LIVESTOCK DEPREDATION AND CROP RAIDING BY WILDLIFE IN THE BUFFER ZONE OF BARDIA NATIONAL PARK, NEPAL

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A thesis submitted in partial fulfillment of the requirements for the award of the degree of Master of Science in Zoology with special paper Ecology and Environment

Submitted to

Central Department of Zoology
Institute of Science and Technology
Tribhuvan University
Kirtipur, Kathmandu, Nepal
July 2021

DECLARATION

I hereby declare that the work presented in this thesis has been done by myself, and has not been submitted elsewhere for the award of any degree. All sources of information have been specifically acknowledged by reference to the author(s) or institution(s).

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RECOMMENDATIONS

This is to recommend that the thesis entitled "Livestock depredation and crop raiding by wildlife in the buffer zone of Bardia National Park, Nepal" has been carried out by Mr. Raj Kumar Sijapati for the partial fulfillment of Master's Degree of Science in Zoology with special paper Ecology and Environment. This is his original work and has been carried out under my supervision. To the best of my knowledge, this thesis work has not been submitted for any other degree in any institutions.

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CERTIFICATE OF ACCEPTANCE

This thesis submitted by Mr. Raj Kumar Sijapati entitled "Livestock depredation and crop raiding by wildlife in the buffer zone of Bardia National Park, Nepal" has been accepted as a partial fulfillment for the requirements for the Degree of Master of Science in Zoology with special paper Ecology and Environment.

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Raj Kumar Sijapati

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LIST OF ABBREVIATIONS

Abbreviated form		Details of abbreviations
BNP	-	Bardia National Park
GIS	-	Geographic Information System
HWC	-	Human-Wildlife Conflict
PA	-	Protected Area

ABSTRACT

Biodiversity is globally declining due to anthropogenic activities. Human-wildlife conflict is one of the major drivers for declining the species. Human-wildlife conflict is common everywhere due to resource use competition between humans and wildlife on limited resources. However, limited information on the livestock depredation and crop-raiding was found from rural areas near Bardia National Park (BNP), Nepal. This study investigated the issues of livestock depredation and crop-raiding using questionnaires survey to the local people. A total of 300 households were asked for a questionnaire survey. The majority of the respondents (64%) were male, and almost all households (95%) relied on agriculture for their livelihood. Overall, 1476 hoofed livestock were reportedly depredated by Leopards and 209 by Tigers during 2015-2019. Leopards killed hoofed livestock each season was at least 86%, and more than killed by Tigers. Most depredations occurred in winter, followed by summer, spring, and fall. In addition, people in the studied area also suffer from herbivores, including Wild Boar, Indian Crested Porcupine, Rhesus Monkey, and Rabbit, through crop raiding. The Wild Boar, Rhesus Monkey, Indian Crested Porcupine, and Rabbit mainly damaged paddy (198.97 kg), maize (132.68 kg and wheat (92.68 kg) per household, respectively. Because of severe effects created by livestock depredations and raiding near to BNP, this study recommends using more efficacious deterrent techniques, where feasible, in addition to improved livestock husbandry practices such as night penning.

1. INTRODUCTION

1.1 Background

Biodiversity is declining globally at an alarming rate (Ceballos and Ehrlich 2002), and currently, many species are threatening extinction (Thomas et al. 2004, Dirzo et al. 2014, Ceballos et al. 2017). Most of these threats are from anthropogenic activities due to wisely using resources (Young et al. 2016), which create conflict between humans and wildlife. Human-wildlife conflict (HWC) is expected due to resource use competition between humans and animals for limited resources (Graham et al. 2005, Peterson et al. 2010, White and Ward 2011, Wang and Macdonald 2006). Nowadays, it seems the conflict is increasing continuously, probably due to the increased human population (Dangol and Gurung 1999, Roser and Ortiz-Ospina 2017). More wildlife attacks on humans and their livestock and crop-raiding incidences were reporting near the areas where habitat encroachment or human-wildlife co-existence occurs (Ogra and Badola 2008, Acharya et al. 2016). As a counter-attack, many wildlife species suffer from retaliatory killing, extensive resource collection from wildlife habitat, and keeping wild animals as a pet (Daniels et al. 1995, Hedge and Enters 2000, Karanth et al. 2006). Therefore, HWC is one of the major problems in many parts of the world for wildlife conservation (Rao et al. 2002, Orga 2008).

People's limited resources forced them to collect resources from the wild (Mishra 1982). These activities depleted the resources for wildlife, and the consequence is that the wildlife attacks on people's property after encroached their natural habitats/extracted natural food sources (Brashares et al. 2014). Among the wildlife, large cats such as Tiger (*Panthera tigris*) and Leopard (*P. pardus*), and some herbivores such as Wild Boar (*Sus scrofa*), Asian Elephant (*Elephas maximus*) are major drivers for creating conflict (MacDougal 1987, Miquelle et al. 2005, Goodrich 2010, Pandey et al. 2016). The consequences of property loss, a direct attack on people/injuries/killed family members, and most people expressed their negative attitudes towards the wildlife (Gurung et al. 2008). Conflicts are severe when the human causalities/livestock depredation directly affects their quality of life (Polisar et al. 2003, Wang and Macdonald 2006). For example, in Pakistan, people expressed their attitude to kill Snow Leopard (*P. uncia*) as a retaliatory action (Khan et al. 2018). The consequences of these activities may drive biodiversity loss.

To overcome these problems for biodiversity conservation, the Government established many protected areas (PAs). However, HWC can be found commonly in most of the PAs of Nepal due to restriction on resource use to local communities (Brown 1997, Nepal and Weber 1993, Baral and Heinen 2007), and probably increasing wildlife population (See increasing tiger population in Nepal, this is also necessary for achieving Nepal's commitment to the St. Petersburg Declaration, in which the Government of Nepal committed to doubling its tiger population by 2023; Acharya et al. 2016), or decreasing prey species in the wild (Soofi et al. 2019). HWC generally dis-balances the relationship between PAs and the people who live near the PAs (Stdusrod and Wegge 1995, Orga 2008). HWC is accelerating by many supporting factors such as demographic and social changes, unmanaged settlements in and around PAs (IUCN 2003), land use, and land cover change (Nyphus and Tilson 2004). Therefore, negative interaction between people and wildlife (Park) has become one of the fundamental aspects of wildlife management as it represents the most widespread and complex challenge currently being faced by the managers/conservation biologist (Ogutu et al. 2014).

People strategically applied some techniques to deter wildlife from protecting their properties from loss and, for example, establishing barriers to prevent movement of animals (Polisar et al. 2003, Sapkota et al. 2014), displaying louder sounds, torching, etc. These techniques can provide essential relief to the local people from damaging their properties by wildlife. For harmonizing the relationship between Park and the people, the existing conflict should be minimized. For developing a policy or management plan to reduce the conflict, baseline data on the level of conflict severity is a prerequisite. HWC is common in Bardia National Park (Bhattrai and Fisher 2014); however, all of the areas of Park are not well studied to date. Therefore, the proposed study aimed to provide baseline data to explore the livestock depredation and crop-raiding in Sukarmala, Area of Bardia National Park, situated at the adjacent side of BNP for developing strategic policy to minimize the conflict.

1.2 Objective

1.2.1 General objective

The general objective of this study was livestock depredation and crop raiding by wildlife in the buffer zone of Bardia National Park, Nepal.

1.2.2 Specific objectives

The specific objectives of the study were:

- To assess the hoofed livestock depredation by large carnivores in the buffer zone of BNP
- To appraise the crop loss from wildlife in the buffer zone of BNP

1.2.3 Rationale of the study

In the context of Nepal, more HWC incidents are reporting from low land's protected areas such as Chitwan National Park and BNP. Among the conducted researches on the conflict in BNP, most of these are from access areas such as Thakura Baba, Chisapani, Manau Ghat area and no more study from the northern part of BNP, mainly from Surkhet Sukarmala Area, Hariharpur Area and Telpani Area (Bhattarai and Fisher 2014). People are personally reporting the issues of their loss; however, the case is not addressed correctly. It means that managers/policymakers might have data deficient on the severity of conflict from all areas of BNP. It's creating a problem for developing policies to minimize the conflict between Park and the people. Therefore, the data obtained from this study on the HWC can be used by policymakers for developing a management plan to minimize the conflict.

1.2.4 Limitation of the study

Because of covid-19, the actual loss of crop in field during harvesting time was not measured.

2. LITERATURE REVIEW

2.1 Livestock depredation

Human carnivore conflict is one of the major issues for biodiversity conservation (Ogutu et al. 2014). People inhabiting near-natural forests protect the biodiversity; however, the underprivileged ethnic communities near the natural habitat suffer from livestock depredation from wildlife (Lamichhane et al. 2018), which might create a conflict between people and wildlife. The shrinking and transformation of wild habitats and decline in the prey species populations are major factors for livestock depredation (Peterson et al. 2010). Reduced and fragmented wildlife habitats also influence livestock depredation (Choudhary 2004). In addition, the migratory route of wildlife and their disturbances from people under various pretexts, teasing wildlife, are also the causes of conflict (Panta et al. 2015). Livestock predation risk has been shown to increase in or near habitat types selected by the predators (Johansson et al. 2015), and livestock depredation by big cats typically increases when wild prey populations decline (Khorozyan et al. 2015). The effects of several factors on livestock depredation have also been investigated, including suitable habitat, prey and predator density, livestock density, and herding practices. With strict protection for natural resource collection from the natural habitats, bans on hunting, and public awareness programs, populations of large cats have increased in some protected areas like Bardia and Chitwan National Park of Nepal (Thapa et al. 2017). The human settlement near protected areas is a major cause of human-wildlife conflict if the area has carnivores of large home range sized (Gurung et al. 2008, Panta et al. 2015).

The primary problematic carnivores in Nepal are Tigers and Leopards (Sapkota et al. 2014). Tiger was the primary driver for creating conflict with humans and livestock globally where this species is present. For example, it was mentioned that 146 people and 870 livestock were killed from Tiger between 1978 to 1997 in Sumatra, Indonesia (Nyhus and Tilson 2004), and these incidences were more common in human-disturbed areas. Livestock depredation by Tiger increased if the area is with low prey availability; for example, 20% of livestock were depredated in BNP (Bhattarai and Fisher 2014). The massive hunting of ungulates decreases the availability of prey species which might increase the livestock depredation by the carnivores (Soofi et al. 2019). In Bhutan, a total of 1,375 domestic animals were killed by wildlife; among them, Leopards killed significantly more livestock (70%) than other wildlife,

including Tigers (19%), Himalayan Black Bears (*Ursus thibetanus)* (8%), and Snow Leopards (2%). Among these depredations, around 50% of killed livestock were cattle, and 33% were horses (Sangay and Vernes 2008), creating livelihood problems for the local people. The annual livestock loss rate of 2.9% was found in Trans-Himalayan among the total livestock husbandry, and the domestic Goat (*Capra aegagrus hircus*) was the major lost livestock (32%), followed by the Sheep *(Ovis aries)* (30%), Yak (*Bos grunniens*) (15%) and Horses (*Equus caballus)* (13%) (Namgail et al. 2007). Wild predators killed a total of 4.5% of their livestock over 12 months outside the Serengeti National Park, Tanzania (Holmern et al. 2007). The research indicated that Leopards' nocturnal and opportunistic foraging behavior makes them remarkably adaptable to anthropogenic environments. The probability of Leopard attacks on livestock was much higher (85% of all livestock lost to depredation) than that of Tiger attacks (8%), in BNP and livestock loss was significantly related to the number of livestock, their ethnic group, and village distance to the park boundary (Upadhyaya et al. 2019). Not only the habitat, prey, and predator density, the depredation from Leopard also influenced by rainfall. A total of 32%, livestock attacked by Leopards was noticed in Kenyan Reserve Border during high rainfall (Kolowski and Holekamp 2006) because of insufficient vigilance of herders and dogs.

In addition, the depredation is also influenced by the time, season, and body size of livestock. For example, in Machiara National Park, Pakistan, the Leopards killed 301 livestock between June 2007 and August 2008 (Kabir et al. 2014). The maximum livestock depredation occurred in May, and the majority of these events were at night time, and small-bodied livestock such as Goat and Sheep were more vulnerable. More livestock depredation was found during the dry season (Karnath and Nepal 2012), it might be due to insufficient food inside the park in the dry season, and the wildlife comes near the farmer's animal farm. Attacked by Leopards and Tigers peaked in winter, it might be prey populations which might be due to shortages of food and water sources, especially in dry months. Consequently, Leopard and Tigers attacked domestic livestock for their nutrition. In addition, the attack by Leopards mainly occurred outside PAs near to human settlements; it might be the behavior of Leopards that can live in human-modified landscapes (Acharya et al. 2016).

Regular livestock depredations create financial problems for the people. In Annapurna Conservation Area, Nepal, (Koirala et al. 2012) mentioned that a 95% economic loss was

found among the local people whose livestock were killed by Leopards between 2009 and 2010. As a consequence of conflicts with large carnivores, many species suffer from retaliatory killing, which can threaten the persistence of wildlife (Nyhus and Tilson 2004). Because of threats to human safety and property, conservation measures to protect large carnivores can be controversial and may lack support from local communities (Graham et al. 2005). However, some people who had a chance to get incentives had positive attitudes toward conservation (Van dewater and Matteson 2018). To minimize the livestock depredation, a visual deterrent, including lighting the surrounding area, can discourage Leopards presence, and the community-based conservation initiatives can be a successful mitigating (Naha et al. 2020), it might be, the community understand why Leopard should be protected.

2.2 Crop raiding

Crop raiding from the wildlife is rampant, and animals including Wild boar, Rhesus Monkey *(Macaca mulatta)*, Indian Crested Porcupine *(Hystrix indica)* are major crop raiders in Nepal. However, the crop raiders can be varied according to the area. The Wild Boar is one of the major wildlife for crop-raiding at Shivapuri Nagarjuna National Park, where approximately US $24,000 (9% of the respondent's expected profit) were lost annually due to wildlife damage (Pandey et al. 2016). In Langtang National Park, (Kharel 1997) mentioned that the Wild Boar was a major crop raider, followed by Himalayan Black Bear, Rhesus Monkey, and Deer species. In Chitwan National Park, One-Horned Rhinoceros, Spotted Deer (*Axis axis*), and Wild Boar were major crop raiders (Bhattarai and Basnet 2004). Wild Boar, Asian Elephant, Rhesus Monkey, and Spotted Deer were crop raiders in BNP, and these animals raided varieties of crops including paddy, maize, wheat, and vegetables (Jnawali 2002). Wild Buffalo and Wild Boar were the main crop raiders in Koshi Tappu Wildlife Reserve, and the main crops were paddy, wheat, and jute (Adhikari 2000). Spotted Deer, Wild Boar, Elephant, Blue Bull *(Boselaphus tragocamelus)*, Monkey, and Indian Crested Porcupine were the main crop pests Suklaphanta National Park (Limbu and Karki 2003). Rhesus Monkey, Barking Deer (*Muntiacus vaginalis*), and Himalayan Crestless Porcupine (*Hystrix Brachyura)* were the main crop raider in and around Makulu Barun National Park (Chalise 1998), as well as Indian crested Porcupine and Rodents were identified as major crop wildlife pests in and around Shey-Phoksundo National Park (Basnet 1998), and

Himalayan Tahr *(Hemitragus jemlahicus)* at Sagarmatha National Park (Shrestha 2004). The majority of these damages/crop raiding's were near the forest or PAs (Bayani et al. 2016); generally, these types of activities might occur due to changes in animals' behavior after intra and inter-species competition for space, food, and mating (Sukumar 1994). Primates are highly noticed pests animals because of their opportunism, adaptability, intelligence, and manipulative abilities. More loss from the primates was found at the crops' harvesting period (Subedi et al. 1993, Lahkar et al. 2007).

Crop raiding is common in a human-dominated landscape at mid-hill, where the number of wildlife is assumed to be increased after the establishment of PA (see Panchase PA and community forest; Adhikari et al. 2018). There are many human settlements in and around PA, where wild herbivores and people shared resources. Consequently, the depletion of resources for herbivores increased crop-raiding (Gurung et al. 2008). Hence, it seems that people who live near PAs or cultivate crops in and around the park boundaries are vulnerable to crop-raiding.

3. METHODS

3.1 Study Area

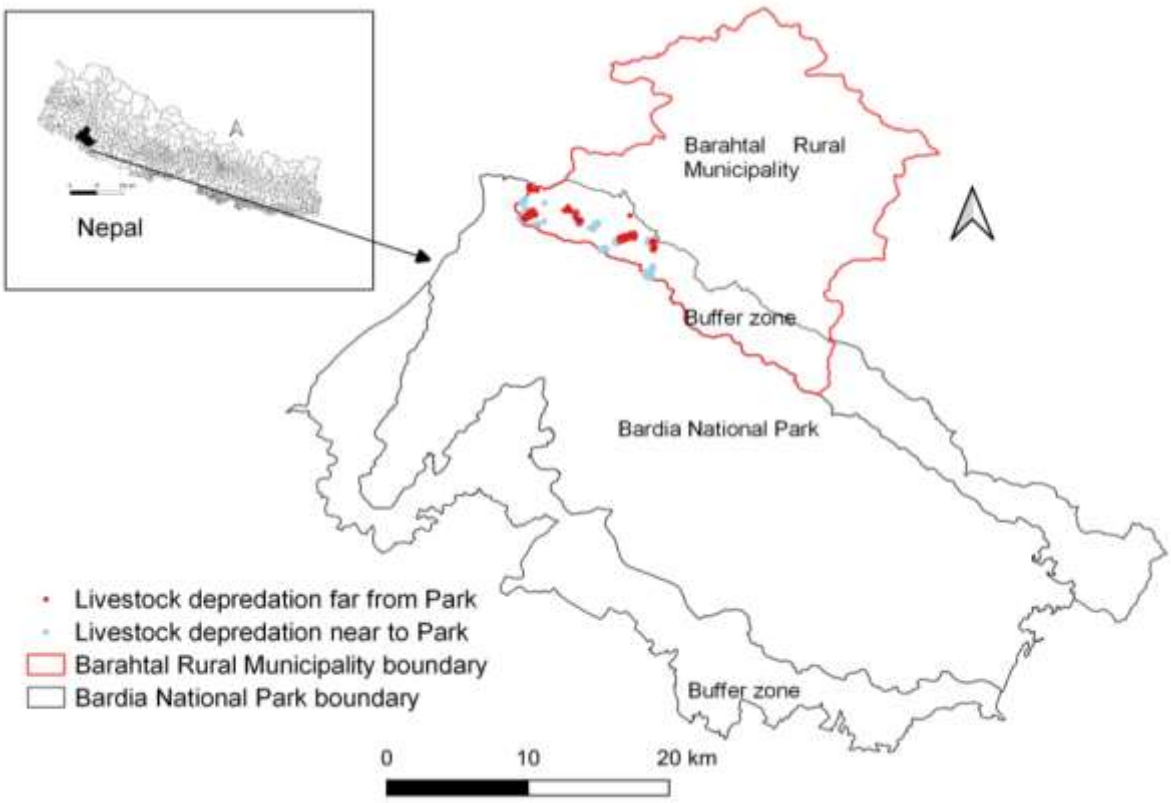

Figure 1. Study area with locations of livestock depredations at Sukarmala, Bardia National Park, Nepal

Bardia National Park (28.43777 to 28.53879 N and 81.20208 to 81.20738 E), established in 1988 AD, comprises 968 km^2, situated from 152 m to 1441 m of elevation above the sea level. The lowest elevation of the Park is at Manau Ghat, and the Sukarmala Danda is the highest. The Karnali River bounds the area in the eastern and Siwalik Hills in the northern. The western boundary of the areas is developed by Geruwa, a branch of the Karnali River, and the southeast by the Babai River. Three types of climatic conditions are found in BNP: sub-tropical monsoon with a rainy season from June to early October, a cool, dry season from October to late February, and a hot season from March to mid-June (Upreti 1994). The proposed study was conducted in Sukaramala, Area (28.62535 to 28.66224 N and 81.408 to 81.32809 E), situated at the BNP buffer zone. This place is the highest elevated part of BNP,

situated Barahatal Rural Municipality 3, Surkhet of Karnali Province. Nearly 400 households are inhabiting the study area (CBS 2011). The people from this area depend on the resources from BNP.

3.2 Flora and Fauna

About 70% of the Park is covered with forest land, which supports 839 plant species, including 173 vascular plants that comprise 140 dicots, 26 monocots, six ferns, and one gymnosperm (Dinerstein 1979). The important flora of the study area includes Sal *(Shorea robusta*), Saj (*Terminalia elliptica*), Khair (*Acacia catechu*), Simal (*Bombax ceiba*), Sissoo (*Dalbergia sissoo*), and Tooni (*Tonna ciliate*). This wide range of vegetation types provides appropriate habitats for the occurrence of 642 faunal species, including 125 species of fish, 23 reptiles and amphibia, 407 birds, and 53 mammal species. Among them, Bengal Florican (*Houbaropsis bengalnesis*), White-Rumped Vulture (*Gyps bengalensis*), Bar-Headed Goose (*Anser indicus*), One Horned Rhinoceros, Asian Elephant, Tiger, Swamp Deer (*Cervus duvaucelli*), and Gangetic Dolphin (*Platanista gangetica*) are more noticeable wildlife in the Park (Bhuju et al. 2007).

3.3 Data collection

A preliminary survey was conducted from 9 November to 12 November 2019, and during that time, the wildlife affected area, number of households, people's local dialect and their understanding during conservation were identified. The questionnaire survey was performed between 2 January and 12 February 2020 with people living in Sukarmala, the BNP buffer zone area of Barahatal Rural Municipality. A total household of 400 of the study area was listed in an Excel sheet and used rand() command and choose only the 300 households for the questionnaire. The minimum required sample size was 242 households for the questionnaire survey at the buffer zone of BNP for this study at a 95% confidence interval with a 5% margin of error (Krebs 2014). From that, 300 households were randomly chosen for the questionnaire survey.

The interview was performed only those people >18 years old from a household. There was no discrimination to the interviewee based on education level, gender, ethnicity, or religion. During the interview, demographic data such as age, gender, education (educated: people who attended school through grade five or above; non-educated: people who did not go to school or attended school through grade four or less), family size, and the occupation of

respondents were collected. People were asked whether they experienced conflicts with carnivores and to characterize these conflicts (e.g., frequency and timing, number of livestock lost). In addition, the number of hoofed livestock they owned and killed by larger carnivores, mainly by leopard and tiger in the last five years, was asked to them, the location of hoofed livestock killed by leopards and tigers was recorded according to the respondent's confirmation. Respondents confirmed the specific attack of carnivores based on their experience and evidence (e.g., leopard or tiger tracks) near the kill site and evidence on the carcass (e.g., hemorrhaging), including differences between species for killing prey (e.g., leopard suffocating prey as evidenced by bite marks whereas tiger kills livestock by biting the nape or backside of the neck). Latitude and longitude of each kill site were recorded, and the distance of each site (whether >1 km or <1 km) was measured using Global Positioning System, and Geographic Information System (GIS), respectively. Finally, the number and type of deterrents used to mitigate conflicts with Leopards and tigers and other wildlife. In addition, interviewees were asked whether they were suffering from herbivore wildlife, i.e., crop raiders. Data on the types of crops, their production for the studied year, and losses were collected from the interviewee. However, the damaged area was not measured in the field because of COVID-19. Therefore, field verification for crop damage was not conducted for this study.

3.4 Data analysis

Chi-square and Kruskal-Wallis tests were performed for binary and numeric responses, respectively, to examine the differences between people living near ($\leq$1 km from the BNP boundary) and far from the protected area (>1 km from the BNP boundary). The location of each livestock depredation was used to estimate the distance to the BNP boundary using GIS. However, data analysis for crop-raiding was not categorized according to near and far from the park boundary due to a lack of spatial data on crop-raiding.

A generalized linear model was performed to identify factors influencing livestock depredation by Leopards and Tigers using data for 2015-2019. Factors included distance to BNP, number of livestock (cow, buffalo, and Goat) owned, number of techniques used to mitigate conflicts, and season. The seasons were defined as spring (March-May), summer (June-August), fall (September-November), and winter (December-February). Models were ranked using Akaike Information Criterion adjusted for small samples (AICc; Burnham and

Anderson 2002) and Akaike model weights to estimate the relative strength of evidence for each model. Models were considered with "AICc scores within 4" of the most parsimonious model to have support (Burnham and Anderson 2002). The model averaging was calculated using models within 4 AICc of the top model to estimate 95% confidence intervals for each variable and accepted statistical significance at $\alpha = 0.05$. All analyses were performed in the R program (R Core Team 2019). Techniques used to deter leopards and tigers from depredating livestock include (Shouting, beating pot/drums, flashlight, and firing), ranging from 0 to 4.

4. RESULTS

4.1 Respondent's demographic condition

A total of 300 households (147 near BNP and 153 far from BNP) were surveyed during this study. The interviewee was categorized near and far from BNP was based on the number of livestock killed locations. The demographic characteristics of respondents near and far from BNP were not different (Table 1). Most respondents were male (66% near BNP and 62% far from BNP), and almost all households (95% near BNP and 95% far from BNP) relied on agriculture for their livelihood. The number of hoofed livestock owned by respondents was similar between respondents living near and far from BNP.

Table 1. Attributes of respondents and their livestock living <1 km (n = 147) and >1 km (n = 153) from Bardia National Park, Nepal. Parameters included Age (years), Gender (male and female), education (educated: people who attended school through grade five or above; non-educated: people who did not go to school or attended school through grade four or less, Occupation (Agricultural: if daily life of the people is sustained from their agricultural products; others: if their daily livelihood depends on other than agricultural income), Family size (Number), Total livestock owned (Number: all hoofed livestock including cow, buffalo and goat), and Total livestock killed (Number: all hoofed livestock including cow, buffalo and goat) for survey year.

Parameters	Near to PA	Far from PA	Statistics
Age	Median = 39	Median = 43	Kruskal-Wallis test, $\chi 2$ = 2.576 p = 0.560
Gender	Male = 66%	Male = 62%	$\chi 2$ = 0.386, df = 1, p = 0.534
Education	Educated = 37%	Educated= 28%	$\chi 2$ = 2.546, df = 1, p = 0.555
Occupation	Agriculture = 95%	Agriculture = 94%	$\chi 2$ = 0.0300, df = 1, p = 0.763
Family size	Median = 7	Median = 7	Kruskal-Wallis test, $\chi 2$ = 0.780; p = 0.855
Total livestock owned	Median = 14	Median = 14	Kruskal-Wallis test, $\chi 2$ = 0.015, p = 0.126
Total livestock killed	Median = 5	Median = 6	Kruskal-Wallis test, $\chi 2$ = 98.023, p<0.055

Table 2. Generalized linear model to identify factors related to cattle killed by leopards and tigers, Bardia National Park, Nepal. Number of livestock killed (number) used as response variable; Total livestock owned (number); Preventive measures (number of techniques used to deter tigers and leopards, 0–4). Season (number of livestock killed: fall, spring, summer, winter), Park distance (near: <1 km and far: >1 km from the park boundary). K is the number of parameters, ΔAICc is the difference between the AICc value of the best- supported and successive models, and w_i is the Akaike model weight.

Species	Covariates	K	ΔAICc	Wi
Leopard	Park distance + Season	6	0.00	0.26
	Park distance + Livestock owned + Season	7	0.19	0.24
	Season	5	0.82	0.17
	Livestock owned + Season	6	1.32	0.14
	Park distance + Preventive measures + Season	7	1.99	0.1
	Park distance + Preventive measures + Season + Livestock owned	8	2.17	0.09
	Null	1	334.9	0.00
Tiger	Season	4	0.00	0.23
	Livestock owned + Season	5	0.89	0.15
	Preventive measures + Season	5	1.46	0.11
	Park distance + Season	5	1.97	0.09
	Preventive measures + Livestock owned + Season	6	2.36	0.07
	Null	1	177.5	0.00

The best model of livestock depredation events by leopards included distance from BNP and season and for tigers included season; however, all factors assessed were included in competing models (Table 2). For leopards, livestock depredations were more likely in locations near BNP and varied seasonally; the number of livestock owned and number of preventative measures used to mitigate conflicts did not reduce depredations (Table 3). For tigers, livestock depredations were more likely to occur during seasons other than monsoon;

however, distance to BNP, number of livestock owned, and number of preventative measures did not influence the probability of livestock depredation.

Table 3. Model-averaged parameter estimates and lower and upper 95% confidence limits describing livestock depredated by leopards and tigers, Bardia National Park, Nepal. Parameter estimates were averaged from all models reported in Table 2. *Significant effects are in bold.

Species	Covariates	Estimate	SE	Lower Limit	Upper Limit	z	P*
Leopard	(Intercept)	0.888	0.078	0.735	1.042	11.342	**<0.001**
	Fall	0.116	0.025	0.067	0.165	4.64	**<0.001**
	Spring	0.139	0.025	0.091	0.188	5.594	**<0.001**
	Summer	0.102	0.022	0.058	0.146	4.54	**<0.001**
	Winter	0.109	0.017	0.075	0.144	6.243	**<0.001**
	Livestock owned	−0.004	0.003	−0.011	0.002	1.298	0.194
	Preventive measures	0.002	0.021	−0.039	0.044	0.111	0.911
	Distance to park	−0.092	0.053	−0.197	0.013	1.718	0.086
Tiger	(Intercept)	−1.849	0.175	−2.191	−1.507	10.589	**<0.001**
	Distance to park	−0.022	0.145	−0.307	0.263	0.152	0.879
	Fall	0.296	0.062	0.175	0.418	4.792	**<0.001**
	Spring	−0.022	0.0721	−0.165	0.119	0.315	0.752
	Summer	0.227	0.057	0.116	0.338	4.015	**<0.001**
	Winter	0.221	0.043	0.137	0.305	5.155	**<0.001**
	Livestock owned	0.009	0.009	−0.008	0.026	1.05	0.294
	Preventive measures	−0.044	0.061	−0.163	0.074	0.732	0.464

4.2 Livestock owned

Almost all respondents had livestock, 97% (n = 291) of respondents had cow and ox, 94% (n = 285) had goat, and 7% (n = 20) had buffalo (Figure 5). The number of average livestock

owned was 14.97 per household: 3.45 ± 0.08 (SD) cows/oxen, 0.083 ± 0.02 (SD) buffalos, and 11.33 ± 0.43 (SD) goats, respectively (Figure 2).

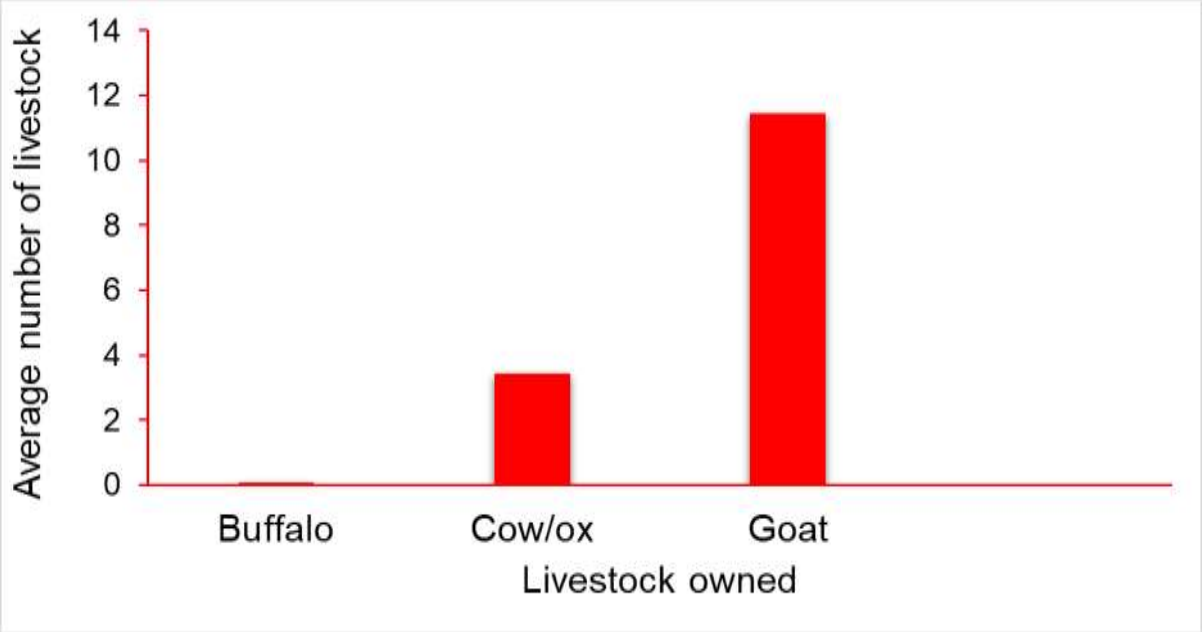

Figure 2. Average number of livestock per household in Sukurmala, Bardia National Park

4.3 Livestock depredation

Overall, 1476 hoofed livestock were reportedly depredated by leopards, and 209 were by tigers. Livestock depredation by leopards and tigers was greater near BNP (Kruskal-Wallis test, $\chi 2$ = 98.023, p < 0.055; Table 1). The total number of livestock killed by leopards and tigers differ seasonally ($\chi 2$ = 116.11, df = 3, p< 0.001; Figure 3). Most reported depredations occurred in winter (n = 626), followed by summer (n = 451), spring (n = 355), and fall (n = 342). More livestock killed was reported far from Park boundary during winter season (Figure 4).

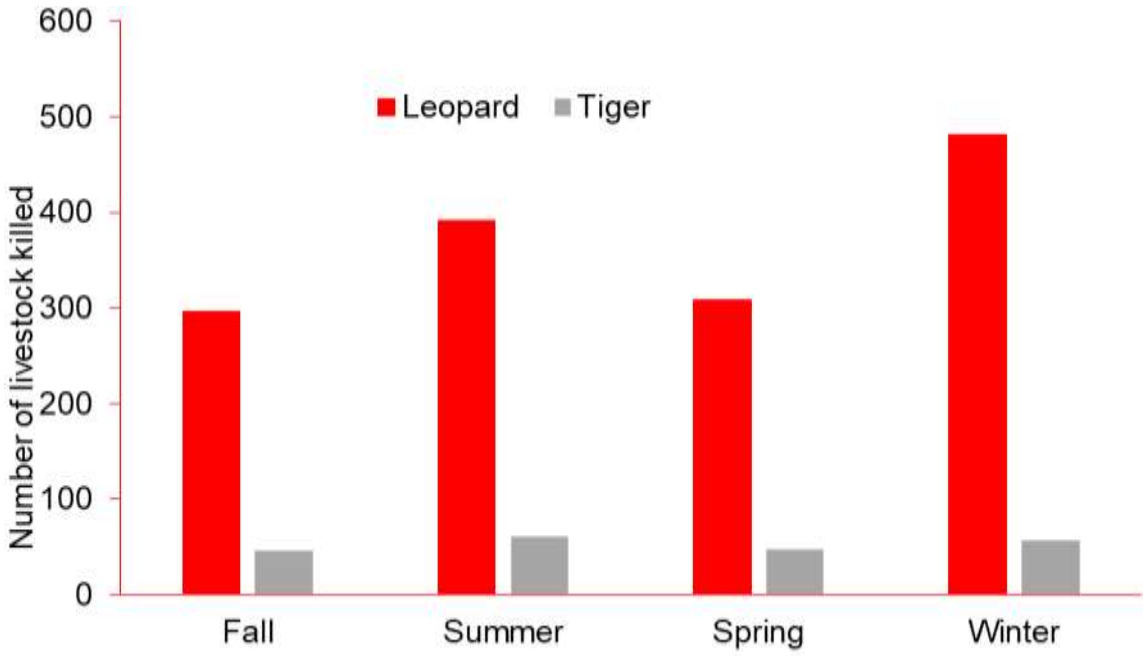

Figure 3. Number of livestock depredations by leopards and tigers seasonally near Bardia, National Park, Nepal within last five years (2015-2019)

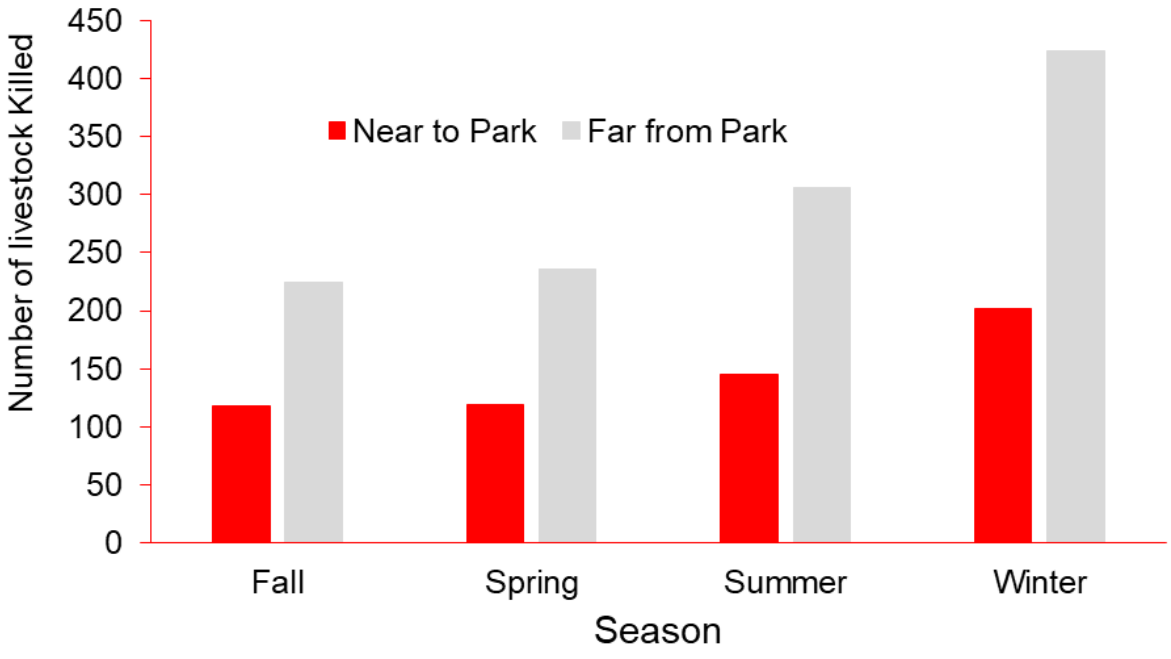

Figure 4. Number of livestock depredations near to Bardia National Park (<1 km) and far from Park (>1 km) at different seasons with in last five years (2015-2019)

4.4 Crop production

Major five crops (paddy, corn, wheat, potato, pulses, and vegetables) were planted by the people at Sukarmala. Paddy was grown in July and harvested in November, while maize was grown in April and harvested in June, wheat was grown in November and harvested in May, and potato in November and harvested in March. The average paddy yield was 680.28 kg per household per year and followed by wheat (343.77 kg), maize (292.89 kg), potato (76.71 kg), pulses (12 kg), and other vegetables (45.28 kg) (Figure 5). The monetary value (according to the local market) of wheat production was 32.23% of total economic yield, followed by paddy (31.39%), maize (18.3%), potato (9.58%), pulses (3.75%) and other (4.25%), respectively.

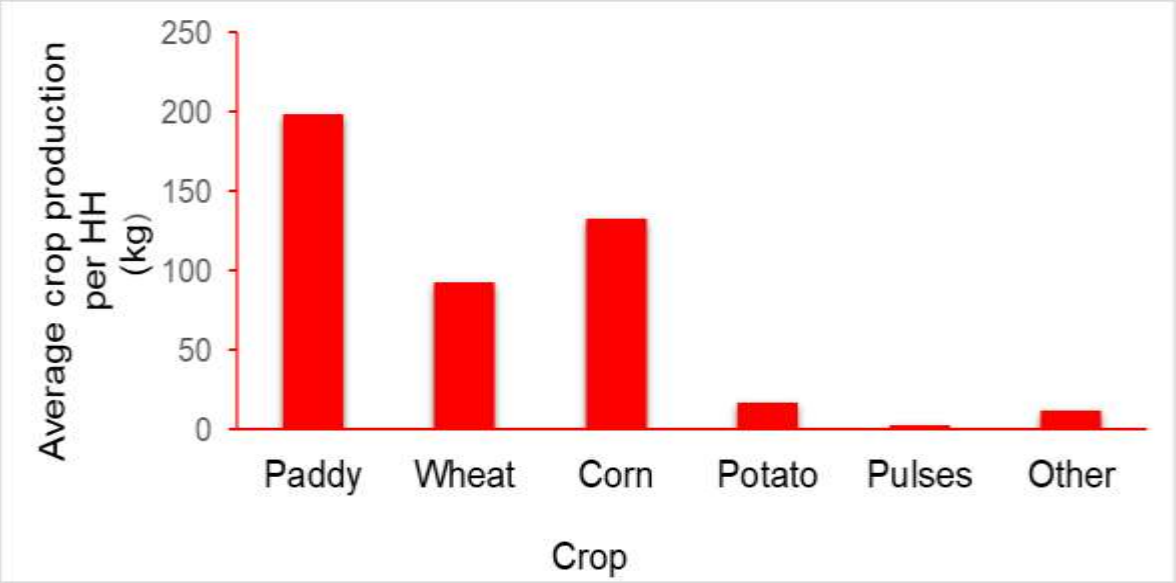

Figure 5. Average crop production per HH in Sukarmala, Bardia National Park

4.5 Crop raiding

Almost all respondents were suffered from wild animals, i.e., crop raiders. Wild Boar, Indian Crested Porcupine, Rhesus Monkey, and Rabbit were main crop raiders. The average crop damage (198.97 kg) was found for paddy per household per year, followed by maize (132.68 kg), wheat (92.68 kg), potato (17.19 kg), pulses (2.65 kg) and other (11.74 kg) respectively). (Figure 6). The average crop damage per household per year was (261.05 kg) by Wild Boar and followed by Indian Crested Porcupine (129.89 kg), Rhesus Monkey (43.1 kg), and

Rabbit (14.06 kg) (Figure 7). The total loss for paddy (56989 kg) was found to all respondents and followed by corn (39806 kg), wheat (27803 kg, potato (5158 kg), pulses (795 kg), and other (3523 kg).

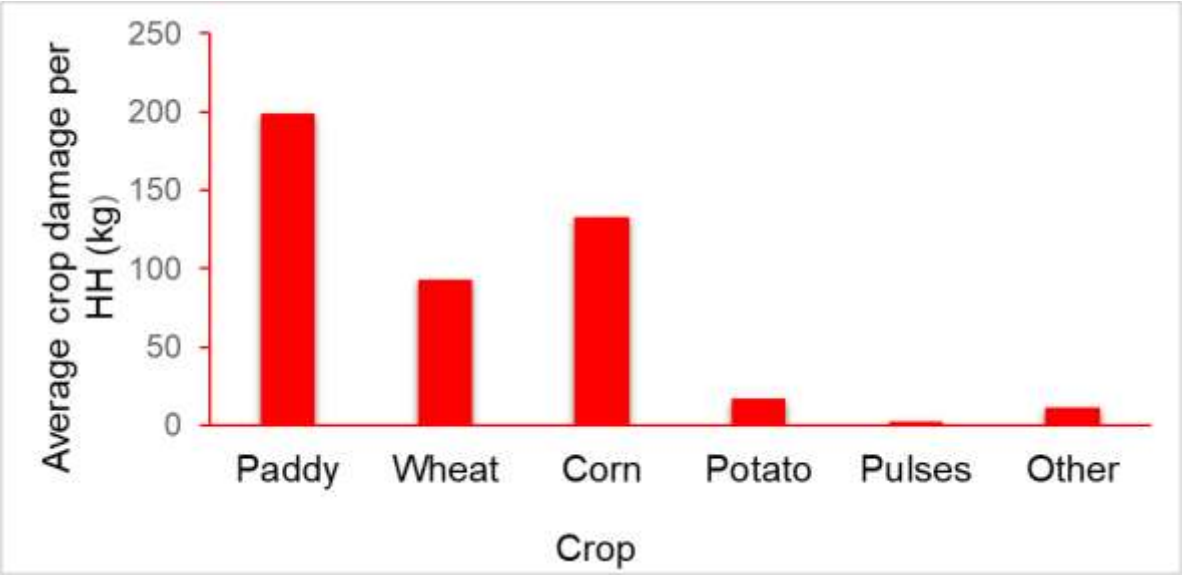

Figure 6. Average crop damaged by wildlife in Sukarmala, Bardia National Park

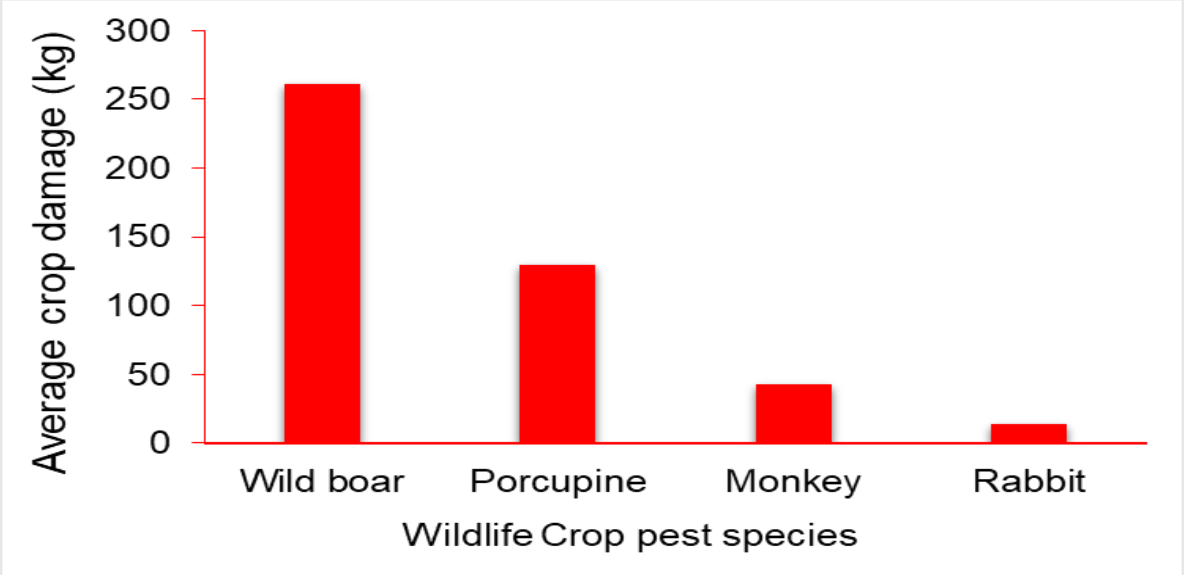

Figure 7. Average crop damage by wildlife crop pest species in Sukarmala, Bardia National Park

5. DISCUSSION

Leopard depredations of hoofed livestock were substantially greater than depredations caused by tigers irrespective of season or proximity to BNP. This study suspects this marked difference in frequency of depredations is a consequence of Leopards being more common than Tigers (Jnawali et al. 2011, Stein et al. 2020). That more depredations from large-bodied carnivores overall occurred near BNP was likely due to increased households moving nearer to BNP since the 1960s (Ojha 1983, DFRS 1999). Livestock depredations were more frequent near BNP due to the greater prevalence of large carnivores within and near this PA. A higher occurrence of carnivores, including Leopards and Tigers, was noticed near the boundary of BNP (Soh et al. 2014, Kissui 2008, Jedrzejewski et al. 2002). Large carnivore populations, including Leopards and Tigers, have increased in Nepal, especially in and near PAs (Wegge et al. 2009, Thapa et al. 2017). A protected area provides refuge for these carnivores, and settlements near PA may provide livestock hunting opportunities (Aryal and Kreigenhofer 2009). Thus, the increased probability of carnivore conflicts with livestock that occur near PAs (Ruda et al. 2020) and near BNP in this study appears a consequence of greater Leopard and Tiger abundance, as well as greater livestock availability. It can be explained by facilitating the rapid movement of carnivores to the security afforded PAs following depredations. In this study area, more livestock depredation occurred during winter. However, at low land, especially in eastern and western regions of BNP, more livestock depredation from Tiger and Leopard was reported during the summer and monsoon seasons (Kissui 2008). Livestock was kept inside corrals with low walls during winter to shelter them from cold weather. However, animals were tethered within these corrals, which constrained their movements, preventing livestock from avoiding Leopards or Tigers when confronted by them. This increased vulnerability and crowding of livestock during winter likely facilitated the increased frequency of reported attacks, especially by Tigers (Murphy 1998). It was also noticed in other parts of BNP (Kissui 2008). In addition, wild prey in this study area was likely more available to Leopards and Tigers in summer than winter; previous studies have demonstrated that wild ungulate prey mortality by carnivores was more significant during summer (Laundre 2008, Thapa et al. 2017). Though it is often assumed that carnivores kill ungulates more frequently in winter due to harsh environmental conditions, which cause ungulates to congregate to account for the higher energetic costs of

thermoregulation (Naha et al. 2020, Adhikari et al. 2020), livestock in our study moved to higher elevations during summer (Odden et al. 1999). Here livestock grazes in croplands, typically far BNP, where Leopard and Tiger abundance is greater (Kathayat P., Member Bufferzone User Committee, Personal communication). Although livestock would be vulnerable to Leopards and Tigers during summer, therefore, a spatial segregation between livestock and these carnivores might limit the depredations.

Different activities affect the events of livestock killing. The cow is larger-sized hoofed livestock, and larger-sized carnivores like Leopards and Tigers hunt it; these events are influenced by the people's activities such as firing, lighting and shouting, and animal husbandry practices. However, these activities in the study area were not significantly important for carnivore deter. Using lights can be effective as a visual deterrent of leopard depredations of livestock in mountainous regions of Nepal (Kideghesho et al. 2007); however, this technique was not used in this study area, undoubtedly due to a lack of electricity. In addition, the ineffectiveness of these techniques might be due to the location of the area. For example, people do lighting and shouting simultaneously if they found any sign of carnivores and assumed they entered the village. It does puzzles to the carnivores for escaping, and the hided individuals probably attack the livestock. Most of the recorded hunting was during the dawn when people are at the deep nap. Mostly they knew the events after the attack. Therefore, the preventive measures after an attack won't be more effective.

Animal husbandry practices can also influence the frequency and occurrence of livestock depredations. Large carnivores, especially Leopard, often kill smaller-sized hoofed animals such as goats and calves rather than larger or mature hoofed animals (Murphy 1998, Khadka and Nepal 2010). Goats were often free-ranging in the study area; more frequent attacks by large carnivores on free-ranging livestock (Bhattrai and Fisher 2014, Odden et al. 1999) may partially explain the high frequency of goat depredations by leopards and tigers. This study area is located in the Northern region, and more depredation was reported from the last few decades (Jędrzejewski et al. 2002, Upadhyaya et al. 2020). It might be due to low prey density in the areas and potentially hunting prey species by poachers in the Northern regions (Bhattarai et al. 2016). Livestock depredation in BNP was noted higher in the low prey density area than higher prey density area at the beginning of 2010 (Bhattrai and Fisher 2014). It might be due to easy access predation on livestock depredation for the increasing

number of Tiger and other carnivore population in BNP [see the number of tigers increased from 30-87 between the year 1995-2018; (NTNC 2019, DNPWC 2018)]. Human-wildlife conflicts, including those involving livestock depredations, can be an essential factor limiting wildlife populations (Woodroffe and Ginsberg 1998). However, this study found no evidence of retaliatory killing from local people in the study area that experienced livestock losses, possibly due to people's belief in Leopard as a cat goddess (Acharya et al. 2016). Despite livestock losses, most people preferred to live near BNP because of more significant opportunities for getting more income from tourists, and the area provides resources (legally and illegally), environmental services, and aesthetic benefits (Bhattrai and Fisher 2014). However, it appears that the benefits of resource use from BNP do not compensate for the economic losses sustained from livestock depredations. In fact, in this study area, depredations appeared more detrimental to people's livelihoods because hoofed animals provide their major sources of milk and meat due to the long distances to local markets. Therefore, the presence of these livestock is crucial for their livelihood.

In the study area, almost all people rely on agriculture, and closer to PA, agriculture production is the main occupation of the local people in the park's vicinity. Households living closer to the park boundaries tend to suffer higher incidents and cost of crop losses than people living further from the park (Mackenzie and Ahabyona 2012). The intensity of crop damage was high; it was probably due to more nutritious food available in agricultural land or perhaps due to an increase in the number of prey species in the PA. The increased prey species moved towards settlements or agricultural land, which causes more crop raiding. In the last few decades, the number of wildlife increased after establishing a buffer zone area, which is consistent with other studies of different parts of Nepal (Bajrachrya et al. 2006, Pokheral and Shah 2008). The human-monkey conflicts and human herbivore conflicts are the most in this area and mid-hills and high mountains of Nepal (Srivastava and Begum 2005, Inskip and Zimmermann 2009, Aryal et al. 2010, Bista and Aryal 2013, Adhikari et al. 2018).

Wild Boar is a major crop raider, which damages all stages and types of crops. It was probably due to the test of crops which prefers by it (Mackin 1970) and its wide distribution in and around PAs (Sukumar 1994, Srivastava and Begum 2005, Inskip and Zimmermann 2009, Pandey et al. 2016). Paddy being the most affected crop, the greatest damage of the

paddy was because it is mainly produced, more palatable, and proteins than any other crops are grown in the study area. In this area, paddy was a highly damaged crop by the wild animals and accounted for nearly 70% of total economic loss in Jhapa, Chitwan, and Shuklaphanta (WWF 2007). Different studies have found that crop-raiding often occurs during the crop harvesting season (Warren et al. 2007). Surprisingly, Rhesus Monkey is not a major problematic animal than other animals like Wild Boar and Indian Crested Porcupine probably due to higher food availability for Rhesus Monkey inside the park or due to large carnivores, including Leopard in the area.

6. CONCLUSION AND RECOMMENDATIONS

Livestock depredations and crop raiding by wildlife in the study area seems severe because the frequency for attack is higher in these years, which adversely affects the livelihood of people. More livestock depredations occur during winter. So better to encourage people to use effective wildlife deterrent techniques to mitigate this risk. Specifically, it is recommended that people in this study area use lighting in and around corrals at night to reduce depredations, particularly in winter when livestock are most vulnerable. Further, consideration of alternate animal husbandry practices such as keeping mixed livestock (i.e., cattle, buffalo, and goat) in the same corral at night to decrease the vulnerability of smaller-bodied livestock is also recommended. Almost all respondents were suffered from wild animal's i.e. crop raider, so better to plant non-palatable crop for wildlife. Raise public awareness on the behavior of Leopard, Tiger and other wildlife and rescue technique in conflict prone areas in the buffer zone area.

7. REFERENCE

Acharya, K.P., Paudel, P.K., Neupane, P.R. and Köhl, M. 2016. Human-wildlife conflicts in Nepal: patterns of human fatalities and injuries caused by large mammals. PLOS ONE **11**(9): e0161717.

Adhikari, B., Odden, M, Adhikari, B., Panthi, S., Lopez-Bao, J.V. and Low, M. 2020. Livestock husbandary practices and herd composition influence leopard-human conflict in Pokhara Valley, Nepal. Human Dimensions of Wildlife **25**(1): 62-69.

Adhikari, J.N., Bhattarai, B.P. and Thapa, T.B. 2018. Human Wild mammal conflict in a Human dominated Midhill Landscape: A case study from Panchase area in Chitwan Annupurna Landscape Nepal. Journal of Institute of Science and Technology **23**: 30-38.

Adhikari, K. 2000. An Assessment on Crop Damage by Wild Animals in the Eastren Part of Koshi Tappu Wildlife Reserve, Nepal. M.Sc. Thesis. Central Department of Zoology, Tribhuvan University, Kirtipur, Kathmandu, Nepal.

Aryal, A. and Kreigenhofer, B. 2009. Summer diet composition of the leopard *Panthera pardus* (Carnivora: Felidae) in Nepal. Journal of Threatened Taxa **1**(11): 562-566.

Aryal, A., Sathyakumar, S. and Schwartz, C.C. 2010. Current status of brown bears in the Manasalu Conservation Area, Nepal. Ursus **21**:109-114.

Bajracharya, B.B., Furley, P.A. and Newton, A.C. 2006. Impacts of community-based conservation on local communities in the Annapurna Conservation Area, Nepal. Biodiversity and Conservation **15**: 2765-2786.

Baral, N. and Heinen, T.T. 2007. Resource use, Conservation attitudes, management intervention and park people relation in the Western Terai Landscape of Nepal. Journal of Environmental Conservation **34**: 64-72.

Basnet, K. 1998. Biodiversity Inventory of Shey-Phoksundo National Park: Wildlife Component. WWF Nepal Program Kathmandu, Nepal. 49p.

Bayani, A., Tiwade, D., Dongre, A., Dongre, A.P., Pathak, R. and Watve, M. 2016. Assessment of Crop Damage by protected Wild Mammalian Herbivores on the Western Boundary of Tadpba-Andhari Tiger Reserve (TATR), Central India. PLOS ONE **11**(4): e0153854.

Bhattarai, B.R., Wright, W. and Khatiwada, A.P. 2016. Illegal hunting of prey species in the northern section of 373 Bardia National Park, Nepal; implication for carnivore conservation. Environment **3**(4): 32.

Bhattrai, B.P. and Basnet, K. 2004. Assessment of Crop Damage by Wild Ungulates in the Eastren Side of Barandabhar Corridor Forest, Chitwan, Nepal. March 23-26, 2004, RONAST Fourth National Conference on Science and Technology, Lalitpur, Nepal.

Bhattrai, B.R. and Fisher, K. 2014. Human-tiger (*Panthera tigris*) conflict and its perception in Bardia National Park. Oryx **48:** 522-528.

Bhuju, U.R., Shakya, P.R. and Basnet, T.B. 2007. Nepal Biodiversity Resource Book. Protected areas, Ramsar sites, and World Heritage Site.

Bista, R. and Aryal, A. 2013. Status of the Asiatic black bear *Ursus thibetanus* in the southeastern region of the Annapurna conservation area, Nepal. Zoology and Ecology **23**: 83-87.

Brashares, J.S., Abrahams, B., Florella, K.J., Golden, C., Hojnowski, C.D. and Marsh, R.A. 2014. Wildlife decline and social conflict. Science **345** (6195): 376-378.

Brown, K. 1997. Plain tales from grassland; extraction value and utilization of biomass in Royal Bardia National Park, Nepal. Journal of Biodiversity and Conservation **6**:58-74.

Burnham, K.P. and Anderson, D.R. 2002. Model selection and Multi model Inference: A Practical Information- Theoretical Approach, 2nd edn. Springer, Berlin.

CBS. 2011. National Population and Household Census. National report submitted to Government of Nepal. National planning Commission Secretariat. Central Bureau of Statistics. Government of Nepal, Kathmandu, Nepal.

Ceballos, G. and Ehrlich, P.R. 2002. Mammal population losses and the extinction crisis. Science **296**: 904-907.

Ceballos, G., Ehrlich, P.R. and Dirzo, R. 2017. Biological annihilation via the ongoing sixth mass extinction signaled by vertebrate population losses and declines. Proceedings of the National Academy of Sciences **114**: 6089-6096.

Chalise, M.K. 1998. Study of Assamese Monkey in Makalu-Barun Conservation Area, Nepal. A Research Report Submitted to Conservation International, USA.

Choudhary, A. 2004. Human-elephant conflict in Northeast India. Human Dimensions of Wildlife **9**: 261-270.

Dangol, D.R. and Gurung, S.B. 1999. Ethnobotany of the Tharu tribe of Chitwan district, Nepal. International Journal of Pharmacognosy **29**: 203-209.

Daniels, R.J.R., Gadgil, M., Joshi, N.V. 1995. Impact of human experience on tropical humid forest in the Westren Ghats Uttara Kannada, South India. The Journal of Applied Ecology **32**: 866-874.

DFRS, 1999. Forest and Shrub Cover of Nepal 1994 (1989-1996). Department of Forest Research and Survey, Kathmandu, Nepal.

Dirzo, R., Young, H.S., Galetti, M., Ceballos, G., Isaac, N.J. and Collen, B. 2014. Defaunation in the Anthropocene. Science **345**: 401-406.

DNPWC, DFSC. 2018. Status of Tigers and prey in Nepal. Department of National Parks and Wildlife Conservation and Department of Forest Soli Conservation. Ministry of Forests and Environment, Kathmandu, Nepal.

Goodrich, J.M. 2010. Human-tiger conflict: a review and call for comprehensive plans. Journal of Integrative Zoology **5**: 300-312.

Graham, K., Beckerman, A.P. and Thirgood, S. 2005. Human-predator- prey conflicts: Ecological correlates prey losses and patterns of managements. Journal of Biological Conservation **122**: 159-171.

Gurung, B., Smith. J.L., McDougal, C., Karki, J.B. and Barlow, A. 2008. Factors associated with human- killings tigers in Chitwan National Park, Nepal. Journal of Biological Conservation **141**: 3069-3078.

Hegde, R. and Enters, T. 2000. Forest products and household economy: A case study from Mudumalai Wildlife Sanctuary, Southern India. Journal of Environmental Conservation **27**: 250-259.

Holmerna, T., Nyahongoa, J. and Røskafta, E. 2007. Livestock loss caused by predators outside the Serengeti National Park, Tanzania. Biological Conservation **135**: 534-542.

Inskip, C. and Zimmermann, A. 2009. Human-felid conflict: a review of patterns and priorities worldwide. Oryx **43**: 18-34.

IUCN. 2003. Guidelines for application of IUCN Red List criteria levels:version 3.0. IUCN, Gland, Switzerland, and Cambridge, United Kingdom.

Jędrzejewski, W., Schmidt, K., Theuerkauf, J., Jędrzejewska, B., Selva, N., Zub, K. and Szymura, L. 2002. Kill rates and predation by wolves on ungulate population in Bialowieza Primeval Forest (Poland). Ecology **83**:1341-1356.

Jnawali, S.R. 2002. Final Report Habitat Restoration in Bardia National Park, Scaling up Effort to conserve the Wild Tiger Population in and around Nepal's Bardia National Park.

Jnawali, S.R., Baral, H.S., Lee, S., Acharya, K.P., Upadhyay, G.P., Pandey, M., Shrestha, R., joshi, D., Lamichhane, B.R. and Griffiths, J. 2011. The Status of Nepal's Mammals: The National Red List Series-IUCN. Department of National Parks and Wildlife Conservation, Kathmandu, Nepal.

Johansson, O., Mccarthy, T., Samelius, G., Andren, H., Tumursukh, L. and Mishra, C. 2015. Snow leopard predation in a livestock dominated landscape in Mongolia. Biological Conservation **184**: 251-258.

Kabir, M., Ghoddousi, A., Awan, M.S. and Awan, M.N. 2014. Assessment of human-leopard conflict in Machiara National Park, Azad Jammu and Kashmir, Pakistan. European Journal of Wildlife Research **60**: 291-296.

Karanth, K.K. and Nepal, S.K. 2012. Local Residents Perception of Benefits and Losses from Protected Areas in India and Nepal. Environmental Management **49**: 372-386.

Karanth, K.K., Curran, L.M. and Reuning-Scherer, J.D. 2006. Village size and forest disturbances in Bhadra Wildlife Sanctuary, Western Ghats India. Journal of Biological Conservation **128**: 147-157.

Khadka, D. and Nepal, S.K. 2010. Local responses to participatory conservation in Annapurna Conservation Area, Nepal. Environment Management **45**: 351-362.

Khan, M.Z., Khan, B., Awan, M.S. and Begum, F. 2018. Livestock depredation by large predators and its implications for conservation and livelihoods in the Karakoram Mountains of Pakistan. Oryx **52**: 519-525.

Kharel, F.R. 1997. Agriculture crop and Livestock Depredation by Wildlife in Langtang National Park, Nepal. Mountain Research and Development **17**(2): 127-134.

Khorozyan, I., Ghoddousi, A., Soofi, M. and Waltert, M. 2015. Big cats kill more livestock wild prey reaches a minimum threshold. Biological Conservation **192**: 268-275.

Kideghesho, J.R., Roskaft, E. and Kaltenborn, B.P. 2007. Factors Influencing conservation attitudes of local people in Western Serengeti, Tanzania. Biodiversity Conservation **16**: 2213-2230.

Kissui, B.M. 2008. Livestock predation by lions, leopards, spotted hyenas, and their vulnerability to retaliatory in the Maasai Steppe, Tanzania. Animal Conservation **11**: 422-432.

Koirala, R.K., Aryal, A., Parajuli, A. and Raubenheimer, D. 2012. Human-Common leopard conflict in lower belt of Annapurna Conservation Area, Nepal. Journal of Research in Conservation Biology **1**: 005-012.

Kolowski, J.M. and Holekamp, K.E. 2006. Spatial, temporal, and physical characteristics of livestock depredations by large carnivores along a Kenyan reserve border. Biological Conservation **128**: 529-541.

Krebs, C.J. 2014. Ecological Methodology, 2nd ed. University of British Columbia, Canada.

Lakhar, B.P., Das, J.P., Nath, N.K., Dey, S., Brahma, N. and Sarma, P.K. 2007. A study of Habitat Utilization Patterns of Asian Elephant (*Elephas maximus*) and Current Status of Human Elephant Conflict in Manas National Park within Chirang-Ripu Elephant Reserve, Assam. A technical report prepared by Aaranyak, Guwahati, India.

Lamichhane, B.R., Persoon, G.A., Leirs, H., Poudel, S., Subedi, N., Pokheral, C.P., Bhattarai, S., Thapaliya, B.P. and De Iongh, H.H. 2018. Spatio-temporal patterns of attacks on human and economic losses from wildlife in Chitwan National Park, Nepal. PLOS ONE **13**: p.e0195373.

Laundre, J.W. 2008. Summer predation rated on ungulate prey by a large key stone predator: how many ungulates does a large predator kill? Journal of Zoology **275**: 341-348.

Limbu, K.P and Karki, T.B. 2003. Park-people Conflict in Koshi-Tappu Wildlife Reserve. Our Nature **1:** 15-18.

Mackenzie, C.A. and Ahabyona, P. 2012. Elephants in the garden: Financial and Social costs of crop raiding. Ecological Economics **75:** 72-82.

Mackin, R. 1970. Dynamics of damage caused by wild boar to different agricultural crops. Acta Theriologica **15**(27): 447-458.

McDougal, C. 1987. The man- eating tiger in geographical and historical perspective, In: Tigers of the world: The Biology, Biopolitices, Management and Conservation of an Endangered Species 435-438.

Miquelle, D., Nikolaev, I., Goodrich, J., Litvinov, B. and Smirnov, E. 2005. Searching for the coexistence recipe: a case study of conflicts between people and tigers in the Russian Far East 305-322.

Mishra, H.R. 1982. Balanching human needs and conservation in Nepal's Chitwan National Park. Ambio **11**: 246-251.

Murphy, K.M. 1998. The ecology of the cougar (*Puma concolor*) in the northern Yellowstone Ecosystem: interactions with prey, bears, and humans. PhD Dissertation, University of Idaho, Moscow, USA.

Naha, D., Chaudhary, P., Sonker, G. and Sathyakumar, S, 2020. Effectiveness of non-lethal predator deterrents to reduce livestock losses to leopard attacks within a multiple-use landscape of the Himalayan region, PeerJ 8: e9544.

Namgail, T., Fox, J.L. and Bhatnagar, Y.V. 2007. Carnivore-Caused Livestock Mortality in Trans-Himalaya. Environment Management **39**: 490-496.

Nepal, S.K and Weber, K.E. 1993. Struggle for existence; park people conflict in the Royal Chitwan National Park, Nepal. In: HSD monograph 28. Division of human settlement development. Journal of Asian Institute of Technology, Bangkok Thailand.

NTNC. 2019. Annual Report, Fiscal Year 2018/019. National Trust for Nature Conservation, Bardia Conservation Program, Bardia, Nepal.

Nyphus, P.J. and Tilson, R. 2004. Characterizing human tiger conflict in Sumatra, Indonesia. Oryx **38**: 68-74.

Odden, J., Smith, M.E., Aanes, R. and Swenson, J.E. 1999. Large carnivores that kill livestock; do "problem individuals" really exist? Wildlife Society Bulletin (1973-2006) **27**(3): 689-705.

Ogra, M and Badola, R. 2008. Compensating human-wildlife conflict in protected area Communities: ground-level perspectives from Uttarakhanda, India. Journal of Human Ecology **36**: 717-729.

Ogutu, J.O., Reid, R.S., Piepho, H.P., Hobbs, N.T., Rainy, M.E., Kruska, R.L., J.S. and Nyabenge, M. 2014. Large herbivore response to surface water and land use in an East African Savanna: implications for conservation and human wildlife conflicts. Journal of Biodiversity and Conservation **23**: 573-596.

Ojha, D.P. 1983. History of land settlement in Nepal Tarai. Contributions to Nepalese Studies CANS, Tribhuvan University **11**: 21-44.

Orga, V.M. 2008. Human Wildlife Conflict and gender in protected area lands: A case study of costs, perceptions and vulnerabilities from Uttarakhanda (Uttaranchal), India. Journal of Geoforum **39**: 1408-1422.

Pandey, P., Shaner, P.J. and Sharma, H.P. 2016. The wild boar as a driver a human-wildlife conflict in the protected park lands of Nepal. European Journal of Wildlife Research **62**: 103-108.

Panta, G., Dhakal, M., Man, N., Pradhan, B., Leverington, F. and Hocking, M. 2015. Nature and extent of human-elephant conflict in Central Nepal. Oryx **50**: 724-731.

Peterson, M.N., Birckhead, J.L., Leong, k., Peterson. M.J. and Peterson, T.R. 2010. Rearticulating the myth of human-wildlife conflict. Journal of Conservation Letters **3**: 74-82.

Pokhrel, G.K. and Shah, K.B. 2008. Role of community forests in faunal diversity conservation: A case study of community forests with in Satbariya Range post Dang District, Nepal. Journal of Science and Technology **19**: 111-117.

Polisar, J., Maxit, I., Scognamillo, D., Farrell, L., Sunquist, M.E. and Eisenberge, J.F. 2003. Jaguras, Pumas, their prey base, and cattle ranching: ecological interpretation of a management problem. Biological Conservation **109**: 2978-310.

R Core Team. 2019. A Language and Environment for Statistical computing; R Foundation for Statistical Computing*:* Viena, Austria.

Rao, K.S., Maikhurai, R.K., Nautiyal, S. and Saxena, K.G. 2002. Crop damage and livestock depredation by wildlife: A case study from Nanda Devi Biosphere Reserve, India. Journal of Environmental Management **66**: 317-27.

Roser, M. and Ortiz-Ospina, E. 2017. World population growth. Retrieved from https://ourworldindata.org/world-population-growth/ [Access on 24 October 2019].

Ruda, A., Kolejka, J. and Silwal, T. 2020. Spatial concentration of wildlife attacks on humans in Chitwan National Park, Nepal. Animals **10**: 153.

Sangay, T. and Vernes, K. 2008. Human wildlife conflict in the kingdom of Bhutan: Patterns of livestock predation by large mammalian carnivores. Journal of Biological Conservation **4**: 1272–1282.

Sapkota, S., Aryal, A., Baral, S.R., Hayward, M.W. and Raubenheimer, D. 2014. Economic Analysis of Electric Fencing for Mitigating Human-wildlife Conflict in Nepal. Journal of Resources and Ecology **5**(3): 237–243.

Shrestha, B. 2004. Status, Distribution, Predator Impact, Crop Depredation and Mitigation Measures of Himalayan Tahr in Sagarmatha National Park. TRPAP/DNPWC, Kathmandu, Nepal.

Soh, Y.H., Carrasco, L.R., Miquelle, D.G., Jiang, J., Yang, J., Stokes, E.J., Tang, J., Kang, A., Liu, P. and Rao, M. 2014. Spatial correlates of livestock depredation by Amur tigers in Hunchun, China; relevance of prey density and implication for protected area management. Biological Conservation **169**: 117–127.

Soofi, M., Ghoddousi, A., Zeppenfeld, T., Shokri, S., Soufi, M., Egli, L., Jafari, A., Ahmadpour, M., Qashqaei, A., Ghadirian, T. and Filla, M. 2019. Assessing the relationship between illegal hunting of ungulates, wild prey occurrence and livestock depredation rate by large carnivores. Journal of Applied Ecology **56**: 365–374.

Srivastava, A. and Begum, F. 2005. City monkeys (*Macaca mulatta*): A study of human attitudes Commensalism and conflict; the human–primate interface. America Society of Primatologists, Norman 259-269.

Stdusrod, E and Wegge, P. 1995. Park people relationships, the case of damage caused by park animals around Royal Bardia National Park, Nepal. Environmental Conservation **22**:133-142.

Stein, A. B., Athreya, V., Gerngross, P., Balme, G., Henschel, P. and Karnath, U., Miquelle, D., Rostro-Garcia, S., Kamler, J.F. and Laguardia, A. 2020. *Panthera*

pardus ((amended version of 2019 assessment). The IUCN Red List of *Threatened Species.* Accessed on 7 June 2021.

Subedi, B.P., Das, C.L. and Messerschmidt, D.D. 1993. Tree and land tenure in the Eastern Terai, Nepal: a case study from the Siraha and Saptari districts, Nepal-Shallon D. ed. Community Forestry Case Study Series 09. Rome: Food and Agriculture Organization, Italy.

Sukumar, R. 1994. Wildlife-human conflict in India; an ecological and social perspective Oxford University press, New Delhi, India, Social Ecology, 303-317.

Thapa, K., Wikramanayake, E., Malla, S., Acharya, K.P., Lamichhane, B.R. and Subedi, N. 2017. Tigers in the Terai: Strong evidence for meta-population dynamics contributing to tiger recovery and conservation in the Terai Arc Landscape. PLOS ONE **12**: e0177548.

Thomas, C.D., Cameron, A., Green, R.E. and Bakkenes, M. 2004. Extinction risk from climate change. Nature **427**(6970): 145-148. ISSN 0028-0836

Upadhyaya, S.K., Musters, C.J.M., Lamichhane, B.R., De Snoo, G.R., Dhakal, M. and De Iongh, H.H. 2020. Dtermining the risk of predator attacks around protected area; the case of Bardia National Park, Nepal. Oryx **54**(5): 670-677.

Upreti, B. 1994. The park-people interface in Nepal: problems and new directions. In: Proceeding of international workshop on the management of National Parks and protected areas in the Hindu Kush-Himalaya. KMTNC and ICIMOD, Kathmandu, Nepal.

Van De Water, A. and Matteson, K. 2018. Human-elephant conflict in western Thailand: Socio-economic drivers and potential mitigation strategies. PLOS ONE **13**: e0194636.

Wang, S.W. and Macdonald, D.W. 2006. Livestock predation by carnivores in Jigmes Singye Wangchuck National Park, Bhutan. Biological Conservation **129**: 558–565.

Warren, Y., Buba, B. and Ross, C. 2007. Patterns of crop raiding by wild and domestic animals near Gashaka Gumti National Park, Nigeria. International Journal of pest Management **53**(3): 207-216.

Wegge, P., Odden, M., Pokharel, C.P. and Storaas, T. 2009. Predator–prey relationships and responses of ungulates and their predators to the establishment of protected

areas: a case study of tigers, leopards and their prey in Bardia National Park, Nepal. Biological Conservation **142**(1): 189-202.

White, P.C and Ward, A.I. 2011. Interdisciplinary approaches for the management of existing and emerging human-Wildlife conflict. Journal of Wildlife Research **37**: 623-629.

Woodroffe, R. and Ginsberg, J.R. 1998. Edge effects and the extinction of populations inside protected areas. Science **280**: 2126-2128.

WWF. 2007. A case study on Human-Wildlife conflict in Nepal (with particular reference to human-elephant in Eastren and Westren Terai regions), World Wildlife Fund, Kathamandu, Nepal. 47-48.

Young, H.S., McCauley, D.J., Galetti, M. and Dirzo, R. 2016. Patterns, causes, and consequences of anthropocene defaunation. Annual Review of Ecology, Evolution, and Systematics **47**: 333-358.

Photo plates from Field Site




QUESTIONNAIRE

Questionnaire survey for household

Date:

Name of the respondent……Village Council

Ward no:……. Age…… Gender: M/F Education:…….Family Size……

Occupation……Religion……

1) How much land do you have?

Kathha…….Bigaha…….

2) What are the major crops that you are cultivating, during last time and their production?

Production amounts	Paddy	Wheat	Maize	Potato	Pulses	Other
Kg						

3) Could you please tell the name of wild animals which you have seen in these areas?.....

4) Which wildlife animals are creating problem to you?

a……b…….c…… ……d …….e……..

5) What types of problem are these animals creating?

a) Crop damage……b) Livestock depredation……

c) Human causalities……...d) other…….....

6) Amount (Kg) of crop damaged by wild animals

Animals	Paddy	Wheat	Maize	Potato	Pulses	Other

6) When they usually visit in the field?

At night…. At day time…… Any time…...

7) How often they come?

Every night/day…….. Every week…….

Per month……. Occasionally……

8) How many livestock do you have?

livestock	Cow/ox	Buffalo	Goat	Pig	Chicken	Other
Number						

9) Number of livestock depredation by wild animals in the last 5 year

Wild animals	Cow/ox	Buffalo	Goat	Pig	Chicken	Other

10) When they usually visit in the field?

At night…. At day time…… Any time…...

11) How often they come?

Every night/day…….. Every week…….

Per month……. Occasionally……

12) Did you injure by wild animals? No…… If yes which animals?

13) Did your any family members injure or killed by wild animals? If yes please write name….

14) If incidence happened when?

At night…. At day time…… Any time…...

15) How often they come?

Every night/day…….. Every week…….

Per month……. Occasionally……

16) What are the precautions measures that you are adopting to minimize wildlife damage?

Shouting……. Beating…….. Firing…….Lighting…….

17) Do you get any support from Park?

Yes….. No……

18) If yes, what are these…….

Ares you satisfied from support? Yes…. No……..

Is wildlife damage increasing? Y/N

Which animals do you like most? ……..Why?.....

19) Do you have any suggestion to minimize the loss from wildlife??

……..

20) What type of materials are you collecting from Park?

…….

21) Is it allowed to collect these resources? Y/N If it is allowed do you have to pay? Y/N What is the quantity ?

22) Do you agree on these Park's rule for resource collection? Yes /no, if No what are they?