Article

Human-wildlife conflict in Uttarakhand: Impact, opportunities and ground level perspectives with mitigating strategies

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Abstract
Human-wildlife conflict has caused high mortality of animals and human in Uttarakhand, India. Due to the continuous changes in forest cover and anthropogenic pressures large groups of animals are forced to occupy the multiuse landscapes outside the reserve forest. The present study is the compiled source of data from Narendranagar forest division with respect to Uttarakhand and adjacent Himalaya. We have recorded about a total of 740 casualties of livestock predation along with 126 incidents of human injured and 36 incidents of human death in Narendranagar forest division in last 20 years. Further we have also compiled the data of main problematic animal viz. leopard involved in livestock predation and human death and injury. Human death, injury along with livestock predation and crop raiding were main issues in present review. Further it was observed that most of the attacks on wild animals occurred when livestock were freely grazing within the multi-use areas without supervision of a herder. Leopard and elephant were mainly involved in human death whereas elephant and monkey in crop raiding. In addition, leopard mortality rate was also observed to be increasing in Uttarakhand which was mainly due to natural deaths, poaching, accidents, declared dangers, burnt, forest fires, food poisoning, mutual fights, and road accidents. The present study suggests public awareness for co-existence strategies, supervised grazing, awareness of high-risk areas, prompt response by the rescue teams, removing of unnecessary canopy of plants around human settlements should be initiated to reduce predation by wild animals. A further study on leopard behavior, relocation, and social collaboration is needed to understand the basic reasons behind the conflict and conservation measures to be taken. The present study areas also demand culturally and sustainable acceptable strategies along with better compensation to mitigate the damages.

Keywords human-wildlife conflict; livestock predation; crop raiding; compensation; Narendranagar forest division.

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1 Introduction

Human-wildlife conflict (HWC) is one of the most important issues in India. It is one of the most important issue where both human and wildlife population coexist and share the available resources thus affects the livelihood and security of local community (Distefano, 2004). Shifting cultivation, encroachment as well as increasing anthropogenic pressures with limited resources, mining, and exploitation of natural wealth are the major problem creating elements in human-wildlife conflict. Further, retaliatory killings, floods and drought and decline of natural forest by increasing of monoculture plantation are other drivers of human-wildlife conflict. They are a higher obstacle to human-wildlife conflicts, conservation and livelihoods of people worldwide (FAO, 2009). Asia is a center of human-wildlife conflicts with higher rate of animals and human mortality. So here, HWC is a challenging issue for conservation biologist. *Panthera* spp. and *Elephus maximum* are major wild animals for HWC in Asia whereas in India *P. pardus*, and *Elephus maximus* causes great loss to human community. The man-eating tiger was one of the important issues for forest department since many decades especially in Central India, Bengal and including the foothills of Himalaya. Tiger has also caused significantly damaged in terms of human life since many years. As per the report about 500 people were killed by wild animals mainly by *P. tigris* in different areas in 1822 (McDougal, 1987), whereas in 1877 British has claimed 798 humans by *P. tigris*, and in 909 in 1908 (McDougal, 1987). Similarly, as per the record of British Government in India, about 7662 killed between 1902-10 (Guggisberg, 1975) whereas in Sundarban region (West Bengal, India) which was a hotspot of man-eating tiger has killed 100 humans annually (Sanyal, 1987). The present study is the compiled source of data from Narendranagar forest division with respect to Uttarakhand and adjacent Himalaya.

2 Study Area and Methology

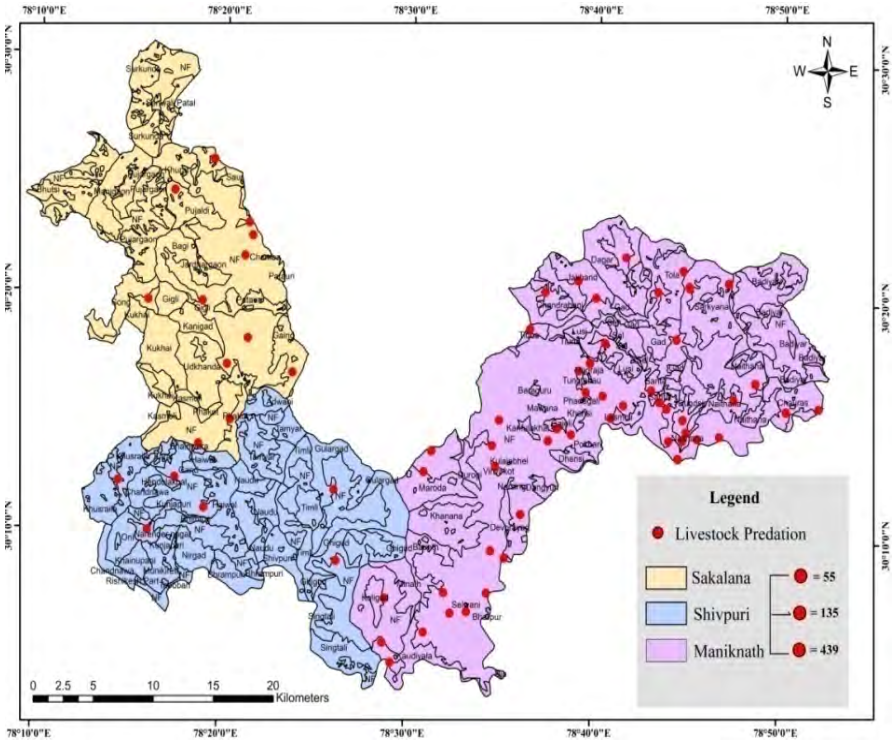
2.1 Study area

The present study was carried out in Narendranagar forest division which is an important part of Garhwal Himalaya located in 30°29’ to 30°3’ N latitude and 78°10’ to 78°53’ E longitude in Uttarakhand (Fig. 1). Alaknanda River in the east with the forest ranges of Rudraprayag Forest Division and by Mussoorie-Dehradun Forest Division in the West. Recently two more ranges named Narendranagar, and Kirtinagarhas been created in Narendranagar forest division. Narendranagar forest division is highly occupied with *Pinus roxburghii* (Chir-Pine) with an area of 22977 ha along with *Quarcus-Rhododendron* community, *Shorea-mallotus* community and mixed dense forest community. Garhwali, the main community of the Narendranagar forest division live in the vicinity of the forest, depends on the forest resource for livelihood. Some of the Muslims families also reside in Tehri (part of Narendranagar forest division) where they also dwell with the forest products. Major crops were grown with subsistence level which mainly includes wheat, rice, maize, soybean, finger millet, cow pea, mustard etc with seasonal vegetables. Farming was the primary occupation of the all villages but income was also contributed through daily wages like MGNREGA, private jobs with salaries of state employees.

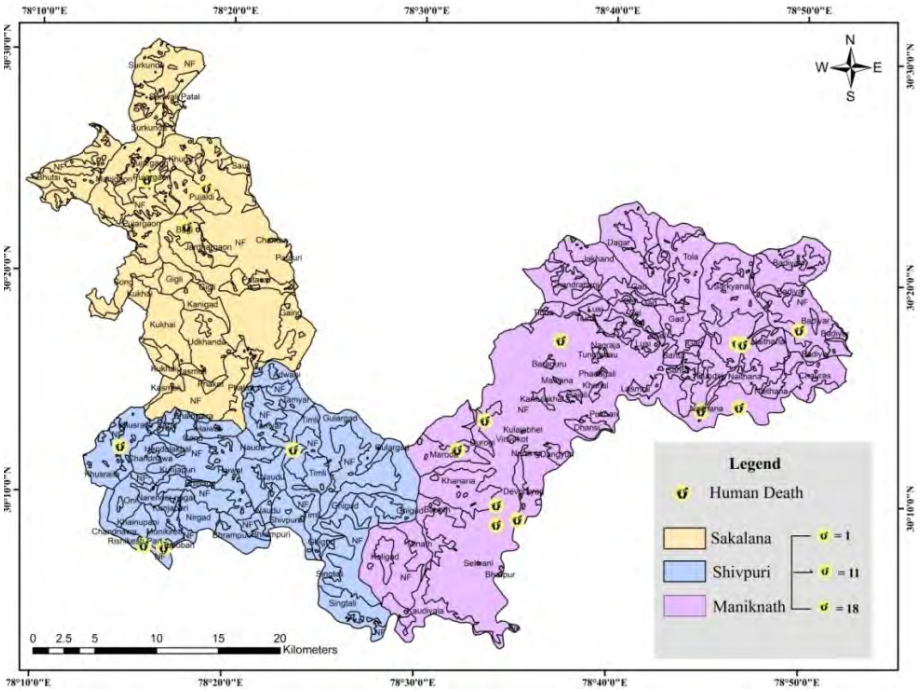
2.2 Data collection

The present study is a combination of a review and filed survey as well as the data of last twenty years from Narendranagar forest division. For this purpose, we have applied several approaches to prepare the manuscript. The literature in the review was selected on the basis of direct observation; information from the registers contained the information about the incident, wild species involved in human injury, death along with killing of livestock, crop raiding by wild animals and compensation provided along with the name of village/locality. The information of the present study is further supplemented with Science Citation Index, Scopus, Google-Scholar and Web of Science searches to fill in gaps along with existing literature from research papers on

Shiwalik. Further special efforts were made to include those research papers which include important finding on fauna in Shiwalik and adjacent areas of the Narendranagar forest division. We have also used human injured and death data register, compensation and livestock predation registers for the report of different incident of livestock predation by wild animals between 2000–2020 of the three forest ranges namely Maniknath, Shivpuri Range and Saklana Range of Narendranagar forest division. Leopard death data was obtained from Wildlife Institute of India, Dehradun, Uttarakhand along with the death cases. The information contained in register about the incident, wild species involved in human injury, deaths along with killing of livestock, crop raiding by wild animals and compensation provided along with the name of village/locality was also cross checked. Further the forest official and the livestock owner who was present during the recent incident has confirmed about the conflict with the research team. If ambiguity occurred for an incident, we have referred the register details of the people of each village were asked about the HWC and further the discussion was made with the local resident and village council to collect the data on HWC and the offence of wild animals. Our primary aim was to avoid bias or any fluctuation in data of so we checked all incidents with the localities or the regions. Second, extensive field survey, group discussions and questionnaire survey were undertaken with the forest official of each beat and the local residing human population of the study area by using a structured questionnaire (Bernard, 1995; LeCompte and Schensul, 1999). Data related to demography, literacy, number of villages and land holding size was obtained from the respective government departments. To address the HWC relating question, local members of each village was involved to participate in the study. In this context, question related to conflict and compensation after conflict was included in the survey with the help of 168 people (132 males and 36 females). Questionnaire related to household's problems and experiences with wildlife along with the compensation**.** Question mainly included occupation of the family, gender of the informants, number of cattle and their death, problematic animals, human injured and human killed. Villagers were also asked about the conflict-management approaches. Analysis of variance (ANOVA) and Pearson correlation was done for statistical analysis by using the SPSS Version 20 (Statistical Package for Social Science).



(a)



(b)

Fig. 1 (a), (b) Map depicting the livestock predation and human threatening beats.

2.3 Human wildlife conflicts in Uttarakhand: an overview with impacts

The forests of Garhwal Himalaya have has been recognized due to habitat of rare and endangered, rare fauna including *Panthera tigris*, *Elephas maximas*, *Panthera pardus* (Johnsingh et al., 2002; Williams, 2002; Johnsingh and Negi, 2003; Table 1).Various flora and fauna in Uttarakhand get conserved through a network of protected areas including Rajaji tiger reserve, Corbett tiger reserve etc. Human-wildlife conflicts are one of the major issues in Uttarakhand which has caused severe damaged in terms of livestock predation, crop raiding along with the loss to human life. Uttarakhand, the hilly state was formed in the year 9 November 2000 with the name Uttaranchal by Government of India with carved out from the state Uttar Pradesh. Uttarakhand has an area of 53, 483 sq. in which 65% of the area is forested (FSI, 2014). About hundreds of HWC incidents occur annually in the area where surrounding communities resides. In Uttarakhand, livestock predation is mainly caused by leopards and tigers crop raiding by elephants, wild boars and various ungulates (Badola, 1998; Johnsingh et al., 2002; Johnsingh and Negi, 2003). As per the report of Badola (1997), 85 people killed by elephants in corridors of Rajaji and Corbett Tiger Reserve between 1982–1993. On the other hand, leopards singly have killed 140 people in Pauri and adjacent areas of Uttarakhand between 1998–2000 (NBSAP, 2002). So, leopards, tigers and elephants have created huge loss of human life in Uttarakhand (Fig. 2).

Narendranagar forest division is an important repository of biodiversity in Garhwal Himalaya. The forest provides favorable condition to large groups of plants and wild animals. The three main ranges of the forest namely Maniknath, Shivpuri and Saklana along with the two recently created new rang viz. Narendranagar and Kirtinagar support viable population of elephants, tigers, leopards, wild boars, monkeys, deer, etc. Locals residing in the vicinity of forest depend on the natural resources of forest for their sustainability and livelihood which become the main reason of HWC. The HWC in the Human-dominated landscape highly affected both human and wild animals in last few decades. As Narendranagar forest division has abundance of leopards and elephants so problems arise repeatedly. Various projects on rail, Char Dham road connectivity, and national

highways are still going on which has greatly affected the habitat of wild animals in Garhwal Himalaya. Cutting of hills for Char Dham also blocked the road for a long period so it gives the wild animals to move around freely. The forest cover great diversity of animals and plant and they are directly connected to the local inhabitants of the area. Narendranagar forest division faced great challenges in terms of HWC in past. About 126 incidents of human injured and 36 incidents of human death along with of 645 incidents with a total of 740 casualties of livestock were recorded in Narendranagar forest division since 2000. On the same ways, about 1396 leopards have been found died due to poaching, accidents, declared dangers and burnt as well as the forest fires, food poisoning, mutual fights and road accidents. As per the report of WII (Wildlife Institute of India. Dehradun) about 121 leopards have been found dead due to different reasons from 1 January 2020 to 30 November 2020. In Narendranagar forest division 3 leopards were killed due to the problematic behavior and 3 were died due to unknown reason. Further, in HWC, leopards also died either through illegally or due to the man eater habit in Uttarakhand. About 1396 leopards died in Uttarakhand from 2000-2020 which mainly include by poaching, accidents, burnt in fires, killing due to man-eating habit, train accidents, mutual fights and by natural deaths. As per the report of Wildlife Institute Dehradun, alone 648 leopards died due to the natural death followed by 152 by accidents, 65 man-eaters by forest officials, 41 by poaching and 212 due to unknown causes.

Although the government is making significant contribution both in terms of conservation of forest and locals' livelihood but problems arise continuously. Narendranagar forest division also has made crucial effort in form of awareness programs, eco-tourism, eradication of *Lantana* and unnecessary canopy of other weed and alien species, better compensation for wildlife protection and for surrounding human population but there is a need of more attention. Sometime direct interaction of human and animals causes HWC. Conflicts in Narendranagar forest division occur in form of livestock predation, crop raiding, human death and injury mainly by leopards, tigers, wild boars and elephants (in Shivpuri range). The incidents of cattle lifting, attack by leopards on the forest dwelling community increases annually in Uttarakhand Himalaya (Johnsingh et al., 2002, 2003). Devprayag-Kirtinagr ranges in Tehri district and Paurirange in Pauri district are most vulnerable for cattle lifting and human death in Uttarakhand. Leopard attack on livestock and human causes severe loss in the past.

Keeping in view of great loss of human and wealth in terms of livestock along with the crop raiding, we examined the capabilities and assets relating HWC by their experience with the wildlife in Narendranagar forest division under Garhwal Himalaya. We have evaluated (1) the spatial distribution of death and injured human along with the compensation provided (2) local perception towards wildlife and conservation (3) enumerating human and livestock activities that were vulnerable to predation (4) socio-economic aspects of the locals (5) documentation of crop raiding sites and compensation provided to the locals and (6) suggesting various management strategies which could reduce the human- wildlife conflicts in Narendranagar forest division.

Table 1 Important wild animals with their IUCN status involved in human-wildlife conflicts in Uttarakhand.

S. No.	Common Name	Scientific name	IUCN status
1	Leopard	*Panthera pardus*	Rare
2	Tiger	*Panthera tigris*	Endangered
3	Himalayan black bear	*Ursus thibetanus*	Vulnerable
4	Wild boar	*Sus scrofa*	Least concern
5	Nilgai	*Boselaphus tragocamelus*	Least concern

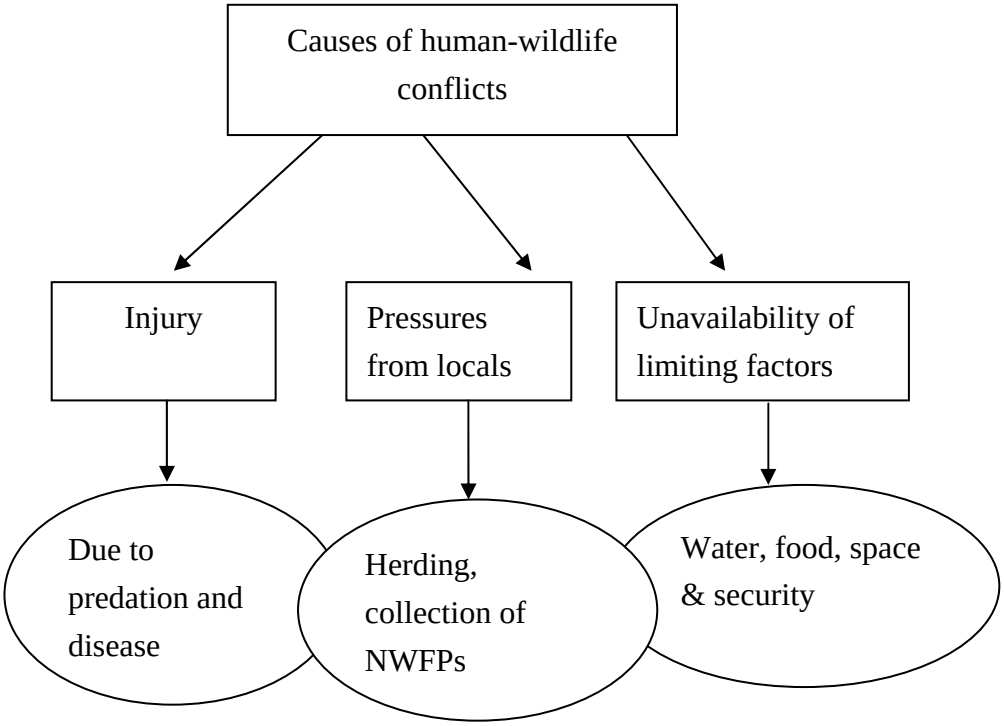


Fig. 2 Summary depicting the causes of Human- wildlife conflicts in Uttarakhand.

3 Results and Discussion

3.1 Human–wildlife conflict: an overview with visible aspects from Narendranagar forest division and adjacent areas of Uttarakhand

HWC has been traditionally viewed when the goals of humans and behavior of the wildlife negatively affect each other (Madden, 2004; Fig. 3). A large number of species has involved in the conflicts with severe effects both on human and surrounding environment (Sillero-Zubiri et al., 2007). The visible impacts mainly involved crop and livestock loss along with the death and severe injury. In Uttarakhand, every year, large number of people and animals gets injured and die due to the human-wildlife conflicts. Conflict by elephants mainly occur in plain areas of Uttarakhand especially in Shivpuri range of Narendranagar forest division and in Haridwar along with some areas of Pauri forest division including Kodiya talla and Malla, Gohri forest division which are prone sites for human-elephant conflicts. In Uttarakhand the mortality rate by elephants is less as compared to other states of India. The death is a person per day in overall states of India (Rangarajan et al., 2010).

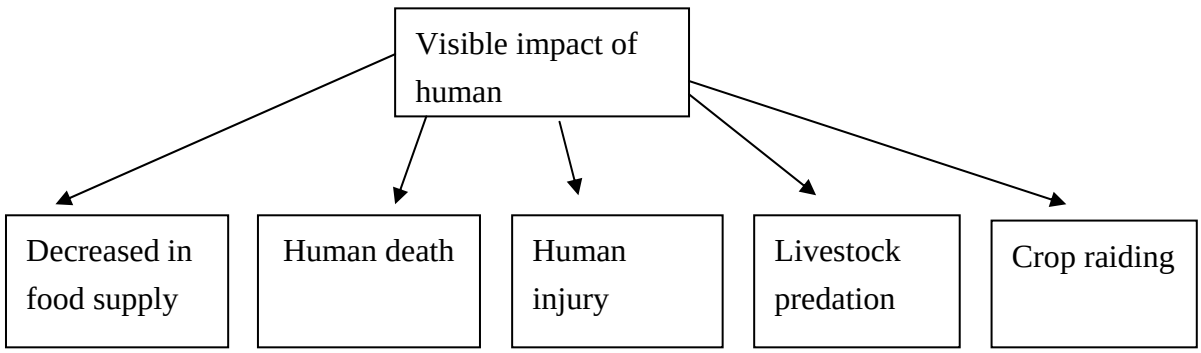


Fig. 3 Summary of visible aspects of human-wildlife conflicts in Narendranagar forest division.

In developing countries, locals lose up about 10–15% of their total agricultural outputs due to elephants (Madhusudan and Sankaran, 2010). These losses seem insignificant at national level which has high cost incurred. In India, about 400 people get injured singly by elephant attack every year (Rangarajan et al., 2010). An injured person mainly belongs to the economic section of the society (Das and Chattopadhyay, 2011).

Crop damage is one of the most harmful activities by wild animals especially in low-income state. Elephants, wild boar are mainly responsible for the crop damages in Uttarakhand. It was observed from various studies that elephant has caused significant damage to crop with 3 million US dollar and breaking of 10,000–15,000 houses annually (Bisi, 2006). On the other hand, loses also has occurred in form of livestock depredation. Such loss often sparks retaliatory killing of wildlife. Although the extant mitigation strategies have emerged from the visible aspects of HWC (Dickman, 2010) which include regulated hunting (Bisi et al., 2007), removal of problematic wild animals (Gurung et al., 2008). Herding of livestock and crop-guarding sometime also has caused severe loss to the human life especially in Western Himalaya. So, reducing the dependency on the NWFP along with the relocation of just adjacent forest communities are great solution in controlling HWC (Ogra, 2009). Other strategies include, separation of locals near wild animals' habitat would be more affecting in reducing the HWC.

3.2 Livestock predation in Narendranagar forest division

The human-wildlife conflicts in Shiwalik have both aspects viz. human safety and local's livelihood which is mainly affected due to the attacks on livestock and humans by leopards, whereas wild animals' conservation on the other way (Fig. 4). Various studies have been carried out on the status of animal attack on human and livestock in Uttarakhand by Agarwal et al. (2011), Goyal et al. (2000, 2007) and Mathur (2014). *Panthera tigris*, *P. leo*, *P. pardus* and *P. unicia*has mainly included in all human-wildlife conflicts that hinder the conservation of the globally threatened species (Rao et al., 2002). Large carnivores including *P. tigris*, and, *P. pardus* are mainly responsible for livestock predation in Uttarakhand. Cattle lifting are one of the main problems in Uttarakhand and Narendranagar forest division has faced severe damages of cattle lifting. It was also observed that livestock predation varies significantly according to species, prey availability and seasons. Narendranagar forest division has faced 645 incidents with a total of 740 casualties from 2000–2020 to livestock by tigers, leopards and snakes (Table 2; Fig. 4). It was also observed that 30.54 % were livestock bull followed by 27.43% were adult cows, 15.13% goats, 6.89% mules, 9.05% horses, 6.21% buffalos, 4.59%, calf and 0.13% were found to be dead mainly by leopard attack.

Table 2 Individual animal mortality cases recorded in wildlife offence cases in Narendranagar forest division.

S. No.	Year	Cow	Bull	Buffalo	Mule	Goat	Horse	Calf	Donkey
1	2000-2005	2	1	1	-	21	1	-	-
2	2006-2010	17	22	4	12	15	4	4	-
3	2011-2015	97	125	24	16	48	38	13	-
4	2016-2020	87	78	17	23	28	24	17	1
	Total	**203**	**226**	**46**	**51**	**112**	**67**	**34**	**1**

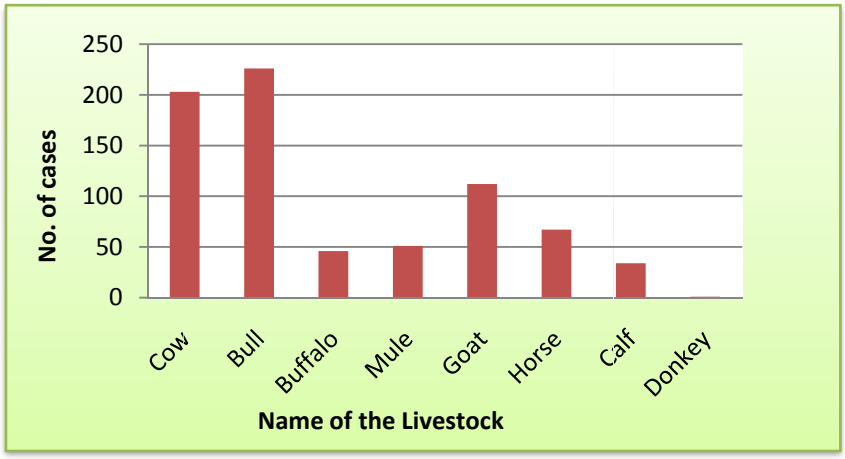


Fig. 4 Number of livestocks involved in HWC in Narendranagar forest division.

3.3 Human injury and death in Narendranagar forest division

India has large history in carnivores' conflicts (Seidensticker and Lumpkin, 1991) while conflicts with elephant and bear occur at the time of protecting their crops **(**FAO, 2009). Conflict with elephant results great loss to property and human life (Twine and Magome, 2008). *Elephus maximus, P. pardus, P. tigris* and *Sus scrofa* are main animals which are mainly responsible for human death and injury in Uttarakhand and also in Narendranagar forest division (Table 3, Table 4). It was observed that hundreds of cases of human death and human injury occurred in Uttarakhand due to the human–leopard conflicts and human-elephant conflicts. Human deaths and injuries are highly observable manifestations of human-wildlife conflicts which are universally regarded as intolerable. In Narendranagar forest division, death of human being and killing of human is also a major problem. As per the report of the division, 126 incidents of human injured and 36 incidents of human death occurred as result of human-wildlife conflicts. There were 54.76 % human injured by bears, 32.53% by leopards followed by 7.93% by elephants and 4.76% by wild boars (Table 3, Table 4, Fig. 5). Further, 63.88% human were killed by leopards followed by 27.77% by elephants, 5.55% by wild boars and 2.77% by bears. It was observed that leopard was main problematic animal in Narendranagar forest division which has caused severe damaged of human life in last twenty year. Although huge leopard death was also recorded in Uttarakhand due to various reason. Natural death was found to higher in Uttarakhand in last twenty years. In Narendranagar forest division the mortality rate was less as compared to other forest division of Uttarakhand. As per the report WII, Dehradun, 3 leopards were killed due to their problematic behavior and 3 were died due to unknown reason in Narendranagar forest division.

Table 3 Individual human injury cases recorded in wildlife offence casesin Narendranagar forest division.

S. No.	Year	Incident	Bear	Leopard	Elephant	Wild Boar
1	2000-2005	32	26	5	1	-
2	2006-2010	57	24	24	7	2
3	2011-2015	31	19	8	2	2
4	2016-2020	6	-	4	-	2
	Total	**126**	**69**	**41**	**10**	**6**

Table 4 Individual human death cases recorded in wildlife offence cases in Narendranagar forest division.

S. No.	Year	Incident	Bear	Leopard	Elephant	Wild Boar
1	2000-2005	3	1	2	-	-
2	2006-2010	19	-	16	3	-
3	2011-2015	11	-	4	7	-
4	2016-2020	3	-	1	-	2
	Total	**36**	**1**	**23**	**10**	**2**

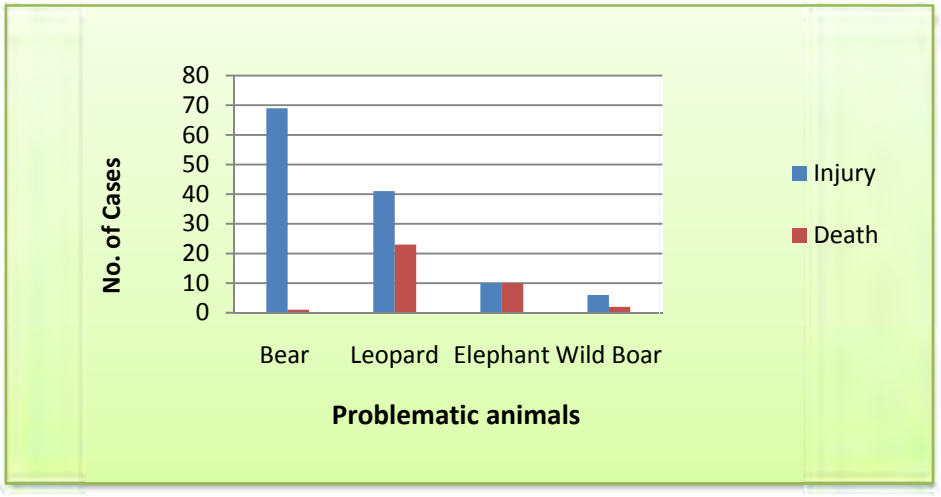


Fig. 5 Number of people affected in last twenty years in Narendranagar forest division.

3.4 Crop loss incurred in Narendranagar forest division

Crop raiding is totally depending on multitudinal conditions which include the type of food source, availability a well as the variability of the food types in an area. Other factors like the maturation time of the particular crop also play important role in crop raiding which provide different food source for the wild animals (FAO, 2009). Different species involves in crop raiding including *E. maximus*, *Ursus* spp., *S. scrofa*, *Macaca mulatta*, *Presbytis* spp., *Hystrix indica*, etc. Crop raiding is one of the most highly occurred forms of conflict in the forest fringe areas with community. In Uttarakhand, crop raiding is occurred significantly especially in hilly areas by wild animals. Majority of the people residing in Garhwal practice subsistence agriculture for their livelihood. *Oryza sativa, Zea mays, Echinochloa frumentacea, Glycine max, Eleusine coracana, Zingiber officinalis, Vigna unguiculata, Tricticumaestivum, , Brassica compestris, Solanum tuberosum, Mangifera indica, Artocarpus heterophyllus* are major crops involved in Narendranagar forest division whereas in Narendranagar forest division. *Tricticumaestivum, Oryza sativa* and *Echinochloa frumentacea, Eleusine coracana* and *Vigna unguiculata* were the major crop involved in the crop raiding by elephants, wild pigs, deers and monkeys (Table 5). In Narendranagar forest division severe loss incurred of local residing communities with an average crop raiding with 11.041 ha area. Further, 2000-2005 were the most affected years for the forest division with 4.063 ha area of crop lost followed by 2006-2010 with 2.547 ha, 2016-2020 with 2.321 ha and 2011-2015 with 2.11 ha by wild animals. Wild animals like elephants, wild pigs were mostly responsible for the crop raiding during 2000-2005. It was also observed that people get affected while

protecting their crops against the wild animals. In Uttarakhand, crop raiding is one of the most wide-spread for of HWC which adversely affected the livelihood especially in hilly areas resulting into people migration toward the plain areas.

3.5 EX-gratia for damages in Narendranagar forest division

Compensation by forest department in form of *anu-grah* i.e., ex-gratia relief were available to the families which were victims of conflict with wild animals. It was observed that communities living in very remote areas could not justify the effort and time so unable to get the compensation (Mathur, 2014). So, they didn't receive the grant properly. The state Uttarakhand has given continuous ex-gratia for the victim's family with respect to livestock predation, crop or any property losses along with human death and also for injured cases (Table 6-8, Fig. 6). Severe loss incurred by the local communities of Narendranagar forest division in form of crop raiding, human death and killing of livestock but at the same time ex-gratia was provided continuously for the locals. Compensation was provided to the villagers for crop raiding with an average amount of Rs.37379 in 2006-2010 followed by Rs.35127 in 2016-2020, Rs.17229 in 2000-2005, and Rs.6460 in 2000-2005. As 2000-2005 were the most affected years with 4.063 ha area of crop lost but less compensation was provided to the villagers due to old compensation policy of the state Government. Further, Rs.37379 in 2006-2010 were provided to the villagers for crop raiding of *Oryza sativa, Triticum aestivum, Zingiber officinalis, Vigna unguiculata, Echinochloa frumentacea* due to the new compensation policy was implanted through the Government order of 2012 in Uttarakhand. It was also recorded that Narendranagar forest division has provided huge amount of ex-gratia to the victim's family for livestock predation with a total amount of Rs.10376150 in which 2016-2020 years has provided high compensating amount of Rs.5314500 followed by Rs.4788400 in 2011-2015 and so on. This was due to the new compensation policy of Uttarakhand government for the wildlife conflicts cases. Furthermore, Rs.2640000 was given in last twenty years to the victim's family for human injured cases along with Rs.6800000 for human death case. Huge amount of Rs. 1245000 was given for injured cases in 2011-2015 due to maximum cases and new policy of government whereas Rs.2700000 was given in human death cases in 2016-2020. Compensation was highly provided by Narendranagar forest division which varied significantly with other protected areas of India like Bandipur Tiger Reserve, Nagarahole Tiger Reserve and Bhadra Tiger Reserve. This was also due to the fact that every state has different forest type, community, along with different crops which was also responsible for varying the ex-gratia mount.

Table 5 Major affected crops of locals with compensation provided in wildlife offence cases in Narendranagar forest division.

S. No.	Year	Area (ha)	Compensation (Rs.)	Animal species involved	Crop affected
1.	2000-2005	4.063	17229	Elephant, Wild pig,	*Oryza sativa, Eleusine coracana*
2.	2006-2010	2.547	37379	Elephant, Wild pig	*Oryza sativa, Triticum aestivum, Zingiber officinalis, Vigna unguiculata, Echinochloa frumentacea*
3.	2011-2015	2.11	6460	Elephant	*Oryza sativa, Triticum aestivum*
4.	2016-2020	2.321	35127	Elephant, Wild pig, Deer, Monkey	*Oryza sativa, Triticum aestivum, Brassica compestris, Glycine max, Solanum tuberosum, Mangifera indica, Artocarpus heterophyllus*

Table 6 Total livestock death cases with ex-gratia provided in wildlife offence cases in Narendranagar forest division.

S. No.	Year	Total	Compensation provided
1	2000-2005	26	16950
2	2006-2010	78	256300
3	2011-2015	361	4788400
4	2016-2020	275	5314500
	Total	**740**	10376150

Table 7 Total human injured cases with ex-gratia provided in wildlife offence cases in Narendranagar forest division.

S. No.	Year	Total	Compensation provided
1	2000-2005	32	135000
2	2006-2010	57	795000
3	2011-2015	31	1245000
4	2016-2020	6	465000
	Total	**126**	2640000

Table 8 Total human death cases with ex-gratia provided in wildlife offence cases in Narendranagar forest division.

S. No.	Year	Total	Compensation provided
1	2000-2005	3	200000
2	2006-2010	19	1400000
3	2011-2015	11	2500000
4	2016-2020	3	2700000
	Total	**36**	6800000

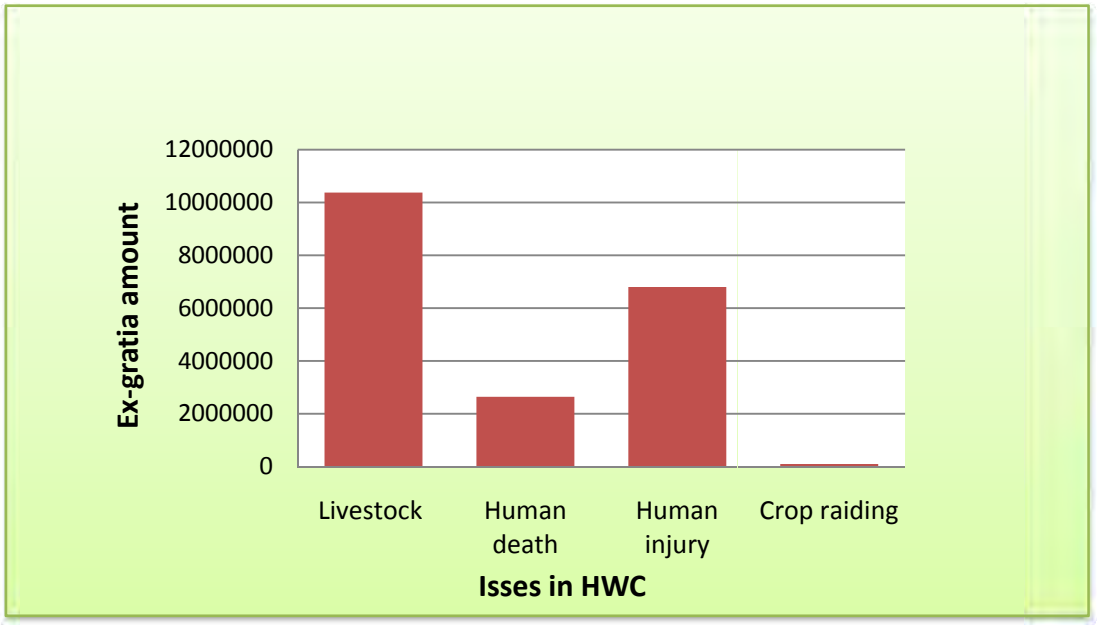


Fig. 6 Ex-gratia given for different issues of HWC in Narendranagar forest division.

3.6 Human–wildlife conflict: an overview with hidden aspects from Narendranagar forest division and adjacent areas of Uttarakhand

The hidden impacts of HWC may be totally temporally, uncompensated with physcological and social in nature (Ogra, 2008; Fig. 7). Hidden impacts are directly associated with indirect or secondary impacts of HWC in an area (Hunter et al., 1990). Hidden impacts mainly include the diminished aspects of psycho-social wellbeing which finally resulted into fatality, family disruption, problem in achieving the sustainability of work and food security through various losses. Hidden impact also includes the poor nutritional status and bad health along with the transaction cost. These impacts are impacts are generally temporally and do not occur suddenly as compared to the visible impact. The effects also come in form of poverty, ethnic and political marginalization with poor access to the resources. Hidden impacts have been observed for the rural people living just adjacent to the forest.

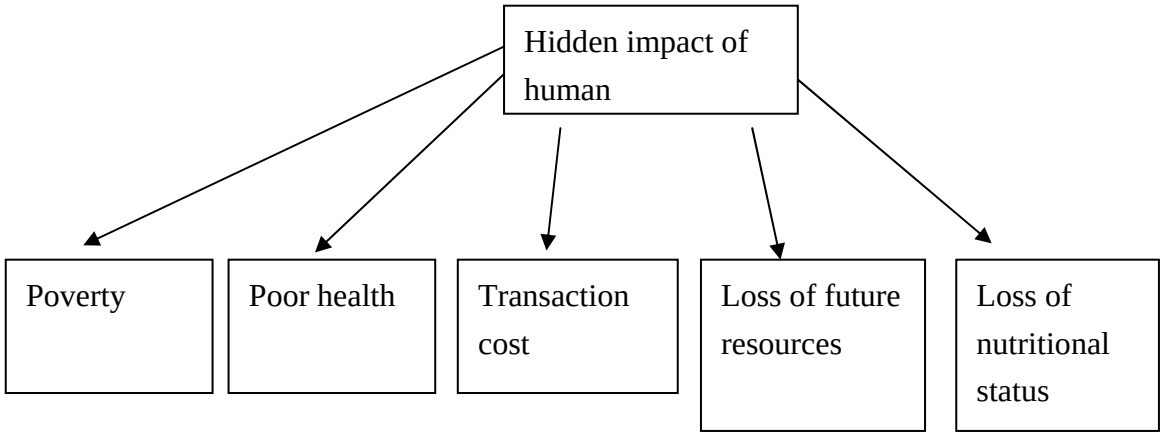


Fig. 7 Summary of hidden aspects of Human wildlife conflicts in Narendranagar forest division.

In the state like Uttarakhand, where 60 % of the area is covered with forest and people are mainly depends on the forest and forest based products. Hidden impacts also arise in family residing in the forest of Narendranagar forest division where sudden death and injury of principle earner of the family (generally male member) causes burden on the other member. The responsibility also transfers to the women and on children. So difficulties arise for livelihood due to the human–wildlife conflicts. They have to find out the paid job or employment with addition to the various household activities. It was observed from the recent studies from North India that fatality to the principal earner led to the debt and increasing poverty in family (Jadhav and Barua, 2012). Further conflicts also affect overall status of the family in terms of poor development of children in that particular family along with the disruption of child parents' relationships. Loss incurred due to crop raiding also has negative effects on the social and economic condition of the victims. This could be due to the poor compensation policy, non-availability of the grant o funds to the victims. Crop raiding also results in the reduction of overall food supply to the family particularly affects women who have to provide the nourishment to the children (Ogra, 2008). In Uttarakhand, continuous crop raiding has forced locals to migrate in plain areas and to other states for livelihood. Most of the locals are has settled in Dehradun and Haridwar for long time as crop raiding is one of the most drastic problem in Uttarakhand. This also leads to various problems anemia, poor child care along with the retarded physical behavior of women (Choudhury, 2004). Elephants raiding sometime ha to abandon the locals their well cultivated fields and to find the other source of income (Maïga, 1999). Such type of displacement may follow social rupture in terms of family support and boding as

well as the increased level of stress. On the other hand, loss of livestock, herd can affect the family wealth as well as the way of life as livestock constitutes a major portion of family socioeconomic development.

3.7 Mortality and killing of problematic wild animals in Narendranagar forest division with adjacent areas of Uttarakhand

Road accidents, diseases, poaching, declared dangers are some of the categories through which wild animal mortality is found highly in Uttarakhand. Road near wild animals' habitant or track are one worse area for sensitive wildlife in last few years. About 58 cases of leopard death in Uttarakhand have been observed mainly due to road accidents. These cases are higher in the protected areas which are adjacent to the local shelters in Hariwar-Pauri forest division. It was observed from the studies that terrestrial ecosystem occurs because of edge effects, pollution, poaching and invasion (Noss, 2002). As per the data, leopard was the most problematic animal in Uttarakhand as well as in Narendranagar forest division. About 1396 animals has been found to death due to various problems viz. poaching, accident, declared rouge/danger, burnt, forest fire, food poisoning, mutual fight, road accidents, train accidents. It was further also recorded that mortality rate of male was higher as compared to the female with some unknown gender. About 660 male and 637 females with 66 unknowns were recorded from the all the forest division of the Utttarakhand. The mortality rate was lower in Narendranagar forest division (Bhagirithi circle=10) as compared to Shiwalik circle (=15), Garhwal (=18), NorthKumaon (=55). It was observed form past few years that various projects of National highway authority of India (NHAI), the vehicle traffic on various highways significantly has affected the status of fauna in Shiwalik landscape. Moreover, linking of various roads in different areas in buffer zone of the protected forest adversely increases the death rate of both human and their livestock along with wild animals. Expanding the roads in protected zone of Narendranagar forest division has also disconnected the leopard to its main habitat and to manipulate its natural route. In Uttarakhand, maximum of the leopard was found to be death due to natural deaths followed by mutual fighting and accidents. The fragmentation results into habitat connectivity, unable to meet the daily requirement, access mates etc (Clevenger and Kociolek, 2006). Further development of rail projects canals, industrial development along with human encroachment led to the blockage of leopard and other habitats (Johnsingh and Sharma, 2001). In Narendranagar, livestock predation cases were higher due to the encroachment of habitat by human. Further wild animals were also involved in casing the casualties to humans in different forms (Table 9, Fig. 8-9). Crop damages were also higher in Narendranagar forest division which could be due to the habitat disruption and unavailability or lack of proper food source for wild animals in forest.

Table 9 Leopard death cases in Uttarakhand in last 20 years.

Year	Female	Male	Unknown	Total
2000-2005	62	142	4	208
2006-2010	172	135	29	336
2011-2015	160	149	16	325
2016-2020	243	234	50	527
Total	637	660	99	1396

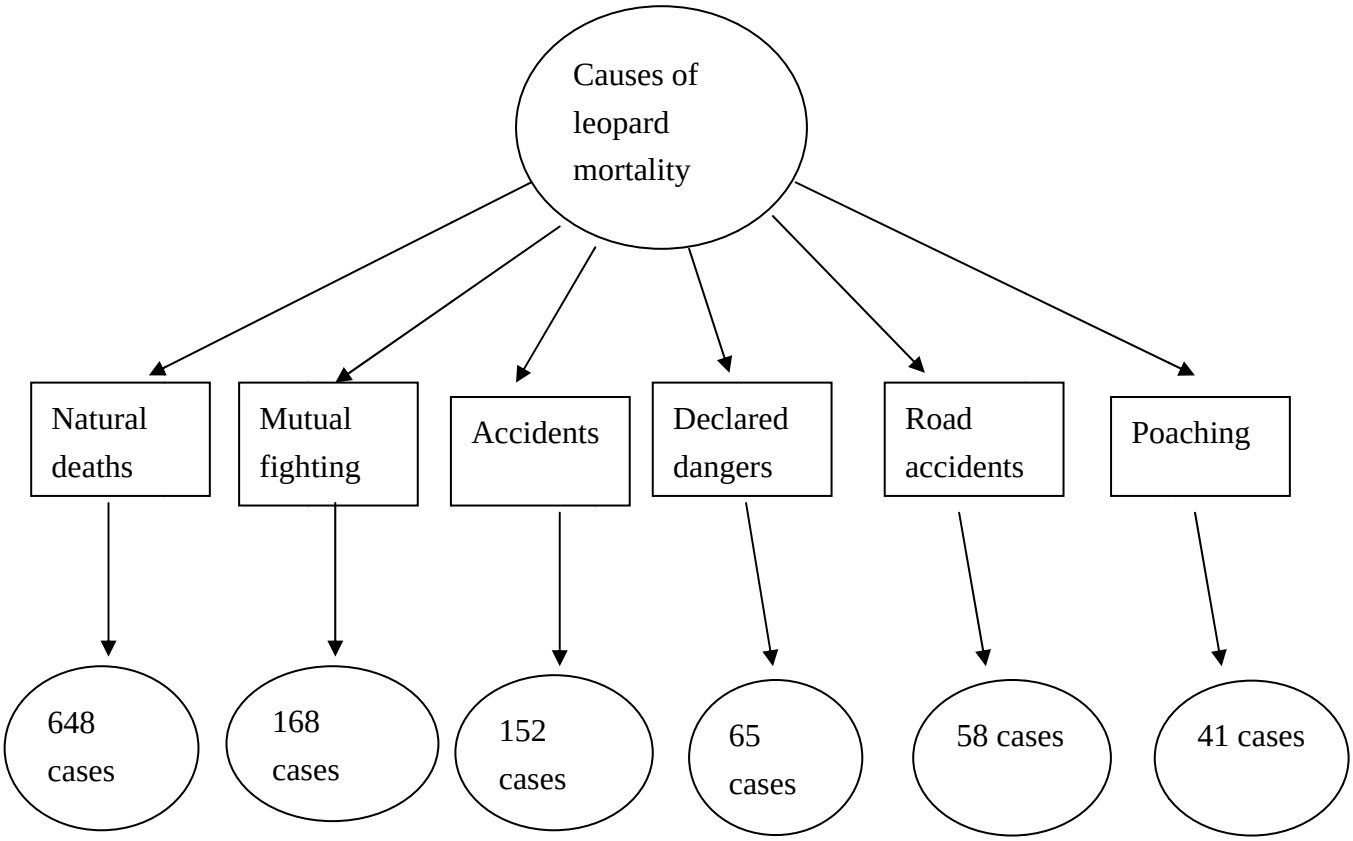


Fig. 8 Summary of leopard death cases with major causes in Uttarakhand.

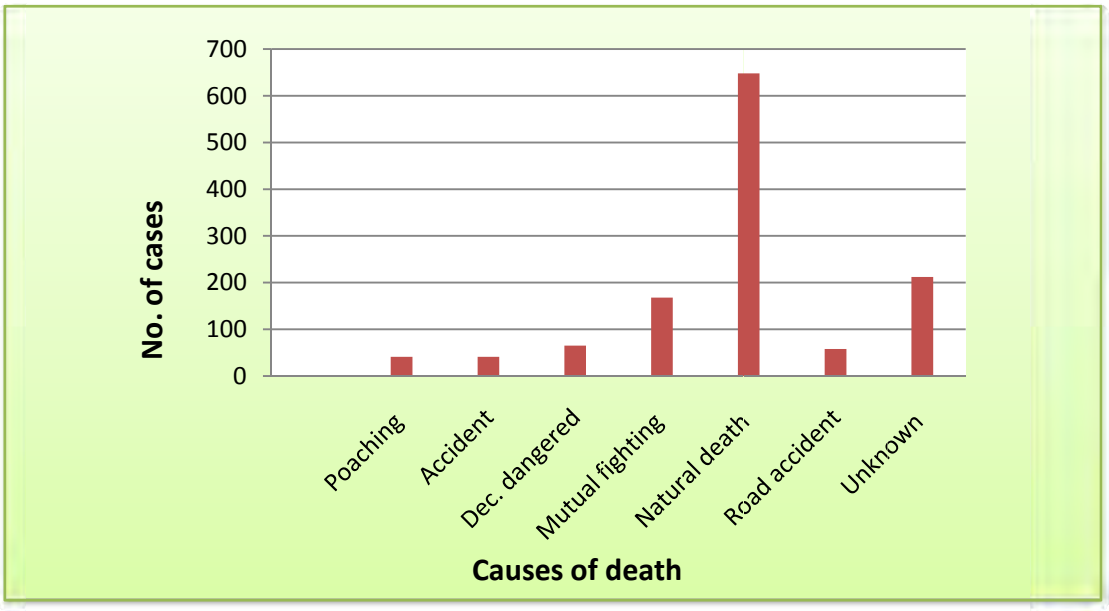


Fig. 9 Causes of leopard death cases in last twenty years in Uttarakhand.

3.8 Human- wildlife mitigation plane with opportunities in Narendranagar forest division

Generally, two strategies involve in the HWC viz. includes prevention before conflict and mitigation after conflict to handle the problems associated in human-wildlife conflicts (Mishra et al., 2003; Pettigrew et al., 2012). Prevention is one of the best strategies (Treves and Karanth, 2003) which include fencing, land zoning and gardening. It also involves the increasing the prey abundance for leopards and tigers (Guo et al., 2012). Human-wildlife mitigation plan includes awareness program, if it is difficult in relocation for local forest dwelling community. Human-wildlife mitigation strategies include community management, their rehabilitations program, good compensation, eco-tourism practices, and peaceful coexistence in the forest (Fig. 10).

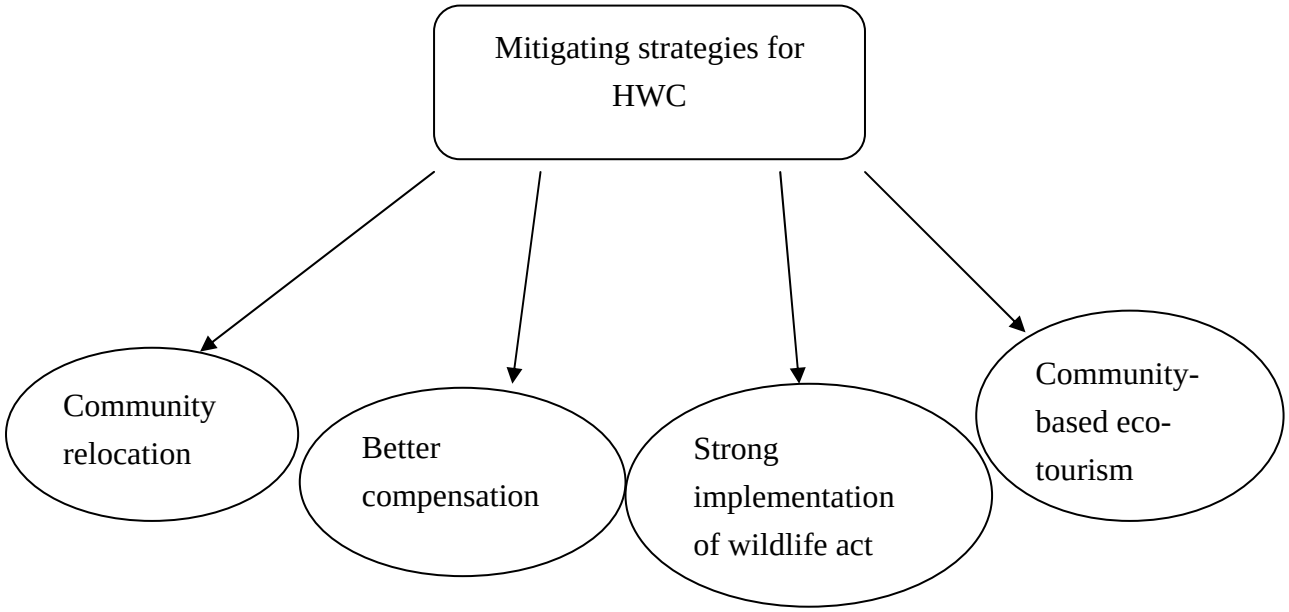


Fig. 10 Human-wildlife mitigation strategies.

4 Conclusions and Discussion

(1) Narendranagar forest division has great capacity to implement the mitigation plane for HWC. Community management through training and awareness is one of the most important aspects in mitigation. Narendranagar forest division has faced severe loss both in terms of human death and injury in past. It was observed that about 54.76% human injured by bears, 32.53% by leopards followed by 7.93% by elephant as well as 63.88% human were killed by leopards followed by 27.77% by elephants, 5.55% by wild boars and 2.77% by bears. Wild animals mainly affect the livelihood of local residing communities. So, implementation a better plan would be a chance to reduce the injury and death of human in the study area. Further movement of restricted zone (if community still resides adjacent to the forest) should be avoided and carnivore proof livestock shelters can be provided to reduce the conflict rate (FAO, 2009). It was observed from Narendranagar forest division that maximum of the conflict's cases occurred when locals went for the collection of many fodder plants *Bauhinia vahlli*, *Celtis australis*, *Ficus auriculata* and *Grewia optiva.* Fencing is another approach for controlling the unnecessary movement of wild animals in the nearer areas of the forest. Further reducing open grazing of livestock, preparing strong awareness programme for the locals must initiate.

(2) Wild animal attack is one of the most frequent issues in Narendranagar forest division especially in Agrakhal, Tehri and nearby areas. Leopards have caused severe harm to human's life because of the frequent movement. So it would be better if the movement of leopards is manipulated to discourage it from the entering sites of the area. Unnecessary canopy of *Lantana camara, Parthenium hysterophorus, Eupatorium adenophorum* and shrubs like *Ziziphus xylopyrus, Z. mauritiana*and *Z. jujupa, Justicia adhatoda, Clerodendrum viscosum* and *Colebrookia oppositifolia* etc. which provide cover to the tiger and leopard. Further locals people should be involved in cleaning of landscape and planting important species like *Grewia optiva, Aconitm heterophyllum, Quercus* spp, so as to avoid the spreading of weed. Huge canopy of *Lantana camara* should be eradicated by the method of C.R. Babu.

(3) Due to the lack of staff, lopping of important plant species like *Pinus, Shorea robusta, Cedrus deodara* also occur in the area. It is well know that lopping of plant species is a conventional practice in forest and a significant forest-based economic for local people residing in the forest areas as it provide various benefits in terms of firewood and fodder. Sometime people visit high risk areas for collection of NWFPs and fodder plants for cattle. So the incidents of maximum attacks occurred significantly. Locals lopped *Woodfordia fruiticosa, Grewia optiva, Ficus palmata, Quercus* spp. *Mallotus philippensis, Shorea robusta, Debregeasia longifolia,* as a fodder for their cattle. It was observed that about 126 incidents of human injured and 36 incident of human death by leopards and elephants were recorded in all the three ranges of Narendranagar forest division. Elephant in Shivpuri range and leopards in Saklana and Maniknath has caused great loss to the human and other wealth. Further open grazing without herd creates huge loss of livestock in Narendranagar forest division. etc. About 30.54 % were livestock, 27.43% were adult cows, 15.13% goats, 6.89% mules, 9.05% horses, 6.21% buffalos, 4.59% calfs and 0.13% donkeys were killed either due to unattended grazing or by carelessness of the villagers at their home. Locals of Saklana and Maniknath left their cattle free for grazing which has caused significant death of cows, bulls, buffalos, mules. Grazing of important plant species like *Tridex procumbens, Abutilon indicum, Colebrookia oppositifolia, Bidens pilosa, Ipomea hederifolia, Cissampelos pareira* etc. may also changes the forest structure and regeneration pattern of species. Herd management strategies like increasing more human per livestock, avoiding free grazing at the protected area, will reduce the predation rate by leopards. Weaker sections which severely affected in the HWC should be given preference while formulating any forest based management strategy for conservation

(4) Ex-gratia is considered one of the important elements for human-wildlife conflict mitigation strategy. It is given as a relief grant for crop raiding, livestock predation as well as for various human casualties. The amount given in compensation further encourages the locals to utilize the forest resource in sustainable manner. Compensation from Narendranagar forest division is better from other state as compared in Uttarakhand. Sometime it was observed that due to ineffective policy for compensation, incidents of poaching, revenge also has increases. So, there is a need for effective ex-gratia for livestock predation and human casualties. Further, wild animal proof sheds insurance schemes and other benefit should be provided to provide security to the communities. In Narendranagar forest division, ex-gratia was given for human death, injury as well as for crop raiding and livestock predation. Locals have received the amount regularly from 2000-2020 for crop raiding with an average amount of Rs.37379 in 2006-2010 followed by Rs.35127 in 2016-2020, Rs.17229 in 2000-2005, Rs.6460 in 2000-2005. In Narendranagar forest division, crop raiding was species-dependent as elephant, wild pig were mainly responsible for damages of large swaths of crops like *Oryza sativa, Triticum aestivum, Vigna unguiculata, Echinochloa frumentacea* and *Gylcine max* than the other wild animals. The amount of compensation varied significantly from year to year but high compensation was given from 2012 with the new compensation policy of the government which was generally high than other Northern states.

(5) Uttarakhand is well known for best tourism spot in India due to the presence of Char Dham roads, beautiful scenery, glaciers and many lakes and high altitudinal mountains which attract most. Although tourism play significant role in the revenue but sometime due to the lack of well-planned eco-tourism policies has made adverse effect on biodiversity. Narendranagar forest has great potential of eco-tourism. The three ranges of this division namely Shivpuri Saklana and Maniknath have great diversity of flora and fauna, and Shivpuri range for elephant safari whereas Saklana, Maniknath, Kirtinagarh as great capacity for bird watching and for scenic beauty. Further these sites can be selected and diverted into eco-tourism zone. Many of the migratory birds like *Anas platyrhynchos, Mycteria leucocephala, Ephippiorhynchus asiaticus* visit the areas every years from America, China, Russia and Europe. Plant species identification, bird watching can be significant source of revenue generation for the state. For this task locals should be involved in management and conservation of the forest. Furthermost, sites like Maniknath and Saklana are supposed to be the best places for observing bird diversity for researcher and scientists in natural environment especially in late evening. Another range viz. Shivpuri range has great potential of elephant safari to attract the tourists and also a source of generating the revenue. Locals can also get benefit due to the high tourism influx in terms of social interaction, purchase power and economic activities. On the other hand, promoting eco-tourism can provide alternate livelihood for forest dwelling communities which may definitely changes their perception towards the management and conservation of flora and fauna.

The state Uttarakhand has huge potential for conservation of flora and fauna. At the same time the state is facing challenges in form of human-wildlife conflicts which are the consequences of local demands and dependency upon the food security, well-being and safety on forest. So, consequence arises in form of livestock predation and loss injuries with death along. The economic losses incurred by the local community put huge burden more especially on poor the section of society. Losses incurred due to conflicts also increase revenge towards problematic animals and hatred on forest officials. Most important tool for preventing the HWC is applying long term prevention strategies with short term mitigation tools. Monitoring the high prone areas of conflicts, community awareness, and eco-tourism with development could reverse the HWC failure in Uttarakhand. On the other hand, well planned management plan which integrate various techniques crop and herd management can be adopted to reduce the pressures in forest.

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