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Living with the Large Carnivores: The interaction between humans, tigers and leopards in Chitwan National Park, Nepal
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6   Synthesis

6.1.   Introduction

Large carnivores play an important role in ecosystem functioning (Ripple *et al*., 2014). On the other hand, these carnivores including tigers (*Panthera tigris*) and leopards (*P. pardus*) are locally and regionally threatened with extinction (IUCN, 2018). Expansion of human land use at the expense of natural areas caused their habitats to become increasingly insular, fragmented and degraded. Survival of these wider ranging species is dependent on conservation in increasingly human-dominated landscapes (Karanth & Chellam, 2009; Lambin & Meyfroidt, 2011). Some of the remaining habitats have been set aside for protection as parks and reserves where their populations are recovering (Bruner *et al*., 2001; IUCN, 2008; Leopold, 1963). However, most protected areas are not sufficient to support viable populations of large carnivores on their own for long-term conservation (Wikramanayake *et al*., 1998). Alternative strategies are required in which wildlife and humans co-adapt and coexist in a shared landscape (Carter & Linnell, 2016). The strategy includes protection of core breeding areas (or source sites) of wildlife connected through the forest corridors and embedded in larger landscapes (Joshi *et al*., 2016). The Terai Arc Landscape (TAL) in Nepal and India supports a wide range of species, including large mammals (both herbivores and carnivores) (Chanchani *et al*., 2014). My study focused on two large carnivores - tigers (*Panthera tigris*) and leopards (*Panthera pardus*) in a protected area (Chitwan National Park) and its buffer zone, within the TAL.

In spite of their ecological and cultural roles, tigers and leopards sometimes affect local communities by killing livestock or attacking humans (causing injury or death). Local people affected by these carnivores may subsequently persecute them or engage in retaliation (Madden, 2004). Management of such negative impacts is challenging when serious damage to human lives or livelihoods is caused by globally threatened large carnivores (Dickman, 2010; Woodroffe *et al.*, 2005). In many cases, such impacts reduce support for wildlife conservation (Acharya *et al.*, 2016). Thus, a holistic understanding of how people and wildlife are interacting with each other is necessary to facilitate the coexistence (Carter, 2013). I focused this study on large carnivores (particularly tigers and leopards) in Chitwan National Park (CNP) and adjoining forests. I used both a socio-economic and an ecological approach by collecting data related to inter-species interaction between tigers and leopards, their impacts on humans and responses (or efforts) of the

communities to minimize the impacts. The combined information was analysed to answer the following research questions of my study:

> i) How does wildlife affect communities in terms of attacks on humans and economic losses?
> ii) Is an entire population of large carnivores or a specific group of individuals (sub-set of the population) causing the conflicts?
> iii) Which factors facilitate the co-occurrence of tigers and leopards in Chitwan and how does it affect the conflict with communities?
> iv) How are communities responding to wildlife impacts?

The four chapters (Chapter 2 - 5, presented as research papers) answer these research questions. Chapter 2 provides an overview of the wildlife attacks on humans and economic losses (livestock depredation, crop raiding and property damage). This chapter also makes a comparison between the wildlife damage caused by herbivores and carnivores. Chapter 3 examined whether all individuals within a large carnivore population have equal chances to cause conflict with communities or whether, in fact, some individuals or group of individuals are disproportionately involved in the conflict. The tiger was studied as a representative member of large carnivores. In Chapter 4, I studied the interaction between two large carnivores, i.e. tigers and leopards, in terms of distribution, density, activity pattern and diet as well as the influence of such interaction in human-large carnivore conflicts. Another chapter (Chapter 5) focused on responses of the communities in terms of reducing wildlife impacts. This chapter (Chapter 6) integrates the findings of Chapters 2 - 5.

6.2. Large carnivore impacts on humans and the social aspects of coexistence

6.2.1. Wildlife attacks on humans and livestock

In Chapter 2, I presented the spatial and temporal patterns of wildlife attacks on humans and wildlife in the buffer zone of CNP. I found 12 wildlife species attacked on humans during 1998 – 2016, with an average of 40.6 attacks (9.3 fatalities and 31.3 injuries) annually. Attacks on humans by herbivores (rhinos, elephants, wild boars etc.) were more numerous compared to attacks caused by large carnivores (tigers, leopards and sloth bears). This indicates that the majority of wildlife attacks on humans may be accidental due to sudden encounters rather than by deliberate attacks to kill for food. The communities whose livelihood is more dependent on forests like the Terai indigenous communities and the *Dalits* (underprivileged group) were attacked more frequently than expected whereas the immigrant communities were attacked less frequently. The reason for this may be that indigenous and *Dalit* communities enter the forests more often to extract natural resources which are necessary for their livelihood. The immigrant community generally tries to find safe and accessible areas to settle. They are also involved in diverse economic opportunities and less dependent on forests, thereby reducing the encounters with wildlife. Alternative livelihoods and awareness programs targeting the vulnerable communities (indigenous and *Dalit*) will help to reduce the conflict.

Similarly, every year an average of 123 heads of livestock was killed by carnivores. Most of the livestock depredation was caused by tigers and leopards. Leopards mostly killed medium-sized livestock (goats and pigs) whereas tigers killed both medium and large-sized livestock (cattle, buffalo). Tigers caused more livestock depredation than leopards during the entire study period; however, leopards have killed comparatively more livestock in recent years (2014 - 2016). The increasing tiger population and density might have exerted pressure on the leopards, pushing them towards marginal habitats close to human settlements where they killed livestock.

The frequency of conflict incidents caused by large carnivores (tigers and leopards) was comparatively lower during a full moon period, but the difference was not statistically significant. In contrast, there was a significantly higher number of conflict incidents caused by herbivores (rhinos and elephants) close to full moon periods. Attacks on humans and livestock by tigers and leopards occur more frequently at night as both tigers and leopards are nocturnal predators (Carter *et al*., 2012; Thapa, 2011) which prefer hunting in the dark. During full moon periods, the higher luminescence at night may prevent tigers and leopards from coming out of the forest, thereby reducing the possibility of attacks on humans and livestock. Such ecological instinct can be utilized for conflict prevention by increasing the light in the periphery of the house (including livestock corrals and in the streets) especially during dark nights (new moon periods). Similarly, using the flashlights when walking at night should be encouraged to prevent wildlife attacks.

6.2.2. Changing social context and conflicts

I found that there was an insignificant but decreasing trend of the wildlife attacks on humans and livestock over time with a significant variation over the years (Chapter 2). An increase in wildlife populations did not result in a respective increase in the number of conflicts. Wildlife populations like greater one-horned rhinos (*Rhinoceros unicornis*) and tigers have peaked in recent years in CNP whereas, the highest conflict incidents were recorded during 2002 – 2004 (Lamichhane *et al*., 2018a). Gurung *et al*. (2008) also documented the higher number of tiger attacks on humans between 1998 and 2004. After 2004, conflict incidents decreased, probably due to introduction of a number of conflict mitigation measures practiced in the buffer zone, including segregation of human use and wildlife areas through grazing restrictions, construction of fences and other measures. The livelihoods of local communities are also gradually changing.

The construction of fences, predator-proof corrals, awareness programs and other mitigation measures practiced by buffer zone communities have reduced human-wildlife interaction ultimately resulting in a lower incidence of conflicts. In addition, the changing social context and diversified livelihood options of local communities in the periphery of Chitwan has also helped to reduce the impacts of wildlife. For example, I found a significant inverse relationship between the number of people who took foreign employment and the number of livestocks killed. When a member of a family takes a job abroad, the household income increases and they have the freedom to choose other economic opportunities that reduce dependency on livestock and forest resources. This

ultimately reduces the possibility of wildlife attacks on family members or their livestock. Thus, the attraction of the younger generation towards non-farming jobs (in service and business sector) or foreign employment may reduce the conflict and facilitates the coexistence between local communities and wildlife. Increasing income from tourism enterprises in the area has also contributed to reduce the number of conflicts by providing an alternative livelihood to locals as tourist guides, jobs in hotels and other tourist facilities.

Similarly, there was a gradual decrease in the percentage of households owning livestock as well as the average size of stock per household in the buffer zone of CNP. Most of the households (more than 80%) practice stall feeding, which is facilitated by grazing restrictions, adoption of improved livestock varieties, the use of commercial livestock feeds and a shortage of labour for grazing. However, in the previous five years (2012 – 2016), most of the livestock killing occurred at stalls or corrals, which suggests a need for better husbandry practices with predator-proof livestock corrals, especially in the forest fringe areas.

Our findings show an inverse relationship between people's migration for remittance and the number of conflict incidents and demonstrate the influence of the household livelihood strategy on human-wildlife conflicts. A study by Bhandari (2013) and one by Han (2014) on rural livelihood changes documented labour shortage as the main reason for local villagers to shift from agriculture to off-farm income options (also called 'farm exit') in Chitwan. As young and working, generally male, community members leave to take up employment abroad, it facilitates the family adopting off-farm activities and reduces the chances of an encounter with wildlife. Thus, the changing social context of Chitwan is also favourable in terms of reducing the human-wildlife conflict and it enhances human-carnivore coexistence.

6.3.   Large carnivores and humans: biological aspects of coexistence

6.3.1. Ability of tigers to coexist with humans

From the study of the Chitwan tiger population (Chapter 3), I found that not all individuals within a population have an equal chance to cause the conflict and the majority of tigers coexist with humans without causing conflict. My finding is consistent with the findings of Sunquist (2010) in Nepal and Kolipaka (2018) in India. Sunquist has described the amazing ability of healthy tigers to coexist with humans based on his study that tracked radio-collared tigers in Chitwan during the 1970s. In spite of this, there have been frequent cases of tiger attacks on humans and livestock in Chitwan (Gurung et al., 2008). For this reason, I looked in detail at the conflict incidents in CNP caused by tigers during 2007 – 2016. I documented that a majority of the tigers in the population avoided encounters with humans. Most of the resident tigers with a territory in prey-rich areas were not recorded coming out of the park or the forest area. Only a small group of individuals (less than 5%) within the tiger population had emerged from the forests and attacked humans

or killed livestock. I concluded that healthy and resident tigers (rather than transient) are less likely to cause such conflicts with humans. Carter *et al*. (2012) reported similar findings from Chitwan regarding resident tigers coexisting with humans and avoiding conflict by temporal separation.

I have also documented the empirical evidence that an increase in tiger population alone does not result in an increase in attacks on humans or livestock in CNP and in the Barandabhar corridor forest. Based on multiple year camera trapping surveys in the Barandabhar, the resident tiger population increased from four to eight between 2013 and 2016 (NTNC-BCC, 2016). In contrast, more attacks on humans by tigers were recorded in 2012 (two persons killed) and 2013 (two killed, one injured) compared to 2016 (no casualties). A human-killing tigress was active during 2012–2013. The tigress started killing humans after she became too old and was pushed out from her territory in the park by other tigers. Although more residential tigers are using Barandabhar, the number of human casualties in this area has dropped afterward (only a woman was killed in 2015). The woman was killed by a transient human-killing tiger (not the residential tigers of Barandabhar) which was later captured by park authorities. The tiger died in captivity (CNP, 2015).

6.3.2. Conflict-causing individuals are different

Based on the findings of my study (Chapter 3), I concluded that there are few individuals within the large carnivore population that disproportionately contribute to human-wildlife conflicts. Similar findings were reported by Swan *et al*. (2017) and Linnell *et al*. (1999). Most of the attacks on humans or livestock depredation were caused by transient tigers without territory. More than half of them were injured or in poor health. I found that most conflict-causing tigers fall into two categories: either they are old and injured animals or they are young dispersing animals forced to reside in the periphery until they establish breeding territories. Only 2% of the resident tigers but 30% of the transient tigers were involved in conflicts. The majority of conflict-causing transient tigers included dispersing sub-adults seeking to establish a territory. An earlier study in Chitwan by Smith (1993) has also reported similar observations about dispersing sub-adults. Kolipaka (2018) also found during his study in India (Panna Tiger Reserve) that young tigers are more likely to visit areas close to the settlements and as they mature, they tend to avoid the human areas and establish territories within the forests.

In my study, I identified 22 tigers that were responsible for most of the conflict incidents during 2007 – 2016 including 13 tigers (including six man-eaters) that killed humans, six serial livestock killers and three stray tigers that threatened the human safety (but did not cause an attack or loss). Thirteen out of these 22 tigers were removed from their habitat (killed or put in captivity) and four were relocated (released at a different location). Some conflict-causing tigers were poisoned (n=3) or killed by villagers in self-defense using a spear (n=1). No action was taken for five of the identified conflict-causing tigers because these tigers either accidentally attacked people in the buffer zone or only attacked people in the core areas of the park, following illegal intrusions. Most tigers that repeatedly

killed livestock or attacked people in the buffer zone, posing a threat to human safety, were captured by the park authority. Such removals have lowered the risks of human-carnivore conflict in CNP and adjoining forests in recent years. I conclude that conflict-causing individuals are atypical and show differences with the main population, i.e. young tigers without an established territory, older tigers pushed out of the territory or injured or unhealthy tigers.

6.3.3. Tigers and leopards co-occurring in a human-dominated landscape

I found a high density of two sympatric large carnivores – tigers as dominant and leopards as subordinate – in CNP and adjoining forests (Chapter 4). In contrast to my findings, other studies report the displacement of the subordinate due to intra-guild competition between the predators (Harihar *et al.*, 2011; Holt & Polis, 1997; Linnell & Strand, 2000; Odden *et al.*, 2010). In my study, the density of both tigers and leopards has increased in the past decade and the populations remained stable between 2010 and 2013. They had a large dietary overlap but their coexistence was facilitated by spatial and temporal segregation of habitats. Tiger distribution was positively related to prime habitats in the river floodplain (alluvial grasslands and riverine forests) having high prey density in core areas whereas it was negatively related to disturbance (livestock presence). In contrast, leopard distribution was positively related to less productive habitat (i.e. sal forests) and locations with livestock presence (disturbance).

Both tiger and leopard occurrence showed a significant positive relation with the detection of their major prey animal, chital *(Axis axis)* in camera. Although chital was the primary prey for both the carnivores, the spatial location was different, i.e. tigers in grasslands and riverine forests, whereas, leopards in sal forests. Leopards also adjusted their activity in locations where tigers were present by increasing their activity in the daytime when tigers are less active. The mosaic of habitats and different levels of anthropogenic pressures in these habitats facilitated tigers and leopards to co-occur by occupying different niches in time and space. The different findings of my research to other studies is probably due to the large prey biomass in the CNP consisting of various sizes of prey including primates (<20 kg) to gaur *(Bos gaurus*, >500kg). A further factor is the habitat mosaics of the park, which consist of grasslands, wetlands and woodlands supporting high densities of multiple carnivore species (Holt & Polis, 1997; Linnell & Strand, 2000; Odden *et al.*, 2010).

6.3.4. Leopards on the edge: effects of large carnivores' interactions on humans

My study reveals habitat partitioning by tigers and leopards (Chapter 4) which could be the result of interference competition between the species. It has also influenced their impact on humans. High and stable densities of tigers in the core areas of CNP in recent years have increased recruitment and dispersal of young tigers. These tigers attempt to occupy forest with a low tiger density inside park, the buffer zone or forests outside of buffer zone(Smith, 1993). This ultimately exerts pressure on leopards and pushes them into marginal habitats and forest edges. For instance, more leopards than tiger scats were detected in the buffer zone and in the corridor forest. Livestock grazing and other human

activities (collection of vegetables, non-timber forest products, firewood and fodder collection) are comparatively more frequent in those areas. This increases the chances of a leopard encounter with humans and livestock. Wild prey is relatively low in such marginal habitats, hence leopards kill the livestock for their diets (Lamichhane *et al*., 2018a; Odden *et al*., 2010). A higher proportion of livestock in the diet of leopards compared with tigers also supports their use of the boundary of CNP and the buffer zone area where cattle grazing is more common compared to the park (Gurung *et al*., 2009). Such effects have already been observed in the buffer zone of CCNP where communities have reported more livestock being attacked by leopards than tigers in recent years (2014 – 2016). This indicates that leopards are probably more involved more in conflicts with humans, compared to tigers around CNP.

CNP is relatively small (~1,000 km^2) and surrounded by the human settlements and agricultural areas with high human densities (~300 per km^2) in the north, south and west. The park is bordered by three rivers, namely the Narayani, the Rapti and the Reu. High densities of large carnivores are concentrated on one side of these rivers (the park side) whereas communities live or conduct intensive agricultural activities on the other side of the rivers. Although these rivers seem to be geographical barriers, the presence of these rivers does not restrict the movement of people or wildlife. Thus, frequent and intense human-wildlife impacts have been documented close to these rivers (Lamichhane *et al*., 2018a). A long interaction zone (~ 150 km) between humans and wildlife along these rivers with a high density of wildlife in the park at close proximity of humans could be the reason for the comparatively higher number of wildlife attacks on humans and livestock in Chitwan compared to other protected areas of Nepal (DNPWC, 2014, 2015a, 2016). This should be considered when preparing strategies to manage human-wildlife conflicts in and around CNP.

6.4. Conflicts to coexistence: the role of buffer zone

The buffer zone around CNP is designated primarily to create human-wildlife coexistence by compensating for negative impacts of wildlife on local communities and by providing an ecological buffer (Budhathoki, 2004; Heinen & Mehta, 2000; Nepal & Weber, 1994). I found that a range of preventive and mitigation measures was practiced over time in the CNP buffer zone in order to reduce the impact of wildlife on local communities (Fig 6.1). These measures have positively contributed to reducing wildlife attacks on humans and livestock, although crop raiding remains widespread (Chapter – 5). I found an inverse correlation between the budget spent on direct interventions for conflict prevention/ mitigation and the number of wildlife attacks on humans and livestock. In spite of the gradual increase in wildlife populations in CNP, the conflict incidents either remained stable or decreased due to fences and other conflict prevention initiatives (Lamichhane *et al*., 2018a). This decrease was also facilitated by the changing social context and preference of the local villagers towards for employment opportunities less dependent on agriculture and forests.

Figure 6.1   Buffer zone users erecting of a wire mesh fence along the forest settlement border to stop animals entering agriculture fields and settlements. Various kinds of fences installed along the forest edges have contributed to reducing the negative wildlife impacts on humans.

However, I documented that a relatively small proportion (13.7%) of the buffer zone fund was spent on direct interventions to reduce wildlife impacts on communities. A relatively higher proportion of the buffer zone fund (24.5%) was spent on development activities (construction of buildings and other community infrastructure) not directly related to human-wildlife conflict mitigation. Similar concern have been raised since the starting of the buffer zone program (Heinen & Mehta, 2000). Aware of the smaller proportion of funding spent on conflict mitigation, the local residents suggested the buffer zone institutions to prioritize their activities and focus more on conflict mitigation (Chapter 5).

Buffer zone committees also provided compensation for losses from wildlife before 2009. The government of Nepal endorsed guidelines for compensation nationally and started providing compensation according to these regulations. Although people were aware of compensation provisions for wildlife damages, the majority (more than 90%) were not satisfied with the current practice. They think the process is highly bureaucratic and the payments are inadequate, especially for livestock loss and crop damage. Locals reported it taking more than six months to receive compensation payment. Such payments cannot deliver the intended outcome, i.e. increasing tolerance of wildlife damage, when the

victims are unhappy with the delays in payment, the amount received and the procedures (Nyhus *et al.*, 2005). Respondents have therefore, suggested to simplifying the payment process and authorizing local institutions such as Buffer Zone User Committees, respective parks or local government (municipalities) to make the compensation payments. Moreover, the existing compensation scheme only covers a limited group of species (tiger, common leopard, snow leopard *Panthera uncia*, clouded leopard *Neofelis nebulosa*, rhino, elephant, gaur, wild water buffalo *Bubalus arnee*, bears, wild boar *Sus scrofa*, wild dog Canis alpinus, grey wolf Canis lupus, mugger crocodile *Crocodylus palustris*, Burmese python *Python bivittatus*). Crop raiding by wild boar and chital is reported frequently but was not covered by the compensation guidelines at the time of our survey (a 2017 amendment includes wild boar in the scheme).

6.5. Human-carnivore coexistence from theory to practice

My study on the social and biological aspects of human-carnivore interactions shows that human-carnivore coexistence in a human-dominated landscape is possible. However, as pointed out by Carter and Linnell (2016), there is no common understanding between social and biological scientists about the meaning of coexistence. Here, I define coexistence as a situation of humans and large carnivores sharing a landscape where carnivore population persistence is ensured, their impacts on humans is socially acceptable and institutions are in place to maintain this balance effectively (Chapron & López-Bao, 2016). Thus, coexistence is possible by managing not only human-carnivore interactions, but also the human-human interactions. The biological needs of carnivores should be considered and social tolerance of carnivores should be enhanced to create a coexistence situation in practice.

6.5.1. Considering the biological needs of the carnivores

My findings (Chapter 3), as well as previous studies, have revealed that large carnivores (especially tigers) naturally avoid human areas when their requirements are fulfilled in natural habitats. However, carnivores require large areas that can support sufficient prey for their survival (Sunquist, 1981; Thapa 2011). But the remaining natural habitats are becoming smaller as a result of habitat fragmentation and degradation. Thus, an alternative approach to large carnivore conservation has been proposed, where the biological needs of large carnivores can be addressed in a shared landscape with humans (Carter & Linnell, 2016). It starts with allocating core protected areas by legal provisions and connecting these areas through biological corridors (Chapron & López-Bao, 2016). Around the core-protected areas, an interaction zone (also known as buffer zone) could be defined where wildlife have refuge habitats and local communities are compensated for any negative wildlife impacts (Fig 6.2) (Budhathoki, 2004; Heinen & Mehta, 2000; Nepal & Weber, 1994).

When multiple carnivore species are share the same landscape, interference competition can result in habitat partitioning or displacement of the weaker species. My study documents the co-occurrence of two large carnivores (leopards being the subordinate

species, and tigers being the dominant one) facilitated by spatial (habitat) and temporal partitioning. A mosaic of habitats in the protected areas with varying degrees of vegetation cover and prey species could facilitate co-occurrence. The density of carnivores also depends on the prey availability (Karanth *et al*., 2004). Diversity and density of prey species is also high in heterogeneous (or mosaics of) habitats (Bhattarai & Kindlmann, 2012a). Thus, the management of habitat mosaics is important for increasing density of multiple carnivore species. This can be done with active floodplain management, by controlled burning, periodic cutting, removing invasive species and woody vegetation or with hydrological measures.

Most large carnivores are territorial. When they breed and new animals are added to the populations, the young (or sub-adults) look for areas to establish a territory. As available habitats are limited, they compete to establish the territory in the park or buffer zone, which often leads to violent fights. Sometimes, the younger animals displace adult or old animals; at other times the young animals may get badly injured. The loser of a fight has a high probability of coming into conflict with local communities. If dispersal corridors are available, younger animals could disperse to larger areas in order to explore and establish their territories (Smith, 1993). This would also reduce the chances of conflict. In cases where no such migration is possible, these animals could be translocated (also called assisted migration) to areas where carnivore density is low.

6.5.2. Proactive management of conflicts-causing animals

My study provides empirical evidence that problem-causing individuals exist in large carnivore populations. These individuals have different characteristics compared to the
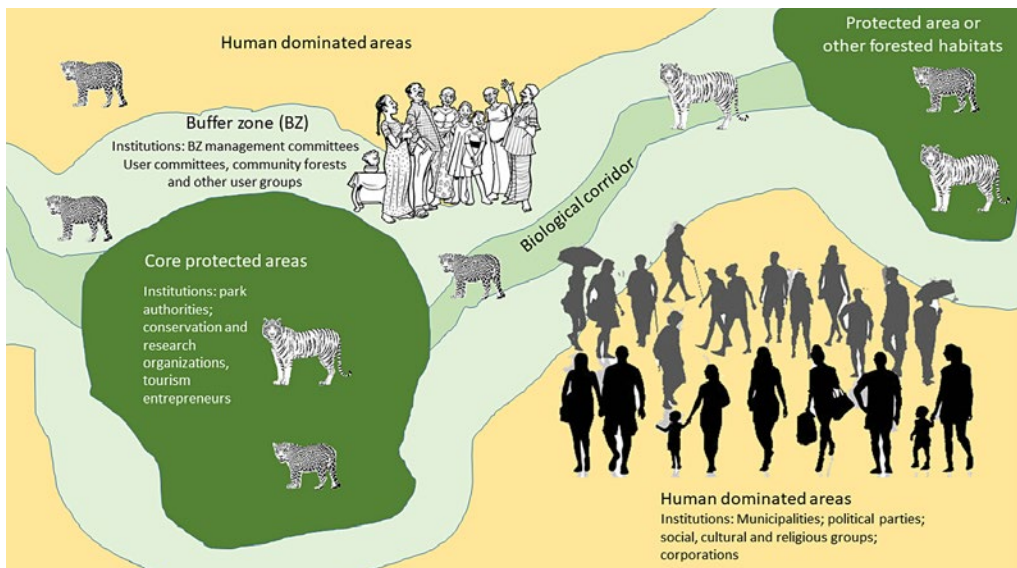

Figure 6.2   Schematic picture of human-large carnivore coexistence in a human-dominated landscape.

main population. Such animals should be identified and removed or managed in a timely fashion in order to reduce conflicts. Regular monitoring of large carnivores in fringe areas using technologies such as camera traps, satellite telemetry and non-invasive genetics paired with the involvement of local communities can deliver crucial information about potential problem individuals (Gurung *et al*., 2008). Community-based rapid response teams (RRT) of para-ecologists should be mobilized in the periphery of protected areas (Schmiedel *et al*., 2016). These teams monitor carnivores and communicate with respective communities (early warning) if such an animal is detected. The preparedness of communities can save human lives and reduce livestock depredation.

As tiger range countries, including Nepal, strive towards doubling the global wild tiger population, it is expected that tiger population grows and recruitment of new tigers increase. This will lead to increased competition for limited habitat available among tigers to establish their territories and pushing out the weaker ones that possibly cause conflict with local communities. Thus, tiger range countries should consider developing and implementing criteria for responding rapidly to such conflict-causing tigers. Along with removal or other mitigation measures for intense conflict scenarios, providing safe passage through corridors to other protected areas or forests with low density (Wegge *et al*., 2018) could reduce the possibility of conflicts. The enhancing of the quality of grasslands and wetlands through intensive management and increasing prey density inside park as well as buffer zones and forest corridors are equally important for reducing conflicts and facilitating dispersal.

6.5.3. Increasing social tolerance

Large carnivores, especially tigers, have a great significance in South-Asian culture (Kolipaka, 2018). The majority of the Nepalese are Hindus or Buddhists who traditionally believe that countless supernatural beings in the form of different creatures are responsible for the creation, protection and destruction of the human life (Berreman, 1997). They believe that every creature in nature has a supernatural role. For example, in traditional societies, if a person is killed by a tiger, instead of blaming the tiger, they consider it to be 'fate of that person' decided at birth and impossible to avoid. Without such a social belief system, it would not be possible to protect life-threatening carnivores freely roaming just a few hundred metres away from the human settlements (Chapter 4). Despite of frequent attacks by carnivores on humans and livestock, most people in the buffer zone support conservation efforts (Chapter 5). However, this traditional belief system is in decline, especially among the younger generation who are increasingly influenced by a modern lifestyle (Ingles, 1995). Thus, economic or socio-cultural incentives combined with legal provisions are necessary to increase the tolerance.

When wildlife and humans share the same landscape, their impacts on each other cannot be avoided entirely. However, the tolerance of communities towards wildlife can be increased by co-managing actual and perceived conflicts (Treves *et al*., 2006) and by ensuring individuals as well as communities benefit from conservation. Integrating the local community's livelihood into carnivore conservation facilitates the desired coexistence (Harihar, Veríssimo, & MacMillan, 2015). As I described in Chapter 5, buffer

zone programs are part of such efforts and they play an important role in building social tolerance. For example, the buffer zone program in Nepal receives 30–50% of all park revenues. As wildlife populations grow in the park, this attracts more tourists and, in turn, increases park revenues. Part of this revenue is shared with the communities. Increased tourist numbers also benefit multiple stakeholders in the country, which also increases the social and economic value of wildlife. Community education and awareness programs are necessary for enhancing society's understanding of the value of wildlife. Quick compensation when losses are incurred due to wildlife will increase community tolerance (Nyhus *et al.*, 2005; Wegge *et al.*, 2018).

Human-wildlife conflict is not a simple competition over shared resources, it is also a political conflict between humans and institutions with contrasting viewpoints about wildlife (Treves *et al.*, 2006). Coexistence is possible only when such conflicts between humans are managed and the various stakeholders have a common understanding (Carter & Linnell, 2016). Common understanding can be built among stakeholders by co-managing conflicts. Participation of different stakeholders facilitates such co-management.

6.6.   Recommendations

I propose the following recommendations based on the results of my study and with respect to different aspects of human and large carnivore interactions. I have compiled specific recommendations for: wildlife managers, the buffer zone institutions, the conservation agencies and the research organizations.

6.6.1. For wildlife managers

Identification and management of the conflict-causing individuals
As our study has shown, only 5% of the CNP tigers population caused conflict with communities. Timely identification of such individuals and quick action to remove or manage them from conflict areas is an important method of reducing negative impacts. Training field staff (game scouts and rangers) in the tracking and monitoring of conflict-causing individuals will help to locate them quickly and avoid loss of human life and economic damage. In addition, monitoring of tigers and leopards in fringe areas using camera traps or radio-telemetry in collaboration with communities and conservation partners will benefit all stakeholders. In addition to tigers, there may be other problem-causing individuals from different large mammal species like elephants, rhinos, sloth bears and leopards. Similar management of such individuals will help to reduce conflict.

Management of habitat mosaics
The high density of tigers and leopards in CNP and adjoining forests is facilitated by high prey density, spatial partitioning occupying different habitat types and temporal partitioning. Management of habitat mosaics is therefore important for maintaining the density levels of both carnivores and herbivores. With reduced human pressure following the establishment of the national park, the open (short) grasslands are gradually

An awareness-raising event for local communities about tiger conservation and avoiding tiger attacks when in the forests.

converting into the tall grasslands, bushes and, ultimately, forests. Grasslands in this sub-tropical regions are only maintained by disturbance factors such as fire, flood, human extraction or livestock grazing. Grasslands provide crucial habitat, food and shelter for many herbivores. Carnivore density is highly dependent on herbivores. For this reason, interventions are required to manage the grasslands regularly in order to prevent their succession to climax forests (sal or riverine) and in order to maintain the habitat mosaics.

6.6.2.   For buffer zone institutions

My study shows that the majority of buffer zone residents are aware of the buffer zone programs but they are not satisfied with the current practices. Based on my research findings, I propose the following recommendations to the buffer zone committees:

Prioritization of buffer zone programs
The buffer zone programs have made a significant contribution to reducing the wildlife impacts but I found that only a small proportion of the buffer zone budget is invested in direct interventions to reduce such impacts. Therefore, propitiation of buffer zone activities with more investment for direct interventions to prevent or to mitigate the wildlife impacts is recommended. Direct interventions may include the designing and constructing fences, alternative crops at the forest edges, installation of predator-proof corrals and relief for wildlife victims. I recommend allocating a certain portion (25 - 50%) of buffer zone funds for such direct investments, which will benefit the local community and reduce the conflict. In addition to these, indirect interventions such as habitat

management inside community forests, tracking and identification of problem-causing individual tigers or other species, awareness programs and alternative livelihoods for vulnerable communities should be considered.

Reaching those most affected

Although buffer zone programs have invested in human settlements around the park for more than two decades, the majority of the locals expressed dissatisfaction with the programs. My research and previous studies have also documented that the most affected group of people in the buffer zone has benefitted at least from the policy. Thus, I recommend to categorize the users in the buffer zone and prioritize those individuals or families who are most affected or vulnerable to wildlife damage. The family members or the affected individuals should be compensated by providing them with both social and economic opportunities to replenish any losses caused by wildlife. To increase the tolerance and support for conservation, buffer zone institutions should also consider compensation for the crop losses, which is not currently covered by the government compensation scheme.

6.6.3. Conservation agencies

Conservation of large carnivores in the human-dominated landscape is challenging and needs the support of multiple stakeholders. Conservation organizations, especially the NGOs and INGOs, can play an important role in conflict prevention and mitigation.

Conservation education and awareness of the vulnerable communities

Human killings by the wildlife is the ultimate expression of man-animal conflict. Such incidents can be reduced to a minimum, if not avoided, by changing the attitudes and the behaviour of local communities living in the forest fringes. Education and awareness raising among the vulnerable communities about wildlife ecology and animal behaviour is necessary for such change to happen. Training these vulnerable communities to avoiding encounters with wildlife as well as to reduce the risks of attacks when animals are encountered will help to minimize the human casualties. The traditional skills of the indigenous groups could be adopted to avoid or minimize the risks of wildlife attacks.

Promoting alternative livelihoods

People's dependency on the forest for their livelihoods makes them vulnerable to wildlife attacks. I found that in spite of increasing wildlife populations, conflict incidents have decreased in recent years with the diversification of household incomes and the changing social context. Such processes can be facilitated by promoting alternative livelihood options that reduce dependency on forests. Some of the identified programs include training youths as tourist guides, homestays, alternative crops (mushroom farming, fish farming etc.) and cottage industry. Such efforts will diversify the household incomes, reduce the wildlife impacts on communities and increase support for conservation. Conservation organizations can help to identify the appropriate livelihood options for a particular location through a participatory process, build local capacity on development or commercialization of the products and linking these products to the market.

Figure 6.4   A female leopard being fitted with satellite-radio collar before releasing to Chitwan National Park in December 2018. The leopard was rescued from Gulmi, Nepal where it was trapped in a snare-trap set for porcupine by local villagers.

Local capacity building

Local communities living in forest fringes are generally deprived of good education and socio-economic opportunities. These are also the people most affected by the wildlife and benefitting the least from the buffer zone programs. Due to limited capacity, they are unable to obtain optimum benefits from participatory conservation programs. Conservation organizations can play an important role filling this gap. Different activities such as informal conservation education sessions, training, exposure visits, interaction programs targeting those deprived and underprivileged groups will help to bring them into the mainstream of participatory conservation. Such capacity building should focus on human-wildlife conflict management. Conservation organizations (I/NGOs) should also help in the adoption of innovative technologies for efficient and effective management of the wildlife and their impacts on communities.

6.6.4. Future research suggestions

I suggest the following research areas that will enhance our understanding of human-carnivore coexistence in human-dominated landscapes.

Understanding the behavior of dispersing tigers/leopards

Tiger and leopard densities are increasing in core protected areas and there is limited space available for sub-adult animals dispersing from their natal territories. These dispersing sub-adults are also often involved in conflicts with humans. Understanding how these dispersing tigers and leopards use the increasingly human-dominated landscape will provide crucial information for their conservation. Such information will also help to understand the causes and identify possible measures for conflict management. Capturing and installing GSM or satellite tags on such animals is a good way of obtaining movement and activity data. If such invasive methods are not possible, the non-invasive methods such as camera trapping and genetic analysis of their scat can also our understanding of the dispersal behaviour of sub-adult tigers and leopards.

Ecological study of leopards

Although tigers are well-studied in Chitwan, and in Nepal in general, there is only limited information about the leopards. Based on the camera trap data, I observed their co-occurrence with tigers. However, I have not explored the actual spatial overlap and adaptation mechanism of leopards to coexist with tigers. Thus, I suggest future research on leopards using radio or satellite tags in areas where tiger density is also high.

Continuous monitoring of tigers and leopards in the buffer zone

Most studies of tigers and leopards are cross-sectional and capture a brief window of time. To gain detailed understanding of human–carnivore interactions, a long-term study is needed. It is important to conduct such studies in the buffer zone where the interaction between humans and large carnivores is intense. Such studies will also support communities to establish an early warning system by detecting problem-causing individuals in fringe areas before they are involved in intense conflict.

Evaluation of buffer zone policy

Buffer zone programs were initiated in the early 1990s in Nepal and formally institutionalized in 1997. Despite long-term investments in the buffer zone, human-wildlife conflict remains a major challenge in Chitwan. With more than 20 years of implementation, it is also time to assess the effectiveness of the programs. Such a study will also help to identify any gaps and generate the necessary information to make adjustments to the buffer zone policy and ensure its effectiveness in a changing social and political context.

Cost-effectiveness of different mitigation measures

My study documented a range of conflict mitigation measures including different types of fences, predator-proof corrals, crop guarding towers, alternative crops, etc. However, we do not know the effectiveness of these measures in reducing losses caused by wildlife as well as the economic value of the construction or maintenance costs, etc. I therefore recommend a study focusing on the effectiveness of conflict-mitigation measures in Chitwan.

Habitat dynamics and its effects on prey and carnivore density

I documented the high density of carnivores facilitated by habitat mosaics. The Terai and Siwalik regions of the outer Himalayas have a dynamic system where both natural and anthropogenic forces are actively changing the landscape and vegetation. Chitwan represents one such system where anthropogenic pressure has been reduced in recent years. Recent assessments show that the vegetation is becoming thicker and grasslands (especially the open grasslands) are shrinking. Quantification of such habitat changes (both in core areas and buffer zone) and their effects on prey and carnivore densities need to be explored. Such studies will also provide guidance for interventions to maintain habitat mosaics.

Photo by: Sagar Giri