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Can tigers survive in human-dominated landscapes?

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A tiger is worshiped by a group of villages near Bandhavgadh tiger reserve, Madhya Pradesh. (Photo by Vijaybhan Singh)

6 Synthesis: Human-tiger coexistence

6.1 Introduction

Tiger conservationists have long supported the notion that the tiger's (*Panthera tigris*) future survival in the wild is dependent on its ability to successfully coexist with humans outside protected areas (Sanderson *et al.* 2006; Walston *et al.* 2010; Wikramanayake *et al.* 2011). The tiger is on the IUCN Red List of Threatened Species and its current population is mostly restricted to isolated protected areas of Asia and Russia (Goodrich *et al.* 2015; IUCN 2017). Most protected areas, on their own, are not sufficient to support the large home ranges and high metabolic needs of the tiger and sustain a viable population (Ramakrishnan *et al.* 1999; Chundawat *et al.* 2016). As an alternative solution, tiger conservation is envisaged in larger landscapes comprising connected networks of protected reserves, multiple-use forests and private lands (Karanth and Gopal 2005; Ranganathan *et al.* 2007; Wikramanayake *et al.* 2011). However, people also live and use lands in the proposed tiger landscapes, and so the tiger must share the same lands and available resources to survive successfully. There is a general belief that the tiger's presence outside protected areas is a recipe for disaster. This is because, people and tigers compete for the same resources, and tigers can attack people and kill their livestock (Madhusudan 2003, 2015). Such negative interactions are thought to trigger people-tiger conflicts and create barriers to tiger conservation efforts (Woodroffe *et al.* 2005; Karanth *et al.* 2012). For these reasons, the ability of people and tigers to co-adapt and coexist is critical for their successful conservation in shared lands (Carter and Linnell 2016). In my study, titled 'Can large carnivores survive in human-dominated landscapes of India?', I investigated the mechanisms that allow people and tigers to successfully co-adapt and coexist in human-dominated lands and used both social science and natural science approaches to study such adaptation. The methodologies adopted to assess the human dimension aspects in this study were ethnography, respondent interviews and observations and they are grounded in values-belief-norm theory (Stern *et al.* 1999). Taking this approach allowed me to develop understanding about the interlinked sociocultural, political and economic factors shaping and influencing local people's views, attitudes, behaviour and practices relevant for coexistence with tigers. By contrast, the tigers were studied by assessing their spatial behaviour using VHF radio collars and by using carcass counts and faecal hair samples collected from human-use areas to review their diet. The combined information is then synthesised and presented to answer the main questions raised in my study:

1) How do people's beliefs and practices influence tiger conservation?
2) What factors influence tiger predation of livestock?
3) How do tigers use space in human-dominated lands?
4) What is the diet of tigers in such shared areas?

My study reveals that people and tigers can share space and coexist with minimal conflict. The principal mechanism underlying the observed coexistence scenario is the ability of humans and tigers to co-adapt, and it is two directional. Such co-adaptation includes:
1) people's ability to cope with the psychological fear of the tiger.
2) People's capacity to avert personal injuries and prevent losses of valuable livestock.
3) The ability of tigers to use space and find suitable prey in human-use lands with minimal conflict.

This chapter examines coexistence in the context of theory and empirical findings and looks at both the human dimension and the ecological aspects relating to the tiger and how these are associated with *co-adaptation* in shared lands. The first section outlines a sociocultural perspective that serves as a framework for examining research findings relevant to coexistence. Notably, the conceptual perspective postulates human adaptation rather than separation from dangerous animals. In line with this position, the second and third sections present conceptual and research findings on people's adaptation to the fear of the tiger and real threats (human attacks and livestock kills). The fourth section discusses the conceptual arguments and empirical research findings related to tiger responses to human presence and activity in an area: avoidance responses, spatial and temporal shifts in activity and finding prey. The final section considers research that would further expand our understanding of drivers of coexistence and suggests research approaches that may shed empirical light on the co-adaptation of people and tigers for successful coexistence.

6.2 A sociocultural perspective on the fear of living with dangerous animals

In some societies, tigers are viewed as godly, spiritual and mystical creatures and evoke feelings of fear within people that is comparable to people's fear of the divine, of the supernatural, of God (Hiltebeitel 1978; Canda 1981; Bakels 1994; Mao 2009; Heneise 2016). In others, people fear the tiger as an animal that attacks people and kills livestock and regard it as a problematic animal capable of creating panic, disrupting normalcy and causing death (Carter *et al.* 2012b; Miquelle *et al.* 2005). While most humans fear the real and the metaphorical tiger and view it as a powerful animal capable of killing a person, there are variations in the way people construct the meaning of the source (instigator) of the fear and the event (attack). While some see the threat as a supernatural manifestation that they have little or no control over, others see the threat as a natural one, i.e. a flesh-and-blood tiger (Bakels 1994; Carter *et al.* 2012b).

People's fear of the tiger is natural and innate. Ulrich (1993), in his study on *biophobia*, meaning 'the fear of living things', suggests that the human feeling of fear for objects in the natural world is inherent. This natural fear is interpreted as an evolutionary mechanism that may have assisted in human survival. Ulrich (1993) suggests that *biophobia* has its grounding in genetics and evolutionary theories and may have developed within people because of negative information or unpleasant past experiences with

dangerous animals. Examples are the natural human aversion to potentially dangerous animals such as crocodiles and snakes, dangerous predators or avoiding forests after darkness.

Other arguments for the human fear of dangerous carnivores (relevant for coexistence), as reported by Chapron *et al.* (2014) and Pilgrim *et al.* (2008), are based on people's disconnect with nature and their fear of economic repercussions. Agrarian societies, semi-urban and urban societie, for example, have distanced themselves from the wilderness and may have lost the adaptation to coexist with dangerous wildlife (Chapron *et al.* 2014). Furthermore, those communities who are highly dependent on their livestock or have changed their animal husbandry practices to new production structures are not willing to tolerate losses from tigers (Chapron *et al.* 2014). Here, the economic consequences and potential harm to people are overpowering, and people perceive the tiger as a pest. Ultimately, the natural fear, loss of adaptation to coexisting and the fear of economic losses all evoke feelings of fear and hostility towards the tiger and people are known to respond to such threats by retaliating or objecting to tiger conservation in areas they use.

Based on my findings, I agree with Bhagwat and Rutte (2006) and Simaika and Samways (2010) that, in many prevailing societies, traditional cultures are still intact and continue to shape the way people live in harmony with nature, including the tiger. Authors such as Berke *et al.* (2000) and Gadgil *et al.* (2003) also refer to the untapped potential of local ecological knowledge within rural communities. As my study shows, local cultures that promote harmony with nature and support the transfer of ecological knowledge from one generation to the next, most likely, support relatively tolerant attitudes towards nature and wildlife. Like the spirit sites that I mentioned in Chapter 2, Ulrich (1993) in his study of *biophobia*, drew attention to the temples people construct for worshipping snakes in India. The psychological impact of worshipping and conducting rituals to snake gods or the spirits of tigers is thought to be a coping process and reduces anxieties associated with a dangerous creature. In Chapter 2, I also elucidate, by way of a case study, how local beliefs and norms guided people's use of forests and shaped their attitudes and behaviours towards wildlife. For instance, residents, over the years, built numerous spirit sites scattered throughout the forests and believed that powerful spirits rest near those sites. They believed that wild animals would not harm them or their livestock while they were near such sites and may be experiencing the placebo effects of the belief-in-faith that Kohls *et al.* (2011) and Vance (2016) described. The forest trails they used frequently crossed these spirit sites, and the proximity to the sites instilled a sense of security in most people while moving in the forests. To ensure the continued protection of the spirits, people periodically stopped near sites and made sacrifices and offerings. They rested near sites, but did not disturb the character and sanctity of these places. Their actions have multiple implications: First, they reduce anxieties about dangerous animals while in the forest. Second, people showed high tolerance of animals as they believed animals were also protected by the spirits. Third, people followed the community norms near spirit sites and did not pollute these areas. As my results show, the wide scale of these local practices in my study region, coupled with the practical and intrinsic benefits people derived from

their practices, influenced their willingness to coexist. These arguments, which I describe in Chapter 2, are undeniable and highlight that some communities have developed and currently maintain traditions and local institutions that guide their interaction with the natural world and foster coexistence.

In addition to beliefs and norms influencing perceptions of fear, my findings also show that resident livestock owners encountered animals frequently and, at the same time, exhibited high levels of local ecological knowledge about carnivores and their habits. My findings support those of Roskaft *et al.* (2003) and Loe and Roskaft (2004), i.e. that the negative experiences and lack of knowledge about wild animals increased perceived fear of these animals in humans. For instance, between 2009 and 2013, the management of the Panna Reserve recorded six fatal attacks by sloth bears on people. In contrast, there have been no recorded attacks by tigers in the last 20 years in the study area. I explained in Chapter 2 how my survey findings on the threat perceptions of local livestock owners showed that people viewed the sloth bear as a greater threat and a more dangerous animal to human safety than the tiger. Seventy per cent of the interviewed households did not see the tiger as a threat. Similarly, greater familiarity and knowledge about the habits of the wolf influenced people's perceptions that the wolf is a threat to livestock and not human safety.

Thus, there are divergent views on factors that shape people's interactions with nature and fear of the tiger. The fear that people have of the tiger need not necessarily translate into a confrontation with the tiger or oppose people promoting tiger conservation. There is substantial evidence that rural communities living within the proposed tiger landscapes in India still follow traditional ways of life and their local cultures, practices and local knowledge provide functional support that helps them cope with the fear of the tiger (Kolipaka *et al.* 2015). Such mechanisms are often referred to as a traditional conservation ethic in literature and are known to have favoured wildlife in India (Berkes *et al.* 1995; Berkes *et al.* 2000). Therefore, the arguments suggesting that fear alone will create permanent barriers to all tiger conservation outside protected areas are not convincing.

6.3 Findings on people's ability to avert personal injuries and prevent livestock losses

The most convincing current arguments against people's ability to cope with the real threat of the tiger come from the reasoning that tigers can attack people and kill livestock. What if tigers are reintroduced into areas where they are currently extinct? What if people have lost their coping mechanisms? For instance, "Elephants and tigers kill one human a day in India," reported India's *Hindustan Times* on 1 August 2017. Tigers killed 92 people and elephants 1052 between April 2014 and July 2017 (Times of India 2017). It is true that large carnivores like tigers, leopards and lions are capable of killing humans. The losses of livestock to large carnivores are also common and high. The general apprehension of conservationists and managers is that human attacks and livestock losses will reduce people's tolerance of wildlife and could trigger retaliatory behaviour towards dangerous

or potentially threatening wildlife. This line of reasoning goes on to suggest that people cannot cope when exposed to new scenarios or when they encounter unfamiliar situations, like newly reintroduced tigers.
Many researchers contradict this reasoning. The view that biological conditioning, learnings derived from cultural practices and local ecological knowledge allow people to avert personal injury has received broad support.

6.3.1 Biological and cultural conditioning developed to avert injuries from wild animals

An important aspect of averting injuries is that, in many existing cultures, people have developed ways to avoid dangerous situations. According to the research findings of biophobia, upon examining human cognitive responses to potentially harmful situations, Ulrich and his colleagues found that exposure to negative feedback and negative experiences make people defensive to potential hazards. Such conditioning allows people to adapt and increase human survival (Ulrich 1993). For example, Jones and colleagues reported that, in Madagascar, the local social norms prohibited people from killing taboo lemurs and other carnivores, even when such animals were perceived as evil and dangerous (Jones *et al.* 2008). Here, by removing the interest in the animal, people limited their interaction, avoided them and potentially saved themselves (irrespective of whether lemurs are dangerous or not). Similarly, widely held beliefs in forests spirits discouraged people in my study area from using forests after dark. The practical advantages of this widely held belief system come from the pacts that people make with their protector spirits. For instance, the protection of spirits is ensured only when certain norms are not violated. Therefore, people strictly adhere to rules and avoid forests at night-time. Avoiding nights in the forest decreases direct encounters with dangerous animals like the tiger, which is most active in the crepuscular and nocturnal hours (Chapter 4). Here, the cultural conditioning leads to the conscious or not-so-conscious acts of people and allowed them to maintain spatial and temporal separation from tigers, thus reducing risks. Ulrich (1993) explains this as cultural and biologically prepared learnings, which might provide communities with efficient ways of adapting to dangerous situations. People, influenced by their conditioning, try and avoid dangerous situations, in a defensive manner, without actually having to have direct and dangerous encounters. This line of reasoning is also applicable to contexts where communities have lost their coping mechanisms or where carnivores are newly reintroduced. In Chapter 1, I described four incidents that took place during my project work, in which I reported people's responses to the presence of a tiger. In all the examples, local communities organised themselves and supported the authorities to ensure the safe movement of the tiger through human-dominated areas and avert a crisis. Initially, the sudden and unannounced arrival of the tiger into human-use areas created panic within local communities. However, there were creative ways to solve these crisis situations, and the anxiety within community members was reduced when local religious leaders intervened in one incident, when local politicians took the lead in another, when locally influential landlords extended support and when local government officers got involved in the fourth. Here, the presence and leadership of the right people influenced the behaviour of the community as a whole. According to Ullrich (1993), when incidents such as a tiger in a human-dominated area take place,

the telling and retelling of such incidents involving the tiger and the ways in which it was tackled when it was in the area, lays the foundations for communities to learn and adapt to future situations.

6.3.2 Local knowledge on carnivores

Knowledge about local carnivores and their habits can reduce the risks of injuries in the event of an encounter. Brown and Conover (2008) compiled information on the responses of people when attacked by bears, wolves and pumas and report that knowledge about the animals influenced people's responses during encounters and saved lives during attacks. Their findings show that there is no single best way to escape injuries during attacks, rather there are many ways to avoid harm. A goat herder from my study area shared his encounter with a tiger (Figure 6.2). One day, as the man was walking home alone from the forest, he encountered a tiger sitting in the middle of the forest path. He recollected his first thoughts on seeing the tiger, "I am seeing a spirit tiger and the spirit will not harm me." He looked at the tiger and realised that the animal was resting. He stopped walking and folded his palms in respect and asked the tiger to spare him. He then slowly walked backwards, without making eye contact, and only then turned around and continued walking. This way, he increased the distance between the tiger and himself and escaped.

Figure 6.2 A goat herder showing the posture of the tiger he encountered.

Here, the cultural conditioning that the tiger is a spirit and that it will not harm the herder and the knowledge and presence of mind to slowly walk away, thus increasing the distance between the tiger and him, saved the herder's life. Penteriani *et al.* (2016) showed in their research on the causes of attacks on people that risk-enhancing behaviour by people lead to most (over 50 per cent) carnivore attacks in America. Such risk-enhancing behaviour included teasing animals, getting too close to animals and leaving children on their own, and all prompted attacks. Their research also showed the indirect effects of risk-enhancing

behaviour and how it led to attacks, i.e. accidentally walking into animals or encountering animals with cubs or pet dogs attracting large carnivores. Overall, the risks of attack are attributed to people's lack of knowledge about carnivores and the resulting risk-enhancing behaviour. As reported by Van der Ploeg and his colleagues, lack of knowledge can also mislead third parties, such as policymakers. In the Philippines, policymakers declared the endangered local crocodile species a dangerous pest while, in reality, people who shared the rivers with the crocodile have learnt to move in groups, use the rivers in designated areas and avoided the crocodile successfully (Van der Ploeg *et al.* 2011). In such cases, the importance of communication and education is emphasised.
There are also local cultures that discourage risk-taking and promote learning. In my study area, Yadav pastoralists adhere to a community norm where members are obliged to help those whose cows or buffalo are missing. The Yadavs believe that if livestock are left to wander in the forests at night-time, the spirits of the forests (including the tiger) have a right to prey upon them. So, community members help each other search for missing animals. Such norms have possible risk-averting consequences. By moving in groups, they decrease their chances of being attacked by animals and increase their chances of finding missing livestock. Furthermore, following local customs, children are taught these local practices and about the risks from carnivores from a young age. Such cultural conditioning and knowledge foster naturally risk-aversive behaviour and are favourable for coexistence.

6.3.3 Averting threats to livestock

Carnivores have killed livestock since time immemorial and at least since humans began domesticating animals. Based on this assumption, it is likely that, through the ages, humans may have tried and explored ways to decrease losses from predators. My results provide proof of this and I agree with other researchers who claim that good knowledge of carnivores and preventive strategies enable owners to reduce livestock losses (Wolf – Ogada *et al.* 2003; Wolves, bears and pumas – Pimenta *et al.* 2017; Lion – Tumenta *et al.* 2013). In my study area, local livestock owners, well-versed in the activity patterns of tigers and wolves, avoided dense forests and grazing between dusk and dawn. Instead, they grazed animals during daytime. Additionally, following an old, customary practice, they held daily evening meetings and discussed animal sightings and local news about carnivores. The combination of local knowledge and local practices allowed herders to consciously avoid grazing in risky areas. According to Carter and Linnell, (2016) knowing this natural ability of local communities to co-adapt with large carnivores and the circumstances that foster such adaptation is vital for coexistence between people and tigers.

Preventive strategies do not always work, and livestock predation persists in many contexts despite people's efforts (Khorozyan *et al.* 2017). I had similar observations and I described in Chapter 3 how contextual social circumstances sometimes promoted lenient livestock husbandry practices and increased risk of predation. Pimenta *et al.* (2017) observed that carnivore attacks in Portugal were higher when free-ranging livestock husbandry systems were adopted. This is confirmed by my results and in both cases owners did not accompany herds. Herds were grazed in communal lands and forest lands and animals were never corralled at night. In comparison, losses were much

lower in husbandry systems where people personally grazed animals and confined them to enclosures after dark. Here, a third dimension, the socio-political situation, created barriers for livestock owners, and livestock losses continued. For instance, my study reveals that socio-political factors surrounding sacred cows in the region encouraged people to abandon unwanted cows in the forests. As a result, commonly, large carnivores preyed on such abandoned animals and sometimes also valuable livestock. The highly contextual situation of my study did not impact livelihoods directly because a majority of the people kept cows for sustenance use only. However, the indirect impact, as local Yadav pastorals revealed, is the decreasing dependence on livestock as a choice of livelihood amongst traditional pastoralists. This shows that there was some adaptation by people and I agree with Traves and Bruskotter (2014) that economic livestock losses alone did not result in any direct retaliatory killings of carnivores. These finding are not only relevant for tigers, but have been observed in contexts where tigers, jaguars, wolves, lions, and bears are present, all of which are potentially dangerous for livestock and contribute to economic losses worldwide (Traves and Bruskotter 2014).

Then again, as Treves and Bruskotter (2014) evidenced, social factors can influence people to poach animals. Such poaching could be for consumption and for trade. Poaching, though a critical and widely recognised threat to tigers outside protected areas and to meeting the 2022 'double-the-tiger' population goal, is not as a result of human-tiger conflicts (Miquelle *et al.* 2005; Wikramanayake *et al.* 2011). For this reason, it is not the focus of my study. As shown in this section, the not so obvious and previously unknown insights into the complex nature of issues shaping livestock losses necessitates the need to understanding the exact nature of the local contexts in order to address livestock predation issues. For instance, Yirga and his colleagues revealed that situations like disease and theft sometimes caused more livestock losses than predators in their study area in Kenya (Yirga *et al.* 2014). I report similar findings and in both cases people followed local practices, accompanied herds, used enclosures at night-time and kept dogs for warning. People were highly satisfied with their preventive measures against predators and felt that factors other than predation were more of a concern. This finding shows that people's prioritisation of threats can vary depending on the locally prevailing contextual factors and the threats predators pose may not necessarily be at the top of their lists.

6.3.4 Adapting to newly introduced carnivores

People's ability to adapt to newly reintroduced or recovering large carnivores may be problematic (Chaperon *et al.* 2014). I agree with this, but also provide evidence in Chapter 1 that people can adapt to new scenarios. In my study area, which is a protected, dry, deciduous forest landscape, tigers naturally occur in low densities (Karanth *et al.* 2004). Additionally, larger stretches of the reserve, including stretches of the newly created buffer zone, are not suitable[18] for tigers (Chundawat *et al.* 1999). As a result, tiger presence and movement in the area is low. However, after the reintroduction of tigers

[18] Unsuitable because large stretches are flat grasslands, which are non-habitat for tiger and also because human overuse of the landscape has rendered the areas inappropriate.

and the subsequent conservation efforts, tiger numbers increased in the core zone and buffer zone and, as I describe in Chapter 4, currently tigers are present in areas that they have not previously used. Herders using the buffer zone areas encounter people monitoring tigers, tiger tracks and signs, and experience livestock losses more often than they have in the past. While there is a high general awareness about tigers, as I describe in Chapter 3, there are herders who do not have the practical knowledge on averting tigers because of their infrequent previous encounters. For instance, goat herders using the buffer zone areas commonly encountered wolves but not tigers. They have developed local grazing strategies that safeguarded their animals against wolves. For instance, they graze their goats in more open areas and avoid thick forest. They throw stones and shout and use sticks to scare wolves. While small-sized goats are not natural prey for the tiger, the strategies that herders use to prevent wolf attacks may not safeguard them against an ambush predator like the tiger. Furthermore, it may also expose them to the risk of tiger attack. While this situation may sound discouraging, I described in Chapter 3 how goat herders periodically asked the tiger monitoring teams about the locations of tigers and consciously avoided such areas. This natural ability of people to adapt to the presence of the new predator should be seen as a positive indication of individuals' adaptation to the emerging new scenario and supports the theory of Ulrich and his colleagues that communities learn (Ulrich 1993). Management strategies should recognise these favourable cues that people give out (more details on the role of the reserve management in the recommendations section 6.3.1). Parallel to this, as I show in my findings in Chapter 2, local herders who are now wary of the personal danger that the large and relatively unknown tiger may pose, started making enquiries about how to make pacts with the spirit of newly reintroduced tigers. The disclosure of a buffalo herder presented in Chapter 2 captures the advice given by the locally trusted spirit intermediary. "Badami baba is a mighty forest spirit. Badami baba can summon the tiger by its ear. If a tiger repeatedly kills domestic animals or creates panic in villages, Badami baba can be requested to summon and tame the tiger." These examples illustrate ways in which local people practically and psychologically try to adapt to the newly reintroduced tigers in their environment. However, only time will tell if people's adaptation is complete.

6.3.5 Summary of Findings: The human dimension

To summarise briefly, my findings support the view that, in many communities, people's beliefs, their cultural practices and local knowledge extend support to cope with their naturally occurring psychological fear of the tiger. Their coping mechanisms, which are embedded in their faith, religious beliefs and practices, are a compelling motivator that allow people to access and use forests with potentially dangerous animals. Furthermore, their cultural practices and knowledge of carnivores provide them with the support to make conscious decisions and avert risk-enhancing behaviours and saves them during encounters.

Research findings also suggest that livestock losses can be reduced by using preventive strategies. However, there is also evidence that preventive strategies may not always work or eliminate losses from occurring. Several factors, including socio-political factors, lack of knowledge and ability of carnivores to adapt to precautionary measures, may create

barriers to preventing losses. Findings indicate that communities naturally learn to adapt and re-adapt to changing scenarios. Such adaptation is likely to encourage adaptation and coexistence with the newly reintroduced or recovering carnivores in human-use areas. At the same time, in heavily modified systems, where people are not willing to adapt or where social factors do not allow people to change, it may be unrealistic to promote large carnivores. Research also suggests that people may not always retaliate if they lose animals and that there may be other underlying social factors or human-human conflicts that trigger retaliation. Furthermore, communities using livestock for sustenance, or where social situations lead to excess livestock, or where people are accustomed to predation incidents, show natural tolerance in the form of acceptance of loss as a natural event. My study concludes that, from a human perspective, there is adequate evidence that, contextually, people can adapt and coexist with tigers. My focus in the next section is on the ability of tigers to adapt in human-use areas.

6.4 Tigers in human-dominated landscapes

My research data does not support my third hypothesis – that tigers will totally avoid areas where human activity is high (Chapter 4). But my data does support my fourth hypothesis – that the presence of feral cattle along with open-access grazing practices in multiple use forests increases the incidents of predation on all livestock by tigers, even when wild prey are available (Chapter 5). My findings suggest that the radio-collared tigers of Panna Tiger Reserve exhibited high behaviour plasticity and adapted their activity patterns to human use and activity in the study area. They avoided areas when human activity was high, but approached villages and water bodies when human activity lowered. Several authors suggested that such behavioural plasticity exhibited by large carnivores as a response to changes in their environments may increase their chances of survival in human-dominated landscapes (Miquelle *et al.* 2010; Rabinowitz and Jr. 1986; Rabinowitz 2014). My findings on the tiger's natural adaptation to human activities are new and will increase the current understanding of tiger-human coexistence in human-dominated landscapes. However, the natural adaptability that I refer to is a biological measure of adaptability and not an absolute indicator of tigers' survivability in human-dominated lands. For this reason, the results of my study should be interpreted with caution and should not be a basis for setting targets for projects, such as the 2022 'double-the-tiger-numbers', which is a social and political target.

I subscribe to the definition of the 'habitat of a carnivore', as proposed by several researchers, that clearly considers the resources that contribute to an animal's fitness while depicting its habitat (Mitchell and Hebblewhite 2012). Based on this definition, carnivores can successfully persist in an area only when they achieve a niche that involves access and selection of resources and the conditions that improve their survivability and successful reproduction (Mitchell and Hebblewhite 2012). Areas where they achieve successful survival and reproduction are called source habitats for carnivores and in India, most tiger source habitats are already protected tiger reserves (Karanth and Gopal 2005; Wikramanayake *et al.* 2011). According to Watkinson and Sutherland (1995) and

other authors, the areas that carnivores use but where their survival is low and their reproduction is decreased are sink habitats (Mitchell and Hebblewhite 2012; Watkinson and Sutherland 1995). By this definition, my study area, which is the newly established human-dominated buffer zone of the Panna Tiger Reserve and the multiple-use forests extending beyond the reserve are *sink habitats* for tigers (Chundawat *et al.* 1999). Since the proposed networks within the tiger landscapes in India comprise both *source habitats* and *sinks* and which are also spatially interconnected, I examined tiger responses to some of the most common human activities seen in such interconnected spaces.

Based on the empirical findings of my study, I reported that my study tigers exhibited a high behavioural plasticity to the various human activities and did not readily conflict with people as generally thought. The most convincing current arguments against the tiger's ability to survive in human-dominated lands come from the reasoning that tiger survival may be limited by human activities and that they may become prone to conflicts with people and livestock (Das 2015; Goodrich *et al.* 2011; Gubbi *et al.* 2016). This line of reasoning suggests that tiger and human coexistence is incompatible and interactions with people will either make them vulnerable or confrontational. As a solution, more protected spaces are proposed by some authors (Gubbi *et al.* 2016). I found that there is little empirical evidence in published literature on tigers' natural ability to adapt to various human activities in human-dominated landscapes and coexist. It is true that when large carnivores like tigers move into human-dominated areas interactions with people are inevitable. It is also true that for a solitary, territorial and obligate predator like the tiger, the resources available in an area such as availability of water, vegetative cover and prey, contribute directly to its fitness (Gour *et al.* 2013; Hayward *et al.* 2012; Karanth and Sunquist 1995). Also, the direct conflicts with people as result of tiger attacks and livestock kills, matter (Goodrich *et al.* 2011; Das 2015). However, the scanty empirical evidence on the ability of the tigers to adapt to human activity is concerning.

6.4.1 Tiger activity patterns

I found that tigers shifted their activity patterns and moved in human-dominated landscapes at night-time, when human activity lessened. They also approached close to villages and used the same water bodies at night that people intensively used during the day. Additionally, tigers made shifts in activity patterns responding to the seasonal temperature variations. In the hot, summer months their presence in human-dominated landscapes increased at night-time. The low vegetation in summers, restricted water bodies and prey that are not active in the heat of the day may have influenced tiger behaviour. In Chapter 2, I showed how this summertime activity pattern of tigers changed in the rainy season and winter months. In rainy and winter seasons, their presence in human-dominated areas increased during the day. This may be because daytime temperatures became more ambient, vegetative cover and water is not scarce and prey become more active during the day. Several large carnivore researchers have showed how lions, brown bears, leopards and spotted hyena demonstrated high behavioural plasticity and adapted their activities to human presence and activities in their environment (Athreya *et al.* 2013; Carter *et al.* 2012; Kojola *et al.* 2016; Martin *et al.* 2010; Oriol-Cotterill

et al. 2015; Yirga *et al.* 2012). For example, Martin *et al.* (2010) reported that brown bears temporally adjusted their activity patterns in human-use areas and only used such areas when human activity lessened. Similar temporal adjustments in activity to human presence have been reported in lions, tigers, leopards and wolves (Athreya *et al.* 2013; Carter *et al.* 2012; Oriol-Cotterill *et al.* 2015; Kojola *et al.* 2016). In Chapter 4, I described how some tigers using the core zone areas moved into the adjoining human-dominated buffer zone areas at night-time when human activity decreased and moved back into the core zone during the day. At the same time, some of my study tigers did not have the possibility to retreat to the core zone and remained in the buffer zone. But they did not show any significant increase in their daytime activity. My findings are consistent and support those of Carter *et al.* (2012) who showed that in Chitwan, Nepal, tigers avoided human areas during daytime, most likely because of disturbance caused by fuel wood collectors and the low vegetative cover caused by over grazing. Contrasting findings are reported by Naha *et al.* (2016) who showed that their study tigers were also active during the day, most likely influenced by local contextual factors, such as absence of livestock rearing, low persecution by residents and the availability of their main prey (Cheetal deer are diurnal). In my study, I did not find any age-group and sex specific variations in activity patterns. These evidences of behavioural plasticity through spatial and temporal shifts in activity indicate that tigers are capable of adapting their activity patterns to the finer-scale changes in human, prey and environmental conditions within their areas. The next topic is the tiger use of areas where human activity is concentrated.

6.4.2 Tiger presence near villages and water bodies

I found that tiger presence near villages and near water bodies in human-dominated areas was high. However, I observed age-group biased variations in tiger presence in these areas with younger tigers using these areas more than adults. My findings support the findings of Kajola *et al.* (2016) who reported that, in Finland, their radio-collared younger wolves, most likely influenced by their naivety, approached villages more frequently than mature wolves. My study on tigers is the first to claim that young tigers behave differently from adult tigers in human-use areas. For example, while all my study tigers approached villages in their environment (showing greater avoidance during day when human activity peaked), the younger tigers were much more present near villages than adult tigers. However, this changed over time and with age (and most likely experience) when their presence near villages decreased. I see this decrease as a natural shift and it is supported by the findings of Kajola *et al.* (2016) who also observed a similar natural decrease in the presence of their study wolves near villages over time. As Figure 3 shows, my study tigers rested close to people's homes in areas where human density and activity was low and were even present during the daytime. This behaviour was not exhibited near villages where human density was high, as also reported by Kojola *et al.* (2016). The ability of tigers to stay unnoticed near some villages may also be dependent on vegetative cover, fewer village dogs and ambient daytime temperatures. The ability to use minimal vegetative cover and yet stay unnoticed may be very useful for those tigers travelling through human-dominated lands or younger animals exploring new territories. My findings support those of Carter *et al.* (2012) and Miquelle *et al.* (2005) who showed that tigers may avoid areas in human-

dominated landscapes if such cover is absent or when human disturbance increased. This understanding of the tiger's ability to use and also avoid spaces with changing conditions near villages can be helpful for planning village peripheries in coexistence scenarios. Otherwise, as I showed in Chapter 2, people's livestock husbandry practices, which provide readily available food near villages, may attract tigers closer to settlements and the younger tigers may be drawn more than the adults because of their naivety about the risks associated with approaching villages.

In Chapter 5, I described how, during my five-year study, I did not find any evidence that tigers, young or adult, targeted animals near villages. In spite of large congregations of cows near village peripheries, tigers did not kill more animals near villages than in other parts of the human-dominated area. It appears that not all visible and abundant prey is available for tigers to exploit. I support the line of reasoning of Nilsen *et al.* (2012) who showed that prey abundance alone does not necessarily contribute to availability, and that availability is a function of several factors, including: abundance, prey-antipredator behaviour; cover, human activity, village dog and others. In my study area, the village cows that congregated near villages may have attracted both young and adult tigers closer to villages, but this did not result in more killings of cows than in other areas. It is likely that the cows had good group vigilance and may have proved difficult to capture. Based on my findings, I agree that tigers will be drawn to villages, but disagree with the argument that tiger presence near villages increases predation of livestock compared to other places in the human-dominated landscape.

Figure 6.3 A dispersing male tiger (in the yellow box) rests close to a human settlement during the day. The tiger may be advantaged by the ambient daytime temperatures and vegetative cover in the study area during overcast days in the winter (November to February). Photo R. Sreenivasa Murthy.

6.4.3 Tiger presence near water bodies

My study findings show that tigers do not avoid using water bodies in the human dominated landscapes. However, their effective use of such water bodies decreased in comparison to those in the undisturbed core zone. I support the findings of Biolatti *et al.* (2016) whose experiments on captive tigers have shown that access to water improves tiger well-being. Tiger well-being, as I explained in Chapter 4, could comprise several factors, including their ability to stay unnoticed, regulate body temperature, and avoid biting ticks (Biolatti *et al.* 2016). Tigers are often found near water, so the existence of a functional relationship has long been known (Chundawat *et al.* 2016); however, empirical data and evidence on how much tigers depend on water in the wild has been lacking. For example, Naha *et al.* (2016) reported that tigers using the waterlogged mangrove forests of the Sundarbans avoided swimming across long channels of water, but readily crossed small distances and accessed land. My studies reveal for the first time that in water scarce, dry landscapes, when human disturbance near water bodies is minimal, tigers spend nearly 25 per cent of their time near water (Chapter 4). Such access to water bodies may have allowed them to cope with high summer temperatures (exceeding 45C) in my study area. I agree with Biolatti *et al.* (2016) that tigers need water to regulate body temperatures. In my study area, their need for water bodies to regulate heat may have decreased in winter and rainy seasons, most likely due to changes in ambient local temperatures. Such decreases in temperature may have allowed some of them to explore further afield in the human-dominated areas, despite low access to water bodies. Here, their ability to move in areas far from reliable water bodies is noteworthy and should be seen as behavioural plasticity, though, as Biolatti *et al.* (2016) showed, it may have some overall negative impact on tiger well-being. Additionally, my findings (Chapter 4) show that younger tigers and adult males moved further away from reliable water bodies in the human-dominated areas and not the adult females and females with cubs. As a result, younger animals and males were more exposed to vulnerability than female tigers. Furthermore, I found no evidence that tigers killed more domestic or wild animals near water bodies than in areas far from water. This was in spite of a high presence of domestic and wild prey animals near water bodies in the study area. While more future research is needed to understand the finer details of the functional relationship tigers have with water, I feel that tigers in human-dominated areas do not target prey exclusively near water. Such targeted killings could reveal their presence to people and increase prey vigilance near water and, consequently, they may lose a precious opportunity to stay close to water bodies.

6.4.4 Tiger predation of livestock

My study findings show that, when livestock were available, all tigers killed more of such animals even when wild prey was available. However, age-group and sex specific variations in predation rates show that younger animals and male tigers killed more livestock than female tigers. For these categories, predation rates did not vary for human-dominated areas and the protected core zone. However, for females it did and they killed more livestock only when they were far from the core zone in the human-dominated landscape.

I agree that tigers are obligate carnivores and I support the explanation of Nilsen *et al.* (2011) that the prey available to a carnivore is not purely a function of abundance, but also includes prey-anti-predator behaviour, differential vulnerability of prey in different lifecycles, seasonality and more. In Chapter 5, I described that male tigers and sub-adult tigers killed more livestock than female tigers. However, the proportion of wild to domestic animals killed remained comparable between all age groups and sexes. I support the explanation of Karanth and Sunquist (1995) that male and young tigers most likely killed more numbers of domestic animals because of their frequent encounters with such animals (influenced by their wide-ranging movement patterns). Further, I also agree with Karanth and Sunquists' explanation that the relative ease of killing domestic animals, in comparison to wild prey, may have played a role in younger tigers killing such animals (Karanth and Sunquist 1995). In my study area, this may have helped younger tigers to use and survive in a disturbed landscape, where preferential wild prey is sparse. Female tigers, on the other hand, killed more wild prey animals than domestic prey animals in the core zone of the study area. I explained in Chapter 3 that female tigers might have preferentially targeted wild prey because they raise their young in the core zone and tend to have smaller home ranges than males. Thus, females probably choose areas that are far from human activity and where they are more likely to encounter more wild prey.

I do not support the argument of Karnath *et al.* (2004), and several other authors, that from a tiger conservation perspective, wild prey species are essential to the tiger's persistence (Chundawat *et al.* 1999; Miller *et al.* 2015; Ramakrishnan *et al.* 1999). However, I do support Karanth *et al.* (2012), and other authors, who argue that human-tiger conflicts have a complex nature and that they can jeopardise tiger conservation. I believe that a habitat outside protected areas of India cannot be realised without livestock in it. From a biological perspective, and based on my findings on tiger adaptability to prey in human use areas, I contradict the general understanding that wild prey species are essential to the tiger's persistence. Metabolically, domestic animals, such as water buffalo and cows, provide all the proteins, lipids and fats required for an obligate carnivore like a tiger. New understanding on large carnivore diets as shown by Athreya *et al.* (2016) and Yirga *et al.* (2013) reveals that large carnivores like leopards and spotted hyenas can thrive in human-dominated lands without wild prey and totally adapt to locally available prey species. Such understanding on tigers is lacking and often supressed by arguments that it is impossible for tigers to survive without abundant wild prey.

In Chapter 5, I described how, as the distance from the core zone of my study area increased, all tigers, irrespective of their age-group and sex differences, resorted to killing more domestic animals. Furthermore, male tigers also preferentially targeted male prey animals (especially male domestic animals), but smaller female tigers killed both male and female domestic animals in similar proportions, suggesting that the predator-prey body weight ratio as explained by Hayward *et al.* (2012) and Miquelle *et al.* (2010) may have a role in a tiger's choice of prey. I agree with Nielsen *et al.* (2012) that the availability of domestic animals to tigers in my study area is not purely because domestic animals are in abundance in this location; but, as I described in Chapters 2 and 3, the presence of male feral domestic animals is a consequence of local people's practice of abandoning unwanted animals in the forests. Tigers killing such unwanted animals should be viewed as a natural, finer-scale local adaptation, which is also socially acceptable. Furthermore,

Figure 6.4 Omnivorous by nature, wild pigs commonly feed on domestic animal carcasses in the study area. They, in turn, are also prey for the tiger. Photo by Shukru Kumal.

livestock is also eaten by other carnivores like wild pigs (Figure 4), which, in turn, are prey for tigers in human-dominated landscapes.

My findings contradict the general notion that livestock predation by tigers is always conflict-prone (Karanth *et al.* 2004). I reason, based on the evidence provided in the above paragraphs, that when feral and not-so-commercially-valuable livestock are available in an area and when local people's wildlife acceptance capacity, as explained by Decker and Purdy (1998), is favourable, conflicts do not occur. Moreover, tigers did not kill more domestic animals in areas intensely used (near villages and water bodies) by people. So the problem animal situations, like those proposed by Swan *et al.* (2017), did not occur in my study area and, therefore, are not applicable in this context. I believe that the local circumstances surrounding livestock are unique in my study area and quite different from those commonly mentioned with regard to Nepal or other parts of the world. I also believe that there may be more such areas in India, where tigers can exploit domestic animals without the threat of conflicts with humans. Realistically, the social and economic costs of removing socially and politically sensitive domestic animals from forests in India are very high (Chapter 3). It is certainly worth exploring the natural decline that tigers and other large carnivores can, together, bring about by suppressing lower trophic levels, especially on unwanted and feral domestic animals populations, without the nuance of the

socio-cultural and political complications (Dorresteijn *et al.* 2015). Based on the empirical findings of my study, I believe that the latter is hugely advantageous and practical to the tiger and the local communities.

6.4.5 Summary of findings: Tigers in human-dominated landscapes

Tigers have long fascinated humans, and people have been observing and studying their behaviour since ancient times. While there is a general acknowledgement amongst present day tiger conservationists and managers that tigers are adaptable animals, their real ability to adapt to human activities in human-dominated landscapes is largely unknown. This lack of knowledge has resulted in a general belief that all tiger-human interactions lead to confrontations and eventually conflicts and, therefore, coexistence is incompatible. My study shows that tigers have a higher natural ability to adapt to some of the most common human activities, such as people's presence, their husbandry practices and use of water bodies, than generally expected. They adapted their activities, showed higher tolerance to changes in land use, tolerated human activity near water bodies and adapted to a diet of locally available but suitable prey (including livestock) and still continued to use space and resources with minimal conflict (acceptable to local communities). This adaptation is not unidirectional, but rather two-directional with the human dimension aspects also playing an important role in the tiger's successful adaptation. For this reason, the described findings are specific (contextual) to the Panna Tiger Reserve and the adjoining areas and may not be directly comparable to contexts in other areas. In other areas, the composition of the local people, their beliefs and practices, their local knowledge on tigers, adaptation ability and tiger characteristics will vary. Therefore, the findings must be interpreted keeping in mind the local human and tiger contexts. In chapters 4 and 5 I also listed a series of contexts where tigers may naturally fail to adapt. For instance, age related issues such as naivety in young animals made young tigers take risks and approach villages and use areas where they have little or no access to water bodies. Likewise, male tiger's, just like young tigers, killed more livestock even when wild prey were available. Tiger's use of water bodies also varied. Undoubtedly, they are able to access water bodies better in the core zone where human disturbance was minimal that in the buffer zones. In spite of these differences, attacks on people were not reported during the five-year study period or previously. I believe that this may be because of local factors unique to the study area. In other areas, other permutations and combinations of people-tiger factors influence outcomes. As shown in Chapters 2 and 3 and section 6.3, human factors create barriers for tigers and reduce their ability to exploit human-dominated landscapes to their advantage. However, based on my study, I believe that focussed and small improvements in human use of the landscape, with the intention of sharing space with tigers, will allow the naturally adaptive tiger to use resources to their advantage and survive in human-dominated landscapes.

6.5 Recommendations

Based on the empirical findings of my study I propose a number of recommendations for wildlife managers and conservation organisations. Following these recommendations will allow them to support tiger-human coexistence in human-dominated landscapes.

6.5.1 For Managers

The findings of my study reveal that the successful conservation of large carnivores such as tigers outside protected areas depends on both on people and tigers. Therefore, without understanding these bio-social and interlinked influences the real factors influencing coexistence will not become clear.

Tackling the social complexity

The sheer numbers of people, the diverse ethnic groups, different cultures and people with varying worldviews all these issues will pose challenges to any manager who wishes to address people aspects in India. Therefore I recommend the following:

Take local practices seriously

My study shows that, in rural India, local people developed many local practices. These practices have both positive and negative influences on large carnivore conservation goals. First, an assessment of the impact of the local practices should be conducted. For example, as shown in Chapter 2, the local practice of dumping domestic animals carcases and allowing unwanted cows to roam feral in the Panna landscape have a positive influence on local large carnivore distribution. While at the same time they could increase interactions between large carnivores and people near villages. In this scenario, managers would benefit by innovatively adapting the positive aspects of the practices while trying to carefully avoiding the negative aspects and adapting them into conservation plans. For example, vulture conservation in France and Nepal are proving to be successful for the recovery of endangered vultures when local livestock herders revert back to age-old practices of leaving dead carcasses for the birds. Of course, management must find ways to eliminate dog packs and the spread of diseases into wild populations. I feel strongly that managers should not try and reinvent the wheel in this regard. Locally prevailing practices can be adapted innovatively to solve some of the most common conservation challenges.

Adapting management practices to local contexts

Defining a scale is very important for conservation interventions. Based on the empirical evidence from my study, it is increasingly clear that most situations are contextual and cannot be readily extrapolated to the large landscape in totality. This means that one-size-fits-all approaches will fail. This is because with changes in local social, cultural and political settings, changes in knowledge on carnivores and changes in local economic factors, people's abilities and willingness to live with carnivores changes. For example, in Chapter 3, I described that local people in my study area have a high awareness of tigers, have good local knowledge to avert accidents and injuries and they also take preventive measures to safeguard valuable livestock. This situation is contextual to study

area because of the local people groups. The local gond tribes and yadav pastoralist have unique practices. They have good local knowledge of the forests and on local carnivores and they believe and worship forest spirits. In this described context, managers need not focus on awareness campaigns or start training local people in new husbandry practices. People are already aware of such issues and have good practices in place. Instead, managers should focus on the land-use regulations in territorial forests and buffer zones or deal with local politicians who are politicising cows with religion and creating barriers for livestock owners wanting to remove unwanted and excess cows from the landscape. Managers should hold meetings with local politicians to highlight the interconnected effects of their political strategies and solving local conservation problems. Managers should incentivise residents with special land-use rights which will automatically motivate residents and give them the right to control unchecked grazing by non-resident outsiders.

The need to involve social scientists

The diverse and complex social aspects are not readily visible for the untrained eyes to see. My study shows that the social conflicts surrounding natural resource use are an integral part of human societies and can only be addressed by a deep understanding of local contexts. This line of thinking is supported by many authors (Dickman 2010; Madden and McQuinn 2014; Redpath *et al.* 2017). This means that managers may need the help of social scientists who, in turn, must engage with local people and develop understanding on local cultures and practices and the interlinked nature of influences. When this information is subsequently communicated with the managers, managers will have the information to make decisions. In a populated and culturally diverse country like India, the recommendation is for managers to involve social scientists to guide them to identify and address the complex social factors influencing tiger conservation.

Promoting the umbrella effect of tiger conservation

Human-dominated landscapes outside PA's in India are known sink habitats for tigers. This means that the current biodiversity holding potential of these overexploited lands is low and therefore these lands do not contribute to human wellbeing in any substantial way. By promoting tiger conservation into these lands the government managers are also promoting the conservation of biodiversity in these lands. Since conserving the tiger has an umbrella effect and will improve the biodiversity in the area which will ultimately be useful for local people and their wellbeing, the reserve management should promote sustainable use of natural resources and conservation of biodiversity. These interlinked effects of conserving the tigers are known to the knowledgeable local people living in my study area. However, if managers become aware of these linkages and together with local communities if they can collaborative plan the use of multiple-use government forests with an aim to improving biodiversity in such lands. Such lands would benefit local people and tiger conservation efforts.

6.5.2 Conservation agencies

Conservation needs in human-dominated landscapes are many and infinite. However, the need to focus on achievable and financially feasible targets is highlighted. The nature of

people's issues, which are set in local cultural practise and habits, and the scale of such practices may be overwhelming in the India context. So, conservation organisations may have to engage people with special skills to tackle problems to tackle herder-less grazing practices. As shown in Chapter 3, the factors influencing the use of herders while grazing animals include the economics underlying livestock keeping, perceptions of local people regarding threats from carnivores, cultural practices and practices grounded in habit and ease of doing. Moreover, the land-use regulations and laws governing grazing encourage herder-less grazing in territorial forests. Conservation organisations may not get to the bottom of the problems unless these deep-rooted issues are understood. Organisations may also be overwhelmed by the diverse nature of influences and conflicts between the diverse rights and stakeholder groups. In the end, there is a very high risk of organisations with good intentions making mistakes and actually creating barriers to conservation. Given the complexity of issues and the need to engage with diverse rights and stakeholders, conservation organisations must have trained staff.

Support the development of paraecologists

Local issues cannot be taken up without involving local people. As I explained in a co-authored publication, a paraecologists is "a professional with local knowledge, being largely trained on the job in one or more fields of ecological science. He or she contributes to scientific research and local capacity development as well as enhances communication between local and scientific communities" (Schmiedel *et al.* 2016). Conservation organisations may benefit from involving local people and developing their capacity to contribute to local projects. In addition, involving trained local people to engage with their own communities and promote conservation has several benefits. First, an internalised approach will largely eliminate organisations from directly getting involved with local communities and their innumerable complications. The example of WWF-India and their attempt to bring change to the children of pardhi hunting tribes is a well-known example. Panna Tiger Reserve was experiencing a crisis as a result of local hunting tribes who set up snares and traps to catch wild animals for bush-meat. WWF-India, along with the Panna Reserve management, conceptualised an idea to adopt children of the pardhi tribes and raise them in a boarding school. The well-intended intention was, if children of pardhi tribes were exposed to a different way of upbringing they may abandon their traditional way of life and become part of the new modern India. By adopting this approach WWF aimed to eradicate the practice of trapping and hunting by traditional communities from its roots. With great reluctance, the generally secretive and cautious pardhi parents allowed their children to be raised in a hostel. The initiators were, however, not prepared for the complexities that followed and the responsibility of changing the way of life of an entire group of pardhi children. Furthermore, they experienced a shortfall in the resources that were needed for the project. Failing to generate resources and realising the long-term nature of the engagement, the well-intended program was stopped five years after its initiation to the dissatisfaction of the parents. This brings us to the second recommendation.

The need to involve trained local people in surveys and collecting data

Social factors influencing carnivores cannot be understood without collecting information.

As my study shows, information collected from people on their herding practices or perceptions on livestock kills or knowledge on local wildlife or ethnographic accounts of cultural practices, all explain their relevance for coexistence. Currently, the reserve management and their staff collect census data on tigers and other wildlife from Protected Areas. Information from people is almost never collected. Firstly, such work is very cumbersome and needs trained manpower. Furthermore, there is need for continuous and different types of information from areas outside PA's to aid management. Often, the government reserve staff are not trained in such data collection work and the authority of forest departments may have limitations in collecting data from local people. This complex and the periodic need to collect data from local people could be undertaken by conservation organisations. However, they must innovatively involve local people in such work, as suggested in recommendation 1.

The need to support local innovation

Local people have developed ways to deal with problem animals. This local innovation cannot be overlooked. For example, people have developed vegetative fences with local thorn bushes and shrubs that deter wild herbivores and livestock from entering fields. Sometimes, this approach may not stop pigs or monkeys that can dig the ground or climb over the fences. In these cases, the old methods should not be abandoned as they serve several other purposes, but new innovation that could address monkeys and pigs should be integrated into the existing structures. In 2017, WWF Netherlands launched an interesting programme in line with the Global Tiger Initiative's goal of doubling the global tiger numbers by 2022. They launched an online open challenge focussed on engineers, scientists, conservationists and others to develop implementable prototypes for mitigating human-wildlife conflicts. The winners would get a 30,000 euro grant to develop their prototype into a full-fledged system that could be implemented at a tiger conservation site. Similarly, conservation organisations should encourage such innovation within local communities to find solutions for their wildlife problems and solutions for their daily needs. Promoting such thinking and innovation will help local communities to come up with locally suitable solutions instead of waiting for external agencies to intervene.

6.5.3. Future research needs

Based on my study, I propose future research topics that will shed more understanding on managing coexistence in human-dominated landscapes.

Human dimension research

1. While the social factors that influence people's ability to support wildlife conservation are clear, modelling them into implementable strategies is still uncertain. For example, my study shows that local religious leaders and intermediaries who are part of spirit worshipping are a big influence on the views people construct of nature and wildlife. However, future research (action research) is needed to find ways to successfully involve religious and faith leaders to support conservation.
   Question: Are there simple and effective ways to involve local faith leaders to support large carnivore conservation efforts?

2. Developing locally relevant financial and non-financial motivators to support conservation. Compensations for crop loss and livestock kills, insurance schemes for livestock, rehabilitation of villagers and eco-tourism are some of the different ways in which financial instruments are used to solicit the support of people to live alongside or tolerate dangerous animals and create more space for wildlife. But, as my study shows, there are several non-monetary motivators grounded in faith, cultural, pride, practical and intrinsic dependence, as shown in Chapter 2, that also instil a desire within people to protect nature and tigers. Research is needed to explore more non-financial motivators and also to find ways to implement them as conservation strategies. Questions include, what are the non-monetary motivators that promote tolerant attitudes towards large carnivores in the landscape? What are the practical and intrinsic benefits that people derive from holding such views? How can this understanding be modelled into conservation plans?
3. Research that captures the processes that take place within communities as people try and cope or fail to cope when large carnivores move into their areas. Such research will shed more understanding on how communities organise themselves or fail to do so when carnivores expand into their areas.

Wildlife Research

1. My study describes behavioural plasticity of tigers to some of the common human activities in my study area, like shared water bodies, unchecked livestock grazing and people's movements in the areas during the day. Such plasticity of tigers to various other forms of human activities has to be explored. Since human activities are numerous, first, an assessment must be conducted of the potentially problematic activities, such as night-time lights, noise, extent of wire snares and foot traps by local hunters and loss of vegetative cover due to over grazing and its impact on tigers' use of space.

   As a second step, thresholds of such plasticity, another key insight that was beyond the scope of my study, essential to reducing intensity of human use in the areas, must be under taken. Only when these thresholds become clear, conservationists will be able to address human issues and when human activity becomes an overbearing disturbance to tigers becomes evident. Till such time, all human activities appear to be disturbances, which is not true.
2. My study shows that tigers readily use livestock in an area and such killing many not always lead to conflicts with local communities. This tolerance of tigers killing livestock is based on the fact that, in my study, tigers killed more unwanted and feral animals. But ways to separate unwanted and valuable animals are not yet clear. Future research should focus on wildlife management issues and ways to separate valuable and not-so-valuable animals in order to assess losses to people. For example, using ear tags, or paint markers or tattoos. Without such understanding, all livestock killed will appear to be valuable animals, which is not the case.
3. Wild prey abundance in human-dominated landscapes could not be assessed in this study. Since abundance on its own is not an indicator of availability to the tiger, prey abundance (including conflict-free livestock), prey-anti-predator behaviour, differential vulnerability of prey at different lifecycles and risk of disease from livestock are

all unknown. These factors, which impact tigers in human-dominated landscapes, should be studied. Research into these topics is needed to secure stepping stones and sanctuary areas, which are human-dominated landscapes but could become potential future source habitats for tigers.