Social Factors Drive Sloth Bear Conflict In Gujarat

An Integrated Interdisciplinary Approach To Human-Wildlife Conflict And Coexistence

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Abstract

Human-wildlife conflict (HWC) is a major and increasing problem around the globe, heavily impacting livelihoods and leading to injury and loss of life of both humans and wildlife. Effective measures are urgently needed to facilitate a sustainable state of coexistence, but are hindered by its high complexity and interdisciplinary nature. In the densely populated state of Gujarat, India, this is not different, where interactions between humans and sloth bears (*Melursus ursinus*) are becoming increasingly problematic and knowledge about both the environmental and the anthropogenic sides is largely missing. This study aimed to increase our understanding of human-sloth bear interactions in Gujarat and HWC and coexistence in general, using an integrative interdisciplinary approach that includes both quantitative and qualitative analyses. Specifically, the predicted probability of sloth bear occurrence is modelled, based on sign survey data and a combination of environmental and anthropogenic variables; an assessment is made of social underlying effects, such as perceptions and attitudes, with a questionnaire survey; and the divergence in viewpoints and values among the local population is identified using Q-methodology. Importantly, this study showed sloth bear occurrence to be limited by forest cover and anthropogenic influences, but to not be related to perceptions of conflict and coexistence. Moreover, it showed HWC and coexistence to be mainly driven by underlying social aspects, including the perceptions affecting attitudes, a general underappreciation of relational values and stakeholder diversity. To more effectively address HWC in Gujarat and facilitate human-sloth bear coexistence, more attention and investment should be directed at the anthropogenic side of this story, in order to increase positive attitudes toward sloth bears. Specifically, building a conservation narrative that includes the full spectrum of viewpoints and values prevalent in this region would be a strong step in the right direction.

Keywords: human-wildlife coexistence, wildlife conflicts, social-ecological systems, interdisciplinary research, *Melursus ursinus*, India

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1. Introduction

Since the earliest cradle of civilization competition over common resources and territory has led to conflicts between our species and others (Nyhus, 2016). These human-wildlife conflicts (HWC) are interactions between humankind and wildlife that have a real or perceived negative consequence to either one or both parties (Madden, 2004; Peterson, Birckhead, Leong, Peterson, & Peterson, 2010). These consequences may include loss of human life and injury (Inskip & Zimmermann, 2009; Packer, Ikanda, Kissui, & Kushnir, 2005), crop raiding (Pérez & Pacheco, 2006), livestock depredation (Gusset, Swarner, Mponwane, Keletile, & McNutt, 2009) and disease transmission (Belant & Deese, 2010). Indirectly, it also raises opportunity and transaction cost and diminishes food security and psychosocial wellbeing (Barua, Bhagwat, & Jadhav, 2013; Bond & Mkutu, 2018). In turn, these events negatively affect perception of the wildlife species involved, leading to increased retaliatory killings (Gusset et al., 2009; Inskip & Zimmermann, 2009; Mateo-Tomás, Olea, Sánchez-Barbudo, & Mateo, 2012). Along with other adverse anthropogenic influences, like destruction and fragmentation of habitat (Haddad et al., 2015; Schwitzer, Glatt, Nekaris, & Ganzhorn, 2011) and changes in ecosystem functioning (Estes et al., 2011), this has resulted in the extinction of species, and the threat of extinction for many more (Ripple et al., 2014, 2015).

Concomitant with the continuing increase of the global human population, habitat-loss for many species worldwide, and increasing mega-fauna populations in regions with conservational successes, the frequency of HWC is rising around the world (Anand & Radhakrishna, 2017; Inskip & Zimmermann, 2009; Skogen, Mauz, & Krange, 2008). However, many of the methods used in HWC mitigation often fail to lead to complete long-term conflict resolution (Dickman, 2010). It is thus imperative that we better understand these complex systems that are the stage for these conflicts, to improve upon mitigation methods and find effective ways to coexist with other species.

An important step is the emerging recognition of the importance of an interdisciplinary approach (Lozano et al., 2019; Pooley et al., 2017). Although the field of HWC covers the environmental sciences, the social sciences and the humanities, much of the actual research has been done within each separated and confined field (Pooley et al., 2017). Furthermore, most studies focus on conflict mitigation through tangible costs and benefits addressing the direct symptoms of HWC, be it social or ecological (Dickman, 2010; Kansky & Knight, 2014; Karanth & Kudalkar, 2017; Pandey, Shaner, & Sharma, 2016), or on social equity in the institutionalised response and compensation of damages (Dickman, Macdonald, & Macdonald, 2011; Zafra-Calvo et al., 2017). However, this focus often fails to account for, or identify, the underlying causes of these conflicts, obstructing our overall understanding and leaving the problems ultimately unsolved (Inskip, Fahad, Tully, Roberts, & MacMillan, 2014; Kansky & Knight, 2014; Redpath, Bhatia, & Young, 2015; Rust, Tzanopoulos, Humle, & MacMillan, 2016). It is vital that we fully breach the boundaries of scientific specialization within our studies of HWC, to better understand the underlying ecological and social drivers and effectively apply them to conflict resolution.

Although the call for interdisciplinarity largely translates to the inclusion of social drivers into the search for the root problems and concomitant solutions of HWC, it does not tell us how to do so. In a recent study, Dorresteijn et al. (2014) combined spatial distribution modelling, based on both biophysical and anthropogenic variables, with a survey concerning the social drivers of local HWC conflicts within a human-dominated landscape. Their results testified to the usefulness of this approach, as the inclusion of both environmental and social data reinforced the evidence and drivers for the possibility of human-bear coexistence. Building upon their methodology, this study goes one step further, by diving deep into the underlying drivers of conflict and coexistence. Furthermore, a strong social context is created, by integrating both quantitative and qualitative assessments, using a case-study on human-sloth bear interactions in Gujarat, India.

India harbours 8% of the world's biodiversity and has an extensive network of protected areas and wildlife sanctuaries (Manral, Sengupta, Hussain, Rana, & Badola, 2016). At the same time, it is home to almost 18% of the global human population (United Nations Department of Economic and Social Affairs Population Division, 2017). Consequently, nearly 90% of India is affected by HWC, concerning 88 different species (Anand & Radhakrishna, 2017). Even so, research and mitigation measures are generally focused on a few well known species, such as the Bengal tiger (*Panthera tigris tigris*) and the Asian elephant (*Elephas maximus indicus*) (Anand & Radhakrishna, 2017). The sloth bear (*Melursus ursinus*) is one of these understudied species, despite being highly aggressive and responsible for the loss of many lives and injuries throughout India (Bargali, Akhtar, & Chauhan, 2005; Rajpurohit & Krausman, 2000). Killings in retaliation to sloth bear attacks and major habitat loss and degradation have caused the decline of this species, which is now classified as vulnerable under the IUCN Red List of Threatened Species (Dharaiya, Bargali, & Sharp, 2017).

In Gujarat, incidents of human-sloth bear conflict are prevalent and increasing (Garcia, Joshi, & Dharaiya, 2016). Local sloth bear habitat is increasingly being degraded and fragmented due to land-use change, increasing tourist pressure, and the construction of roads and railways. In addition, bears are threatened by an increase in human-bear interactions due to a growing human population and the increasing use of resources shared by bears and local people (Joshi, Dharaiya, & Singh, 2015), as a consequence of a heavy dependence on forest products for their livelihood (Dharaiya, 2009; Sukhadiya, Joshi, & Dharaiya, 2013). A better understanding of the roles both sloth bears and humans play within this conflicting relationship is urgently needed, in order to design mitigation measures and facilitate human-sloth bear coexistence.

This study aims to increase our social-ecological understanding of human-sloth bear interactions to highlight challenges and opportunities to human-sloth bear coexistence in Gujarat State. Specifically, it aims to (1) address the scientific gap in sloth bear ecology and distribution; (2) assess the underlying drivers of conflict and coexistence with wildlife; and (3) identify different viewpoints within the local population on wildlife and HWC.

In doing so, this study addresses important deficiencies in scientific understanding concerning sloth bears, as well as the interdisciplinary nature of HWC and social-ecological systems. It has direct relevance to the Sustainable Development Goals (SDGs) to end poverty (SDG 1), halt biodiversity loss and protect threatened species (SDG 15.5) and integrate biodiversity and ecosystem values into national and local planning (SDG 15.9), and indirectly to ensure food security (SDG 2).

2. Theory

In this chapter, theory important for understanding the context of this study is expanded upon. Specifically, social-ecological system theory, its link with ecosystem services and values, and the current understanding of sloth bear ecology. Furthermore, important distinctions are made between concepts intrinsically connected to this field of research. Finally, the theoretical framework that guides this research is introduced and motivated.

2.1. Important contextual theory

2.1.1. Social-Ecological Systems

In the human-dominated world of the Anthropocene, purely environmental driven systems have become a rarity (Ellis & Ramankutty, 2008). Instead, human activities have become a major influence in ecological processes (Crutzen, 2006). Concomitantly, the social and environmental sciences have increasingly recognized the arbitrarity of boundaries between their fields, ultimately leading to the theory of social-ecological systems, which is, simply put, any system that links people with nature (Folke, 2007; Redman, Grove, & Kuby, 2004). This contemporary increase in interdisciplinary research (Van Noorden, 2015) has had profound implications for the understanding of our world. Most notable of which is the acknowledgement of much higher complexity in coupled human and natural systems, than originally understood (J. Liu et al., 2007). Understanding these social-ecological systems is vital for our ability to predict the effects of change within a system, but also to ensure that implemented policies and management within these systems are effective and desirable (Levin et al., 2013).

2.1.2. Ecosystem Services and Values

In order to explain and underline the link between the social and the ecological systems, the concept of ecosystem services is often used. Although definitions vary, ecosystem services can be described as the benefits of nature to households, communities and economies (Boyd & Banzhaf, 2007; Daily, 1997). In essence, it is the categorization of all the benefits natural ecosystems may bring our species, both directly and indirectly. Ecosystem services are usually grouped into four distinct types of benefits: regulating (e.g. carbon sequestration), supporting (e.g. nutrient cycling), provisioning (e.g. food and raw materials), and cultural (e.g. recreation) (Millennium Ecosystem Assessment, 2005). This qualification underlines the benefits of healthy and sustainable natural assets and is thus often used to motivate conservation efforts (Naidoo et al., 2008). Unfortunately, ecosystem functions may also have effects that are harmful to humans, called disservices, ranging from pests to natural disasters (Dorresteijn et al., 2017; von Döhren & Haase, 2015). Just as ecosystem services can prove beneficial for conservation efforts, so can ecosystem disservices pose an obstacle. This is also the case with HWC, as the negative impact on financial, health and safety conditions may turn local residents against the idea of preserving the species perceived to be at fault (Dickman, 2010).

Although all of the different types of benefits derived from ecosystems are good incentives for their preservation, not many will view them as equally important, or agree on how they should be part of our lives. To understand the effect a discourse of services and disservices can have on the protection, use and management of our natural systems, it is important to understand the values of the people that live in these systems (Satz et al., 2013). In general, values can be categorized into three distinct groups: instrumental values, in which nature (or any other entity) is viewed as a means to a particular end; intrinsic values, in which life or nature is viewed as an end in itself, irrespective of its use to humans; and relational values, which relates to the meaningfulness of the relations with, and responsibilities to, humans, nature and the environment (Arias-Arévalo, Martín-López, & Gómez-Baggethun, 2017; Klain, Olmsted, Chan, & Satterfield, 2017; Pascual et al., 2017). Understanding how these values affect people's opinions and decision may help in better understanding how social-

ecological systems work and consequently increase managerial effectiveness of environmental policy (Jones, Shaw, Ross, Witt, & Pinner, 2016).

2.1.3. Sloth Bear Ecology

Sloth bears are endemic to the South-Asian subcontinent, specifically to India, Nepal, Bangladesh, Bhutan and Sri Lanka, of which around 90% of its estimated range is found in India (Dharaiya et al., 2017). Unfortunately, current information on sloth bear density and distribution is little and estimates are often unreliable or subjective (Dharaiya et al., 2017; Puri, Srivathsa, Karanth, Kumar, & Karanth, 2015). Their habitat range includes wet and dry tropical forests, savannah, scrubland and grassland and are generally found below 1500 m altitude (Dharaiya et al., 2017). Furthermore, a strong positive connection has been observed between occurrence and forest density, as well as with terrain ruggedness (Puri et al., 2015).

Sloth bear diet consist primarily of termites, ants and fruit, with the insect-fruit ratio differing extensively depending on seasonal and geographic availability (Garshelis, Joshi, Smith, & Rice, 1999). They breed typically from May to July, giving birth to one or two cubs every two or three years (A. R. Joshi, Smith, & Garshelis, 1999).

Global sloth bear populations are currently declining. The main threats involve habitat loss, degradation and fragmentation, retaliation killings and poaching (Dharaiya et al., 2017; Puri et al., 2015).

2.2. Conceptual distinctions

Within HWC literature, there are many ambiguities in the use of language, which may lead to misunderstandings or misinterpretations. For the purpose of this study, some of the relevant concepts will be explicitly defined to prevent confusion.

First of all, the words ‘mitigation’ and ‘resolution’ are often used interchangeably in regard to addressing the issue of HWC. A possible reason for this could be the implausibility of resolving HWC altogether, as conflict may be inevitable while living alongside some species. Conflict mitigation, on the other hand, may facilitate coexistence by increasing local tolerance to a species (Treves, Wallace, & White, 2009), which may realistically be the closest one can get to HWC resolution. Even so, in this study, conflict mitigation will always refer to the alleviation of the negative impacts of HWC, while conflict resolution will refer to diminishing or solving HWC in itself.

Then there are the concepts of ‘attitude’, ‘perception’ and ‘behaviour’, often used when describing the underlying reasons for local reactions to conflict mitigation measures. Although not always used interchangeably, the usage of these words does differ throughout literature. To be thorough, within the context of HWC, these concept will be defined as follows: ‘attitude’ refers to a positive or negative disposition towards HWC or measures related to HWC (Manfredo & Dayer, 2004); ‘perception’ refers to the opinion someone (often a local resident) has towards the underlying reasons or causes of HWC, independent of (scientific) evidence (Kahler & Gore, 2014); ‘behaviour’ refers to changes in lifestyle or actions undertaken in response to HWC (Treves, Wallace, Naughton-Treves, & Morales, 2006).

Finally, the concepts of ‘co-occurrence’, ‘coexistence’ and ‘conflict’ need defining. ‘Co-occurrence’ describes the simultaneous presence of both humans and wildlife in the same spatial area (Carter & Linnell, 2016). ‘Coexistence’ describes a social-ecological system in a state in which humans and wildlife can sustainably co-occur (Carter & Linnell, 2016). Finally, ‘conflict’ refers to only those systems, or interactions within a system, that have a negative real or perceived consequence to human, wildlife

or both (Nyhus, 2016). Note: in these concept definitions, the term 'wildlife' does not necessarily refer to all species within a system, but to the species of interest within a study.

2.3. Theoretical framework

The goal of studying HWC in general is to find ways to resolve or mitigate these conflicts and their impact, to find a point of tolerance between humans and wildlife that can serve as the basis of coexistence. This study investigates how a set of environmental and anthropogenic factors affect the possibilities of achieving coexistence between humans and sloth bears. Based on the available data, contemporary literature, and the scope of this research, the factors presented in Figure 1 were chosen as the factors of interest. This section will serve to motivate and explain each factor, working backwards from the ultimate goal of coexistence. The most direct effects are attitudes towards sloth bears and human-sloth bear coexistence, and the knowledge and perception of conflict avoiding behaviour.

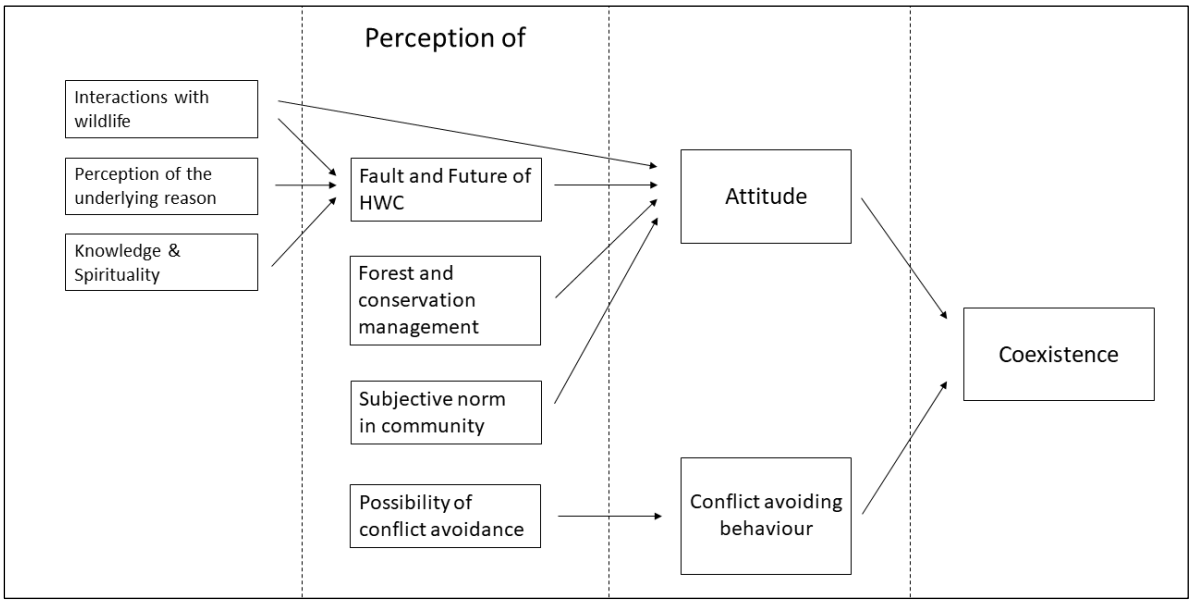

Figure 1. Visual representation of the theoretical framework. These factors define the boundaries and scope of this study. The arrows indicate a proposed effect on the subsequent factor by the former factor.

2.3.1. Attitudes

A person's attitude towards living in a state of sustainable coexistence with local wildlife is a major factor in the potential to realize coexistence (Dickman, 2010; Kansky, Kidd, & Knight, 2014). The affiliation someone has to wildlife, conflicts with wildlife, or conservation, disposes that person either in favour of or in opposition to the prospect of living together indefinitely (Kansky et al., 2014). These attitudes are influenced by a variety of factors. Within the context and scope of this study, the main factors to influence attitudes are direct interactions with wildlife, the perception of fault, as well as of the future, of HWC, the efficacy and perception of forest- and conservation management, and the subjective norm of the community.

<u>Interactions with wildlife</u>

The most obvious factor that could influence an individual's attitude would be through direct experience and interaction with wildlife itself, be it positive or negative (Kansky et al., 2014). This is underlined by a recent study on human-bear coexistence in Romania by Dorresteijn et al. (2016), which found a direct positive relationship between interactions, attitudes and perceptions of coexistence. Managing interactions between humans and wildlife thus seems like an effective conflict

mitigation strategy and indeed is often attempted (Dickman, 2010). However, such mitigation policy is often only based on wildlife density indicators (Morzillo, de Beurs, & Martin-Mikle, 2014), which may be an invalid simplification, as indicated by Dorresteijn et al. (2014), who found no relation in their study between frequency of bear attacks and bear activity. It would thus be valuable to not only understand the relations between attitudes and interactions, but also the interactions themselves, and if they are indeed related to conflict and coexistence, as so often assumed.

Perception of fault and future

A perception of fault relates to which party is seen as the instigator of conflict. Perceptions that conflict is caused exclusively by wildlife may give rise to negative attitudes towards these animals through a discourse of blame, which criminalizes their natural behaviour (Hill, 2015). Such negative emotions, along with a perceived inability to control one's environment, can adversely impact a person's psychological wellbeing, increasing their willingness for extreme measures to alleviate this problem, like killings, further fuelling and perpetuating conflict (Bencin, Kioko, & Kiffner, 2016). Inversely, a perception of a human or shared fault for HWC, could lead to a more constructive attitude, as it inherently acknowledges the fact that this conflict could be solved or lessened by adjustment of one's own behaviour, increasing one's perceived control and through it their tolerance (Bruskotter & Wilson, 2014). Which perception an individual has, may depend on multiple different factors. The most apparent of which, would be through the direct consequences of their experiences with wildlife.

However, Dickman and Hazzah (2016) argue that the level of positivity or negativity from interactions is often disproportional to what would be expected from interactions or damages, advocating for the existence of underlying causes, often social in nature, to explain these anomalies. The perception of the existence of these underlying causes could change the narrative of the debate around local conflict and identify areas that are less about wildlife and more about, for example, management or differences between stakeholder groups, thus nuancing the perception of fault (Marshall, White, & Fischer, 2007).

Furthermore, if there is no outlook of improvement (e.g. a continuous increase in human and wildlife populations, concomitantly increasing the number of human-wildlife interactions; Bencin, Kioko, & Kiffner, 2016), than attitudes could be negatively affected through a worsening of the perception of the future, which, in the form of social imaginaries, are determinants of the actual directions the future can take (Behrends, 2019). In other words, the perception individuals have of the future, in this case of HWC, directly influence what the future may look like. These perceptions too, are affected by interactions with wildlife, as lasting negative experiences, such as attacks that lead to deaths, disability or a large loss of livestock, can severely diminish financial stability and future prospects of a household, often not included in compensation schemes (Barua et al., 2013).

Additionally, knowledge and spirituality are two factors that could influence the perceptions of fault and future of, and thereby attitude towards, HWC (Dickman & Hazzah, 2016; Espinosa & Jacobson, 2012). However, whether this has a positive or a negative influence largely depends on the specifics. For example, a study assessing students' attitudes towards bats, showed a direct relation between biological knowledge and a positive attitude (Prokop, Fančovičová, & Kubiatko, 2009). On the other hand, the evaluation of an environmental educational program in Ecuador, revealed a mixed response, with increased positive attitudes towards bears, but more negative attitudes towards bear conservation (Espinosa & Jacobson, 2012). Similarly, spirituality, in the form of religious and cultural beliefs, may explain a large deviation of expected behaviour, either facilitating coexistence, e.g. a taboo on killing snow leopards in rural Nepal, where their attacks are interpreted as divine retribution (Dickman & Hazzah, 2016), or obstructing it, e.g. killings of aye-ayes (a species of lemur) as they are believed to be harbingers of dead in Madagascar (Simons & Meyers, 2001).

Forest and conservation management

The manner in which a governing body manages forests and conservation in an area, can be of major influence to the overall attitude a person has towards conservation and coexistence (Vodouhê, Coulibaly, Adégbidi, & Sinsin, 2010). Both the perception of the efficacy of implemented policies and the equity of the policies themselves are important to consider. As coexistence is inherently a compromise between the needs and wants of local residents and local wildlife, any policy to the purpose of achieving coexistence will be less than ideal from the perspective of either party. Thus, the perception whether the benefits of coexistence outweigh the downsides of the implemented policy will affect someone's attitude towards the governing body, and by extension their attitude towards wildlife and conservation (Rust & Marker, 2013; Wani & Kothari, 2007). Moreover, a feeling of marginalization through negatively perceived policies forced upon a community can be majorly detrimental to the attitude towards targeted wildlife, even if wildlife itself is not the problem, as it creates a perception that wildlife is valued more by the governing body, than the residents or the communities (Bond & Mkutu, 2018; Wani & Kothari, 2007). On the other hand, institutionalised incentives, such as compensation for damages, or punishments, such as fines or even incarceration can improve attitudes towards governing bodies, if perceived as fair and adequate (Dickman & Hazzah, 2016). Overall, proper management of conservation areas plays an important part in the facilitation of positive attitudes towards wildlife conservation and coexistence.

Subjective norm in the community

A different kind of influence is through the subjective norm of an individual's peers. According to the Theory of Planned Behaviour an individual may perform a behaviour, based not only on its own attitude towards it, but also based on its perception of the opinion of others, called the subjective norm, as well as of the existence of behavioural controls, which would limit their perceived ability to successfully perform that behaviour (Ajzen, 1985). In other words, the potential incremental change any deviation from the status quo may have, is limited by the perceived attitudes of others. It is thus valuable to determine how values and opinions are shared by the majority of people, to better understand the effect it will have on new policy and on other proposed changes to the status quo.

2.3.2. Conflict avoiding behaviour

Conflict avoiding behaviour is any behavioural change a person may make to minimize interactions with wildlife, thus also decreasing negative interactions, such as fencing or guarding of farms, avoiding the forest at night, or the use of buffer crops (Carter & Linnell, 2016; Dickman, 2010). However, apart from the behaviour itself, the perception of the possibility of avoiding conflict through changes in behaviour may be just as important (similar to the behavioural controls mentioned in the previous section). If someone would perceive it impossible to avoid conflict, or perceives known methods as ineffective or unaffordable, it is unlikely that they would adopt such behaviour, especially if this behavioural change comes with a cost in resources or energy, consequently decreasing the likelihood of realised coexistence (Carter & Linnell, 2016).

3. Methodology

The diversity of the factors in the theoretical framework make it difficult to assess them all using a single holistic analysis. Instead three distinct types of analyses, using three different types of data, were used to complement one another and provide different scientific viewpoints. First, the factor 'Interactions with wildlife' was assessed using social-ecological modelling, based on sign survey data. Second, the factors 'Attitude', 'Perception of Fault and Future of HWC', 'Perception of forest- and conservation management', 'Conflict avoiding behaviour' and 'Perception of the possibility of conflict avoidance', were studied through a questionnaire survey. Finally, the factors 'Perception of the underlying reason', 'Knowledge & Spirituality' and 'Subjective norm of the community' were approached using Q-methodology. All data was provided by Hemchandracharya North Gujarat University in India and collected independent of this thesis project.

3.1. Study area

This research was conducted in three wildlife sanctuaries and one protected area (henceforth referred to as 'the sanctuaries') in the state of Gujarat in India (Figure 2). It concerns Jessore Sloth Bear Sanctuary (181 km^2), Balaram-Ambaji Wildlife Sanctuary (542 km^2), Ratanmahal Sloth Bear Sanctuary (56 km^2) and Polo Forest (400 km^2). All sanctuaries mainly consist of dry mixed deciduous forest, along with areas of thorn- or shrub forest and interspersed with, or adjacent to one or more rivers (Arya, Albert, & Nagadesi, 2008; Jangid, Prajapati, & Dharaiya, 2017; Mewada, Tiwari, & Kotia, 2019; Trivedi, 2009). Temperatures and rainfall display great seasonal variation, causing the rivers to almost dry up during the summer (Sukhadiya et al., 2013). All sanctuaries contain villages, of which the people use

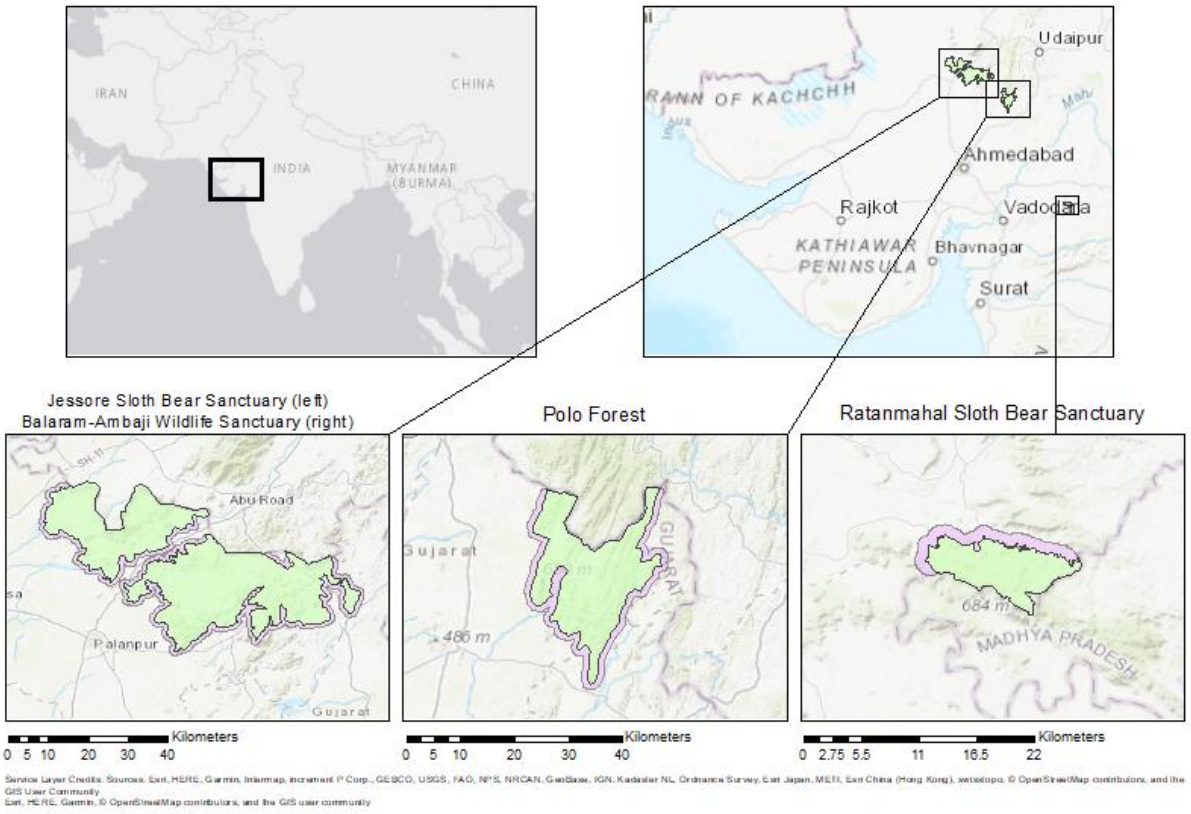

Figure 2. The protected areas that make up the study area, located in the state of Gujarat in India. The green area indicates the actual sanctuaries, while the purple area indicates an additional 1000m-wide land area around the sanctuaries, relevant to the study design. Note that the state line limits the size of both the sanctuaries and the additional land stretch.

these forests for resource extraction and employment as critical parts of their livelihoods (Bahuguna, 2000).

3.2. Social-Ecological modelling

3.2.1. Study design

To gain insight into sloth bear distribution in Gujarat, and subsequently to determine if there is a relation between sloth bear interaction and local conflict, the probability of sloth bear occurrence was modelled. Occurrence was estimated using presence-only data, as absence points were not recorded, and were collected through sign surveys. 514 transects were conducted during the months of May and June of 2016, based on a 5 x 5 km grid system (Jessore Sloth Bear Sanctuary: 95 transects; Balaram-Ambaji Wildlife Sanctuary: 114 transects; Polo Forest: 192 transects; Ratanmahal Sloth Bear Sanctuary: 113 transects). Signs that were surveyed included opened termite mounds, scats, pug marks, claw marks and live sightings, all commonly used to indicate bear activity (Clevenger & Purroy, 1996; Dorresteijn et al., 2014; F. Liu et al., 2009; Mewada et al., 2019). As official records of conflict were unavailable, the local perceptions of both conflict and coexistence were used instead, to investigate their relation to sloth bear interactions.

3.2.2. Environmental and anthropogenic variables

The environmental and anthropogenic variables chosen for modelling were selected based on sloth bear ecology. Five variables (resolution $7.521 \cdot 10^{-4}$ dd x $7.521 \cdot 10^{-4}$ dd; or ~83 m x ~25 m) were used, namely: (1) Forest density, based on forest cover, using a weighted kernel density estimation with an approximately 1000 m search radius (Puri et al., 2015); (2) Terrain Ruggedness Index (TRI), based on the definition by Riley, DeGloria and Elliot (1999) and calculated using a digital elevation map (DEM) of Gujarat (Dorresteijn et al., 2014; Puri et al., 2015); (3) Distance to settlements, as a measure of human pressure (Dorresteijn et al., 2014); (4) Distance to roads, as a measure of forest fragmentation, including local, district and national roads, including highways (Ansari & Ghoddousi, 2018); (5) Distance to surface water, observed as the most predictive resource for other species of bears in South-East Asia (Ansari & Ghoddousi, 2018). The variables used for distance were sourced from the Space Applications Centre (2004). All sanctuaries were analysed with an additional 1000m wide stretch of land around the sanctuary borders (Figure 2, purple zone), with exclusion of the sanctuary boundaries along the state lines, as all data was limited to within state boundaries. The variables were checked for co-linearity before modelling. A sixth variable, agricultural density, was omitted due to high correlation with Forest density (Pearson's $r = -0.616$, $p < 0.0005$). All other variables were not correlated (Pearson's $r < 0.5$). Both the presence-only data and the variables were processed using Esri's ArcMap with spatial analyst extension (ESRI, 2018).

3.2.3. Analysis

A map of the special distribution of the predicted probability of sloth bear occurrence was made using Maxent software (Phillips, Dudík, & Schapire, 2017) and analysed using Esri's ArcMap. Maxent uses maximum entropy modelling to predict spatial suitability for one or more species, based on georeferenced presence data and chosen environmental grids. Although the use of Maxent is steadily gaining popularity, some authors have highlighted an apparent lack of justification for the underlying assumption this software uses, undermining the applicability of the results (Elith et al., 2011; Merow, Smith, & Silander, 2013). For this reason, a number of assumptions and related settings considered as critical by the aforementioned authors are explicitly motivated in Annex A. Apart from the spatial predicted probability of presence, the model also calculates the relative importance of the five variables in their contribution to the model's predictive power, using plotted response curves of each variable and a jackknife test of variable importance, suggesting concomitant importance of these variables in sloth bear distribution.

To analyse the relationship between human-sloth bear interactions and local conflict, an estimation of the local chance of occurrence was compared with the perceptions of conflict and coexistence for each village. The local chance of occurrence was estimated by calculating the distance from a village to the nearest grid cell with a high probability of occurrence, which is here defined as a probability of 0.5 or higher. Distance was chosen, as the probability of occurrence in the same location as the village (i.e. the same grid cell) was deemed insufficient to portray a realistic chance of actual human-sloth bear encounters, as villagers live and work, not only in the village itself, but also in the surrounding area.

Next, a Pearson's correlation analysis was applied to analyse the relationship between the distance to a high probability of sloth bear occurrence and the perceptions of conflict and coexistence. These perceptions follow from a subset of the questions from the questionnaires (see section 3.3.1. and Annex C, bottom rows). The questions leading to the perception of conflict were framed around experience with negative interactions with sloth bears, either by the participant, or by family or friends, as well as their view on resource competition as a cause for conflict. The perception of coexistence was based on a single question that directly asked about the current relation between humans and sloth bears (i.e. peaceful or unpeaceful). Fifty-eight villages were included in the questionnaire, however six villages were excluded from this analysis, because they could not be georeferenced or were only sampled once, leaving 52 locations.

3.3. Questionnaire survey

3.3.1. Study design

A total of 184 semi-structured questionnaires were completed in 58 villages (Jessore Sloth Bear Sanctuary: n = 41 in 12 villages; Balaram-Ambaji Wildlife Sanctuary: n = 63 in 23 villages; Polo Forest: n = 26 in 7 villages; Ratanmahal Sloth Bear Sanctuary: n = 54 in 16 villages). The participants were selected randomly by walking through the village, with the exception of victims of sloth bear attacks, who were selected purposefully by asking around in each village. The surveys were conducted in the form of face-to-face interviews. The questionnaires included both open-ended and closed-ended questions, and were categorized based on pre-provided answers in the case of close-ended questions, or on the spectrum of all given answers on the open-ended questions. The questionnaires consisted of five distinct sections aiming to (1) assess respondent's experiences with sloth bear interactions and conflicts; (2) to assess the extent and perception of resource sharing within the protected area and sanctuaries; (3) to assess lifestyle changes to facilitate human-sloth bear coexistence; (4) to assess general attitudes towards sloth bears and sloth bear conservation; and (5) to assess the role of the local government in sloth bear conservation and their response to sloth bear conflict. The complete questionnaire is provided in Annex B.

3.3.2. Variables

The questions were divided over the factors from the theoretical framework relevant to this analysis. These were: 'Attitude', 'Perception of Fault and Future of HWC', 'Perception of forest- and conservation management', 'Conflict avoiding behaviour' and 'Perception of the possibility of conflict avoidance'. The answers to the selected questions were then standardized by placement on a scale from 0 (negative association) to 1 (positive association). Whether an answer was considered as positive, negative or neutral was dependent on the context of the factor it was associated with. Not all questions were deemed relevant. The exact questions for each factor, along with the association of their standardized answers, are listed in Annex C. Finally, to determine the association per factor per respondent, the average was taken of the questions associated with each factor.

3.3.3. Analysis

The connections between the factors were statistically analysed using three linear mixed regression models with a normal distribution, using IBM SPSS Statistics version 26.0. A mixed model was used to compensate for spatial autocorrelation as multiple surveys were conducted in each settlement. The three models had (1) 'Attitude' as dependent variable and 'Interaction with wildlife' (based on distance to high probability of occurrence), 'Perception of fault and Future' and 'Perception of Forest- and Conservation management' as fixed effects; (2) 'Conflict avoiding behaviour' as dependent variable and 'Perception of the possibility of conflict avoidance' as fixed effect; (3) 'Coexistence' as dependent variable and 'Attitude' and 'Conflict avoiding behaviour' as fixed effect, independent of the connections to the preceding factors. Village location was uniformly used as random effect. None of the fixed effects were correlated with each other for each model (Pearson's $r < 0.5$). Normality was checked statistically using the Kolmogorov-Smirnov Normal Test and visually with Q-Q plots. Significance in the connections between factors would suggest the following factor to be influenced by the former factor.

3.4. Q-methodology

3.4.1. Study design

A photo-based Q-methodology approach was used to gain insight into the opinions and values local people assign to wildlife, both to understand thematic diversity and approximate the subjective norm of the community. Q-methodology is a method that allows to quantitatively interpret qualitative statements while preserving the diversity of perspectives given by the participants (Zabala, Sandbrook, & Mukherjee, 2018). It is ideally suited to identify relevant local viewpoints on a specific topic and has been used in a variety of different fields, including that of nature conservation (Zabala et al., 2018). Data collection comprises of ranking a set of statements or photographs, called a Q-set, accompanied by justifications for any particular order (Jiren et al., 2018; Milcu, Sherren, Hanspach, Abson, & Fischer, 2014). These sets are then statistically analysed for patterns and grouped in a way that explains the highest possible variance.

The Q-set in this study consisted of 30 photos of different wildlife species found in the forests inside and surrounding the sanctuaries. Although this study is mainly concerned with sloth bears, a more holistic approach to local wildlife was taken to avoid predisposing participant to a potential prevalent norm about sloth bears, and to assess the attitudes and opinions towards sloth bears relative to other wildlife. Photographs were chosen, as scientific names or translations of common names may be unknown to participants. The chosen species include mammals, birds and reptiles, ranging from the common house sparrow to the rare leopard, and from least concern to vulnerable in the IUCN Red List of Threatened species. A full list of all species is included with the results in Table 4 in the next chapter.

Twenty people were interviewed in each sanctuary, totalling 80 participants. With the aim to maximize participant diversity, the following actors were included in the survey: farmers, herders, tour guides, those employed in forest management, and victims of sloth bear attacks and their relatives. Participants were asked to sort the 30 photographs into three stacks of wildlife species they liked, did not like, or were neutral to. They were then asked to place them into a forced normal distribution, ranging from the most positive association at the top, to the most negative association at the bottom (Figure 3). As shown in the figure, the distribution was divided into multiple layers, representing increasing levels of positive or negative associations, with a pre-fixed number of spots in each layer, forcing the participants to differentiate beyond a simple positive-or-negative association. After both rounds of sorting they were asked if they wanted to make any changes. When the final sorting was

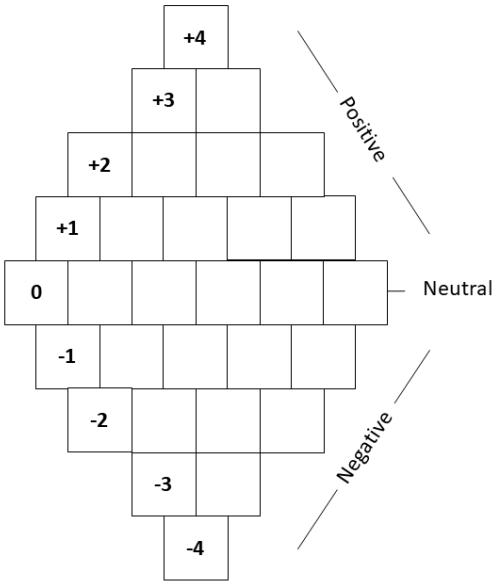

Figure 3. A representation of the forced normal distribution given to participants of the Q-method analysis.

done, the participants were asked to provide a statement for their placement of each of the top seven photographs (layers +2, +3, +4) and of each of the bottom seven photographs (layers -2, -3, -4). These statements were recorded and subsequently transcribed into English.

3.4.2. Analysis

To find patterns among the 80 sets of photographs, a factor analysis was applied, using the 'qmethod' package in R software (R Core Team, 2019; Zabala, 2014). Three factors were extracted using Principal Component Analysis with Varimax rotation (Milcu et al., 2014). The number of factors to be extracted was based on eigenvalues, a Scree test plot and interpretability, before rotation. The association of the individual participants with each of the three factors was assessed by calculating factor loadings. 70 of the 80 participants (88%) could be considered factor defining for at least one of the three factors, based on statistical significance. Using the weighted average of the sets of these 70 participants, a factor array was then created, displaying the overarching ranking of the photographs in each factor.

Following the statistical analysis, a quantitative assessment of the statements accompanying the individual sets of photographs was made for each of the three factors. This assessment was based on qualitative content analysis to categorize the statements into common themes, differentiating between positive and negative associations with individual species (photographs). Categorization was based on the full spectrum of given statements by the 70 factor-defining participants.

Factor interpretation was based on significant differences, as well as consensus, of both the ranking of the species in the factor array, and the number of participants that mentioned each theme in each factor, enriched by the qualitative content of the categorization. To define significance between species rankings, a categorization was made between the top 10, median 10 and bottom 10 ranks. A difference was considered significant when a species was ranked both in the top 10 ranks and bottom 10 ranks between factors. Consensus was considered significant when a species was ranked similarly in all three factors. Significance between the amount a theme was mentioned between factors was defined as a difference of at least 15 percentage points.

4. Results

4.1. Social-Ecological modelling

Out of the 514 transects, 78 contained presence signs (n = 449; opened termite mounds n = 36, scats n = 344, pug marks n = 46, claw marks n = 21 and live sightings n = 2). Transects and sightings were heterogeneously distributed among the sanctuaries (Jessore Sloth Bear Sanctuary: 18 transects, 90 sightings; Balaram-Ambaji Wildlife Sanctuary: 28 transects, 78 sightings; Polo Forest: 29 transects, 191 sightings; Ratanmahal Sloth Bear Sanctuary: 3 transects, 90 sightings). Model output (Figure 4) shows all sanctuaries to have areas of very high and of very low suitability for sloth bears. The Area Under the Curve (AUC; 0.904 ± 0.007) was used as a measure of predicted accuracy for this model and can be interpreted as an excellent prediction (AUC > 0.9) according to Araujo, Pearson, Thuiller and Erhard (2005).

Moreover, all sanctuaries have villages located in the areas of highest and of lowest probability of occurrence, except for Ratanmahal Sloth Bear Sanctuary, of which most of the relatively low number of villages are located in areas of high probability of occurrence. There was no correlation found between either the chance of occurrence and perceived conflict (Pearson's r = 0.104, p = 0.533), or between the chance of occurrence and perceived coexistence (Pearson's r = -0.006, p = 0.972).

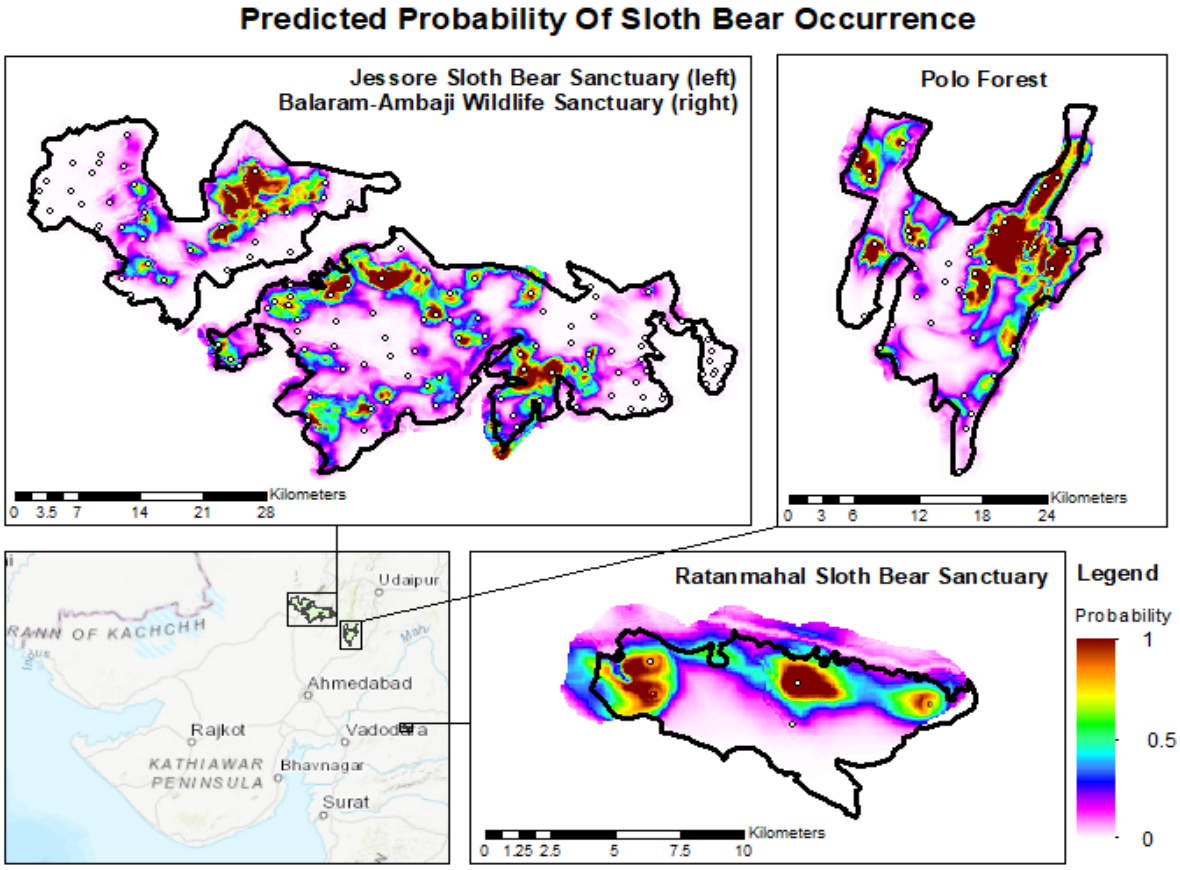

Figure 4. The predicted probability of sloth bear occurrence in the sanctuaries, based on the presence-only data, forest density, TRI, distance to settlements, distance to roads and distance to surface water. The black lines indicate the actual borders of the sanctuaries, the area drawn outside the lines is the additional stretch of land that is used as a buffer zone in the model. The white circles indicate the settlements found within the sanctuaries.

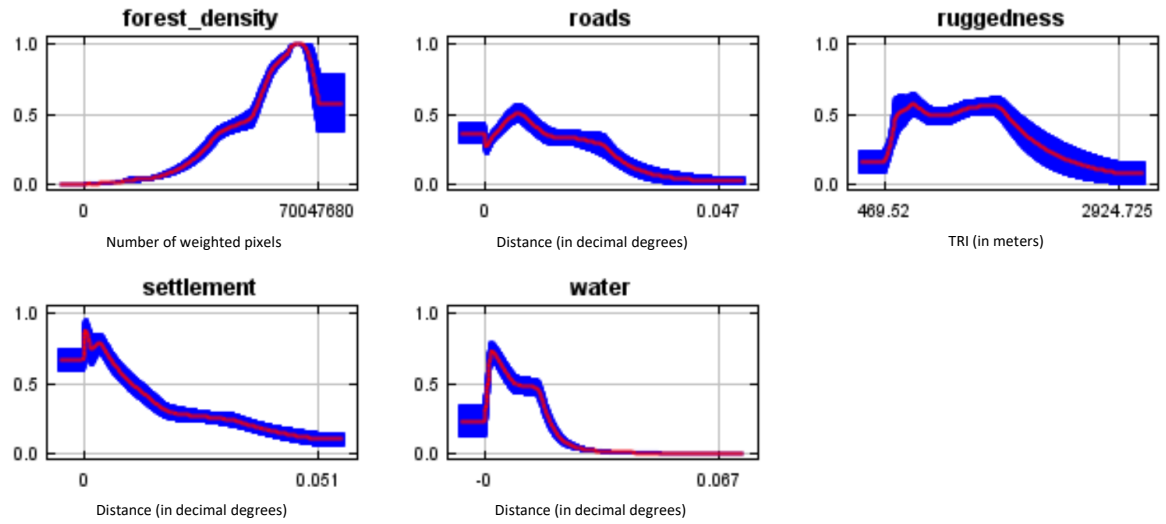

Figure 5. Plots of the relative importance of each variable in modelling the predicted probability of occurrence. The red line represents the average over 20 replicated runs. The blue area represents one standard deviation. The effect of each variable was measured by varying it over the entire spectrum of values it has within the study area, while keeping all other variables constant at their average. A value of 1 of the y-axis would indicate that occurrence could be completely predicted based on this variable alone. As forest density was calculated using kernel density, the x-axis represents the weighted amount of pixels, instead of an amount of forest per area. As these numbers are not very intuitive to interpret, it should be read as a scale from least dense (no- or open forest) to most dense (very dense forest).

Forest density was the most important variable for predicting sloth bear occurrence, containing the most useful and the most unique information (Figure 5 and 6). For areas of very high forest density, this variable alone was enough to predict occurrence, in contrast to a very small effect with low density. Distance to roads, settlements and surface water, were only important for short distances (Figure 5). TRI maintained a moderate influence on model predictions throughout its range, within the bounds of the study area, and held the second most information when modelled in isolation (Figure 5 and 6). Presence records were spread throughout the range of all variables, with the exception of the lower limit of forest density and the upper limit of distance to surface water (Figure 7). Note that in figure 5, values at zero for the three distance variables, and values below 608 m and above 1650 m of vertical change for TRI should be ignored, as the model here predicts beyond the values of the study area.

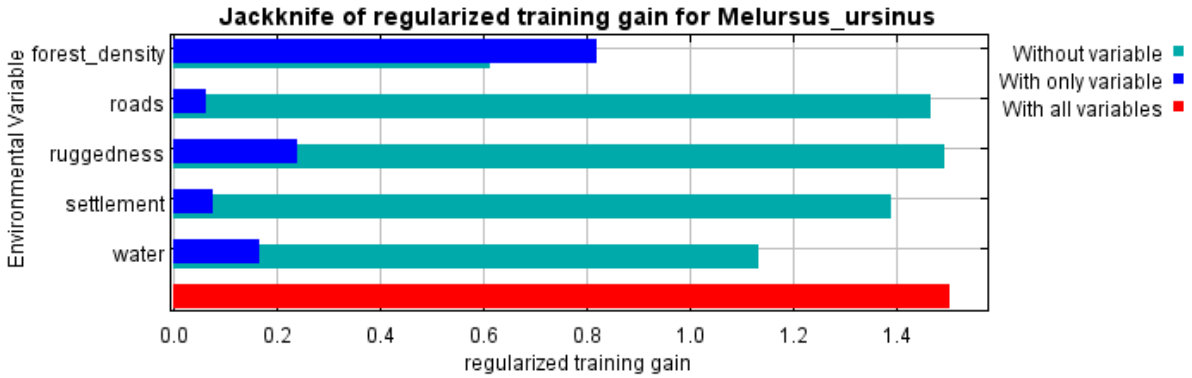

Figure 6. A jackknife test of variable importance measured in regularized training gain. A higher gain corresponds with a more accurate predictive model. The level of gain for variables used in isolation (blue) suggest the amount of useful information each variable has. The drop of gain when omitting a variable (the green-blue bars compared with the red bar) suggest the amount of information that isn't present in the other variables. Values shown are averages over 20 replicated runs.

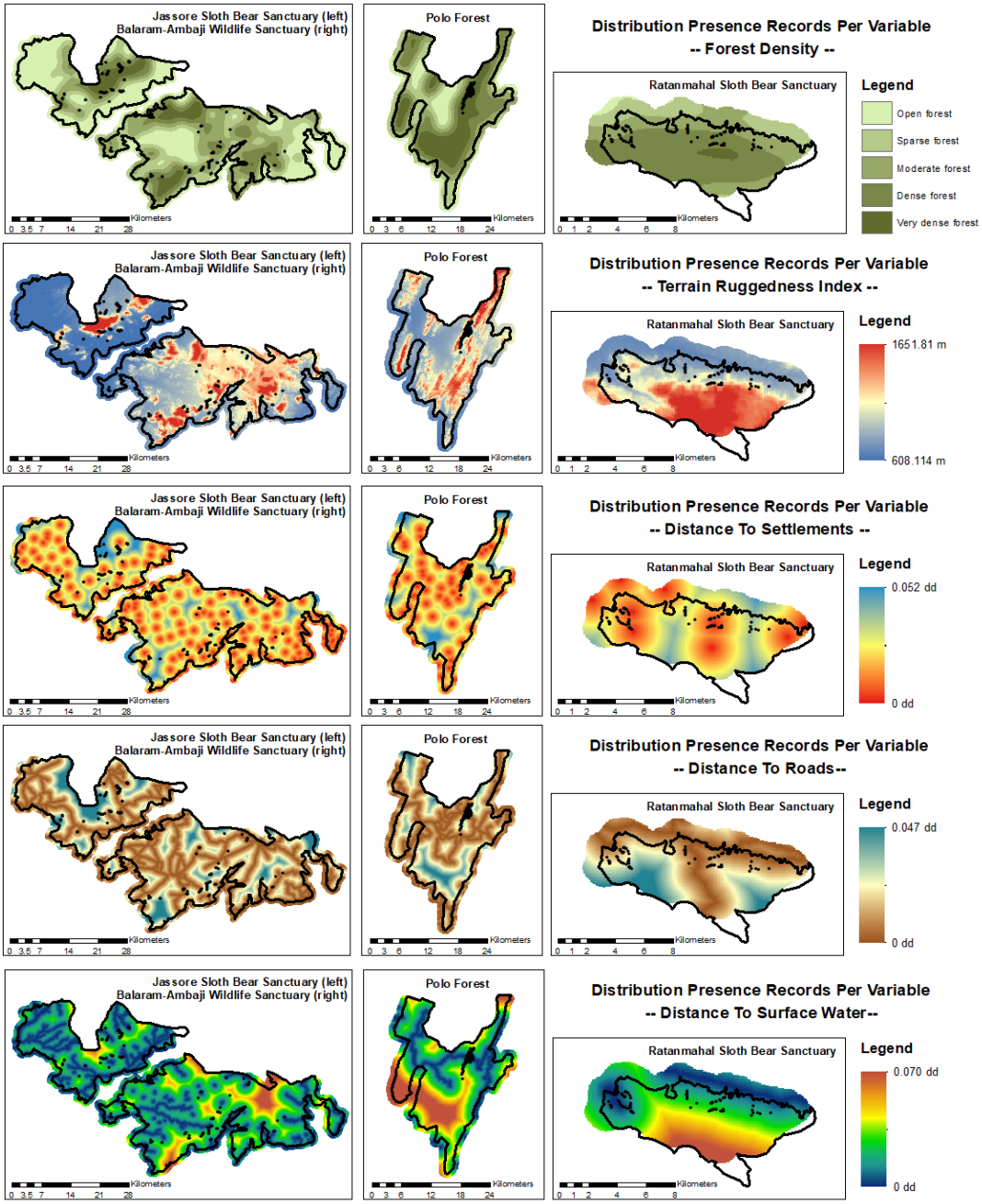

Figure 7.The distribution of presence records used in this study per variable used to model predicted probability of occurrence. From top to bottom: Forest density, displayed as categories of equal size (opposed to the continuous kernel density raster used in the model) for improved visualization; Terrain Ruggedness Index in meters of total vertical change around each raster cell; Distance to settlements in decimal degrees; Distance to roads in decimal degrees; and distance to surface water in decimal degrees. The black dots represent the presence data records.

4.2. Questionnaire survey

184 people agreed to participate in the survey. 157 were male and 27 were female. Most participants were aged between 26 and 50 years old, along with 2 participants aged 25 or younger, and 49 older than 50. Furthermore, of the 184 participants, 15 had enjoyed prior education, of which two held an university degree. This distribution of population characteristics among the participants is to be expected from the demographic structure and social context of rural India (Andrist, 2008; Office of the Registrar General & Census Commissioner, India. Ministry of Home Affairs, 2017). Finally,

stakeholders can be divided into three general categories: those that live in the forest (n = 70), those that visit the forest regularly (n = 86), and those affiliated with managing or protecting the forest (n = 28).

Both 'Attitude' and the factor 'Conflict avoiding behaviour' had a significant effect on 'Coexistence' ($p < 0.0005$). 'Attitude' seems to have the most influence, although the 95% confidence intervals do overlap slightly (Table 1). Furthermore, 'Attitude' itself was significantly ($p < 0.0005$) influenced by 'Interactions with wildlife', Perception of fault and future' and 'Perception of forest- and conservation management', of which 'Perception of fault and future' had the largest effect (Table 1). Finally, the factor 'Conflict avoiding behaviour' was significantly affected by 'Perception of the possibility of conflict avoidance ($P < 0.005$).

Table 1. The results of the linear mixed regression model. A total of three regression analyses were performed, for each of the overarching factors ('Attitude', 'Conflict avoiding behaviour' and 'Coexistence'). 'Random effect' represent the effect the correction for spatial autocorrelation in the data has on the estimation of the slope.

Factor	Estimation of slope	SE	p-value	95% Confidence interval		Random effect (SE)
				Lower	Upper	
Analysis: Attitude						5.845e-5 (2.92e-4)
Interactions with wildlife	0.237	0.012	<0.0005	0.212	0.261	
Perception of fault and future	0.282	0.010	<0.0005	0.263	0.302	
Perception of forest- and conservation management	0.214	0.010	<0.0005	0.194	0.233	
Analysis: Conflict avoiding behaviour						0.010 (0.005)
Perception of the possibility of conflict avoidance	0.322	0.025	<0.0005	0.273	0.370	
Analysis: Coexistence						0.003 (0.002)
Attitude	0.326	0.040	<0.0005	0.246	0.406	
Conflict avoiding behaviour	0.214	0.021	<0.0005	0.172	0.256	

4.3. Q-methodology

Of the participants, 57 were male and 13 female. The stakeholders were grouped according to similarities for convenience: farmers and cattle herders (n = 48; 60%), victims and victim relatives (n = 14; 18%) and jobs directly related to the forests (n = 18; 23%). Three factors were extracted, which explained 53% of variance after Varimax rotation (F1: 30%; F2: 13%; F3: 10%). The sanctuaries were all similarly represented in the factors (20-30% of participants per factor residing in each sanctuary), except for factor 2, from which 43% of participants resided in Jessore Sloth Bear Sanctuary and only 14% in Ratanmahal Wildlife Sanctuary.

4.3.1. Qualitative content analysis

A total of 13 common themes were identified that categorized 97.5% of all statements offered by factor-defining participants. A description of each theme can be found in Table 2, as well as whether it was used as a statement for a positive or a negative association with a wildlife species.

Table 2. The description of each theme as categorization for the qualitative statements given during the q-methodology data collection, along with its use as either a positive or a negative association. Descriptive quotes are added for each theme as illustrative examples. P# refers to the participant the quote is taken from.

Theme	Association	Description
Harmful to humans	Negative	wildlife that is potentially or historically able to physically harm humans, or is perceived or feared to be able to physically harm. "*It is scary and its saliva can kill us."* (P6)
Harmless	Positive	A specific experienced or perceived lack of a harmful ability in wildlife, or due to a specific mention of a lack of property- or crop damage. "*It is very harmless and causes no economic loss."* (P44)
Direct benefits to human life	Positive	Wildlife that has a direct benefit to peoples everyday life. This includes mainly: pest control of species harmful to crops or humans, alerting farmers to the vicinity of intruders through sound, and the use of (parts of) these animals in medicine. "*It is our friend as it eats small insects from our farm."* (P28)
Economic loss	Negative	Wildlife related to economic losses, or opportunity losses, suffered through crop raiding, livestock killings, or property damage. *"They destroy our farm and we have to guard our field the whole night."* (P59)
Bush meat	Positive	Wildlife that is regarded as a noteworthy source of food. *"I like to eat this."* (P27)
Aesthetic value	Both	Specifically related to sightings of a wildlife species and the sounds it makes (positive or negative), or a wish to see this species (positive). *"I like the way it changes colour."* (P21)
Value as pet	Positive	Wildlife that is easy or pleasant to keep as pet. *"I have one as pet and like to play with it."* (P70)
Agreeable nature	Positive	Attributed to wildlife that is well adjusted to humans, or has otherwise pleasant behaviours. *"I like them the most as they are very friendly."* (P53)
Symbolic value	Positive	Attributed to wildlife that symbolize a god, ancestors or the nation. *"We worship it. It is our god."* (P3)
Omens and predictions	Both	Wildlife that is perceptually related to good or bad events, or that is used in (mostly weather-related) predictions. *"It's call is considered a symbol of dead."* (P24)
Forest services	Positive	Wildlife that contributes to the health of the forest, either by clearing away dead matter, or by protecting it from harmful anthropogenic influences. *"They protect the forest from cutting, so I like them."* (P38)

Forest threats	Negative	Attributed to wildlife that is perceived to harm the forest, by uprooting trees, or clearing all fruit and foliage of trees. *"They destroy the tree on which they live."* (P65)
Not in this area	Negative	Wildlife species that the participant either does not know about, or has never seen in the area, yet still has negative associations with. *"It is not found here. I don't know this animal."* (P63)

4.3.2. Factor interpretation

Although the three factors contain clear distinctions in their perceptions of wildlife, they also share a number of priorities among them. The two most obvious of these, as Table 3 shows, is a general concern for safety and economic security, both with a special focus on species that negatively impact these elements. For example, the common krait and the Indian chameleon are ranked at the bottom of the spectrum (Table 4), due to their perceived threat to human health. Moreover, wildlife that regularly attacks livestock, such as the Indian civet, or destroys crops, like the wild boar, received very low ranks. On the other hand, a large portion of the participants in each factor valued a species positively, due to a perceived lack of harmful qualities. An example of this is the house sparrow, which ranked within the top-10 of all three factors. Even so, the most frequently given reason for a positive ranking of wildlife is aesthetic value, be it the way they look, or the sounds they make, often stated as one of the reasons for the high ranks given to Alexandrine parakeets and Indian peafowl. Another reason similar between factors, is the ability to keep a species as pet, especially so with the Alexandrine parakeet. Finally, participants in each category, gave negative ratings to wildlife they did not know, or believed to not be present in their area.

Table 3. The relative number of times each theme is mentioned by a participant as justifications for positive or negative associations with wildlife. The themes have been further categorized in overarching themes, for easier interpretation. The displayed numbers are normalized to percentages based on the total number of factor-defining participants in each factor. Numbers in bold represent significant differences between factors, defined here as a difference of at least 15 percentage points.

Theme	**Factor 1 (n = 45) in %**	**Factor 2 (n = 14) in %**	**Factor 3 (n = 11) in %**
Safety			
Harmful to humans	100	93	100
Harmless	76	71	**91**
Life and economy			
Direct benefit to human life	64	57	64
Economic loss	100	100	100
Bush meat	**53**	**21**	36
Intrinsic animal			
Aesthetic value	91	100	100
Value as pet	49	36	36
Agreeable nature	33	43	**18**
Spirituality			
Symbolic value	47	**79**	**18**
Omens and predictions	36	43	**18**
Forest preservation			
Forest services	7	21	**73**
Forest threats	24	21	**0**
Miscellaneous			
Not in this area	33	**64**	45

Table 4. List of species used in the Q-methodology and their overall ranking per factor. Top ranks (1-10) are highlighted in light green, median ranks (11-20) in grey and bottom ranks (21-30) in dark red.

Common name	Scientific name	Overall ranking		
		Factor 1	Factor 2	Factor 3
Alexandrine Parakeet	*Psittacula eupatria*	2	3	6
Barn owl	Tyto alba	11	20	14
Bengal fox	Vulpus bengalensis	21	16	18
Bengal monitor	*Varanus bengalensis*	20	29	25
Black kite	*Milvus migrans*	10	26	12
Blue bull	*Boselaphus tragocamelus*	8	9	26
Cattle egret	*Bubulcus ibis*	7	14	11
Common krait	*Bungarus caeruleus*	27	28	28
Grey francolin	*Francolinus pondicerianus*	5	12	4
Grey wolf	*Canis lupus*	22	18	10
Hanuman langur	*Semnopithecus entellus*	9	8	27
House sparrow	*Passer domesticus*	3	7	8
Indian chameleon	*Chamaeleo Zeylanicus*	23	27	21
Indian cobra	*Naja naja*	26	2	29
Indian crested porcupine	*Hystrix indica*	16	17	5
Indian flying fox	*Pteropus medius*	14	22	19
Indian giant flying squirrel	*Petaurista philippensis*	18	19	23
Indian hare	*Lepus nigricollis*	4	6	7
Indian hedgehog	*Paraechinus micropus*	12	15	16
Indian peafowl	*Pavo cristatus*	1	1	2
Indian python	*Python molursus*	25	25	20
Jungle cat	*Felis chaus*	15	10	9
Leopard	*Panthera pardus*	29	5	3
Rhesus macaque	*Macaca mulatta*	13	4	22
Red sand boa	*Eryx johnii*	17	23	17
Red-wattled lapwing	*Vanellus indicus*	6	11	13
Sloth bear	*Melursus ursinus*	28	21	1
Small Indian civet	*Viverricula indica*	24	24	24
Striped hyena	*Hyaena hyaena*	19	13	15
Wild boar	*Sus scrofa*	30	30	30

Factor 1 (F1): Economic impact of wildlife

This factor (n = 45) mainly consists of farmers and cattle herders (64%), along with most (64%) of the victims and their relatives (20% of this factor), and those that find their employment in jobs directly related to the forests themselves (15% of factor; 39% of total stakeholder group). Furthermore, this factor contains the largest number of participants in this study (56%).

Despite the importance of relational values such as aesthetics, this factor appears to prioritise instrumental values more than factors 2 and 3, especially concerning economic impact. Bush meat is often given as a reason for positive opinions of wildlife, such as the Indian hare. Furthermore, wildlife, such as the black kite and grey francolin, is valued for their indirect contribution to the livelihood of farmers, by containing pests and warning of intruders, respectively. The importance of the economic impact of wildlife, for the people in this factor, is further underlined by the differences in species rankings. For example, this was the only factor in which the grey wolf was ranked in the lowest ten,

attributed to a tendency to kill livestock. Furthermore, the leopard ranked second lowest here, compared to their top 10 rankings in the other two factors, due to the perceived danger to both humans and livestock. Finally, the six lowest scored categories in Table 3 all have a lack of a direct benefit or lack of direct threat to humans or their livelihoods in common, again emphasizing the importance of a tangible link to human livelihoods and wellbeing, to the people in this factor.

Factor 2 (F2): Spiritually grounded

Stakeholder distribution in the second factor is exactly the same as in factor 1. However, the factor itself is a lot smaller, counting 14 participants (18% of total).

Although this factor shares many similarities with factor 1, there is much less emphasis on the economic impact of local wildlife. This is most obvious in the very low score of justifying positive rankings with a species' value as bush meat. Instead, there is large emphasis on relational values between human and wildlife, be it the belief of the divinity of the Indian cobra, a representation of ancestors in the hanuman langur, or as a symbol of national pride for the Indian peafowl. This emphasis is mirrored in the overall rankings of the wildlife species, with the Indian cobra ranked second highest, in contrast to the very low rankings it has in the other factors. Interestingly, the black kite is ranked as fifth lowest, attributed to it feeding on chickens and livestock offspring, something the economy focussed participants of factor 1 did not seem to mind. Finally, despite a relatively low score for valuing wildlife for being good pets, this is precisely the reason the rhesus macaque gained such a high rank, suggesting this to still be of great influence on the opinions of participants in this factor.

Factor 3 (F3): Holistic forest

The final factor (n = 11; 14% of total) differs greatly in stakeholder distribution from the other two. Most importantly, this factor does not contain any victims or relatives of victims. Furthermore, only 36% is a farmer or cattle herder, compared to 64% of participants employed in forest-related jobs (39% of stakeholder group).

In this factor, many more species are considered (relatively) harmless, including large carnivores like the grey wolf and the sloth bear. Moreover, concerns about economic losses are much more focussed on property damage, and less so on livestock killings. On the other hand, just as in the other two factors, damage to agriculture was seen as a major reason for a negative association with wildlife. However, the species blamed for it differed greatly, with their focus on the blue bull and the hanuman langur, both species that were well liked, and consequently high ranked, in the other factors.

Even more so than factor 1, this factor puts a focus on the instrumental value of wildlife, albeit less so on their economic impact. As such, subjective norms such as spirituality and behaviour interpreted as the nature of an animal, scored extremely low. Instead, the participants in this factor valued wildlife on its contribution towards the health of the forest. This deviation from the other factors is most notable in their opinion of the sloth bear, which they ranked as their favourite species, due to its adverse effect on illegal resource extraction. This paints an image of a more holistic appreciation of the instrumental value of the forest, whereas the participants of factor 1 were mostly concerned with tangible benefits of the individual species.

4.3.3. Differences concerning sloth bears.

Themes relevant specifically to the sloth bear are displayed in Table 5. As mentioned in the previous section, there is an obvious difference in attitude towards sloth bears between factor 3 and factors 1 and 2. Aside from their focus on forest services, no participant of factor 3 mentioned potential harmfulness in their valuation, while these are by far the most important reasons for the low ranking received in the other factors. Indeed, some of factor 3's participants even considered sloth bears to

be harmless. Interestingly, only 43% of participants from factor 2 gave a reason for their valuation of sloth bears, even though it was, on average, still ranked with the bottom 10 species.

Table 5. Contains all themes addressed by all factor-defining participants concerning the sloth bear. The most frequent themes for each factor are marked in bold. The direct benefits to human life, in this case, refers to the financial benefit sloth bear-tourism brings. The forest services provided are mainly the perceived protection that sloth bears provide versus harmful human individuals.

Themes relevant to sloth bears	**Factor 1 (n = 45) in %**	**Factor 2 (n = 14) in %**	**Factor 3 (n = 11) in %**
Harmful to humans	**69**	**29**	0
Harmless	2	0	**27**
Direct benefits to human life	2	7	9
Aesthetic value	7	0	18
Forest services	2	7	**55**

5. Discussion

This study aimed to increase our understanding of HWC by taking a social-ecological systems perspective to identify challenges and opportunities in pursuit of human-sloth bear coexistence in Gujarat. It crossed the boundaries of several research fields related to HWC, and the divide between qualitative and quantitative analyses. It showed sloth bear occurrence to be limited by forest cover and anthropogenic influences, but to not be related to perceptions of conflict and coexistence in the sanctuaries. Moreover, HWC and coexistence are shown to be especially driven by the perceptions underlying attitudes, a general underappreciation of relational values, and stakeholder diversity.

5.1. Sloth bear occurrence is not related to conflict perceptions

No correlation was found between the predicted probability of occurrence and the perceptions of coexistence and conflict with sloth bears. It thus seems that people's perceptions are not affected by sloth bear occurrence rates. This is the first study that connects local perceptions and wildlife distribution in India in the context of HWC and coexistence. However, there have been studies researching associations between actual conflict frequency and wildlife species distribution or density in India and other parts of the world, which ultimately found no connection either (Dorresteijn et al., 2014; Gubbi, Swaminath, Poornesha, Bhat, & Raghunath, 2014; Rigg et al., 2011). Although the perception of conflict and actual conflict frequency are not entirely the same, it does imply a more socially grounded reason for the underlying causes of conflict and coexistence with wildlife (Dickman, 2010; Inskip et al., 2014).

Forest density was the most important variable in predicting sloth bear occurrence. Especially high forest density seems to be an important indicator, similar to the results of Puri et al. (2015). On the other hand, anthropogenic variables, like the distances to roads and settlements, only had a large influence on the model at short distances (Ghimire & Thapa, 2015; Ratnayeke, van Manen, Pieris, & Pragash, 2007). This is in contrast to Ramesh, Kalle, Sankar, and Qureshi (2012), who found no relation between distance to settlements and sloth bear occurrence in Mudumalai Tiger Reserve. A possible explanation may be that Mudumalai is surrounded by large areas of continuous forest (Ramesh et al., 2012), whereas the sanctuaries in this study are located within an area of high human density. These findings highlight the limiting effect of forest fragmentation on sloth bear distribution and the concomitant importance of large and well-connected forest patches to sloth bear conservation (Dorresteijn et al., 2014; Ramesh et al., 2012).

The final two variables, distance to surface water and TRI, were moderately influential in predicting sloth bear occurrence. For surface water this is only true for short distances, as its effect on occurrence quickly diminishes to zero as distance increases, which is also found in other studies (Akhtar, Bargali, & Chauhan, 2007; Sahlén, Støen, & Swenson, 2011). The connection with TRI on the other hand, seems to be lower than could be expected based on a study by Puri et al. (2015), and on sloth bear ecology, as it provides denning sites and concealment (Akhtar et al., 2007; Sahlén et al., 2011). This is likely explained by a lack of variation in TRI within the sanctuaries, as they only contain areas of moderate or higher ruggedness. Therefore, even though both variables may have importance for sloth bear habitat, within these sanctuaries their effect on sloth bear occurrence is limited.

Thus, there is no indication that sloth bear distribution has an effect on the perceptions of living alongside this species. Nevertheless, these results do have implications for sloth bear conservation, emphasizing the necessity for areas of well-connected dense forest for a healthy population. However, it seems that the answers needed to illuminate the way to understanding human-sloth bear conflict and facilitate coexistence are to be found in the social arena.

5.2. Underlying perceptions impact wildlife attitudes more than interactions

Attitude significantly affected coexistence. Moreover, all three studied factors leading into attitudes (interactions with wildlife, the perceptions of fault and future of HWC, and the perception of forest- and conservation management), were found to be of influence. Other studies found similar results for interactions with wildlife (Kansky & Knight, 2014) and forest- and conservation management (Fiallo & Jacobson, 1995; Vodouhê et al., 2010). Inversely, apart from a recognition of a discourse of wrongful blame on some species involved with HWC (Dickman, 2010; Gusset et al., 2009), little research has been done on the perception of fault itself. Moreover, so far, no research has been done on the perception of the future of HWC. However, the factor 'perception of fault and future of HWC' had a significantly larger effect on attitude, than the other factors, indicating that this factor indeed plays an important role. This is interesting, because it suggests that tangible beneficial effects of HWC policy, such as a decrease in negative interactions, may be partially disconnected from changes in attitudes. This would likely result in a lower-than-expected rise in wildlife tolerance from successful policy interventions. On the other hand, it acknowledges the potential of utilizing less direct methods, through public discourse and mass media, that use these perceptions to rally support and increase local tolerance to wildlife-related policy and conservation (Bhatia, Athreya, Grenyer, & Macdonald, 2013; Hart, Nisbet, & Shanahan, 2011). In any case, it affirms suggestions by Dickman (2010) and Kansky et al. (2014) of underlying causes, independent of the interactions themselves.

Furthermore, coexistence is also influenced by conflict avoiding behaviour, which is itself affected by the perception of the possibility of conflict avoidance. Importantly, this area of research seems to be completely overlooked in contemporary literature. Moreover, research concerning conflict avoiding behaviour itself rarely goes beyond the implementation stage, without concern for long-term viability or local acceptance (Webber, Hill, & Reynolds, 2007). Without a solid understanding of the effects and perceptions of the behavioural change we advocate in order to facilitate coexistence, the expected effectiveness of any policy implementation can never be more than an educated guess.

It is clear that much progress can be made in the facilitation of human-wildlife coexistence within the many facets of the social sciences. However, is also clear that important gaps in knowledge remain and that some aspects of this complex issue are still completely missing. These results acknowledge the necessity to incorporate new viewpoints into HWC research, such as local perceptions on future directions of HWC and on the existence and effectiveness of conflict avoiding behaviour. Finally, although excluded from this study due to a lack of variation, it may be of great interest to include the effects of gender and age on perceptions of, and willingness to, participate in conservation or coexistence schemes into future research. This is underlined by the findings from Gore and Kahler (2012) concerning gender, as well as a complete lack of environmental research in general on the effects of age.

5.3. Relational values play an underappreciated role in HWC

Zooming out to a more general view of wildlife, it appears that instrumental values and a general regard for safety are the foremost concerns about wildlife among the population in the sanctuaries. Especially a potential or historic negative financial impact of certain wildlife species seems to dominate opinions, along with, to a lesser extent, potential benefits of other species. This is not surprising as crop raiding or livestock killings, as well as injuries from wildlife attacks, have a direct and often critical impact on the already tenuous livelihoods of local farmers (Barua et al., 2013). This focus is mirrored in the narrative of favoured policy approaches, often concentrating on financial compensation for attacks, or on the segregation of humans and wildlife to prevent attacks altogether (Dickman, 2010; Fisher & Brown, 2015). Interestingly, aesthetical values were also universally stated as valuations

towards wildlife, indicating that relational values too, have an influential role in the formation of opinions (de Pinho, Grilo, Boone, Galvin, & Snodgrass, 2014).

That is, however, only part of the story. Not all values are shared by all participants. Although the majority of participants are still concerned with individual benefits from wildlife, others seem to have a more holistic point of view, valuing species for their benefit to the forest as a whole. Here too, do relational values play an important role, as a significant part of the participants state spiritual and cultural beliefs as the most important considerations in the valuation of wildlife, at least for a number of specific species (Clifton & Majors, 2012). Thus, although a narrative focussed on instrumental values, like the financial benefits of HWC policy, still seems to be the most direct way to facilitate coexistence, it would be remiss to ignore the parts of the population with diverging views. Rather than focussing on only one facet of the value of nature, conservationist should extent their narrative beyond mere economic incentive, and tap into this well of plenty so often ignored, to fully reach their audience (Clifton & Majors, 2012; van der Ploeg, Cauillan-Cureg, van Weerd, & Persoon, 2011).

5.4. Stakeholder diversity within communities as underlying driver

Both conflict avoiding behaviour and attitudes were shown to be drivers of coexistence. Within the boundaries of the theoretical framework used in this study, and the lack of research in this area, there is not much more to add to the discussion of conflict avoiding behaviour itself. Attitude, however, is influenced by a wide web of perceptions and other factors, underlining the underlying complexity of the associations with wildlife and HWC.

Interestingly, in the context of the case study in Gujarat, there was a very clear divide between negative and positive associations with sloth bears along the factor lines of the Q-methodology. The negative associations centre around a perception of fault that blames sloth bears for a tendency to attack humans, emphasizing the effect these perceptions can have. On the other side of the divide however, sloth bears are admired for scaring away would-be perpetrators and some even consider them harmless, unless provoked by humans. Neither of these results receive much attention in current literature as drivers of human-sloth bear conflict. Notwithstanding, a possible explanation for this divergence may be found in the distribution of stakeholders. F3 (holistic forest), the Q-methodology factor that stands on the side with a positive association, does not contain any victims or relative of victims, indicating fewer intense negative interactions compared to the other side. Moreover, a much larger part of this group is itself involved with forest management, suggesting a broader understanding of these animals and the forests as a whole, as well as a disconnect with the financial vulnerability of, for example, livestock farmers. Although there was not enough variety to include prior education as a measure of knowledge into the quantitative assessment, this divide does indicate knowledge to play an affective role, albeit through the characteristics of the diversity of stakeholders (Kanagavel, Raghavan, & Veríssimo, 2014). Apart from reiterating the diversity of factors influencing attitudes and subsequently coexistence, these results also display viewpoints within these factors to be diverse, which requires nuance beyond a generalization of ‘the local community’ when tackling conservation and conflict issues (Duncker & Gonçalves, 2017).

At the same time, there may be a negative subjective norm among the local communities, at least towards sloth bears. This is suggested by the observation that most participants of the Q-methodology analysis that didn’t provide a statement for their valuation, which could indicate a lack of directly related pressing or conscience concerns, still had a negative association with this animal. This seems in line with the finding that interactions with wildlife are not correlated with perceived conflict and coexistence. Although the subjective norm was only qualitatively approached in this study, other studies did find a strong relation between subjective norms and attitude and effectiveness of intervention programs, in a wildlife or forest context (Primmer & Karppinen, 2010; Sakurai, Jacobson,

Matsuda, & Maruyama, 2015). Thus, understanding the effect a potential subjective norm has on attitudes, and possibly perceptions, within the sanctuaries (or any other area of interest) could help predict or increase effectiveness and reception of policy implementation; an avenue for future research.

Finally, spirituality is an important influence in the obstruction or facilitation of coexistence (Struebig et al., 2018). Its effect, however, will be completely different, if present at all, within the context of different species of wildlife, as well as between individuals within a community, again illustrating the diversity of viewpoints within a community. Indeed, this factor has no effect at all on the attitudes towards sloth bears in these sanctuaries. Nevertheless, it provides one more piece to the puzzle of understanding HWC and coexistence in this region, allowing for more informed policy decisions to be made.

5.5. Implications for human-sloth bear coexistence efforts in Gujarat

Human-sloth bear conflict in Gujarat is rising and solutions or mitigation measures are urgently needed (Garcia et al., 2016). A number of studies already set out to provide effective recommendations to this purpose, often promoting environmental measures or physical segregation (Ghimire & Thapa, 2015; Ratnayeke, van Manen, & Padmalal, 2007; Yoganand, Rice, Johnsingh, & Seidensticker, 2006). However, the sloth bear occurrence model used in this study indicates that this area is too densely populated to create a habitat large enough to effectively segregate humans and sloth bears. Moreover, although forest cover remains an important factor, it seems other environmental factors lose out to the more anthropogenic influences. It may thus be better to focus on reversing the current fragmentation of the forests in and between the sanctuaries, consequently facilitating bear movement away from busy roads, decreasing the number of interactions (Choudhary & Singh Nama, 2016). Nevertheless, measures like these ultimately only constitute to treatment of the symptoms of human-sloth bear conflicts. In order to find actual solutions and facilitate coexistence, focus should be diverted towards the underlying social factors, as so often mentioned in this study and others (Dickman, 2010; Dorresteijn et al., 2016; Kansky et al., 2014). Regrettably, the social factors influencing sloth bear coexistence are many and often unstudied. Yet, waiting for the gaps in our understanding to be filled before acting is not a possibility as meanwhile lives are being lost on both sides of these conflicts.

What can be done, is focussing attention and investment towards changing the image of sloth bears, and concomitantly the attitudes towards coexistence. In contrast to the often prevalent predisposition of negative attitudes towards sloth bears (e.g. Debata, Swain, Sahu, & Palei, 2017; Rajpurohit & Krausman, 2000), this study showed them to be both loved and hated, underlining the diversity of opinions and viewpoints within these communities. Consequently, improving these attitudes should be done by acknowledging this diversity and addressing the specific concerns and interests brought forth by the people actually living alongside these animals, as opposed to a generalized idea of ‘community concerns’. These interests go beyond safety and the financial and health effects of an attack, but also include more abstract qualities, such as a sense of pride and the sloth bear’s role in the forest. Thus, while much is still to be learned before we can expect to fully understand and realize coexistence between humans and sloth bears, much can already be gained through changes in narrative and marketing, and by making sure all members of the communities are able to feel included and heard.

5.6. Limitations

The results of this study are only applicable to the sanctuaries themselves, and not the region beyond. This is because of the inherent differences in the characteristics of protected areas, as compared to

other public areas, not least due to the non-random nature of choosing a location for the establishment of a protected area (Carlson, Browne, & Callaghan, 2019; Joppa & Pfaff, 2009). Nevertheless, it showed important avenues in HWC research and an integrated approach that can be applied outside the sanctuaries, or other regions of the world.

Additionally, this study took advantage of previously gathered data sets. Although this made it possible to compare and integrate such a diverse set of analyses within the scope of this thesis, it does have implications for the alignment between data collection and the theoretical framework guiding the study. This is especially so for the questionnaire survey, which required a part of the categorization of the answers to be based on indirect associations, inherently subject to some researcher bias.

Furthermore, this study only had access to presence-only records of the data collected in the sign survey. However, a comparison between a presence-only design and a presence-absence design using Maxent revealed strong agreement between the two models (Gormley et al., 2011). Moreover, Maxent is shown to perform well with a sample size as is used in this research (Wisz et al., 2008). Thus, for this study at least, using presence-only records can be assumed to have a minimal effect on the model's accuracy. Notably, during the analysis of variable importance, Maxent expanded the range of the variable TRI beyond the input range. Multiple runs showed this anomaly to be a robust peculiarity for which no explanation was ultimately found. To improve upon this model, areas outside the sanctuaries could be incorporated, to understand how they differ from the areas within and to allow extrapolation to the entire conflict- or sloth bear distribution area.

Finally, not all settlements present in the sanctuaries have available georeferencing. Thus, the number of settlements per sanctuary may be underestimated, consequently overestimating the distance to the nearest settlement in some areas. However, this only implies that the anthropogenic influences in the sanctuaries may be even larger than found in this study, further emphasizing the need for effective mitigative measures.

6. Conclusion

This study aimed to increase our social-ecological understanding of human-sloth bear interactions in Gujarat and of HWC and coexistence in general. It found perceptions and attitudes to be the most important drivers underlying coexistence and consequently the most effective targets for HWC resolution. Moreover, it suggests narrative construction during the design and implementation stages of policy to be an important influence on these drivers, indicating an opportunity for conservation and coexistence facilitation that is relatively easy and non-invasive to achieve. However, this may only be achieved if it is properly adapted to the multiple facets of communities and incorporates a much wider set of values than is currently the norm.

Specifically concerning sloth bear conservation and human-sloth bear coexistence facilitation in Gujarat, this study recommends focussing on changing the image of sloth bears in the region, by acknowledging the differences in viewpoints within the communities and addressing individual concerns to increase feelings of inclusion.

Finally, this study contributed to the current gap in ecological knowledge of sloth bears, by indicating their distribution patterns in the sanctuaries, based on predicted probabilities of occurrence. However, during the course of this research many other knowledge gaps were uncovered, which should become priorities for future research opportunities, to approach the holistic understanding of HWC that is needed to realise actual coexistence. These include perceptions about the future trends of local HWC, perceptions and actual use of conflict avoiding behaviour and their long-term effectivity, and the effect of subjective norms in changing attitudes towards wildlife and wildlife policy.

By identifying challenges and opportunities towards human-sloth bear coexistence, and by contributing to the understanding of this issue, this research worked towards reaching conservation targets, as well as addressing sloth bear related poverty alleviation and safety in this region, and may help local governance actors in creating effective and sustainable policy.

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Annex A. Justification for model assumptions

As mentioned in section 3.2.3., some authors have expressed concern with the lack of justification in the literature for the assumptions underlying models made with Maxent. Merow et al. (2013) identified six main categories that they consider critical, to be explicitly motivated when using this software. These are: background data, features, regularization, sampling bias, output and evaluation. Here, these categories are briefly explained and explicitly motivated for this particular study.

According to Merow et al. (2013) background data (i.e. the locations were presence is unmeasured) should be both environmentally relevant to the modelled species, and only extent to within the range where the species is equally likely to reach, unless this is accounted for within the model. The relevance of the chosen variables has already been motivated in sections 2.1.3 and 3.2.2. Moreover, the background data extents only to the border of the sanctuaries, and thus always within the range of the sloth bear populations living within them, meeting the above condition.

By default Maxent uses sample size to determine which feature classes (linear, quadratic, product, threshold, hinge) to use to build the model with. However, this if often not the ideal method, according to Merow et al. (2013), leaving a wide variety of possible combinations to use for this model. However, Phillips & Dudík (2008) observed a significant improvement in the AUC, when including hinge features, which when included, according to Elith et al. (2011), makes linear and threshold features redundant. Moreover, as there is little to no correlation between variables, based on a Pearson's correlation analysis, interactions between variables are assumed to be neglectable, allowing for the omission of product features (Elith et al., 2011; Merow et al., 2013). This leaves three more possibilities: only hinge features, only quadratic features, or both hinge and quadratic features. To determine which would be most appropriate for this data set, the AUC was used as a measure for predictive accuracy. Running the model with each different (set of) feature type(s), demonstrated a loss in predicted accuracy when using only quadratic features (AUC = 0.872). There seems to be little difference between using only hinge features (AUC = 0.894) or both hinge and quadratic (0.893). However, Elith et al. (2011) suggest that using only hinge features creates a smoother and easier to interpret image. Thus, for this study only hinge features were chosen to build the model.

The default regularization parameter in Maxent (here called β), used to reduce over-fitting of the data, is based on the performance of models across a large range of taxonomic groups (Merow et al., 2013). As there is only one species being studied here, the default β shouldn't be assumed to still be ideal. To be sure which value for β is optimal for this study, Merow et al. (2013) suggest to manually explore a range of values and compare their fit. This was done using ENMTools v1.3 (Warren, Glor, & Turelli, 2010). This software is able to compare Maxent models using raw data outputs and provide a variety of comparable criteria to select the best fit. Here, the Akaike Information Criteria with corrected complexity based on sample size, or the AICc, was used to find the best fit, as suggested by Galante et al. (2018) and Warren & Seifert (2011). Models were run with β's varying from 0.1 to 20.0. The AICc was smallest for β = 0.7, which has thus been chosen as the most appropriate regularization parameter for this study.

A more difficult assumption to justify concerns sampling bias. Maxent assumes by default that all locations are equally likely to be sampled (Merow et al., 2013). In reality, however, this is often not the case, as, for example, areas may be out of reach for the researcher. As sampling effort is typically unknown in presence-only data, as is the case in this study, two methods have been suggested to account for sampling bias. The first is to use Target Group Sampling (TGS), which uses known presence locations of taxonomically related species to estimate sampling (Elith et al., 2011; Merow et al., 2013). For this particular study this is impossible, both due to a lack of taxonomically related species and to an overall lack of presence studies related to this study area. Another possibility would be to resample

known locations several times to determine a probability of the accuracy of each presence record, which could then be used to create a bias grid to incorporate in the overall model. However, within the scope of this study, it is not possible to resample these locations. On the other hand, the presence data seems to visually cover most of the spectra of each variable used in the model, without obvious clustering around any single variable, taken over all sanctuaries, which can be observed for each variable in figure 7. Although this is far from an accurate analysis of sampling bias, for a lack of better options, this visual confirmation is used to assume minimal sampling bias.

Maxent allows for four different output formats: raw, cumulative, logistic and a complementary log-log function (cloglog). Each output scales the model differently and may lead to different interpretations and visualizations (Merow et al., 2013). Raw output can be interpreted as relative abundance, but is often not very intuitive (Phillips, Anderson, Dudík, Schapire, & Blair, 2017). Cumulative, rescales the raw output between 0 and 1 and can be interpreted as the omission rate of presences (Merow et al., 2013). Logistic and cloglog outputs both transform the raw output using prevalence, i.e. the average probability of presence. These output formats rely on different theoretical derivations, but can both be interpreted as the predicted probability of presence, which is the most useful output for this study. Moreover, Phillips et al. (2017) suggest cloglog to be the most appropriate of these two for estimating probability of presence. Even so, Merow et al. (2013) caution against using logistic output (cloglog was not yet available at the time they wrote their paper), due to the arbitrarity of using prevalence. By default, maxent uses a value of 0.5 (an average of 50% change that any location may have a presence), which is not biologically justifiable. In contrast, Elith et al. (2011) discuss this effect only within the context of modelling multiple species. To determine how much influence this parameter could have on this model, values for prevalence ranging from 0.05 (very rare) to 0.5 (moderately abundant) were modelled using the cloglog output format. There was no difference between the AUC of each model, nor between their visualizations. For this reason, it is assumed that cloglog is an appropriate output format for this study and will result in a reliable interpretation as the predicted probability of presence.

Finally, Merow et al. (2013) discusses using cross-validation over multiple replications of the model to determine the predictive accuracy of the model, approximated with the AUC. However, they did not discuss the possibility of bootstrapping as an alternative to cross-validation in their paper, which showed on a preliminary analysis of the data used in this study, a slightly higher AUC over 20 replications with bootstrapping, along with a much smaller standard deviation. The predictive accuracy of the model made in this study will thus be evaluated using bootstrapping.

Annex B. The questionnaire

Human-Sloth bear Interaction Project Questionnaire

Aims:

1. Interaction experienced by the local people
2. Sharing of resources with sloth bear from the protected area
3. How do the people cope while living in the same area as that of sloth bear
4. Local people attitude towards sloth bear and its conservation
5. Role of forest department in managing, supporting and mitigating the resources, conservation and conflicts.

Place		Study Site ID	
Location		Date	
Time Start		Time End	

Respondent's Data		Stakeholder Type	
Name		Gender	
Age		Education	

Aim 1:	**Respondent's Experience & Interaction with Sloth bear**						
1	Can you identify the signs of sloth bear?	A: Yes		B: No			
	If yes, which sign you can identify?	Claw Mark	Scat	Foot print	Sound		
2	Have you ever seen a sloth bear?	A: Yes	B: No	C: Not sure			
3	How often per year do you see a sloth bear?						
	Often *(12 times/year)*	Frequently *(6 times/year)*	Sometimes *(3 times/year)*	Rarely *(1 time/year)*	Never		
4	Where do you see bear most often (In case of more than once)	In village	In forest	On road	Not sure	All three	
5	If yes to 4, When and Where did you last saw a bear?						
6	What activity you were doing when you last saw the bear?						
7	At what time of the day did you last saw a bear?						
	Early Morning *(4am to 8am)*	Morning *(8am to 12pm)*	Noon *(12pm to 3pm)*	Evening *(3pm to 6pm)*	Late Evening *(6pm to 9pm)*	Night *(9pm to 12am)*	Midnight *(12am to 4am)*
8	What do you do after seeing the bear?						
	A: Run away	B: Climbed tree	C: Lied on the Ground	D. Made noise	E: None	F: Other:	
9	Have you sighted any bear near your village?	Yes		No			
		Where	Season				
10	Why do you think bears come to village? (More than one answer possible)						
	A: Food	B: Water	C: Liking for Crop	D: Negligence of Authority	E: Over population		
11	Has it ever caused any harm to you or your infrastructure? (If yes, tell in details)						
12	Do you know any other person who has been harmed by the bear?						

13	Did the bear ever attacked on cattle?	Yes	No	
14	Why do you think bear attacks cattle/human?			
15	According to you, in which season do bear attacks happen more frequently?			
	A: Winter	B: Summer	C: Spring	D: Monsoon
16	According to you what can be the reason for more attacks on human/cattle during that season?			
17	Have you ever heard that any human has beaten or killed a bear?		Yes	No
	How?			
	Why?			
	Other details			
	What happened to that bear?			

AIM 2: Sharing of resources

18	Do you visit forest?			Yes	No
19	If yes to que. 18 How often do you visit forest?				
	A: Daily	B: Once a week	C. Twice a week	D:More than that (specify)	
20	At what time of the day you visit forest?				
	Early Morning *(4am to 8am)*	Morning *(8am to 12pm)*	Noon *(12pm to 3pm)*	Evening *(3pm to 6pm)*	Late Evening *(6pm to 9pm)*
21	Why do you go to forest?	A: Cattle herding	B: Collect Forest Produce	C: Other (Specify)	
22	What products do you collect from forest?				
	A: Friuts	B: Fuelwood	C:Honey	D: Fodder	
	E: Medicinal Plants	F: Construction material	G: None	H:Other (Specify)	
23	What do you think bear eats?				
	A: Fruits	B: Honey	C: Cattles	D:Humans	E: Insects	F: Other (Specify)
24	Which resources do you think you and bear use in common from the forest?						
	A: Fruits	B: Honey	C: Timber	D: Water	E: Land	G: None	H: Other (Specify)
25	Do you think human and bear have equal rights to share the forest resources? Justify						
26	Does sharing of resources leads to conflict between human and bear?						
27	Is it possible for humans and bear to share the same resources in future?						

AIM 3: How do people cope with bears

28	How many years you have been living in this area ?						
29	Is it somehow possible to avoid bear confrontation?				Yes		No
					How:		Why:
30	Did you change your lifestyle to adjust with the bear? If yes, specify.						
31	Do you think other peoples have changed their lifestyle due to bears in this area? And how did it change?						
32	From where did you learn about these changes to live a safe life?						
	Parents	School	Forest department	From my experience	Grandparents	From other peoples experience	Other (specify)
33	Are these changes helping you to prevent the confrontation?				A:Yes	B: No	C: Not Always
34	What do you do to prevent bear attacks in village?						
	A: Night Guard	B: Make noise to frighten away bear			C: Fencing	D: None	E: Other (specify)
35	Do you have anything else to say about how you manage to live with bears?						
36	In your opinion, how do bears and humans live together in this region						
	A:Peacefully (without conflicts)	B: Relatively peacefully (with tolerance for occasional conflicts)			C: Relatively unpeacefully (due to occasional conflicts)		D: Unpeacefully (due to escalating conflict)
	Please explain why?						
37	In your opinion, how do you see the relationship between humans and bears in the future?				A: Better	B: Worst	C: No Change
	Please explain why?						

AIM 4: Local people attitude towards sloth bear and its conservation

	Towards Bear					
	Statements	1	2	3	4	5
38	I see sloth bears as a harmless animal					
39	Bears are harmful for cattle and humans					
40	I feel scared to visit forest due to presence of bears					
41	I like to see bears in the forest					
42	I feel proud to have sloth bears present in my area.					
43	Sloth bears are important part of my culture.					
	Towards Conservation					
44	I would like to see more bears in the area in future.					
45	Presence of sloth bear is important for protection of forest.					
46	Bears should be killed when sighted in the vicinity of village					
47	Bear hunting should be allowed					
48	Bear hunting prevails in this area					
49	There is need to reduce the bear population					
50	Well trained bear rescue team is an urgent need					

AIM 5: Role of forest department in managing, supporting and mitigating the resources, conservation and conflicts.

	Statement	1	2	3	4	5
51	I am satisfied with the present conservation practices for bears.					
52	I would like to participate in the conservation practices for bears					
53	Forest department plays important role in conserving forest.					
54	Bear population is increasing due to the efforts of forest department.					
55	Forest department provides compensation to the victims					
56	The amount of compensation is adequate.					
57	Compensation is passed very rapidly.					
58	Forest department provide adequate information about bear ecology and behavior.					
59	The forest department plants enough fruiting trees to meet the food demand of the sloth bear					
60	Please specify the tree species planted by forest department.					
61	What efforts the forest department does to mitigate the bear attacks?					
62	Do you think, the forest department is capable enough to mitigate the problem bear?					

63	When the bear attacks in village or appear in village, what is the response of forest department?			
64	Do you know any victim who received compensation from department? If yes, give details.			
65	Do you think the efforts of the forest department are enough for sloth bear conservation?		Yes	No
	Give details:			
66	In your opinion, could there be any improvements in sloth bear conservation or conflict mitigation by the forest department?		Yes	No
	Give details:			
67	Has anybody been booked by the forest department for causing harm to bear or bear habitat?		Yes	No
	Give Details:			
68	What measures are taken by forest department for conservation of bear habitat?			
	Planting fruiting trees	created artificial water sources	keep vigil on bear movement	law enforcement
	rescue operation	awareness	other (please specify)	
69	Would you like to provide any additional information?			

Annex C. Questions related to theoretical framework

Table 6. A listing of all questions from the questionnaire (Annex B) used per factor defined in the theoretical framework. All answer were transformed to a 0 (negative association) to 1 (positive association) scale before analysis. For yes/no questions, only 'Yes'-answer are indicated here as either positive or negative. The bottom two 'factors' are not part of the theoretical framework, but are used to determine a relation with the spatial probability of encountering a sloth bear. Question 26 is used twice, but in two different, independent, analyses.

Factor	Question (type)	Association
Attitude	25 (yes/no)	'Yes' is associated with a positive answer, as it indicates an attitude of equality between human and sloth bear.
	38, 41-45, 49 (ordinal)	A high score is associated with an positive attitude.
	39, 40, 46, 47 (ordinal)	A low score is associated with a positive attitude.
Perception of Fault and Future of HWC	14 (open)	Answers that blame bears for this conflict are considered a negative perception. Answers that blame humans are considered positive perceptions, as it inherently acknowledges that it can be solved by humans as well.
	26 (open)	Positive answers include all answers placing humans at fault. Negative answers include all answers blaming sloth bear behaviour or purposeful attacks. Other reasonings, not blaming a side are considered neutral.
	27 (yes/no)	'Yes' is considered a positive perception towards future human-sloth bear conflict.
	37 (categorical)	'Better', 'Worse', 'No Change' are considered as positive, negative and neutral, respectively.
Perception of forest- and conservation management	51, 53, 56, 57 (ordinal)	A high score is associated with a positive perception of forest- and conservation management.
	62 (yes/no)	'Yes' is considered as a positive perception, as it indicates current management to be adequate.
Conflict avoiding behaviour	19 (categorical)	Any answers above the average of all participants is considered negative, as the chance of encountering a sloth bear (based on number of forest visits) is relative high.
	20 (categorical)	As sloth bears are nocturnal, participants that visit the forest at night (categories: Early morning, Late evening and Night) are considered negative. Those that visit the forest during the day (categories: Morning, Noon and Evening) are considered positive, as this behaviour minimizes chances of encounter.
	30 (yes/no)	'Yes' is considered positive, as it indicates an active change in behaviour to avoid conflict.
Perception of the possibility of conflict avoidance	29 (yes/no)	'Yes' is considered a positive perception, as it indicates a perceived ability to minimize conflict through behavioural change.
	31 (yes/no)	'Yes' is considered a positive perception, as it indicates a perceived realization of behavioural change to minimize conflict.
Perception of Conflict	11, 12 (yes/no)	'Yes' indicates known conflict at this location.
	26 (yes/no)	A positive answer indicates conflict. A negative answer indicates a lack of conflict.
Perception of coexistence	36 (categorical)	A perception of a (relatively) peaceful relation between sloth bear and humans indicates a positive perception of coexistence.