

Chapter 3

A case study on sloth bear occupancy near natural waterholes in Jessore and Balaram Ambaji wildlife sanctuaries

3.1 Introduction

In Gujarat, an increase in human-bear conflicts have been reported over the past decade (Malik et al. 2018) due to multiple reasons including resource sharing and competition, changes in land-use patterns, and lack of community awareness which has led to human intolerance to bears (Garcia et al. 2016). Mewada (2015) has reported that food and water resources have been shown to influence sloth bear movements and habitat use (Mewada 2015). Few studies have also reported frequent presence of sloth bears near water sources. While, Ghimire and Thapa (2014), reported 45% of sloth bear sign in immediate surroundings of water sources and Bargali et al. (2012) and Sultana et al. (2015) reported the same within 500 m of water sources.

Access to available surface water is an important factor affecting population dynamics of bears (Simpsons et al. 2011; Larsen et al. 2012). Natural water sources are fundamentally important for species survival, especially in arid and semi-arid areas. The semi-arid areas of western India which cover states of Gujarat and Rajasthan receiving low to scanty rainfall are no exception where water can be an important limiting factor for wildlife movements (Krausman et al. 2006), owing to high summer temperatures leading to high evaporative losses. Furthermore, these regions also experience significant overlap between sloth bear habitat and human-populated areas (Puri et al. 2015), which are expected to drive sloth bear-human interactions.

The very low rainfall with hot and dry climate in western India often bring drought to the two wildlife sanctuaries Jessore and Balaram Ambaji located in North Gujarat leading to water scarcity for wildlife including sloth bears. A recent

study within and surrounding of Jessore sloth bear sanctuary has reported that sloth bear attacks on people occurred within a kilometre radius to water sources (Malik et al. 2018). This led to the objective of this study: to assess the relationship between natural water availability and bear movements in the pre- and post-monsoon as these movements are likely to differ and thus influence human-bear interactions.

3.2 Study Area

This study has been carried out in the protected areas with the highest sloth bear density estimated in Gujarat state i.e. Jessore and Balaram Ambaji Wildlife Sanctuaries, encompassing 180 km² and 540 km² area respectively (Figure 3.1).

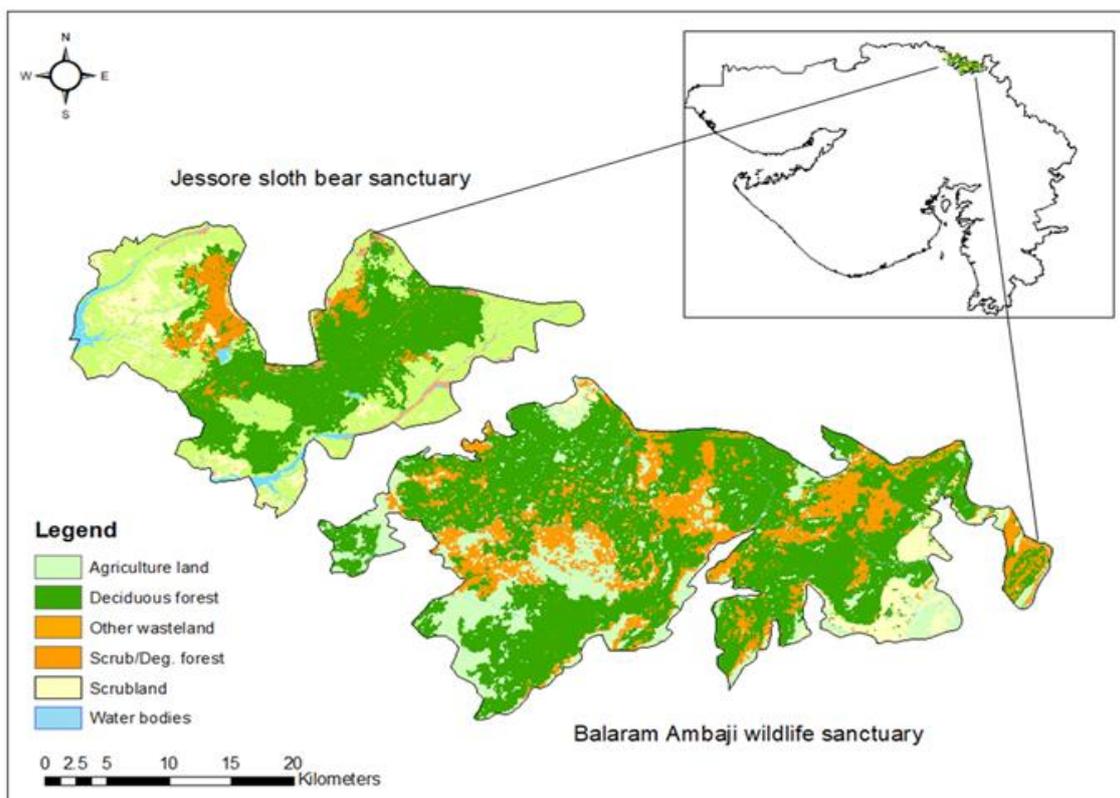


Figure 3.1. Location of two sloth bear sanctuaries with landuse landcover patterns in North Gujarat.

3.3 Methodology

The study required identification of water sources to monitor associated sloth bear presence. These water sources were perceived by developing a waterflow (stream) map of both sanctuaries (Figure 3.2a Jessore and 3.2b Balaram Ambaji) using hydrological modelling in ArcGIS® 10.8 (Malik et al. 2018). Small streams converge to create potential areas where water can accumulate. To create these streams, features such as Fill sinks, Flow Direction, Flow Accumulation and Stream order were calculated and generated using Digital Elevation Model (DEM) in ArcGIS® 10.8. (Malik et al. 2018; Dharaiya et al. 2021). For this, Bhuvan portal (<https://bhuvan-app1.nrsc.gov.in>) was accessed to acquire CartoDEM captured by Cartosat I.

Feature “fill sinks” as the name indicates, removes the depressions in the input layer (DEM) to identify the direction of flow by filling sinks. Based on the output layer, another feature “flow direction” estimates the weight of cells based on the values assigned to grid cells by the software tool. It utilises the pour point model to raise the elevation to lowest level while assigning the ranges with unique geometrical sequence values (Mark 1988; Khezri et al. 2013). This generates accumulated flow based on weight of grid cells of the output with the help of flow direction. Further, concentrated flow was identified based on high flow accumulation to develop stream order (Dharaiya et al. 2021). Stream order functions on the values estimated using the previous functions as an input raster. It utilises the method Strahler order to classify a numeric value based on tributaries. Streams generated without any intersection are given order one whereas streams with further tributaries joining in or extending out are given second or third order (Pradhan et al. 2012; Malik et al. 2018). In the final output, streams generated were further vectorised to identify the areas of potential water accumulation.

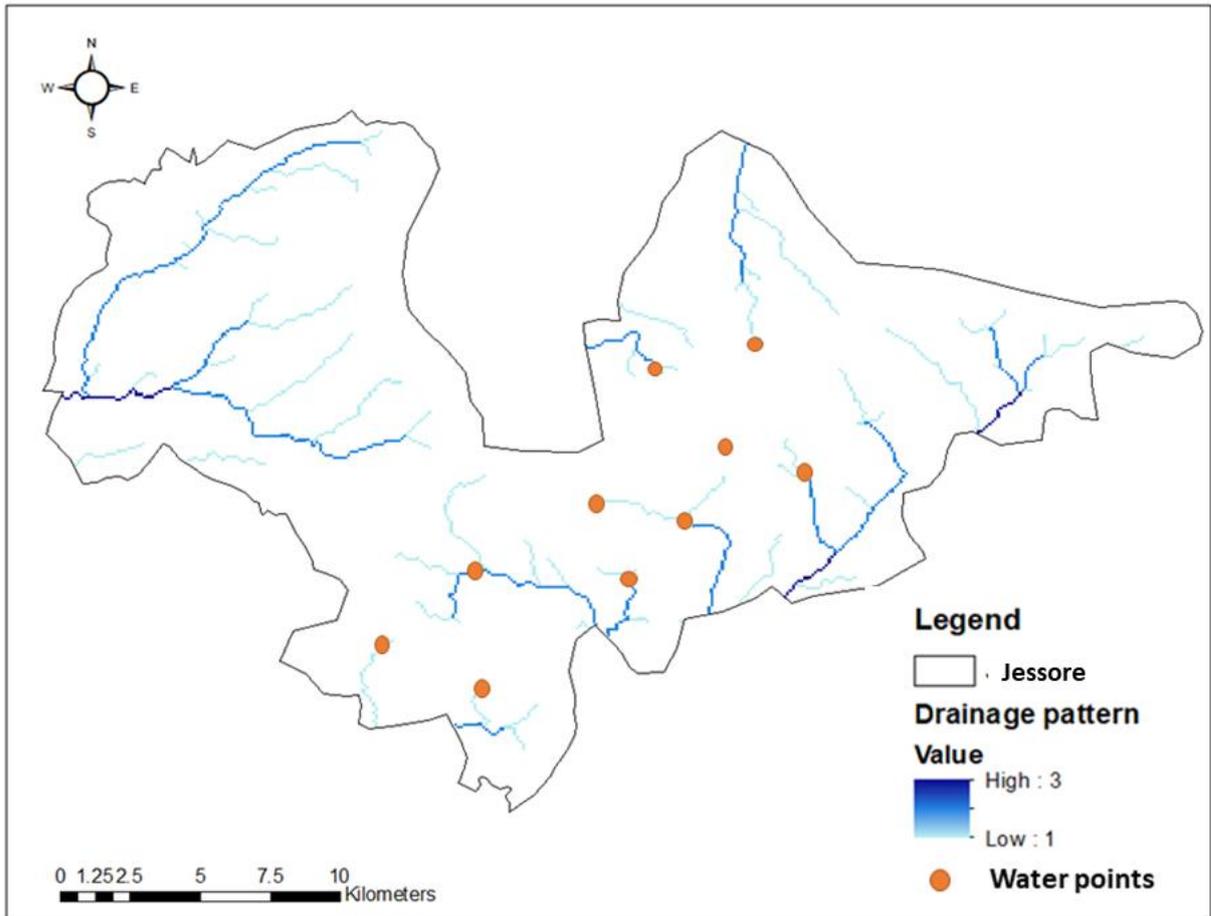


Figure 3.2(a). Drainage pattern of Jessore Wildlife Sanctuary by hydrological modelling. The orange dots illustrate the water points monitored for the present study.

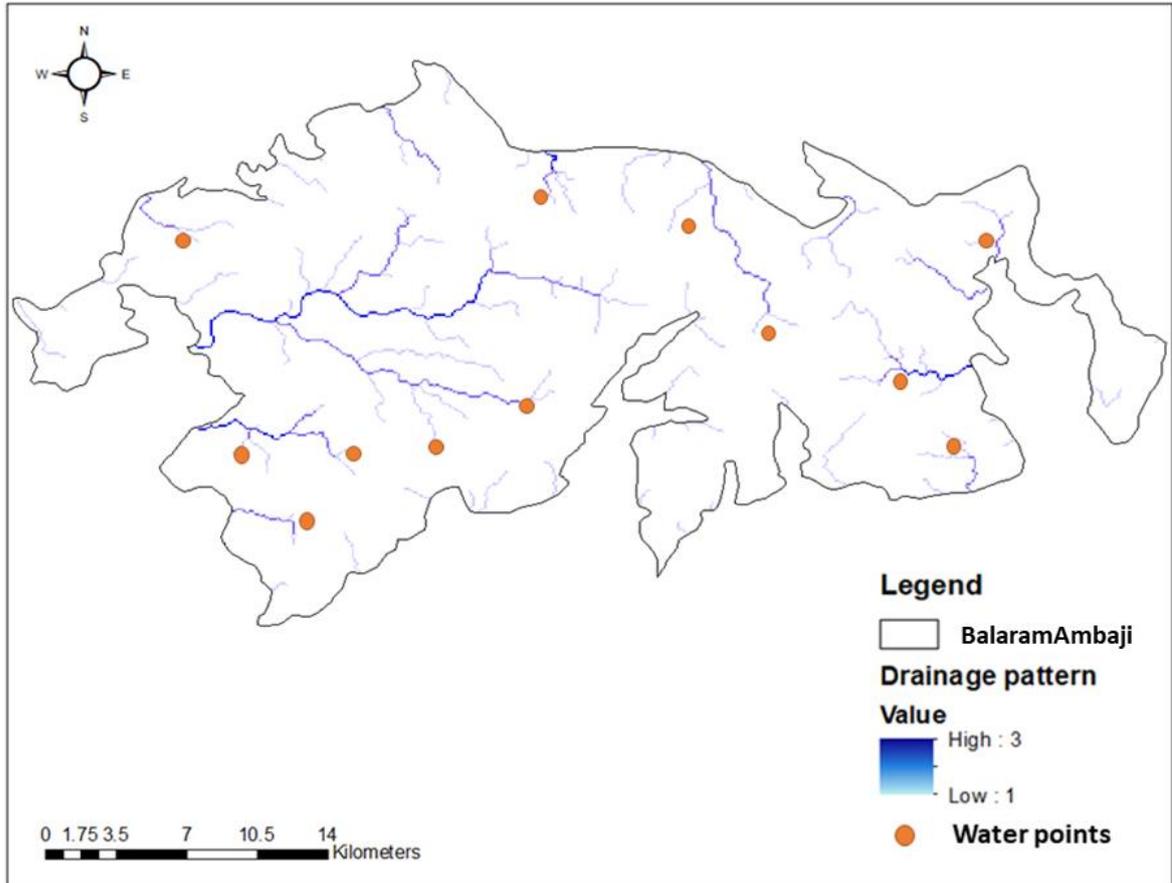


Figure 3.2 (b). Drainage pattern of Balaram-Ambaji Wildlife Sanctuary by hydrological modelling. The orange dots illustrate the water points monitored for the present study.

This led to identification of specific points as shown in the Figures 3.2a and 3.2b, to conduct ground survey validating points. To compensate for the scarcity of water, the forest department has constructed water holes such as guzzlers and check dams in the areas peripheral to these sanctuaries that are regularly filled. These artificial waterholes were not considered in the study here.



Image 5. An image of sloth bear's claw marks

Major part of Indian subcontinent depends on monsoon for its freshwater requirements. To understand the dependence of sloth bears on seasonally

fluctuating water resources, surveys carried out were divided into two time periods, pre-monsoon (the hot season - March-April 2019) and post-monsoon (the cold season December 2019-January 2020). Line transects were carried out around these water sources to find out presence of bears by indirect evidences (the bear signs) (Plumptre 2000; Fragoso et al. 2016). These transects were straight lines of 100m in three directions due to undulating terrain. Sloth bear signs including scats, claw mark, and pug marks were recorded at each natural water resource.



a.



b.

Image 6. An image of sloth bear's a. pug mark and b. scat

Other factors potentially affecting bear movement such as and habitat type, elevation, proximity to human settlements, fruiting tree species (preferred by sloth bears) and slope (Dutta et al. 2015; Mewada 2015) were also noted and used as covariates in the analysis (Table 3.1).

Table.3.1. List of covariates affecting sloth bear movement in the study area

Covariates	Range/Categories
Habitat type	1. Open Forest, 2. moderately dense forest, 3. Mixed Forest, 4. Rocky, 5. <i>Prosopis sp.</i> dominated
Elevation	200 – 700 (meters)
Proximity to human settlements	1000 – 7000 (meters)
Food resources (Tree species)	<i>Zizyphus sp.</i> , <i>Cassia fistula</i> , <i>Grewia flavescens</i> , <i>Diospyros melanoxylon</i>
Slope	0 – 30 (Degree)

An estimate for habitat was determined using forest canopy/trees species dominance based on the sky visibility (Jennings et al. 1999). Habitat was categorised into open forests (10-40% density), Moderately dense forests (more than 40% density), Mixed forests (more than two tree species abundantly present), no vegetation- rocky (boulders with no or less vegetation) and *Prosopis* dominated (large number of *Prosopis* species) around the water points. At every site canopy was observed by looking upward vertically. The distance to human settlements and elevation was recorded using GPS (Garmin etrex10) and slope was recorded using Clinometer in degrees. The data collected on the presence of sloth bear signs at 26 water holes (12 in Jessore and 14 in Balaram Ambaji) in summer of 2019 (pre-monsoon) and winter of 2019-2020 (post-monsoon) was used to evaluate the dependency of sloth bears' presence on water bodies. The paired data before and after the monsoons (26 water holes observed twice each; $n = 52$) was analysed statistically to test null hypothesis ($H_0 =$ presence of sloth bear signs at water holes was the same before and after the monsoon) and address the lack of independence at sites between seasons. To understand the presence of sloth bear's signs between pre and post monsoon, McNemar test was performed which is considered to be equivalent to a chi-square test for paired data and works better with binomial responses. The test was performed first using R package in R studio version 12.1-402 to test significance of the variables listed in Table 3.1.

The McNemar test is a non-parametric test used on dichotomous data to analyse the dependency of one independent variables on two set or more of dependent variables (Smith & Ruxton 2020; Sundjaja et al. 2023). Furthermore, to confirm the result from McNemars test, a generalised linear mixed model on sloth bear presence signs between the two seasons was performed that further accounted for lack of independence for sloth bear's presence at each waterbody. The script used for performing the McNemars test is given in Annexure I.

3.4 Results

The habitat around the natural waterholes in Jessore varied between open forests (5/12) to moderately dense forests (4/12). Only two locations were found with presence of boulders, and rocks with minimum vegetation in the surrounding (Table 3.2. a). Water point no. 7 (Table 3.3) was the only location observed to be dominated with *Prosopis species*. The highest and the lowest elevation recorded for water points in Jessore were 450 meters and 200 meters respectively (Table 3.2.b). The nearest village recorded from the waterhole with sloth bear presence sign was at less than 2000 meters (Table 3.2.c). Towards eastern border of the sanctuary, two waterholes (Water point no. 11 and 12, Table 3.3) were closely located to the farmlands. The farthest distance between waterhole where the sloth bear presence sign was noted, and the nearest village was approximately 6000 meters away. There is only one (1/12) waterhole location where no fruiting tree species preferred by sloth bears could be found (Table 3.2.d). The waterholes were located at varied degrees of slope, where four locations were at low gradient (0-10 degrees). However, only two waterholes were at slightly inclined locations (20-30 degrees) (Table 3.2.e).

Comparatively, in Balaram Ambaji, both moderately dense forest (6/14) and mixed forests (4/14) were predominant in surrounding areas of natural water points studied (Table 3.2. a). Rest of the sites were lying within the range of open forests to no forests. Out of 14 waterholes within the sanctuary, 11 were found

with bear presence signs (Table 3.3). In Balaram Ambaji, no significant variation was found in distance of waterholes from the nearest human settlements. The distance to villages from waterholes where sloth bear signs were noted were between minimum 2000 meters to a maximum distance up to 7000 meters (Table 3.2.c). The highest elevation for the water points recorded was 615 meters and lowest was similar to that in the Jessore estimated to be at 200 meters (Table 3.2.b). In terms of food resources available, almost all the locations at Balaram-Ambaji sanctuary were found with the presence of fruiting tree species preferred by sloth bears (Table 3.2.d). The high gradient slope was recorded for five water locations (20-30 degrees) (Table 3.2.e).

Table 3.2 Difference in variables recorded in surrounding of waterholes in both the sanctuaries.

a. Number of waterholes in various identified habitat categories.

Habitat type (Categories)	Open forest	Moderately dense forest	mixed forest	Rocky terrain	Prosopis dominated forest
Jessore (waterholes)	5	4	0	2	1
Balaram Ambaji (waterholes)	2	6	4	2	0

b. Number of waterholes located at different elevation ranges.

Elevation range (in meters)	200-300	300-400	400-500	500-600	600-700
Jessore (waterholes)	7	3	2	0	0
Balaram Ambaji (waterholes)	3	7	2	1	1

c. Number of waterholes at various distance from human settlements.

Proximity to human settlements (in km)	1-2	2-3	3-4	4-5	5-6	6-7
Jessore (waterholes)	2	0	0	7	3	0
Balaram Ambaji (waterholes)	2	3	2	0	4	1

d. Number of waterholes with sloth bear preferred fruiting tree species.

Presence of fruiting tree species	Presence	Absence
Jessore (waterholes)	11	1
Balaram Ambaji (waterholes)	13	1

e. Number of waterholes at various degree of slopes.

Slope (Degree)	0-10	10 -20	20-30
Jessore (waterholes)	4	6	2
Balaram Ambaji (waterholes)	5	4	5

The McNemar test performed on the combined data set for two sanctuaries to find out the seasonal differences for use of water holes by sloth bears, indicates that sloth bears visit water holes irrespective of season. Hence, the results support the null hypothesis that presence of sloth bear signs is not significantly different between seasons ($\chi^2 = 1.5312$, $df = 1$, $p = 0.216$). Although not statistically significant, presence of sloth bear signs declined from ~77% of water holes (20/26) in pre-monsoon to ~54% of water holes (14/26) having signs in post-monsoon (Figure 3.3).

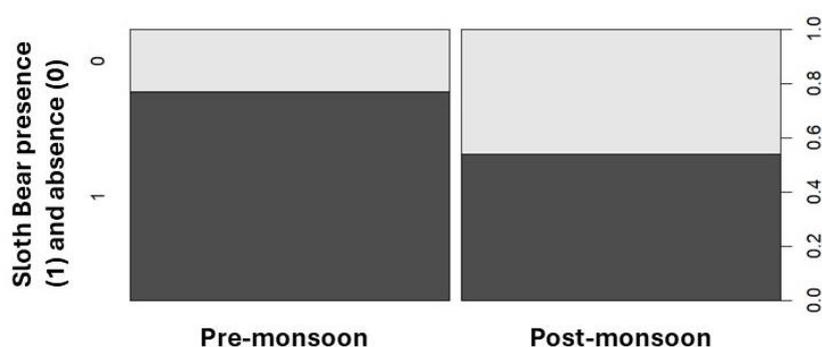


Figure 3.3. Sloth Bear presence and absence in two different seasons (2019-2020) generated using R package

Table 3.3. Presence of Sloth Bears around water points surveyed.

Water points	Pre- Monsoon (Summer)	Post- monsoon (Winter)
Waterholes in Jessore		
1		
2	●	●
3	●	●
4	●	●
5	●	●
6	●	●
7	●	
8	●	
9	●	
10	●	●
11		
12	●	●
Waterholes in Balaram Ambaji		
13	●	●
14	●	●
15	●	
16	●	●
17		●
18	●	●
19	●	●
20		●
21	●	
22		
23	●	
24		
25	●	
26	●	

Table 3.4 Results from generalised linear mixed models for sloth bear visits between two seasons (α value=0.01

	Estimates Std.	Error	Z value	Pr(> z)
Intercept	1.47	0.662	2.23	0.026
Sloth bear's presence signs	-1.28	0.747	-1.72	0.086

Sloth bears used most of these water holes in one or both the seasons, but there was variation in, when or if, these water holes were used. Sloth bear signs were noted in both the seasons at 11/26 (~42%) waterholes. Whereas 8/26 (~31%) waterholes were found with presence signs in summer 2019 only, and 2/26 (~8%) water holes in winter 2020. These two waterholes are present in Balaram Ambaji sanctuary. The remaining 4/26 (~15%) of waterholes did not have sloth bear signs in either season. Comparing the two seasons, after accounting for the lack of independence between sites, there is a very weak difference ($p=0.08$, α value=0.01) in the proportion of waterholes that have signs between seasons (Table 3.4). There is strong correlation between seasons indicating that waterholes that were visited by bears in the summer are also likely to be visited during winter. In this case, other variables did not show any statistical significance on sloth bear's presence signs.

3.5 Discussion

Northern part of Gujarat considered as one of the drier regions in the country, is highly susceptible to changes in precipitation patterns which can lead to condition ranging from extreme floods to extreme drought-like conditions (Conesa et al. 2014). The region is prone to frequent water scarcity as the lowest annual rainfall recorded is 345 mm designating it as a drought-prone zone where increased temperatures in summer elevates evaporation (Patel et al. 2015). With seasonal rivers as the only source of water in the dry season, water scarcity can be a limiting factor driving sloth bears out of their safer sanctuary habitat leading to frequent encounters with human. Hence, the study is conducted to find out the dependency of sloth bear's occupancy near natural waterholes.

When in dry summers of north Gujarat temperatures reaches up to 45-48 °C during the day (Bandyopadhyay et al. 2016), the wildlife shows minimum or no movements at daytime minimising evaporative water loss from their body. Further, the high temperature leading to intense evaporation and surface water

scarcity is likely to drive wildlife to move outside the sanctuaries in search of water. This is the time when the sudden encounters with humans can possibly occur. The increased number of attacks have been recorded during summer in Jessore sanctuary (Malik et al. 2018). In the present study, sloth bear signs are more prevalent near water sources in dry summer conditions though statistically found non-significant indicating comparatively low dependency of the species on waterholes studied.

A difference in sloth bear movement in dry and wet seasons has been observed in Sri Lanka, with an increase in home range size during the dry season (Ratnayeke et al. 2007). Sloth bears have also been observed frequenting water resources in dry seasons in different regions of India (Bargali et al., 2012; Sultana et al., 2015). A study conducted in other protected areas for sloth bears within Gujarat also recognizes the influence of surface water availability on the sloth bear's presence (Ketting 2020). In the present study, it was observed that during pre-monsoon (i.e. March), water quantity was visibly reduced to less than half that fully evaporated by June. However, sloth bears have been observed living close to the permanent water sources as a preferred site (Pokharel et al. 2022). This has been attributed to the fact that moist grounds are potentially suitable for foraging and denning, also noted with other bear species like Asiatic and American black bears (Akhtar et al. 2004; Benson & Chamberlain 2007; Bashir et al. 2018; Jain et al. 2021). Such sites are very few in north Gujarat or at lower elevation constructed by forest department and filled regularly. Nevertheless, in the habitats with prolonged monsoon no affinity has been established between sloth bear occupancy and surface water (Ramesh et al. 2012).

Along with water sources, food availability is recognised as an important variable determining the habitat suitable for sloth bears (Akhtar et al. 2004; Jain et al. 2020). This is supported by Mewada (2015) who has observed that that sloth bear's habitat use is greatly influenced by the availability of preferred fruiting

tree species, ant hills and termites. In our study area fruiting trees preferred by sloth bears such as *Zizyphus sp.*, *Cassia fistula*, *Grewia flavescens*, *Diospyros melanoxylon* were present in the transects around water sources. Fruits of these trees are likely to be the source of water as they are also abundantly present inside the sanctuaries. No significant relationship has been reported between them and sloth bear presence (Patel 2019; Desai 2020). Thus, these food resources perhaps fulfilling the water requirements of the species implying that surface water cannot be a limiting resource in this region.

The habitat in the studied area comprises of mixed dry deciduous forests; with sloth bear preferred fruiting tree species; interspersed with scrublands and open woodland (Rot et al. 2023). Sloth bear's presence signs were mainly recorded from the water points in mixed dry deciduous to open forests. Sloth bear's distribution has been most substantially impacted by deciduous forests, arid & semi-arid plains, and scrublands with considerable forest cover across their range (Garshelis et al. 1999; Yoganand et al. 2006; Puri et al. 2015; Rot et al. 2023). Conversely, more open, and drier habitats have been reported to be preferred by sloth bears in the Bhadra region of Western Ghats (Srivastha et al. 2018). However, forest cover has not been identified as a strong contender for maneuvering sloth bear's movement (Dutta et al. 2015) as is observed in present study too. The change in the movement patterns of different bear species is influenced by season and the availability of food resources (Ordiz et al. 2014).

Though, elevation and terrain have been identified as important variables considerably influencing sloth bear's presence (Rot et al. 2023), in the present study, most of the water points visited by sloth bears in dry season were situated at different variation of slopes varying between 0-30 degrees. However, statistically, variation in slope did not show any impact on sloth bear's presence. There are studies reporting that habitat suitability hasn't been significantly influenced by physical factors such as slope and elevation (Larson 2003; Akhtar

et al. 2004; Jain et al. 2020). Nevertheless, sloth bear occurrence was found to be negatively affected by the slope in the Meghamalai hills of Western Ghats (Babu et al. 2015). In the case of other bear species slopes are suggested to be having a positive association to zero consistency with bear density in different areas (Schwartz et al. 2006; Cozz et al. 2016; Morell et al. 2021). Compared to the other bear species, the sloth bear is a low elevation species found mostly below 500 meters and do not prefer steep slopes and higher altitudes (Dharaiya et al. 2016). In accordance with this, the variability in elevation of water points in present study lies between 200 meters to 700 meters. Again, there is a need for more temporal data to establish a significant relation between the two.

Habitats with low availability of food resources, scarcity of water and vicinity of human establishments make them highly unsuitable for the species (Jain et al. 2020). Hence, distance to villages is an important variable to be considered to understand human influence on the sloth bear's occupancy in an area. A study by Singh et al. (2018) has also reported that presence of sloth bear, search for water and food resources, increases around villages and farmlands in dry summers. Humans residing close to bear habitats have had a negative influence on sloth bear's occupancy (Yoganand et al. 2006; Bargali et al. 2012; Kaminski et al. 2013). Though, the present study does not conclude any significant relationship between distance to waterholes with sloth bear's presence signs and human settlements.

The analysis revealed that none of the covariates we tested showed significant influences on the sloth bear occupancy around natural waterholes in either season, indicating that sloth bear's movement is not affected by these factors in the studied area. The frequency of sloth bear visits to the water bodies could not be assessed due to covid lockdown conditions. However, there is a requirement for developing more water containment structures near natural resources in the core region of sloth bear habitats that will be able to retain water for longer duration,

hence restricting the movement of bears outside their habitat. Also, there is a need for a longer-term study to obtain robust data to reveal the limiting factors influencing sloth bear's movement to water sources in North Gujarat. It is strongly suggested that this work should be expanded in other regions inhabiting sloth bears assessing the availability of natural water resources inside their habitats.