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UNDERSTANDING STAKEHOLDERS PERCEPTION TOWARDS HUMAN-WILDLIFE INTERACTION AND CONFLICT IN A TIGER LANDSCAPE-COMPLEX OF INDIA

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UNDERSTANDING STAKEHOLDERS PERCEPTION TOWARDS HUMAN-WILDLIFE INTERACTION AND CONFLICT IN A TIGER LANDSCAPE-COMPLEX OF INDIA

A Thesis Presented

by

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UNDERSTANDING STAKEHOLDERS PERCEPTION TOWARDS HUMAN-WILDLIFE INTERACTION AND CONFLICT IN A TIGER LANDSCAPE-COMPLEX OF INDIA

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ABSTRACT

UNDERSTANDING STAKEHOLDERS PERCEPTION TOWARDS HUMAN-WILDLIFE INTERACTION AND CONFLICT IN A TIGER LANDSCAPE-COMPLEX OF INDIA

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Human-population of the earth exceeding 6 billion and growing at an estimates rate of 1.2% per year (US census Bureau, 2002) will lead to increase in human-wildlife encounters. Attacks on humans are perhaps the least understood of these encounters, but the most interesting and emotionally connected to people (Quigley Howard 2005). The main aim of the study if to understand stakeholders' perception towards human-wildlife interaction and conflicts in Corbett National park, India. We used a standardized IRB (Institutional Review Board) approved questionnaire to survey 315 household from 15 villages lying within and around Corbett National Park of India using snow-ball technique and stratified random sampling technique.. We also surveyed and analyzed the head of the village, snow-ball technique and stratified random technique survey differently. We used multivariate regression analysis to understand the data obtained from questionnaire survey. Later, we also designed a conceptual model to understand factors influencing human-wildlife interaction; and an empirical model to identify factors affecting human-wildlife conflicts. The results of the study identified that most of the encounters with wildlife occurred while collecting timber or grass from forests. Wild pigs, elephants and cheetal are the species mainly responsible for crop-loss in our study area. Majority of the stakeholders were engaged in timber and grass collection from forested area. Multivariate regression results suggests that stakeholders whose farms were located far from highway, had good fencing and who had better socio-economic status faced least threat from wildlife with respect to crop-loss, livestock loss and human-life loss/injury. The simulation results of dynamic system experiment suggests that habitat loss and poaching play a very significant role in tiger population and its future. The study concludes that a holistic multi-disciplinary conservation approach is needed to address the increasing conflict issues in India. More emphases should be given on community based-conservation strategies and policies. Watch-towers, pits, solar-powered fencing are the best and most effective ways to keep wildlife away from damaging crops and killing livestock. Sustainable development and better higher education is the key to conserving tigers in India.

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CHAPTER 1

INTRODUCTION

Rarely do forest-dwelling pastoral communities coexist in harmony with large predators. Either the communities incur substantial economic loss due to predation on their stock and/or large carnivores suffer heavy losses and even subject to extirpation from retaliation (Ogada et al., 2003 & Inskip et al., 2009). Where humans and large carnivores interface, conflicts of three types are common: livestock depredation, prey depletion from overhunting, and direct human-caused mortality of carnivores (Treves & Karanth, 2003). In many countries all over the world, and particularly in zones surrounding national parks and other protected areas, borders between ‘‘human” and ‘‘wild” spaces have become blurred. Wild animals frequently leave protected areas and enter nearby human settlements, and people in forest- dependent villages may enter protected areas where they come into close proximity with wildlife. The resulting human–wildlife conflict often undermines local support for conservation. Such lack of support is evidenced by damage inflicted to wildlife by humans, including habitat degradation or ‘‘retaliation” killings in which waterholes, crops, or baited carcasses are deliberately poisoned (Bachi & Mishra, 2006).

The Tiger (*Panthera tigris* Linnaeus, 1758) is one of the world's most endangered animal (IUCN), having being driven to near extinction throughout its native Asia. A critical issue that has accelerated the depletion of tiger population is habitat-loss, prey depletion and accelerated rates of human-tiger conflict and poaching (Lanz Tobias, 2009). The evidence of data world-wide indicates that wild tiger population continues to decline despite substantial conservation efforts by international agencies, local conservation groups and governments (Seidensticker, Christie & Jackson 1999). Wherever tigers and people coexist, conflict between the two is likely. Tigers sometimes kill domestic animals or people, and humans often kill tigers in fear, in retaliation and/or to sell their body parts. Such conflicts exacerbate at least two major threats to tigers: (i) conflicts often result in mortality or removal of tigers from the wild and are probably second only to poaching as a source of human-caused tiger mortality; and (ii) they result in negative attitudes towards tigers by local people, thereby reducing support for tiger conservation (Gorokhov, 1983 & Nikolaev, 1993). Reducing human-caused mortality is critical to successful tiger conservation because it is usually the primary cause of mortality in tigers. This is a major reason for precipitous decline of tiger populations in much of their habitat range (Dinerstein et al., 2007). In well-managed protected areas, tigers will enjoy high prey density, little persecution from humans and, consequently, high reproductive rates. Some young tigers will disperse into human-dominated landscapes in search of vacant territories, and some old, wounded and/or diseased tigers will be pushed into these landscapes, often leading to conflicts (Karanth & Gopal 2005). The economic and emotional impact of conflict on local communities is considerable and can result in strong negative responses towards tiger conservation (Quigley & Herrero 2005). If tiger populations increase, the number of people killed per year also might increase, unless necessary steps are taken to reduce these incidents. Depredations on domestic animals are the most common type of human-tiger conflict. Tigers readily kill livestock and domestic dogs in areas where wild prey species are depleted through hunting, and habitat degradation through competition from livestock (Madhusudan & Karanth, 2002 and Miquelle et al., 2005).

According to the nonprofit agency Panthera, the habitat of tiger is unique to parts of East and South-East Asia and has been shrinking over years. The subcontinent of India has one of the most diverse landscapes, providing unique habitat for tigers and is facing the problem of poaching. Hundred years ago, there were estimated to be as many as 100,000 wild Tigers living in Asia. Today fewer than 3,200 remain in Asia and estimated 1520 to 1909 occur in India. India, known as the ‘Land Of Tigers’ for its unique combination of nature and culture, has supported tiger populations for centuries. Six subspecies of Tigers continue to persist, but three have gone extinct in the last 80 years. Tigers are only found in 13 countries in Asia, but have gone extinct from 11 other countries and no longer live in 93% of their historic range. All these alarming data reveal that tiger's survival depends on more than good conservation (Lanz Tobias, 2009).

Panthera also identified critical threats faced by tigers in India that include: (i) consumption of tiger body parts for traditional medicines; (ii) lack of intact habitat and large forested area to survive which is being destroyed because of urbanization, fragmentation, colony formation, agriculture and mining; (iii) human-tiger conflicts because of settlements, agriculture and livestock; (iv) lack of game population or prey because of over-hunting and (v) hunting for trophies or for recreation.

The tiger population in India was officially estimated to be on average at 1706 (varying between 1520 to 1909) in 2010. Many of tiger populations across the nation particularly those outside protected reserves, face a variety of threats of which human-tiger conflict and poaching is most significant. These problems are directly or indirectly linked to anthropogenic factors. Decades of scientific research on tigers and their prey have provided us with a set of guidelines to develop and to design protected areas to help the species survive. However, these reserves protect only a fraction of potential tiger habitat, and most of them are under severe human pressure. Large development projects, such as mining, hydroelectric dams, resorts & hotels for tourism and construction of highways are also taking their toll on the tiger's habitat. In the past few years, thousands of square kilometers of forestland have been diverted and destroyed to facilitate such development projects. Though mostly outside the protected network, the loss of this vital habitat will have serious repercussions on tiger conservation in India (WPSI, 2012).

In Indian subcontinent, Tiger is an intrinsic part of culture and national identity and in April 1973, India recognized Tiger as a national animal (NTCA, 2012). Tigers can occupy a wide range of habitat types, but will usually require sufficient cover, proximity to water, and an abundance of prey. Bengal tigers (*Panthera tigris tigris*) live in many types of forests, including wet, evergreen, the semi-evergreen of Assam and eastern Bengal; the swampy mangrove forest of the Ganges

Delta; the deciduous forest of Nepal, and the forests of the Western Ghats. The tiger prefers denser vegetation, for which its camouflage coloring is ideally suited, and where a single predator is not at a disadvantage (Novak, 1999). The forest that tigers and their prey inhabit provides a wide range of economic, social, and environmental benefits to people. These benefits contribute greatly to human welfare, but they are valued differently by different people and different groups. To governments policymakers, tiger habitat are often seen only for their ability to generate income, employment, revenue, and foreign exchange when converted to agriculture, timber, mines or other development-oriented activities. To a small proportion of the humans living in and around forests, killing tiger for their body parts yields a substantial greater income than live tigers roaming free. Many small-scale agricultural producers view tigers as pests that damage their livestock and crops (Damania et al., 2003).

1.1 What is needed?

We need a multi-disciplinary approach to reduce human-wildlife interaction and conflicts within and around Corbett National Park. There is an urgent need to implement community-based conservation strategies in this area to help sustain the tiger population.

1.2 What does this research focus on?

In this research we will focus on analyzing socio-economic and demographic factors that affects human-wildlife interaction and conflicts. We will develop an empirical model to understand how each factor plays a significant role in influencing conflicts. We will suggest new policies and strategies to reduce conflict within and around Corbett National Park, India. We will also simulate two scenarios using the empirical model predicting tiger population for India for next 85 years.

1.3 General objectives

The main objective of the study is to understanding stakeholder’s perception towards human-wildlife interaction and conflict in a tiger landscape-complex of India

1.4 Specific objectives

I. To evaluate human-behavior for resource extraction around Corbett National Park.

Ho: Human behavior doesn't explain resource extraction from national park.

Ha: Human behavior significantly influences resource extraction from national park

II. To evaluate factors influencing human-wildlife conflict around Corbett National Park

Ho: Determining factors influencing human-wildlife conflicts will not help understand the conflict scenario which can further help develop policies to reduce conflicts

Ha: Determining factors influencing human-wildlife conflicts will definitely help understand conflict scenario which will further lead to design and implement policies to reduce conflicts in our study area.

III. To develop a dynamic, systems model of human-wildlife conflict.

Ho: The dynamic system of human-wildlife interaction is not sensitive to changes in human variables.

Ha: The dynamic system of human-wildlife interaction is sensitive to changes in human variables.

1.5 Thesis Plan

The first chapter is about basic introduction on tigers in India and human-wildlife conflicts within and around Corbett National Park, India. The second chapter will focus on factors identified using questionnaire survey which affects human-wildlife interactions and conflicts in our study area. In the third chapter we will study specific geographic and demographic factors influencing exposure to crop-loss, live-stock loss and human wildlife conflict in and around Corbett National Park. In the fourth chapter we will discuss about the empirical model designed to understand how each factor contributes towards increasing or decreasing human wildlife conflicts.

CHAPTER 2

FACTORS INFLUENCING HUMAN-WILDLIFE CONFLICTS IN CORBETT TIGER RESERVE OF INDIA

2.1 Introduction

At global and national levels, large carnivores are regarded as flagship species, and conservation efforts aim to maintain or reestablish viable populations (Treves & Karanth 2003). At a local level, however, large carnivores are often regarded as undesirable in human-dominated areas (Saberwal & Rangarajan 2003; Bradley et al. 2005; Woodroffe et al. 2005) and are associated with attacks on humans and livestock. Human–carnivore conflicts are particularly frequent in India because human population densities are high and several species of potentially dangerous large mammals live outside of protected areas (Karanth & Madhusudan 2002). Elephants and other herbivores damage crops and property, and carnivores prey on livestock (Treves & Karanth 2003; Sillero-Zubiri et al. 2007). Most species of large carnivores in India are known to attack and sometimes kill people (e.g., Saberwal et al. 1994; Jhala & Sharma 1997; Karanth & Gopal 2005). As a result, forest managers are often forced to remove individual animals in response to complaints from people. Although lethal methods have been used extensively in the past, there is a growing public demand to apply nonlethal methods (Shivik et al. 2003).

Although large carnivores sometimes kill humans (Saberwal et al., 1994 & Packer et al., 2005), the major form of human-wildlife conflict arises due to preying on livestock and the resulting threat on economic security of the pastorals (Karanth & Chellam, 2009). Understanding people-carnivore relationship, therefore, becomes crucial especially for the conservation of large carnivores (Treves & Karanth, 2003 and Karnth & Chellam, 2009). Human communities react differently to this conflict depending on their religious beliefs, customs, cultures, actual and perceived magnitudes of economic losses and the legal status of carnivores (Goldman et al., 2010). Reactions range from total extermination of large carnivores (Mech, 1991) and occasional removal of problem animals (Athreya et al., 2011 & Karanth et al., 2005) to tolerance and coexistence with the wildlife (Raval, 1991). Two-thirds of India's wildlife reserves are grazed by livestock (Kothari, 1995), where they are often predated upon by large carnivores (Sawarka, 1986). Resolving human-wildlife conflict fundamentally requires managing these risks (Treves et al., 2006 & 2003). Solutions are often forged using community-based or participatory approaches (Agrawal, 2011 & Raik et al., 2005), particularly in regions of the world where resources available to management agency are limited or decentralized. Such efforts ideally incorporate context-specific factors (Naughton-Treves, 1999). Neglecting stakeholders can lead to an incorrect assessment of intervention success in terms of achieved levels of equitable participation and efficiency. This may also result in devastating and irreversible impacts for wildlife and people (Gore et al., 2008). Omitting stakeholders may also obscure the difference between those who have a stake in [wildlife conservation] and those who have the ability to act on it (Agrawal, 2000).

The long-term viability of threatened carnivores is significantly jeopardized when local people take action to eliminate so-called problem animals (e.g. by poisoning them). Human-caused mortality affects carnivore population dynamics by creating population sinks and decreasing the probability of population persistence (Woodroffe & Ginsberg, 1998). The extent and degree of these impacts on carnivore populations are substantial as much of the remaining range of threatened carnivores are on human dominated land (Dickman et al., 2011). Sustaining threatened carnivore species therefore depends on the capacity of local people to tolerate carnivore related risks and to desire increasing or expanding carnivore populations or, at the very least, policy favorable to their conservation (Riley & Decker, 2000b). The capacity of local people to cohabit with wildlife is strongly influenced by subjective psychological factors, including beliefs and perceptions (Decker & Purdy, 1988; Riley & Decker, 2000b; Zinn et al., 2000; Bruskotter et al., 2009). Several studies have assessed these factors independently with respect to threatened carnivores in various regions (Saberwal et al., 1994; Marker et al., 2003; Romañach et al., 2007) but none of these studies integrate psychological concepts into a comprehensive framework. Personal interactions with carnivores may occur in places where humans and carnivores live in close proximity (Saberwal et al., 1994; Wang et al., 2006). Where people live inside protected areas, controlling resource extraction is typically a management challenge (Terborgh & Peres, 2002). Studies have linked human density to declining ungulate densities as a result of hunting (Woodroffe, 2000), which consequently leads to declines in tiger abundance (Karanth & Stith, 1999; Madhusudan & Karanth, 2002; Karanth et al., 2004).

Around the world, HWC can pose severe problems for people such as decreased food security, increased workload, decreased physical and psychological well-being, economic hardship, and at times an increase in illegal or dangerous activities such as poaching (Ogra et al., 2008). Debate among affected parties regarding appropriate management responses to HWC can erupt (Treves A. et al., 2009) and may generate political conflict between people and institutions (Hill CM. et al., 2003). HWC can be similarly problematic for wildlife, contributing to population suppression, range collapse, or extinction (Woodroffe R. 2005). HWC is a highly complex phenomenon that transcends ecological, economic, management, political, and social systems (Gore ML et al., 2008). Resolving HWC fundamentally requires managing risk (Treves et al., 2006; 2003). Consent should be taken from communities prior to implementing any community-based conservation strategies (Agrawal B., 2001; Raik DB et al., 2005), particularly in regions of the world where management agency resources are limited or decentralized. Such efforts ideally incorporate context-specific factors (Naughton-Treves L., 1999; Wilson RS., 2008). Participatory approaches to biodiversity conservation can be viewed differently by various subgroups of people within a community (Ogra MV., 2008; Agrawal B., 2000; Agrawal A, Gibson et al., 2001). Who has a voice in community conservation influences how well a group functions and who gains and losses from or is affected by interventions (Agrawal B., 2000). Neglecting stakeholders can lead to an incorrect assessment of intervention success in terms of achieved levels of equitable participation and efficiency. This may result in devastating and irreversible impacts for wildlife and people (Gore et al., 2008). Omitting stakeholders may also obscure the difference between those who have a stake in (wildlife conservation) and those who have the ability to act on it (Agrawal B et al., 2000). Participatory approaches often aim to overcome stakeholder neglect by purposefully including diverse stakeholders in wildlife decision making. Ideally the approach leads to more democratic, executable, and creative management decisions through increased diversity in issue-related information and perspectives on conservation issues (Lauber TB, Knuth BA., 2000; Zanetell BA., 2001).

Although we may expect differences among different stakeholders' perceptions of and preferences for participatory HWC management (Anthony ML et al., 2004), differences are not always purposefully measured or incorporated (Agrawal, 2001), (Lauber et al., 2001; Anthony et al., 2004;Gore et al., 2006; Orga 2008). Whereas historically wildlife decision-making literature focused primarily on stakeholder groups who were mostly comprised of men (e.g. Anthony et al., 2004), women are now recognized as important players in contemporary conservation contexts (Anthony et al., 2004). Given the potential for gender differences in wildlife-related attitudes, perceptions, and behaviors, women need to be recognized as a unique and critical stakeholder group in HWC-related decisions (Anthony et al., 2004; Hunter ML et al., 1990). Risk perception [i.e., intuitive judgments as opposed to technical assessments about risk (Slovic P., 1987)] has been applied to gender and HWC although the three concepts are rarely, if ever, applied together. The risk and decision sciences literature tells us men and women commonly differ in their perception of risk (Flynn et al., 1994; Gustafson PE., 1998). Variations in risk perceptions seem to reflect not only gender differences in activities and social roles, but also unequal power relations and different levels of trust in authorities and institutions (Verchick RRM., 2004).

Psychologists offer insights about perceptual differences between risks (Gore et al., 2009). Human–wildlife conflict– e.g., crop damage, livestock predation, property damage, and attack of humans– often undermines local support for conservation. Such lack of support is evidenced by damage inflicted upon wildlife by humans, including habitat degradation or ‘‘retaliation” killings in which waterholes, crops, or baited carcasses are deliberately poisoned (Bagchi and Mishra, 2006; Sifuna, 2005). For example, in an extreme case from 2001, angered residents in northeast India (Assam) selectively targeted their paddy fields with poison for crop-raiding elephants; a mutilated elephant carcass was subsequently discovered in the field with the words, ‘‘Paddy Thief Bin Laden” scrawled upon its body (WTI,2007; Sethi, 2003). Two large gaps remain in the literature. First, while the visible costs (i.e., direct economic losses) of HWC have often been quantified, other ‘hidden’ costs are often not fully examined. A second gap within the HWC literature is that gendered aspects of conflict have not been identified or examined adequately (Ogra, 2007).

2.2 Literature Review

Velho Nandini et al (2012) used a meta-analysis of 143 hunting studies from India to identify the species and geographic regions most at risk, and to assess their legal protection. Hunting is one of the greatest conservation challenges facing tropical wildlife. They found evidence of hunting in 114 mammal species, with larger- bodied mammals being particularly vulnerable. Although 75% of all studies focused on mammals, few actually quantified hunting impacts. Further, among studies of all terrestrial vertebrates where hunting was mentioned, only 6% focused exclusively on hunting. With further research, they expected that the suite of species known to be exploited by hunters would increase. Later they concluded that the Eastern Himalaya and Indo-Myanmar biodiversity-hotspot complex is particularly vulnerable to hunting. Quantitative studies of hunting impacts are urgently needed across India, especially in this biodiversity-hotspot complex.

Badolo Ruchi et al (2010) examined the economic value of Corbett Tiger Reserve, India. They derived the direct cost from secondary sources, and indirect and opportunity costs through socioeconomic surveys. For recreational value the individual approach to travel cost method was used, and to assess carbon sequestration the replacement cost method was used. The maintenance cost of the reserve was estimated at US $2,153,174.3 year-1. The indirect costs in terms of crop and livestock depredation by wild animals ranged from US $2,408 to US $37,958 village -1 over a period of 5 years. The dependence of local communities was for fuel wood (US $7,346 day-1), fodder (US $5,290 day-1), small timber, and other non-timber forest products. The recreational value of the reserve was estimated at US $167,619 year-1. With the cost per visitor being US $2.5, the consumers' surplus was large, showing the willingness of visitors to pay for wildlife recreation. The forests of the reserve mitigate carbon worth US $63.6 million, with an annual flow of US $65.0 ha-1 year-1. The other benefits of the reserve include US $41 million through generation of electricity since 1972. The analysis revealed that, though the benefits outweigh costs, they need to be accrued to local communities so as to balance the distribution of benefits and costs.

Rastogi Archi et al (2010) analyzed stakeholder analysis (SA) to identify important stakeholder groups and assess their relationships, relative power and importance in Corbett National Park, India. This exercise was undertaken to assist the managers of CNP with future strategy formulation and implementation. The results demonstrated SA to be a simple, yet effective, method that can help PA managers understand the social dimensions of their undertaking, without waiting for long-term policy changes. The results also revealed possible stakeholder alliances, and those that may need strengthening to guarantee the welfare of Corbett National Park. Divergent opinions on the same issue were also discovered. This underlined that addressing low levels of knowledge and misplaced information may be of strategic importance in reducing conflict against a PA. This research also helps theorize previously unexplored relationships among stakeholders in India, using the framework of Stakeholder Theory.

Mehta Jai and Heinen Joel studied whether the approach of ‘people-oriented’ conservation adopted by Government in Nepal leads to improved attitudes on the part of local people or not. They study was conducted in Annapurna and Makalu-Barun conservation areas in Nepal. The data was collected using random household questionnaire surveys, informal interviews and review of official records and published literature. The study results indicated that the majority of the local people help favorable attitude towards conservation areas. Logistic regression results revealed that participating in training, benefits from tourism, wildlife depredation issue, ethnicity, gender and education level were the significant predictors of local attitudes in one or the other conservation area. They concluded that CBC approach has potential to shape favorable local attitudes and that these attitudes will be mediated by some personal attributes.

Damania Richard et al (2003) conducted a formal economic analysis of the two most imminent threats to the survival of wild tigers: poaching tigers and hunting their prey. They developed a model to examine interaction between tigers and farm households living in and around tiger habitats. They collected data by looking at existing literature on tiger demography, incorporating predator-prey interactions and exploring the sensitivity of tiger populations to key economic parameters. The analysis of the study aims to the sensitivity of tiger population to poaching incentives in prey depleted reserves. Tiger population appears to exhibit threshold responses to increase in poaching intensity. In particular, when prey levels are depleted, a relatively small increase in tiger poaching may trigger extinction. Thus, the control of poaching in prey-depleted environments remains a matter of critical concern. This suggests the need for increasing the conviction rates for poaching. The study concludes with a number of alternative measures to tackle the problem of tiger poaching. These include strategies to reduce the demand for tiger products in traditional oriental medicines and policies to control the illegal cross-border trade in tiger products which is controlled by criminal organizations.

2.3 Research Need

Human population of the earth exceeding 6 billion and growing at an estimated rate of 1.2% per year, or about 80 million (US census Bureau 2002), human-wildlife encounters will continue to increase. Attacks on humans are perhaps the least understood of these encounters, but the most interesting and emotionally connected to people. This lack of understanding, couples with the intense interest that attacks elicit, makes the situation ripe for reaction that will not only cause human injury or death but will also damage wildlife populations. There is a need for approaches to mitigate wildlife attacks on human, based on scientific understanding of conflict and behavior. Reducing attacks has the potential to reduce injury and loss of lives in human populations, conserve wildlife populations, promote good will towards wildlife, minimize economic loss, and improve quality of life for humans. Despite the need to understand attacks and circumstances associated with attacks, little objective information exists about attack incidences and there are little information. Moreover, there is a need for global perspective to minimizing conflicts. Local success in reducing conflict can bring gratification and can inspire others. But the sharing of such information and the standardization of information-gathering can bring a greater good outcome of an integrated approach (Quigley Howard & Herrero Stephen., 2005).

Natural resources like trees and grasses in Corbett National Park are exploited by the local population while encroachment of at least of 13.62 ha (0.05 sq. mi) by 74 families has been recorded (Corbett National Park-Project tiger directorate). The villages surrounding the park are at least 15–20 years old and no new villages have come up in the recent past. The increasing population growth rate and the density of population within 1 km (0.62 mi) to 2 km (1.24 mi) from the park present a challenge to the management of the reserve (Tiwari & Joshi 1997:263). Incidents of killing cattle by tigers and leopards have led to acts of retaliation by the local population in some cases. The Indian government has approved the construction of a 12 km (7.5 mi) stone masonry wall on the southern boundary of the reserve where it comes in direct contact with agricultural fields (Corbett National Park- Project tiger directorate). The habitat of the reserve (Corbett National Park) also faces threats from invasive species such as the exotic weeds *Lantana*, *Parthenium* and *Cassia*. The heavy influx of tourists has led to visible stress signs on the natural ecosystem. Excessive compaction of soil due to tourist pressure has led to reduction in plant species and has also resulted in reduced soil moisture. The tourists have increasingly used fuel wood for cooking. This is a cause of concern as this fuel wood is obtained from the nearby forests, resulting in greater pressure on the forest ecosystem of the park (Tiwari & Joshi 1997:309). Additionally, tourists have also caused problems by making noise, littering and causing disturbances in general (Tiwari & Joshi 1997: 311).Booming human population results in loss of natural habitat which bring wild animals closer and in contacts with each humans. A multidisciplinary research is needed to understand factors influencing human-wildlife interactions and conflicts. There is a need to scientifically analyze and understand how socio-economic factors and demographic factors influence human-wildlife interactions and conflicts; and how this affects stakeholders perception towards wildlife.

So to fill the research gaps in human-wildlife conflict dimension, this study is very significant. The important outcomes from this study will be the graphs and the tables which will help identify factors influencing conflicts. It will also help identify which animal species is responsible for maximum crop-loss, livestock loss and for human wildlife conflicts. The empirical model will help understand the nature of human-wildlife conflict and factors driving it and will also help suggest several crucial recommendations and management implications to manage conflicts. These outcomes will play a very significant role in exploring and understanding interaction between human and wildlife at a very fine scale.

2.4 Aim

The main objective of the study is to understanding stakeholder's perception towards human-wildlife interaction and conflict within and around Corbett National Park, India.

2.5 Specific objectives

The specific objectives of the study are:

i. To evaluate human-behavior for resource extraction around Corbett National Park.

ii. To quantify crop-loss and livestock predation in study-area.

iii. To identify major reasons for human-wildlife interactions and conflicts.

2.6 Study area

Jim Corbett National Park (Coordinates: 29'32'00" N latitude and 78'56'7" E longitude) is the oldest national park in India *(*Riley et al., 2005). The park is named after the hunter and conservationist Jim Corbett who played a key role in its establishment in 1936 as Hailey National Park. Situated in the Nainital district of Uttarakhand the park acts as a protected area for the endangered Bengal tiger of India. The park had 154 Tigers in 2009 but after implementing core-buffer zone strategy and increase in number of park rangers, the number has risen to 214 tigers as per 2010 tiger census undertaken by Government of India. Still the tigers face a serious threat in Corbett National Park because of human-tiger conflict and poaching.

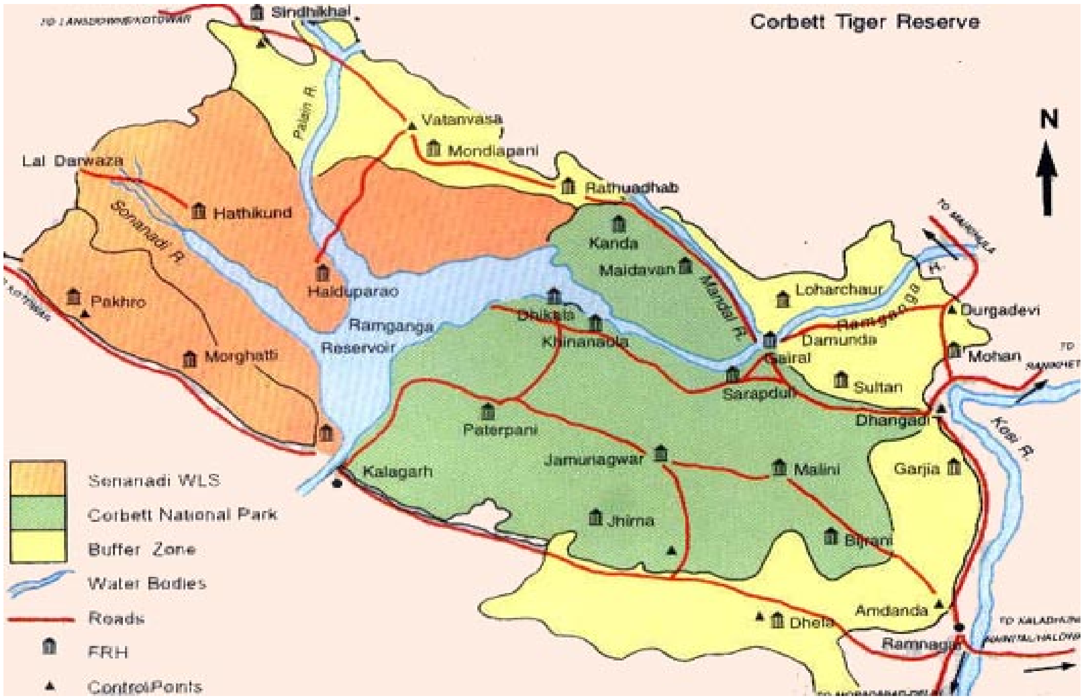


Figure 1: Corbett National Park map

(**Source**: Compiled from http://www.panthera.org/landscape-analysis-lab/maps/Tiger and http://www.corbett-national-park.co.in/corbett_national_park_map.html)

The park has geographical and ecological characteristics of sub-Himalayan belt (Tiwari et al. 1997). An ecotourism destination, it contains 488 different species of plants and a diverse variety of fauna (Tiwari et al. 1997 & Pant, 1976. Corbett National Park is India's first national park which comprises of hills, riverine belts, marshy depressions, grass lands and large lake. The elevation ranges from 1,300 feet (400 m) to 4,000 feet (1,200 m). Winter nights in Corbett national park are cold but the days are bright and sunny. It rains from July to September. The core area is 821.99 Sq. Kms, Buffer area is of 466.32 Sq. Kms, and the total Area of the National Park is 1288.31Sq. Kms. Dense moist deciduous forest mainly consists of Sal, Haldu, Pipal, Rohini and mango trees, and these trees cover almost 73 per cent of the park. The 10 per cent of the area consists of grasslands. It houses around 110 tree species, 50 species of mammals, 580 bird species and 25 reptile species.

2.7 Methodology

To better understand stakeholders' perception towards human-wildlife interaction and conflict, we surveyed stakeholders living in villages surrounding Corbett National Park using a standardized questionnaire. The survey was reviewed and approved by the IRB (Institutional Review Board) of University of Massachusetts, Amherst. We surveyed the following 15 villages lying in and around Corbett National Park using a standardized questionnaire. Geographic coordinates of the villages survey are: (1) Dhapla/ Chukham (29°19' 05.34" N 79°24' 23.17" E); (2) Dhara (29°25'57.12" N 78°50'48.81" E); (3) Phanto (29°21'17.39" N 78°52'55.67" E); (4) Dhela (29°24'59.58" N 78°59'39.23" E); (5) Lal-dhang (29°26'02.13" N 78°58'01.44" E); (6) Choi (29°21'07.53" N 79°08'41.53" E); (7) Maloni (29°27'50.76" N 78°48'45.92" E); (8) Lal-baugh (29°27'38.83" N 78°49'17.85" E); (9) Teda (29°25'23.84" N 79°08.20.04" E); (10) Patarpani (29°13'13.67" N 79°41'33.50" E); (11) Hathidagar (29°22'41.90" N 79°01'15.19" E); (12) Aamdanda (29°25'02.93" N 79°07'18.04" E); (13) Marchula (29°36'24.35" N 79°05'31.91" E); (14) Ringora (26°26'11.24" N 79°07'50.23" E); and (15) Sunderkhal (29°30'08.63" N 79°07'30.79" E). We surveyed a total of 314 households from 15 villages; sampling more than 25% of the total household population from each village.

For unbiased sampling, we used two survey methods to collect data from each village. The field work was conducted from May till August 2013 during the monsoon season. During the monsoon season, the roads are badly affected by rains in Corbett National Park which makes it almost impossible to access certain villages and area of the park. So we tried to survey all the possible villages which were accessible by car and on-foot during that time of the year. Once the village was selected, we used two different survey methods: A) Snow-ball technique and B) Stratified random sampling method. The first method we used to survey was the snow-ball technique (Goodman L.A., 1961). We started the survey by contacting the head of the village and explaining him the exact motive for the survey. We interviewed him with his proper consent and later asked him to recommend us to a household who faces crop-loss, livestock loss or human-life damage because of wildlife. After surveying the first household facing damage because of wildlife we requested the respondent to assist us to some another household in the same village who faced similar issues related to wildlife conflict. Snowball sampling is a non-probability sampling technique that is used by researchers to identify potential subjects in studies where subjects are hard to locate. Researchers use this sampling method if the sample for the study is very rare or is limited to a very small subgroup of the population. This type of sampling technique works like chain referral. After observing the initial subject, the researcher asks for assistance from the subject to help identify people with a similar trait of interest. The process of snowball sampling is much like asking your subjects to nominate another person with the same trait as your next subject. The researcher then observes the nominated subjects and continues in the same way until the obtaining sufficient number of subjects. This method helped us get much focused samples from each village.

The very next day we went to the same village and surveyed it using stratified random sampling method. According to this method, we randomly surveyed households from the central part of the village and also from each of the four sides of the village. We avoided those household which were already surveyed using snow-ball technique. This helped us survey the entire village more randomly in which each and every household had equal chance of getting selected for survey within the sampling area/individual village. A larger sample size was obtained in stratified random sampling than in snow-ball sampling for every village.

Using a standardized survey questionnaire, we aimed to understand stakeholder's perception towards existence of tiger in their surrounding forested area and also towards human-wildlife conflict. Majority of the questions were specifically focused towards tigers and its conservation in the study area. We assessed tolerance level of stakeholders to livestock loss, crop loss and human-life injury/loss by wildlife and also quantified willingness of stakeholders to contribute towards tiger conservation and reducing human-wildlife conflicts in the study area. Evaluating reasons for human-wildlife interaction and conflicts and assessing dependency of stakeholders on forest and non-timber products was also an integral part of the study. We also gathered some information on poaching scenario of herbivores and carnivores within the study area. The questionnaire was pre-tested on 25 people to ensure clarity before use. The survey covered four main areas: (i) socio-economic characteristics of respondents; (ii) Interviewees' perception and knowledge of wildlife; (iii) human-wildlife interaction, conflicts and consequences; and (iv) Current strategies implemented by stakeholders, Governments and NGO's to reduce conflicts and stakeholders willingness to contribute towards tiger conservation and reducing human-wildlife conflicts.

Only those respondents' who voluntarily agreed to take part in the study were interviewed in person. Any form of compensation was not paid to respondents and they were informed about this prior the interview. The sampling unit was the household, with interviews restricted to one respondent per household. To assess the knowledge and perceived problem with wildlife regarding livestock loss, respondents were shown photographs of tiger, leopard *(Panthera pardus)*, cheetah *(Acinonyx jubatus)* and lion *(Panthera leo)* and for crop-loss we showed them a photograph of cheetal *(Axis axis)*, sambhar *(Rusa unicolor)* and nil-gai *(Boselaphus tragocamelus)*. In order to test respondent reliability, we checked whether the respondent could identify and differentiate between the 4 species or not. Once the respondents were clear about the species, we asked them question related to human-wildlife interactions and conflicts. We quantified and analyzed several variables that could potentially influence people's perception at individual and village level. These included the age and education level of the interviewee, based on Kellert (1985, 1991), who reported that in Minnesota young, urban, educated people tended to have relatively positive attitudes toward carnivores relative to older, rural, less educated people. We also included gender, following Bjerke et al. (2001), who reported that in Norway, women were less accepting of carnivores due to fear. Livestock holdings and proportions of livestock killed by predators were included as explanatory variables (Suryawanshi et al. 2013), as were the number of sources of income because economic loss due to large carnivores generally contributes to the negative attitudes toward them (Williams et al. 2002; Bagchi & Mishra 2006). Village size was included following Klieven et al. (2004), who reported that people were more accepting of carnivores when they lived far away from them and when the human communities were larger.

The language of communication was in Hindi. Each and every individual participating in the survey was very well informed about the motive of the research prior their interview and no private information were collected. Each interview session lasted for around 12 to 15 minutes per person. We only interviewed the head of the household with their prior consent. Only when the respondent consents to the interview, we proceed further. The participants were informed that they will never be contacted in future. To avoid any kind of potential risk we protected the confidentiality of the study records. No identity of the respondent was collected during the survey such as name/address/phone number. All the data was kept anonymous and the original data sheets were never shared with anyone else except for those involved in this project. We used a blind number to represent each respondent and were not having any personal information attached to this number. In the process of the interview, we tried our best to minimize the chances of response bias. We had a local guide to accompany us during the household interviews. Those questions related to potential illegal behavior would be asked in a smart way and we would also crosscheck their answers by asking similar questions in different ways, or by asking our local guides or their neighbors.

2.8 Analysis

Data was processed using a simple spreadsheet and analyzed using graphs and tables. The head of the village questionnaire sheets, snow-ball technique questionnaire sheets and stratified random sampling questionnaire sheets were analyzed separately. To compare and analyze the variables at village and species level, we developed bar-graphs. We calculated the percentage of each variable at village and species level and compared them with each-other in order to find the most influencing variables and least influencing variables amongst all. The variables used in the analyses were determined from the questionnaire survey results.

2.9 Results

We surveyed 314 households within and around Corbett National Park, India. Out of 314 households surveyed, 15 were head of the village (Sarpanch), 119 households were surveyed using snow ball sampling technique and remaining 180 household were surveyed using stratified random sampling technique.

2.9.1 Dependency of stakeholders on forests and forest products

From the questionnaire data, we observed that the head of the village was generally a wealthy person with a good socio-economic status in the society. Socio-economic status of a stakeholder and the head of the village were determined by the construction type of his/her house, size of the house, agricultural land owned, livestock owned and vehicles owned. The size and construction type of the house were both closed ended questions. Construction type of the house focused on the material used to build the house. We enquired if the house was constructed using cement, bricks or mud and cow dung. Size of the house was determined by the area of the house constructed.

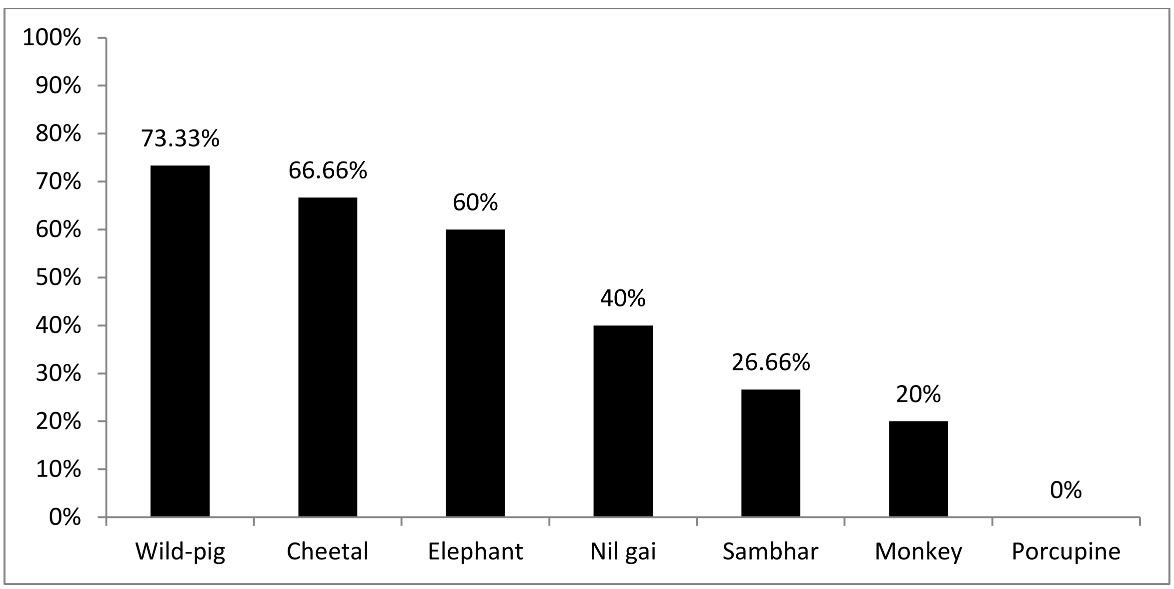
We observed that out of the 15 head of the village surveyed 93.34% were engaged in grass collection from the protected area, 86.67% were involved in timber collection and fruit collection contributed to 6.70%. Whereas none of the heads were involved in honey collection, vegetable collection, worked on daily wages. The stakeholders used timber as fuel wood and/or to construct fences and houses. Grass is collected from forest to feed livestock like cow, buffalo, ox and goat. Out of 119 household surveyed using snowball sampling techniques, timber and grass were the major collections with 93.38% and 94.21% respectively. Minor collections were contributed by Honey with 5.78%, Fruit with 8.26% and Vegetable with 5.78%. Most of the stakeholders own agricultural land or/and livestock which helps them generate income and only 2.47% were reported to work on daily wages. 180 household were surveyed using stratified random sampling method out of which 85.55% stakeholders reported to be engaged in timber and grass collection whereas 3.24% gathered honey, 4.44% collected fruits, 1.66% collected vegetables from the protected area and only a small fraction of 1.11% were dependent on daily wages.

Stakeholders have several advantages as well as disadvantages of being located near protected area. Amongst the 15 head of the village surveyed we noticed that 93.34% used forest products for household use, 86.67% used open land for livestock grazing, 66.67% took advantage of forest based agriculture, 6.66% believed that the forest provided them clean environment and had food security. While none of the heads generated any revenue by trading forest products. Along with the advantages 93.34% of the total of head of the village surveyed faced disadvantage of crop loss, livestock loss and human-wildlife conflict. 46.67% faced disadvantage of restricted grazing areas for the livestock and 53.33% had issues on prohibition of forest product collection. The snow ball sampling technique results suggest that 93.38% of stakeholders used forest products for household use, 90% took advantage of open land for livestock grazing, 81% conducted forest based agriculture, 16.52% appreciated clean environment and 13.22% had food security. More than 90% of them faced crop loss (91%), livestock loss (95.87%) and human-wildlife conflict (94.21%). More than 50% of them had disadvantage over prohibition of collecting forest products (56.2%) and restricted area for livestock grazing (53.72%). The data obtained from stratified random sampling technique indicates that 95% of stakeholders used forest products for household use, 91.66% appreciated having open land for livestock grazing, 70% were involved in forest based agriculture, 11% relished clean environment, 5.55% had food security and only 1.11% generated revenue trading forest products. This clearly shows that stakeholders had more disadvantages than advantages of being located near a protected area.

2.9.2 Crop-loss to wildlife per year

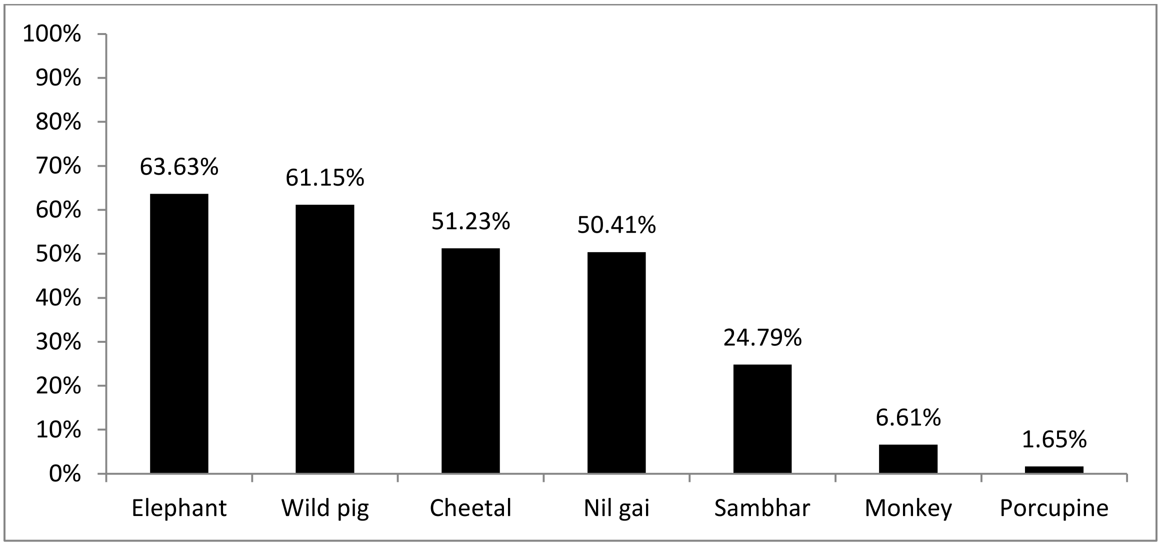
The questionnaire also focused on assessing crop lost to wildlife per year in acres. The head of the village survey data reported 36.50% of crop lost to wildlife per year of the total crops harvested. As shown in the fig.2 wild pigs *(Sus Scrofa)* played a major role in damaging the crops in this area by raiding 73.33% of the total crops harvested per year. Cheetals and Elephants were responsible for 66.66% and 60% of the crop loss per year. Nil gai was responsible for 40%, Sambar for 26.66% and Monkey for 20% crop loss of the total crop harvested per year. Porcupine did not contribute to the any loss of crops.

Figure 2: Head of the village survey data analysis for crop-loss per year



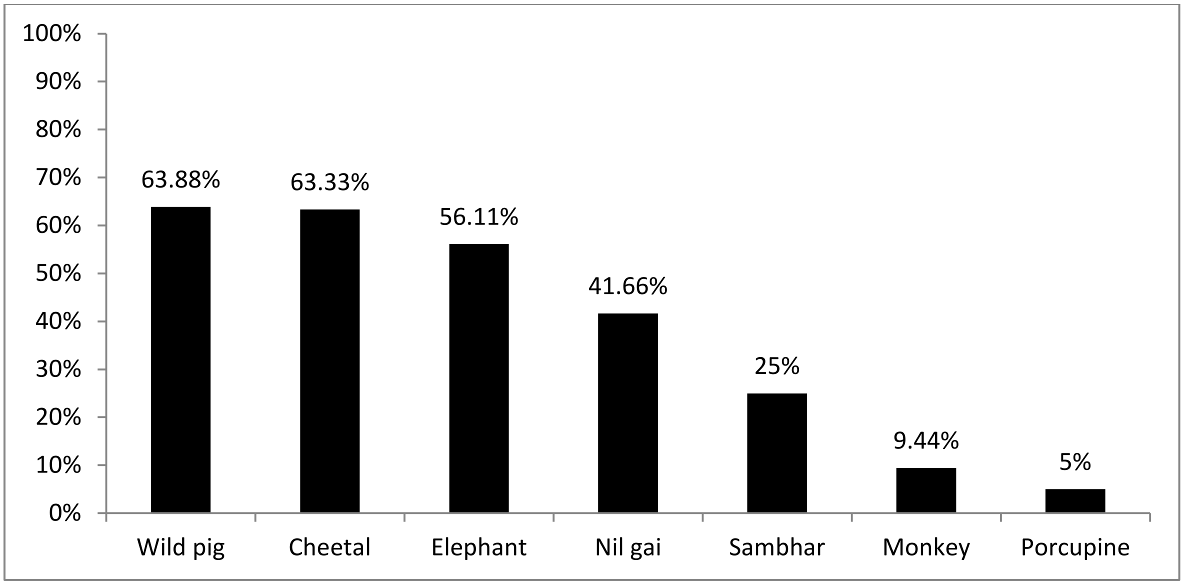
The results from snow ball sampling data analysis show that 44.40% of total crops harvested per year were lost to wildlife. As shown in fig.3, elephants damaged the crops by 63.63%, wild-pig by 61.15%, cheetal by 51.23%, Nil gai by 50.41%, sambhar by 24.79%, monkey by 6.61% and the least damage was caused because of porcupine by 1.65% within all the villages lying around Corbett National Park.

Figure 3: Snow-ball technique survey data analysis for crop-loss per year.



The stakeholders' surveyed using stratified random sampling technique reported 46.50% crop-loss to wildlife of total crop harvested per year. Out of 180 household surveyed using stratified random sampling technique, 63.88% of them incurred crop damage by wild-pig, 63.33% by cheetal, 56.11% by elephants, 41.66% by nil gai, 25% by sambhar, 9.44% by monkey and only 5% by porcupine.

Figure 4: Stratified random sampling technique survey data for crop-loss per year



We also assessed the tolerance level of stakeholders towards crop-lost to wildlife per year of the total crops harvested. The results reflect that the head of the village questionnaire survey data had 20% crop-loss tolerance level to wildlife of the total crop-harvested per year, snow-ball sampling technique survey data showed 2.40% tolerance level to crop loss per year and stratified random sampling technique survey data indicated 13.88% tolerance level to crop-loss per year to wildlife.

2.9.3 Livestock lost to wildlife in past 5 years

To assess livestock loss in past 5 years we categorized prey species into large prey (cows, oxen, buffalo) and small prey (goats and pet dogs). According to the head of the village survey data analysis, tigers were the only species that killed large prey and leopards were responsible for only small prey killed. As per snow-ball survey technique data analysis, tigers killed 97.50% of the total large prey in this area, but were responsible for only 2.52% of total small prey killed. Leopards were responsible for 100% of small prey killed. Stratified random sampling data analysis suggests that 100% of the large prey were killed by tigers and 100% of small prey were killed by leopards.

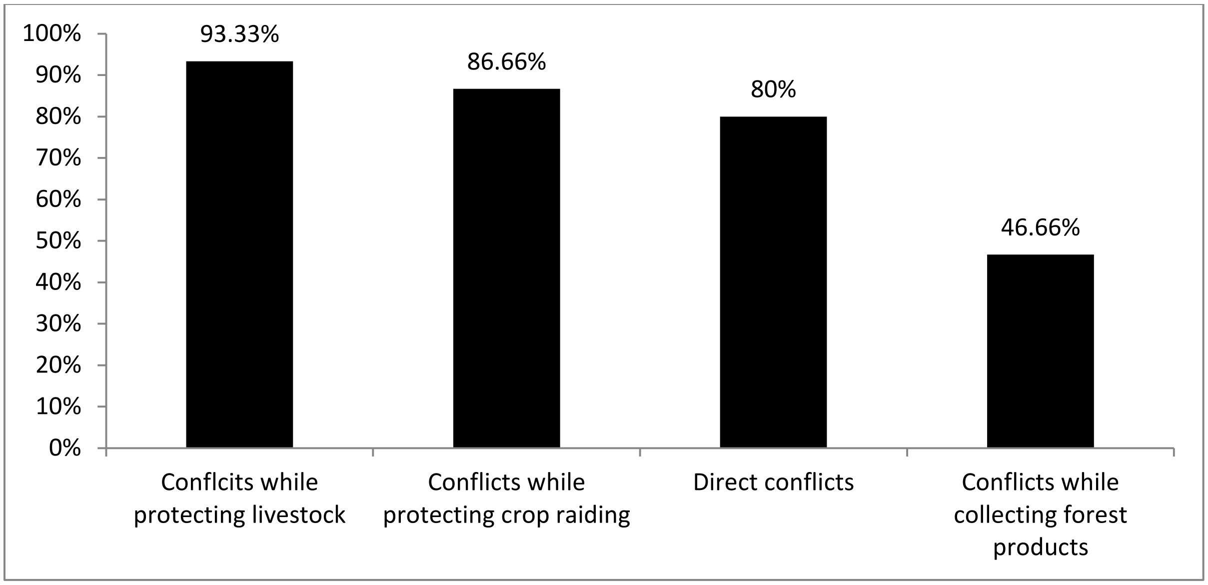
We quantified tolerance level of stakeholders towards livestock loss within and around Corbett national park area. Only those stakeholders who were surveyed using snow-ball sampling technique showed 2.4% tolerance towards livestock lost to wildlife per year. The rest of all household had no tolerance at all towards livestock loss.

We also analyzed stakeholders perception towards tigers in all 15 villages. We found that 80% of the head of the village had negative perception towards tigers. They considered them to be cruel, cunning, nature's killing machine and frightening. Only 20% of them had positive perception towards tigers and considered them to be beautiful creatures holding religious values and also helped in maintaining herbivore population and ecosystem. The results from snow-ball sampling technique indicated that 70% of the stakeholders had negative perception, 22.50% had positive perception and 7.50% had neutral views towards tigers. The stratified random sampling method indicated that 72.60% stakeholders had negative perception, 22.40% had positive perception and 5% had neutral perception towards tigers.

2.9.4 Human-wildlife interaction and conflicts

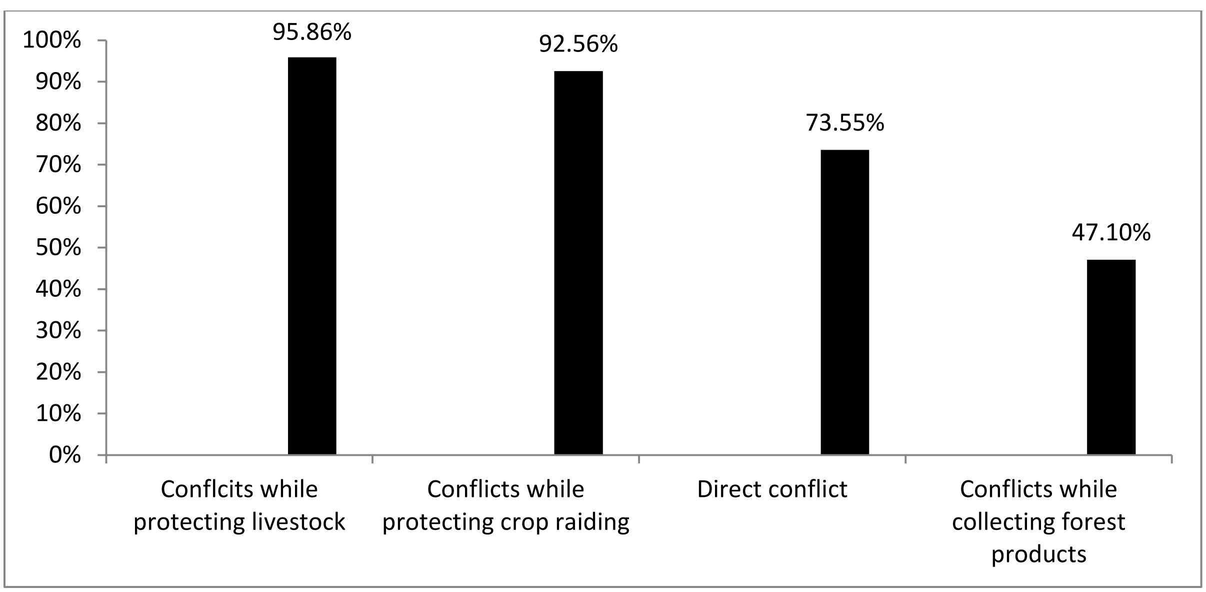
From the questionnaire survey data, we identified four main reasons for human-wildlife interaction and conflict in our study area. Out of the 15 head of the village surveyed, 93.33% of them agreed that they faced conflicts while protecting their livestock's when predated by wildlife, 86.66% of them agreed on facing conflicts while protecting their crops when raided by wild animals. While 80% of them admitted that they had direct conflicts with wildlife. Whereas, 46.66% told that they had conflicts while collecting forest products.

Figure 5: Major reasons for HWC as per head of the village survey data analysis



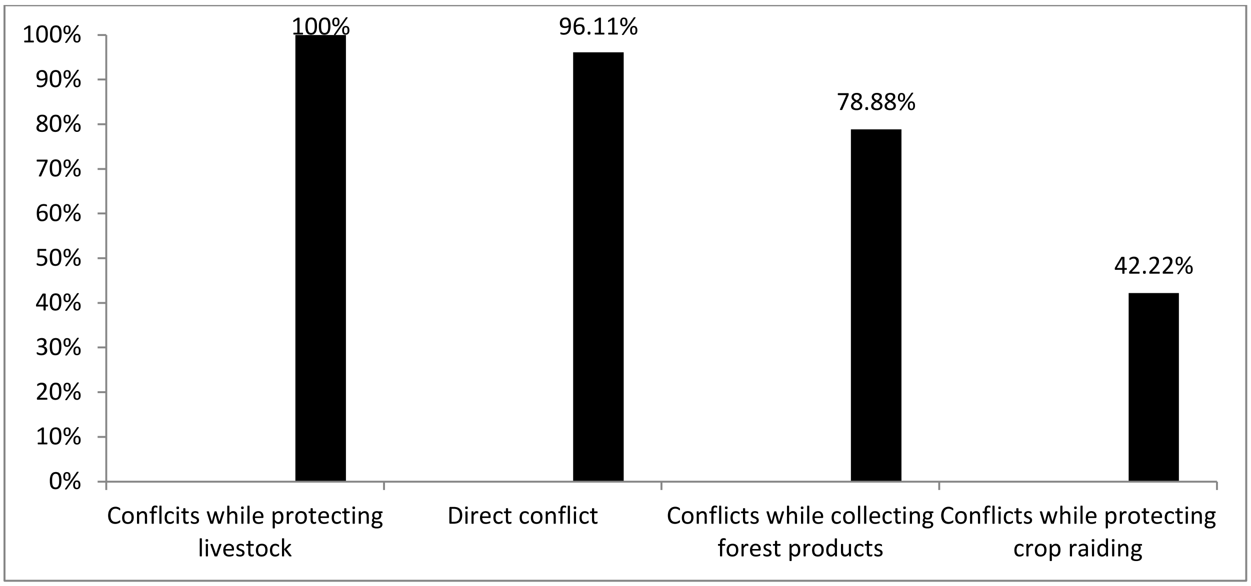
Out of 119 households surveyed using the snow ball sampling technique, 95.86% of them had conflicts while defending their livestock s from wild animals, 92.56% of them agreed that they had conflicts with wild animals while protecting their crops. 73.55% of the stakeholders had direct conflicts with wildlife and only 47.10% faced conflicts while collecting forest products.

Figure 6: Major reasons for HWC as per snow-ball technique survey data analysis



The stratified random sampling data reflects that all of the 180 households surveyed had conflicts while protecting their livestock and 96.11% of them faced direct conflicts. 78.88% of the stakeholders reported conflicts with wildlife while collecting forest products. Only 42.22% stakeholders reported conflicts while protecting their crop from being raided by the wild animals.

Figure 7: Major reasons for HWC using stratified random sampling technique data analysis



Human-wildlife interaction and conflict is a serious issue in the villages lying in our study area. The head of the village survey data result reports that in past 1 year, the stakeholders faced 7 encounters with wildlife. Of the 7 encounters, 28.58% of them were recorded individually by elephants, tigers and leopards. 14.29% of them were because of black bear whereas none of them faced any conflicts with wild pig. Of the 7 encounters reported, 6 individual faced minor injuries and only 1 individual was seriously injured.

Out of 119 households surveyed using snow ball sampling technique, 22 encounters with wildlife were reported in past one year. 59.09% of them faced conflicts with elephants, where as 18.19% and 13.63% of them had conflicts with tiger and leopard respectively. Only 9.09% of them reported conflicts with black bear and none was reported due to wild pigs**.** 13 individual suffered from minor injuries and 9 suffered severe injuries.

34 encounters with wildlife were reported in past one year of 180 household's surveyed using stratified random sampling technique. More than 50% of the encounters (52.94%) of them had conflicts with elephant and 23.52% of them had conflicts with tiger. 11.76% and 8.82% of them had conflicts with leopard and black bear respectively. While 2.94% of them reported conflicts with wild pigs. 25 individuals reported to incurred minor injuries while 9 individuals faced severe injuries. More than 85% of the stakeholders from all the three types of survey: head of the village, snow-ball technique and stratified random sampling agreed to volunteer to prevent conflicts. They agreed to volunteer in form of providing time, monetary contribution, labor to help construct and maintain fence, pit and tower.

2.10 Discussion

This samples collected using snow-ball technique belonged to a focused group of people who were severely affected by wildlife with respect to crop-loss, livestock loss and human-wildlife conflicts. While the stratified random samples were the rest of the stakeholders who were missed during snow-ball sampling. Head of the village where mostly those people who had lived for a longer period of time in that village, who held a good socio-economic status and influence in the society and all of them where financially sound. The stakeholders who were surveyed using snow-ball technique depended more on forests products than the rest of them. None of the head of the village where involved in honey collection, vegetable collection or worked on daily wages. Similar results were observed by Rastogi A et al. in 2012 during their study on reviewing the social factors affecting tiger conservation around Corbett National Park. Most of the stakeholders believed that they had more disadvantaged than advantages of being located near a protected area. Four major reasons for human-wildlife interactions and conflicts were identified in our study area. More than 90% of the total stakeholders surveyed reported conflicts because of livestock predation and crop raiding. About 73.56% of the conflicts were reported as direct conflicts and 42.67% conflicts occurred while collecting forest products. Although extracting forest products from protected areas is prohibited by the rules of Government of India, still villagers collect them in order to sustain their basic livelihood needs. Stopping the villagers from collecting forest products for their daily needs will generate hostile behavior towards forest department and Government of India which can prove very challenging for sustaining the protected area implementing community-based conservation practices. We suggest that stakeholders should only be allowed to collect forests products from park boundary/peripheral areas only. Entry deep inside the park should be strictly monitored as most of the conflicts were observed to have taken place deep inside the park areas. While collecting forests products from the border area, villagers should walk in groups carrying sticks, making loud noises and singing songs in order to keep wild-animals away from them. Pet dogs can prove to be very useful in detecting wild animals while collecting forest products. Alternate and renewable source of energy to fuelwood like solar powered appliances should be promoted in order to minimize forest product dependency.

Direct conflicts are the most lethal of all conflicts in which both- the animal and humans have risk to fatal injuries or even death sometime. We observed that some weakly constructed houses in our study area were easily damaged or collapsed when attacked by wild-animals like elephants that were searching for food. So we suggest that villagers should construct their houses strong enough to resist wild animals attack or should be designed in such a way that they avoid animals attack. If possible, relocating the villages lying within the national park area can be a most effective approach undertaken with the help of Government officials, forests department officials and NGO’s. Relocation should only be taken into action with stakeholders consent to relocate and incentives to stakeholders should be provided in order to give them a head-start to a new place. Stakeholders should be strictly warned about not engaging in direct conflict with wild animals when they raid their crops or predate their livestock. Several strategies to prevent crop-raiding and livestock predation should be carefully used as mentioned above. Wandering deep into the forests for timber or grass collection should be strictly restricted as it has been a major cause for direct conflicts in Corbett national park. In our study area it was noted that stakeholders used to track and kill the problem animal predates their livestock. This leads them into direct conflict with wild animals mostly carnivores. In most cases the problem animal is eradicated because of retaliation and anger in villagers caused by the loss of livestock. In some cases, innocent animal is targeted who did not kill the livestock; while the one predating on livestock escapes away. As the villagers don't have any significant evidence on which animal killed their livestock and what animal was it, they just track the livestock carcass and kill the one found closest to it. In few scenarios, it was also observed that the villagers were not able to differentiate between tiger and leopards. The stakeholders were aware of the fact that the tiger and the leopard are two different animals, but they used the term 'tiger with stripes' for an actual tiger and 'tiger with spots' to represent leopard. So this is how they blamed tigers for most of the livestock predated and developed an hostile behavior towards tigers even though leopard had killed their cattle. This is where education and awareness amongst local people play a significant role. Education focusing on teaching local people the common names used by the entire world for animals living in their close proximity and also teaching them the difference between two animals is must. This will help them identify and differentiate between two animals when there is a livestock kill or human wildlife conflict. This will also help them convey proper names of the problem animals to the government and forest officials while reporting any kind of conflict incidences. Our study observed that 100% of the total big livestock like cow, buffalo or Ox were killed per year by tigers in our study area and 97% of the small livestock like goat, sheep and dogs were killed by leopards. Still the tiger was the one at blame by villager even though there was a small livestock kill in the area. This has caused more anger amongst villagers for tigers and they want them out of the national park. Few of the villagers even mentioned that they want the tigers, leopards and elephants to be behind bars in zoo and they don't want them inside national park. Similar results were observed by Karanth Kirthi et al which undergoing a study on local resident perception of benefits and losses from protected areas in India and Nepal in 2011. Many also argued that the Government and forest department should allow villagers to at least kill porcupines and pigs entering their farms, which according to them held no significant value and were major threat to their crops. Some of the angry villagers also commented that if they cannot remove the elephants from the national park then the Government should tie all the elephants with ropes and chains to trees inside the forest so that they cannot move and cannot cause any damage to their crops. We also noticed an unusual and rare activity being carried out within the park boundary. Few villagers were reported to be involved in prey scavenging activities which lead to direct conflicts with wild animals. The villagers would track down the prey killed by tigers or leopards in small groups and steal it from them by scaring them away using sticks, stones and making loud noises. Later they sell the meat in market for money or consume the fresh one left in it. This behavior will make the wild animal more aggressive and hungry. So in order to satisfy his hunger, the tiger or the leopard will again go for a hunt and will kill another livestock which will make villagers more hostile towards wild animals. Prey scavenging needs urgent attention and needs to be monitored very strictly.

Wild pig, Elephant, Cheetal and Nil gai were identified as the main species responsible for crop loss in our study area. Porcupine and monkey played a negligible role in crop raiding in our study area. Stakeholders were able to identify and differentiate between cheetal, sambhar and nil gai. We also confirmed their reports by visiting recently raided crop-lands and by analyzing the foot-prints of animal, if they were in herds or single and by the way the crops were damaged. Elephant raiding was identified by their large foot-prints and by the way they crushed the crops while they moved through the fields. Cheetals graze in groups and were easily identified by multiple foot-prints and by the smaller size of the foot-prints compared to sambhar or nil gai. Sambhar usually wanders solitary and was identified because of its dark-dull complex and larger foot-prints compared to cheetal. Nil gai was identified by the foot-prints, sighting by villagers and by their huge size.

The stakeholders were also able to easily identify between and elephant and cheetal when we showed them the photographs. It took a while for the stakeholders to differentiate between sambhar and nil-gai but they figured it out correctly by differentiating between the size and color of both the species. Nil gai appeared to be bright in color while sambhar has dull and dark color. Moreover, nil gai is larger in size than sambhar and appeared to resemble a cow.

Preventing Elephants, Nil Gai, Cheetal and Wild pigs from entering farmlands within our study area will significantly reduce crop raiding. To prevent elephants from entering crop lands, solar powered electric fence should be installed encircling every village. The height and quality of the fence should be tall and strong enough that no animal should jump over it or break it. The electric-current through the fence should be preciously regulated in order to avoid causalities to animals or humans. The fence should be properly maintained and any damage should be fixed immediately. Pits should be built around farms which will help restrict Elephants, Cheetal, Sambhar, Nil Gai and Wild pigs from entering farms. The pits should be constructed deep and wide enough so no animal can jump over it. Pits should be regularly cleaned and properly maintained to avoid the pit from refilling. Watchtowers should be constructed at couple of points in every village. The number of watchtowers to be build depends on the area of the village. Watchtowers should have a huge bell, a big torch light and should have enough space to accommodate at least 2 people for prolonged hours. Watchtowers need to be high enough to be able to survey/cover significant area of the village. They can play a very helpful role in tracking group of animals marching towards farms. Villagers should be alarmed by ringing the huge bell installed on watch towers. Though this can be a very costly option but it will prove to be a very significant and efficient in preventing crop-loss. Security dogs can also be used to keep wild animals from entering farms. Training street dogs can be a very cost effective approach in India. They can help detect animals, chase them away and also alert villagers by barking prior crop raiding or livestock predation. Once wild animals are detected entering farms, loud noises can help to scare and drive these animals away using fire-crackers, loud speakers, torch lights, flash lights. These are the best ways to drive wild animals away avoiding damage to crops, humans and animals. Hand-made bombs are used by certain villagers to drive away elephants but this can be a dangerous option causing injuries to both- wildlife and humans; if not used properly. A small group of villagers should be formed in every village, who will appoint a leader amongst them. This group shall be responsible for maintaining the solar-powered fences, pits, watchtowers, security dogs and officials to guard the towers.

Government and NGO's helped installed solar powered fences, constructed pits and built walls across few villages reported with high crop-raiding and livestock predation around Corbett National Park. A committee was also appointed in every village that was responsible for maintenance of all these structures. But no one took care of those fences and wall and everything got destroyed. Some villagers even sold the stones and bricks from the wall to make some money and few also sold the solar powered fence wires for money. Pits were filled with sand and soil by few villagers to get easy access to their farms and also to help save fuel used in their vehicles. This destruction again gave access to farms and livestock. In future to avoid this, Government should ask the villagers to invest some money from their own pocket in order to help build such structures to protect their farms and livestock. This will develop a sense of responsibility amongst villagers and they will properly maintain them as they too have invested into it. Contribution to build these structures should depend on the socio-economic status of the individual. Few cases of herbivore in farmlands were reported. Villagers' plant traps for herbivores to catch them and prevent their crops from being raided. Few villagers even consumed the meat of animals caught in the trap.

2.11 Conclusion

Mitigating human wildlife conflicts and interactions has become a major conservation challenge for biologist since past few decades. There is very little literature available on human-wildlife conflict and interaction for Corbett National park, India. To understand how socio-economic status influences stakeholders perception towards wildlife, we surveyed a total of 314 households from 15 villages within and around Corbett National Park. We analyzed the questionnaire survey data using simple spreadsheet and found that most of the stakeholders depend on forest products for their basic necessities of timber, grass and livestock grazing. We observed that there was a research gap in past literature on predicting or blaming the animal responsible for livestock kill around the national park area. We tried to cover that research gap by properly analyzing our survey results and found that most of the time when a small or a big livestock was killed, the villagers would directly blame tiger without any sort of evidence. This is one of the major factors which alters people's perception towards wildlife and makes them more hostile towards tigers. Our data reflects that in our study area, leopards mainly killed the small-sized livestock like goat, sheep and dogs; and tigers only preyed on large livestock like cows and buffalos. Proper education focusing on teaching people the difference between species, their names and their identity is the key to address this problem and to help keep stakeholders perception positive towards wildlife. One of the unique things about this study is that we identified five major reasons which lead to interactions and conflicts between stakeholders and wildlife in this area and also identified major species responsible for crop-loss, livestock loss and for human-wildlife conflicts. To need better management practices, better education, community-based conservation, efficient and fast incentive schemes and promote eco-tourism to help mitigate human-wildlife conflict and help stakeholders maintain a positive perception towards wildlife within and around Corbett National Park.

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CHAPTER 3

FACTORS INFLUENCING HUMAN-WILDLFE CONFLICTS IN CORBETT NATIONAL PARK: A MULTIVARIATE ASSESSMENT

3.1 Introduction

Human-wildlife conflicts have far reaching environmental impacts. Species most exposed to conflict are also shown to be more prone to extinction (Ogada *et al.*, 2003). Conflict could also be either accidental, such as road traffic and railway accidents, capture in snares set for other species or from accidental falling into farm wells, or intentional causes like retaliatory shooting, poison or capture. Such human-induced mortality affects not only the population viability of some of the most endangered species, but also has broader environmental impacts on ecosystem equilibrium and biodiversity preservation (Distefano Elisa). Human-wildlife conflicts also undermine human welfare, health and safety, and have economic and social costs. For example, nuisance encounters with small animals, exposure to zoonotic diseases, physical injury or even death caused by large predators' attacks have high financial costs for individuals and society in the form of medical treatments to cure and prevent infections transmitted from animals through human-contact (MWLAP, British Columbia 2003). Humans can be economically affected through destruction and damage to property and infrastructure (e.g. agricultural crops, orchards, grain stores, water installation, fencing, pipes) livestock depredation and transmission of domestic animal diseases, such as foot and mouth. Negative social impacts of these conflicts include missed school and work, additional labor costs, loss of sleep, fear, restriction of travel or loss of pets (Hoare, 1992). Demographic and social changes place more people in direct contact with wildlife: as human populations grow, settlements expand into and around protected areas (IUCN, World Park Congress 2003) as well as in urban and sub-urban areas. But a majority of these conflicts are observed in and around protected areas, where wildlife population density is higher and animals often stray into adjacent cultivated fields or grazing areas.

Sustaining threatened carnivore species therefore depends on the capacity of local people to tolerate carnivore related risks and to desire increasing or expanding carnivore populations or, at the very least, policy favorable to their conservation (Riley & Decker, 2000b). The capacity of local people to cohabit with wildlife is strongly influenced by subjective psychological factors, including beliefs and perceptions (Decker & Purdy, 1988; Riley & Decker, 2000b; Zinn et al., 2000; Bruskotter et al., 2009). Several studies have assessed these factors independently with respect to threatened carnivores in various regions (Saberwal et al., 1994; Marker et al., 2003; Romañach et al., 2007) but none of these studies integrated psychological concepts into a comprehensive framework. Increased visibility for conflict incidents may be attributed to actual increase in incidents taking place or just greater reporting by affected local people (Treves A, Naughton-Treves L., 1999). Dearth of knowledge about conflict loss and compensation distribution contributes to poor allocation of conservation resources (Linkie M. et al., 2007; McDonald-Madden E et al., 2008). Failure to address emerging issues with conflict losses and distribution of compensation may lead to escalation of tensions between people and wildlife, and promote retaliatory actions leading to extirpations of species (Bulte EH,Rondeau D., 2005; Treves A., 2011). Preventing conflict and improving distribution of compensation are important to fostering co-existence in landscapes that surround protected areas and function as critical buffers for wildlife (Madden F., 2004, DeFries R., 2010). Indian protected areas (PAs) support a huge array of wildlife that is prone to conflict with people. People tolerate some species such as Nilgai Boselaphus tragocamelus, Chinkara Gazzella bennetti and Blackbuck Antilope cervicapra but are less tolerant of other species such as wild pigs Sus scorfa and elephants Elephas maximus (Karanth et al., 2002; Shekar., 1998). Crop loss is more common than livestock loss, human injury and death (Karanth, Nepal S., 2012). Local residents most often directly bear the costs of living alongside wildlife and may have limited ability to cope with losses (Karanth, Nepal S., 2012). Understanding the factors associated with conflict and where they are likely to occur is important for conservation management of conflicts (Dickman AJ., 2010; Mateo-Thomas et al., 2012).

In most countries, development imperatives favor uses of land, natural resources, and funds that yield immediate and demonstrable financial returns. Given society's increasing demands for employment, income, and infrastructure, development decisions tend to maximize short-term economic gains. Prices generated for natural resources often do not reflect the true social costs and benefits of resource use, convey misleading information about resource scarcity, and provide inadequate incentives for management, efficient use, and conservation of natural resources (Panayotou 1993). Protected areas generate significant economic, environmental, and social benefits (Myers 1990; Dudley and Stolton 2005). These benefits are realized at local, national, and global levels. However, people living in and around PAs, while deriving little benefits from conservation, pay enormous costs in terms of lost access to their life-support system, particularly in developing Third World countries (Wells 1992; Brockington 2002). Three types of costs are associated with PAs, viz. direct costs that include acquisition costs, management costs, and transaction costs; indirect costs associated with damage to economic activities arising from conservation, for example, damage to crops, livestock, and human beings from wild animals living in PAs adjacent to human settlements (Hoare 2000; Naughton et al. 1999); and opportunity costs or benefits forgone from the next best use of the resource: in case of terrestrial PAs, the highest extractive value of that land (Naidoo et al. 2006; Adams et al. 2010). Unless the costs of conservation are assessed and it is clear who pays these costs and what they get in return, conservation interventions will not be effective. Compensation for impoverishment caused by PAs requires knowledge as to who has been affected and how it has influenced their lives. Appreciation of the multiple benefits of conservation will be incomplete without good understanding of the costs involved. Hence, measures devised to conserve biodiversity must provide economic incentives to increase net local benefits from conservation and sustainable resource use, along with good community engagement and education. To ensure their sustainability and develop rational natural resource use policies, valuation of ecosystem services provided by PAs has become an essential analytical tool. Ecosystem services are the processes and conditions of natural ecosystems that support human activity and sustain human life (Daily 1997). The type, quality, and quantity of services provided by an ecosystem are affected by resource use decisions of individuals and communities (Jack et al. 2008). At the landscape level, conservation of biodiversity and maintaining the sustained flow of ecosystem services that it provides are now increasingly becoming the focus of ecosystem-based natural resource management (Ehrlich and Wilson 1991; Fisher et al. 2008).

3.2 Research need

Understanding relationships between local people and natural resources is critical in designing and sustaining effective conservation strategies. Such relationships have particular relevance to the management of protected areas (PAs), where long-standing tensions over land tenure, local use of natural resources, and human–wildlife conflicts may limit local acceptance of conservation goals (Newmark and Leonard 1991; Newmark et al. 1994; Lilieholm and Romney 2000; Whitesell et al. 2002; Balint 2006). Most conflict studies are characterized by poor spatial sampling and modeling (Paterson MN et al., 2010; White PC et al., 2011). To improve efficacy and efficiency of conservation actions, managers require surveying and modeling approaches that are spatially explicit and rigorous (MacDonald-Madden E et al., 2008). The concept of ecosystem services provides a robust rationale for biodiversity conservation complementary to traditional arguments based on intrinsic value. In principle, it also provides a mechanism for optimizing investments in biodiversity conservation and directing them to where they are most useful (Kinzig et al. 2007). This requires the valuation of ecosystem services, and in particular, the contribution that biodiversity makes to that value. The establishment of protected areas (PAs) forms the cornerstone of the strategy for biodiversity conservation; however, in economic and development terms, it is difficult to justify the costs involved. When PAs are undervalued, their conservation appears to be less desirable in development terms. Because it is difficult to demonstrate the high economic value of PAs or to make the case for PAs as an option that economically benefits land, resource, and investment, it is also difficult to argue for their establishment, to ensure that they are managed sustainably, or to defend them against conversion to other land uses. Cost–benefit analyses, where the economic costs and benefits of conservation are estimated and incorporated into decision-making, would help planners to make informed decisions regarding allocation of resources to PA conservation as well as to understand their distributional impacts. They would also indicate the overall economic efficiency of various competing uses of natural resources and thereby help society to make informed choices about trade-offs (Loomis 2000; Christe et al. 2006; Pearce 2001; OECD 2001). This approach can also identify marginalized stakeholders who threaten natural resources due to unsustainable use and indicate ways of capturing the values derived by beneficiaries, thereby guiding management practices in terms of efficiency and distributional impacts (Howarth and Farber 2002; Costanza 2001; Costanza and Folke 1997). India has a large number of PAs which correspond to International Union for Conservation of Nature (IUCN) categories II, IV, and VI. The first among these is Corbett National Park. Established as India’s first national park on August 8, 1936, it was named Hailey National Park after Sir William Malcolm Hailey, then governor of Uttar Pradesh State, who was instrumental in its creation. Some recent studies have attributed the sustained flow of services to the health of ecosystems resulting from improved conservation (Naidoo and Ricketts 2006; Chan et al. 2006). Despite the vital importance of ecosystem services, there has not been much progress in incorporating these into conservation planning, largely due to poor characterization of the flow of services from conserved ecosystems such as PAs (Chan et al. 2006). Inclusion of ecosystem services in conservation planning would provide opportunities for biodiversity protection (Naidoo et al. 2006) as well as for advancing human well-being.

Human population of the earth exceeding 6 billion and growing at an estimated rate of 1.2% per year, or about 80 million (US census Bureau 2002), human-wildlife encounters will continue to increase. Attacks on humans are perhaps the least understood of these encounters, but the most interesting and emotionally connected to people. This lack of understanding, couples with the intense interest that attacks elicit, makes the situation ripe for reaction that will not only cause human injury or death but will also damage wildlife populations. There is a need for approaches to mitigate wildlife attacks on human, based on scientific understanding of conflict and behavior. Reducing attacks has the potential to reduce injury and loss of lives in human populations, conserve wildlife populations, promote good will towards wildlife, minimize economic loss, and improve quality of life for humans. Despite the need to understand attacks and circumstances associated with attacks, little objective information exists about attack incidences and there are little information. Moreover, there is a need for global perspective to minimizing conflicts. Local success in reducing conflict can bring gratification and can inspire others. But the sharing of such information and the standardization of information-gathering can bring a greater good outcome of an integrated approach (Quigley Howard & Herrero Stephen). Moreover, many tropical regions suffer from chronic and intense hunting, which can have far-reaching impacts on wildlife and can affect entire food webs and ecosystems (Wright et al., 2000; Milner-Gulland et al., 2003; Wright, 2005; Bennett et al., 2006). Reducing or mitigating the impacts of hunting on wildlife is often difficult to implement because it involves grappling with a range of socioeconomic, cultural and biological challenges (Price and Gittleman, 2007). So to fill the research gaps in human-wildlife conflict dimension, this study is very significant as the important outcomes from this study are a potential conflict index, model to understand nature of human-wildlife conflict and factors driving it and numerous recommendations and management implications. These outcomes will play a very significant role in exploring and understanding interaction between human and wildlife at a very fine scale.

3.3 Literature review

Benerjee et al (2013) conducted a study to understand the socio-economic aspect of coexisting with Lions in Gir forests, India. They monitored six Maldhari settlements for 2 years to quantify seasonal livestock holding, density and losses due to predation and other causes. Capture-recapture method was used to estimate lion density; head-count method is used to estimate livestock population density. Analysis of Lion scat was done to understand Lion feed habits. They concluded that a combination of strict protection regime for Lions, Maldharis' traditional reverence towards lions and their livelihood economics permits the delicate balance of Lion-Maldhari coexistence. The current lifestyle and livestock holding is also beneficial for both Lions and local pastoralists. It also stated that indefinite increase in human and livestock population within Gir might upset the equilibrium of peaceful coexistence undermining the conservation objectives.

Vidya atreya et al (2009) conducted a study to examined the efficacy of a translocation program in which large numbers of leopards (Panthera pardus fusca)were trapped in human-dominated landscapes where livestock attacks were common and human attacks rare and released into adjoining forested areas in an attempt to reduce leopard presence and mitigate conflicts at the capture site. After undergoing rigorous data analysis using correlation statistics on data obtained from Forest departments and Government of India on Leopard attack sites, attack frequency, translocation and introduction; the results suggested that leopards did not stay at the release sites and that translocation induced attacks on people. They concluded that reactive solutions to attacks on humans by leopards, such as translocation, could in fact increase human–leopard conflict. Measures to reduce human–carnivore conflicts may include more effective compensation procedures to pay livestock owners for the loss of animals to predation by carnivores, providing better methods of protection for livestock, and encouraging greater social acceptance of the presence of carnivores in human-dominated landscapes.

Carter H. Neil et al (2012) initiated a study to examine the capacity of local people to cohabit with carnivore species by developing a novel psychological framework for conservation in regions of the world where there are human–carnivore conflicts, and used the Endangered tiger *Panthera tigris* to explore the utility of this framework. The study took place in Chtiwan National Park in Nepal where they administered a survey to 499 individuals living ,2 km from the Park and in nearby multiple-use forest, to record preferred future tiger population size and factors that may influence preferences, including past interactions with tigers (e.g. livestock predation) and beliefs and perceptions about tigers. The results suggest that Over 17% of respondents reported that a tiger had attacked their livestock or threatened them directly. The respondents who preferred fewer tigers in the future were less likely to associate tigers with beneficial attributes, more likely to associate tigers with undesirable attributes, and more likely to believe that government officials poorly manage tiger-related risks and that people are vulnerable to risks from tigers.

Johnson et al (2006) examined the effects of human– carnivore conflict on tiger and prey abundance and distribution in the Nam Et-Phou Louey National Protected Area on the Lao–Vietnam border using intensive camera-trap sampling of large carnivores and prey at varying levels of human population and monitored carnivore depredation of livestock across the protected area. The results suggested that the relative abundance of large ungulates was low throughout whereas that of small prey was significantly higher where human density was lower. The estimated tiger density for the sample area ranged from 0.2 to 0.7 per 100km2 and tiger abundance was significantly lower where human population and disturbance were greater. They concluded that three factors, commercial poaching associated with livestock grazing followed by prey depletion and competition between large carnivores, are likely responsible for tiger abundance and distribution. Moreover, maintaining tigers in the country's protected areas will be dependent on the spatial separation of large carnivores and humans by modifying livestock husbandry practices and enforcing zoning.

Kudzai Kusena (2009) studied the impacts of land-cover change on human-elephant conflict in Zimbabwe, Mozambique and Zambia trans-boundary Natural resource management area. Three factors, commercial poaching associated with livestock grazing followed by prey depletion and competition between large carnivores, are likely responsible for tiger abundance and distribution. Maintaining tigers in the country's protected areas will be dependent on the spatial separation of large carnivores and humans by modifying livestock husbandry practices and enforcing zoning. The results pointed that Three factors, commercial poaching associated with livestock grazing followed by prey depletion and competition between large carnivores, are likely responsible for tiger abundance and distribution. Maintaining tigers in the country's protected areas will be dependent on the spatial separation of large carnivores and humans by modifying livestock husbandry practices and enforcing zoning. They concluded that extensification of agriculture and human-elephant conflict will continue to increase in the study area and suggest the need of paradigm shift for agriculture-based livelihood to conservation-based livelihood.

Joshi Ritesh and Singh Rambir (2007) studied the nature of conflict and co-existence between Asian elephants and human-beings in Rajaji national Park in Northern part of India where the elephants were losing their natural ground/habitat because of agriculture. They used direct & indirect data on elephant crop-raiding behavior for past seven years and they also conducted questionnaire survey. The results suggest that trend of crop raiding was mainly undertaken by solo adult and sub-adult bulls (45%), bull group (14%) and group including males, females and juveniles (37%) whereas group sizes ranged from 1-14 individuals. They concluded that elephants came out of the forest after sunset and return before dawn but had gradually begun moving towards outside areas after mid-day.

Ogra V. Monica (2007) conducted a study on Human–wildlife conflict and gender in protected area borderlands with respect to a case study on costs, perceptions, and vulnerabilities from Uttarakhand (Uttaranchal), India. The study uses a feminist political ecology approach to examine the problems of crop-raiding events and attacks by wild animals in an agricultural village located at the border of Rajaji National Park in Uttarakhand (formerly Uttaranchal), India. They collected data from survey and interviews from over 100 individuals in the study site over a period of 9 months in 2003–2004. The results point that for participants in this study, costs of HWC included decreased food security, changes to workload, decreased physical and psychological wellbeing, economic hardship, and at times an increase in illegal or dangerous activities. The research also showed that although women in the study area bore a disproportionate burden of these effects, roughly half of survey respondents perceived that men and women were equally affected. A possible explanation for this gap considers the relationships between gendered uses of space, work, status, and identity. The study illustrate the importance of addressing both visible and hidden costs of HWC for members of park communities and support a call for increased gender-sensitivity in HWC research.

Clevenger et al (2002) undertook a study on GIS-Generated, expert-based models for identifying Wildlife habitat linkages and planning mitigation passages. They developed three black bear (*Ursus americanus*) habitat model in the context of geographic information system to identify linkage areas across a major transportation corridor. One model was based on empirical habitat data, the other two were based on expert information developed in a multi-criteria decision-making process. The study concluded that the empirical and expert models represent useful tools for resource and transportation planners charged with determining the location of mitigating passage for wildlife when baseline information is lacking and when time constraints do not allow for data collection before construction.

Gubbi sanjay (2012) conducted a study to understand the patterns and correlates of human–elephant conflict around Nagarahole National Park, southern India. Using applications and documents filed with the wildlife department by affected farmers during the period 2006–2009, he analyzed crops affected, compensation payments made by the Government, spatiotemporal patterns of conflict and identified the key correlates of human–elephant conflict. The results reflect that 98.8% of the conflict incidences occurred in villages that lie within 6 km from the national park boundary. Of the 26 crop types affected by elephants, finger millet, maize, cotton, paddy and sugarcane formed 86.34% of the total crop losses. Conflict frequencies were highest during August–November, a period when there was a decrease in rainfall and important crops such as finger millet, maize and paddy were ripening. Multiple linear regression results suggest that villages with higher protected area frontage and un-irrigated land were key variables underlying conflict frequency. The study concluded that there are other probable factors such as elephant behavior, movement patterns and/or maintenance of physical barriers which could be more important determinants of conflict.

Winterbach et al (2011) studied the key factors and related principles in the conservation of large African carnivores By reviewing existing literature, they identify 14 key factors that influence large African carnivore conservation, including ecological (biodiversity conservation, interspecific competition, ranging behavior, ecological resilience, prey availability, livestock predation, disease and population viability), socio-economic (people's attitudes and behaviors and human costs and benefits of coexistence with large carnivores) and political (conservation policy development and implementation, conservation strategies and land use zoning) factors. They identified the key principle that underpins each factor and its implications for both large carnivore conservation and human–carnivore conflict. The results of the study suggests that the 14 key factors identified in this review as features of large African carnivore conservation reflect the breadth and scope of the systems that collectively may lead to the successful conservation of large carnivores. They concluded that all key factors are interrelated, and the importance of individual factors depends on the species of large carnivore in a site-specific context. Activities designed to improve large carnivore conservation are likely to be less effective if they focus on one key factor without complementary action to influence a linked factor in another layer. The conservation and human–carnivore implications guide the implementation of the key principles in large carnivore conservation policies, conservation strategies and actions.

Woodroffe Rosie and Frank G. Laurence (2004) studied the impact of lethal control, associated with livestock depredation, on a population of African lions (*Panthera leo*) living outside protected areas. The results suggest that farmers shot lions only in response to livestock attacks. Nevertheless, adult mortality was high and a simple model predicted that the population was marginally stable or slowly declining. Mortality was four times higher among lions radio-collared in association with attacks on livestock, than among lions with no known history of stock killing, suggesting that some animals were habitual stock killers. Mortality was higher among lions whose home ranges overlapped a property where non-traditional livestock husbandry was associated with chronic depredation by lions. The concluded that sustainable coexistence of lions and people demands livestock husbandry that effectively deters predators from acquiring stock-killing behavior, but that lethal control may play an important role in avoiding the spread of such behaviors through the population.

3.4 Aim

The main objective of the study is to understanding stakeholder's perception towards human-wildlife interaction and conflict in a tiger landscape-complex of India.

3.5 Specific objectives

The specific objectives of the study are:

I. To study factors influencing exposure to crop-loss in and around Corbett National Park.

II. To quantify livestock loss experienced by stakeholders in the study area.

III. To evaluate factors influencing human-wildlife conflict around Corbett National Park

IV. To identify mitigation strategies to reduce human-wildlife conflict at regional and landscape level.

3.6 Study area

Jim Corbett National Park (Coordinates: 29’32’00” N latitude and 78’56’7” E longitude) is the oldest national park in India (Riley et al., 2005). The park is named after the hunter and conservationist Jim Corbett who played a key role in its establishment in 1936 as Hailey National Park. Situated in the Nainital district of Uttarakhand the park acts as a protected area for the endangered Bengal tiger of India. The park had 154 Tigers in 2009 but after implementing core-buffer zone strategy and increase in number of park rangers, the number has risen to 214 tigers as per 2010 tiger census undertaken by Government of India. Still the tigers face a serious threat in Corbett National Park because of human-tiger conflict and poaching.

The park has geographical and ecological characteristics of sub-Himalayan belt (Tiwari et al. 1997). An ecotourism destination, it contains 488 different species of plants and a diverse variety of fauna (Tiwari et al. 1997 & Pant, 1976. Corbett National Park is India's first national park which comprises of hills, riverine belts, marshy depressions, grass lands and large lake. The elevation ranges from 1,300 feet (400 m) to 4,000 feet (1,200 m). Winter nights in Corbett national park are cold but the days are bright and sunny. It rains from July to September. The core area is 821.99 Sq. Kms, Buffer area is of 466.32 Sq. Kms, and the total Area of the National Park is 1288.31Sq. Kms. Dense moist deciduous forest mainly consists of Sal, Haldu, Pipal, Rohini and mango trees, and these trees cover almost 73 per cent of the park. The 10 per cent of the area consists of grasslands. It houses around 110 tree species, 50 species of mammals, 580 bird species and 25 reptile species.

3.7 Methodology

To better understand stakeholders’ perception towards human-wildlife interaction and conflict we surveyed respondents living in villages surrounding Corbett National Park using a standardized questionnaire that is approved by IRB (Institutional Review Board) of University of Massachusetts, Amherst. We surveyed the following 15 villages lying in and around Corbett

National Park using a standardized questionnaire [1] Dhapla/ Chukham (29°19' 05.34" N 79°24' 23.17" E) [2] Dhara (29°25'57.12" N 78°50'48.81" E) [3] Phanto (29°21'17.39" N 78°52'55.67" E) [4] Dhela (29°24'59.58" N 78°59'39.23" E) [5] Lal-dhang (29°26'02.13" N 78°58'01.44" E) [6] Choi (29°21'07.53" N 79°08'41.53" E) [7] Maloni (29°27'50.76" N 78°48'45.92" E) [8] Lal-baugh (29°27'38.83" N 78°49'17.85" E) [9] Teda (29°25'23.84" N 79°08.20.04" E) [10] Patarpani (29°13'13.67" N 79°41'33.50" E) [11] Hathidagar (29°22'41.90" N 79°01'15.19" E) [12] Aamdanda (29°25'02.93" N 79°07'18.04" E) [13] Marchula (29°36'24.35" N 79°05'31.91" E) [14] Ringora (26°26'11.24" N 79°07'50.23" E) [15] Sunderkhal (29°30'08.63" N 79°07'30.79" E).

For unbiased sampling, we used the snow-ball technique (Goodman L.A., 1961) and random sampling survey methods to collect data from each village using a standardized survey questionnaire. We aimed to understand stakeholder's perception towards existence of tiger in their surrounding forested area and also towards human-wildlife conflict. Majority of the questions were specifically focused towards determining major factors influencing crop-loss, livestock loss and human-wildlife conflict across the study area. We also assessed tolerance level of stakeholders to livestock loss, crop loss and human-life injury/loss by wildlife and also quantified willingness of stakeholders to contribute towards tiger conservation and reducing human-wildlife conflicts in the study area. The questionnaire was pre-tested on 25 people to ensure clarity before use. The survey covered four main areas: (i) socio-economic characteristics of respondents; (ii) Interviewees' perception and knowledge of wildlife; (iii) human-wildlife interaction, conflicts and consequences; and (iv) Current strategies implemented by stakeholders, Governments and NGO's to reduce conflicts and stakeholders willingness to contribute towards tiger conservation and reducing human-wildlife conflicts. This chapter reports on results from (i) and (iii).

We quantified and analyzed several variables that could potentially influence people's perception at individual and village level. These included the age and education level of the interviewee, based on Kellert (1985, 1991), who reported that in Minnesota young, urban, educated people tended to have relatively positive attitudes toward carnivores relative to older, rural, less educated people. We also included gender, following Bjerke et al. (2001), who reported that in Norway, women were less accepting of carnivores due to fear. Livestock holdings and proportions of livestock killed by predators were included as explanatory variables (Suryawanshi et al. 2013), as were the number of sources of income because economic loss due to large carnivores generally contributes to the negative attitudes toward them (Williams et al. 2002; Bagchi & Mishra 2006). Village size was included following Klieven et al. (2004), who reported that people were more accepting of carnivores when they lived far away from them and when the human communities were larger.

3.8 Regression Analysis

Data was analyzed using 'R' statistical software. The variables used in the analyses were determined from the questionnaire survey results. We determined variables that can play significant role in influencing crop-loss, livestock loss and human-wildlife conflicts. These factors very selected from the results presented in the graphs in chapter 1. We focused on three major events that could influence stakeholder's perception towards wildlife- crop loss, livestock loss and human-wildlife conflicts. We used Microsoft Excel 2010 for correlation analysis between variables for all three events. Later we used the same variables used in correlation analysis; for Generalized Liner Model (GLM) regressions using 'R' statistical software for each of the three events. The correlation table and GLM regression analysis results will help to determine the variable which is most responsible for crop loss, livestock loss and human wildlife conflicts in the study area. We took the dependent variable as 'Y' and other potentially influencing independent variables as 'X'. We measure the distance of each village from the highway using Google Earth and google maps.

3.9 Results

3.9.1 Crop-loss regression

India is an agricultural country. Majority of its income is generated through agriculture (citation needed). A significant portion of agricultural land is cultivated in a close proximity to national parks and forests in India. Wild-animals invade this crop-lands and farms in search of easy food. This leads to interaction between wildlife and humans. Humans in order to protect their crops try various methods to scare and drive away wild animals raiding their crops such as gun-shots fired in air, making loud noises, throwing burning tires or throwing hand-made bombs. This can cause serious injuries or even death of wild animals. In defense, the wild animals charge back upon humans, this can too lead to lethal injuries and even death sometimes.

For this study, we used the crop-loss data collected from questionnaire survey to run regressions using 'R' statistical software. We used eight parameters to run crop-loss regression analysis in 'R'. We took the dependent variable Y as areas of crop lost to wildlife in acres and independent variables X as total land owned by stakeholder; total land cultivated; socio-economic status of stakeholder; if they had fencing around their farms or not; if they practiced forest-based agriculture or not; elevation of the village and; distance of the village from highway.

We used the following generalized linear model for the regression:

Glm (formula= Area lost in acres~ Total land owned in acres+ Total cultivated land in acres+ Socio economic status + Fencing scenario + Forest based agriculture + Elevation in fts+ Distance of village from highway in kms, data= newdata)

From the regression table shown below, we interpret that those stakeholders who owned larger cropland areas faced less crop-loss per year from wild-animals. The stakeholders who cultivated a larger portion of the total land-owned faced significant crop-loss. Socio-economic status and fencing also played a crucial role in determining crop-loss to wild animals. Wealthy stakeholders have large crop-land areas, which increases crop-raiding risk by wild animal and also leads to more crop-damage. But it was also observed that the crop-loss decreased if the stakeholders had better fencing around the farms. The stakeholders engaged in forest-based agriculture owned less farmland and cultivated less area compared to those stakeholders having farmlands far away from forested area. Further they were also provided with natural defense of huge trees and bushes surrounding their farms as fence to prevent entry of wild animals. So the stakeholders engaged in forest-based agriculture and whose farms were located far away from highways into the boundary of forests faces less crop-loss damage per year comparatively.

With increasing elevation, open space for agriculture is hard to find and it is also smaller in area compared to that of less-elevated areas. Moreover, the stakeholders residing on elevated areas have access to limited resources and have very fewer source of income. So, it is difficult for them to afford and build fences around their farms in elevated areas. So with increasing elevation, crop-loss was observed to rise.

3.9.2 Live-stock loss regression

To better understand livestock lost to wildlife in our study area, we used the livestock-loss data collected from questionnaire survey to run regressions using 'R' statistical software. We used eight parameters to run livestock-loss regression analysis in 'R'. We took the dependent variable Y as livestock killed by tiger or not (binomial values) and independent variable X as total livestock owned by stakeholder; socio-economic status of stakeholder; grazing livestock in forest area; if they had fencing around their farms or not, prey scavenging by stakeholders, elevation of the village; and distance of the village from highway.

We used the following generalized linear model for the regression:

Glm (formula= Livestock killed by tiger~ Total livestock owned + Socio economic status + Livestock grazing in forest area+ Fencing scenario + Prey scavenging by stakeholders + Elevation in fts + Distance of village from highway in kms, family= "binomial", data= newdata)

In our study area it was noticed that stakeholders who own large crop-land area and have a higher socio-economic status, generally owned more number of livestock comparatively. So as shown in figure below it was observed that they are prone to more livestock loss to tigers even if they have better fencing. Tiger predation on livestock grazing in forests was observed to be less because of certain techniques and safety measures used by stakeholders while moving their livestock through forests. Over the period of time, stakeholders have developed certain techniques to prevent their livestock while grazing in forest which includes a strategic formation in which one person with a stick leads the way ahead escorting the livestock from the front, while the other person follows the last cattle from the rear end. They continuously sing songs and make loud noises in order to scare away predators. They also keep constant watch over their livestock while they are grazing. Moreover, the stakeholders residing on elevated areas have access to limited resources and have very fewer source of income. So, it is difficult for them to afford and build fences around their houses to protect their livestock in elevated areas. So with increasing elevation, livestock-loss was observed to rise. Farther the distance of settlement from highway, the more remote and closer it gets to the forested area. This leads to more predation of livestock by tigers.

Scavenging is one of the most interesting practices which we observed being carried out in our study area. Two types of prey-scavenging were noticed during our study period. The first type is where the stakeholders would scare away a tiger or a leopard feeding on its prey using sticks and stones and later stealing the kill. A portion of the scavenged meat from the kill would be sold in the market for money while the rest would be consumed as food. The second type of scavenging is when a domesticated cattle or livestock is killed by a tiger/leopard; the stakeholders would form a group to avenge the death of their livestock and their loss. They will track down the kill-hide, scare away the predator using sticks and stones, and steal the kill meat to compensate some portion of their monetary loss by selling the meat in the market. In both the cases of scavenging the predator remained hungry and lost a lot of energy invested in hunting, as his kill was stolen. So in order to satisfy his hunger, the predator would move towards hunting more livestock for easier food and to save his energy. The rates of livestock killed by tigers because of prey scavenging are going up in villages lying in and around Corbett National park.

3.9.3 Human-wildlife conflict regression

To understand the influence of various variables on human-wildlife conflicts in our study area, we used the human-wildlife conflict data collected from questionnaire survey to run regressions using 'R' statistical software. We used 14 parameters to run human-wildlife conflict regression analysis in 'R'. We took the dependent variable Y as encounter between stakeholders and wildlife (binomial values) and the independent variables X as Socio economic status of stakeholders; collecting timber form forest area; collecting grass from forest area; collecting non-timber forest products; grazing livestock in forest areas; total livestock owned by stakeholder; total livestock killed by wild animals; total area cultivated; proportion lost to wildlife of total area harvested; if they had fencing around their farms or not, prey scavenging by stakeholders, elevation of the village; and distance of the village from highway.

We used the following generalized linear model for the regression:

Glm (formula= Total encounters between wildlife and stakeholders~ Socio economic status+ timber collection+ Grass collection+ Non timber forest product collection (NTFP) + Livestock grazing in forest area+ Total livestock owned by individual stakeholder+ Total area cultivated in acres+ area lost to wildlife of total area cultivated in acres+ Fencing scenario + Prey scavenging by stakeholders + Elevation in fts+ Distance of village from highway kms, family= "binomial", data= newdata)

The stakeholders who had a better socio-economic status, owned large number of livestock, and had a larger cultivated area faced less encounters with wild animals as they could afford better housing facilities and security. Total livestock killed is a comparative ratio to total livestock owned which indicates that more the livestock owned by a person, the more income he has and holds a higher socio-economic status. So the table below suggests that total live-stock killed decreases the encounter chances. Collection of timber and grazing livestock in forested area is banned by Government of India. Still a majority of the stakeholders practiced timber collection and grazed their cattle in forested area. But they took precaution by only collecting timber from trees standing at the border of the forest area. This prevents them from entering the deep woods and also helped gather necessary timber required for cooking and constructing houses and fences. So very less human-wildlife encounters were recorded while timber collection. Over the period of time, stakeholders have developed certain techniques to prevent their livestock while grazing in forest which includes a strategic formation in which one person with a stick leads the way ahead escorting the livestock from the front, while the other person follows the last cattle from the rear end. They continuously sing songs and make loud noises in order to scare away predators. They also keep constant watch over their livestock while they are grazing. Because of this measure, the human-wildlife encounters are less while grazing livestock in forest areas.

Stakeholders wander deep inside the forest in order to collect grass as food for their livestock and various other non-timber forest products (NTFP) such as honey, herbs, fruits, vegetables, etc. Though it is banned to collect any kind of forest product from National parks by Government of India still the stakeholders find their way inside the open forests of Corbett National Park. Going deep inside the forest increases risk and leads to higher rate of human-wildlife encounter. Wild animals such as Elephants, Pigs, Cheetal, Sambhar, and Porcupine raid crop-lands for easier food. The stakeholders respond by sticks, stones, loud noises, bombs, and throwing burning tires to scare away the animals. This battle to save crops leads to higher rate of human-wildlife encounters. So as shown in table below, more the area cultivated more are the chances of human-wildlife encounters. The larger the area cultivated, more frequently the wild animal will raid the farms.

Scavenging is one of the most interesting practices which we observed being carried out in our study area. Two types of prey-scavenging were noticed during our study period. The first type is where the stakeholders would scare away a tiger or a leopard feeding on its prey using sticks and stones and later stealing the kill. A portion of the scavenged meat from the kill would be sold in the market for money while the rest would be consumed as food. The second type of scavenging is when a domesticated cattle or livestock is killed by a tiger/leopard; the stakeholders would form a group to avenge the death of their livestock and their loss. They will track down the kill-hide, scare away the predator using sticks and stones, and steal the kill meat to compensate some portion of their monetary loss by selling the meat in the market. In both the cases of scavenging the predator remained hungry and lost a lot of energy invested in hunting, as his kill was stolen. So in order to satisfy his hunger, the predator would move towards hunting more livestock for easier food and to save his energy. So more the prey scavenging, higher the rate of human-wildlife encounter goes.

The stakeholders residing on elevated areas have access to limited resources and have very fewer source of income. It is difficult for them to afford and build fences around their farms and houses in elevated areas to protect their crops and livestock. So, they own less number of livestock and have smaller areas for farming; which reduces their chances of being attacked by wild animals. Most of the stakeholder, who resided on elevated areas in our study area hardly owned any livestock or had any crop-land. Their basic source of income was timber and non-timber forest product collection. Some of them were also engaged in illegal marijuana farming. So, as they do not have any livestock to be predated or any crop-land to be raided, the wild animals stay away from them causing them least damage. So with increasing elevation human-wildlife encounter decreases.

3.10 Discussion

Four variables- total land cultivated, fencing scenario around cropland, elevation of the village and distance of the village from highway; showed significant influence for crop-loss within and around Corbett National Park. It was observed that better fencing around farms helped reduce crop-loss to wildlife. So the stakeholders need to construct some kind of strong fencing around their farms to protect their crops from being raid by wild animals. Various kinds of fences are available in market which can keep animals away from crops. Of all, the most effective and expensive fence is solar powered fence. Being costly this is will difficult for majority of the stakeholders to install them. It can be installed with some financial aid from Government and/or NGO's. This fence should be properly maintained and repaired immediately if damaged or else the animals will again start raiding the crops. There is also an option for barbed wired fence which can be very effective if maintained properly but it is also costly. Wooden fences have proved to be useful and effective against wild animals raiding crops in several countries like India and Africa (Sillero-Zubiri R et al., 2007). They are cost-effective and easy to install. Constructing pits around village is a very effective method to prevent crops from being raided. But it is very time consuming and costly to construct them; and requires constant management and maintenance. Villages located on elevated areas faced high crop damage. These villages should be relocated with prior and proper consent from villagers without any kind of pressure on them. Compensation in form of agricultural land or small-scale business should be provided to villagers willing to relocate.

No variable showed significant influence for livestock loss in our study area. For human-wildlife conflict, only 2 variables showed significant influence- socio-economic status and elevation. Stakeholders with higher standard of living were able to afford better housing facilities and security. So they faced least threat from wild animals. Stakeholders who were not involved in livestock grazing and farming faced least threat from wildlife as they did not wander into forest in search of grass or wood; nor did they have to scare away wild animals raiding their crops. This suggests that alternate source of income and growth in eco-tourism will significantly reduce human-wildlife conflicts.

3.11 Conclusion

Very few past studies have focused on geographic and demographic factors/variables affecting crop-loss, livestock-loss and human-wildlife conflict. In this study we tried to cover that research gap by adopting a multi-disciplinary approach involving geographic, demographic and social factors influencing human-wildlife relation. We used ‘R’ statistical software to run generalized linear regression for data obtained from 314 questionnaire survey sheets. We found that better fencing, farther from highway and management could significantly reduce crop-loss in our study area. Better standard of living and currently used livestock grazing technique in forest will help reduce livestock-loss to wild animals. Avoiding collecting timber, grass and other NTFP from national park will reduce chances of human-wildlife conflict. Better socio-economic status, confronting wild animals in proper manner while protecting crops and livestock. Preventing prey scavenging will also play a crucial role in reducing human-wildlife conflict within and around Corbett National Park.

Government needs to develop and plan conservation strategies and policies which are effective at village level and also at landscape level. Village level conservation strategies are required because depending on the geography and demography of village each village faces different challenges against wildlife. This strategies and policies will help in developing positive attitude towards wildlife amongst stakeholders. Fair and timely compensation, insurance for crop-loss and livestock, relocation of settlements from deep within the forest and elevated areas, community-based conservation, promoting eco-tourism, proper fencing, pits and watch towers are the key strategies to sustainable conservation; and help thrive wild animal population in close proximity to humans.

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Table 1: Multivariate assessment of crop-loss

Deviance residuals:					
Min	1Q		Median	3Q	Max
-12.1112	-0.5118		-0.1446	0.5204	8.1100
Coefficients:					
	Estimate		Std. Error	t-value	Pr (>|t|)
(Intercept)	2.4910156		0.6106409	4.079	5.76e-05 ***
Total land owned in acres	-0.0148780		0.1353446	-0.110	0.912539
Total land cultivated in acres	0.3459078		0.1350272	2.562	0.010892 *
Socio economic status	0.0053866		0.0925509	0.058	0.953626
Fencing scenario	-0.5759884		0.1446107	-3.983	8.50e-05 ***
Forest based agriculture	-0.0133200		0.3100722	-0.043	0.965763
Elevation of the village in fts.	0.0004711		0.0001774	2.656	0.008320 **
Distance from highway in Kms.	-0.1596691		0.0448455	-3.560	0.000429 ***
Significance codes: 0 '****' 0.001 '**' 0.01 '*' 0.05 '*' 0.1 ' ' 1					
(Dispersion parameter for Gaussian family taken to be 3.415708					
Null deviance: 4341.3 on 314 degree of freedom					
Residual deviance: 1048.6 on 307 degree of freedom					
AIC: 1290.8					
Number of Fisher Scoring interaction: 2					

Table 2: Multivariate assessment of livestock loss

Deviance residuals:				
Min	1Q	Median	3Q	Max
-1.8598	-1.0514	-0.9053	1.2177	1.5807

Coefficients:				
	Estimate	Std. Error	t-value	Pr (>|t|)
(Intercept)	-1.3592736	0.6381561	-2.130	0.0332*
Total land owned in acres	0.0233934	0.0152021	1.539	0.1238
Socio economic status	0.1292714	0.0903589	1.431	0.1525
Grazing in forest area	-0.1938652	0.04160679	-0.466	0.6413
Fencing scenario	0.1335787	0.1516632	0.881	0.3784
Scavenging	0.0354097	0.5406024	0.066	0.9478
Elevation of the village in fts.	0.0001116	0.0001963	0.568	0.5697
Distance from highway in kms	0.0663167	0.0467661	1.418	0.1562
Significance codes: 0 '****' 0.001 '**' 0.01 '*' 0.05 '*' 0.1 ' ' 1				
(Dispersion parameter for Gaussian family taken to be 1)				
Null deviance: 434.01 on 314 degree of freedom				
Residual deviance: 422.14 on 307 degree of freedom				
AIC: 438.14				
Number of Fisher Scoring interaction: 4				

Table 3: Multivariate assessment of human-wildlife conflicts

Deviance residuals:				
Min	1Q	Median	3Q	Max
-1.1368	-0.6084	-0.4231	-0.1783	3.0253

Coefficients:				
	Estimate	Std. Error	t-value	Pr (>|t|)
(Intercept)	1.584e+00	1.149e+00	1.378	0.1682
Socio economic status	-4.152e-01	1.615e-01	-2.570	0.0102*
Timber collection	-1.292e+00	9.906e-01	-1.304	0.1922
Grass collection	4.949e-02	7.145e-01	0.069	0.9448
Non timber forest product	9.914e-02	5.339e-01	0.186	0.8527
Grazing in forest area	-6.940e-01	7.966e-01	-0.871	0.3837
Total livestock owned	-3.778e-03	2.238e-02	-0.169	0.8659
Total livestock killed	-1.403e-02	2.725e-02	-0.515	0.6065
Total area cultivated in acres	-2.412e-02	3.146e-02	-0.767	0.4432
Total area lost to wildlife per year of total harvested in acres	5.141e-02	7.746e-02	0.664	0.5069
Fencing scenario	3.408e-01	3.276e-01	1.040	0.2982
Prey Scavenging	1.995e+01	9.811e+02	0.020	0.9838
Elevation of the village in fts.	-8.963e-04	4.275e-04	-2.097	0.0360*
Distance of village from nearest highway in kms.	-6.463e-02	8.518e-02	-0.759	0.4480
Significance codes: 0 ‘****’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘*’ 0.1 ‘ ‘ 1				
(Dispersion parameter for Gaussian family taken to be 1)				
Null deviance: 309.63 on 314 degree of freedom				

Residual deviance: 227.70 on 301 degree of freedom
AIC: 255.7
Number of Fisher Scoring interaction: 16

CHAPTER 4

DYNAMIC SIMULATION EXPERIMENTS IN HUMAN-TIGER CONFLICTS POTENTIAL IN INDIAN SUBCONTINENT

4.1 Introduction

4.1.1 Nature of human-wildlife conflict

One of the challenges to the development of effective management strategies for predators' lies in understanding spatial variation and predicting what might happen under different scenarios (Sitati N.W et al., 2003). In the absence of any human interference, we would expect the abundance of predators to vary between areas in relation to, among other factors, food abundance and habitat. An understanding of this variation is valuable in predicting where the impact of predators on prey of human interest is likely to be greatest and therefore where the often limited conservation resources should be focused. Scientific findings and expert opinion have been relied on to identify important predictors and combined with analytical modelling for the extrapolation of factors across the landscape (Le Hay G et al., 2001). Where data on predictors of spatial patterns in wildlife and human activity are available, these models can produce strategic management recommendations which can aid human-wildlife coexistence (Merkle J.A et al., 2011). Individual-based models (IBMs) have become popular in recent years in the fields of ecology and evolution (e.g., Jeltsch F et al., 1997; Benette VJ et al., 2011). Such models enable demographic processes to be represented based on the ecology and behavior of the study species and to incorporate individual variability (Grimm V et al., 2006; Jorda'n F et al., 2011; Travis JMJ et al., 2011), thus allowing exploration of the effect of local mechanisms on population trends and spatial pattern formation and vice versa (Treves A et al., 2004; Grimm V et al., 2006). The model provides a tool incorporating specific behavioral mechanisms used by organisms. This tool can be used in the mapping of spatial and temporal patterns in the abundance of a species, and hence in mapping of conflict areas. Our results illustrate that while historical trends in populations cannot be replicated exactly, a reasonable representation of reality can be achieved when producing a model which is simple enough to allow some inference about the mechanisms of the processes controlling population growth. Further exploration of the model dynamics, perhaps through Bayesian-based sensitivity analyses (see, for example, Parry HR et al., 2013), can improve understanding of which model parameters and processes are most crucial and hence where data collection efforts should be focused to improve our representation of the hen harrier behavior and population dynamics, in order to better inform management decisions.

In ecosystems where wildlife coexist with people, natural food shortages can lead to increased use of anthropogenic food sources (e.g., livestock and garbage) that can positively impact the demographics (e.g., survival and reproduc- tion) of animals utilizing these resources (Fedriani et al., 2001; Webb et al., 2004). In other cases, lack of tolerance to wildlife conflict by humans and subsequent wildlife removal can lead to negative demographic impacts and population decline (Linnell et al., 2001; Mech, 1995). Thus, knowing how a wildlife population responds to availability of anthropogenic food requires under- standing of natural food production variability, the intensity of management of conflict wildlife, and the resulting demographic response. The conflicts are difficult to understand and manage, because they are influenced by many factors, including religious values, the cultural and economic value of carnivores and their body parts, and the economic loss imposed by the carnivore damage (Dickman, 2010; Michael and Ashley, 2004). As a consequence, it is important to identify the degree of influence of these factors in order to lay a foundation for designing of specific conservation programs and policies. Almost no systematic studies have been conducted in Central Asia, which has a unique faunal assemblage that inhabits land used traditionally by local communities for grazing livestock. The few existing studies stopped at characterizing attitudes of local people toward carnivores or protected areas and did not identify the drivers of attitudes through robust empirical frameworks (e.g., Oli et al. 1994; Bagchi & Mishra 2006; Wang et al. 2006; Liu et al. 2011). Attitudes toward carnivores are influenced by diverse and complex factors—from individual human attributes and socioeconomic indices to appearance and behavior of the carnivore—which makes it difficult to understand their drivers. Because human societies are organized hierarchically—an individual is a part of a family group that lives within a community and so forth—the process of decision making, influenced by social perception and cognition, takes place at multiple hierarchical levels (Hinsz & Matz 2003). Even as the conservation field moves toward more collaborative governance models of engagement (Ansell and Gash, 2008; Leong et al., 2011; Reid et al., 2009), too often the processes used (or the individuals or organizations driving the process) fail to recognize or reconcile the deep-rooted conflict among stakeholders, and as a result, conservation goals are hindered (Balint et al., 2011; Clark and Slocombe, 2011; Dickman, 2010; Doucey, 2011; Peterson et al., 2013). This happens for two reasons: first, analysis is limited to the presenting disputes (and potentially common interests), and takes incomplete account of the deeper social conflicts often entangled in these disputes (Coleman, 2011; Deutsch and Coleman, 2012; Dickman, 2010; Jeong, 2008; Peterson et al., 2013). Without thorough analysis of these deeper social conflicts, stakeholder engagement processes often overlook (or exacerbate) this hidden dimension of conflict that, if accounted for, would help create the conditions for more sustainable long-term agreements (Jeong, 2008; Lederach, 1998; Levinger, 2013; Rothman, 1997). Second, there is a tendency to negotiate short-term, superficial solutions to these complex conflicts (Balint et al., 2011; Coleman, 2011; Dickman, 2010; Doucey, 2011; Fisher et al., 1991; Leong et al., 2009). In many cases, this tendency is due to a lack of capacity for employing more comprehensive approaches, a lack of mandate or willingness to change existing methods, or a desire to avoid the messy complexity of conflict that, on the surface, may seem tangential or irrelevant to the conservation mandate (Ansell and Gash, 2008; Coleman, 2011; DeCaro and Stokes, 2008; Leong et al., 2011; Manolis et al., 2009; Messmer, 2009).

Conservation conflicts often serve as proxies for conflicts over more fundamental, non-material social and psychological unmet needs—including status and recognition, dignity and respect, empowerment, freedom, voice and control, meaning and personal fulfillment, identity (one's sense of self in relation to the outside world), belonging and connectedness, social, emotional, cultural, and spiritual security (Burton, 1990; Marker, 2003; Satterfield, 2002)—which are not addressed by the technical fixes or approaches described above. Indeed, conservation efforts often falter because they fail to fully account for the history, diversity and multiple levels of social conflict influencing conservation actions (Burton, 1990; Lederach, 2003; Madden, 2004; Marker, 2003). Even when more effective stakeholder engagement is suggested or conducted, as in Barlow et al., 2010; Redpath et al., 2013; Treves et al., 2009, conservation practitioners may not have the skills or capacity to design and lead effective processes that transform destructive conflict into productive conflict (Leong et al., 2011, 2009; Manolis et al., 2009). Well-intentioned but poorly designed efforts may only address superficial aspects of the conflict and thus limit stakeholder receptivity to change and commitment to conservation goals (Leong et al., 2009; Reed, 2008). Without attention to the history of how previous decisions were made and implemented and the influence of deeper-rooted social and psychological factors in the conflict, the overall conflict may move further toward intractability, despite interventions that address the immediate or material issues at hand (Coleman, 2011; Deutsch and Coleman, 2012; Lederach, 2003, 1997; Naughton-Treves et al., 2003). In many cases, because the communities' social-psychological needs were ignored, these communities resented the imposed solution, and failed to implement or maintain the chili peppers or tore down wire from fences to use for other purposes, including illegal snaring (Bird, pers. comm., 2013; Sitati and Walpole, 2006; Songhurst, 2010). Beyond the narrow focus on addressing the material losses, analyzing the conflict dynamics and developing appropriate decision-making processes that address these deeper drivers of conflict would build genuine community receptivity to, commitment in, and ownership of the solutions

(Frahm and Brown, 2007; Lachapelle, 2008; Senge, 1997). Better understanding and accounting for the social conflicts as part of conservation efforts would likely prevent or overcome obstacles and help create conditions for greater receptivity and ownership by the very group who must be responsible for maintaining solutions (Jackson et al., 2001; Smith and Torppa, 2010). The Levels of Conflict model enables analysis of the complexity, scope, and depth of conflict in a given setting. This model classifiesthree levels of conflict: disputes, underlying, and identity-based (CICR, 2000).

Analyzing wildlife conservation conflicts with the Levels of Conflict model might reveal, for example, that a dispute about livestock depredation, crop damage, or the legal determinants for wildlife management is fueled by underlying and identity issues. Or it may suggest that a conflict that began as a material dispute has evolved into an identity conflict over time, as those involved invest themselves more in the dispute and come to identify themselves and their group with their positions in the dispute (Lederach, 1997). Eventually, these identity conflicts become so deep-rooted that they become an integral part of a person's or group's identity. This identity-based level of conflict is intense and complex, and may appear 'irrational' compared to the specific current conditions or material issues in question. The model employs the term 'settlement' to describe efforts to solve the problem at the dispute level. The levels of conflict model uses the term 'resolution' to describe efforts to solve underlying conflicts, while 'reconciliation' is used to reflect the shift in identities of the disputants necessary to address identity-based conflicts. The Conflict Intervention Triangle model provides a conceptual orientation to conflict intervention planning. Our adaptation of the Conflict Intervention Triangle provides a useful framework for relating three dimensions of conflict: process, relationships, and substance (Moore, 1986; Walker and Daniels, 1997). 'Substance' is the most straightforward and largely corresponds to the dispute level conflict in the Levels of Conflict model. Process factors relate to decision-making design, equity and authority, and how (and by whom) these are exercised. The relationship factor of conflict interventions is most easily illustrated in personal conflicts between individuals where the quality of a relationship or the level of respect and trust that exists between two people can itself become a source of contention. Conservation conflict transformation (CCT) enables the development of innovative, durable solutions through analyses and processes that simultaneously help reconcile negative relationships and transform the political, social, or economic structures and systems— the enabling environment—impacting conservation efforts. CCT recognizes the natural ebb and flow of conflict, and as such, is a dynamic, continually evolving opportunity for creativity through and evolution of relationships (Lederach, 2005, 2003). The continual engagement that maintains constructive and positive relationships and decision-making processes allows conservation efforts to adapt more effectively to ongoing changes in social and ecological systems. Successful integration of conflict transformation into conservation requires analysis of all levels and sources of conflict within the social system in which conservation is embedded. Such a thorough analysis is an essential first step to avoid unintended consequences and foster social conditions that support decision-making directed toward sustainable conservation (Hendrick, 2009; Lederach, 1997;

Lederach et al., 2007). Madden Francine and McQuinn Brian argues that conservation efforts would benefit from improved capacity and resources for understanding and transforming the complex drivers of deep-rooted social conflicts impacting wildlife conservation and management actions.

4.1.2 Factors contributing towards human-wildlife conflict

Carnivores can have devastating impacts, as even relatively low levels of stock loss can impose intolerable costs on poor households (Jackson et al., 2010; Yirga and Bauer, 2010). People commonly respond to this threat by killing problematic wildlife, either pre-emptively or in response to damage (Thirgood et al., 2005). Mitigating conflict is therefore a priority for large carnivore conservation (IUCN, 2006, 2007a; Ray et al., 2005). However, effective mitigation relies upon an in-depth understanding of the magnitude and drivers of human-wildlife conflict at a local level – for instance, if antagonism towards a species actually reflects hostility towards protected areas, the government or other groups, then reducing damage caused by that species is unlikely to significantly reduce conflict (Knight, 2000). Carnivores face increasing pressure worldwide as human populations expand (Woodroffe, 2000; Fascione, Delach & Smith, 2004), primarily from habitat conversion and destruction, prey depletion, commercial exploitation and disease outbreaks (Nyhus & Tilson, 2004; Kolowski & Holekamp, 2006). There is an emerging consensus, however, that retaliatory killing of problem animals is one of the most urgent threats to carnivore conservation (Woodroffe & Ginsberg, 1998; Woodroffe, 2000; Michalski et al., 2006), thus managers require a better understanding of how to predict and prevent attacks. Identifying underlying causes and predicting conflict hot spots would help conflict– mitigation efforts, but resources are rarely adequate to collect detailed spatial data over broad geographical areas. Risk-mapping studies come from research on bears (Nielsen et al., 2004; Wilson et al., 2005, 2006; Kretser, 2008; Kretser, Sullivan & Knuth, 2008; Northrup, Stenhouse & Boyce, 2012), wolves (Treves et al., 2004, 2011) and large felids (Jackson et al., 1996; Michalski et al., 2006). These predictive studies have examined location of housing, industry, roads, rivers, pastures, agriculture, vegetation, land cover and prey, but only Treves et al. (2004, 2011) attempted to predict conflict hot spots over a larger region outside their primary study area. Risk mapping has been employed to identify hot spots of human–elephant conflict (Hoare, 1999), patterns of crop damage (Naughton-Treves, 1998), poisoning of predators (Marquez et al., 2013) and conflict with birds in urban areas (Le Lay, Clergeau & Hubert-Moy, 2001). Numerous authors have shown that risk mapping can identify and explain underlying causes of conflict, pinpoint locations for interventions, inform stakeholders about risks and predict future conflicts (Jackson et al., 1996; Naughton-Treves, 1998; Hoare, 1999; Le Lay, Clergeau & Hubert-Moy, 2001; Treves et al., 2004, 2011; Northrup, Stenhouse & Boyce, 2012; Marquez et al., 2013). Risk mapping is especially effective for predicting conflict hot spots outside intensive study areas.

Researchers in South America studying jaguar (Panthera onca), puma (Puma concolor) and domestic cattle conflicts on large, privately managed ranches have implicitly addressed spatial dimensions of conflict (Polisar et al., 2003; Mazzolli et al., 2002) and other conservation biologists in Kenya have focused on temporal factors regarding lion (Panthera leo) – livestock conflicts on ranches (Patterson et al., 2004). Investigators in the mid-western USA have done the most, to date, to extend spatial analysis of conflict between humans and large carnivores on private lands, with a focus on conflicts involving gray wolves (Canis lupus) on farms (Mech et al., 2000; Treves et al., 2004). Dickman Amy et al in 2014 conducted 262 semistructured interviews with villagers around Tanzania's Ruaha National Park. The surveys provided data on respondents' perceived problems with wildlife, knowledge, reported killing of carnivores, and their socio-economic characteristics. Linear regression, combining eight non-collinear predictors, revealed the strongest predictor of people's perceived problem with large carnivores was the intensity of perceived problems with other wildlife. The next most important factor was reported attack history, with people who had experienced depredation by more than one carnivore species reporting particularly intense problems. Religion emerged as another significant predictor, with adherence to formal religions rather than traditional beliefs associated with higher perceived problems with carnivores. This was particularly interesting given that religious respondents lost significantly fewer livestock to depredation than other respondents. Wanting lions to decline or disappear, and living close to Ruaha National Park, were both predictors of greater perceived problems with large carnivores. Respondent age and vulnerability were not significant predictors. This study revealed a widespread perception that wildlife caused problems on village land in the Ruaha landscape, with nearly everyone reporting some kind of problem. The main reason given for perceiving a problem was the direct threat posed by wildlife to humans or their assets. Large carnivores were viewed as particularly problematic, due to the perceived risk to livestock and humans, with lions viewed as the single most problematic species due to their predation upon culturally and economically valuable cattle. Most respondents wanted large carnivores to decline or disappear, which is unsurprising as people in these communities rely heavily upon livestock for wealth and status. Human attacks were very rare, but nevertheless, such incidents obviously result in severe animosity and widespread fear (Knight, 2000). Reducing human attacks further could potentially improve attitudes, but the impact may be low as stories of attacks tend to be widely recounted for many years, leading to a ‘hyperawareness’ of risk (Dickman, 2010). Carnivores were perceived as more problematic amongst people living close to the Park, while other wildlife was viewed as more problematic amongst people living further from it. However, people may share common experiences which increase perceptions of problems with all wildlife, such as perceived disempowerment regarding wildlife use, poor relationships with the Park, and a lack of benefits from wildlife – this is certainly conceivable here, as less than 2% of all respondents received any wildlife-related income. Furthermore, people are often influenced by other peoples’ views – instead of being individualistic, attitudes (particularly about emotionally-charged issues) are often based upon a shared, socially constructed model (Degoey, 2000). Therefore, someone else’s problems with carnivores or other species might heighten a respondent’s antagonism, even towards species that they have not directly experienced problems with. Alternatively, directly experiencing problems with one group of species (e.g. crop loss from herbivores) could increase someone’s vulnerability towards the impacts of any further wildlife damage, reducing their tolerance and increasing their antagonism towards even relatively small amounts of damage. ‘Contagious’ conflict has been explored in other disciplines, such as warfare, rebellion and justice (Danneman and Ritter, 2014; De Maio, 2010; Degoey, 2000; Fox, 2004), but its occurrence and mechanisms have not yet been investigated in human-wildlife conflict. For example, it is possible that dealing with one issue– such as reducing depredation – could help improve attitudes towards wildlife in general, but conversely, reducing attacks may not significantly improve views towards carnivores unless conflict with other wildlife is also lessened. In such circumstances, conflict mitigation should ideally not be taxon-specific, but should consider how views towards wildlife in general can be improved. Moreover, there appeared to be some degree of contagion even within a taxon: conflict scores across carnivores were highly correlated, with people who assigned them all the same score tending to view them as more problematic than others, suggesting they were biased by the more problematic species. Therefore, if a problem caused by one species reduces tolerance for another species, then species which do not cause much damage may benefit from improving attitudes towards other, more problematic species. Improving knowledge might also reduce this contagious effect, because if people struggle to differentiate between carnivore species, a species which has never caused problems could be viewed as problematic purely due to confusion with another species – this certainly seems likely for the cheetah, which was confused with the more problematic leopard by 90% of respondents.

4.2 Literature review

Lewis L. D. et all (2014) developed a population projection matrix model that included survival and reproduction as a function of variation in natural food production, use of urban food resources, and conflict-bear management. They parametrized our models using demographic data from a 6-year study of urban bears (Aspen study), supplemented with vital rates from a meta-analysis of Western black bear populations (Beston, 2011). Later they developed a Baseline scenario where the bear population did not have access to urban food sources or experience management removal of conflict bears and used computer simulation to compare this with two management scenarios where bears utilized human foods and managers removed conflict bears. They evaluated how an increase in the number of natural food failure years could impact the population by calculating population growth rates at six different natural food failure year frequencies. They quantified the potential impact that vital rate changes can have on the stochastic population growth rate using prospective perturbation analyses to calculate vital rate elasticity values. Additionally, they used elasticity values in conjunction with changes to vital rates between scenarios to assess overall cost and benefit of each management scenario and to show the impact each vital rate change had on the population growth rate. They then used additional simulations to assess how much each vital rate contributed to variation in the population growth rate over 50-year projections. Their modeling effort is unique because we model changing environmental conditions, allowing a more realistic understanding of the influence that changes in vital rates will have when management actions respond to changing environmental conditions.

Wine Stuart and Meentemeyer R.K. (2014) explored the relative importance of socioeconomic variables compared to those describing coyote habitat in predicting human–coyote encounters in highly urbanized Mecklenburg County, North Carolina, USA using 707 public reports of coyote sightings, high-resolution land cover, US Census data, and an autologistic multimodel inference approach. Three of the four socioeconomic variables which they hypothesized would have an important influence on encounter probability, namely building density, household income, and occupation, had effects at least as large as or larger than coyote habitat variables. The results indicate that the consideration of readily available socioeconomic variables in the analysis of citizen science data improves the prediction of species distributions by providing insight into the effects of important factors for which data are often lacking, such as resource availability for coyotes on private property and observer experience (Wine Stuart et al., 2014).

Heinonen Johannes et al (2014) introduced a an individual based model for understanding and predicting spatial hen harrier (Circus cyaneus) population dynamics in Great Britain. The model uses a landscape with habitat, prey and game management indices. The hen harrier population was initialized according to empirical census estimates for 1988/89 and simulated until 2030, and predictions for 1998, 2004 and 2010 were compared to empirical census estimates for respective years. The model produced a good qualitative match to overall trends between 1989 and 2010. This tool can be used in the mapping of spatial and temporal patterns in the abundance of a species, and hence in mapping of conflict areas. The results illustrated that while historical trends in populations cannot be replicated exactly, a reasonable representation of reality can be achieved when producing a model which is simple enough to allow some inference about the mechanisms of the processes controlling population growth. Further exploration of the model dynamics, perhaps through Bayesian-based sensitivity analyses can improve understanding of which model parameters and processes are most crucial and hence where data collection efforts should be focused to improve our representation of the hen harrier behavior and population dynamics, in order to better inform management decisions.

Li Juan et al (2013) investigated human-snow leopard conflicts in the Sanjiangyuan Region of the Tibetan Plateau, by conducting household interviews about local herders' traditional use of snow leopard parts, livestock depredation, and overall attitudes towards snow leopards. The results suggested that most respondents (58%) knew that snow leopard parts had been used for traditional customs in the past, but they claimed not in the past two or three decades. Total livestock losses were damaging (US$ 6193 per household in the past 1 year); however snow leopards were blamed by herders for only a small proportion of those losses (10%), as compared to wolves (45%) and disease (42%). Correspondingly, the cultural images of snow leopards were neutral (78%) and positive (9%) on the whole. The authors recommend a multi-pronged conservation program that includes compensation, insurance programs, and training local veterinarians to reduce livestock losses.

Madden Francine and McQuinn Brian (2014) discussed current limitations of practice when addressing conflict in conservation, define conflict transformation, illustrate two analytical models to orient the reader to the benefits of CCT, and present two case studies where CCT was applied usefully to a conservation-related conflict. The conservation conflict transformation (CCT) offers a new perspective on, and approach to, how conservationists identify, understand, prevent, and reconcile conflict. The Human-Wildlife Conflict Collaboration (HWCC) has adapted and demonstrated these principles for application in conservation through capacity building and conflict interventions, transforming how many practitioners in the conservation field address conflict.

Douglas Leo and Alie Kelvin (2014) discussed the role that wildlife can play in national and international security interests, including wildlife's role in financing the activities of belligerent groups and catalyzing social conflict. They believe that wildlife can have a powerful influence on violent conflicts and security interests, particularly in developing and weak states, where the earth's biological resources are disproportionately found. They suggested that recognizing this relationship is important because it illuminates the gravity of the threat facing several charismatic species. The association also illuminates a neglected link between wildlife conservation and high-priority security and development policy concerns. They also advocate that documenting and deconstructing the relationship between the wildlife trade and international crime, armed conflict, security, and development concerns within the context of our knowledge of other high-value natural resources has policy and management implications of great important in conservation practice.

Suryawanshi Kulbhushansingh et al (2014) used structured interview surveys to quantitatively assess the attitudes of a Buddhist pastoral community toward snow leopards (Panthera uncia) and wolves (Canis lupus). They interviewed 381 individuals from 24 villages within 6 study sites across the high-elevation Spiti Valley in the Indian Trans-Himalaya. They gathered information on key explanatory variables that together captured variation in individual and village-level socioeconomic factors. Later they used hierarchical linear models to examine how the effect of these factors on human attitudes changed with the scale of analysis from the individual to the community. Factors significant at the individual level were gender, education, and age of the respondent (for wolves and snow leopards), number of income sources in the family (wolves), agricultural production, and large-bodied livestock holdings (snow leopards). At the community level, the significant factors included the number of smaller-bodied herded livestock killed by wolves and mean agricultural production (wolves) and village size and large livestock holdings (snow leopards). The results reflected that scaling up from the individual to higher levels of social organization can highlight important factors that influence attitudes of people toward wildlife and toward formal conservation efforts in general. Such scale-specific information can help managers apply conservation measures at appropriate scales.

Kushnir Hadas et al (2014) developed a logistic regression model that predicts probability of lion attacks based on landscape characteristics, creating a risk map for two well-studied districts in Tanzania as well as for three neighbouring districts. The results of the model identify a number of factors that increase probability of attack. Probability of attack decreases with distances >1 km from villages, showing that attacks occur in areas nearest to human habitation. Probability of lion attack also decreases between 25 and 100 km from protected areas, indicating that attacks either occur in close proximity to protected areas, where lion and lion prey are more abundant, or further from protected areas, where lions may be present but prey are scarce. High proportions of three cover types significantly increased probabilities of attack: open woodland/bushland, grassland with crops and woodland/bushland with crops. In a fine-scale landscape analysis of lion predation in Serengeti National Park, Hopcraft, Sinclair and Packer (2005) showed that lions prefer areas with hunting cover where prey is easier to catch. Open woodland and bushland are ideal habitats for lions in Lindi and Rufiji, providing access to grazing and browsing prey and cover for stalking. People tend to live in temporary structures and stay outside to protect crops in these areas owing to the high abundance of bush pigs, a common nocturnal crop pest that lure lions into agricultural fields (Packer et al., 2005; Kushnir et al., 2010). Recent increases in grassland and grassland with crops also increase probability of attack, while increases in wetlands and bare areas decrease the probability of attacks. Identification of high-risk areas allows wildlife managers to pinpoint locations for interventions such as training local game scouts to assist in controlling maneaters or helping villagers improve their personal safety. By identifying characteristics of high-risk locations, village land-use planners could encourage villagers to avoid farming in high-risk areas or to maintain low-risk land-cover types near their villages.

Behdarvand Neda et al (2014) studied Conflicts between humans and wolves (Canis lupus) in western Iran, especially Hamedan province (HP). To determine the most important predictors of such conflicts and to identify the distribution of areas with potential risk of wolf attack on humans and livestock in HP, they employed Maximum Entropy (Maxent) algorithm to build predictive models with reported conflict data from 2001 to 2010. The resulting models correctly assigned subsequent attack sites from 2011 and 2012 to high-risk areas. They found that variables related to land use/cover types affected by anthropogenic influences on the landscape, such as irrigated farms and human settlements, were the most important in predicting wolf attack risk levels

Wilson Seth et al (2005) used multiple logistic regression to model how different landscape conditions contributed to the probability of human–grizzly bear conflicts on private agricultural ranch lands. They used locations of livestock pastures, traditional livestock carcass disposal areas (boneyards), beehives, and wetland-riparian associated vegetation to model the locations of 178 reported human–grizzly bear conflicts along the Rocky Mountain East Front, Montana, USA during 1986–2001. Then they surveyed 61 livestock producers in the upper Teton watershed of north-central Montana, to collect spatial and temporal data on livestock pastures, boneyards, and beehives for the same period, accounting for changes in livestock and boneyard management and beehive location and protection, for each season. They also used 2032 random points to represent the null hypothesis of random location relative to potential explanatory landscape features, and used Akaike's Information Criteria (AIC/AICC) and Hosmer–Lemeshow goodness-of-fit statistics for model selection. Later, they used a resulting ‘‘best’’ model to map contours of predicted probabilities of conflict, and used this map for verification with an independent dataset of conflicts to provide additional insights regarding the nature of conflicts. The presence of riparian vegetation and distances to spring, summer, and fall sheep or cattle pastures, calving and sheep lambing areas, unmanaged boneyards, and fenced and unfenced beehives were all associated with the likelihood of human–grizzly bear conflicts. The model suggests that collections of attractants concentrated in high quality bear habitat largely explain broad patterns of human–grizzly bear conflicts on private agricultural land in our study area.

Goswami Varun et al (2014) distinguish the role of wildlife-friendly land uses as being (a) subsidiary, whereby they augment PAs with secondary habitat, or (b) substitutive, wherein they provide comparable habitat to PAs. They tested our hypotheses by investigating the influence of land use and human presence on space-use intensity of the endangered Asian elephant (Elephas maximus) in a fragmented landscape comprising PAs and wildlife-friendly landuses. They applied multistate occupancy models to spatial data on elephant occurrence to estimate and model the overall probability of elephants using a site, and the conditional probability of high-intensity use given that elephants use a site. The probability of elephants using a site regardless of intensity did not vary between PAs and wildlife-friendly land uses. However, high-intensity use declined with distance to PAs, and this effect was accentuated by an increase in village density. Therefore, while wildlife-friendly land uses did play a subsidiary conservation role, their potential to substitute for PAs was offset by a strong human presence.

4.3 Aim To develop a dynamic, systems model of human-wildlife conflict.

Ho: The dynamic system of human-wildlife interaction is not sensitive to changes in human variables.

Ha: The dynamic system of human-wildlife interaction is sensitive to changes in human variables.

4.4 Specific objectives

1) To develop a dynamic system model of tiger habitat in Corbett National Park.
2) To model human-factors influencing conflicts with tiger population.
3) To simulate various scenarios to observe change in tiger population trend across India.
4) To develop strategies for tiger conservation in India.

4.5 Methods

4.5.1 Conceptual model

To take into account all the factors and components influencing human-wildlife interactions we designed a conceptual model using Edraw Max 7 software (licensed version). The model is divided into three major factors – environment, humans, and wildlife. Each factor is further divided into its components which directly or indirectly play a significant role in influencing human-wildlife interactions in nature. Each and every factor in the model is connected directly or indirectly with each other. This model can be used for any carnivore species in the world to study their interactions with humans. For this study we are focusing this model on tigers of Corbett National Park in India.

The first factor-environment consists of biotic and abiotic components of environment which play an integral part in building the system. Temperature, humidity, precipitation and climate change are the crucial biotic factors and habitat type, habitat area, landform type, fragmentation, isolation, connectivity, elevation and latitude are the abiotic factors identified in this model. These factors are identified as playing crucial role in affecting the environment directly which later affects human-wildlife interactions indirectly.

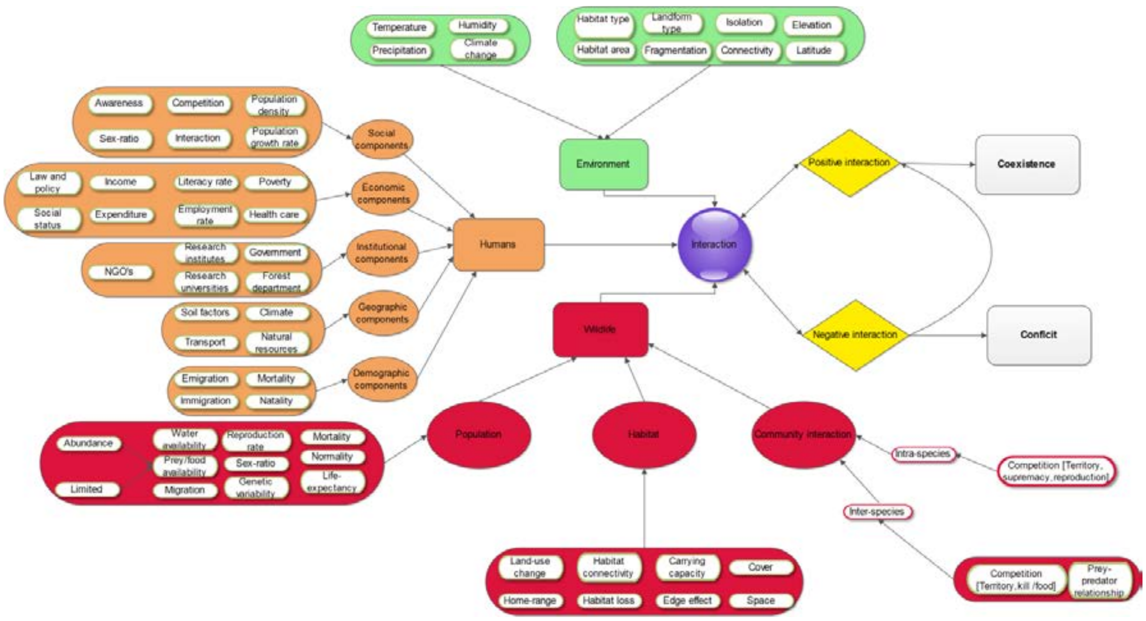

Figure 8: Conceptual model for factors influencing carnivore interaction and conflicts

The second factor-human is further classified into 5 categories: Social, economic components, institutional components, geographic components and demographic components. We identified that the social components of this model are awareness, sex-ratio, competition, interaction, population density and population growth-rate. The economic components are law and policy income, literacy rate, poverty, social status, expenditure, employment rate and health care. The institutional components are NGO's, research institutes, research universities, government and forest department. The geographic components are soil factors, transport, climate, and natural resources. Demographic components are emigration, immigration, mortality and natality.

The third factor-wildlife is divided into 3 categories: population, habitat and community interaction. The major components of population are prey/food availability with respect to abundance and scarcity, water availability, migration, reproduction rate, sex-ratio, genetic variability, mortality, normality and life-expectancy. The component of habitat consists of land-use change, home range, habitat connectivity, habitat loss, carrying capacity, edge effect, cover and space. The community interaction is divided into two sub-sections- intra species, which incorporates territory, supremacy and reproduction; and intra-species, which consists of competition for food and territory and prey-predator relationship.

4.5.2 Empirical model

We designed an Empirical model using STELLA software considering an ideal scenario for accounting human-wildlife conflicts. We divided the entire model into 3 major factors- environment, humans and wildlife. All the factors and their variables are interlinked with each other. Each factor is assigned several variables in the model. We can add or change values of each and every variable in the model according to the research needs. If we add or change a value of any variable, it affects the entire model and finally changes the human-wildlife conflict potential value. This model can be used to study any carnivore species associated in conflicts with humans in the entire world. This will give a clear understanding of how and to what extent does each variable play a role in influencing human-wildlife conflict.

We will discuss the model by explaining each factor individually. There are inflow function (variables) that plays a major role in increasing human-wildlife conflict and there are outflow function (variables) that plays a significant role in decreasing human-wildlife conflicts. The first factor we will discuss is Environment; which has 6 major variables linked to it. The variables that influence human-wildlife conflict under the banner of environment are precipitation, temperature, habitat loss, elevation, latitude and increase in habitat. Out of the 6 major environmental variables, some of the variables in the model play a role in increasing human-wildlife conflicts; some help in decreasing human-wildlife conflicts and few help in both-increasing as well as decreasing human-wildlife conflicts. Precipitation, temperature, elevation and latitude help in both-increasing as well as decreasing conflicts. Habitat-loss leads to increasing conflicts; whereas increase in habitat area helps in decreasing conflicts.

Most of the variables linked with human factor lead to increase in conflicts. Immigration, increasing competition for resources and land, prey scavenging, bad governance, high unemployment rate, poverty, increase in livestock population and increasing human population are the variables which increase human-wildlife conflicts out of the 13 other identified variables under the title of human factors. Awareness, literacy rate, proximity to national park are the variables listed under human factors that play a role in both-increasing as well as decreasing human wildlife conflicts. Emigration and good governance are the only two identified factors that can help decrease conflicts when considering human factors.

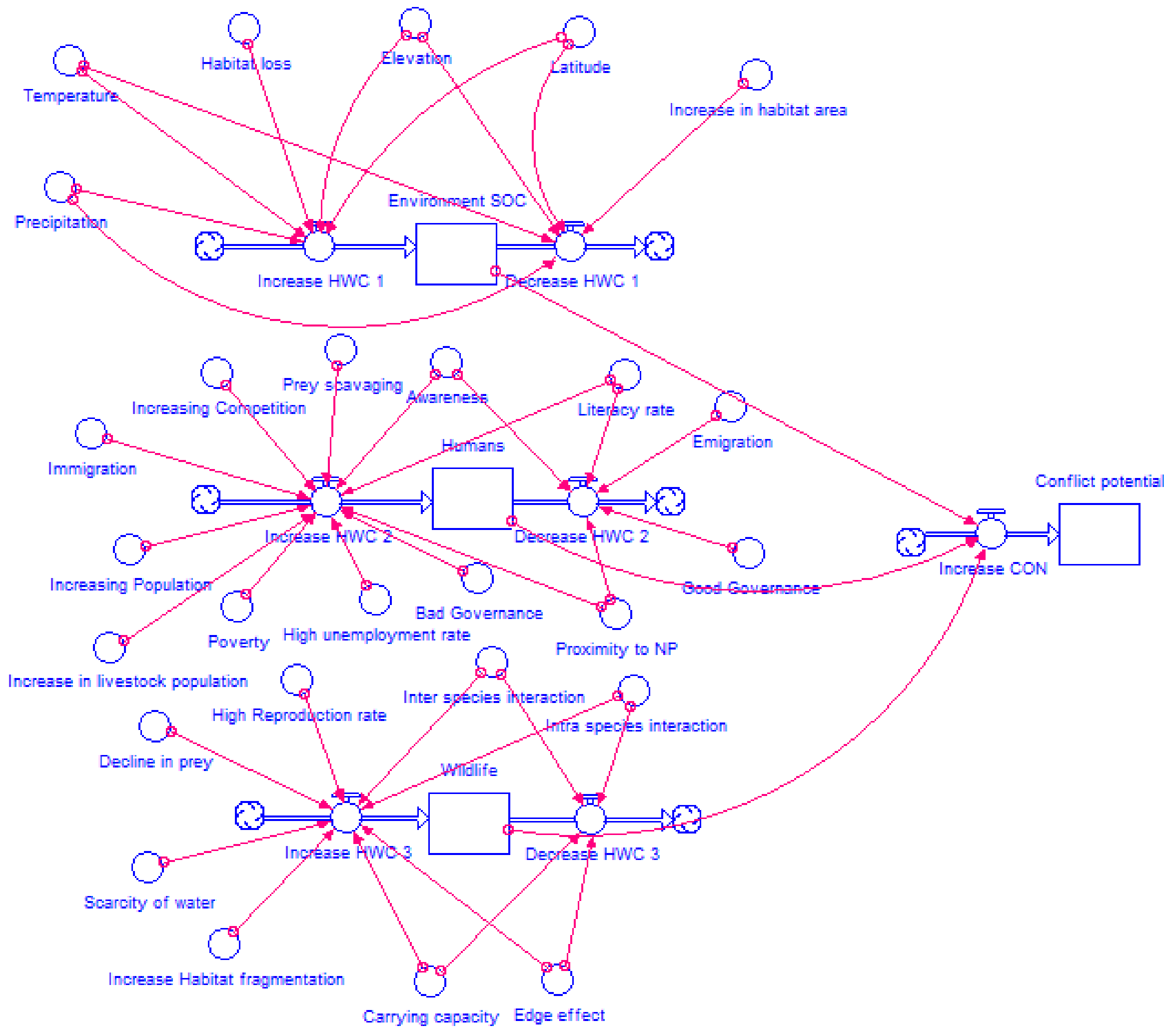

Figure 9: Empirical model to understand the nature of conflict between carnivores and humans.

The model does not identify any variable associated with wildlife factors that lead to decrease in conflicts. We identified that decline in prey, high reproduction rate of animals, increased habitat fragmentation and scarcity of water will led to increase in human-wildlife conflicts. The variable that plays a role in both-increasing and decreasing human-wildlife conflicts under the title of wildlife factors are inter-species, interaction, intra-species interaction, edge effect and carrying capacity. All 3 major inflow function (factors)-environment, humans and wildlife directly or indirectly influences conflict potential, which is out final outflow.

4.5.3 Baseline model for tiger population uncertainty analysis

Using STELLA modeling software, we designed a tiger population prediction model to predict tiger population for next 85 years (till 2100) by collecting data from past literature. Tiger national parks in India are categorized into four major tiger landscape complexes by Nation tiger conservation authority of India under Project tiger- Shivalik-Gangetic landscape complex (SGL), North Eastern Hills and Brahmaputra flood plains (NEBL), Central Indian landscape complex and Eastern Ghats landscape complex (CIEGL), Sundarbans landscape complex (SL) and Western Ghats landscape complex (WGL). We collected data for year 2006, 2010 and 2014 on total tiger population, natural deaths and poaching for each landscape-complex in India (Annexure-I; and Jhala, et al., 2015. The status of tigers in India, 2014).

Then we calculated the birthrates of tigers in each tiger landscape complex of India using STELLA model by calibrating it with the official tiger population census conducted every 5 years by Government of India. Using 2006 total tiger population, birthrates, natural death-rates and poaching rates; we constructed an empirical model for predicting tiger population in India for next 85 years based on their landscape complexes. The inflow functions of this model are birthrates and immigration rates; and the outflow functions are death-rates, emigration and poaching for each landscape.

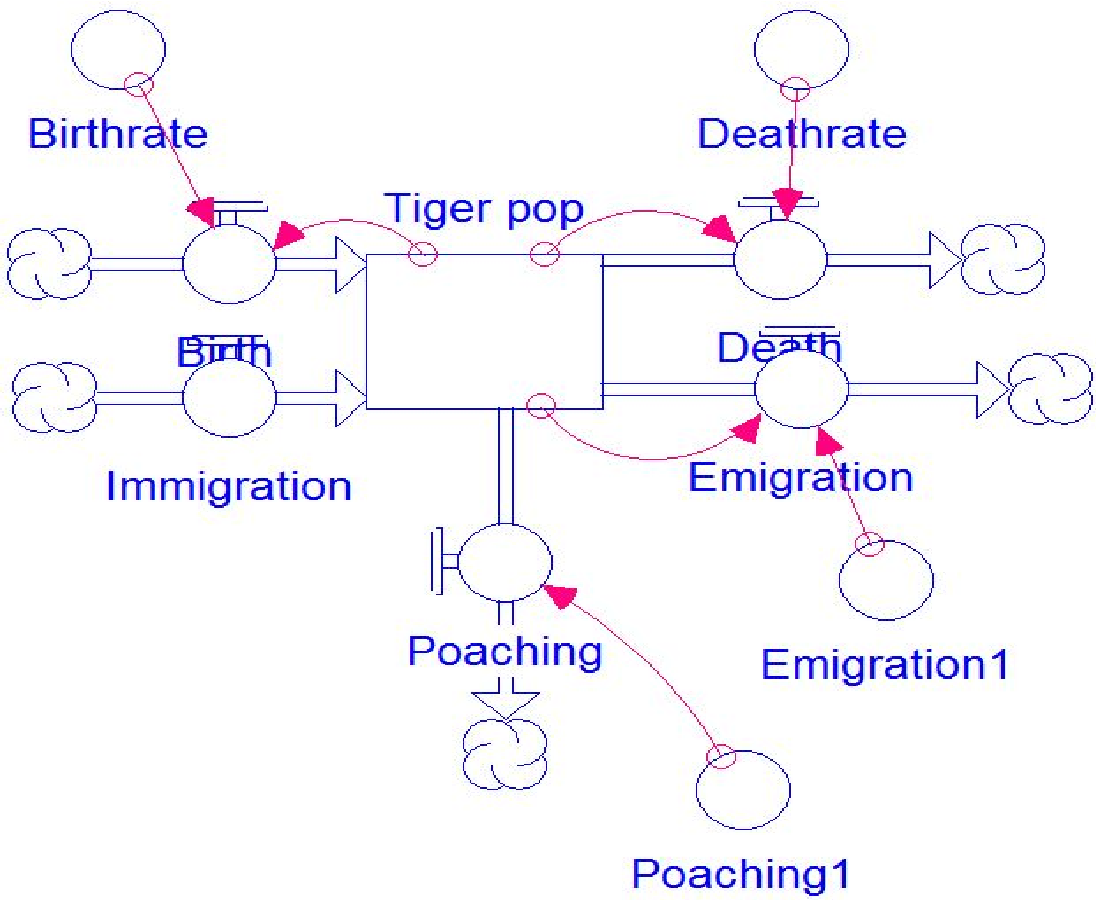

Figure 10: Baseline model

We used the data presented in Table 4 for building a baseline tiger population prediction model using 2006 data set. We have used abbreviated names for each tiger landscape complex of India in the table. SGL stands for Shivalik-Gangetic landscape complex, NEBL stands for North Eastern Hills and Brahmaputra flood plains, CIEGL stands for Central Indian landscape complex and Eastern Ghats landscape complex, SL stands for Sundarbans landscape complex and WGL stands for Western Ghats landscape complex. Government of India does not have any data on tiger population estimates for Sundarbans landscape (marked with double stars in the table) complex for 2006 year. So we calibrated 2006 tiger population for Sundarbans landscape complex from 2010 and 2014 tiger population estimates and assumed it to be 64 tigers. This is represented by (**) in the table.

Table 4: Data used to construct the model

Tiger landscape complex	Total tiger population as per 2006 Govt. census	2006 Birthrate	2006 Natural death-rate	2006 Poaching rate
SGL	297	2.33	1.42	0.85
NEBL	100	6.17	4.05	2.03
CIEGL	601	1.51	1.49	2.16
SL	64**	0.83	0.8	0.5
WGL	412	1.01	0.93	1.7
TOTAL	1474	---	---	---

Based on baseline model calibrated data shown in Table 4, we simulated the tiger population prediction landscape-wise for entire India from year 2006 to 2100. Table 5 shows simulation results for tiger population estimates using 2006 baseline model and data. We found that the tiger population is going up in India as per the current scenario because of extensive conservation practices and anti-poaching units.

Table 5: Baseline model simulation results

Baseline model for tiger population prediction till 2100					
Year	**CIEGL**	**NEBL**	**SGL**	**SL**	**WGL**
2006	601	100	297	64	412
2010	641.64	141.16	374.96	69.94	552.86
2014	685.63	199.26	473.37	76.63	744.5
2018	733.24	281.27	597.62	84.15	1,005.22
2022	784.78	397.03	754.48	92.62	1,359.94
2026	840.57	560.44	952.52	102.16	1,842.52
2030	900.96	791.11	1,202.53	112.89	2,499.07
2034	966.32	1,116.71	1,518.17	124.96	3,392.29
2038	1,037.08	1,576.33	1,916.66	138.55	4,607.52
2042	1,113.66	2,225.12	2,419.73	153.85	6,260.81
2046	1,196.56	3,140.94	3,054.86	171.07	8,510.11
2050	1,286.30	4,433.70	3,856.69	190.45	11,570.25
2100	3279.49	329678.64	71040.79	778.51	541687.78

We also noticed that the tiger populations appeared to be unrealistic for 2100 year as shown in Table 5. So we later introduced population density parameter to the empirical baseline model to generate some realistic tiger population prediction scenarios for India till 2100. Population density parameter in the empirical model will help in restricting population growth of tigers beyond the carrying capacity of their habitat. To generate data for tiger density in the model, we first need to find the carrying capacity of the tigers for each landscape complex in India.

So, we first collected data on total tiger habitat area in Sq.km per landscape complex. We got the total area for each tiger reserve in Sq.km individually from Indian Government reports (Project Tiger report and NTCA). We segregated every tiger reserve amongst 5 major identified tiger landscape complexes of India according to their geographic location. After adding all the tiger reserve area within a landscape complex, we derived the total tiger habitat area for each of the 5 landscape complexes. Now to calculate the carrying capacity for tigers in each landscape complexes, we also have to find a male tiger habitat range. A.Majumder et al in 2012 carried out a study on estimating home-range of radio-collared tigers in Pench tiger reserve, Madhya Pradesh, India. The results of their study estimated that using 95% FK, 19.2 sq.km area overlapped between adult male and adult female; and 15.4 sq.km area overlapped between adult female and semi-adult male tiger. They also found that 25-35 Sq.km undisturbed area is required for breeding females. For our study, we took an average of 19.2 sq.km and 15.4 sq.km home range area of tiger to calculate our carrying capacity. An average home-range of 17.3 sq.km was considered for an adult tiger in India. We divide each of the total landscape complex area with the estimated average home-range area for tigers in India which is 17.3 sq.km. The outcome of this gave us the total carrying capacity of tigers in each of the 5 tiger landscape complexes of India as shown in Table 6. The star symbol (*) in the table indicates that the landscape has reached or crossed its carrying capacity for tigers.

Table 6: Population density and carrying capacity of tiger landscape complex in India

Tiger landscape complex	Total area of the landscape complex in sq.km	2006 tiger population estimates	2010 tiger population estimates	2014 tiger population estimates	Population density with reference to 17.3 sq.km home range
SGL	6,350.31	297	353	485	367*
NEHBL	9,665.67	100	148	201	558

CIEGL	36,510.05	601	601	688	2110
SL	2,584.89	64**	70	76	149
WGL	12,145.74	412	534	778	702*
Total	67,256.68	1474	1706	2228	3887

*=Indicates that a particular landscape has reached/crossed its carrying capacity for tigers.

Now using the carrying capacity data, we will introduce a population density parameter in the baseline empirical model using STELLA software. For those landscape complexes whose carrying capacity has already been reached or crossed, we will use their 2014; most recent population census data in the empirical model to simulate tiger population from 2006 till 2100. So we will use 485 tigers for SGL and 778 tigers for WGL as per their carrying capacity according to their recent census figures. Figure 14 shows the new empirical model with population density parameter in it.

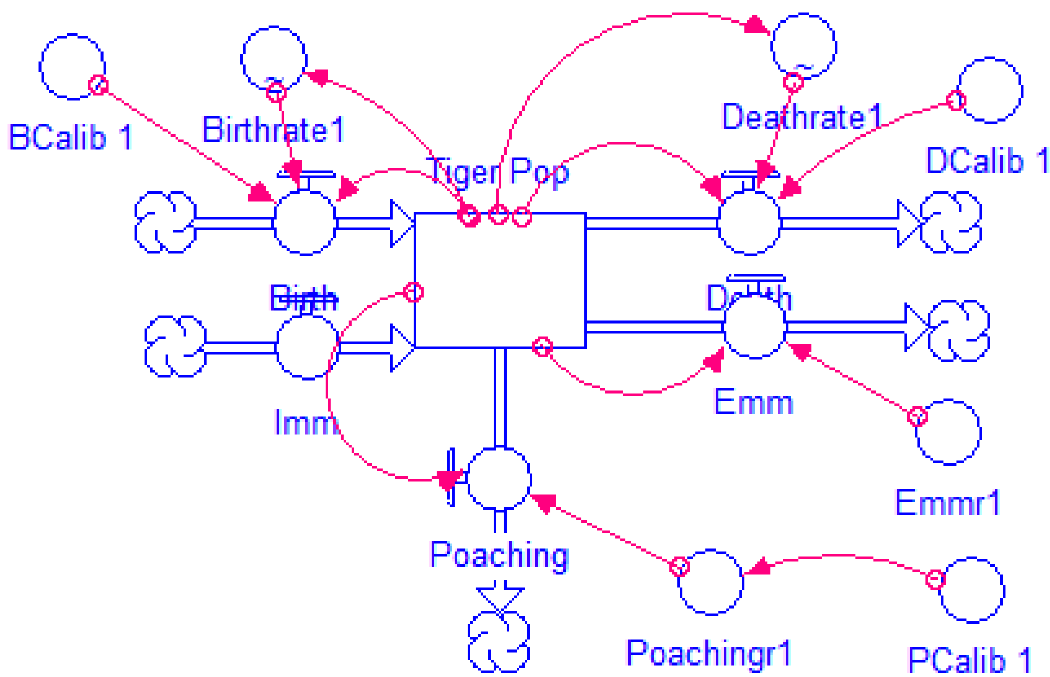

Figure 11: Empirical model diagram with population density

The inflow functions of the model are birthrate and immigration; and the outflow functions are death-rate, emigration and poaching. We calibrated this model with official tiger population census and simulated the data to observe tiger population for each of the five landscape complexes in

India from 2006 till 2100. The word ‘Calib’ in the figure stands for calibration and ‘Pop’ stands for population. To run this model we used the data show in Table 7. We took the highest birthrate (0.0617) and death-rate (0.05) values and considered to be constant for every landscape complex. We did not find any past literature mentioning migration rates or number of tigers from one landscape complex to another. So we considered immigration and emigration rate to be 0 for every landscape complex in India.

Table 7: Data used to run calibrated baseline model with population density parameter

Tiger landscape complex	2006 Tiger population	Birthrate	Calibrated birth-rate	Death-rate	Calibrated death-rate	Poaching	Calibrated poaching rate	Carrying capacity of the habitat
SGL	297	0.0617	3	0.05	0.002	0.009	0.002	485
NEHBL	100	0.0617	2	0.05	0.4	0.02	0.4	558
CIEGL	601	0.0617	4	0.05	0.006	0.022	0.006	2110
SL	64**	0.0617	5	0.05	0.001	0.005	0.001	149
WGL	412	0.0617	1.33	0.05	0.01	0.017	0.01	778
Total	1474	---	---	---	---	---	---	4080

After running the calibrated simulation model, we created 2 scenarios for uncertainty analysis for tiger population in India. The two scenarios were (A) Habitat scenario and (C) Poaching scenario. We simulated the empirical calibrated model for two scenarios, one by one.

For scenario A, which focused on habitat uncertainty analysis; we changed the values of birthrate rate and death-rate in the model and simulated the results. We created two situations to predict the tiger population from 2006 to 2100 using the calibrated baseline model. For the first situation, we increased the current birthrates by 25% and kept the death rates to be the same. For the second situation we changed the death-rate by 25% for each landscape complex and kept the birthrates unchanged. In the first situation, the birthrates are higher and the death rate is lower. While in another situation, the death rate is higher and the birthrates are lower. Both of these situations will help us clearly understand the role of habitat in sustaining tiger population in India as shown in table 9 and 10.

For scenario B, we analyzed poaching uncertainty. For this, we simulated 2 situations by significantly changing poaching rate values; which will help predict tiger population from 2006 to 2100 in India. The first situation concentrates on zero poaching rate and the second situation aims for higher poaching rates. In the first situation we took zero poaching as poaching rate for each landscape complex in empirical model and for the second situation we increased the poaching rate by 20% and considered it to be the higher poaching rate values for every landscape complex.

4.6 Results

Table 8 shows the results for the calibrated baseline model for tiger population in India for all the 5 designated tiger landscape complexes in India from 2006 till 2100.

Table 8: Calibrated baseline model results

Simulated baseline model with population density parameter for tiger population prediction from 2006 till 2100					
Year	**CIEGL Pop**	**NEBL Pop**	**SGL Pop**	**SL Pop**	**WGL Pop**
2006	601	100	297	64	412
2010	705.29	147.54	356.46	70.35	534.43
2014	789.78	215.85	394.35	75.57	619.76
2018	860.43	309.41	419.29	80.13	674.9
2022	921.22	412.72	436.34	84.33	709.6
2026	974.57	482.57	447.91	88.14	732.48
2030	1,020.29	515.81	456.12	91.64	748.01
2034	1,058.68	522.03	461.86	95.3	758.34
2038	1,093.72	522.82	465.82	99.21	765.12
2042	1,129.27	522.92	468.55	103.39	769.53
2046	1,165.29	522.93	470.41	107.76	772.38
2050	1,201.76	522.93	471.67	111.94	774.22
2054	1,238.62	522.93	472.53	115.88	775.4
2058	1,275.83	522.93	473.11	119.56	776.16
2062	1,312.87	522.93	473.51	123.22	776.65
2066	1,349.36	522.93	473.78	127.12	776.96
2070	1,385.22	522.93	473.96	131.3	777.16
2074	1,420.39	522.93	474.08	135.73	777.29
2078	1,454.80	522.93	474.16	139.42	777.37
2082	1,488.38	522.93	474.22	142.14	777.42
2086	1,521.09	522.93	474.25	144.12	777.45

2090	1,552.89	522.93	474.28	145.55	777.47
2094	1,583.72	522.93	474.3	146.56	777.49
2098	1,613.57	522.93	474.31	147.29	777.5
2100	1,628.12	522.93	474.31	147.57	777.5
Total Pop	3550				

The results suggests that as per the 2014 tiger census data published by Government of India, Shivalik Gangetic Landscape complex (SGL) and Western Ghats landscape complex (WGL) have already reached their carrying capacity with respect to their total tiger habitat area. Central Indian landscape complex and Eastern Ghats landscape complex (CIEGL) and Sundarbans (SL) landscape complex have the highest potential for tiger population to flourish in India, with respect to their habitat area. The results reflect that tiger population in India can still go up by significant number if proper conservation strategies and planning are applied.

Now, we will discuss about uncertainty analysis for tiger population in India. Table 9 shows the results from the uncertainty analysis scenario A; if the habitat quality and area increases what effects it will have on the total tiger population in India. We can clearly see in table 9 that the population of tigers will thrive if the habitat area and quality increases. Increasing the birthrates by 25%, the total tiger population rapidly went up from 3550 tigers to 4577 tigers by year 2100.

Table 9: Scenario A (Situation 1- Higher birthrate)

Year	**CIEGL Pop**	**NEBL Pop**	**SGL Pop**	**SL Pop**	**WGL Pop**
2006	601	100	297	64	412
2010	733.85	183.17	372.91	71.57	619.22
2014	836.85	326.5	414.42	77.58	720.19
2018	920.45	482.24	439.07	82.9	768.94
2022	991.79	533.2	453.92	87.67	795.1
2026	1,050.49	534.92	463.17	91.97	820.13
2030	1,101.14	534.96	468.78	96.49	845.95
2034	1,152.73	534.96	472.15	101.38	872.58
2038	1,205.46	534.96	474.14	106.67	900.05
2042	1,259.25	534.96	475.32	111.82	928.38
2046	1,313.59	534.96	476.01	116.62	957.61
2050	1,367.33	534.96	476.42	121.08	987.75
2054	1,420.19	534.96	476.66	125.72	1,018.85
2058	1,471.97	534.96	476.8	130.75	1,050.92
2062	1,522.48	534.96	476.88	136.14	1,084.01

2066	1,571.54	534.96	476.93	140.45	1,118.13
2070	1,619.00	534.96	476.96	143.42	1,153.33
2074	1,664.74	534.96	476.97	145.43	1,189.64
2078	1,708.82	534.96	476.98	146.76	1,227.09
2082	1,753.40	534.96	476.99	147.65	1,265.72
2086	1,799.09	534.96	476.99	148.23	1,305.56
2090	1,845.93	534.96	477	148.61	1,346.66
2094	1,893.95	534.96	477	148.86	1,389.06
2098	1,940.43	534.96	477	149.02	1,432.79
2100	1,960.90	534.96	477	149.09	1,455.16
Total Pop	4577				

The results from table 10 describes situation 2, where the habitat quality was poor. In this situation the death rates were increased by 25% and the birthrates were kept unchanged. The results showed a rapid decline in the population of tigers throughout all the landscape complexes in India. The total population tigers declined to 2270 from 3550 tigers in India. This shows how the habitat area and quality can influence population growth of tiger over a period of time.

Table 10: Scenario A (Situation 2- Higher death-rate)

Year	CIEGL Pop	NEBL Pop	SGL Pop	SL Pop	WGL Pop
2006	601	100	297	64	412
2010	662.65	131.09	321.52	67.85	518.88
2014	701.23	168.57	333.66	70.47	580.94
2018	730.33	212.92	339.23	72.2	609.32
2022	751.62	263.9	341.72	73.31	620.61
2026	766.86	315.91	342.84	74.01	624.85
2030	777.59	360.7	343.34	74.45	626.39
2034	785.05	391.83	343.57	74.73	626.94
2038	790.21	409.27	343.67	74.94	627.14
2042	793.74	416.96	343.71	75.09	627.21
2046	796.16	420.2	343.73	75.2	627.23
2050	797.81	421.54	343.74	75.28	627.24
2054	798.93	422.09	343.74	75.34	627.24
2058	799.70	422.32	343.74	75.39	627.25
2062	800.22	422.41	343.75	75.42	627.25
2066	800.57	422.45	343.75	75.44	627.25
2070	800.81	422.46	343.75	75.46	627.25
2074	800.97	422.47	343.75	75.47	627.25
2078	801.08	422.47	343.75	75.48	627.25
2082	801.15	422.47	343.75	75.49	627.25
2086	801.21	422.47	343.75	75.49	627.25
2090	801.24	422.47	343.75	75.5	627.25
2094	801.26	422.47	343.75	75.5	627.25

2098	801.28	422.47	343.75	75.5	627.25
2100	801.28	422.47	343.75	75.5	627.25
Total Pop	2270				

Now we will take a look at the results from Scenario 2, where we had two situations- zero poaching and higher poaching rate for each landscape complex of India. Table 11 shows the results from zero poaching rate situations. This will be one of the most ideal situations if Government and NGO's in India can bring down poaching to a negligible rate. We can clearly see in table 11 how the tiger population has gone up significantly from 3550 to 5056 tigers when we consider poaching to be zero across India.

Table 11: Scenario B (Situation 1- zero poaching)

Year	CIEGL Pop	NEBL Pop	SGL Pop	SL Pop	WGL Pop
2006	601	100	297	64	412
2010	720.33	151.9	358.69	70.6	551.22
2014	819.75	228.62	398.31	76.05	651.1
2018	905.15	334.61	424.91	80.87	717.83
2022	981.87	444.33	443.1	85.33	763.68
2026	1,049.17	511.09	455.89	89.38	796.57
2030	1,110.23	530.59	464.92	93.26	828.7
2034	1,173.34	533.04	471.19	97.41	862.12
2038	1,238.76	533.33	475.49	101.88	896.89
2042	1,306.25	533.37	478.42	106.64	933.06
2046	1,374.61	533.37	480.41	111.31	970.69
2050	1,443.34	533.37	481.75	115.72	1,009.84
2054	1,512.14	533.37	482.65	119.87	1,050.57
2058	1,580.69	533.37	483.26	124.05	1,092.94
2062	1,648.70	533.37	483.66	128.52	1,137.02
2066	1,716.02	533.37	483.94	133.33	1,182.88
2070	1,785.07	533.37	484.12	138.06	1,230.59
2074	1,856.84	533.37	484.24	141.65	1,280.22
2078	1,930.90	533.37	484.33	144.27	1,331.85
2082	1,999.13	533.37	484.38	146.17	1,385.57
2086	2,059.03	533.37	484.42	147.52	1,441.45
2090	2,111.07	533.37	484.44	148.49	1,499.59
2094	2,159.08	533.37	484.46	149.17	1,560.07
2098	2,208.19	533.37	484.47	149.78	1,622.99
2100	2,233.15	533.37	484.47	150.08	1,655.39
Total Pop	5056				

Now we will consider taking poaching rates to be as high as 20% for every landscape. This will give us a very clear picture of how poaching has influenced tiger population in India since ages. As show in table 12, only 879 tigers are predicted to survive in India if the poaching rate for every landscape goes up by 25%. Poaching poses a major threat to tigers in India. NEBL is the only landscape complex which shows some potential to sustain tigers even at an alarming poaching rate of 25%. Population of tigers collapsed in Western Ghats landscape complex by 2150 as observed in table 12. Poaching can be a very serious issue for WGL, SL and SGL.

Table 12: Scenario B (Situation 2- 0.2 poaching)

Year	CIEGL Pop	NEBL Pop	SGL Pop	SL Pop	WGL Pop
2006	601	100	297	64	412
2010	420.74	149.71	181.92	38.94	261.29
2014	373.3	222.16	136.66	35.73	158.14
2018	346.47	321.86	112.35	35.17	95.71
2022	330.06	428.58	96.84	35.06	57.92
2026	319.53	496.83	85.6	35.04	35.06
2030	312.57	523.78	76.43	35.03	21.22
2034	307.89	527.62	68.81	35.03	12.84
2038	304.70	528.09	62.38	35.03	7.77
2042	302.51	528.14	56.89	35.03	4.7
2046	300.99	528.15	52.14	35.03	2.85
2050	299.94	528.15	47.99	35.03	1.72
2054	299.20	528.15	44.29	35.03	1.04
2058	298.69	528.15	40.89	35.03	0.63
2062	298.33	528.15	37.79	35.03	0.38
2066	298.08	528.15	34.94	35.03	0.23
2070	297.90	528.15	32.33	35.03	0.14
2074	297.78	528.15	29.93	35.03	0.08
2078	297.70	528.15	27.72	35.03	0.05
2082	297.63	528.15	25.69	35.03	0.03
2086	297.59	528.15	23.81	35.03	0.02
2090	297.56	528.15	22.08	35.03	0.01
2097	297.53	528.15	19.37	35.03	0.00
2098	297.53	528.15	19.01	35.03	0.00
2099	297.52	528.15	18.66	35.03	0
2100	297.52	528.15	18.31	35.03	0
Total Pop	879				

4.7 Discussion

From the results of our study, we derive that deforestation, loss of habitat and poaching are very serious threats to tiger population in India. In order to answer this challenge, Government, NGO's and local communities need to work together to preserve the environment in India. Certain strategies and policies that aim to help increase the habitat area and helps in reforestation need to be implemented effectively. Sustainable agriculture and agroforestry BMP's can be a good option for an agriculture based-country like India. Policies that promote community based conservation, eco-tourism, community based tourism industry and which help local people reduce dependency on forest and forest-products; must be practiced. Relocation of villages lying in the proximity of national park should be relocated with prior concern from the villagers and they should be also compensated with proper incentives.

Constructing, developing and improving natural corridors connecting habitat fragment and meta-populations of wild animals can prove to be one of the most efficient steps towards conservation in India. Prey abundance and habitat quality should be monitored and maintained in every national park in India in order to help carnivores like tigers survive. Poaching should be strictly monitored in all the protected areas in India. Better technologies like drones and hi-tech camera should be used to survey and monitor any illegal activity in forested areas. More anti-poaching units, more recruits in patrolling units, increasing salary of forest guards to motivate youth to join forces, better facilities and incentives to forest department officials and guards; can help strengthen the guarding pillar of tiger conservation in India against all illegal activities. Local community should be involved in conservation practices and should be motivated to participate in tracking poachers and getting leads on their activities. They can also prove to be very resourceful in stop illegal logging and deforestation.

4.8 Conclusion

There are very less facts and figures available on tiger population prediction. This is a very unique research where we have predicted tiger population for over a time span of 85 years from year 2006 till 2100 using STELLA modeling software. We designed an empirical model which can be used to model population trend of any carnivore species in the world and which can also help understand human-wildlife conflict at 3 different levels- environment (abiotic components), human (anthropogenic components) and wildlife (biological components). This model can help deeply understand the nature of conflict and various factors influencing it. We also constructed and simulated 2 different uncertainty scenarios studying tiger population change in India with change in habitat quality (associated with birthrates and death-rates) and poaching rates. The results of the simulation study suggests that any minor change in any of the 2 parameters- habitat (birthrate and death-rate) and poaching can lead to a large fluctuation/change in total tiger population of India. This study concludes that more corridors should be constructed in India to help tigers migrate from one landscape complex to another. It also suggests that habitat quality and habitat area should be increased which will help reduce death rate and increase birthrate of tigers. We also conclude that poaching is a serious threat to tiger population in India, and so it should be strictly monitored and significantly reduce in order to help tiger population thrive in India.

4.9 Bibliography

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APPENDIX A

SURVEY QUESTIONNAIRE COPY

I am a research student from University of Massachusetts, Amherst working in collaboration with Wildlife Institute of India, Dehradun. Thank you for participating in this survey. The main aim of this survey is to build a framework to better understand stakeholder's perspective towards human-wildlife interaction & conflict and also on tiger conservation; living in tiger landscape complex of India. The study will also look at the tolerance level of stakeholders to loss of livestock to tigers per year. The later phase of the project will deal with developing strong and practically applicable strategies to reduce conflict to a significant extent.

The information collected from the survey will be held confidential and we will not collect any personal information. The survey is purely voluntary and if you do not want to participate please feel free to stop at this time. Thank You.

Ronak Sripal

1. Age-
2. Sex-
3. Name of the village/town-
4. How long have you been living in this village/town- ____Years/___Months
5. Source of income/occupation-

   □Agriculture – Total number of vigahs owned _____

   □Livestock – Total number of livestock owned_____

   □Forest products

   □Daily wage

□Others ____

6. Total number of people living in the house-

7. What is your education qualification-

   □No school □<5 class□ <10 class □Graduate college □Graduate

8. Socio-economic status-

   □Very rich □ Upper middle class □Middle class □Lower class □Very Poor

   Details regarding assets owned:-

a) Size of house- □Huge □Big □Medium □Small □Very small

b) House-construction type- □Cemented □Brick □Mud & cow dung

c) Number of vehicles owned- Two-wheelers-____ Four wheelers-____

d) Total number of people earning in the house- ____

9. What are the benefits that people of your village derive from forests?

   □Fuel-wood □Meat □Livestock grazing □Forest products □Others________________

   ____

10. What are the advantages of being located near/inside the forested area?

    □Using forest products for household use

    □Forest-based agriculture

    □Open land for livestock to graze

    □Food security

    □Sale of forest products help generate revenue

    □Clean environment

    □Others ____

11. What are the disadvantages of being located near/inside the forested area?

    □Livestock loss to large carnivores

    □Crop-loss to wild animals

□Restricted grazing area for livestock

□Prohibition on collection of forest products

□Human-wildlife conflict

□Others____

12. What sort of *'wild meat'* do people consume in this/nearby villages?

____

13. What are your views about tiger?

□Cruel and cunning

□Nature's killing machine

□Frightening

□Beautiful

□Religious value

□Important for maintaining herbivore population and ecosystem

□Others____

14. In your opinion, what are the reasons for human-wildlife conflict in this area?

□Livestock loss

□Indirect conflict while collecting forest products

□Direct conflict

□Crop raiding

□Others____

15. Livestock loss as per species-

Species	Livestock Loss			Compensation details			
	Past 3 months	Past 1 year	Past 5 years	Paid/Unpaid	By whom	How many	How much

						times	
Tigers							
Leopards							
Others							
Total							

16. Crop loss as per species-

Crops harvested each year	Season	Total area harvested per year (in vigahs)	Proportion lost to wildlife per year	Species responsible for damage	Compensation paid/unpaid

17. Loss to human-life as per species-

Species in conflict	Context for conflict	Results of conflict-Injury/death	Loss to human life/injury during conflict			Compensation details
			Past 3 months	Past 1 year	Past 5 year	

18. Current scenario-

Current strategies to reduce conflict	Loss to human-life	Livestock loss	Crop loss/damage
Stakeholders			
Government and Forest department			
NGO's			

19. Tolerance level-

	Tigers	Leopards	Other carnivores

Tolerance level to livestock loss of total livestock owned			
Tolerance level to crop loss of total crop land harvested			

20. How much are you willing to contribute per year towards reducing conflict?

Monetary Contribution per Year	
Time per year	
Others	

21. How much are you willing to contribute per year towards tiger conservation?

Monetary Contribution per Year	
Time per year	
Others	

APPENDIX B

IRB APPROVAL LETTER COPY

University of Massachusetts Amherst
108 Research Administration Bldg.
70 Butterfield Terrace
Amherst, MA 01003-9242

Research Compliance
Human Research Protection Office (HRPO)
Telephone: (413) 545-3428
FAX: (413) 577-1728

Certification of Human Subjects Approval

Date:	July 22, 2015
To:	Ronak Sripal, Environmental Conservation
Other Investigator:	Timothy Randhir, Environmental Conservation
From:	Lynnette Leidy Sievert, Chair, UMASS IRB

Protocol Title:Understanding stakeholders perception towards human-wildlife interaction and conflict in a tiger landscape-complex of India
Protocol ID: 2013-1786
Review Type:EXPEDITED - RENEWAL
Paragraph ID: 7
Approval Date: 07/22/2015
Expiration Date:07/22/2016
OGCA #:

This study has been reviewed and approved by the University of Massachusetts Amherst IRB, Federal Wide Assurance # 00003909. Approval is granted with the understanding that investigator(s) are responsible for:

Modifications - All changes to the study (e.g. protocol, recruitment materials, consent form, additional key personnel), must be submitted for approval in e-protocol before instituting the changes. New personnel must have completed CITI training.

Consent forms - A copy of the approved, validated, consent form (with the IRB stamp) must be used to consent each subject. Investigators must retain copies of signed consent documents for six (6) years after close of the grant, or three (3) years if unfunded.

Adverse Event Reporting - Adverse events occurring in the course of the protocol must be reported in e-protocol as soon as possible, but no later than five (5) working days.

Continuing Review - Studies that received Full Board or Expedited approval must be reviewed three weeks prior to expiration, or six weeks for Full Board. Renewal Reports are submitted through e-protocol.

Completion Reports - Notify the IRB when your study is complete by submitting a Final Report Form in e-protocol.

Consent form (when applicable) will be stamped and sent in a separate e-mail. Use only IRB approved copies of the consent forms, questionnaires, letters, advertisements etc. in your research.

Please contact the Human Research Protection Office if you have any further questions. Best wishes for a successful project.

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Annexure I- Annexure referred to in reply to parts (a) & (b) of the lok sabha unstarred question no. 1752 on protection to leopards and tigers due for reply on 16.12.2013.Page 134,135 and 186.)

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