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Assessment of traditional techniques used by communities in Indian part of Kailash Sacred Landscape (KSL) for minimizing human-wildlife conflict

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ABSTRACT

Communities living in Kailash Sacred Landscape India are often receiving damage from wildlife in the form of property damage, crop loss, and livestock depredation. This study was conducted to assess the use and effectiveness of traditional practices for minimizing human-wildlife conflict (HWC) by communities in KSL India. The fieldwork was carried out in four forest ranges in the Indian part of KSL where 584 respondents participated in interviews. The finding indicates that there are 16 types of traditional methods used by the KSL community in the area including guarding, fencing, night vigilance, scarecrow, and making noise. Around 61% of the respondents in KSL-India identified vigilance as an effective measure to mitigate HWC, while 14% of the people interviewed consider that vigilance by humans is not fully effective. A total of 36% of the respondents reported that the use of a guardian dog an effective measure to mitigate HWC while 47% of the respondents claimed that the use of a guardian dog is not fully effective. According to the respondents, only 20% said that fencing is effective to mitigate HWC while 10% disagreed, 15% neither agreed nor disagreed, 12% agreed while 42% strongly disagreed. Around 34% of the respondents agreed that the use of multiple deterrents is effective in mitigating HWC while 51% strongly disagreed, 0% agreed and 6% disagreed. The study underlines the importance of traditional practices used in KSL-India in mitigating human-wildlife conflict. It also found that traditional knowledge is being lost due to out-migration, reduced social cohesion and erosion of interest in traditional techniques.

1. Introduction

Over several centuries, human communities have developed indigenous methods to manage human-wildlife conflicts (Conover, 2002; Balodi and Anwar, 2018; Gross, et al., 2019; Meena et al., 2021). Each human community has its unique cultural and value belief systems that have enabled them to coexist with wildlife (Nchanji and Lawson, 1998; Anand et al., 2018; Gross, et al., 2019). Crop raiding and livestock depredation by wild animals in many states of India forced farmers to develop various traditional practices to reduce their vulnerability and losses (Sukumar, 1985; Ahmad, 1991; Ogra, 2008; Chetri, et al., 2019; Naha, et al., 2018; Konig et al., 2020). These practices include exclusion of wild animals through the use of physical barriers to reduce human-wildlife conflicts. The effectiveness of such measures depends on a number of factors including design, quality of construction, and maintenance. The barriers include fences, stonewalls, trenches, and moats to prevent wild animals from accessing cultivated areas (Nelson et al., 2003; Ogada et al., 2003; Pradhan, 2018). Cost is an important limiting factor in the use of physical barriers. The cost for the development of a phsycial barrier depends on a number of factors including terrain, barrier design, and the species in question. In addition, many people also deploy fear-inducing stimuli to manage human-wildlife conflicts. This includes visual stimuli such as scarecrows, auditory stimuli such as crackers, banging objects, and use of distress calls, or olfactory stimuli (Nath and Sukumar, 1998; Nelson et al., 2003; Ogada et al., 2003). All these practices have to be constantly changed. This is due to the fact that repeated exposure results in habitation wherein wild animals realize that many of these stimuli and measures do not pose a real threat to them (Sukumar and Gadgil, 1988; Sharma, et al., 2020). This is also true for other traditional methods such as chasing, lighting of fires along fields, beating of drums, and throwing of objects at animals (Hambali et al., 2012; Balodi and Anwar, 2018; Gross, et al., 2019). Some measures remain effect even with repeated exposure This includes the use of watchtowers that serve as a vantage point and increase the probability of sighting potentially harmful wild animals before they cause any damage (Naughton, 1998; Chetri, et al., 2019; Naha, et al., 2018; Konig et al., 2020; Meena et al., 2021). Other similar measures include alarm systems such as the use of rope with small bells or tins, which ensure that farmers do not have to maintain night vigils and is alert to the movement of animals. In addition, some communities also use chemical repellents to manage human-wildlife conflict. This includes area repellents meant to keep wildlife away from an area while contact repellents are used on a

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food item, and systemic repellents are integrated within the food plant (Sukumar, 1985; Parker et al., 2007).

Human-wildlife conflicts are prevalent in Kailash Sacred Landscape (hereafter KSL), where large numbers of mammals such as common leopard, Asiatic black bear, wild pig, and rhesus macaque still roam freely in marginal rangelands and fringes of the human dominant landscape. The increase in the human population in KSL-India has resulted in encroachment into more marginal lands inhabited by wildlife, leading to fragmentation and conversion of forested land in agriculture and buildup areas. It found that people who live in these areas depend more on natural resources and find it difficult to tolerate wild animals in their lands when they consider them a threat to their lives and livelihoods (Hussain et al., 2018; Naha, et al., 2018; Chetri, et al., 2019; Sharma, et al., 2020; Sharma, et al., 2021). The significant conflicts between humans and wildlife in the area include crop damage, livestock predation, and increased risk of attack on humans. In many places in KSL-India, it found that wild animals, many of which are already threatened or endangered were killed in retaliation or to prevent future conflicts. In a few areas, few traditional mitigation measures were used by the local community to reduce human-wildlife conflict found to be less successful. Many traditional mitigation strategies have been initiated to reduce and manage human-wildlife conflicts and provide a long-term solution to the prevalent resource use conflicts within KSL-India. However, there has been an increase in the human-wildlife interface problem, with serious consequences for sustainable conservation practice. Concurrently, the traditional strategies for resolving these conflicts that have existed in KSL communities have gradually eroded in the KSL landscape. The migration of people from villages to cities plays a crucial role in the unsuccessful full of most of the mitigation measures in the landscape. There are variations in traditional practices used to manage human-wildlife conflicts in KSL-India based on diversity of ecosystems and cultural systems. There are numerous instances where local communities have successfully integrated traditional practices with modern technology to mitigate human-wildlife conflicts. A variety of traditional practices, used by the local community of KSL for minimizing of HWC, such as creation fence, burning fires, manual guarding, guard animals, making noises, colored cloths fence, fire & smokes of dung, plastic bottle hang, scarecrows, shining torches and throwing stones to chase away wild animals. Unfortuantely, many of these approaches are not sustainable and environmentally friendly. For instance, the use of fire may cause forest fires, which may result in damage to the ecosystem and biodiversity in general. In this study, we assessed the various traditional mitigation measures for controlling human-wildlife conflict in KSL-India.

2. Study area

The KSL is an important transboundary landscape comprising portions of the southwestern Tibetan Autonomous Region of P. R. China, adjacent portions of northern India, and northwestern Nepal (Zomer and Oli, 2011). The landscape is mountainous, remote, with steep topography, high spatial heterogeneity, and difficult access. The total area of KSL extends over 31000 km^2 area and covers mainly Pithoragarh district in Uttrakhand state of India (Fig. 1), with a geographical area of 7,120 Km^2 lies between 29° 20'-30° 55'N Latitude and 79° 50'- 81° 0'E Longitude, with a total population of 4,83,439. The KSL-India has seven forest ranges, viz. Ask, Berinag, Dharchula, Pithoragarh, Didihat, Munshiyari, and Gangolihat. The forest types range from moist subtropical broadleaf to temperate oak forests, sub-alpine conifers, high-altitude birch forests, alpine meadows, and grasslands. The KSL-India covers 29.53% of the area under forest cover. The forests in this landscape fall under two categories Protected Areas (PA) and non-protected areas. Under Protected Area includes Askot Wildlife Sanctuary and Nandadevi Biosphere Reserve. However, the non- PA category of forests includes reserved under the control of the State Forest Department and community forest i.e. Van Panchayat protected by the community panchayat members. Most of the community forest i.e. Van Panchayats is devoted to the deity by the village forest community, which helps in protecting the forest. Among all the seven ranges, human settlement is very much high in these two ranges as the district headquarter is in Pithoragarh Range. Nearly 80% of the villages are connected with roads in the study area. 63% of people in the study area site is dependent on agriculture and livestock farming. Nearly 53% of the agricultural land share its boundary with forest, and 90% of the agricultural land is rain-fed areas. The landscape has been intersected by numerous rivers, tributaries, and springs. The landscape described above has a distinct geographical identity and represents one of the diverse cultural landscapes (Zomer and Oli, 2011). The landscape exhibits great variability in geological and physiographic forms. The study area shows great variation in altitude which ranges from < 428 m to peaks ranging > 6895 m above mean sea level. The types of land use/cover in the Indian part of KSL, are Barren land, Waterbody, Human settlement, Agriculture land, Range Land, Forest cover, and Glacier & Snowbound areas.

3. Method

The data was collected between September 2013 and July 2016. It used secondary and primary data. Secondary data was collated from the forest department while primary data was collected through the use of a standardised questionnaire administered to respondents living in four forest ranges i.e., Pithoragarh, Dharchula, Askot, and Gangolihat of KSL-India. The questionnaires included fixed-response questions on local conditions, socio-economic characteristics of the local communities, level of human-wildlife interactions, responses concerning traditional mitigation measures, and also in assessing the level of traditional practices for minimizing HWC in the area and whether it has been effective or not. (Adams and Hulme, 2001; Mackinnon 2001; Muruthi 2005; Karanth et al., 2012; Ocholla et al., 2013). Households were identified through the use of stratified random sampling. The entire study area was divided into 1*1 km^2 grids (Fig. 1) and from each accessible grid, 10% of households were surveyed. Through this approach, 584 heads of household were interviewed along with one Focused Group Discussion (FGD) in each village in the four forest ranges of KSL-India. A total of 63 FGDs were help with forest officials, local community members, women and elderly community members. General observations were made on fields and data were collected on several mitigation measures used and their effectiveness, species-specific mitigation measures, level of traditional knowledge among gender, and efforts made by the farmers in the field for chasing animals (Hussain et al., 2018).

We tested the effectiveness of these traditional techniques by coding and labeling each variable. In addition, observation notes were also maintained on traditional techniques used by local communities to manage HWC in KSL-India. Photographs were also taken to record the techniques used by the community. We also collected data pertaining to the reaction of local community members towards wild animals and their attitude of traditional techniques. All the observation was made whenever we come across any mitigation measure and interview were taken of the owner. This method helped us to understand more about the effectiveness of the techniques and the level of effort made by the respondent. The data analysis includes exploration and interpretation as it required the use of qualitative and quantitative analytical tools. We used an Excel sheet to organize data followed by the use of SPSS Statistics 22 to process the data to generate results. The output of the SPSS analysis has been presented through the use of graphs and frequency distribution tables. The coding and labeling for the analysis area are in Table 1.

4. Result

During the field survey, it was found that farmers employed 16 types of control measures in KSL India (Table. 2). Cloth fencing, Watch and ward, and bio fencing was recorded from all Forest Ranges to deter wild pigs, porcupine, rhesus macaque, and birds. Around 61% (n = 360) of

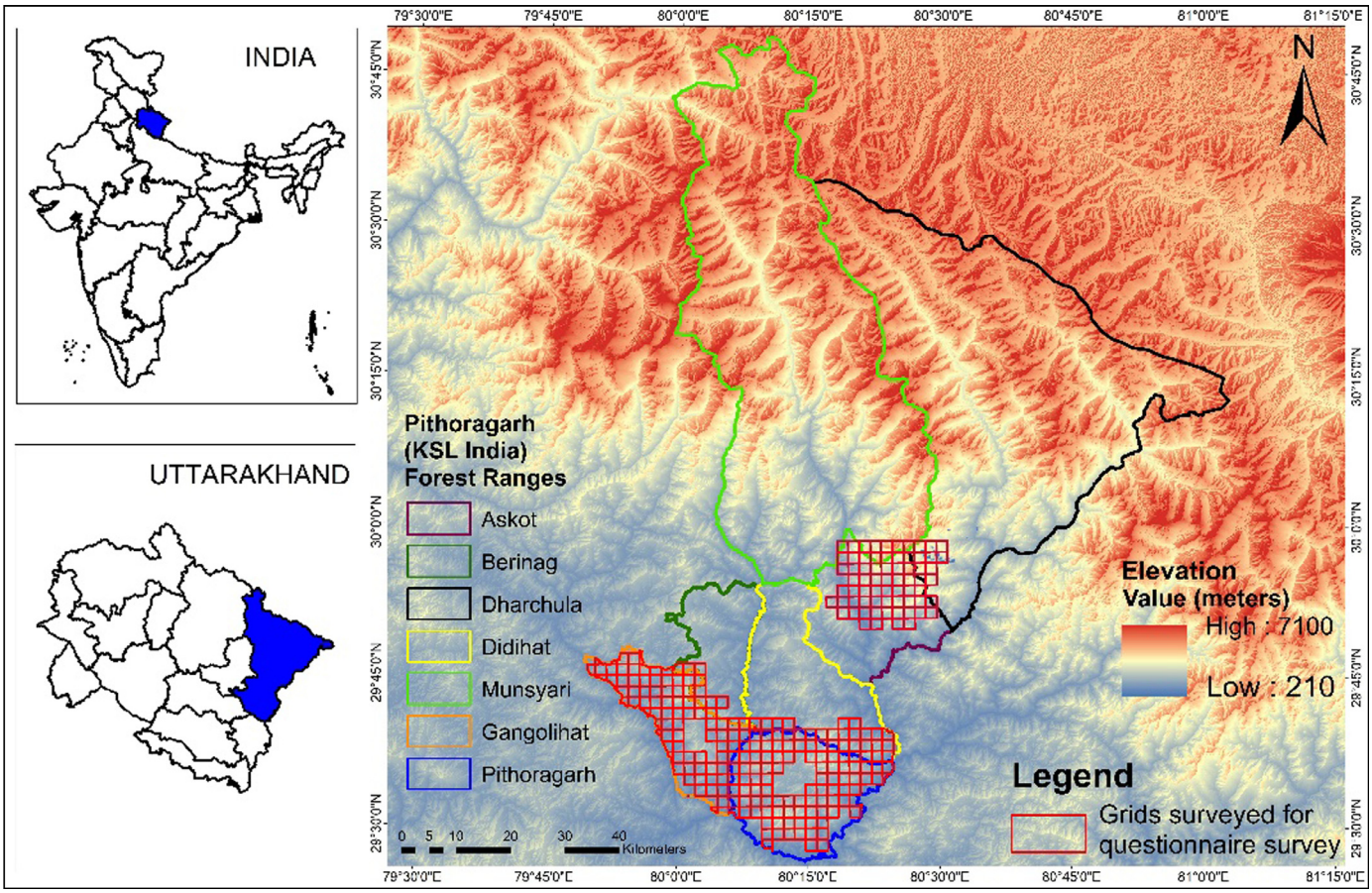

Fig. 1. Map of the study site showing the surveyed grids and study site.

Table 1
Coding and labelling for analysis of Traditional techniques.

Variable (s)	Coding and labeling
Time	0.00 = "No answer"&&&1.00 = "Long"&&&2.00 = "Whole night"&&&3.00 = "Few hours"&&&4.00 = "No time"
Cost	0.00 = "No answer"&&&1.00 = "Expensive"&&&2.00 = "Cheap"&&&3.00 = "No cost"&&&4.00 = "very expensive"
People needed	0.00 = "No answer"&&&1.00 = "Many"&&&2.00 = "Few"&&&3.00 = "None"
People Using	0.00 = "No answer"&&&1.00 = "None"&&&2.00 = "Few"&&&3.00 = "Many

Table 2
Various traditional mitigation measures adopted by local communities in KSL-India.

S.NO	Traditional Mitigation Measure	Forest Range	Target Species
1	Fences 1 Bright color cloth fence (Cloth fencing) 2 Stone Wall Fence 3 Concrete wall fence	All the 7 Ranges of Pithoragarh district	Birds, Wild Pig, Sambar, Porcupine, Goral, Barking Deer and Rhesus Macaque
2	Guardian Dog	Munshiyari and Dharchula ranges	Rhesus Macaque, Black Bear, and Snow Leopard
3	Bio fencing (Barberries and agave plant species)	Gangolihat, Pithoragarh, Mushiyari, and Didihat ranges	Wild Pig, Hare, and Crested Porcupine
4	Trenches	All Ranges	Wild Pig
5	Watch and ward	Pithoragarh, Munshiyari, and Dharchula	Common Leopard (for Livestock), Rhesus Macaque, and Wild Pig
6	Scarecrow	All ranges	Rhesus Macaque and Birds
7	Hanging bright colored polythene	Gangolihat Range (Simalkot Village)	Wild Pig and Rhesus Macaque
8	Beating drums for making sound	Gangolihat and Didihat Ranges	Wild Pig and Rhesus Macaque
9	Air gun/Cracker	Pithoragarh Range (Near to city areas)	Rhesus Macaque and Birds
10	Dung fire	Dharchula Range	Asiatic Black Bear
11	Traps and snare	Very few areas	For wild pigs and common leopard
12	Killing problematic animal	Very few areas	Common leopard and wild pig
13	Poisoning	Very few areas	Common leopard
14	Throwing stones	All Ranges	For rhesus macaque, birds, wild pigs

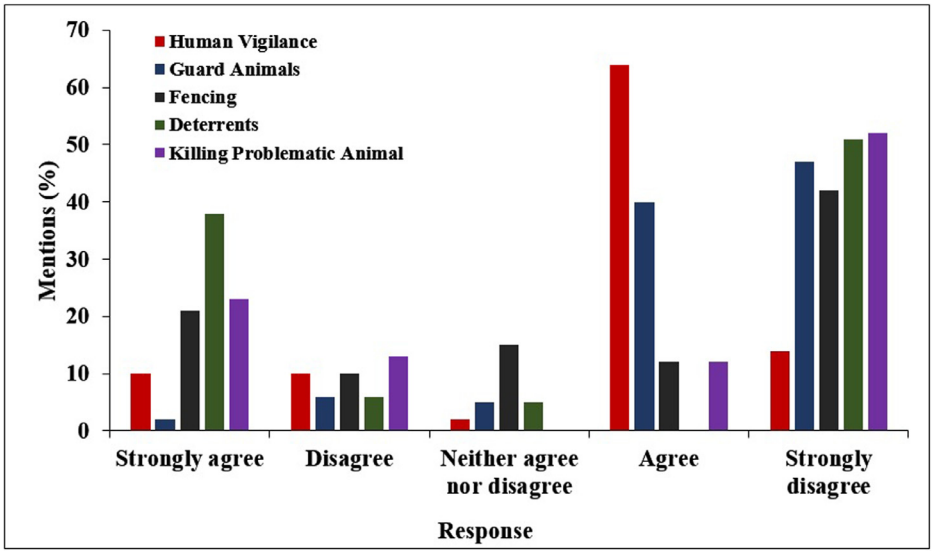

Fig. 2. Evaluation of human vigilance, guard dogs, fencing, deterrents and killing a problematic animal in controlling HWC.

the respondents in KSL-India reported that vigilance is effective in mitigating HWC (Fig. 2). Based on the economic loss and frequency of attack, respondents reported that vigilance is effective as conflict species such as common leopard, wild pig, and rhesus macaque do not raid crops and attack livestock in the presence of humans. In contrast, 14% of the respondents reported that vigilance is not fully effective as conflict species such as wild pigs and small mammals are active during the night when people are not able to guard their fields effectively. Around 36% (n = 210) of the respondents claimed that the use of the guard dog is effective in managing HWC (Fig. 2). Guard dogs usually chase the conflict animal away or alert people about their presence especially at night. In contrast, 47% of the respondents claim this method is not fully effective as the guard dog may attract wild animals such as leopards who are known to prey on them.

Only 20% (n = 115) of the respondents reported being fully satisfied with fencing to manage HWC while 10% disagreed, 15% neither agreed nor disagreed, 12% agreed while 42% strongly disagreed (Fig. 2). Around 34% (n = 200) of the respondents reported that the use of multiple deterrents is effective in managing HWC while 51% strongly disagreed, 0% agreed with 6% disagree (Fig. 2).Those who agreed reported that visual deterrents such as scarecrows and open fires are effective as they drive away wild animals. On the other hand, those who disagreed said that wild animals such as wild pigs and rhesus macaque become habituated to scarecrows over time and they cease to be effective. Around 47% (n = 275) of the respondents claimed that killing a problem animal is not a solution for managing HWC, while 21% (n = 125) of the respondents said that they are fully satisfied, while 16% disagreed, and 12% agreed (Fig. 2). Most of the respondents who disagreed justified their response in the context of religious beliefs and legal sanctions. A few respondents also claimed that killing may result in the extinction of various species in the area. A majority of the respondents claimed that the choice and use of technique is dependent on the species with which humans are in conflict. For example, techniques used to deal with rhesus macaque will not be effective in dealing with ungulates and carnivores. The respondents identified rhesus macaque (45%), wild pig (36%), common leopard (41%), and porcupine (34%) are the most problematic animals in KSL (Fig. 3).

4.1. The attitude of the KSL community towards wildlife

The communities in KSL India are keenly aware of the importance and cultural value of biodiversity in the landscape. The attitude of local communities of KSL India towards wildlife had an average value of 1.97 (+ S.E). Around 51% of the respondents claimed that wildlife is important, 29% stated that wildlife is very important, 17% felt that wildlife is unimportant while 3% thought that wildlife is of moderate importance. However, 80% of the respondents in the landscape who reported a positive attitude towards wildlife justified their response using cultural and religious arguments.

The respondents who reported negative attitudes towards wildlife claimed that wild animals kill their livestock and destroy their crops. There was a significant correlation of this attitude and gender (r = 0.50, p = 0.009) with female respondents reporting a more positive attitude towards wildlife. The responses were not correlated with age (r = -0.07, p = 0.40), level of education (r = 0.21, p = 0.19) or the respondent's access to indigenous knowledge on wildlife (r=-0.06, p = 0.40). The responses were insignificantly correlated to the occurrence of conflicts with wildlife (r = 0.26, p = 0.11), which indicates that the severity of conflict with wildlife is directly related to a significantly lower response that wildlife is important. The correlation analyses of traditional knowledge and attitude towards wildlife were positively correlated (r = 0.23, p = 0.17). We found that respondents with no knowledge of traditional techniques have negative attitudes towards wildlife as compared to some level of traditional knowledge.

4.2. Effectiveness of various techniques in the study area

The results in Fig. 4 indicate that there are more non-lethal than lethal traditional techniques. There are nine non-lethal techniques most frequently used and mentioned 266 times, which is 40% of the respondents. On the other side, lethal techniques were less used and mentioned 99 times only which makes 13% of the respondents. However, throwing stones at the animal and using an air gun to scare the animal, which is a lethal technique, was the most mentioned (25 and 19 times) and used techniques in KSL. Other lethal techniques mentioned by respondents include the use of traps & snares (15 times mentioned), killing a problematic animal (13 times mentioned), and poisoning (9 times mentioned). The effectiveness of each traditional technique was assessed by the frequency of use as mentioned by the respondents and the effectiveness rank given by the respondents. Therefore, effectiveness of traditional techniques was initially interpreted based on the assumption that "the more times a technique is mentioned the more effective it is".

The non-lethal traditional techniques used and mentioned by the KSL community include the use of cloth fencing along agricultural fields (19%), use of scarecrows to scare rhesus macaque and birds (18%), making noise by beating of drums and iron sheets to drive wild animals away (14%), hanging of bright colorful polythene sheets along the edges of agriculture field (14%), human guarding of agriculture land and live-

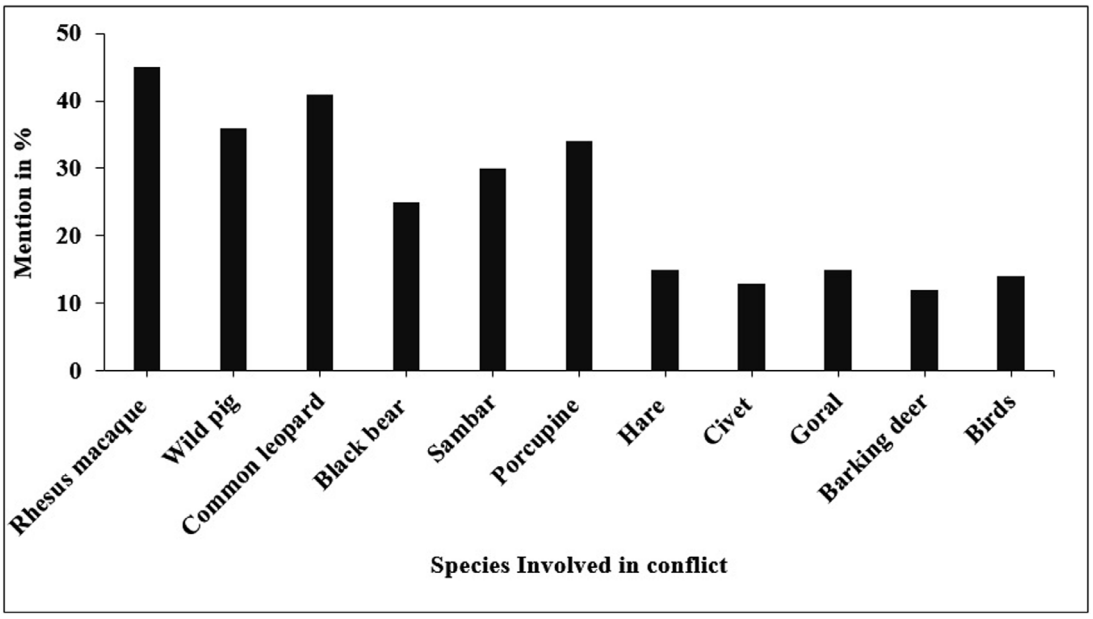

Fig. 3. Wild animals involved in conflict in KSL-India.

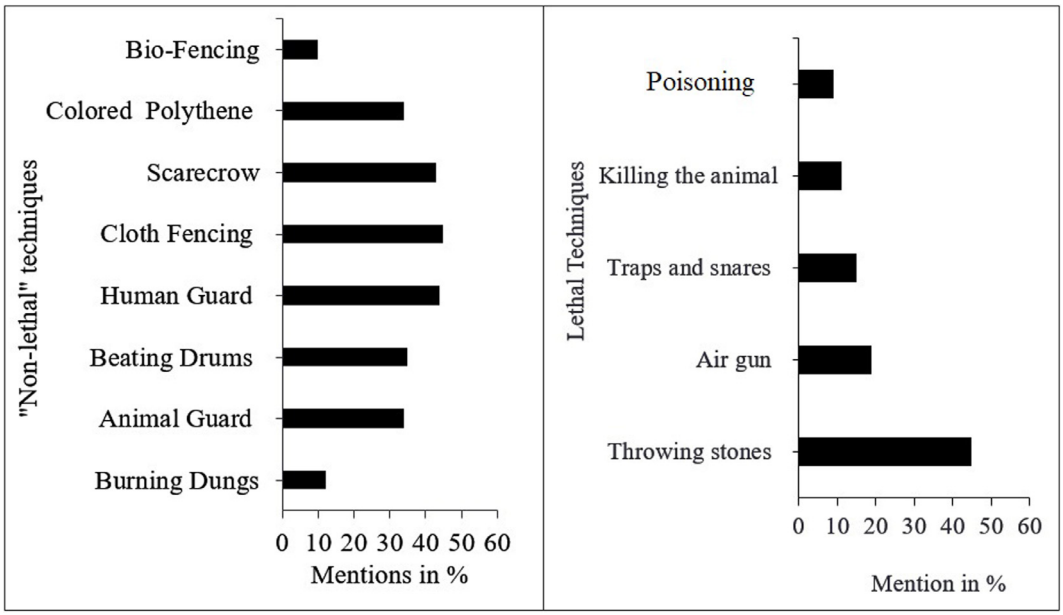

Fig. 4. Some of the 'non-lethal' and lethal traditional techniques used by KSL-India farmers.

stock (17%), guardian dogs to guard and chase away the wild animals (5%), burning dung during night time to scare the animals (5%), and use of bio-fencing along the boundary of the agricultural field (4%) were identified as the most effective techniques reported by the respondents.

The KSL community mentioned 16 traditional techniques, which were used to mitigate human-wildlife conflicts, of these 13 traditional techniques were the most mentioned hence an indication of effectiveness (Table 3). The effectiveness of these traditional techniques is further divided in two broad categories, lethal techniques such as throwing stones at the animal, use of air gun/crackers to scare the animal, traps and snares, killing problematic animals, and poisoning. Non-lethal techniques include the use of cloth fencing along agricultural fields, use of scarecrows to scare rhesus macaque and birds, making noise by beating of drums and iron sheets to scare wild animals away, etc. Effectiveness of each traditional technique is analyzed based on the ranks given by respondents, field observation, efficiency in terms of time and money, fewer people required and use by many people, recorded during the interview and focal group discussion (Table 3).

4.3. Effectiveness of traditional techniques used by the KSL community in terms of time, a person needed, and cost

In terms of cost, human guard, bio-fencing, killing problematic animals, beating drums were cited as the cheapest with a mean of 4.5 and 4.3 respectively (Table 3). These traditional techniques incur little and no cost and describe as cheap techniques. Guardian dogs (1.5), air guns (1.7), and poisoning animals (2.6) were mostly cited as expensive use of these techniques (Table 3).

Buying good breeds of guardian dogs, air guns/ammunition, and buying poison is expensive. Time-wise, killing a problematic animal (4.5), air guns (4.3), and burning dung (4.1) were the most effective

Table 3
Mean of variables and summary of each traditional technique used by the community.

Techniques	N (Count frequency)	Time	Cost	People needed	People using
Kill Problem Animal	11	4.5	4.3	3.4	0.3
Burning Dungs	12	4.1	2.1	2.3	2.4
Animal Guard	34	1.5	1.5	3.5	3.4
Beating Drums	35	1.6	3.3	2.1	3.7
Human Guard	44	1.1	4.5	3.9	3.5
Cloth Fencing	45	3.9	3.0	2.3	3.7
Traps and Snares	15	4.1	2.2	2.2	2.2
Scarecrow	43	3.7	2.1	2.3	3.5
Colored Polythene	34	3.2	2.0	2.9	2.3
Bio-Fencing	10	1.1	4.5	3.0	1.2
Throwing Stone	45	1.4	3.1	2.1	3.7
Air Gun	19	4.3	1.7	0.0	0.2
Poisoning	9	3.1	2.6	2.0	0.1

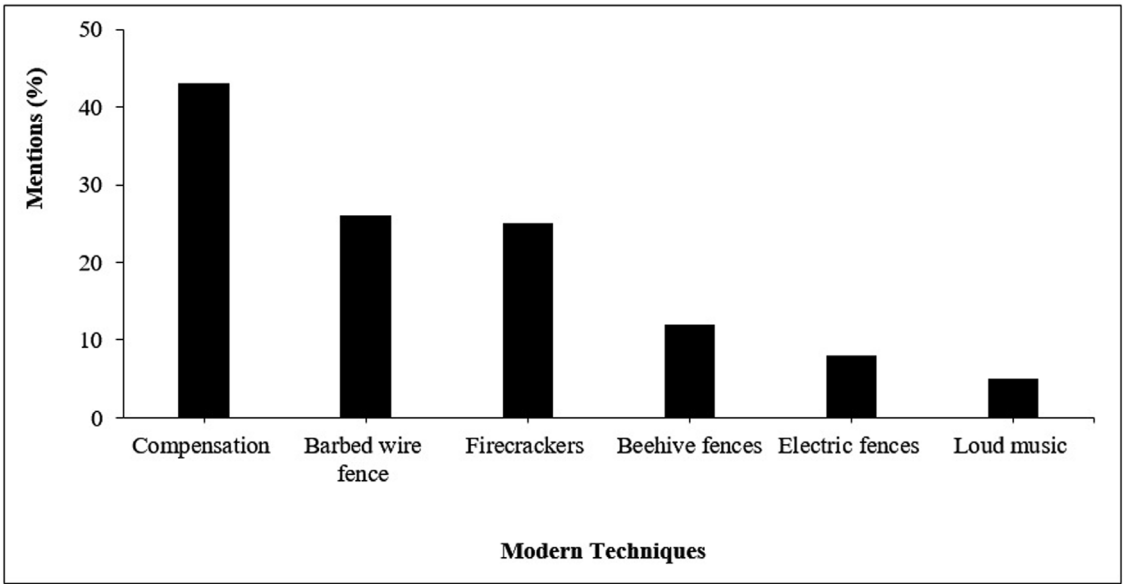

Fig. 5. 'Modern' techniques used to mitigate HWC in KSL-India.

traditional techniques. This implies that using these traditional techniques takes less time and the problem animal leaves soon hence no time is wasted. Human guard (1.1), bio fencing (1.1), throwing stones (1.4), animal guard (1.5), and beating drums (1.6) takes the longest time to work, hence ineffective in a matter of time (Table 3). Bio fence takes the longest time since plants are used for bio fence so it takes the longest time to keep away the conflict animal. The effectiveness of the technique is also governed by the number of people needed. Air guns, poisoning animals, and animal guards do not need many people; therefore, these techniques are effective in terms of the people needed. While human guard and fencing needed more people participation so these are less effective in terms of people needed. Cloth fencing (4.7), throwing stone (4.7), human guard (4.5), scarecrow (4.5), beating drums (3.7), and animal guard (3.4) are cited as the most preferred traditional techniques by the respondents in KSL India. While, poisoning (0.1), air gun (0.2), killing the problematic animal (0.3), and bio fencing (1.2) were cited as the least used techniques by the respondents in the study area (Fig. 5). We also assessed modern methods used by the KSL community to minimize HWC during the field survey. As shown in Fig. 5 the most commonly used modern methods are barbed fences (26%), firecrackers (25%), and beehive fences (12%) to keep away problem animals. On the other hand, 43% of respondents mention compensation as one of the best modern methods, which helps in tolerating wild animals (Fig. 5). The forest department in KSL-India paid compensation for livestock depredation, human injury/kill, and crop damage by wild mammals. The Crop damage compensation started in 2016.

5. Discussion

The study investigated the level of traditional techniques used by the community to minimize HWC in KSL-India. Analysis of data and interpretation of interviews of respondents from KSL-India revealed that traditional techniques among the KSL community are average. This might be because of declining traditional knowledge due to fewer social gatherings and out-migration of people in the study area. Decreasing trends in traditional techniques were also documented by Mong'ou (2008) and Ansah and Mji (2013) in Kenya, while Ocholla et al. (2013) work found that lack of proper record of traditional knowledge as the main cause. There is not a single study from Indian Himalayas on traditional mitigation measure use. Our study found that, lack of awareness and negative perceptions about wildlife among locals is also a reason for the decrease trends in traditional knowledge in KSL India; the same view was also addressed by Ocholla et al. (2013) among the Samburu community in Kenya. S, till the traditional knowledge for minimizing HWC is preserved in many villages in the study site by practicing. We found that elderly people and people with lower levels of education in villages had higher levels of traditional knowledge as compared to those who live in cities. Based on the community response traditional techniques varies according to problem animal, for instance, throwing stones is effective for rhesus macaque, human and animal guards is effective for wild pigs, and beating drums and dung fires are effective for large ungulates and carnivores, the same view was also addressed by King (2014) and Yamakoshi and Leblan (2014) in their research in Kenya and Guinea.

From the study, we found that the most used techniques in KSL-India are bright cloth fencing, scarecrow, community guarding, night guarding, use of animal guards, making noises, beating drums, burning dung, traps, and throwing stones.

Based on the response we found that colored cloth fence is very common in the study site, while concrete and bio fence are not that common. Anthony et al. (2010) work in Limpopo Province supported the use of well-designed live fences like constructed and maintained fence. In contrast, Lamarque et al. (2009) and Yamakoshi et al. (2014) do not support the use of fences as animals may jump over them, may get trapped, interfere with dispersal behavior and local migration. During our study period, we did not record any trapping animals in wire fence incidence in KSL India. Killing problem animals, poisoning, electrocution, and air gun were among the least preferable techniques used by the community in the study site. We found that Acoustic traditional methods such as beating drums, making the nose, and firecrackers are highly supported and used by the KSL community because these methods are very cheap in terms of money. King (2014) and Yamakoshi et al. (2014) in their research highly support acoustic merits as it has no environmental impact, except firecrackers. Around 12% of respondents support burning dungs or wooden logs near agricultural filed helps scare animals, but many disagree with this method as human negligence leads to catastrophic incidence of fire. We found that in KSL-India, lethal techniques are preferred over non-lethal techniques and among lethal techniques, the ones that are cheaper and require fewer people are more commonly used.

We found that the effectiveness of traditional techniques is influenced by factors such as investments such as time, resources, and manpower along with frequency of use and their impact. In this regard, lethal and non-lethal techniques that are cheap and require less time are preferred by people in the landscape. Thus, traditional technique that are expensive and risky are generally not used by the community. Among modern techniques firecrackers, loud music sounds, and air guns are the most effective techniques adapted by the KSL-Community, because, their cost and man effort requirement are less same statement was also stated by Gompper et al. (2006) in his finding of non-invasive techniques used for carnivores. The study indicates that most of the traditional techniques which were passed down from generation to generation for dealing with HWC problems are very crucial and need to record at the same time to pass down the knowledge, which is now decreasing. The same statement was also stated by Yin (2009), Anthony, et al. (2010), and Ansah and Mji (2013) in their study on human-wildlife conflict management and indigenous knowledge across Limpopo Province and Africa.

In KSL-India, we found that some non-lethal techniques are not effective to manage HWC due to religious beliefs related to specific animals such as rhesus macaque and common leopard. People in many parts of the landscape worship these animals, and hurting them is regarded as a sin. While discussing with the forest authority, they state that the high use of the non-lethal techniques in the study area is because of the fear of government authority among the locals. In remote areas in the landscape, we record less government support for compensation in dealing with HWC, which in turn increased the trust of KSL residents in a few traditional methods. Respondents in KSL-India reported that traditional knowledge varies according to the animal in question. For instance, fencing, guarding and animal guards are effective for rhesus macaque and lesser animals while beating of drums and burning dungs are effective against wild pigs. From the findings, the most used techniques in KSL-India are guarding, fencing, animal guards, and making noise. We found that by and large community members in KSL-India did not support killing of problem animals by poisoning, shooting, and throwing stones.

6. Key recommendations

Based on the findings of the study recommends that:

(a) During fodder and fuelwood collection from the forest women should move in groups, children should also move in groups when they go or return from schools, the dense bushes along the human trails should remove and clean from time to time as leopards use such bushes to ambush its prey.
(b) Government should provide sanitation facilities to each household, because most human casualties happen when people got outside in open areas for the toilet.
(c) The forest department should help the villagers to remove bushes from the vicinity of agriculture, as these bushes serve, as a daytime refuge for wild pigs and porcupines, removing these bushes will help in minimizing HWC.
(d) Villagers should use the traditional techniques, such as hanging bells around the neck of the cattle, when the cattle realize the danger, it will try to escape and produce alarm, which alerts the grazers, which help in reducing the killing of livestock.
(e) Local NGOs and concerned government departments must document and strengthen traditional mitigation measures knowledge at the landscape level.

7. Conclusion

We investigated the effectiveness of traditional mitigation measures to manage human-wildlife conflicts in the Indian part of Kailash. We wanted to determine the effectiveness of traditional mitigation measures in mitigating conflicts in this landscape. We found that there are some traditional techniques still being used in the study area that are effective in mitigating human-wildlife conflicts. These techniques can be divided into lethal and non-lethal techniques. We found that some of the lethal techniques being used have a negative impact on the environment and people. Thus, we conclude that interventions are required to preserve existing traditional knowledge to prevent the loss of sustainable techniques to mitigate human-wildlife conflicts. We also found that all traditional techniques are not always effective (100%) due to factors such as cost, time, labor, and impacts on people and the environment. At the same time, some of these techniques have an adverse impact on the ecosystem and the target species and must remain the last option to manage a conflict. There is an urgent need to integrate traditional techniques and modern scientific knowledge. This will improve the traditional technique and increase their effectiveness in managing human-wildlife conflicts.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Ajaz Hussain: Conceptualization, Investigation, Data curation, Formal analysis, Writing – original draft, Writing – review & editing. **B.S. Adhikari:** Writing – original draft, Writing – review & editing. **S. Sathyakumar:** Writing – original draft, Writing – review & editing. **G.S. Rawat:** Conceptualization, Investigation, Writing – original draft, Writing – review & editing.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.envc.2022.100547.

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