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Source: Journal of Resources and Ecology, 15(4) : 838-849

Published By: Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences

URL: <https://doi.org/10.5814/j.issn.1674-764x.2024.04.005>

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J. Resour. Ecol. 2024 15(4): 838-849
DOI: 10.5814/j.issn.1674-764x.2024.04.005
www.jorae.cn

Patterns, Causes and Perceptions of Human-Large Carnivore Conflict in the Chitwan National Park, Nepal

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Abstract: One of the major management problems in and around protected areas is the intensifying conflict between local people and wildlife, especially large carnivores. Livestock depredation and human fatalities caused by attacks of carnivores are found to be serious obstacles in conflict management. This study aims to explore the patterns, costs, causes and perceptions of human large carnivore conflict in the Nawalpur area of Chitwan National Park. The patterns of livestock loss and human casualties due to large carnivores (*Panthera tigris* and *Panthera pardus*) were analysed using the secondary data reported to Chitwan National Park from 2001 to 2019. To understand the people's perception towards carnivores and wildlife conservation, 150 victim respondents were asked, with one household selected from each grid. During 19-year study period, a total of 521 incidents caused by large carnivores were reported, which included 33 human casualties and 488 livestock depredations. Tiger was responsible for the maximum conflict incidents in Nawalpur. The total relief provided for human deaths and injuries was US\$17524.41, whereas US\$13702.18 was used to compensate for livestock depredation in the Nawalpur area by authorities of the Chitwan National Park. More than 64% of the respondents liked the presence of carnivores in their area and had a positive attitude toward the conservation of large carnivores, even though the carnivores were responsible for livestock depredation and human injury and death. People's satisfaction with the relief scheme provided by the government depended on ethnicity, gender, age class, occupation, education, insurance, and livestock ownership, but they believed the scheme was not effective. Hence, an effective relief scheme and awareness about the process of relief funding should be conducted in conflict areas. Conducting awareness programs for local communities about large carnivores, their behavior, and preparing predator-proof corrals would be helpful in minimizing conflict in the study area.

Key words: depredation; human wildlife conflict; leopard; tiger; relief fund

1 Introduction

Human wildlife conflict (HWC) is an increasingly significant challenge for conservation practitioners. Conflict occurs when human and wildlife have adverse effects on one another due to spatial overlap or competition for resources (Suryawanshi et al., 2013). Human-large carnivore conflict becomes serious when there are human casualties and livestock depredation in the life of the local community (Bhattarai and Fischer, 2014). Bengal tiger (*Panthera tigris*)

and Leopard (*Panthera pardus*) are the main large carnivores causing conflict in lowland Nepal (Jnawali et al., 2011). Human-Large Carnivore Conflict (HLCC) has led to a global decline in the population of large carnivores (Koziarski et al., 2016). Human intrusion into the habitats of wild prey species causes a decrease in prey abundance for tigers in the Terai region of Nepal (Barber-Meyer et al., 2013). In Nepal tiger's population has doubled over the last decade (DNPWC and DFSC, 2022). However, there is no exact information

Received: 2023-04-22 Accepted: 2023-12-29

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Citation: Parwati TIWARI, Bishnu Prasad BHATTARAI, Jagan Nath ADHIKARI, et al. 2024. Patterns, Causes and Perceptions of Human-Large Carnivore Conflict in the Chitwan National Park, Nepal. *Journal of Resources and Ecology*, 15(4): 838–849.

about the population of leopards. Competition for medium-sized prey in the scarcity of large prey impels leopards to move towards peripheral areas where they may easily encounter locals and their livestock, anticipating carnivore conflict (Karanth and Sunquist, 2000). Large home range and huge diet requirements of large carnivores might be the main reasons of conflict (Inskip and Zimmermann, 2009). Competition of carnivores with humans for spatial and resource requirements can have significant economic impacts and casualties. The aggressive nature of carnivores can sometimes result in the killing of humans, which generates the antagonistic behaviour towards the presence of carnivores near human residences (Lagendijk and Gusset, 2008).

Close proximity to human settlements, competition for space and resources, and resulting conflicts are the leading causes of carnivore mortality in and around protected areas (Lamichhane et al., 2019a). The border between human habitation and protected areas is a hotspot for such conflicts (Gurung et al., 2008). In Nepal, human-wildlife conflict is a major problem in many protected areas, buffer zones, and community forests as local people are often unable to access resources that they had been using for a long time before such activities were legally prohibited (Lamsal, 2012). Human-carnivore conflicts usually arise from livestock depredation, human injuries caused by carnivores, illegal grazing, fodder collection and timber collection, and misunderstanding between local people and conservation authorities (Distefano, 2005; Adhikari et al. 2018; Lamichhane et al., 2019a).

People residing near the protected areas often directly bears the cost and have less ability to deal with the losses (Karanth and Nepal, 2012; Karki et al., 2022). Information about the factors associated with conflict and the place of frequent occurrence is important for conservation manager of conflict (Dickman, 2010; Mateo-Tomás et al., 2012). Carnivores that cause the livestock depredation and human injury or death by entering the settlements are suggested to translocate to the other protected areas than killing (Madhusudan and Karanth, 2002). In recent years, many countries have endorsed strict regulations in response to a significant decline in carnivore populations. The cost associated with managing conflicts between humans and carnivores using conservation strategies can be considerable, given that many nonfatal methods are involved and financially expensive to sustain (Treves and Karanth, 2003).

Chitwan National Park (CNP) covers major parts of tiger conservation landscape, symbolises Churia habitat which is important corridor linking Valmiki Tiger Reserve in India and Parsa National Park in east (DNPWC, 2022). Cooler microenvironment in summer and availability of perennial water resources has created suitable habitat for wild prey and dispersing tiger population in Churia range (Karki et al., 2015). Prey density in a few protected areas of Nepal where tigers are found seems to be less than half the prey density

required to sustain the government target of doubling the population i.e., 250 (DNPWC, 2022). But the population of tigers has now tripled (355 individuals) in Nepal and these protected areas may not hold this number. This might force tigers to move outside of the protected areas to search for domestic prey causing human-tiger conflict (Aryal et al., 2016). Wildlife mainly large mammals attack on people, crops and livestock (Lamichhane et al., 2019a), so, we must find solutions to mitigate human-carnivore conflicts to ensure that local communities are not unethically burdened by the consequences of conservation efforts, which could potentially lead to opposition against conservation. Hence, to guarantee the effectiveness of conservation initiatives, it is crucial to verify that local communities benefit from these efforts. Conservation policies should be strongly based on complete understanding of conflict pattern. This study reveals the pattern of human large carnivore conflict since past 19 years, identifying main cause of conflict, determining the cost, and understanding the attitude of local people towards the management plan of national park as well as buffer zone policy.

2 Materials and methods

2.1 Study area

Chitwan National Park and its Buffer Zone located in south Central region of Nepal with warm subtropical climate. CNP spreads over Chitwan, Parsa, Makawanpur and Nawalparasi Districts in between 27°20'19"N and 27°43'16"N longitude and from 83°44'50"E to 84°45'03"E latitude, similarly, the Buffer Zone is located between 27°28'23"N and 27°70'38"N longitude and 83°33'48"E and 84°37'38"E latitude and covers 952.63 km² area (CNP, 2019). CNP is the prime habitat for the large viable population of tigers and leopards across Tarai Arc Landscape (TAL) (Karki et al., 2015). The average annual temperature ranges from minimum 18 °C to 28.5 °C. CNP receive a very good rainfall in summer and very little in winter. In 2020 annual mean rainfall was 211.75 mm. The mean annual humidity of Nawalpur District in the year 2020 was 73.83%. The most humid month was July (89%) and least was April (50%) in the district (Fig. 1). CNP is drained by two rivers Narayani and Rapti.

The study was carried out in the western sector (Amaltari) of CNP located in Nawalpur District. Nawalpur (Nawalparasi east of Bardaghat Susta) is in Gandaki Province of Nepal. Study has been focused in following Buffer Zone User Committees (BZUC) of Amaltari sector; Lamichaur BZUC, Sikhraili BZUC, Siswar BZUC, Amaltari BZUC, Nandabhauju BZUC, Gosaibaba BZUC and Daunne devi BZUC.

Nawalpur District has warm and subtropical climate. The average annual minimum temperature of the district is 18.4 °C whereas average maximum temperature is 28.55 °C. Maximum temperature was 34.2 °C in April and minimum

temperature was 9 °C in January. Nawalpur District have very good amount of rainfall in summer and very little in winter. Annual mean rainfall of the district was 211.75 mm

in 2020. Maximum rainfall was 640 mm in the month of July and minimum was 13 mm in the month of November and December in 2020.

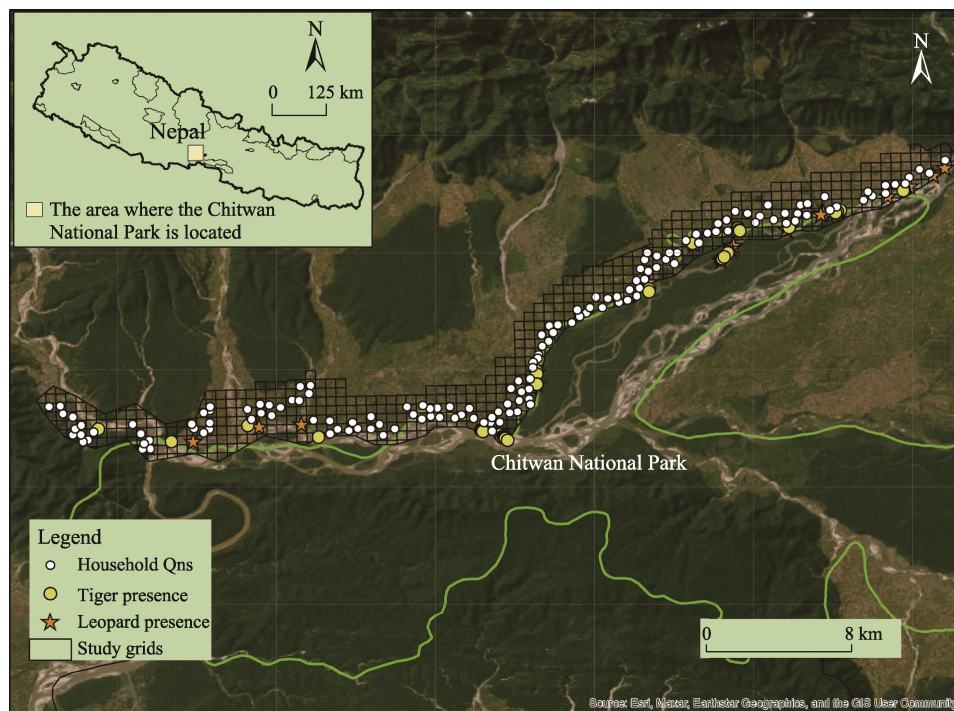


Fig. 1 Map of study area showing sampling locations for questionnaire survey along with tiger and leopard presence locations

2.2 Data collection

Two types of data (i.e., primary and secondary) were collected from the study area. Primary data were collected through sign survey of conflict species (tigers and leopards) and through household questionnaire survey and secondary data were collected from records of CNP office. Field data were collected during October–December 2020.

2.3 Household survey

The prime purpose of the survey was to investigate the extent of HLCC and to understand the people's attitude towards large carnivores. Purposive sampling method was used to conduct the questionnaire survey (Campbell et al. 2020). Household who lost livestock and were victims of large carnivore attacks during 2001–2019 were visited. Grid of 500 m×500 m was generated over study area using QGIS. Out of 606 grids, sampling grids were selected based on 95% confidence level, 5% margin of error. A total of 236 grids were obtained, only 150 grids were selected for the questionnaire survey and others were excluded. If there was no victim household in the selected grid, that grid was excluded from the survey. In each grid, the nearest victim household from the grid centroid was selected for the questionnaire survey.

A semi structured questionnaire was developed to collect

data from the victim households. Prior consent of respondent was taken verbally before starting the interview. All the respondents agreed to take part in the survey. In majority of the cases, the head of family was selected for interviewed. On the absence of the head of family, the interview was taken from the next adult person present in the house. The questionnaires were divided as household information i.e., demographic profile of respondents such as age, gender, ethnicity, occupation, education level and household information such as livestock owned, forest resources used, husbandry practices (stall fed or grazed outside), understanding of the respondents towards large carnivores, compensation scheme of national park and their attitudes towards human-carnivore conflict. The specific information related to livestock depredation, the number livestock killed, location of attack (outside or home) and time of attack (morning, afternoon, and night) was asked and reported. Respondents report of large carnivore attacks were based on sighting of conflict species, pugmarks, sounds, or wounds observed (Appendix).

Data on large carnivore attacks on humans and livestock and economic loss reported to CNP authorities and BZUC from past 19 years (2001 to 2019) was collected. The incidents of attacks were reported by victims themselves or by their relatives through applications to the local authorities to claim the relief amount. The BZUC verified the incidents of

attacks and recommend for the relief fund as per the guidelines of Government of Nepal.

2.4 Data analysis

Student t-test was applied to compare frequency of livestock depredation caused by tiger and leopard. Generalized linear model was used to determine the prey preference of tiger and leopard using R software (R Core Team, 2021). Pearson Chi-Square test was employed to examine difference in frequency of livestock attack in different time of the day. Variation in the people's perception with respect to their education status, age group and occupation was examined from Pearson Chi-Square test. Ordinary least square (OLS) regression was performed to predict the livestock depredation pattern. Pearson Chi-Square test and OLS regression was performed using PAST version 4.3.9 (Hammer et al., 2001). Results were presented graphically in form of tables, figures, and text in a descriptive way.

3 Results

3.1 Demographic profile of respondents

Altogether 150 respondents from different households, who were victims of livestock depredation and human fatalities were interviewed. The age of respondents ranged from 16 to 83 years (mean age 46.14 ± 15.7 (SD)). Among the respondents, 29.33% ($n=44$) were between 16–37 years, 44.66% ($n=67$) were between 37–57 years and 26% ($n=39$) were above 57 years. Forty one percent respondents were male and 59% were female. All respondents were from the different buffer zones user groups of CNP (Nawalpur District part). Among them, 97.33% ($n=146$) households were suffering from livestock depredation and 2.77% ($n=4$) were of human fatalities.

The respondents belong to different ethnic groups which were categorized as Brahmin/Chhetri, Janajati/Adibasi, Dalit and marginalized groups. About 42% of the respondents received basic level education whereas only 12% of respondents had secondary level education. About 75% ($n=112$) of respondents were farmers followed by services (11% ($n=17$)), business (11% ($n=17$)), and daily wages (3% ($n=4$)). Average family size of the respondents from the study area was six members (mean 5.71 ± 2.61 (SD)). Currently about 67% ($n=130$) households had at least one livestock. About 33% ($n=20$) households were not keeping livestock currently.

3.2 Pattern of human large carnivore conflict

Between 2001 and 2019, a total of 521 cases of human and economic loss by large carnivores (*Panthera tigris* and *Panthera pardus*) was reported from the record of BZUC or CNP authority. In total, 314720.4 US\$ was paid to victims as compensation for their loss over period of 19 years. Over time 33 human attack cases (15 casualties and 18 injuries)

have been reported from this study area. Among the reported casualties, tiger alone contributed by 72%, whereas, 28% contributed by leopards (Fig. 2).

Total 488 incidents of livestock depredation were recorded over 19 years of period from the seven buffer zones located in Nawalpur District (Fig. 2). Major target livestock were goat, sheep, pig, buffalo and cows. The annual frequency of livestock depredation by tiger was significantly higher ($t=2.23$, $df=20$, $P=0.037$) than leopards. But in recent 6 years (after 2013) leopard caused comparatively higher livestock depredation. Livestock depredation reported by the buffer zones or CNP authority from Nawalpur was the highest in 2003 ($n=98$) but there was no livestock depredation cases in the year 2017 and 2018 (Fig. 2).

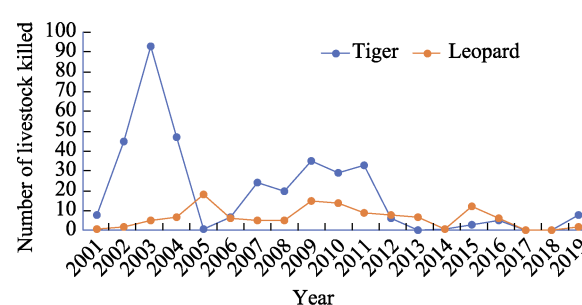


Fig. 2 Livestock depredation during 19-year period in the buffer zones of Nawalpur

A total of US\$ 13702.18 was paid as compensation to victims for livestock depredation by large carnivores in Nawalpur during 2001–2019. This showed per household loss was US\$ 30.31 in the study area (Fig. 3). The trends of compensation paid to victim showed the decreasing trend, i.e. it indicates that the livestock depredation trend was in decreasing trends.

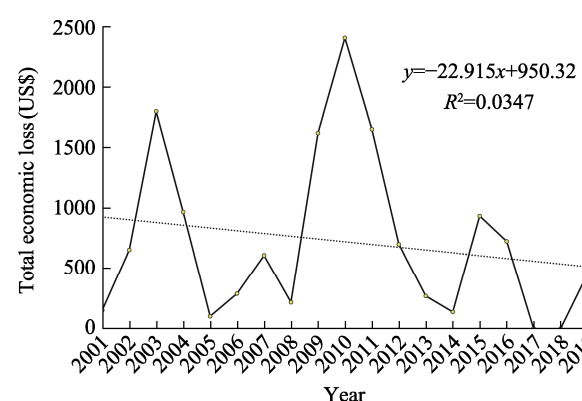


Fig. 3 Total economic loss from livestock depredation between 2001 to 2019

Generalized Linear Model (GLM) for livestock selectivity of tiger showed significantly positive relation with cattle/buffalo ($Z=6.878$, $P<0.0001$) and positive relation with

goat/sheep but not for pigs. Livestock preference of leopard indicated significantly positive relation with pigs ($Z=8.549$, $P<0.0001$) and goat/sheep ($Z=6.654$, $P<0.0001$). (Table 1).

Table 1 Generalized linear model with binomial distribution and logit function showing livestock selectivity of tiger and leopard in buffer zones of Nawalpur

Item	Estimate	Z-value	P-value
Tiger			
Goat/Sheep	0.5032	1.449	0.1473
Pig	-1.0133	-1.784	0.0745
Cattle/Buffalo	4.4664	6.878	<0.0001 *
Leopard			
Goat/Sheep	1.6594	6.654	<0.0001 *
Pig	3.8747	8.549	<0.0001 *

Note: '**' means $P<0.001$.

Animal husbandry is the major source of income of the respondents of our study area. About 87% of the respondents had owned livestock like goat, sheep, cow, buffalo, pigs, and chickens. The respondents said that most of livestock depredation (84%, $n=150$) was inside the shed or huts. On the basis of respondents, a total of 238 livestock and avian stock were killed within last six years in the study area. in which 66% were goat/sheep followed by 24% cow/ox, 5% poultry, 3% buffalo and, 3% pig (Fig. 3). Tigers and leopards were the major livestock depredators which contributed 53% and 47% respectively (Fig. 4).

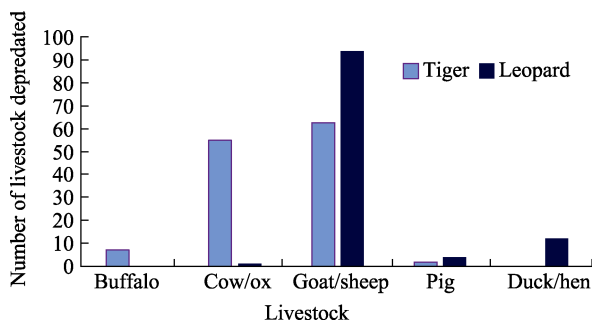


Fig. 4 Number of different livestock depredated by tiger and leopard in the study area on 2020

3.3 Costs of human large carnivore conflict

A total economic loss from livestock and avian stock depredation was found to be US\$ 295.51 per household in which US\$ 235.63 contributed by tiger and US\$ 59.89 by leopard (Table 2). Most of the livestock depredation incident occurred during night (88%) and least in the morning (5%).

3.4 Human injuries and fatalities

A total of 33 large carnivore attacks cases with an annual average of 0.68 human deaths and 1.05 human injuries were documented between 2001 and 2019 from buffer zones of

Table 2 Estimated economic loss in US\$ from livestock depredation by large carnivores

Livestock	Number of killed	Farm get price	Total loss
Buffalo	7	862.07	6034.483
Cow/Ox	56	431.03	24137.93
Goat/Sheep	157	86.21	13534.48
Pig	6	86.21	517.2414
Hen/Duck	12	8.62	103.4483
Total	238		44327.59
Per HH	1.5867		295.5172

Note: exchange rate: 1 US\$= NRs 116; HH= Household.

Nawalpur. All human death and 75% of injury were caused by attack of tiger and leopard caused only 25% injury. Total US\$17524.41 was spent for human deaths and injury as compensation in study area by Chitwan National Park for 19 years (2001–2019). Highest amount (US\$ 4535.89) was spent in 2013 for human loss by large carnivores from Chitwan National Park (Fig. 5). The trend of human injury and death by large carnivore was in increasing trend ($R^2=0.099$).

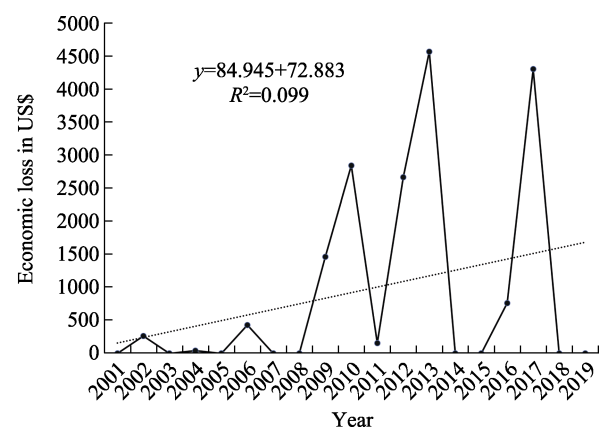


Fig. 5 Loss from large carnivores over years, Number of human deaths and injury between 2001–2019

3.5 People's perception towards large carnivores

Of the total respondents, 64% liked the presence of large carnivores in the forest while 36% of them did not like their presence because of fear of attack and livestock depredation. Most of the respondents (95%) were highly positive for the right of large carnivores to live in the forest. Education status and age groups of the respondents showed significantly positive response ($\chi^2=13.67$, $df=6$, $P=0.032$ and $\chi^2=16.48$, $df=6$, $P=0.011$) respectively and the occupation of the respondents showed the positive attitude ($\chi^2=9.18$, $df=6$, $P=0.16$) towards the rights of large carnivores to live in the forests (Table 3).

When the respondents were asked about their willingness to participate in buffer zone management program, about

59% of respondents agreed for the participation while 29% were neutral. In this response, the education level, occupation showed the significantly positive relation ($\chi^2=32.31$, $df=6$, $P<0.0001$ and $\chi^2=22.58$, $df=6$, $P=0.0009$) respectively while age groups of the respondents showed positive response only ($\chi^2=10.14$, $df=6$, $P=0.11$). Even though all the respondents were victims of large carnivore attack, 73% disagreed for the termination of problem species in case of severe conflict as they understood the importance of large carnivores to maintain natural beauty. Local people perceived significantly positive thinking based on their education status, age groups and occupation respectively ($\chi^2=13.5$, $df=6$, $P=0.035$, $\chi^2=31.75$, $df=6$, $P<0.0001$ and $\chi^2=12.46$, $df=6$, $P=0.052$) (Table 3).

About 65% of the respondents agreed on the increasing population of the tiger and leopard in recent years. Impression of respondents on increasing large carnivore population was notably different according to education level, age groups and occupation ($\chi^2=14.62$, $df=6$, $P=0.024$, $\chi^2=16.99$, $df=6$, $P=0.0093$ and $\chi^2=14.05$, $df=6$, $P=0.02$). About half of the respondents (46%) disagreed with the statement of government relief is helping victims as the process of claiming compensation is long, complex, and expensive. They said that cost of complaining is higher than their relief amount.

While 37% agreed in government relief scheme is helping victims and 17% were neutral about it. In terms of education, age groups and occupation view of respondents on government relief program was significantly affected ($\chi^2=16.38$, $df=6$, $P=0.012$, $\chi^2=12.95$, $df=6$, $P=0.04$ and $\chi^2=19.14$, $df=6$, $P=0.003$) respectively. Of the total respondents, 55% were neutral in the question asking about efficiency and sufficiency of government and national parks program for the mitigation of human large carnivore conflict. 35% of respondents disagreed and only 10% agreed with the efficiency and sufficiency of government mitigation program. The knowledge on the sufficiency and efficiency of mitigation measures significantly varied base on different age groups, education level and occupation of respondents ($\chi^2=12.8$, $df=6$, $P=0.046$, $\chi^2=30.9$, $df=6$, $P<0.0001$ and $\chi^2=22.58$, $df=6$, $P=0.0009$) respectively (Table 3).

The best model of satisfaction of local peoples towards the relief scheme provided by the government included ethnicity, insurance, and the number of livestock they own; however other factors were also competing in models (Table 4).

3.6 Causes of human-large carnivore conflict

About 96% of the respondents were aware of the relief distribution program of national park for the economic loss

Table 3 People's perception towards large carnivores

Questions	Education	Age	Occupation
Wildlife have right to live in forest	$\chi^2=13.67$, $P=0.032$	$\chi^2=16.48$, $P=0.011$	$\chi^2=2.76$, $P=0.83$
Large carnivores attract tourist and bring revenue to park	$\chi^2=13.7$, $P=0.032$	$\chi^2=12.82$, $P=0.04$	$\chi^2=9.18$, $P=0.16$
Participation in the buffer zone management program	$\chi^2=32.31$, $P<0.0001$	$\chi^2=10.14$, $P=0.11$	$\chi^2=22.58$, $P=0.0009$
In case of severe conflict, problem animal should be terminated	$\chi^2=13.5$, $P=0.035$	$\chi^2=31.75$, $P<0.0001$	$\chi^2=12.46$, $P=0.052$
Tiger and leopard population should be increased in future	$\chi^2=14.62$, $P=0.024$	$\chi^2=16.99$, $P=0.0093$	$\chi^2=14.05$, $P=0.02$
Government relief for loss done by large carnivores is helping victims	$\chi^2=16.38$, $P=0.012$	$\chi^2=12.95$, $P=0.04$	$\chi^2=19.14$, $P=0.003$
Mitigation measure for conflict is adequate	$\chi^2=12.8$, $df=6$, $P=0.046$	$\chi^2=30.9$, $df=6$, $P<0.0001$	$\chi^2=15.86$, $df=6$, $P=0.014$

Table 4 Generalized linear models to identify the factors related to the people's satisfaction about the relief scheme provided by the government

Covariates	Intercept	Ethnicity	Insurance	Livestock	Gender	K	AICc	$\Delta AICc$	W_i
Ethnicity +Insurance	1.07	-0.352	17.08			3	191.4	0.00	0.062
Insurance	0.4		17.09			2	191.8	0.39	0.051
Ethnicity+Insurance+No of Livestock	1.425	-0.424	17.14			4	192.0	0.65	0.045
Ethnicity+Insurance+Gender	0.972	-0.360	17.14	-0.043	0.269	4	192.9	1.54	0.029
Ethnicity+Insurance+Livestock Number+ Gender	1.345	-0.445	17.22	-0.049	0.359	4	193.2	1.81	0.025
Education+Ethnicity+Insurance	-0.199	-0.344	-0.344				193.2	1.82	0.025

Note: People's satisfaction was used as the dependent variable. The covariates used were ethnicity, gender, age class, occupation, family size, no of livestock owned, insurance and education. K is the number of parameters and, $\Delta AICc$ is the difference between the AICc value of the best supported model and successive models, and W_i is the Akaike model weight

caused by wildlife. The relief amount provided by concerned authority was not enough for 69% of the respondents in the study area. When respondents were asked about the time to get relief amount, 3% were unaware of it, 47% of respondents replied to very long time (more than a year), 44% of them replied to long time (more than 6 months and less than a year) and only 6% said short time (below 5 months) (Fig. 6).

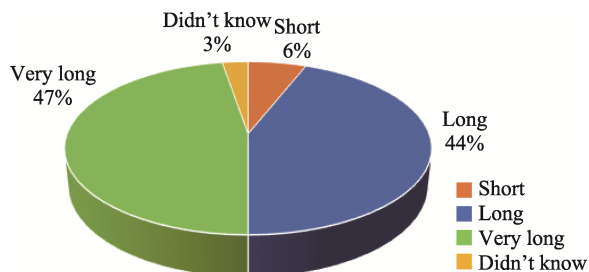


Fig. 6 Perception of respondent on duration of relief distributed

More interesting thing is that only 58% of respondents had claimed for the compensation of their livestock loss. Long and expensive procedure of reporting was the main reason of respondents for not claiming compensation. Among claimed respondents, 46% of them had not received compensation amount till date.

Several reasons why large carnivores come out of the

forest have been reported. According to the respondents, searching of easy prey (62%) was the main conflict reason, followed by lack of prey in wild (19%), incompetent to prey in wild (12%) and habituated man eater carnivore usually come out of the forest (7%). Old, weak, and diseased carnivores are incompetent to prey in wild due to which they come out of the forest for easy prey.

Table 5 Model-averaged parameter estimates at 95% confidence level describing the satisfaction of local people about the relief scheme for HLCC in Chitwan National Park.

Coefficients	Estimate	Std. Error	t value	P (> t)
Intercept	0.97	0.232	4.175	0.0000052
Gender	0.096	0.092	1.046	0.297
Ethnicity	-0.1	0.053	-1.86	0.065
Age class	0.049	0.137	0.358	0.72
Age	-0.003	0.006	-0.501	0.617
Occupation	-0.024	0.094	-0.255	0.798
Family size	0.001	0.015	0.112	0.911
Livestock number	-0.011	0.008	-1.294	0.197
Insurance	0.4	0.171	2.434	0.016
Education	-0.07	0.1	-0.709	0.479
Feeding place	-0.0008	0.001	-0.904	0.367

Note: Significant effects are in bold fonts

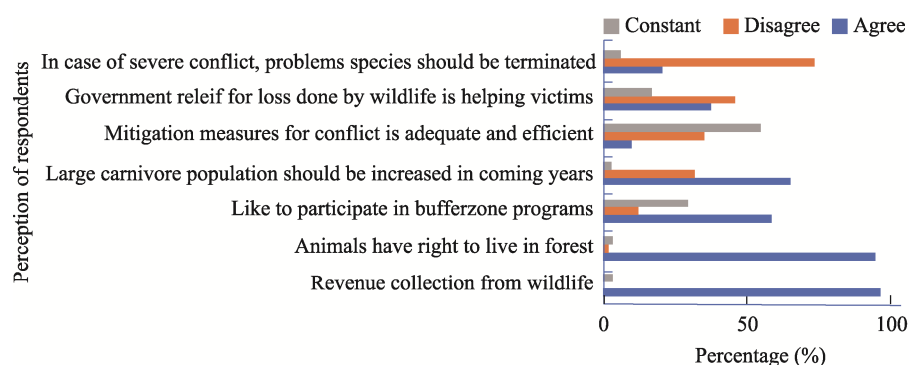


Fig. 7 Perception of peoples towards large carnivores and conflict

Ordinary Least Square (OLS) regression analysis showed that distance to nearest water sources and distance to forest was negatively correlated with the number of livestock killed ($r^2=0.22$, $P<0.001$ and $r^2=0.21$, $P>0.001$) (Fig. 8). With the increasing distance to water body from household, number of livestock depredated seems to be declining.

4 Discussion

4.1 Patterns and causes of human-large carnivore conflict

Few decades ago, people usually don't praise the large carnivores as the conflict between them and human may cause the loss of human lives (Oli et al., 1994) however, peoples now are much aware of the ecological importance of large

carnivores, so they have much positive attitudes towards the HCC. We found tigers attack more livestock than leopards even tiger's population is lower than the leopards. Inside the CNP buffer zone, tigers attack human more frequently than leopards. Tigers are the top predator of the forest ecosystem so that they do not fear to hunt down any animal, but the leopards are shy in nature and prefer to attack small mammals like goats and sheep. In recent years (after 2014) depredation caused by leopard were higher than tiger as rising population of tiger might have pushed leopard towards park boundary where it can encounter with livestock easily (Odden et al., 2010, Upadhyaya et al., 2018). Leopard was found to be the main predator of livestock in Bhutan, Pakistan and midhill of Nepal (Wang and Macdonald, 2006; Dar

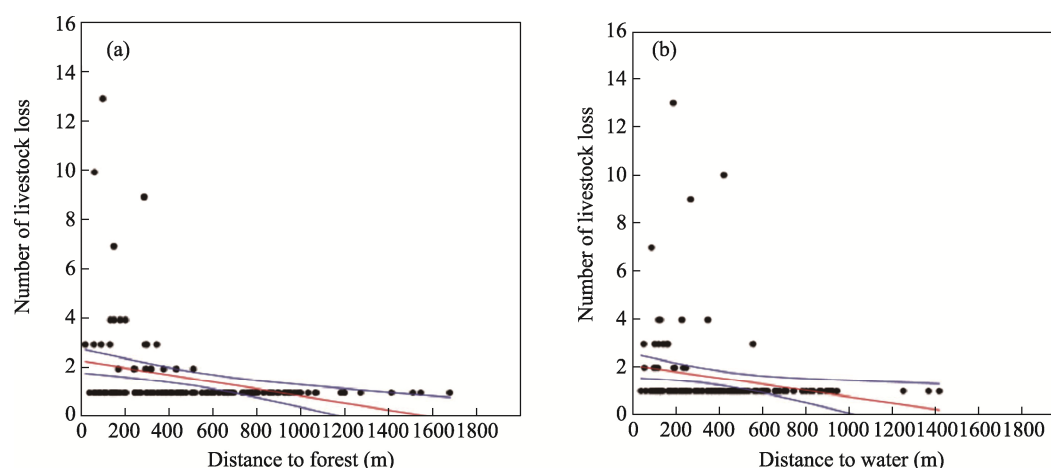


Fig. 8 Relation between the livestock loss and distance to forest (a) and distance to water sources (b)

et al., 2009; Adhikari et al., 2018). Similar result was observed in Pakistan where goats were the primary prey (57.3%) of the leopard (Dar et al., 2009).

Tigers and leopards preferred to hunt during night (Lamichhane et al., 2018). Most of the livestock attacks were during night from the stall because it is easier for large carnivore to hunt tied cattle from stall. Once large carnivore gets to know the cattle are easier prey for them, they repeatedly attack cattle from stall. Most of the livestock killing reported from questionnaire survey occurred at stall during the study period. Carnivores preferred to hunt down livestock inside the corral and tied in the stall (Tamang and Baral, 2008).

Number of livestock depredation seems to be decreasing in recent 5 years of time in the study area. Rising trend of local people to rear livestock at stall might have prompted reducing livestock loss due to large carnivores. Similar outcome of decreasing livestock loss was mentioned by Dhungana et al. (2019) in CNP as consequence of increasing stall-feeding practice, rearing of improved breed and restriction of livestock grazing in buffer zone forest. Livestock depredation rate and involvement of local people in foreign employment was negatively correlated as it lowers dependency of local on forest resources. Furthermore, strict policy of park and community managed bufferzone forest helped in lowering depredation rate in CNP (Lamichhane et al., 2018).

Preference of livestock by tiger and leopard in the study area were examined by employing numbers of depredation events and species involved in the incident. Tiger selected cattle/buffalo more significantly than goat/sheep and avoided pig as prey while leopard preferred pig and goat/sheep and avoided cattle buffalo. Tiger is a large predator which can easily capture large sized prey like cattle/buffalo while leopard being smaller predator may not be able to defeat large sized prey and can get injured itself. So, leopard selects small and medium sized prey (Karanth and Sunquist, 1995). Similarly, Bhattarai and Kindlmann (2012) found remnant of large and medium sized prey in scat of tiger

where as more remnant of small sized prey was observed in leopard scat which indicate the preference of large sized prey by tiger than leopard. Tiger selected large prey (e.g., gaur, chital, sambar in wild and cow and buffalo in domestic) which remains active particularly during dawn and dusk and leopard preferred small sized prey (e.g. northern red muntjac and wild boar in wild and goats/sheep indomestic) that remained active during day (Adhikari et al., 2018; Vinitpornsawan and Fuller, 2020). Low sign density was observed far from the forests.

4.2 Costs of human large carnivore conflict

A total of US\$ 13702.18 was spent by CNP as relief for livestock depredation in Nawalpur District during 19 years. CNP spent total of US\$ 17524.41 for human casualties caused by large carnivores in the study area. The relief distributed for livestock depredation and human casualties in this study area is much lower than reported by Lamichhane et al. (2018) which is US\$ 60288.74 for livestock depredation and US\$ 305007.77 for human casualties caused by wildlife in CNP during 1998–2016. Since our study covered only Nawalpur area of CNP and only large carnivores related incidents are reported, the relief distributed in my study area is relatively lower in comparison to data of whole CNP. Similarly, the study conducted by Dhungana et al. (2019) reported the loss of US\$ 24621 from livestock depredation caused by leopard in CNP during 2007–2016. A total of US\$ 14573 was estimated to be cost of livestock depredation by predators for 297 surveyed households of BNP (Upadhyaya et al. 2018).

4.3 People's perceptions towards human-large carnivore conflict

About 90% of the respondents from study area are still depending upon the forest for different type of resources. This induces human disturbance in the habitat of large carnivores leading to increasing HLCC in the study area. Expansion of human activities in natural habitat of wildlife resulted ris-

ing frequency of conflict worldwide (Graham and, 2005). About 45% of respondents from study area rear their livestock outside of corrals near to forest, inside forest, along river banks and agricultural fields where carnivores have easy access to livestock. Similar result was observed in the study of Lamichhane et al. (2018) where 46.7% of the grazing households graze their cattle in community forest in Chitwan. In Abbotabad District of Pakistan, communities are highly dependent on forest for resource like fuelwood, timber, grass, livestock grazing etc. which facilitated conflict with wild animals (Khan et al., 2018). People in the study area believe that large carnivores come out of the forest in search of easy prey and due to lack of abundant wild prey. Limbu and Karki (2003) also identified lack of sufficient food in the reserve, search of palatable food and lack of fences in the boundary as the main causes of conflict in KTR.

Distance to forest and water resources is another factor resulting increased HLCC in the study area as most of the household with livestock depredation which occurred at stall was found within 1000 meter from forest and water resources. The number of livestock depredation was higher in the households nearer to forest and water resources. Khan et al. (2018) also reported most of the livestock depredation (90%) events happened within 1000 m from forest border in Pakistan. Reported human casualties from my study area occurred in forest and agricultural field near to the forest. Similar pattern of attacking human within 1 km of park boundary was reported by Silwal et al. (2017) in CNP. Dhungana et al. (2018) also reported 67% of the human casualties occurred within one kilometre distance from park boundary and 80% of the events within two kilometre of park boundary in CNP.

Average of 0.68 human death per year and 1.05 human injury per year was observed in 19 years of duration in buffer zones of Nawalpur District which is relatively lower than previously reported in CNP (Lamichhane et al., 2018) since this study only covered the bufferzone of Nawalparasi and only large carnivores related incidents were reported. Silwal et al. (2017) reported 68 human attacks by tiger and 18 attacks by leopard in CNP during 2003–2013. A total of 54 human casualties by tiger was reported by Dhungana et al. (2018) during 2007–2014 and 11 human casualties was reported during 2007–2016 in CNP by Dhungana et al. (2019). Mean of 0.15 fatalities per year caused by tiger attack reported from Khata Corridor linking BNP in Nepal and Katarniaghat Wildlife Sanctuary in India during 1993–2013 (Wegge et al., 2018).

Local resident attitudes towards large carnivore conflict was positive similar to the study of Lamichhane et al. (2019a). In this study ethnicity and management sector influenced the attitude of people which appear to be similar finding of my study. The perception of respondents from study area varied significantly in terms of their education

status, age groups and occupation (Table 6). Despite the fact that all respondents were victim of large carnivore conflict, most of them showed positive opinion on the survival of large carnivores and agreed for the increasing population of tigers and leopard in our study area which is similar to the study of Wegge et al. (2018) in Khata Corridor reporting support of 44% of respondents whose family members or relatives were victim of tiger towards tiger conservation. Residents of the buffer zone areas not only suffering from the human wildlife conflicts but enjoy the natural beauty of the park and also get benefits from park (Lamichhane et al., 2018). About 50% of the park's revenue is invested in the buffer zone, facilitating the growth and development of local communities (DNPWC, 2022). Moreover, ecotourism plays a major role in sustaining the livelihoods of the people in these areas. Community forests are utilized as prime sites for wildlife viewing and other resource collection, creating a positive connection between the local communities and wildlife conservation efforts. Similarly, most victims of livestock depredation also supported for the conservation of tigers. About half of the respondents (46%) denied government relief is helping victims as the process of claiming compensation is long, complex and expensive which mirror with the result of Lamichhane et al. (2019b) where more than 75% of the respondents were not satisfied with the current compensation practice. Most of the respondents who have insurance of livestock are positive about the presence of large carnivores in the forest.

5 Conclusions

Human-large carnivore conflict is a major issue in Nepal. A trend analysis of human carnivore conflict of 2001–2019 and survey-based study around the buffer zone of Chitwan National Park in Nawalpur District revealed that two carnivores *Panthera tigris* and *Panthera pardus* caused 521 incidents of incidents of livestock depredation and human casualties. The trends of livestock depredation were decreasing in trends whereas the human injury and death cases were increasing in trends. The main target livestock of the leopards were goats/sheep, duck, hens whereas cows, goats/sheep, buffalos were major target of tiger. The government paid US\$ 13702.18 as compensation to victims for livestock depredation whereas US\$ 17524.41 was paid for human injury and death. More than 64% of the respondents among 150 respondents from the victim group had positive attitude towards the presence of the carnivores and their conservation even though they were suffering from the cases of conflict. The education, age, profession of the respondents also affected the positive response towards the conservation. The people around the buffer zone of CNP were getting the compensation for their loss but the respondents questioned on the process of granting compensation. Hence, this study recommends to conduct awareness about the process of compensation, prepare predator proof

corals and find sustainable solutions to mitigate human wildlife conflict.

Acknowledgements

We would like to Department of National Park and Wildlife Conservation (DNPWC) and Chitwan National Park for research permission. We are grateful President Chure Terai-Madhesh Conservation Development Board for providing thesis grants. We thank to CNP for providing the data of compensation provided to local community who were victim due to human wildlife conflict and all the respondents who took part this study.

Appendix

Questionnaires

Household survey Questionnaire on Human carnivore interactions

Name: Age: Gender: M/F

Address (VDC/ward/tol name): Occupation:

Family size: Education:

1. Do you have livestock? Yes / No. If yes, how many and what kind of livestock?

a. Cow b. Buffalo c. Pig d. Goat/Sheep e. Other

2. How do you rear your livestock?

a. Stall fed b. Grazing in forest c. Grazing in own field
d. Grazing in park e. Other

3. What types of forest resource do you use?

a. Grass b. Timber c. Firewood d. Medicinal plants
e. Others

4. Do you know about livestock insurance? If yes, have you done it?

a. Yes, I have done b. Don't know c. Know, but not done

5. If you have not done, are you interested to do? Yes / No. If No, why?

6. Do you or any of your family member go to forest? Yes / No

7. What time of the day you go in forest?

a. Morning b. Afternoon e. Evening

8. Have you ever seen any carnivores? Yes..... No.....

9. Do you like if there are tigers and leopards in forest? Yes / No
If No, why?

10. Which livestock is mostly attack or killed by carnivores?

11. Do you know anybody in your village who were attacked / killed by tiger or leopard? Yes..... No.....

If yes, number of people..... Where (forest / village / agricultural field)

12. What do you think the reason for large carnivores to come out of the forest?

13. What are the precautionary method that you adopt to minimize the large carnivore damage?

14. Do you know that you get compensation if your livestock is killed or your family member is attacked? Yes.... No.....

15. If yes, is it enough for compensation?

16. How long does it take to get compensation?

17. Are you satisfied with the compensation scheme? Yes / No
If no, why?

18. Are you happy with the conflict mitigation measures?

Yes..... No..... If no, what should be done?

19. Which agency will be appropriate for relief distribution?

a. Community forest b. Buffer zone offices
c. National park d. VDC / municipality

20. Do you know about buffer zone programmes and national park?

Yes..... No..... If yes, what are the major activities?

Perception of people

1. Wild animals have a right to live in the forest.

a. Agree b. Disagree c. Neutral

2. Wildlife attracts tourists and brings revenue to the park, which benefits us

a. Agree b. Disagree c. Neutral

3. I would like to participate in community wildlife conflict mitigation programs.

a. Agree b. Disagree c. Neutral

4. In case of severe conflict, problem animals should be terminated.

a. Agree b. Disagree c. Neutral

5. Tiger and leopard population should be increased in coming years

a. Agree b. Disagree c. Neutral

6. Government relief for loss done by wildlife is helping to victim families.

a. Agree b. Disagree c. Neutral

7. Mitigation measures for wildlife conflict is adequate

a. Agree b. Disagree c. Neutral

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尼泊尔 Chitwan 国家公园人类-大型食肉动物冲突的模式、原因和感知

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摘要: 人与野生动物尤其是大型食肉动物之间不断加剧的冲突是保护区面临的主要管理问题之一, 食肉动物对牲畜的损害和对人类的袭击造成的人员伤亡是管理中面临的严重挑战。本研究旨在探索 Chitwan 国家公园纳瓦尔普尔地区人类与大型食肉动物冲突的模式、成本、原因和感知。利用 2001 年–2019 年报告给 Chitwan 国家公园的数据分析了大型食肉动物(虎和豹)对牲畜损失和人员伤亡的方式。为了了解人们对食肉动物和野生动物保护的看法, 我们询问了 150 名受害者, 每个格网选择一个家庭代表。在研究的 19 年期间, 共报告了由大型食肉动物引起的 521 起冲突事件, 其中包括 33 起人员伤亡和 488 起牲畜损害。虎在纳瓦尔普尔地区造成的冲突事件最多。Chitwan 国家公园当局在纳瓦尔普尔地区提供的人员死亡和伤害救济总额为 17524.41 美元, 用于赔偿牲畜损害的总额为 13702.18 美元。尽管食肉动物对牲畜损害、人员伤亡和死亡负有责任, 但仍有超过 64% 的受访者喜欢食肉动物在他们所在地区的存在, 并对大型食肉动物保护持积极态度。人们对政府提供的救济计划的满意程度取决于种族、性别、年龄、职业、教育、保险和牲畜所有权, 但他们认为该计划并不很有效。因此, 应在冲突地区开展有效的救济计划和宣传活动, 提高人们对救济资金使用方式的认知。向当地社区开展关于大型食肉动物及其行为的宣传活动, 并准备防损围栏, 有助于减少研究区域的冲突。

关键词: 损害; 人类与野生动物冲突; 豹; 虎; 救济基金