondents (65%) felt that their neighbor, village elders, family, and friends will disapprove of their killing a bear. Majority (89%) reported that their priests will disapprove on their killing a bear. Overall, people perceive that the act of killing a bear will be looked down upon by the society **(Figure 4).**

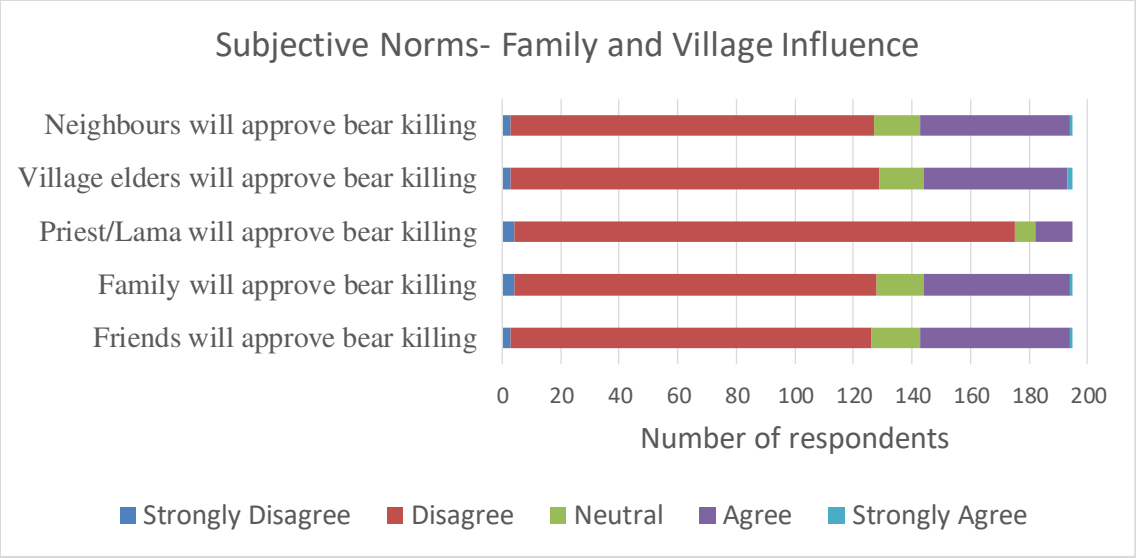

Figure 4. The influence of societal norms in decision making. Respondents were asked 5 questions to measure subjective norms using a 5-point Likert scale. Most people perceive that killing a bear will be disapproved by the society (n= 196)

Regarding behavioural response of the respondents, a majority of people (91%) reported that it is difficult to get the tools for killing a bear. Many (96%) believe that they can dissuade others from killing bear or can convince them to protect bear and many (76%) feel that they can't involve others to kill bear. About half (46%) feel that people might report killing of bear to authorities. It shows that people perceive getting the tools or the support for killing bear to be difficult (**Figure 5**).

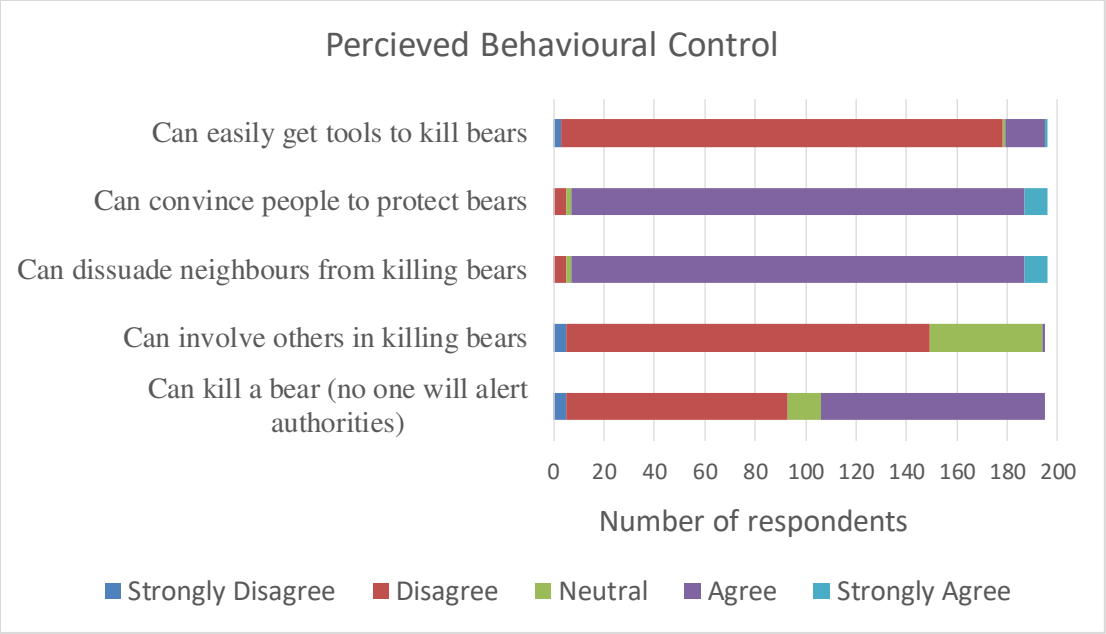

Figure 5. The influence of perceived behavioural control in decision making. Respondents were asked 5 questions to measure perceived behavioral control using a 5-point Likert scale. Majority people reported that finding tools or the support for killing bear is difficult (n=196)

When asked about potential cost-benefit of living with bears, almost all the respondents (99%) agreed that they can't kill bears because of customary laws and that having bear is a trade-off for living near forests (98%). Many (83%) agreed that the losses are irregular or low and many (81%) and agreed that forest department responds to conflict so they don't take matters in their own hands. About half of the respondents (51%) feel that bear can aid tourism **(Figure 6).**

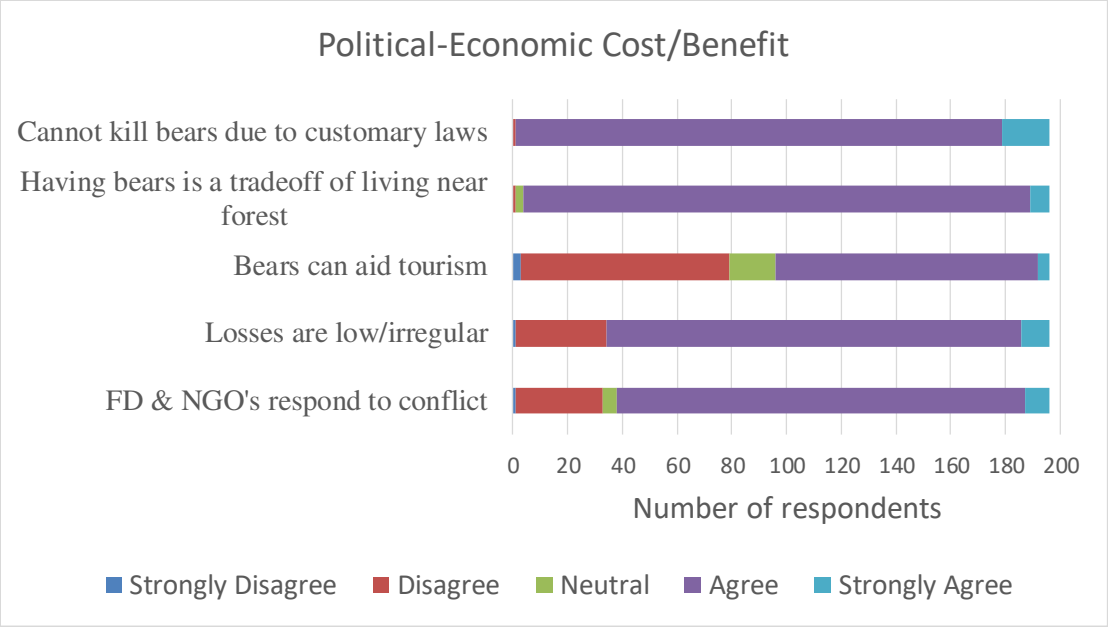

Figure 6. The influence of political-economic cost-benefit analysis on decision making. Majority respondents perceived that bear can't be killed because of political and economic reasons (n= 196)

Among the female respondents 33% and among the male respondents 28% reported being afraid of bear **(Figure 7).** Overall, 70% respondents reported that they were not afraid of bear. This can be because many villages do not encounter bear frequently and many villages reported being habituated to bear presence.

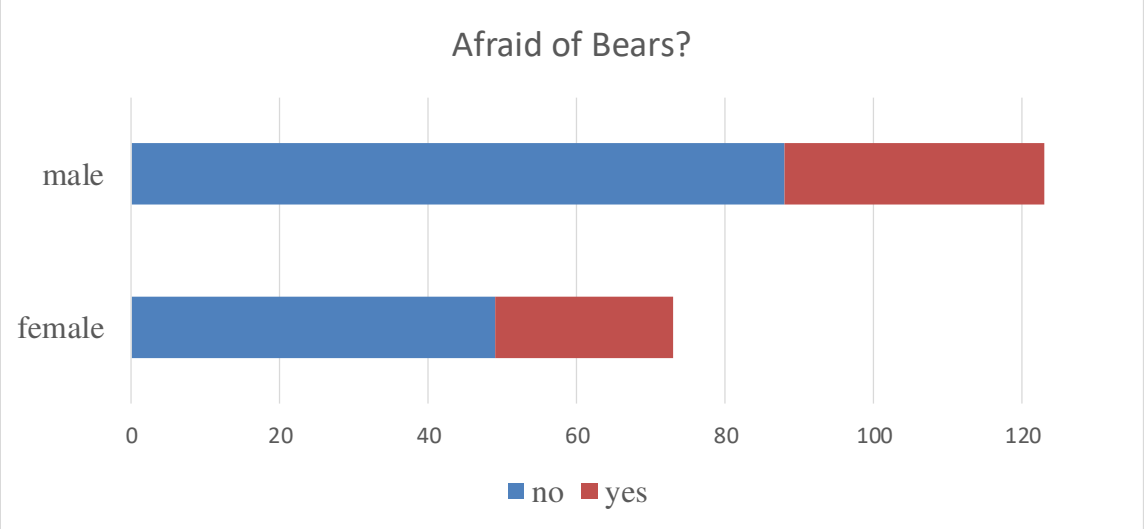

Figure 7. The distribution of fear of bear among respondents (n= 196)

The general patterns of tolerance towards bears were similar among the two genders. Among the females (n= 73), most (73%) want the bear population to be reduced, some (26%) want it to remain the same, and a few (1%) want it to be increased. Among the males (n= 122) too, many (59%) want the bear population to be reduced, some (30%) want it to be the same, and few (11%) want it to be increased **(Figure 8)**.

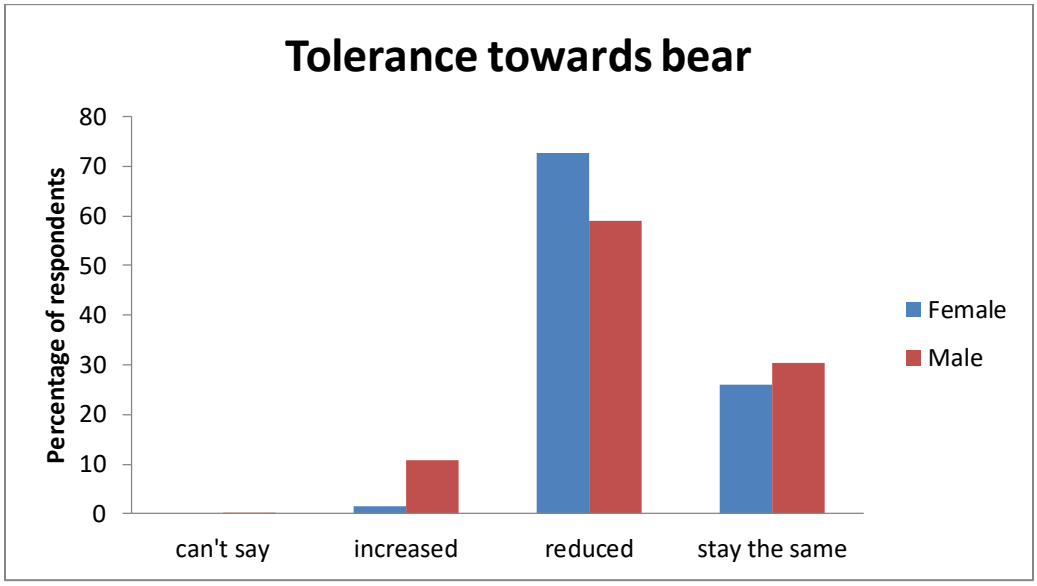

Figure 8. The distribution of tolerance of male and female respondents towards bear. Majority of respondents (64%) want bear population to be decreased, some (29%) want it to remain the same, and few (7%) want it to be increased (n= 196)

Ordinal logistic regression was done to examine determinants of tolerance towards bears where response variable was 'Tolerance' and explanatory variables included 'gender', 'education', 'crop damage by bear', 'number of livestock owned', and 'attitudes towards bear.' Multiple models with single and a combination of covariates were developed and tested. The model with crop damage by bears emerged as the best model **(Table 5),** which indicates that people who suffered crop damge tended to have poorer attitudes towards bears.

Model Number	Model Covariates	df	logLik	AICc	delta	weight
Model 3	**Crop damage by bears**	**3**	**-154.13**	**314.4**	**0**	**0.62**
Model 5	livestock_owned + crops_damage_by_bears	4	-153.89	316	1.6	0.28
Model 6	Attitude + gender + livestock_owned + crops_damage_by_bears	6	-153.13	318.7	4.31	0.07
Model 7	Attitude + gender + livestock_owned + crops_damage_by_bears + years_in_primary_occupation	7	-153.13	320.9	6.46	0.03
Model 4	Livestock owned	3	-161.89	329.9	15.51	0
Model 1	Attitude	3	-161.93	330	15.6	0
Model 2	Gender	3	-162.26	330.7	16.27	0

Table 5. Models run for finding the primary determinant of the reduced tolerance for bears. Model 3 i.e. Crop damage by bears was the best-fit model.

4.1. 5. Heat map:

The heat map (**Image7**) shows the distribution of bear conflict throughout the study area. The bear conflict is higher on the left bank of the Chandra-Bhaga river which has denser forests and rugged side valleys providing resting and foraging habitat for the bears. For villages with high bear conflict see (**Appendix: 2**).

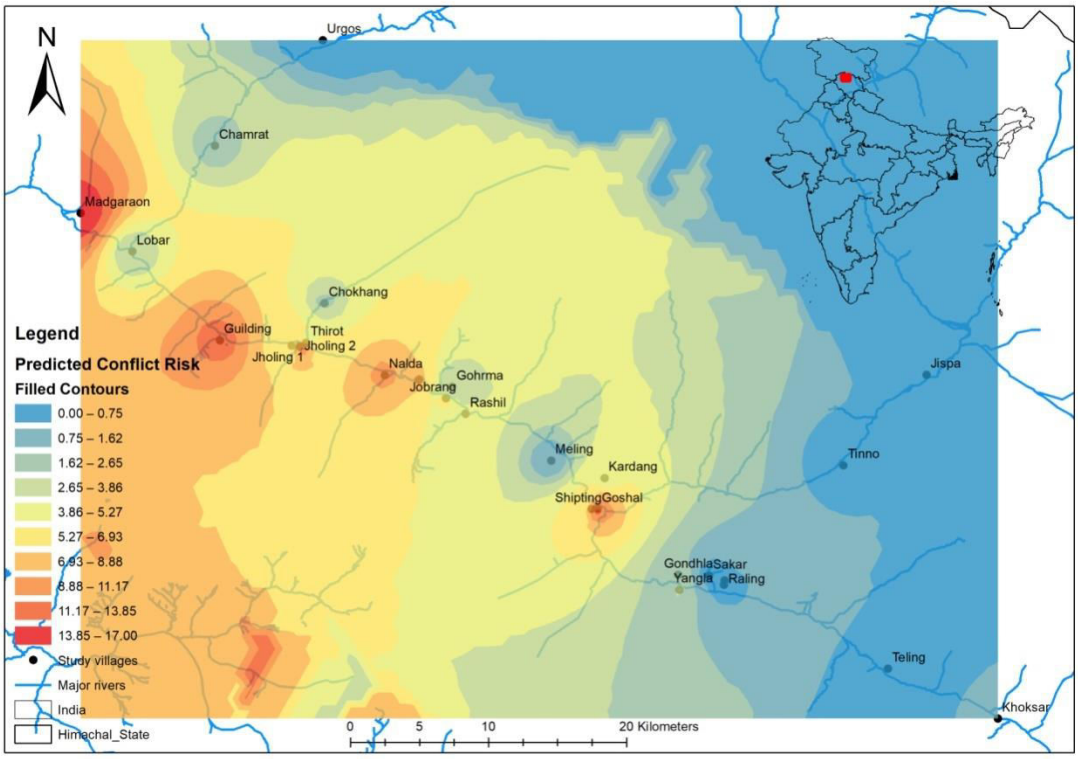

Image 6. Heat map of the study area. Villages on left bank of the river appear to have greater probability of conflict with bears.

4.1. 6. Changes in Bear Population and Damage as Perceived by Lahaul Agro-pastoralists:

Out of the 44 respondents only 19 (44%) reported a change in bear encounters (30% increase, 14% decrease: **Table 6**) in their respective village. While many respondents didn't know the reason for the change, some key observations behind the change were reported by few. For villages where bear encounters have increased the key perceived reasons given were increased orchard area (9%) and less forest resources for bear (9%). For villages who reported decreased bear encounters, the key perceived reasons increased construction (13.6%), change in vegetation (6.8%), and decreased forest area (6.8%).

The changes mentioned by people	No. of people mentioning the change (%, N=44)	Reason for change if any	No. of people mentioning it (%, N=44)
Bear more frequent	30	More Orchards and more bear damage	9
		Bear population increased	6.8
		Bears don't get food in forest	9
		No hunting	2.3
Bear less frequent	14	Change in forest area	6.8
		Change in vegetation	6.8
		Bear population decreased	2.3
		More road, construction scares bears	13.6

Table 6: Changes in bear encounters representing population change as reported by agropastoralists from Lahaul

While most respondents reported no livestock depredation or no change in livestock depredation by bear, some reported an increase (2%) or decrease (14%) in depredation in their respective village **(Table 7).** The change in depredation differ in villages because in many villages people have reduced their livestock holding (decreased prey) while, in others the bear population could have increased (increased predator). People from Raling and Gondhla villages (7%) reported bear presence for the first time in their village. They attributed this to decreased activity during the pandemic that allowed bears to explore new regions.

The changes mentioned by people	No. of people mentioning the change (%, N=44)	Reason for change if any	No. of people mentioning it (%, N=44)
Less livestock damage by bears	13.6	Lesser dependence on livestock husbandry and reduced livestock taken out in pastures	16.0
More livestock damage by bears	2.3	Bear population increased	2.3
No change	16.0		
No damage	68.0		
This is the first year when bears sighted	6.8		
Rarely come	6.8		

Table 7: Changes in livestock damage as reported by agropastoralists from Lahaul

4.1. 7. Mitigation:

For respondents who mentioned bear conflict (n = 97), one or many methods for crop protection are being used simultaneously depending on the degree of threat to their crops from wildlife**.** Crackers/fire, wire/wire-mesh/ barb-wire fence are widely adopted due to relatively better efficiency (**Table 8**). Solar fences are not effective in the region due to their high capital costs and that the heavy snowfall often breaks them. Along with fencing, people guard their crops at night using deterrents or sound to scare the animals. People complained that it is difficult to stay in the field throughout the night to light crackers and some (5%) mentioned that bear get habituated to them and don't get scared anymore. All the people using fences complained that fencing can't stop bear.

	cracker/fire	wire fence	barb wire	wire mesh	sound	solar fence	dog	pelting stone
% respondents using it	37	18	14	11	10	7	1	1
Effective	74	4.5	0	7	100	14	100	0
Moderately effective	24	91	100	93		76		100
Not effective	2	4.5	0	0		0		0

Table 8. The distribution of mitigation methods for crop protection and the percentage of people who mentioned their efficiency when each method is used individually (n= 123; people used >1 method).

Among the people who own livestock and faced bear conflict (n = 26) ca. 100% use corrals for livestock protection and 96% of them find it to be efficient. One respondent used crackers and dog along with corrals to scare the predators. The livestock losses that took place in 2019-20 were at pasture grounds (86%), outside corral (9%), and one instance of bear attack in corral (5%) **(Table 9).**

	corral	cracker	dog
% people using it	100	4	4
Efficient	96	100	100
Moderately efficient	4	0	0

Table 9. The distribution of mitigation methods for livestock protection and the percentage of people who mentioned their efficiency when each method is used individually (n= 29; one person used >1 method).

Image 7. Corral (the ground floor) used by village people for LS protection

Image 8. Drum and fire used to scare bears at night

2: Human Wildlife Conflict in case of Gaddi community

We looked at the different reasons for livestock losses of the Gaddis, the spatio-temporal patterns of such losses, and their extent. Since the attitude towards a species determines the success of implementation of conservation laws, we looked at the attitudes of the respondents towards bears. We also tried to understand the gap in the implementation of the compensation policy of the government.

4.2.1. Livestock losses:

a. **Causes of livestock loss:**

The perceived causes of livestock loss as mentioned by the Gaddis includes depredation by bear, theft, disease, depredation by snow leopard and wolf, and climate, in this order **(Table 10).** The 'other' perceived causes of livestock losses include vulture, accidents and landslide. Bear was the most important perceived cause of livestock losses as reported by respondents (91.3%). For those who responded about bear as a cause of livestock loss, most (42.3%) reported them to be 'damaging'. Interestingly, theft (78.3%) and disease (78.3%) were

perceived as more damaging than snow leopard or wolf. Climate, though reported by few (4.3%), was perceived as 'highly damaging' (100%).

	Bear	Wolf	Feral dog	Snow Leopard	Theft	Disease	Climate	Others
% people mentioning them as a cause (N= 23)	91.3	60.9	39.1	43.5	78.3	78.3	4.3	43.5
Most damaging	33.3	21.4	55.6	20	89	27.8	100	20
Damaging	42.3	57.1	44.4	70	11	44.4	0	50
Less damaging	23.8	21.4	0	0	0	22.2	0	20
Least damaging	0	0	0.0	10	0	5.6	0	10

Table 10. Causes of LS loss and their relative importance as mentioned by Gaddi (N= 23). The level of perceived importance of the cause is also given. Please note that respondents reported multiple causes and thus the row total of the percent people mentioning a cause needn't total to 100. The level of damage (highly damaging, etc) is calculated for only those respondents who highlighted the cause.

b. Livestock lost in 2019-20

Gaddis are present in the Lahaul Valley only between May and August every year. Most Gaddi respondents (78.3% of our study population (N= 18)) reported a total of 165 livestock losses due to wildlife conflict (107 sheep, 54 goats and 4 horses) during the summers of 2019 and 2020. This amount to an economic loss of approximately 17,30,000 INR or 23,767.4 USD (96,111 INR/individual). These losses were attributed to black bear, brown bear (both together 57%), snow leopard (12.1%), Wolf (20%), and feral dogs (1.2%). Since many respondents were not able to distinguish between Black bear and Brown bear, their losses have been combined. Bear alone caused damage of 44 livestock (21 sheep, 20 goats and 3

horses). In some of the cases the Gaddis were unsure about what caused the damage (9.7%) (**Figure 9**). All these depredation events took place at the pasture grounds of Lahaul. Bear, Snow leopard and Wolves caused more damage at night.

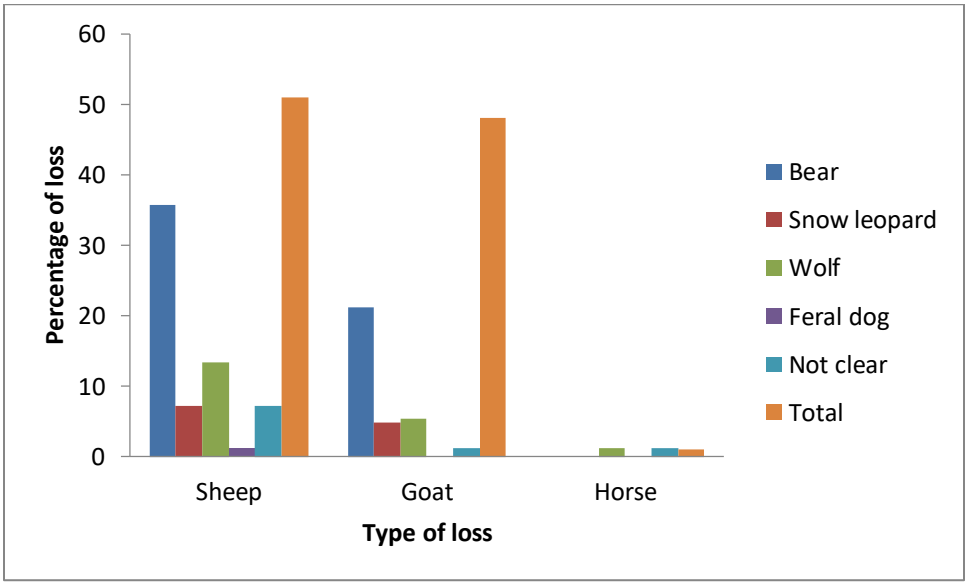

Figure 9. The Livestock lost by Gaddis in 2019-20. 165 livestock were lost to 15 Gaddis (n= 165)

4.2.2. Compensation and mitigation

Respondents facing Bear conflicts (n= 20) reported wide range of methods for guarding livestock from predators (**Table 11**). All respondents kept dogs as they provide early warning signals, while many (85%) pelt stones to scare them. Some Gaddis also used, crackers (30%), and corral (10%) in combination with the dogs and deterrents in order to scare bears and other predators. Losses are high because most losses take place at night when the people aren't prepared with crackers and stones. Corrals aren't strong enough to prevent attack from bears. Respondents mentioned that dogs aren't fierce enough to scare bears (30%), bears get habituated (10%), or the dogs are lost on the way (5%). It requires the combined effort of dogs and Gaddis to scare the predators by risking the dogs' and their own lives.

	Dog	Pelting stone	Crackers/ fire	Corral
% respondents using it	100	85	30	10
Effective	55	47	83	50
Moderately effective	45	53	17	50

Table 11. The distribution of mitigation methods and the percentage of people who mentioned their efficiency when each method is used individually (n=46; people used >1 method).

Only 13% respondents reported receiving compensation from forest department for their livestock losses. Most (65%), however, did not apply for compensation due to different reasons such as insufficient amount of compensation, sparse knowledge about such schemes, the complicated procedure, time lag in getting compensation (**Fig. 10**). The Forest department Record for the past 20 years has only 4 cases (for 26, 6, 8, and 106 livestock loss) of compensation given to Gaddis. The amount varies from 6000 to 7,50,000 INR. Four out of 23 respondents declined to answer these questions. Measures that herders proposed to prevent future depredation of livestock from bears included: making reserves for bears, providing guns and license for killing wild animals, translocation of bears.

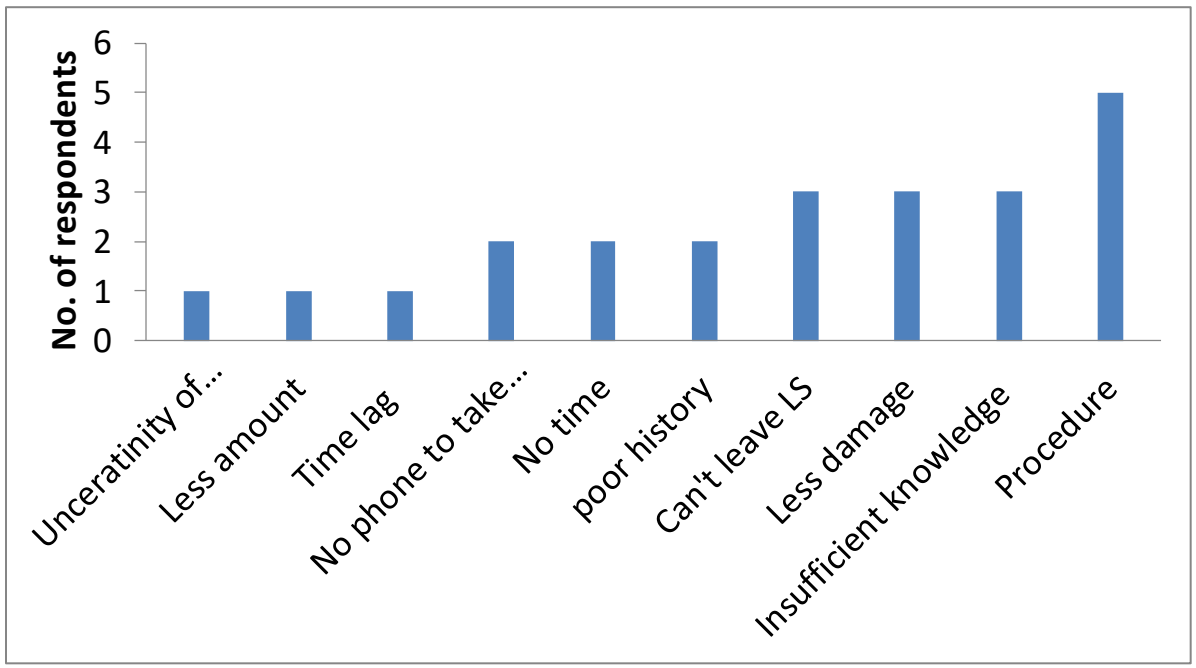

Figure 10. Reasons for not applying for compensation given by Gaddis were: Uncertainty of getting compensation, the monetary amount being less, time lag in getting compensation, no phone to take pictures to complete the application procedure, no time to go to the office, poor history of compensation, can't leave livestock at pasture, the losses were not severe, insufficient knowledge about scheme, and procedural complexity (n=15). Note that each respondent was allowed to give more than one reasons for not applying for compensation.

Image 9. Corral built by Gaddis in a pasture. Such corrals are designed to keep livestock in rather than predators out.

Chapter 5.

Discussion and Conservation implications

5.1 Discussion

The expansion of settlements and cultivated land, and the shift to apple orchards and cash crops such as peas, potato, iceberg lettuce, and carrots, are the most probable reasons for the human-bear conflict in different villages of the valley. Among the people that reported crop losses, maximum people (64%) reported losses by bear. Bear cause damage to orchards, and important economic crops such as peas, potatoes, and iceberg lettuce. In some villages such as Gushal and Rashil, the damage to carrot and iceberg lettuce by bear was so extreme that they stopped growing these crops altogether. Further, for both, the agropastoral Lahaulis and the pastoral Gaddis the primary cause of livestock losses was bear. Other losses include damage of the uncultivated area that the bear dig for searching wild roots, damage to water source (in Sakar village), damage to property (in Gondhla village bear tore the tent of a person), and injuries to people. Many people reported that actual losses due to consumption of crops/orchard produce by bear was far lesser than the damage they cause in the process e.g. by tramping over crops, breaking tree branches and killing more livestock than they can eat (surplus killing). This damage is extreme for apple orchards which take 10-15 years to fruit. There has been only one case of physical injury by bear in Tindi village to a woman.

The proximity of good bear habitat areas such as woodlands and narrow nullahs to anthropogenic food sources like cropland and orchards allow the bear to fulfill their dietary requirements before going into hibernation. Conflict is higher in the left bank of the Chandra-Bhaga river which has higher proportion of forests. The fact that these areas are contiguous with the Kugti Wildlife Sanctuary (in Kangra) which has a good bear population (Rathore, 2008) also may be an important factor. Many Gaddis enter into the valley from this path which has led some people to believe that bears enter into the valley following the livestock of the Gaddis.

The theory of planned behaviour and its' modifications have been widely used in conservation studies to predict the drivers of people's behavior towards wildlife (Ajzen,

1985; Fishbein and Ajzen, 1975; Homer and Kahle, 1988; Ajzen, 1991; Bhatia et al., 2019; St. John et al., 2010; Liu et al., 2010). According to this theory, the behavior of a person is determined by the person's attitude towards the behavior, the subjective norms, and perceived behavioural control (Ajzen, 1991; Bhatia et al., 2019; St. John et al., 2010; Liu et al., 2010). For the Lahauli agro-pastoralists, although the attitude of majority of people towards bear was positive, the willingness to co-exist was low. Other studies (Zimmerman et al., 2005; Meena et al., 2020) also found positive attitude towards predators.

Tolerance is the expression of attitude and behavioural intention of a person (Bruskotter et al., 2015; Meena et al., 2020). Majority of the Lahauli agro-pastoralists had low tolerance for bears. Even in villages where conflict is minimal, people believed that the increase in bear population will lead to increased damage and threat to life. This is particularly applicable to the villages where the people have to travel through the forests to the irrigation water sources during early mornings or late evenings when bears are most active. Another study (Liu et al., 2010) also reported that the perceived threats of destroying property and bodily harm shaped the negative attitude among people for bear. Even though the tolerance of people was low, people reported no or little inclination towards retaliatory actions. Many even mentioned that it would go against their religious beliefs to retaliate.

To deal with the conflict, people are using a wide range of methods to protect their crops and livestock. But the methods come with certain challenges. People have to spend their night at fields in order to guard the orchards and crops. Some even mentioned that bears are getting habituated to them. Literature (Get Bear Smart Society, 2015) also suggests that bear may get habituated to noise deterrents over a period of time. People lack effective mitigation measures to deal with bear at the pasture grounds which is leading to livestock losses to Lahaulis and the Gaddis.

The Gaddi people face several challenges from wildlife depredation throughout their journey to and from Lahaul, which includes increasing theft cases, and loss by natural calamities like landslide and glaciers. They also face life threat from wildlife whose habitats often overlap with the grazing grounds. The losses can be severe as is indicated from an incident where about 250 livestock of one Gaddi were lost to a bear attack when in haste all the livestock jumped into the river to save themselves, but perished in the process. Another incident took

place in 2020 where while defending his livestock from a charging bear the Gaddi lost his life by falling over a cliff. Such incidents show the risk they face at the higher pasture grounds from potentially dangerous wildlife.

The low tolerance of the Lahaulis and the Gaddis can also be due to inefficient compensation program. Recently the Pradhan Mantri Fasal Bima Yojana (PMFBY), an insurance scheme for farmers, has started functioning in the region. However, it is yet to be implemented widely. Before this, people had no option for crop compensation. For livestock losses in the two decades (from 2000-2020) 227 compensation cases have been filed in the Forest Department altogether. There were no compensation records for the years 2002, 2003 and 2004. People might be reluctant to apply for compensation due to different reasons (**Figure 10**). The maximum compensation cases are for snow leopard (82) followed by wolf (31) and bear (17), although the pattern of losses for Lahaulis and Gaddis together is highest for bear. The amount paid for the compensation for livestock losses varied from INR 400 (in the years 2000 for 1 sheep) to INR 7,50,000 (in year 2019 for 250 livestock), which was against an overall loss of about three times this value. The failure of compensation scheme and the current mitigation methods have led to resentment among people. In future, due to more cash crops, and less bear habitat due to change in land use and climate change can further escalate the conflict. Since, bear population may increase withfood availability, there can be an increase in conflicts in the region.

Effective mitigation measures are likely to improve people's attitudes towards bears. Studies have shown that educational programs can increase the tolerance towards wildlife (Ogada et al., 2003; Lindsey et al., 2005; Liu et al., 2011). This may be particularly effective as people largely have positive attitudes towards bears although have relatively low tolerance. Educational programmes for better awareness can greatly help improve tolerance, while simultaneously working on preventing losses. It will take efforts from the forest department and conservation organizations to convince people about importance of bears and their protection. The key factor here is to identify key messages for the stakeholders and convey it to them though suitable media.

5.2 Conservation implications:

Although this study has been completed in brief time period, it has important implications for managing bear conflicts in the region, especially during pre-hibernation periods. To resolve the conflict, the rights of wildlife as well as the people need to be protected. Since conflict is more in certain pockets across the valley, village cluster-wise participatory conflict-management strategies can be prepared. These can include coming up with action plans using the traditional wisdom and modern technology (Can et al., 2014). Preventive measures such as effective barriers, community guarding, dogs, noise and physical deterrents can be used. Consistent aversive conditioning of bear with deterrents can modify bears' behavior by associating undesired behavior with the unpleasant stimuli over a time (Get Bear Smart Society, 2015). If losses still take place, compensation and insurance schemes can be implemented. However, compensation schemes are not financially stable and come with operational difficulties such as the failure to ensure timely payments, no clear guidelines, and difficulty in measuring success (Pettigrew et al., 2012; Alexander et al., 2015). Further, implementing compensation schemes can lead to inflated claims and people can become complacent and more losses can happen (Sekhar, 1998). It heavily relies on budgets of the governing bodies, and does not encourage villagers to coexist with the conflict species. Community based insurance programs are an alternative where the people can contribute monthly premiums and receive compensation in proportion to the livestock lost (Mishra et al., 2003). Involving the Mahila Mandals and Panchayats of the villages will facilitate easier access to official compensation schemes. The inclusion of cultural and social institutions within conservation framework has been proposed to increase effectiveness (Berkes, 2004; Waylen et al.,2010; Dhee et al., 2019).

Economic losses can be offset by increasing the alternative source of livelihood. With the establishment of Atal Tunnel there is a possibility of increase in alternate source of livelihood such as tourism, and business which might make up for the economic losses due to conflict. But this will not be applicable in distant areas like Miyar and Tindi where conflicts are high. Additionally, the tolerance of people towards bear might not change.

The local communities can be trained in growing unpalatable high value crops like medicinal plants (the area is good for Sea Buckthorn, hing (asafetida), Hops and Kuth production) and

ornamental plants (area is good for *Lilium*). The state government and forest department can provide with sufficient incentives to start the shift to non-palatable crops in affected villages.

For the Gaddis, the compensation process can be made easier with the help of technology. Such incentive has been implemented in Bandipur Nagarhole National Parks, Karnataka (Sidder, 2016; Manral et al., 2016). The claimants were taught to use cell phones to file the claims to get timely compensation. This, along with sufficient compensation amount and providing solar cell phone chargers might solve the major problem. A community based insurance program can be undertaken on experimental basis. A study on bear-sheep interaction (Jorgenson, 1983) showed that herders who kept their sheep in tight bands close to themselves suffered lower losses than the ones who let the sheep wander freely (Rathore, 2008). Worldwide, the most mentioned approach to deal with human-bear conflict is education (Can et al., 2014). A multi-stakeholder awareness program that will include the community, the government, and the forest department, along with further research on bear behavior and conservation education can contextualize the conflict and increase the tolerance of people (Liu et al., 2010). Involving the local communities by making them a stakeholder in such projects result in communal empowerment, self-reliance, and willingness to co-exist with the problem species (Wangchuk and Jackson, 2004; Manral et al., 2016). Thus, promoting conservation of bear will require not only reduction in economic losses but also communal and locally adapted solutions to promote co-existence.

In essence, multipronged actions to prevent losses, offset losses that still happen, spread better awareness among stakeholders to deal with the issue and strengthen local institutions to work with government agencies, are the key to manage the burgeoning problem of human – bear conflicts in Lahaul.

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Appendices

Appendix:1

Section 1: OBJECTIVE 1: Spatial patterns, extent and nature of conflict

A. CROP LOSSES:

1. What are the different losses to crops you need to deal with? (Make a list and rank**1- least damaging, 2-moderately damaging, 3-highly damaging 4- severely damaging**)

S.No.	Cause of losses	Remarks	Ranking
1			
2			

2. What are different crops grown and in what percentage area? What is the avg yield and losses of crops in last yr? Losses are due to which species? The location and characteristic of the field.

SrNo	Crops you grow	% area	% Losses in 2019-20, % WL losses	Species of wild animal (also domestic)	Location of fields (see RM) [central/peripheral/ isolated]	Any other characteristics of the field?*
1						
2						
3						
5						

* Can ask about proximity to forest, forest patch, road, cliffs,rivers , etc.

Get the average crop wise yield, crop type, and rate per kg for each crop from field assistant or a few respondents.

3. When does the most damage by the following animals occur? In which seasons and what time?

	Morning/ Afternoon/ Evening/ Night	Season of loss
Brown Bear		
Black Bear		
Ibex		
Livestock		
Monkeys		

B. LIVESTOCK LOSSES:

1. What are the different causes of mortality for each livestock? (Make a list and rank, **1- least damaging, 2-moderately damaging, 3-highly damaging 4- severely damaging**)

S. No.	**Livestock species**	**Cause of loss 1**	**Rank**	**Cause of loss 2**	**Rank**	**Cause of loss 3**	**Rank**	**Cause of loss 4**	**Rank**	**Remark**
1							-			
2										

2. Specific Household level details: Would you please give details of the livestock you own and livestock you have lost in the past 1 year.

	Cow		Donkey		Goat		Horse		Sheep		Yak		Cow-Yak Hybrids	
	Adu	Juv	Adu	Juv	Adu	Juv	Adu	Juv	Adu	Juv	Adu	Juv	Adu	Juv
Livestock owned														
Disease														
Snow and cold														
Brown Bear														
Black Bear														
Snow Leopards														
Wolves														
Free ranging dogs														
Lost														

3. Quantify under what condition depredation events occurred

Species Killed/injured	**Killed/Injured By**	Number killed/injured with **age** (adult/juvenile), **sex** (male/female), **season** (winter/summer/spring), **time** (morning, noon, evening, night)	**Location of attack (Field / Village / pasture / corral / forest/ other)**	**Accompanied by herder (Yes/No)**
Cow				
Donkey				
Goat				
Horse				
Sheep				
Yak				
Cow-Yak Hybrids				

Get info on age-sex wise costs of livestock's, and avg ratio of herder/LS from F.A. or a few respondents.

Open ended Questions to understand people's perception of conflict Questions in red below to be asked only to key respondents, you may choose them based on your assessment of knowledge and interest in the questionnaire.

1. Do you see any changes in the crop damage by wild animals? What are those changes? Why do you think these changes occurred?
2. Have you observed any changes in livestock predation by carnivores? What are those changes? Why do you think those changes occurred?
3. Do you see any connection between conflict and other changes around you? Please elaborate.

4. How do you see the future of livestock rearing in the region?

Section 2: For objective 2: Socio-psychological factors: Attitude, Societal norms, and Perceived Behavior Control

a. Measure Tolerance (capacity for people to accept bears)

1. Would you prefer the bear population to be?
    a. reduced/eradicated
    b. stay the same
    c. increased.
2. Did you or a family member face any **other** losses due to bears in the last 12 months?
    a) House-wall was broken
    b) Food grains were consumed
    c) A human was mauled
    d) Attack on dog
    e) Other (mention)

b. Understand/quantify motivation to co-exist/retaliate

Please circle the number corresponding to whether you agree or disagree with the Hypothetical statement below:

*(1 = StronglyDisagree/*मजूबतीसे*, 2= Disagree* असहमत*, 3=neutral, 4=agree, 5 = Strongly Agree/*सहमत*)*

Attitude towards Bears

	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree
1. Bears have an equal right to live in the mountains here	1	2	3	4	5

2. Bears have an important role in nature	1	2	3	4	5
3. I think it is important to protect bears	1	2	3	4	5
4. We need to know and learn more about bears	1	2	3	4	5
5. I am ok if bears raid my crops or kill a livestock occasionally	1	2	3	4	5

Attitude towards sharing resources with bear and living in harmony (co-existence)

	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree
1. I do not mind sharing the resources nature provided with bears	1	2	3	4	5
2. Even if bears consume my crops, I do not want to harm them	1	2	3	4	5
3. Even if bears kill the livestock, I do not want to harm them	1	2	3	4	5
4. People and bears should continue to live together	1	2	3	4	5
5. I do not want bears to be translocated.	1	2	3	4	5

Subjective Norms – Family and Village Influence

	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree
1. My close friends in the village will approve if I kill a bear	1	2	3	4	5
2. My family will approve of my killing a	1	2	3	4	5

conflict bear					
3. My religious priest/lama will approve if I kill a bear	1	2	3	4	5
4. My village elders will approve if I kill a bear	1	2	3	4	5
5. My neighbors will approve if I kill a bear	1	2	3	4	5

Perceived Behavioral Control

	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree
1. If I want, I can kill a bear and no one from my community will report it to authorities.	1	2	3	4	5
2. I am confident that I can involve people in killing a bear, if it harms our crops/ livestock.	1	2	3	4	5
3. I can easily dissuade my neighbor from killing a bear.	1	2	3	4	5
4. I can easily convince people for helping in protecting/conserving bears.	1	2	3	4	5
5. It is easy for me to get the tools for killing bears.	1	2	3	4	5

Political-Economic Cost/Benefit

	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree

1. I have seen Forest department/NGOs respond to the conflict and would not like to therefore engage in it myself.	1	2	3	4	5
2. The losses suffered are so low/irregular that I do not mind bearing the cost of the loss.	1	2	3	4	5
3. Bear presence will aid in the economic growth of the region through tourism.	1	2	3	4	5
4. I do not harm Bears because living near the forests is important to me and conflict with Bears is a trade-off that one must bear.	1	2	3	4	5
5. We can't kill bears because of customary laws	1	2	3	4	5

Section 3. Objective 3 Local Knowledge, fear and mitigation measures

Evaluate for how long a family has been engaged in livestock/crop production activity.

1. For how long have your family been actively engaged in livestock rearing? Have you always done so? (Pay attention if there is a recent switch and note down the approximate Year).
2. For how long have your family been actively engaged in crop production? Have your family always done so? (Pay attention to a recent switch and note down the approximate Year).

Measuring Fear

Quantifying sense of fear of bears (Guttman Scale of the Measurement of fear of crime)

Question: Is there any area near your village you would be afraid to walk alone due to bears? (Ask about where it is and later try and locate on a google earth map to get coordinates)

1. Would you be afraid to walk alone to your neighbor's house during daytime? (Yes/No/No Response)
2. Would you be afraid to walk alone within a kilometer of your village during daytime? (Yes/No/No Response)
3. Would you be afraid to walk to your neighbor's house at night if accompanied by a friend? (Yes/No/No Response)
4. Would you be afraid to walk to any area near your village at night if accompanied by a friend? (Yes/No/No Response)
5. Would you be afraid to walk to your neighbor's house alone at night? (Yes/No/No Response)
6. Would you be afraid to walk to any area near your village alone at night? (Yes/No/No Response)

Current mitigation strategies:

1. What are the methods you currently use to protect livestock? Rank them in order of effectiveness.

   (Get Pictures if possible)

Method	Rank
Use of bear deterrents like water, stones, etc.	
Crackers	
Guard dogs	
Corrals and fencing	
Solar fencing	
Any other	

2. For methods ranked highest, ask why it is effective and for method ranked lowest ask why its ineffective. Is it effective against all carnivores including bears?

3. What are the methods you currently use to protect crops? Rank them in order of effectiveness.

   (Get Pictures if possible)

Method	Rank
Use of bear deterrents like water, stones, etc.	
Use of physical barriers like barb-wire fencing	
Guard dogs	
Production of sound by banging utensils, etc.	
Solar fencing	
Any other	

4. For methods ranked highest, ask why it is effective and for method ranked lowest ask why its ineffective. Is it effective against all crop raiding animals including bears?

For quantifying risk of bear encounter:

A. Record as many coordinates (or name of location with enough details to plot on map) of (a) bear sightings (b) bear attacks on livestock (c) bear attack on people (d) any area near your village where you would be afraid to walk alone due to bears (**in last 5 yrs**)

	Location	Landmark	latitude (x.y °)	longitude (x.y °)
Bear sightings				
Bear attacks on livestock				
Bear attacks on people				
Bear depredating crops				
Any area near village with high risk of encounter				

Appendix: 2

Villages with High Bear conflict as Determined by Interviews With Key Local Forest Officials

Villages with high conflict	Villages with low-medium conflict
Goshal	Gondhla
Jasrath	Thirot
Nalda	Chokhang
Shipting	Raling
Mooling	Khoksar
Jobrang	Phuda
Rashil	
Rapay	
Yangla	
Gharri (Miyar)	
Tindi	
Madgaraon	

*NOTE:

Gharri, Tindi, and Phuda are the villages which have not been surveyed but are in the list based on what was heard from people.