Human-Tiger (*Panthera tigris tigris*) Conflict in Chitwan National Park, Nepal

Rajendra Dhungana

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science in Ecology (International Program)

Prince of Songkla University

2016

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I hereby certify that this work has not been accepted in substance for any degree, and is not being currently submitted in candidature for any degree.

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ABSTRACT

Human-tiger conflict is one of the most prominent issues of tiger conservation worldwide. This study was conducted to examine spatiotemporal patterns, correlates, causes and context of human-tiger conflict as well as adopted mitigation measures in Chitwan National Park and its buffer zone for the period 2007-2014. The data mainly collected from the park office were triangulated by conducting semi-structured questionnaire surveys (n=83) and key informant interviews (n=13). Tigers resulted in 54 human casualties (32 killings, 22 injuries) and 351 livestock depredations. Over three-quarters (75.9%) of human casualties occurred in the buffer zone, and two-third within one kilometer from the park boundary. Both the killings of human (7.38±7.37 persons per year in 1999-2006 to 4.0±3.25 in 2007-2014) and livestock (60.25±19.31 heads per year in 2007-2010 to 27.5±8.35 in 2011-2014) dropped significantly. Goats were the predominantly (55%) killed livestock. The scale of livestock depredations was significantly positively correlated with the length of national park frontage. Wild prey density was not identified as an underlying cause driving conflicts. Examination of tigers removed for conflict-reasons indicated that males (73.3%) were mainly responsible for conflicts. Most human casualties occurred during fodder/fuelwood collection (53.7%), especially in the forests of buffer zone (48.2%). A total compensation payment of US$ 93,618 ($ 11,702.3 per year) was made for human killings (65%), livestock depredations (29.3%) and human injuries (5.7%). The payments ranged from $ 2000 in 2007 to $ 21,536 in 2014 making a jump of 976%. A total of 15 tigers were removed from the wild for conflict-reasons; 11 by authorities and four retaliatory killed by people. At least 80% of the removed tigers were killed, or died after removal, despite the most (60%) being healthy.

ACKNOWLEDGEMENTS

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CONTENTS

Abstract………………………………………………….……………….……..….……v

Acknowledgements……………………………………....………….………...vi-vii

Contents……………………………………………….……………….….…...viii-ix

List of Figures...x

List of Tables…….……………………………………...………...…………….…..x

Abbreviation……………………………………………………………....………..xi

Chapter 1: Introduction …………………………...………………….……...……...…1

1.1 Objectives………………..…………………………………….....………...3

Chapter 2: Literature review……………………………………………….…...….....…4

Chapter 3: Methods…………………………….…………………………..…..………9

3.1 Study site…………………………………………………………......…....9

3.2 Spatiotemporal patterns of conflict and mapping…………….………..……12

3.3 Correlates of conflict…………………………………………......………..14

3.4 Causes and context of conflict…………………………………….....….15

3.5 Adopted mitigation measures…………………………………......……15

Chapter 4: Results…………………………………….…..………………….…...…..17

4.1 Extent and nature of conflict…………………………..…....………....17

4.2 Spatial patterns of conflict and mapping……………………….……...…..17

4.3 Temporal patterns of conflict……………………………....…..……19

4.4 Correlates of conflict…………………………………..……………..20

4.5 Causes and context of conflict ……………………………….…...…….20

4.6 Compensation payments for conflict ……………………………..…….21

4.7 Removal of conflict-involved tigers…………………….……..…......……..22

Chapter 5: Discussion……………………………………………………………24

Chapter 6: Conclusion and suggestions……………………....…..………...…....30

6.1 Conclusion………………………………………..………...……..30

6.2 Suggestions……...…………………………………..…..……...…….31

References…………………………………………………..…....……...…..........35

Appendices………………………………………………..…...…….….……40

Appendix 1: Format for questionnaire survey……….….……..…..……..40

Appendix 2: Format for key informant interview……..…………...…...…..42

Appendix 3: Photo plates……………………………………...………..43

Vitae……………………..………………………......…………………….…………45

LIST OF FIGURES

Figure 1: Map of Chitwan National Park and Buffer Zone showing land cover, management sectors, and VDCs/municipalities in Buffer Zone (BZ)…….10

Figure 2: Mean monthly temperature in Chitwan National Park during 2007-2014..11

Figure 3: Mean monthly rainfall in Chitwan National Park during 2007-2014……..11

Figure 4: Annual rainfall in Chitwan National Park during 2007-2014………........12

Figure 5: Location and extent of human killings and injuries, and livestock depredations by tigers in Chitwan National Park and Buffer Zone, 2007-2014………………………………………..………………………...18

Figure 6: Number of human casualties by tigers in and outside the boundary of Chitwan National park, 2007-2014…………………………………….…….19

Figure 7: Number of human casualties by tigers in Chitwan National Park and Buffer Zone by activity of victims, 2007-2014…………………………….....……21

LIST OF TABLES

Table 1: Year-wise details of human casualties and livestock depredations by tigers in Chitwan National Park and Buffer Zone, 2007-2014………...……….……17

Table 2: Year-wise details of compensation payments and claims for tiger attacks in Chitwan National Park and Buffer Zone during 2007-2014……………..…22

ABBREVIATION

AIC	Akaike information criterion
BZMC	Buffer Zone Management Committee
CBAPU	Community Based Anti Poaching Unit
CBS	Central Bureau of Statistics, Nepal
CNP	Chitwan National Park, Nepal
DNPWC	Department of National Parks and Wildlife Conservation, Nepal
GIS	Geographical Information System
GLM	Generalized Linear Model
GoN	Government of Nepal
HTC	Human-Tiger Conflict
INGO	International Non-Governmental Organization
KMUTT	King Mongkut's University of Technology, Thailand
MoFSC	Ministry of Forests and Soil Conservation, Nepal
NGO	Non-Governmental Organization
NPR	Nepalese Rupees
PSU	Prince of Songkla University, Thailand
SD	Standard Deviation
TICA	Thailand International Development Cooperation Agency
UNESCO	United Nations Educational, Scientific and Cultural Organization
VDC	Village Development Committee

CHAPTER 1

INTRODUCTION

Nepal is sandwiched between India and China occupying an area of 147,181 sq. km, with nearly a quarter (23.3%) of the country comprised of network of protected areas. Nepal is disproportionately rich in biodiversity relative to its size and draws flora and fauna from two realms namely, Palearctic and Indomalayan. Chitwan National Park (CNP), established in 1973 as the first protected area of the country and a UNESCO world heritage site, is considered to be a global biodiversity hotspot representing one of the last surviving examples of natural ecosystems of the Terai region that provides critical habitat for several globally endangered species including Royal Bengal Tiger (*Panthera tigris tigris*) (DNPWC/MoFSC/GoN, 2013). Despite four-decades of investments and experiences in park management, CNP continues to witness the conservation threats arising from several causes including human-wildlife conflict. Fortunately, since late 1990s, with the introduction of participatory model of conservation (buffer zone program) and proactive park management efforts, a few species such as tigers are reported to exhibit population increment trend in recent years. CNP harbors the largest tiger population (120) of Nepal but still struggles with the problems of conflict with humans, poaching for illegal trade, habitat deterioration affecting prey abundance, and limited connectivity to adjoining landscapes (Dhakal et al., 2014; DNPWC/MoFSC/GoN, 2013; Karki et al., 2015). Human-tiger conflict (HTC) has been identified as one of the most prominent continuing threats affecting not only the survival and viability of tigers (Dhakal et al., 2014; Gurung et al., 2008) but also the well-being of local communities living around. HTC might lead to retaliatory killings by local communities, lethal control or removal from the wild by authorities, and eroded public support in tiger conservation (Goodrich, 2010; Graham et al., 2005). These impacts of conflict are likely to derail Nepal in achieving the international commitment of doubling tiger population by 2022 if adequate efforts are not made (Dhakal et al., 2014).

To cope up with the issues, Nepal implemented Compensation Scheme (1998), Tiger Conservation Action Plan (2008-2012), National Tiger Recovery Program (2010-2022), Tiger Conservation Special Program 2011, and institutionalized multi-sector cooperation in conservation (Dhakal et al., 2014; DNPWC/MoFSC/GoN, 2013; Karki et al., 2015; Thapa, 2011). While these initiatives are reported to be successful in increasing tiger numbers, the investigation on HTC is scanty with its scenario known poorly. The challenge ahead is to maintain momentum of tiger increment while mitigating conflict (Dhakal et al., 2014). Management Plan of Chitwan National Park and Buffer Zone (2013-2017) and other policy documents have underscored the need for detailed assessment of conflict as a prerequisite for effective conflict mitigation efforts. Previous HTC studies in CNP (Carter et al., 2012; Carter et al., 2014; Gurung et al., 2008; McDougal et al., 2005) mainly focused on attitudes, coexistence mechanisms, human-killing patterns, and few associated factors. However, as conflict scenarios are dynamic, complex and deep-seated, their broader understanding is crucial to propose viable and effective site-specific interventions that would adequately address conflict in the long-term (Goodrich, 2010; Inskip and Zimmermann, 2009). Thus, in this particular study, I investigated spatiotemporal patterns both of human casualties and livestock depredations along with socio-ecological and meteorological correlates, underlying causes and context, and adopted conflict mitigation measures as well. The investigated correlates include: the human population, the livestock population, forest area in Village Development Committee (VDC)/municipality in the buffer zone, national park frontage (defined as the length of VDC/municipality boundary abutting CNP), rainfall, and temperature. Similarly, causes and context were examined in terms of wild prey availability, characteristics of tigers involved in conflicts, human/tiger behavior during attack, human victim's activity, and attack site. The adopted conflict mitigation measures in CNP mainly include compensation payments and tiger removals. The study was based on HTC incidents occurred in CNP and its buffer zone during the period of 2007-2014.

1.1 Objectives

The aim of this study was to explore human-tiger conflict in Chitwan National Park and buffer zone so as to help minimizing conflicts and formulating long-term conservation strategies and conflict management plans.

The **specific objectives** were:

i) To characterize spatiotemporal patterns of human-tiger conflict
ii) To examine correlates of human-tiger conflict
iii) To examine causes and context of human-tiger conflict
iv) To summarize the mitigation measures adopted to reduce human-tiger conflict

CHAPTER 2

LITERATURE REVIEW

Human-wildlife conflicts appear as crop damage, property damage, livestock depredation, and human casualties (Ogra and Badola, 2008). Conflicts have been reported from across the globe for a wide range of wildlife especially mammalian carnivores such as snow leopard (*Uncia uncia),* leopard (*Panthera pardus),* Himalayan black bear (*Ursus thibetanus),* tiger, and lion (*Panthera leo*) in Asia (Gurung et al., 2008; Oli et. al., 1994; Saberwal et al., 1994; Sangay and Vernes, 2008), Jaguar (*Panthera onca)* and puma (*Puma concolor)* in south America (Polisar et al., 2003), lion, cheetah (*Acinonyx jubatus*), leopard and spotted hyena (*Crocuta crocuta)* in Africa (Kolowski and Holekamp, 2006; Patterson et al., 2004), wolf (*Canis lupus)* in North America (Musiani et al., 2003), and dingo (*Canis lupus dingo)* in Australia (Allen and Sparkes, 2001). The conflict becomes critical when the species involved is endangered while it gets involved in conflict affecting human welfare (Saberwal et al., 1994).

Tigers, once widely distributed across Asia remain only in the scattered habitats which are now reduced to less than 7% of historical (Dinerstein et al., 2006). Main threats to the survival of tigers are: habitat loss and degradation, prey depletion, poaching, greater isolation and conflict with humans (Dhakal et al., 2014; Dinerstein et al., 2006; Goodrich et al., 2011; Miquelle et al., 2005). HTC, primarily arising from real or perceived threat of tigers to human and livestock, is prevalent in almost all across the tiger's distribution range (Goodrich et al., 2011). But, its intensity has been reported to be higher in south Asia where human population surrounding tiger habitats is high (Barlow, 2009; Sethy, 2013) and so is considered the tiger density (Barlow, 2009; Karanth, 2003). Although tiger's prey ranges in size from frog to adult gaur (*Bos gaurus*), the bulk of their diet comes from pigs, deer, and wild or domestic cattle weighing 20-1000 kg (Karanth, 2003). Livestock are reported to contribute up to 10-12% of tiger's diet (Bagchi et al., 2003) while incurring a loss of as much as 12% of livestock holding and 17% of annual household income

(Madhusudan, 2003; Wang and MacDonald, 2006). Tigers have been reported to kill human ranging in number of less than one per year in Russian Far East to dozens in the Sundarbans of Bangladesh and India (Barlow, 2009). Human killings coupled with human injuries and livestock depredations have lead to animosity from neighboring communities creating an ongoing challenge to managers in getting public support for tiger conservation.

In Nepal, tiger populations are fragmented and distributed mainly in five protected areas - Parsa Wildlife Reserve, Chitwan National Park, Banke National Park, Bardia National Park and Shuklaphanta Wildlife Reserve, with the total population of 198 (163-235) (Dhakal et al., 2014). All these protected areas are surrounded by dense populations of human who depend highly on forest resources for farming and livestock husbandry. Chitwan National Park harbors the largest and increasing tiger population of Nepal (Dhakal et al., 2014). However, HTC exists as one of the most evident factors likely to determine their viability and survival in future (Gurung et al., 2008; Dhakal et al., 2014). Gurung et al. (2008) reported the increasing trend of human killings from an average of 1.2 people per year prior to 1998 to 7.2 people per year in 1998-2006 in CNP and buffer zone. Minimization of conflicts and acquisition of public support in conservation requires recognition of attack patterns and associated key factors (Löe and and Röskaft, 2004).

The occupancy of tigers in Nepal is very high within protected areas and lower outside (Barber-Meyer et al., 2012). However, implementation of community forestry program in and outside the buffer zone since late 1990s has resulted in restoration of forests and favored the recovery of tigers outside the core protected areas (Gurung et al., 2008) with the facilitation of buffer zone forests which potentially function as dispersal corridors or even breeding habitats. This may have resulted in higher flow of tigers from the national park to such restored but less-occupied areas due to dispersal of young, old, injured and/or diseased tigers for failing to defend territories in intact habitat (Gurung et al., 2008; Karanth, 2003). Population increment in core protected areas along with the recovery of tigers in adjoining human-modified landscapes are likely to increase HTC unless effective mitigation measures are adopted (Goodrich, 2010; Nyhus and Tilson, 2004). As highest levels of conflict occur where tigers and people extensively overlap (Goodrich, 2010; Nyhus and Tilson, 2004; Sethy, 2013), the national park fringes, buffer zone, and areas outside the buffer zone may be highly vulnerable to tiger attacks.

The extent and intensity of human-carnivore conflict depends largely on wide array of socio-economical, ecological, landscape and meteorological factors (Graham et al., 2005; Inskip and Zimmermann, 2009). Though many of the studies fail to examine such conflict-related factors (Graham et al., 2005), livestock husbandry practice, people's attitude, education, economic status, human density and activity patterns, wild prey abundance, forest area, predator density, landscape matrix, proximity to predator habitats and water bodies, rainfall, and temperature are commonly referred to influence conflicts (Dar et al., 2009; Graham et al., 2005; Gubbi, 2012; Inskip and Zimmermann, 2009, Michalski et al., 2006, Sangay and Vernes, 2008). However, there exist wider geographical as well as intra-specific and inter-specific variations in influence of such factors on conflict rates (Inskip and Zimmermann, 2009). So far, the examined factors for HTC mainly include livestock management (Sangay and Vernes, 2008), attitude and wild prey abundance (Bhattarai and Fischer, 2014; Neumann-Denzau and Denzau, 2010), human activity and poaching attempts (Gurung et al., 2008; Miquelle et al., 2005; Neumann-Denzau and Denzau, 2010), forest cover and human density (Sangay and Vernes, 2008). Understanding associated factors of conflict is critical to devising conservation strategies so as to ensure long-term survival of tigers and well-being of local people living nearby to protected areas and forests (Goodrich, 2010; Graham et al., 2005).

Conflicts stem from several causes and occur in various contextual settings. Wild prey availability as well as physical status, age-class and reproductive stage of tigers are commonly held responsible for HTC (Gurung et al., 2008, Miquelle et al., 2005). Abundant population of big ungulates with the standing prey base of 400-500 is necessary to support a single tiger throughout a year (Karanth, 2003). Failure to fulfill dietary requirements from wild prey might switch the tigers towards livestock or even humans. Lower availability of wild prey is considered to result in higher conflict rates in many studies (Bhattarai and Fischer, 2014; Goodrich, 2010; Miquelle et al., 2005). However, the case may also be opposite, due to increased density of predators in response to an increase in prey densities (Stahl et al., 2002). The injuries caused as a result of intra-specific fights, retaliatory killing attempt and during chasing events by farmers might reduce the ability of tigers to catch wild prey (Graham et al., 2005; Gurung et al., 2008;). In Russian Far East, tiger injuries, arising from poaching attempts for illegal trade or with intention to kill tigers to avoid competition for ungulates, escalated tiger attacks on humans and livestock (Miquelle et al., 2005) in addition to the contribution of physical stress likely to be brought about by prevailing lower temperature (Goodrich et al., 2011). The injured, old, sub-adult or orphaned cubs which are likely to be displaced from intact habitats or fail to readily kill wild prey can kill humans and livestock upon opportunity. Besides these, records of human attacks during pirating attempts of tiger kills for meat, and from the tigress defending cubs are reported from Nepal (Gurung et al., 2008). Interestingly, more aggressiveness and human-killing behavior of Sundarbans tigers is often suspected to high water salinity (Barlow 2009; Löe and Röskaft, 2004; Neumann-Denzau and Denzau, 2010). In addition, human disturbances and accidental meetings during fuelwood/fodder collection, logging, fishing, herding have highly contributed to HTC in many areas (Gurung et al., 2008; Neumann-Denzau and Denzau, 2010). Identification and assessments of causes and context of conflict might help in avoiding tiger attacks and designing proper mitigation measures.

According to Global Tiger Recovery Program (GTRP) 2010-2022 endorsed in Tiger Summit 2010, Nepal including 13 tigers range countries are required to double tiger populations by 2022. The Chitwan population occupies the largest tiger habitat of Nepal, and obviously has a major role to contribute in attaining the national goal (Dhakal et al., 2014). Despite recent reports of tiger increments in CNP, impacts of HTC are however inevitable to achieve the goal. The possible impacts can be minimized by adoption of HTC mitigation measures. Various measures have been put into effect worldwide to mitigate HTC that include zoning, relocation of people, compensation payments, insurance schemes, tiger removal, radio-monitoring of potentially risky tigers, and livestock husbandry improvement (Goodrich, 2010; Miquelle et al., 2005). CNP has implemented 3R (rescue, relief and reduce) strategies including compensation payments to human casualties and livestock depredations, and removal of conflict-related tigers as the ways to address conflict issues. However, their proper assessment and documentation are lacking (DNPWC/MoFSC/GoN, 2013). Such assessments will be helpful in revising existing measures, examining their effectiveness, and also in taking proper decision regarding tiger removal and their subsequent management.

CHAPTER 3

METHODS

3.1 Study site

The study was conducted in Chitwan National Park, and its buffer zone which includes whole or part of 34 Village Development Committees (VDCs) and two municipalities (Fig. 1).

CNP is the first protected area of the country and is situated in southern part of central Nepal on the Nepal-India border occupying an area of 932 sq. km. The geographical coordinates of the national park is between N 27°20'19" to 27°43'16" longitude and E 83°44'50" to 84°45'03" latitude, and of buffer zone is between N 27°28'23" and 27°70'38" longitude and E 83°83'98" and 84°77'38" latitude (DNPWC/MoFSC/GoN, 2013). The park is dominated by sal (*Shorea robusta*) forests (73%), followed by riverine forests (7%), grassland (12%), exposed surface (5%) and water bodies (3%) (Thapa, 2011). CNP complex including Parsa wildlife reserve and Valmiki tiger reserve (India) forms one of the Priority Tiger Conservation Landscapes of the Indian subcontinent.

In 1996, an area of 750 sq. km around the park was declared as the buffer zone extending over four districts namely, Chitwan, Nawalparasi, Makwanpur, and Parsa. The buffer zone has a human population of 260,352 in 45,616 households and livestock population of 150,000 (DNPWC/MoFSC/GoN, 2013). Majority of the people depend highly on forest resources for farming and livestock rearing. Mainly reared livestock species include goat, cattle, buffalo, sheep and pig. The buffer zone has been divided into 21 user committees and one sub-user committee as management units, which together form one Buffer Zone Management Committee as an apex body. These committees are instrumental to involve people in conservation and in mobilization of funds. There exists provision of channeling back 50% of the park's revenue directly to the buffer zone communities for implementation of conservation and community development programs. The climate is humid subtropical and seasonal (winter, summer and monsoon) with mean annual temperature of 8°C to 37°C, and average rainfall reaching 2600 mm annually (DNPWC/MoFSC/GoN, 2013; Fig.2, Fig.3, Fig.4).

The major wild prey species present include chital (*Axis axis*), sambar (*Rusa unicolor*), wild boar (*Sus scrofa*), hog deer (*Heylaphus porcinus*), and barking deer (*Muntiacus muntjak*) (Dhakal et al., 2014). The carnivore species present include tiger, leopard (*Panthera pardus*), jungle cat (*Felis chaus*), fishing cat (*Prionailurus viverrinus*), toddy cat (*Paradoxurus hermaphrodites*), wild dog (*Cuon alpines*), and jackal (*Canis aureus*) (Karki et al., 2015). Tiger density was 3.84 per 100 sq. km and that of wild prey population estimated at 73.63 animals per sq. km in 2013 (Dhakal et al., 2014).

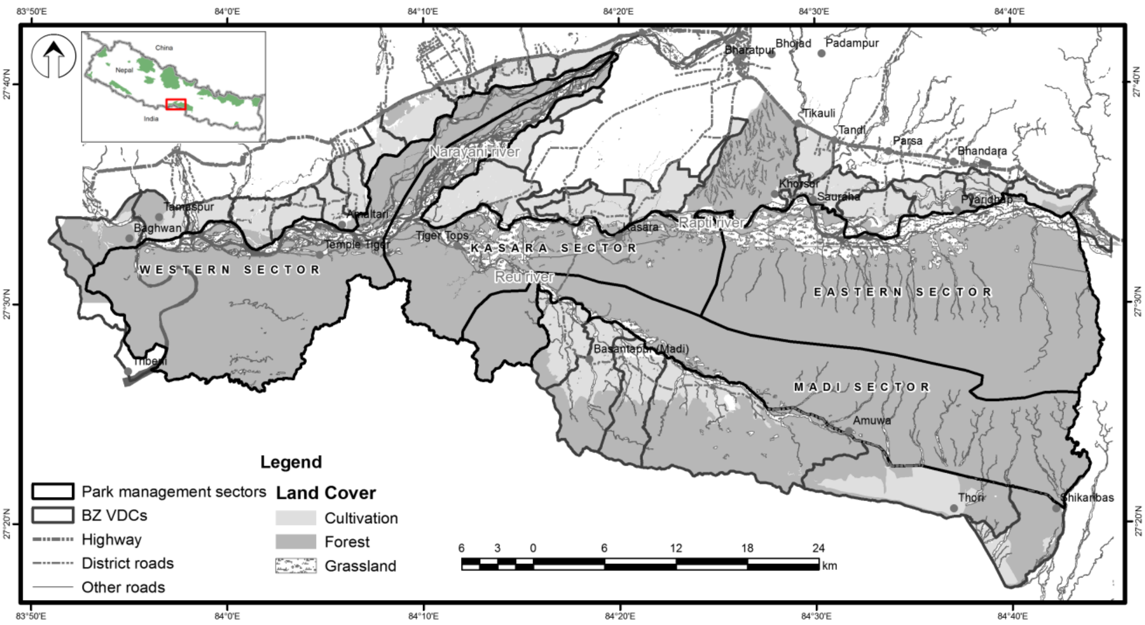

Figure 1: Map of Chitwan National Park and Buffer Zone showing land cover, management sectors, and VDCs/municipalities in Buffer Zone (BZ)

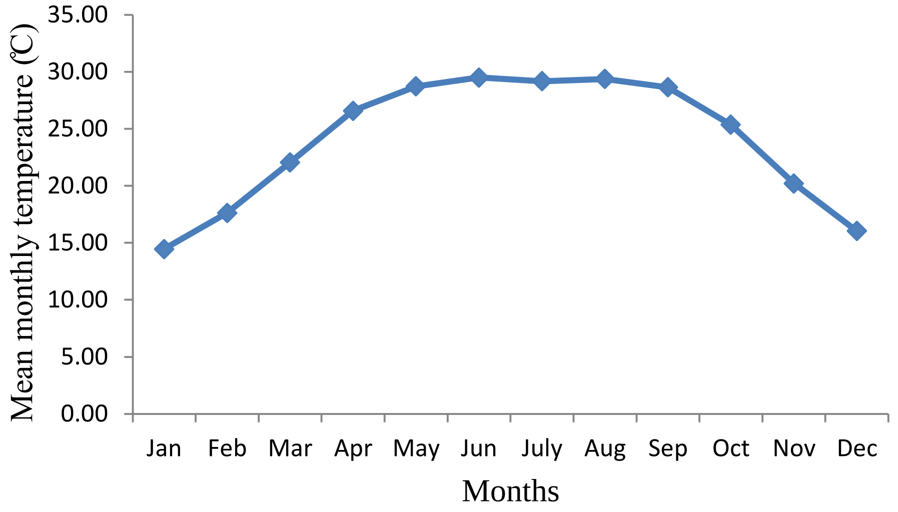

Figure 2: Mean monthly temperature in Chitwan National Park during 2007-2014
(Data reference: Rampur Meteorological Station)

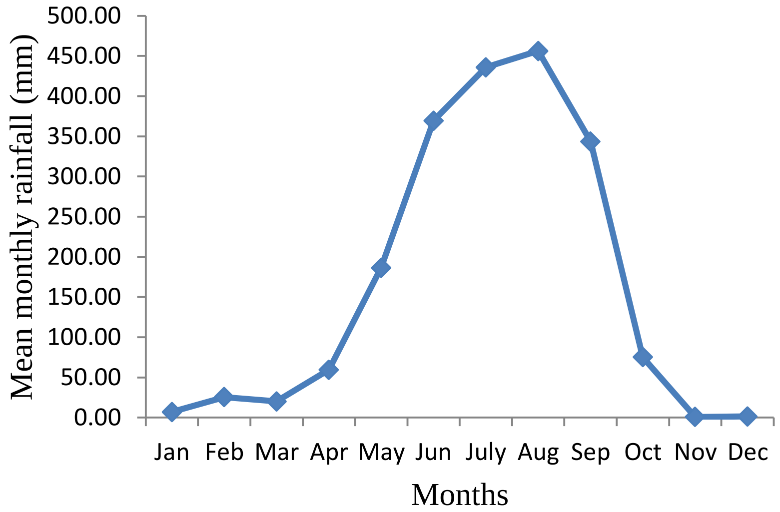

Figure 3: Mean monthly rainfall in Chitwan National Park during 2007-2014
(Data reference: Rampur Meteorological Station)

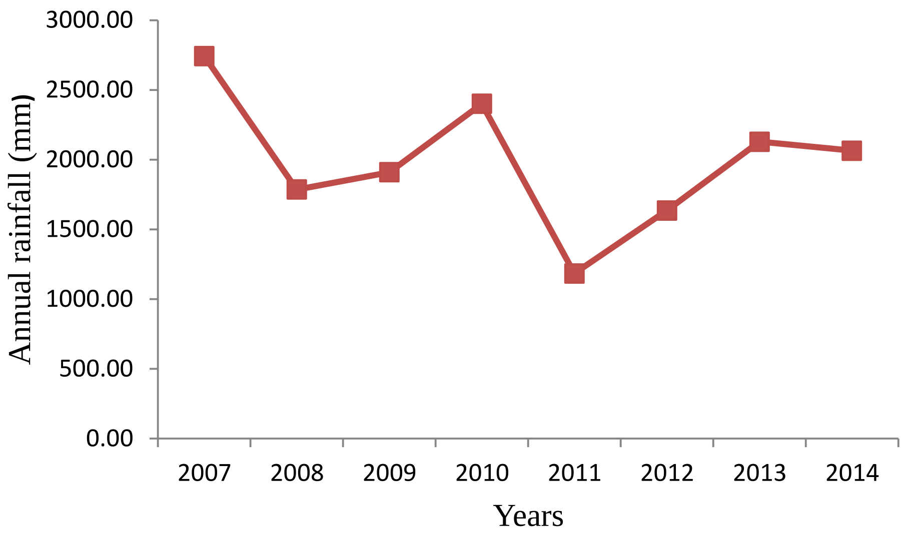

Figure 4: Annual rainfall in Chitwan National Park during 2007-2014
(Data reference: Rampur Meteorological Station)

3.2 Spatiotemporal patterns of conflict and mapping

The data on human casualties and livestock depredations for the period 2007-2014 were mainly collected from the CNP office initially recorded on the basis of compensation applications (Gubbi, 2012; Sangay and Vernes, 2008). Further, additional omitted data (compensation unclaimed) on human casualties were collected from anecdotal records and reports of CNP Range Offices. The human casualty data include: type (killed or injured), date and location (national park or buffer zone, VDC/municipality of buffer zone). GPS locations of each human casualty site were recorded using hand-held GPS units in accompany of attack-familiar person. The human killing data for 1999-2006 were obtained from Gurung et al. (2008). The livestock depredation data include: livestock type (goat, cattle, buffalo, sheep or pig), and date and location of attack (VDC/municipality of buffer zone).

Additionally, human casualty data were triangulated and augmented by conducting questionnaire survey (n=54) with victim, victim's family member, or other attack-familiar person. For livestock depredations, 10% of owners losing livestock to tigers were randomly sampled and surveyed (n=29). Consistency of depredation information obtained from this sample survey to their corresponding CNP records enhanced confidence to use remaining CNP data on livestock depredations without further surveys. A semi-structured questionnaire was used for conducting questionnaire surveys (Appendix 1).

Wildlife Damage Relief Support Guidelines (2009) have outlined clear methodologies involving the mechanism of multiple checks to avoid false claims and exaggerations while verifying attacks and making compensation claims. Victims immediately report an attack including date, place, number and type of livestock, and species involved. Field investigators as soon as possible diagnose wildlife species involved in an attack (including tiger or leopard) by examining circumstances surrounding the kill such as indirect evidence including marks on carcasses, pug marks (size, shape, carcass dragging) and scats, if available (size, appearance, shape), as well as occasional direct observations near the site (Thapa, 2011).

Chi-square goodness-of-fit test was applied to examine if: (i) human casualties were equally distributed between national park and buffer zone, (ii) VDCs/municipalities suffered livestock depredations in proportion to their relative availabilities, (iii) human or livestock attacks were equally distributed among years, seasons (summer 16 February-15 June, monsoon 16 June-15 October, and winter 16 October-15 February) or months, (iv) human or livestock attacks varied between 2007-2010 and 2011-2014, and (v) human killings varied between 2007-2014 and 1999-2006 (from Gurung et al. 2008). The livestock availabilities of each VDCs/municipalities in buffer zone were calculated from the livestock densities of corresponding districts computed from census of 2011/12 (CBS, 2013). Similarly, Chi-square test was used to examine if cattle, buffalo, goat, sheep and pig suffered losses in proportion to their relative availabilities. Bonferroni confidence interval method was used to: a) determine which of the five livestock species suffered significantly different losses than expected, and b) calculate their deviation percentages from expected attack rates (Iliopoulos et al., 2009).

A conflict map was prepared to depict location and extent of human casualties and livestock depredations with ArcGIS 10 (http://www.esri.com) using

GIS maps (2011) available from the Department of National Parks and Wildlife Conservation (DNPWC), Kathmandu. For human casualties, GPS location points of each incident were plotted on GIS map, and their shortest distances from park boundary (both in and outside) measured with ArcGIS 10. For livestock depredations, each buffer zone VDCs/municipalities were categorized and mapped into four classes based on number of cases in between 2007 and 2014 i.e. very high (>50), high (11-50), low (1-10), and no depredation.

3.3 Correlates of conflict

Human population for each VDC/municipality were calculated from census data of 2011 (CBS, 2012), and livestock population (total of all species) were computed from census data of 2011/12 considering mean densities in corresponding districts (CBS, 2013). GIS maps (2011) available from DNPWC were used to compute the forest area (sq. km), and national park frontage (km) of each VDC/municipality, using ArcGIS 10. The data on monthly rainfall (mm), yearly rainfall (mm), and monthly temperature (°C) of Rampur station (approximately 10 km from CNP) were obtained from the Department of Hydrology and Meteorology, Kathmandu, for 2007-2014.

Generalized linear models (GLMs) were performed using negative binomial distribution with log link function using R-3.2.3 (http://www.r-project.org) to investigate the correlates (human population, livestock population, forest area, national park frontage and their interactions) against human casualty or livestock depredation frequencies (by collating data for VDCs/municipalities). Separately, by collating data for months, GLMs were done using monthly rainfall, monthly temperature, and their interaction as explanatory variables. The terms were removed considering AIC value as well as chi-square testing for significance. Additionally, by collating data for each VDC/municipality, Spearman correlation analysis was used to assess general bivariate relationships between the human population, livestock population, forest area in the buffer zone and national park frontage of VDCs/municipalities against the frequency of human casualties or livestock depredations. Similarly, by collating data for months/years, Spearman correlation analysis was performed with mean monthly rainfall, yearly rainfall, and mean monthly temperature.

3.4 Causes and context of conflict

Overall wild prey densities of four sectors of CNP (eastern, Kasara, western and Madi; Fig. 1) were computed with software Distance 6.0 (http://distancesampling.org) using best fit model with minimum AIC value, using the survey data of 2013 obtained from DNPWC (collected from line transect survey). Incident data for all sectors were collated by summing up data of respective VDCs/municipalities. The data on tigers (sex-class) removed from the wild by both authorities, and people (in retaliation) for conflict-related causes, tiger/people behavior that led to attack, activity of victims during attack, and attack sites were collected from the CNP office and verified during questionnaire surveys (Appendix 1; n=83).

The correlation analysis was used to test if human casualties or livestock depredations by tiger vary proportionally to wild prey densities so as to determine whether wild prey density was an underlying cause driving conflicts. Chi-square test was applied to determine if male and female tigers get involved in conflict proportionally to their relative availabilities. The availabilities were obtained from 2010 tiger census (Karki et al., 2015). The attacks were categorized as accidental meetings, predation attempt by tiger, or provocation by people (Goodrich et al., 2011).

3.5 Adopted conflict mitigation measures

Adopted mitigation measures in CNP mainly include compensation payments and tiger removals. The data on compensation payments made to tiger attacks during 2007-2014 were collected from the offices of CNP, and Buffer Zone

Management Committee (BZMC) initially mainly maintained on the basis of compensation applications (Gubbi, 2012). The data were then triangulated and augmented through questionnaire surveys (Appendix 1; n=83). The data collected on compensation claims and payments include: human casualty type (killed or injured), livestock type (goat, cattle, buffalo, sheep, or pig) and incident date. These data on compensation were totaled for each year and converted to US$ by taking the average value of currency conversion from Nepalese Rupees to US$ for that particular year (Gubbi, 2012).

The data on tigers removed for conflict-reasons (human/livestock attack or perceived threat) were collected for the period 2007-2014 from the offices of CNP and anecdotal records. This followed verification and augmentation by conducting key informant interviews (Appendix 2; n=13) with veterinarian, rangers, game scouts, and buffer zone representatives who were directly involved in tiger removals. The data on removed tigers include: age-class, health condition, habitat occupied (degraded/intact), area occupied (national park/buffer zone/outside buffer zone), date, and management of live-removed ones.

CHAPTER 4

RESULTS

4.1 Extent and nature of conflict

During 2007-2014, tigers resulted in 54 human casualties (32 killings and 22 injuries) and 351 livestock depredations (Table 1). Goats were the main victims that shared 55% of all livestock killings, followed by cattle (23.36%), buffalos (11.96%), pigs (7.69%), and sheep (1.99%). Buffalos were killed 35% less and pigs 138% more often than expected from their availabilities (Bonferroni confidence interval, $P<0.01$) whereas goats, cattle and sheep were killed in proportion to their availabilities.

Table 1: Year-wise details of human casualties and livestock depredations by tigers in Chitwan National Park and Buffer Zone, 2007-2014

Year	Human casualties			Livestock depredations					
	Killed	Injured	Total	Cattle	Buffalo	Goat	Sheep	Pig	Total
2007	0	2	2	11	2	19	3	2	37
2008	2	3	5	10	4	38	0	1	53
2009	7	0	7	16	7	46	0	12	81
2010	2	2	4	22	7	35	3	3	70
2011	1	4	5	6	7	19	0	5	37
2012	8	4	12	3	2	11	0	1	17
2013	4	5	9	9	10	6	0	1	26
2014	8	2	10	5	3	19	1	2	30
Total	32	22	54	82	42	193	7	27	351

4.2 Spatial patterns of conflict and mapping

The human casualties and livestock depredations varied spatially, with greater clustering in some defined locations (Fig. 5). Over three-quarters (75.9%) of human casualties occurred inside the buffer zone (χ2=14.05, df=1, P<0.0001) with greater clustering around Narayani river in northern boundary between Kasara and western sectors (see Figs. 1 and 5). Three-quarters of human casualties occurred within one km from the park boundary (Fig. 6). Clear gradation in livestock depredations was observed among 36 Village VDCs/municipalities of buffer zone. A single VDC (Ayodhyapuri) in southern section of CNP "very highly (>51)" suffered livestock depredations sharing over a quarter (n=89) of total losses. Eight VDCs (22.2%) "highly (11-50)" suffered livestock depredations whereas nearly 60% (n=21) had "low depredation rates (1-10)" and the remaining six VDCs suffered no losses during the eight-year period.

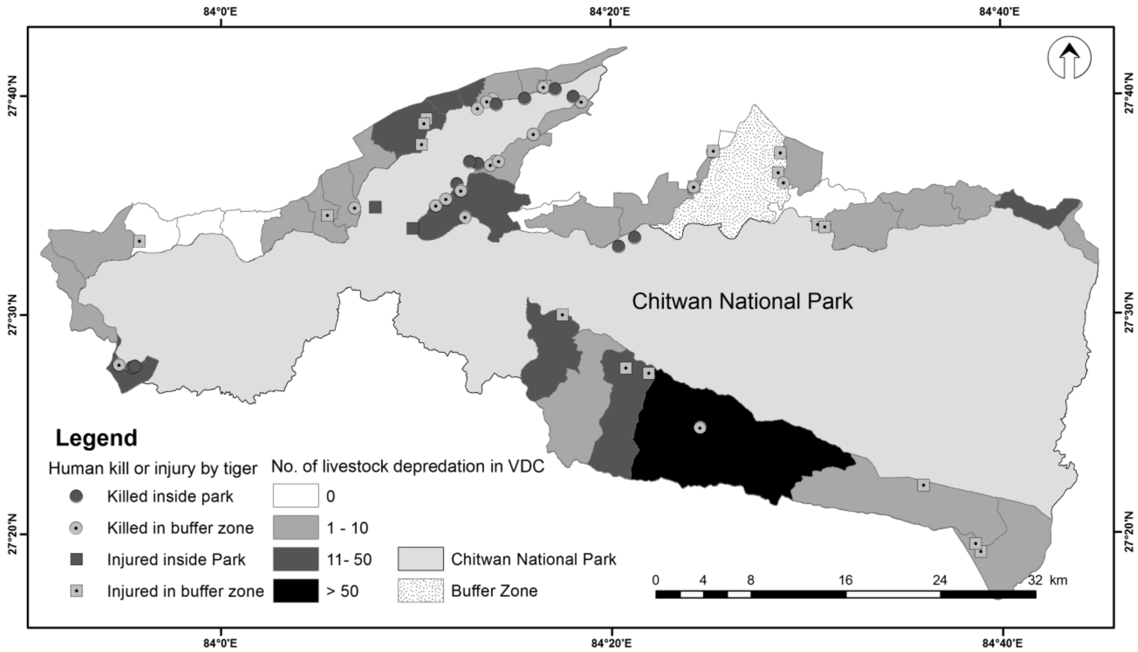

Figure 5: Location and extent of human killings and injuries, and livestock depredations by tigers in Chitwan National Park and Buffer Zone, 2007-2014

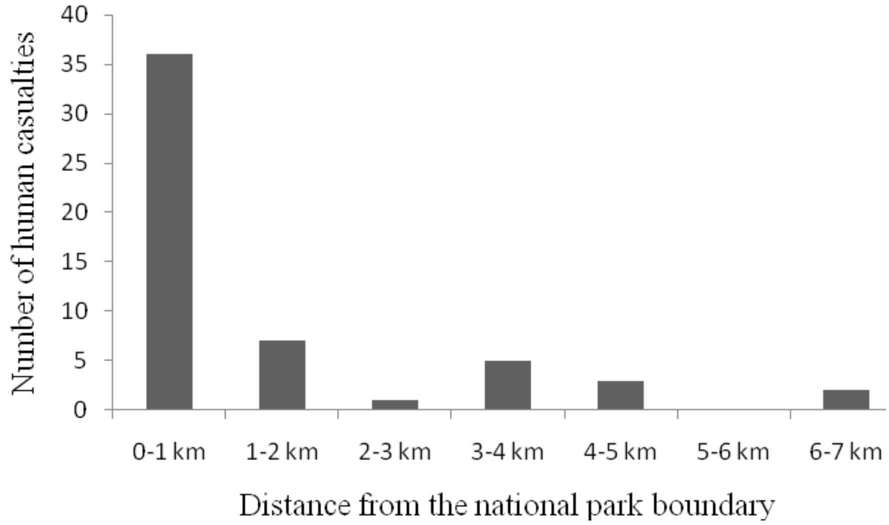

Figure 6: Number of human casualties by tigers in and outside the boundary of Chitwan National park, 2007-2014

4.3 Temporal patterns of conflict

During 2007-2014, tigers annually killed an average of 4 people (SD=3.25, range 0-8) and injured 2.75 people (SD=1.58, range 0-5). The number of human killings dropped significantly from 7.38±7.37 people per year in 1999-2006 to 4.0±3.25 in 2007-2014 ($\chi2$=7.43, df=1, P<0.01); whereas no significant variation was observed neither in human killings nor injuries between 2007-2010 and 2011-2014. Similarly, tigers killed an average of 43.88 (SD=22.27, range 17-81) livestock per year. The livestock depredations dropped significantly from 60.25±19.31 heads per year in 2007-2010 to 27.5±8.35 in 2011-2014 ($\chi2$=48.15, df=1, P<0.0001). While human casualties neither varied among years ($\chi2$=11.78, df=7, P>0.05), nor among seasons ($\chi2$= 0.33, df=2, P>0.05) or months ($\chi2$= 9.11, df=11, P>0.05), livestock depredations varied among months ($\chi2$=12.78, df=11, P<0.0001) and years ($\chi2$=79.15, df=7, P<0.0001), but not among seasons ($\chi2$=2.58, df=2, P>0.05). June-July suffered more than 25% (n=90) of all livestock losses, and August had least (n=13).

4.4 Correlates of conflict

GLM found that none of the examined correlates was significantly associated with human casualties or livestock depredations. Similarly, the correlation analysis found no significant correlation of human casualties with any of the variables examined. However, for livestock depredations, correlation analysis revealed a significant positive correlation with national park frontage (r_s=0.43, n=36, P=0.009), but not with the human population, livestock population, forest area in buffer zone, mean monthly rainfall, mean monthly temperature, or yearly rainfall.

4.5 Causes and context of conflict

The wild prey density was not significantly correlated with the frequency of human casualties (r_s= -0.74, n=4, P=0.26) or livestock depredations (r_s= -0.20, n=4, P=0.8). Male tigers were highly removed from the wild (73.3%) for conflict-reasons than females, as expected from their availabilities. Over 75% (n=42) of human attacks occurred during accidental meeting between human and tigers, whereas nearly 20% occurred from predation attempt where the tigers killed people while at home or fishing in river, and the provocation by people to retrieve a human body resulted in one death and one injury. The context of human attacks was defined by victim's activity and attack site. Majority of human attacks occurred when victims were involved in fodder/fuelwood collection activities (53.70%), followed by fishing (20.37%) (Fig.7). Tiger attacks varied with site types with nearly a half (48.2%) occurred in the forests of buffer zone and nearly a quarter (24.1%) in national park's forests. Eight casualties occurred in the river area, five in village/home, and the remaining two in farmland.

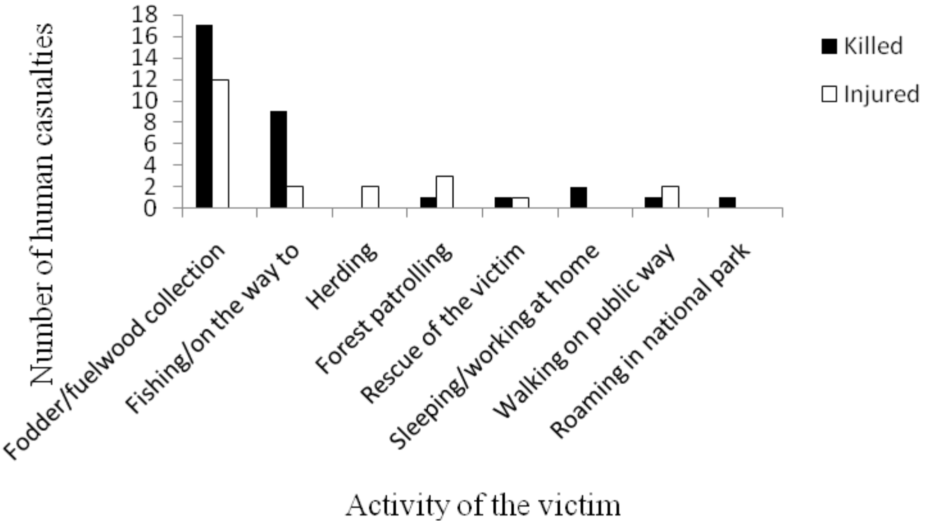

Figure 7: Number of human casualties by tigers in Chitwan National Park and Buffer Zone by activity of victims, 2007-2014

4.6 Compensation payments for conflict

A total compensation payment of US$ 93,618 (11,702.3 per year) was made towards tiger attacks during the eight-year period (Table 2). Of this, 65% was paid for human killings, 5.7% for injuries, and 29.3% for livestock killings. On an average, the payments covered 80.7% of medical expenses of injured person, and 61.7% of monetary value of killed livestock. Compensation payments covered full-expense of 63.6% of injured persons whereas for livestock it covered full-monetary value of 46.7% of depredated animals. In remaining cases payments only covered the losses (expenses) partially. Goats shared the highest proportion (43.5%) of total livestock depredation payments, followed by cattle (28.2%), buffalo (18%), pig (9%), and sheep (1.3%). The total annual payments ranged from US$ 2000 in 2007 to 21,536 in 2014, making a jump by 976%. Likewise, total annual claims (losses) ranged from US$ 3923 in 2007 to 23,279 in 2014 making a jump by 493%.

Table 2: Year-wise details of compensation payments and claims for tiger attacks in Chitwan National Park and Buffer Zone during 2007-2014

Tiger attack details		Amount (US$)	Year								Total (US$)
			2007	2008	2009	2010	2011	2012	2013	2014	
Human casualties	Killed	Paid	0.0	1476.4	8485.6	4021.5	2106.7	13383.9	12540.5	18799.0	60813.6
		Claimed[a]	0.0	1476.4	8485.6	4021.5	2106.7	13383.9	12540.5	18799.0	60813.6
	Injured	Paid	359.3	686.7	0.0	1075.8	612.4	1027.2	1397.2	208.9	5367.5
		Claimed	535.5	896.3	0.0	1290.3	619.8	1070.2	1973.5	263.0	6648.5
	Total	Paid	359.3	2163.1	8485.6	5097.2	2719.1	14411.1	13937.7	19007.8	66181.1
		Claimed	535.5	2372.8	8485.6	5311.7	2726.5	14454.1	14514.0	19062.0	67462.2
Livestock depredations	Goat	Paid	638.3	1318.6	2918.0	2529.5	1924.2	752.8	423.2	1421.4	11926.0
		Claimed	1275.8	2612.8	3378.8	2529.5	1931.2	752.8	423.2	1822.5	14726.6
	Cattle	Paid	692.2	483.5	1398.8	2647.5	758.4	334.6	940.5	501.3	7756.9
		Claimed	1476.8	967.1	2356.4	3304.3	1264.0	948.0	2508.1	1180.2	14004.8
	Buffalo	Paid	188.4	420.8	817.9	938.3	983.1	223.1	1045.0	313.3	4930.0
		Claimed	376.9	841.6	1531.3	1032.2	2457.9	412.7	4702.7	887.7	12242.9
	Sheep	Paid	84.6	0.0	0.0	181.0	0.0	0.0	0.0	94.0	359.6
		Claimed	169.2	0.0	0.0	181.0	0.0	0.0	0.0	128.5	478.6
	Pig	Paid	37.7	110.7	1129.9	375.3	418.5	89.2	104.5	198.4	2464.4
		Claimed	89.2	221.5	1394.6	415.5	489.5	89.2	135.9	198.4	3033.9
	Total	Paid	1641.3	2333.6	6264.6	6671.6	4084.3	1399.7	2513.3	2528.5	27436.9
		Claimed	3387.9	4642.9	8661.2	7462.5	6142.6	2202.8	7769.9	4217.2	44486.9
	Total amount paid		2000.6	4496.8	14750.3	11768.8	6803.4	15810.8	16451.0	21536.3	93618.0
	Total amount claimed		3923.4	7015.7	17146.8	12774.2	8869.1	16656.8	22283.9	23279.2	111949.0

4.7 Removal of conflict-involved tigers

A total of 15 tigers were removed from the wild for conflict-reasons; 11 by authorities (including one shot dead), and four killed by local people in retaliation. Nine of the removed tigers were adults (3-12 year) while five were post-dispersal floaters (>2 year), one juvenile (1-2 year), and no cubs (<1 year; Karanth, 2003). Nine were healthy and five injured, with the unknown physical status of the remaining one. Eight tigers had occupied areas with no or low wild prey (e.g. farmlands/settlements and degraded habitat), whereas seven were removed from good habitat with abundant wild prey. Thirteen tigers were removed from buffer zone, and one each from outside the buffer zone and inside national park. One each tigers were removed in 2007, 2009, 2010 and 2014, two in 2008 whereas three each tigers were removed in 2011, 2012, and 2013. Of the 10 live-removed tigers, five died in enclosure (within 10 days to 14 months), two each were released in CNP and to another national park (Bardia), and one was translocated to the central zoo. The fate of both tigers removed in CNP was unknown whereas both the tigers translocated to Bardia national park were reported dead within few months of release (one from poisoning and another from unknown reason). In overall, at least 80% (n=12) of the removed tigers were confirmed dead indicating higher impact of conflict on tigers in CNP.

CHAPTER 5

DISCUSSION

The scale and extent of HTC varied spatiotemporally across the area studied, with greater clustering of incidents in a few locations. Over three-quarters of human casualties occurred in the buffer zone and two-thirds within one kilometer from the national park boundary. The killings of human and livestock have decreased over the periods; (1999-2006)/(2007-2014) for human killings, and (2007-2010)/(2011-2014) for livestock depredations. Correlation analysis found national park frontage as the only examined variable that was significantly positively correlated with livestock depredations. Unlike many areas, wild prey density was not associated with the scales of HTC. Male tigers (73.3%) were indicated to be mainly responsible for conflicts. Over three-quarters of human casualties occurred during accidental meetings, mostly while victims were involved in fodder/fuelwood collection. The buffer zone forest habitat experienced nearly half of all human casualties. Limitation of this study includes the inclusion of livestock depredation cases occurred only inside the buffer zone. The possibilities of accounting of few livestock depredations by leopard to tigers (or vice versa) cannot be totally ruled out.

The scales of human casualties and livestock depredations were within the range reported elsewhere (Barlow, 2009; Bhattarai and Fischer, 2014; Miquelle et al., 2005; Nyhus and Tilson, 2004; Sangay and Vernes, 2008). Unlike in this study where goat shared the highest proportion of livestock killings, cattle were the main victim (75%) of tigers in Bhutan (Sangay and Vernes, 2008). However in either study, goat/cattle were killed according to their relative availabilities. The preference of tigers towards the prey weighing 60-250 kg (Hayward et al., 2012) might have led to lower killing of the buffalo (300-600 kg) which exceeds the preferred range and higher killing of the pigs (60-120 kg) which falls within the preferred range. Importantly, higher killing of domestic pig is comparable to wild pig (*Sus scrofa*) which is preferred by tigers (Hayward et al., 2012). Higher preferential predation of suids is attributed to possession of retractile claws by tigers (helpful in avoiding injuries), and the low centre of gravity of suids that reduces effectiveness of coursing the predators (Hayward et al., 2012). The pigs, and goats (for highest killing share, 55%) can therefore be regarded as key victims requiring focus on protection.

Higher casualties in buffer zone can be attributed to extensive overlap of people and tiger activities, and likely occupation of buffer zone forests by the injured, old and transient tigers displaced from the intact habitat in national park (Gurung et al., 2008; Karanth, 2003; Sunquist, 1981). However, such tigers might not always be responsible for human attacks; rather the tigers with higher chance of human encounters could be (Miquelle et al., 2005). Higher human casualties around one kilometer of national park boundary indicate the zone immediate inside the national park, and also immediate outside the national park (i.e. buffer zone) to exhibit very high resource extraction activities (e.g., fodder, fuelwood, thatch grass, grass, medicinal plants). Higher clustering of human casualties around the boundary area between Kasara and western sectors (constitutes Narayani river) can primarily be attributed to its location (surrounded by human settlements from three sides - higher edge), higher anthropogenic activity in the river, and likely attraction of tigers due to occasional presence of human bodies in the river. The gradation of livestock depredations across VDCs/municipalities of buffer zone is more likely due to poor husbandry practice involving open grazing, poor guarding, improper corrals, and large numbered low-productive local breeds. These factors along with other socio-ecological and landscape factors might have acted variably across different VDCs/municipalities resulting varied scales of livestock depredations. The highest killing in Ayodhyapuri VDC, among other factors, is likely due to contribution of longer national park frontage on tiger-livestock proximity.

The significant decrease in human killing and livestock depredations over the periods as observed in this study [(1999-2006)/(2007-2014) for human killing, and (2007-2010)/(2011-2014) for livestock depredations)] is attributed to restoration of forests in the buffer zone and increased habitat management interventions in national park as a result of several conservation initiatives implemented in CNP mainly since late 1990s. The initiatives include Buffer Zone program (1996), Nepal-Terai Arc Landscape Strategy 2004-2014, Tiger Conservation

Action Plan (2008-2012), Tiger Conservation Special Program 2011 and inter-sector cooperation in conservation (Dhakal et al., 2014; DNPWC/MoFSC/GoN, 2013; Gurung et al., 2008). These initiatives may have increased prey density [62.6 animals per sq. km in 2008 (Karki et al., 2009), 73.63 in 2013 (Dhakal et al., 2014)] and improved habitat suitability resulting reduced conflicts. Further, tiger removal efforts and provision of compensation payments might have contributed in better park-people cooperation and conflict reduction (Ogra and Badola, 2008; Goodrich, 2010). Similarly, reduced forest dependency of local residents, remittance and other alternative income sources, increased stall feeding of livestock, changes in lifestyle probably have also played important role in reducing HTC. Similar to our findings, Carter et al., (2012) suggested that tigers can co-exist with humans at fine spatial scales in Chitwan by behavioral adjustment of spatiotemporal activities, where the core area (national park) is managed to foster high tiger densities, and the buffer zone for co-existence of humans and dispersing tiger populations (Karki et al., 2015).

The monthly variations in livestock depredations with higher depredations in June-July was likely due to poor guarding or even unattended status of livestock because these months coincide with the peak period of harvesting and transplantation of a major crop (paddy) resulting reduced availability of work force for herding. Importantly, higher vegetative cover in these rainy months may have provided adequate stalking cover for tigers while decreasing their detection by humans and livestock. Other studies in various areas have also reported higher livestock depredations by carnivores during the rainy season (Patterson et al., 2004; Woodroffe and Frank, 2005; Kolowski and Holekamp, 2006; Sangay and Vernes, 2008).

The retention of none of the examined correlates as the predictor of conflict incidents from GLM analysis denotes that besides the variables examined in this study, there exist additional significant factors influencing conflicts. The positive correlation of livestock depredations with national park frontage signifies the villages sharing longer boundary with national park may expect more tiger attacks; the conclusion comparable to incidents of crop damage by elephants (*Elephas maximus)* in India (Gubbi, 2012). This finding may have management implications especially while constructing tiger-proof physical barriers, and in identification of vulnerable areas. Unlike common public perception that conflict increases with increase in forested areas in human-modified landscapes like the buffer zone, this study did not found such relationship between the forest area and conflict incidents. Previous studies have suggested such relationship to vary with carnivore species involved. While no correlation between forest area and livestock depredations was observed for tigers and leopards in Bhutan, bears (*Ursus thibetanus*) and snow leopards (*Uncia uncia*) showed negative correlation (Sangay and Vernes, 2008). However, jaguars (*Panthera onca)* and pumas (*Puma concolor*) showed positive correlation in Amazonia (Michalski et al., 2006). In overall, the unassociated relationship between tiger attacks and forest area can partially be explained by avoidance by tigers the disturbed and fragmented forest habitats available in the buffer zone. Also, it indicates that the availability of forest patches in human-modified areas does not necessarily induce conflicts.

Wild prey density has been widely invoked as one of the important drivers of conflict with the negative association between wild prey and conflict rates (Goodrich, 2010; Miquelle et al., 2005). However, our study did not find any correlation between wild prey density and conflict incidents. As tigers might attack livestock upon opportunity (Graham et al., 2005), or as surplus, the prevalence of open grazing and poor husbandry practice that increases susceptibility of livestock losses to tigers might have affected the rates of livestock attacks rather than by wild prey density. This finding indicates that unless well-managed livestock husbandry system is ensured, the decrease in conflict might not be expected with only increase in prey densities. Our study indicated the varying chances of involvement of male and female tigers in conflicts. The higher involvement of males in conflict, as indicated by higher removal of conflict-involved male tigers in this study, is likely due to more resource requirements (e.g. diet, space, and dispersal distance), higher competition and shorter land tenure of males than females (Karanth, 2003; Sunquist, 1981). Higher human casualties of fodder/fuelwood collectors and in the forested areas indisputably indicate higher dependency-driven flow of people in forests for such resources.

Compensation payments and tiger removals are the main conflict mitigation measures adopted in CNP so far. Though compensation schemes in some areas are cited to raise negligence to preventive measures and increased dependency (Goodrich, 2010; Ogra and Badola, 2008), based on questionnaire surveys conducted with local people and park authorities in this study, the scheme is concluded to be important in addressing the issue of conflict, though some improvements were strongly noted. Given the poor economic status of most local communities and observed cases of retaliatory killings, provision of fair and timely compensation is very important to gain public support in conservation while addressing economic hardships. Despite lower lethal control by authorities, higher cost of tiger removal in CNP was exemplified by higher mortality of tigers where at least 80% of removed tigers were killed, or died. Though tiger removals has been considered important in minimizing conflicts (Gurung et al., 2008), it should follow proper identification of the offending individual with the focus to maintain population in the wild. As such, execution of tiger removals only under absolutely necessary condition followed by proper management of captured tigers or radio tracking of wild-released individuals (helps to gather information on survival and its further involvement in conflict) are important to minimize unnecessary tiger mortalities.

As an alternative to tiger removals, other non-lethal measure such as hazing (e.g. use of deterrents like sound/light/visual stimuli to frighten animals) might be useful to reduce conflict through driving animals away from human settlements or decrease their intention to enter in such areas (Goodrich, 2010; Zarco-González and Monroy-Vilchis, 2014). Light and sound devices were effective to deter wolves (*Canis lupus*) but not bald eagles (*Haliaeetus leucocephalus)* and black bears (*Ursus americanus)* (Shivik et al., 2003). Use of alien objects and sounds were effective in reducing livestock predations by felids such as jaguar and puma (Zarco-González and Monroy-Vilchis, 2014). For tigers, their efficacy is however unclear and is likely to be achieved (Goodrich, 2010). Main advantage of such techniques is that they can produce immediate results, while drawbacks include habituation of animals and short-term effects (Zarco-González and Monroy-Vilchis, 2014). Therefore, park authority after assessment could promote simultaneous use of multiple hazing techniques with their periodic modifications to avoid tiger habituation (Treves and Karanth, 2003). The assessment should demonstrate that they are safe, economically feasible and efficient in reducing tiger impacts over a reasonably long duration.

CHAPTER 6

CONCLUSION AND SUGGESTIONS

6.1 Conclusion

This study found that human-tiger conflict does not necessarily escalate with increased tiger numbers if effective conservation initiatives are put into effect. However, prevalence of higher levels of conflicts in the buffer zone coupled with records of retaliatory tiger killings indicates still the existence of conflict as a prominent threat to both human/livestock and tigers. This highlights the need for adoption of effective conflict mitigation measures that would also be instrumental in doubling the tiger populations by 2022, the commitment endorsed by Nepal in Tiger Summit 2010. The study reported the goats sharing the highest proportion of livestock killings and the pigs being killed preferentially by tigers. The need ahead is to focus protection measures on such more vulnerable species. Several social, ecological and landscape factors, besides the national park frontage and other examined correlates, are likely to affect the scale and occurrence of conflicts. Unlike previous reports which suggested wild prey density as one of the key underlying causes behind conflicts (Goodrich, 2010; Miquelle et al., 2005), this study identified and proposed improvement of livestock husbandry practice and reduction of dependency-driven flow of people in the forested areas as the main ways to arrest tiger attacks on livestock and humans (in addition to prey increment). Regarding mitigation measures, existing compensation scheme should be improved so as to provide fair compensation payments to the victims with promptness, and the tiger removal effort should aim at minimizing the tiger removals from the wild and translocation of the removed individuals into the wild as far as possible. Higher removal of male tigers for being involved in conflict incidents indicates the need of greater attention and monitoring of such tigers to proactively minimize likely chances of attacks on human and livestock.

6.2 Suggestions

Based on the study, following suggestions are made that could be helpful in mitigating conflict and tiger conservation.

6.2.1 Effective zoning enforcement

This study found spatial variations of incidents across CNP and buffer zone with their higher occurrences in a few locations and habitat types. In this regard, the concept of zoning that limits the activity of human and livestock in prime tiger locations (e.g. forest areas and movement corridors) is suggested as one of the preventive measures to reduce conflicts. Though successive Management Plans of CNP proposed and implemented zoning, higher levels of conflict did occur in the forests of national park which were primarily designated for exclusive use of wildlife, and in the forests of buffer zone which were designated to serve dual functions (refuge for dispersing wildlife population and regulated exploitation of forest resources). The areas therefore require effective zoning enforcement that constitutes limit in flow of people and livestock in forested areas, with prioritized enforcement in higher conflict zones. In this regard, park authority could use the conflict map that we prepared here to identify higher conflict areas.

6.2.2 Exploration of additional causes of higher human casualties around the Narayani River

The study revealed Narayani river area (northern boundary area between Kasara and western sector) to have higher clustering of human casualties. The reasons behind such scenario concluded in this study include increased proximity between human and tiger activities (because it is surrounded by human settlements from three sides), higher anthropogenic activity in river, and provocation of man-eating behavior among tigers due to occasional availability of human bodies in river deposited during religious rites. However, there might be additional causes behind such findings. Further studies are therefore needed to make more reliable conclusions and explore additional probable causes (e.g. wild prey density and status of large ungulates such as sambar deer, grazing and livestock husbandry system, intact/degraded habitat, status of community forests, and level of anthropogenic activities).

6.2.3 Improvement of livestock husbandry practice

This study identified open livestock grazing, poor guarding, grazing in or adjacent to forested area, use of improper corrals, and significant population of low-productive native breeds as the contributing factors of livestock killings. The existing but limited efforts that include establishment of a few veterinary centers and grazing abstinence in forested areas (to avoid loss) could be supplemented by improving husbandry practice. It might include the promotion of improved livestock breeds, stall feeding, improved corrals, strict prohibition of grazing in forests, and forage production in agriculture lands. This will help to reduce livestock losses and reduce costs in guarding while ensuring higher economic returns to farmers.

6.2.4 Exploration and examination of additional conflict-correlates

The study concluded livestock depredations to be significantly associated with national park frontage. However, as GLM could not develop a model to reliably predict conflict incidents, further studies involving exploration and examination of additional correlates might be very helpful in predicting conflict and formulating conservation strategies and conflict mitigation plans. The candidate correlates may be: livestock grazing system (guarding status, grazing site), corral type, herd size and composition, habitat quality (intact/degraded), distribution of settlements, density of roads, status of community forests in buffer zone, and density spectrum of wild prey especially spotted deer and other big ungulates across the area.

6.2.5 Participatory tiger monitoring and development of tiger-removal protocol

Regarding tiger conservation and management, two areas of improvement observed in this study are: limited involvement of local people in tiger monitoring, and arbitrary tiger management and removal. The initiative of involving local youths in tiger monitoring as already implemented in two VDCs needs to be replicated to other regions especially Narayani Island area and Ayodhyapuri VDC which suffered highest levels of human casualties and livestock depredations respectively. The park authority could mobilize already formed Community Based Anti Poaching Units (CBAPU) by first providing training on camera trapping and potentially dangerous tigers' identification skills, followed by field gear supports with other necessary assistances. This effort will create local tiger experts, disseminate early-warning on risks, and develop public ownership in tiger conservation. Regarding tiger removal and management, there is an urgent need for development of well-defined protocols with the focus to maintaining population in the wild. Compulsory radio-tracking of wild-released tigers and well attention to captive-held tigers are necessary to minimize unnecessary tiger mortalities. Further studies should attempt to characterize each tigers involved in each individual conflict incidents, if feasible.

6.2.6 Accelerated compensation payments and promotion of insurance scheme

As in many areas, mechanisms of fair and speedy compensation payments are suggested here onto. This might be possible by revision of payment rates such that tiger attacks would not create substantial economic crisis in the family affected. As ways to reduce financial liabilities to the government, variation in rates of payments for livestock depredations according to site of occurrence (cattle-shed, forest area), and reduced payment to losses occurring under adoption of poor livestock husbandry practice (e.g. leaving livestock unattended, failing to replace low-productive breeds with improved ones) might be helpful. Despite current provision of rapid payments of 10% of maximum possible compensations, the issue of delayed full-payments (took months or even a year to receive) might be addressed by establishment of a compensation basket fund in CNP, local awareness on compensation procedures, allocation of resources to field staff, and rapid disbursal from relevant ministries. Nevertheless, as conservation sector is not the priority of the government and compensation payment scheme incurs perpetual liability to government, promotion of long-term measures such as insurance scheme (especially for livestock) is recommended. Insurance scheme will reduce financial burden to the government, ensure sustainability and develop public ownerships.

6.2.7 Conservation awareness program

All these aforementioned measures should be accompanied by conservation awareness program in the buffer zone focusing highly affected communities and schools as well. Collaboration with INGOs, NGOs, buffer zone committees, and women groups should be done to produce better outcomes. The awareness programs should be included with priority in the annual program of CNP and Buffer Zone Management Committee as well. The matters of tiger behavior/ecology and possible mitigation measures could be of more importance to be included in these programs.

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APPENDICES

APPENDIX 1: Format for questionnaire survey

Name of the respondent:

Address:

Occupation:

Age:

1. Details on human casualties

Name and address of the victim:

Age/sex:

Date of incident:

Time of incident:

Casualty type: (i) killed (ii) Injured

Incident area: (i) National park (ii) Buffer zone

Incident site type: (i) forest (ii) grassland (iii) river (iv) village (v) farmland (vi) others (specify)

Victim's activity during tiger attack:

(i) fodder/NTFP/timber/fuelwood collection (ii) fishing

(iii) herding (iv) working at farmland/home

(v) others (specify)……

Tiger/human behavior during incident:

(i) provoked (the tiger was intentionally approached or shot by people)

(ii) accidental meetings (a person and tiger came into close proximity accidentally provoking an aggressive response from the tiger),

(iii) predation attempt (a tiger approached and attacked a person without provocation)

Details on attacking tiger (if known):

Did victim/victim's family received relief (compensation) grant: Yes/No

If yes, how much: NPR……………….

How long it took to receive the relief grant?

What you think the government should do to support the tiger victims?

What you think the government should do to minimize human-tiger conflict?

Any additional comments: ……….

2. Details on livestock depredations

Name and address of livestock owner:

Date of depredation:

Time of depredation:

Livestock type: (i) buffalo (ii) cow (iii) goat (iv) sheep (v) pig
(vi) others (specify)……..

Number of livestock depredations (and specify details separately for each, if>1):…….

Incident area: (i) national park (ii) buffer zone

Incident area: (i) name of VDC (village development committee)/Municipality………
(ii) ward number:………..

Incident site type: (i) forest (ii) grassland (iii) river (iv) village
(vi) shed (vii) others (specify) ……..

Claimed (loss) amount: NPR…….

Did the owner received compensation grant: Yes/No

If yes, how much: NPR………..

How long it took to receive the compensation?

Did the compensation payment you received cover actual loss by livestock depredation: Yes/No

What you think the government should do to minimize human-tiger conflict?

Additional comments, if any: …………………

APPENDIX 2: Format for key informant interview

Name of the key informant:

Address:

Occupation:

Designation:

Affiliated organization:

Tiger characteristics

ID of the removed tiger:

Date of removal:

Cause of removal: (i) human attack (ii) livestock attack
(iii) human and livestock attack (iv) posing potential threat

Removal type: (i) live-removed (ii) killed by authorities (iii) killed by people

Age class: (i) cubs (<1 year) (ii) juvenile (1-2 year)
(iii) post-dispersal floaters or transients (>2 years)
(iv) breeding adults (3-12 years)

Reproductive stage (if female): (i) with cubs (ii) without cubs

Physical condition: (i) healthy (ii) injured (iii) diseased (iv) old (v) orphaned

If injured, for what reason: (i) by people (ii) mutual fight (iii) others (specify)

Area occupied: (i) national park (ii) buffer zone (iii) outside buffer zone

Habitat occupied: (i) settlement/farmland (ii) degraded habitat (iii) intact habitat

Management (fate) of live-removed tigers: (i) died in enclosure (ii) released in CNP
(iii) translocated to another protected area
(iv) translocated to zoo
(v) Others (specify)………..

Duration between capture and specified management (fate):………….

Additional comments, if any: …………………

APPENDIX 3: Photo plates

Forest habitat inside Chitwan National Park

Grassland habitat inside Chitwan National Park

Office of the Chitwan National Park (CNP)

GPS location recording of a human kill site

Questionnaire survey with a buffer zone official

Tiger enclosure in CNP under maintenance

Tranquilized man-eater tiger under examination   Bull buffalos used in carriage of rice hay

Women in buffer zone forest to collect fodder   Spotted deer, main prey of tigers in CNP

A wild tiger observed inside CNP   Electric solar fence in buffer zone installed to prevent wildlife entering human settlements

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List of Manuscripts and Proceeding

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Dhungana, R., T. Savini, J.B. Karki, M. Dhakal, B. R. Lamichhane, S. Bumrungsri. Living with tigers: patterns, correlates and causes of human-tiger conflict in Chitwan National Park, Nepal **(Submitted)**

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