Chapter 1- INTRODUCTION

1.1 Introduction to Sloth Bears

Sloth bears are among the eight bear species found across the world; inhabiting a diverse range of habitats varying from tropical (dry & wet) forests, grasslands, savannahs, to scrublands (Yoganand et al. 2006; Seidensticker et al. 2011; Ramesh et al. 2012) of the Indian subcontinent. Primarily being a lowland species, presence of sloth bear has been recorded from below 300 meters in Sri Lanka to high elevation of 2000 meters in Western Ghats (Johnsingh 2003; Ratnayeke et al. 2007; Seidensticker et al. 2011).

Image 1. Camera Trap image of a Sloth Bear captured in Jessore Sloth Bear Sanctuary

Sloth bear is the only bear species dispersed across mainland India. It is native to the Indian subcontinent including Sri Lanka, and Nepal (Dharaiya et al. 2016).

Approximately, 85% of the total sloth bear population of the world is found in India, where they are distributed from the southernmost forests of the Western Ghats to the foothills of the Himalaya (Shivalik ranges) in the north (Yoganand et al. 2006; Dharaiya et al. 2016). Its western range is limited by the desert of Rajasthan. The states of Gujarat and Rajasthan are considered as the western most extent of their range. In north-eastern India, it is known to occur in the state of Assam. Sloth bears are relatively common in the Central Indian landscape and Western Ghats regions (Yoganand et al. 2006). The sloth bear is the only species of bear occurring in Gujarat and is one of the four resident bear species of the Indian subcontinent: the other three being Asiatic black bear, Himalayan brown bear, and the Malayan sun bear.

Image 2. Camera Trap image of a Sloth Bear captured in Balaram Ambaji Wildlife Sanctuary

In Gujarat, sloth bears are found in five protected and several non-protected forests spread from north to south restrained towards the eastern border. In North Gujarat, they show their presence within the districts of Banaskantha, Sabarkantha, Aravalli and Mehsana; in Central Gujarat region Dahod,

Panchmahal and Chhota Udepur districts; and Narmada district in the South Gujarat. As of now the five protected areas (known for sloth bears) are scattered across the above-aforementioned regions (Chapter-2). Jessore Sloth Bear Sanctuary and Balaram-Ambaji Wildlife Sanctuary in the North, Jambughoda Wildlife Sanctuary and Ratanmahal Sloth Bear Sanctuary in Central and Shoolpaneshwar Wildlife Sanctuary in South Gujarat. Balaram-Ambaji and Jessore in the North Gujarat region have reported the highest density of sloth bears in Gujarat (Gujarat Forest Department 2021).

1.2 Current Status and Threats

The Sloth bear is listed as a Schedule – I species under the Indian Wildlife (Protection) Act, 1972 and is listed as Vulnerable under the IUCN Red List of Threatened Species (Dharaiya et al. 2016). Its historic range has been fragmented and degraded because of large-scale deforestation for various developmental projects (Palita et al. 2014). Populations of sloth bear are presently under threat of urbanisation, increasing agricultural activities, mining, loss of habitat by destruction, fragmentation, and degradation; and conflict with humans (Garshelis et al. 1999; Dharaiya et al. 2020). Additionally, decline in food resources (Murthy & Sankar 1995) and direct competition with humans for these resources have led to a rise in human–bear conflicts (Rajpurohit and Chauhan 1996). As there has been a decline in forests land outside the protected parks and reserves, sloth bear populations are becoming increasingly dispersed (Garshelis et al. 1999).

1.3 Human-Bear Conflict

Rise in human–bear conflicts is also considered a major threat for the conservation of species (Rajpurohit and Chauhan 1996). The growing human footprints have led to an increase in their basic needs for land, altering and modifying its use (Tucker et al. 2018; Lehman 2021; Bombieri et al. 2023), affecting the biodiversity (Basak et al. 2023). As a result, extirpation of species from an area, habitat degradation, fragmentation and human-wildlife conflict are

some of the few impacts that are extensively being observed (Naim & Chauhan 2008; Dharaiya et al. 2016; Karanth & Kudalkar 2017). This raises a concern, specifically for the communities residing close to the habitats of large carnivores (Bombieri et al. 2023). These populations are more at risk due to their livelihood dependency on the forests. Hence, human bear conflict is a major challenge to be addressed due to shared geographical spaces and resources (Treves & Karanth, 2003; Quigley & Herrero 2005; Inskip and Zimmerman 2009).

Reports suggest that most conflicts have occurred during livestock grazing, farming, and collecting forest produces. Although, the conflict situation varies geographically across their distribution ranges (Can et al. 2014). Through time, increasing demands of human societies on forest produce as well as land, the pattern of human bear conflicts has been altering (Krofel et al. 2020). Hence, human bear conflicts have been recognized as a great concern affecting bear conservation efforts due to reduced human tolerance, retaliatory killing, poaching and competition for shared resources (Krofel et al. 2020). Hence, it becomes imperative to understand and analyze the different conflict situations for developing a mitigation strategy as a crucial part of bear conservation plans. Among the large carnivores found in India, sloth bears are swiftly gaining a position of being a potentially dangerous species. Incidents reporting encounters with sloth bears have increased dramatically resulting in human fatalities in several cases.

1.4 Human Sloth Bear Conflicts in India

Different studies published within the time span of 2000-2020 have analysed the conflict number and patterns in various states as shown in Figure.1.1. Being an omnivorous species, sloth bears feed on wide variety of food resources, mainly fruiting trees like Garmalo (*Cassia fistula*), Jamun (*Syzygium cumini*), ber (*Ziziphus mauriticzna*), bel (*Aegle marmelos*), and flowers of Mahua (*Madhuca longifolia*) as well as honey used by local people residing close to the forests.

Therefore, their chances of direct encounter with bears increase, making them vulnerable to sudden attacks by bears (Rajpurohit & Krausman 2000).

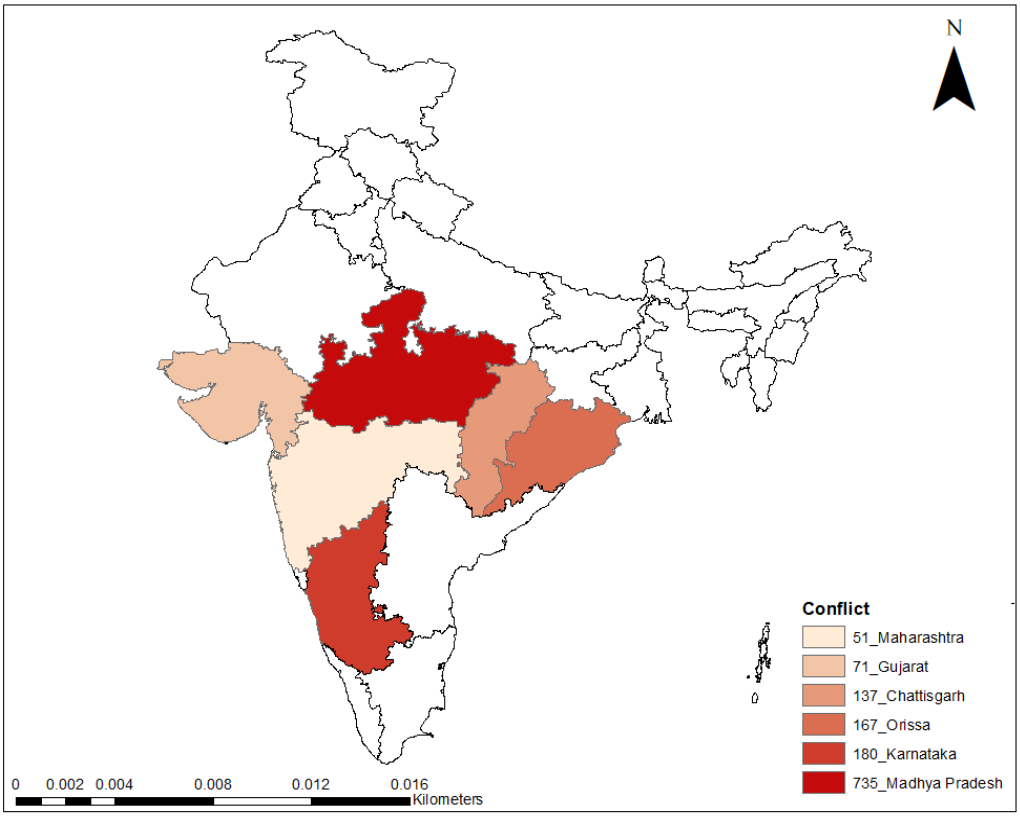

Figure 1.1. Human-sloth bear conflict recorded in different states of India.

Evidently, 735 (Table 1.1) attacks have been reported from Madhya Pradesh between 1989-1994 with a significant number recorded (185) within one-year 1993- 1994. The study shows that most attacks have occurred in the forested areas outside the protected zones defined by Forest Department (Rajpurohit & Krausman 2000). However, in another case study in Kanha-Pench corridor, Dhamorikar et al. (2017) interviewed 166 victims, mostly tribal mauled by sloth bears (Madhya Pradesh). Majority of incidents are reported inside the forests when people were collecting forest produce. The studied corridor connects two important tiger reserves, with a great biodiversity including sloth bears and

comprising of a composite of reserve forests, agricultural fields, villages, and small scales mines (Jena et al. 2011; Sharma et al. 2013). Succeeding Madhya Pradesh, Deccan plateau in Karnataka has recorded more than 300 attacks within the time span of thirty-two years (1985-2016). This area is recognised as good quality habitats with relatively high density of sloth bears (Puri et al. 2015). Presence of caves provid a good space sheltering sloth bear from scorching heat in summers as well as protecting them from potential predators. Here, attacks reported on humans were more frequent in farmlands followed by locations inside the forests (Sharp et al. 2020). Only two studies have reported conflicts from different parts of Orissa/Odisha, a prime habitat on eastern coast of India (Yoganand et al. 2006). Balasore wildlife Division located (BWLD) in northern Orissa has recorded 167 conflict cases between 2002-2013. Consistent with previous study the habitat here is interspersed with farmlands, human settlements, reserve forests and caves providing a suitable habitat. BWLD is a densely populated area with 609 human /km^2 as per the district census (2012) leading to high human encroachment into the forest. Contrary to other studies, most incidences of conflicts have occurred near forest edges (Debata et al. 2017). Relatively low numbers of conflicts (33) have been recorded from Semiliguda Forest Range, southern part of Orissa. Though, Sloth bears signs are quite frequently observed outside the villages in the area. Here, most attacks were reported on cattle herders in and around the sloth bear habitats. Sloth bears often known to venture into farmlands to raid crops such as sugarcane, maize, and groundnuts (Palita et al. 2014). North Bilaspur Forest Division (NBFD) in Chhattisgarh also represents a fragmented habitat with sporadically distributed villages and farmlands. The area is interspersed with small hillocks with boulders providing den sites to bears. In 1990, Servheen reported that Chhattisgarh and Madhya Pradesh harboured a high density of sloth bear. Bargali et al. (2005) reported 137 incidents of conflicts here in two years (1998-2000).

Table 1.1. Human- Sloth bear conflict compiled from studies conducted in India published between 2000-2022.

Sr. No.	Conflict Data (Year)	State	Location	No. of Attacks	Author
1.	1968-2008	Gujarat	North Gujarat	71	Garcia et al. 2016
2.	1985-2016	Karnataka	Deccan Plateau	180	Sharp et al. 2020
3.	1989-1994	Madhya Pradesh	Madhya Pradesh	735	Rajpurohit & Krausman 2000
4.	1998-2000	Chhattisgarh	North Bilaspur Forest Division	137	Bargali et al. 2005
5.	2002-2013	Orissa	Balasore Forest Division	167	Debata et al. 2017
6.	2004-2016	Madhya Pradesh	Kanha-Pench corridor	166	Dhamorikar et al. 2017
7.	2007-2013	Orissa	Koraput Forest Division	33	Palita et al. 2014
8.	2009-2017	Maharashtra	Dnyanganga Wildlife Sanctuary	51	Singh et al. 2018
9.	2016-2018	Bihar	Nawada Forest Divsion	16	Kumar et al. 2022

It was implied that people defecating in the open were more prone to attacks followed by cattle grazers. In Bihar (Nawada Forest Divison) also sloth bear habitats are patchy, fragmented, interspersed with farmlands and villages (Kumar et al. 2022).

There is a lack of study on number of sloth bear attacks on humans from Bihar. Kumar et al. (2022) reported 16 attacks within two years (2016-2018) in NFD. A

significant number of people were attacked inside the forests while collecting NTFP followed by people passing through or living near the habitat (Kumar et al. 2022). In Maharashtra, attacks were more frequent around farmlands (66.7%) with few incidences reported around forest fringes (Singh et al. 2018). Studies in Gujarat have also highlighted habitat fragmentation as a major factor aggravating human-sloth bear conflicts (Dharaiya 2009; Garcia et al. 2016). Here, dry deciduous habitats with open to dense forests combined with patchy scrublands provide suitable home for sloth bears. However, local populations, representing largely tribal communities, directly depend on forest produces especially on trees like Mahua (*Madhuca indica*), garmalo (*Cassia fistula*), jujube (*Zizyphus jujuba*), Palash also known as flame of the forest (*Butea monosperma*) and date palm (*Phoenix sylvestris*) which are also preferred by sloth bears (Garcia et al. 2016). Total 71 victims interviewed during the study reported that attacks were more frequent when victims were engaged with livestock herding, venturing into forests, and least during forest produce collection (Garcia et al. 2016).

1.5 Mitigation Strategies: prediction models and landscape connectivity

Research gaps have been addressed when it comes to mitigating measures introduced or suggested across the world for human-bear conflicts (Can et al. 2014). Targeted studies have been conducted to resolve conflicts, though it becomes difficult to implement similar measures at spatially large scale with varied geographical and social factors associated with them (Lischka et al. 2018). Researchers have advised the use of safety messaging as an important tool to reduce the conflict and facilitate co-existence (Sharp et al. 2022).

One of the common and important measure traditionally undertaken to avoid human-bear conflict is to segregate bears and humans spatially preventing their potential interaction (Can et al. 2014; Penteriani & Melletti, 2020). Though, comprehensive understanding of species co-existence in human-dominated landscapes is crucial for conservation (Tarjuelo et al. 2014), it helps in gaining an

insight into complex interactions between the two, their occurrence and resource accessibility (Oriol-Cotterill et al. 2015; Gehr et al. 2017; Milleret et al. 2018; Li et al. 2019; Suraci et al. 2020). Further, this information is also important to develop an understanding on effect of human based activities, such as infrastructure development, agricultural activities, and urbanization on species co-existence in such surroundings which can potentially lead to human-wildlife conflicts (Levine et al. 2017; Bhandari et al. 2022; Pant et al. 2023). This facilitates in developing measures for promoting practices for sustainable land use to attenuate negative impacts of conflicts (Sillero-Zubiri & Laurenson 2001; Ahmadi et al. 2013; Carricondo-Sanchez et al. 2019; Soga & Gaston 2020).

Across the sloth bear distribution range in India, its habitat is overlapped or shared with humans as country is densely populated. Rapid fragmentation and degradation of habitats are the major consequences that the species is facing in the country. This has a negative influence on the occurrence of sloth bears in those spaces (Puri et al. 2015). Many studies have recognized and studied the human-sloth bear conflict patterns in the distribution range of sloth bear (Ratnayeke et al. 2014; Garcia et al. 2016; Debata et al. 2017; Dhamorikar et al. 2017; Sharp et al. 2020; Prajapati et al. 2021). Nonetheless limited studies are available with spatio-temporal use along with its effect on sloth bear distribution across the entire range (Joshi et al. 1995; Ratnayeke et al. 2007; Puri et al. 2015; Srivathsa et al. 2018). Few studies in India have represented the multi scale habitat assessment using occupancy models at the large scale (Puri et al. 2015) highlighting the importance of social demographics, forest, and landscape heterogeneity on species occurrence (Puri et al. 2015). There is a gap in usage of advanced technologies in determining the wildlife interaction patterns with their environment and humans (Sharma et al. 2021). Use of these technologies can shed light on the importance of understanding the drivers determining sloth bear occupancy at a fine-scale evaluation and can emphasise on species specific

relationship especially for the fragmented habitats (Akhtar et al. 2004; Puri et al. 2015).

It is crucial for managers to work in partnership with local communities as they represent stakeholders affected by wildlife conflicts. Hence, designing the framework for alleviating the situation would be more effective when all the parameters associated with humans and ecology are being considered (Lischka et al. 2018; Soliku & Schraml 2020). The spatio-temporal assessments using advanced tools and techniques, therefore, enhance the quality of work and ensure safety of both humans and wild animals (Puri et al. 2023).

1.5.1 Occupancy Model Studies

Numerous studies have been published where occupancy models have been applied to understand ecological processes at a fine scale incorporating large datasets, multi-scale assessments and species population dynamics (Ball et al. 2005; Royle et al. 2005; Ferraz et al. 2007; Kery et al. 2013). Occupancy model works on the assumption of species or sample unit to be static in defined period and predict its probable distribution while determining the influence of hypothesised covariates (MacKenzie et al. 2002, 2017; Nichols et al. 2007; Devarajan et al. 2020; Regmi et al. 2023). It provides an advantage to the researchers who can work with the occurrence data in freely available software packages (White & Burnham 1999; Hines 2006; Lunn et al. 2009; Fiske & Chandler 2011). These models also benefit the investigators in resolving species specific questions, especially for the elusive ones, that require an intensive surveys and sampling designs (Karanth et al. 2011; Johnson et al. 2013).

The potential areas of human-wildlife conflicts can be predicted based on the species spatial use and historical records of actual occurrences (Baruch-Mordo et al. 2014; Athreya et al. 2015). Based on presence/absence data patterns of spatial use by a species can be estimated by using a species distribution models (SDMs) (Elith and Leathwick, 2009; Morelle and Lejeune 2015; MacKenzie et al. 2017).

However, studies have also investigated human wildlife conflict patterns utilising these models (Karanth et al. 2013; Goswami et al. 2015; Miller 2015). Such studies help in correlating the spatial and temporal aspects of conflict locations to delineate the high-risk zones for the potential conflicts (Warrier et al. 2021). As a result, reliability on predictive models is increasing to estimate and understand the species distribution patterns for effective conservation practices (Peterson & Robins 2003; Araújo et al. 2004). Risk models require relatively less effort and are cost effective techniques suitable for wildlife managers for identifying the spatial patterns of conflicts based on historical records available in databases (Inskip and Zimmermann 2009; Dickman et al. 2011).

Approaches have been initiated across the world which include habitat connectivity across landscapes for large mammals (Brodie et al. 2016). However, in such scenarios, the needs of other species sharing the same geographical zones gets undermined (Wang et al. 2021). Hence, it seems more challenging to conserve species that are less charismatic such as sloth bears with poorly connected network of habitats (Guan et al. 2015; Puri et al. 2015; Wang et al. 2021).

Conservation of any species under threats rely on protected areas, while these areas in some cases are smaller in size compared to their home ranges or not optimal for them, restrictions on their movements of wide-ranging animal have negative effects on their life cycles, colonisation, genetic diversity, and affecting viability of population (Thatte et al. 2021). Hence it has been suggested that preserving and maintaining the non-protected sloth bear habitats is fundamentally essential to increase genetic connectivity in the principal landscapes (Dutta et al. 2015; Thatte et al. 2020; Jayadevan et al. 2020).

Majority of studies are dedicated to protected habitats and the surrounding areas. In India the forest cover is accounted for 21.71% whereas, protected areas are roughly 5% of country's total geographic area (FSI 2021) leaving a large portion

of the natural habitat vulnerable to conversions due to increasing human pressures (Manral et al. 2016) that produce hindrance to the movement of wildlife. Defining protected areas cannot be the only practical solution to the problem addressed without recognising the other variables associated with it. This is presenting a potential challenge for the policy makers (Young et al. 2010; Manral et al. 2016).

Studies have also shown that human induced modifications have different responses to landscape connectivity for different species in fragmented habitats (Jayadevan et al. 2020). Animals such as tiger, elephants and leopards that show long distance movements, despite being negatively affected by human infrastructures, disperse through human dominated landscapes (Joshi et al. 2013; Odden et al. 2014; Dutta et al. 2018; Thatte et al. 2018). Compared to these species, sloth bears have shown an average level movement, as is reported in Central Indian landscape (Dutta et al. 2015). In India, the studies have majorly concentrated on tigers' landscape connectivity which might not be the correct representation for other large mammals (Cushman and Landguth 2012; Joshi et al. 2013; Kanagaraj et al. 2013; Dutta et al. 2018; Pariwakam et al. 2018; Thatte et al. 2018; Reddy et al. 2019). Hence, it is imperative to understand landscape connectivity and permeability for movements of mammals, further allowing researchers and managers to come to an informed decision for developing infrastructures. With the absence of tigers and elephants in Gujarat, sloth bears require much needed attention for connectivity between five protected areas inhabited by them.

Thatte et al. (2021) in their review of studies on landscape connectivity iIn India, have highlighted an inclination of researchers towards Central Indian Landscape followed by few in the Terai Arc Landscape focussing majorly on tiger conservation. Further, a bias has also been observed towards multi species modelling based studies conducted on large mammals like tigers and elephants.

Relatively less focus has been given on other mammals such as sloth bears when this approach is considered (Thatte et al. 2021).

Comprehensively, the particulars discussed above indicate that the sloth bears are facing major threats in non-protected habitats overlapping with human dominated landscapes. Researchers have tried to understand different aspects affecting human-bear conflicts and to develop mitigation strategies. Sharing of resources has been identified as an important factor for encounters between the two. Increase in anthropogenic pressure on the bear habitat, decrease in habitat size and easy availability of resources have driven bears towards the human inhabited areas. Even though sloth bears are nocturnal, they have been increasingly seen active during daylight. There is no uniformity in the pattern of attacks occurring in different geographical regions. It largely depends on the time of activities by humans in the bear habitats especially in monsoon due to dense vegetation. Therefore, it is crucial to promote co-existence by implementing multifaceted approach to conserve sloth bears as well as their natural habitats. However, it is strongly felt that conservation practices should be region specific given the variability in conflicts.

With advancement in technology, it is only becoming plausible to incorporate use of technologies in developing ground models for human-bear conflict mitigation. This can be helpful in putting emphasis on approaches towards habitat as well as species protection enabling the wildlife managers to increase connectivity between the fragmented or isolated habitats of the targeted species. Hence use of spatial models is developing to promote wildlife movements across the potential habitats thereby increasing the genetic diversity amongst the existing populations is required. Thus, the present study focuses on sloth bears in Gujarat as a focal species while evaluating the factors affecting their occurrence in the five protected sloth bear habitats of the state and proposing the potential measures to

increase the connectivity between the existing sloth bears habitats and alleviating human sloth bear conflicts.

Based on this, three objectives have been identified for the present research work as mentioned below:

1. **A case study on sloth bear's occupancy near natural waterholes inside Jessore and Balaram Ambaji sanctuaries**
2. **Mapping of potential conflict zones in and around sloth bear habitats**
3. **Identification of ecological corridors for the movement of sloth bears between sanctuaries of Gujarat**