

Draft

# Spatial analysis of livestock predation by leopards in the Greater Gir Landscape



**Project: Reconciling development with conservation: Delineating habitat  
patches and corridors for Gir lions**  
*Technical Report 2019*

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*Front cover photograph –Keshab Gogoi*





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## **Summary:**

Data on livestock kill by leopard were collected from the districts of Junagadh, Amreli, Gir Somnath and Bhavnagar, accounting for 711 villages between 2012 to 2016. These data were further translated into English, digitized and spatially mapped in GIS. We obtained remotely sensed as well as spatial covariate layers of forest cover, refuge patches, drainages and night-light intensity. We conducted a fixed Kernel analysis of spatially explicit livestock predation events at the village resolution to obtain a consolidated “predation risk map” by leopards of the landscape and used it for subsequent analysis.

The tehsils of Talala, Sutrapada, Kodinar, Visavadar, Palitana, Gir Gadhada, Junagadh, Una and Mendarada recorded highest livestock predation by leopards. A temporal increasing trend was observed for number of leopard-predation events as well as in the spatial extent of predations. However, the intensity (number of livestock kills/village/year) of livestock predation did not show any increasing trend, this suggests that though there is an increase in the geographical extent of conflict, the intensity in a given area has remained constant. This could be interpreted as geographical range expansion of the leopard without increasing its density within occupied areas. Proximity to wildlife habitats, proportion of wildlife area and urbanization enhanced chances of leopard predation. A significant deficit between the market rate and compensated amount for leopard predation was observed with an increasing trend. As a management strategy we recommend a revision of compensation rates to match the market price and an efficient system to pay compensation promptly. Improved husbandary practices and, as well as managing leopard density below social carrying capacity is recommended. This would help maintaining tolerance towards leopards under an increasingly conflict scenario.



## **Introduction:**

Population of human is increasing world wide (Bongaarts 2009) and hence the demand for resource mostly at the cost of natural habitats (Meyer & Turner 1992), forcing wildlife to live in close proximity to humans (Inskip & Zimmerman 2009). As a result, competition arises for shared resources, often leading to negative interactions between the two. Such interactions are often termed as conflict when wild animals attack livestock, raid crops, threaten human safety and livelihoods (Knight, 2000). Two broad dimensions of such conflict situations can be seen: a) the negative interactions between humans and other species, b) as a result conflict arises between those seeking to protect wild animals and those affected by wild animals (Redpath et al., 2012) and ultimately within such landscapes conservation of the wild animal rests in uncertainty.

Conservation of large carnivores in modern times represent unique challenges, i.e. reconciling the needs of human development with the needs of wildlife in socio-political landscapes (Barua et al., 2013). The protected areas represent a tiny share of about 14% for the wildlife amongst the vast extent of human dominated landscapes worldwide (UNEP, 2013). Large carnivores due to their extensive range, unique ecology and social dynamics inhabit areas that extend beyond these boundaries, drawing them into conflict with people (Woodroffe & Frank, 2005, Inskip & Zimmermann, 2009). Wherein livestock in these habitats are often vulnerable to predation due to inadequate anti-predator responses diminished by domestication (Bagchi and Mishra, 2006).

Leopards in this context are highly likely to be involved in conflicts due to their adaptability to thrive in various ecological condition and close proximity to humans (Daniel 1996, Hayward et al. 2006). They are one of the most widely distributed large carnivores in India. Leopards are known to prey on dogs, cows, goats, other domestic species and even in



humans on areas with low density of wild prey (Marker & Sivamani, 2009). On the other hand, people have converted natural habitats into sugarcane fields or other cultivational purpose where the climate and soil are ideal to meet the demands of the increasing population. These agricultural areas provide shelter and cover for the leopard outside protected forests (Athreya & Belsare 2007). There is higher probability of occurrence of conflict in such areas.

Current conservation ideology correctly recognizes that participation or active involvement of local communities is crucial to make conservation efforts successful (Robinson & Sasu, 2013). However, protected areas impose significant social impacts on rural people including displacement from land, restricted access to natural and cultural resources and increased threats from damage-causing animals (Hill, 2004, West et al., 2006, Anthony and Szabo, 2011). In addition, where the balance of benefit sharing systems to local people have not occurred, relations between management authorities and surrounding communities have become increasingly stressed (Dickman, 2009). Human-wildlife conflict presents a challenge for protected areas, particularly, when conflict impacts the quality of life for local people, especially in areas that lack of suitable compensation (Bajracharya et al., 2006). These factors increase opposition and weaken support for conservation efforts. People are more likely to tolerate risks that are undertaken voluntarily rather than enforced upon them (Starr, 1969, Skogen et al., 2008). Religious beliefs and cultural importance have undoubtedly played a significant role in India towards losses to wildlife conflicts but such values are changing fast and wildlife managers need innovative mechanisms for conflict resolution (Sukumar, 1994). In this report we analyses livestock predation by leopards between 2012 to 2016 to understand spatial and temporal patterns and potential explanatory factors in an attempt to guide management of leopard-human conflict.



## **Study area description:**

The study was carried out in more than 22,000 km<sup>2</sup> of the Greater Gir Landscape, spreading across 29 talukas of five districts in the Saurashtra peninsula of Gujarat, western India (Fig 2). The study landscape includes the protected areas of Gir (Gir Protected Area, Girnar Sanctuary, Pania Sanctuary and Mitiyala Sanctuary), vidis (protected grasslands), coastal forests and multi-used human dominated agropastoral landscapes.

## **Brief history of the landscape:**

The ecological boundaries of Gir covered half of the Saurashtra peninsula a couple of centuries before (Divyabhanusinh 2005). However, due various anthropogenic alteration of the habitats, Gir forest has shrunk to almost the current legal boundaries of the protected forest areas. Currently the landscape can be described by the intact protected forests of Gir under the jurisdiction of the Gujarat Forest Department and many scattered patches of small forests and hills under private ownership or multi use revenue land. Geographically, the protected forests of Gir National Park and Wildlife Sanctuary lies between 21<sup>0</sup> 20' N to 20<sup>0</sup> 40' N and 70<sup>0</sup> 30' E 71<sup>0</sup> 15' E. The total area under protection as sanctuary (1153.42 km<sup>2</sup>) and National Park (258.71 km<sup>2</sup>) is 1412.13 km<sup>2</sup>. Mitiyala Sanctuary in the Eastern landscape covers around 18.22 km<sup>2</sup> and Chachai-Pania wildlife sanctuary (39.64 km<sup>2</sup>) which is at the northern boundary of Gir PA has also been included as part of the Gir Conservation Unit (GCU). Additionally, there is a buffer area of reserved forest (227.90 km<sup>2</sup>), protected forest (107.51 km<sup>2</sup>) and coastal and unclassified forest (77.63 km<sup>2</sup>) comprising of valuable grassland and forests (Meena and Kumar 2012). The Gir protected area is divided into three managerial zones viz. Sanctuary west, Sanctuary East and National Park. Due to a rainfall gradient increasing from east to west, these three zones differ ecologically which reflects in the vegetation types (Qureshi and Shah 2004) and associated productivity. The Gir reaches its greatest length of 80 km along the east-west



axis, whereas north south width is 16-24 km, on an average, except eastern and western ends. Gir is located about 50 km from Junagadh in south west and 75 km from Amreli in south east, headquarters of adjacent districts. The coast line is 25 to 50 km away from southern park boundary.

Santapau and Raizada in 1956 estimated around 2560 km<sup>2</sup> area under forest cover which was significantly contributed by the revenue forests. Later, Joslin (1973) reported 87% decline in forest cover outside the sanctuary area between 1872 and 1969, mostly for cultivation purpose. Uncontrolled commercial exploitation of forest resources and increasing demand for cultivation land by the expansion of human settlement led to continuous decline in the area under the forest cover. It was not until 1920 that a small portion of Gir forest (Devalia Block in the south-western boundary of the Gir PA) declared as a lion sanctuary by the erstwhile Nawab of Junagadh. After independence, in 1965, the Government of Gujarat constituted the Gir Wildlife Sanctuary and later it was expanded in 1974 to present size of the PA. Subsequently, a tract of land nearly 150 km<sup>2</sup> was declared as a national park in 1975 and enlarged to its present size in 1978.

### **Geography and habitats:**

The terrain of Gir includes undulating surface with rolling hills of low to moderate height traversed with several perennial rivers for example, Ozat, Minsar, Machhundri, Madhuwati, Megal, Hiran, Rawal, Rupen, Sangavadi, Saraswati, Shahi, Singhoda, Malan and Bagot are some of the major river systems flowing through the landscape. Several artificial dams (around 111 major dam) created for as a measure to conserve water for irrigation and other household use in the study landscape provides good amount of water for the wildlife as well thriving in this landscape. The altitude ranges from 100 m MSL to 648 m (Sarakala hill on the northern boundary of Gir PA. Within the protected area the central part of Gir has a



more hilly terrain when compared to the rest of the park. The terrain has been classified into the following categories (Chellam 1993): flat plain; gentle slope; steep slope; hill top; river bed; and reservoir bed. The physiography is intersected by narrow seasonal streams. The drainages are mostly from North to South. Within the protected area several perennial rivers like Hiran, Singawada, Machhundri, Jatardi, Ghodawadi and Rawal provides abundant supply of water and grazing that have made the Gir reserve as the centre of cattle rearing and breeding.

The climate of the study area is classified under 'Tropical Savanna' according to Koppen's (1931). It is hot and humid during and after monsoon season. Rainfall is brought by south-westerly winds from Arabian Sea and the monsoon extends between June and September. There is a distinct dry spell in winter but pretty heavy dewfall is common. The area experiences three distinct seasons as the other part of the country. There is cool dry winter in Gir from December to March (average minimum temperature is 9<sup>0</sup> C), followed by a hot dry season (average maximum temperature 42<sup>0</sup>C), which lasts until mid-June. The monsoon breaks in June and continues till September and is followed by a dry post monsoon season till mid-December. The average rainfall based on the past 28 years data from the western part of the sanctuary and 10 years data from the eastern part of the sanctuary are approximately 1000 mm and 800 mm, respectively (Khan et al. 1996). The rainfall gradient increases from east (850 mm at Jasadhar) to west (1000 mm at Sasan). However, the annual variation in rainfall is large. About 94 % of the rainfall is received during monsoon, with July – August being the maximum rainy months. On an average there are 40 rainy days in a year. Long dry spell during monsoon is common. Moreover, the area is roughly affected by a 4 year drought cycle.

The floral wealth of the Gir forest includes some 500 flowering plant taxa (Singh and Kamboj 1996). Gir lies within the Afro tropical realm (Singh and Kamboj 1996) in the 4B Gujrat Rajputana biotic province of Biogeographic Classification of India (Rodgers and Panwar 1988). Gir comprises one of the largest compact tracts of dry deciduous forest, which



falls under the 5A/C1b forest subtype (Champion and Seth 1968). Gir vegetation was classified into three broad classes namely Moist Mixed vegetation, Thorn forests and Hill forests which were further divided into eight types (Qureshi and Shah 2004).

The rich biodiversity of fauna in Gir protected areas as well in the human dominated landscape comprises of the iconic Asiatic lion, along with other carnivores such as leopard (*Panthera pardus*), striped hyena (*Hyaena hyaena*), jackal (*Canis aureus*), ratel (*Mellivora capensis*), jungle cat (*Felis chaus*), rusty spotted cat (*Prionailurus rubiginosus*), ruddy mongoose (*Herpestes smithi*), common Indian mongoose (*Herpestes edwardsi*) and small Indian civet (*Viverricula indica*). Major wild prey species were chital (*Axis axis*), sambar (*Rusa unicolor*), nilgai (*Boselaphus tragocamelus*), wild pig (*Sus scrofa*), chinkara (*Gazella bennettii*) and four horned antelope (*Tetracerus quadricornis*). Chital constituted about 91% by number, and 78% by biomass, of the wild ungulate community in Gir (Dave 2008).



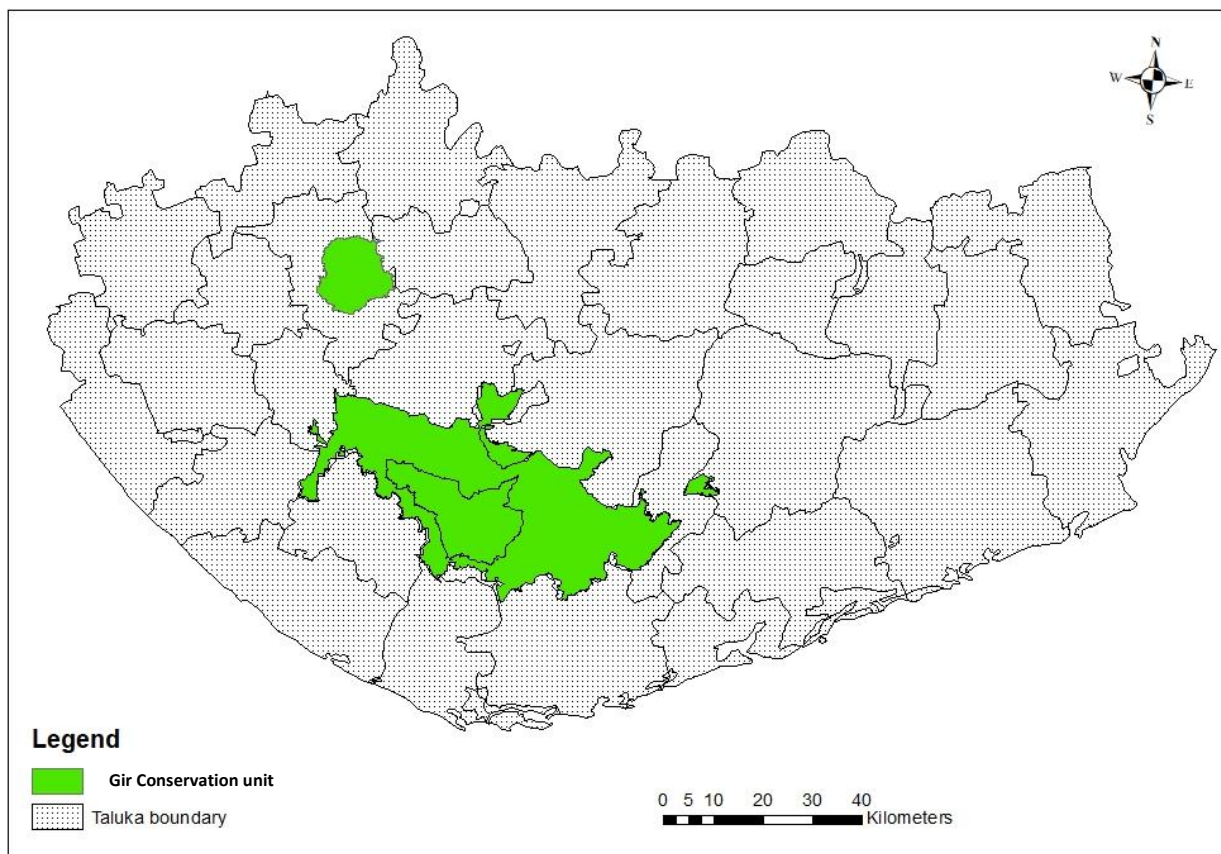
**Fig 1:** A leopard awaiting to cross a road



## Methods:

### Field method:

Data on leopard livestock predation from 2012 to 2016 were collected from the respective forest divisions and ranges across the Asiatic Lion Landscape. Often sites were visited to validate actual locations of conflicts and other relevant information if such were not available on the records. Data were collated from 711 villages identified correctly with the village shapefiles of Saurashtra. The villages come under the forest divisions of Junagadh, Gir West, Gir Somnath, Dhari, Amreli and Bhavnagar in the districts of Junagadh, Gir Somnath, Amreli and Bhavnagar.



**Fig 2:** Map showing the study area of Saurashtra with talukas and Gir Protected area representing the Greater Gir Ecosystem.



### **Analytical methods:**

We translated all the information from local language Gujarati into English and subsequently geo-referenced each data point into an analyzable format using excel spread sheet (Microsoft Inc 2016) and Arc Gis 10.2 (ESRI). Village shapefiles were obtained from Survey of India. The magnitude of livestock predation at every village was attached to the centroid of that village. These point locations were then used to map the predation hotspots by using Kernel density estimator (KDE) (Silverman 1986; Brunsdon 1995). KDE is a fundamental data smoothing technique where inferences about the populations are made based on finite data samples. In its usual form, kernel density estimation is a spatial method of estimating the probability density function of some variable  $x$  from a data set of observed values of  $x$  (in this case leopard predation events in villages). The shape of the kernel depends on the smoothing parameter ( $h$ ). When  $h$  is too small, kernel becomes very 'spiky' and when  $h$  is too large, it is oversmoothed. We used a value of  $h=5$  km to obtain a realistic smoothing of our data based on leopard movement. The information on the values of the utilization distribution function of the fixed kernel estimator were subsequently extracted for every  $5 \text{ km}^2$  grid and used for spatial analysis.

We used the following remotely sensed and derived spatial variables to analyze livestock predation by leopard.

**Night light (NL):** Surrogating for human habitation areas and urbanization. Acquired from United States Air Force Defense Meteorological Satellite Program (DMSP) and National Oceanic and Atmospheric Administration's (NOAA) Operational Linescan System (OLS) with a pixel size of  $2.7 \text{ km} \times 2.7 \text{ km}$ . (<http://www.ngdc.noaa.gov/dmsp/sensors/ols.html>; accessed 30 May 2015) (Elvidge *et al.* 1997). We computed the intensity of the nightlight by averaging the pixel values of night-light within the grids. We also computed the distance of a grid from



night-light above the threshold intensity of 10 using ArcMap 10.2 (ESRI) as Euclidean distances.

**Forest patches:** The locations of the forest patches, generated by unsupervised classification (Basu et al 2013) including National Parks and Sanctuaries were {obtained from the Wildlife Database cell of the Wildlife Institute of India (<http://www2.wii.gov.in/nwdc/index.html>)}. Area under forest cover and euclidean distances from such forest patches for each grids were generated using Arc GIS 10.2 (ESRI).

**Wildlife habitat:** Ecological Niche Factor Analysis (ENFA) with GPS fixes from radio collared lions, lion signs (scats, predation events etc.) and historical ad-libitum lion sightings presence data were used in the program Biomapper to model lion habitat in this landscape (Basu et al. 2013). The area of wildlife habitat in each grid and distance of a grid from wildlife habitat were computed and used a covariate to explain livestock predation by lions. Since, the suitable areas are also optimal for other wild animals, henceforth we are using this covariate to depict the same as suitable wildlife habitats hereafter.

**Drainage:** Lion and leopards often use drainages as corridors and cover for movement. The major drainage maps of the digital chart of the world (ESRI 1992) for the landscape at a scale of 1: 1000,000 were used. Total length of drainage in each of the grids was quantified using Hawth's tool in ArcMap 10.2 (ESRI). This drainage density for each grid along with euclidean distance from drainage calculated using ArcMap 10.2 (ESRI) were used as covariates of leopard predation.

We analysed temporal pattern in livestock predation of leopards by exploratory analysis and logistic regression. To explore the relationship of different factors that could potentially influence the occurrence of predation in a grid, we categorized the grid cells into presence or



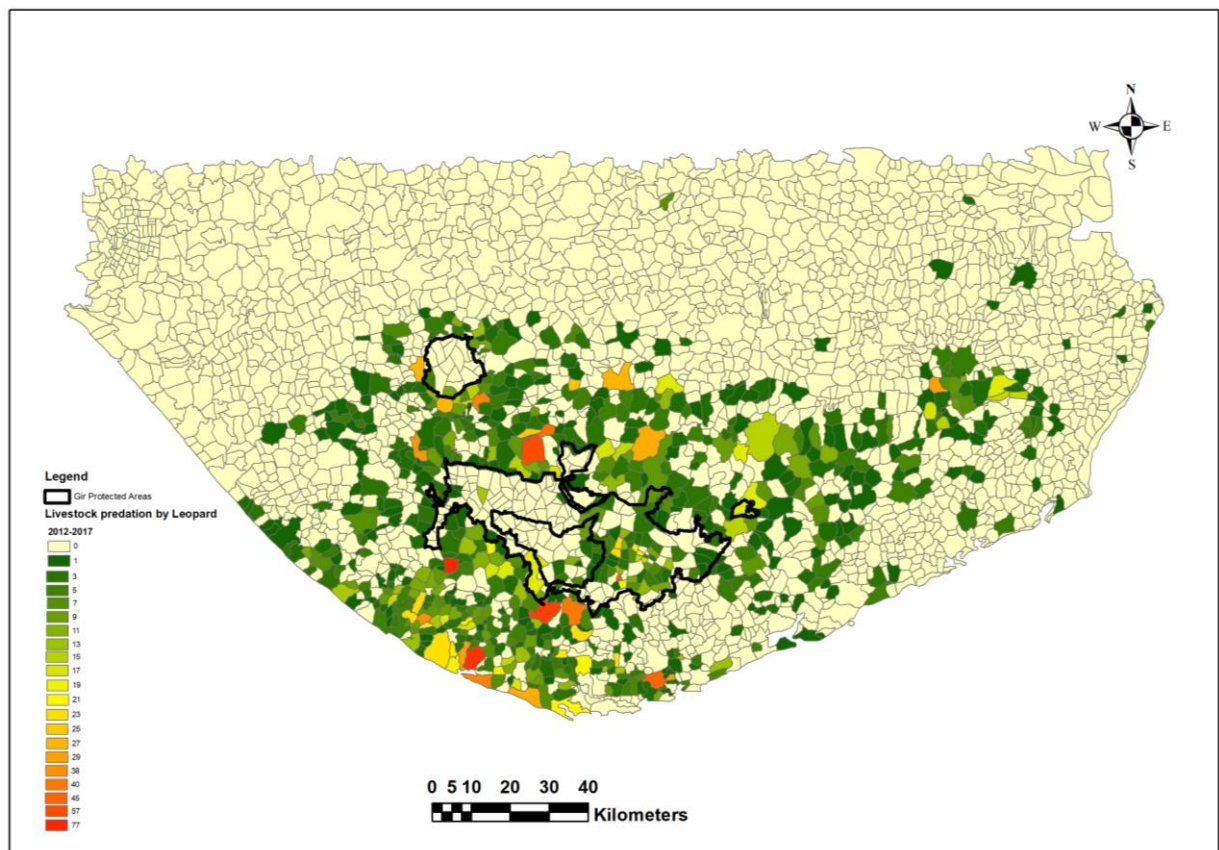
absence of predation events and box-whisker plots were plotted for each of the explanatory variables in NCSS (Fig 13 – Fig 22). Subsequently, to explore how the magnitude of conflict is influenced by different covariates, we categorized the predation events into No predation, Low, Medium and High predation magnitude and box-whisker plots were plotted against each of the variables in NCSS.

The Gujarat Forest Department pays compensation for damage caused by lion and leopard. Though it is one of the finest schemes in the country the compensation is a measure of reducing the impact of predation and does not fully cover the actual market price loss. We compiled the number of livestock killed by leopards in the Greater Gir Landscape annually and computed the compensation amount that would have been paid by the Gir Forest Department as per the official revised rates of 2015-2016. We compare this amount with the actual loss as computed from current market price of each livestock to estimate the actual monetary loss incurred by local community due to leopard predation despite being compensated. A temporal trend would provide an index of monetary loss and likely a source of resentment by community.



## Results:

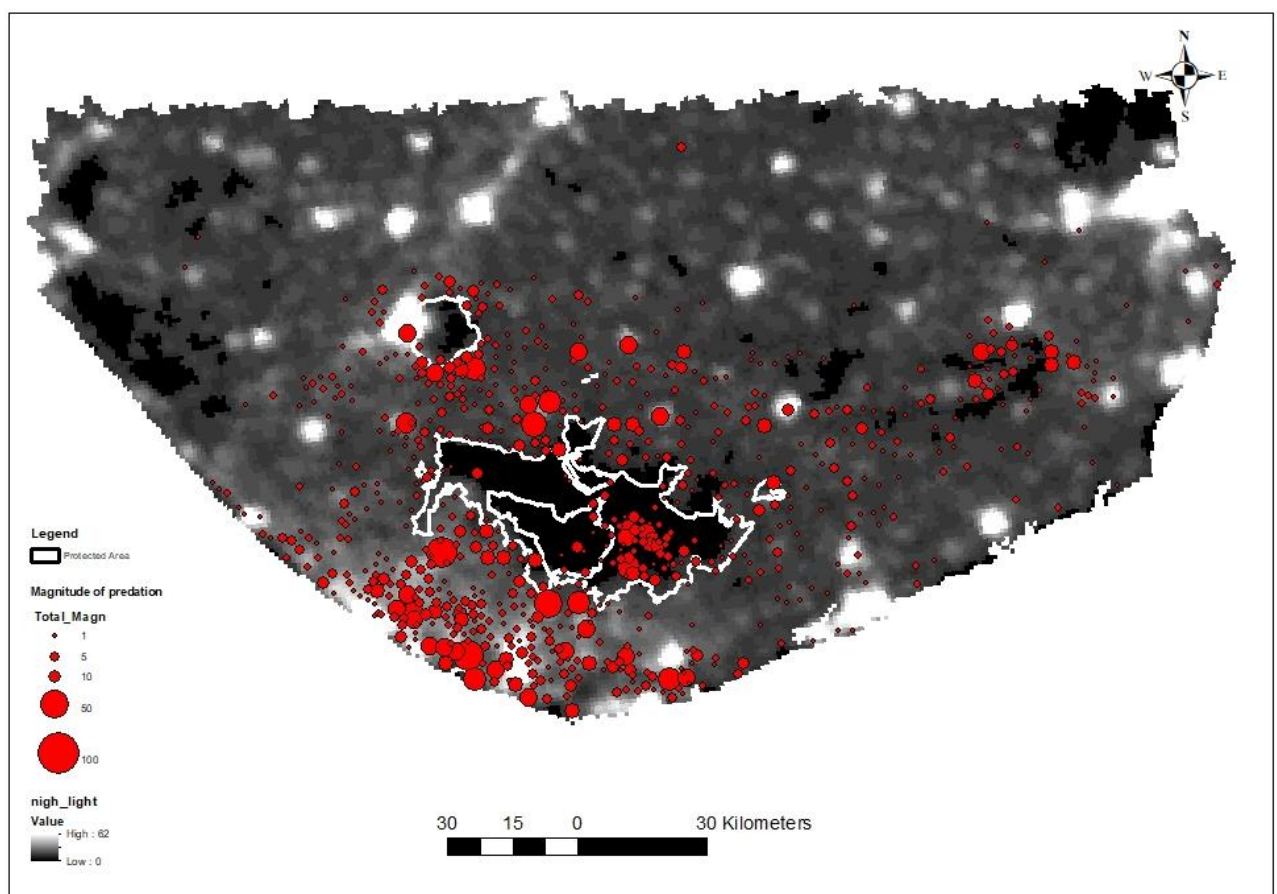
The extent of livestock predation by leopard across the Greater Gir Landscape of Saurashtra was found to be skewed. The Western and Coastal belt of the landscape had higher extent of livestock predation which towards the eastern side have very disjunct distribution. This is likely a function of habitat favourable to support higher leopard densities in the western and coastal zone as horticulture and orchards, mostly contributed by sugarcane which provides good cover and breeding ground for the large carnivore.



**Fig 3:** Village level magnitude of livestock predation by leopard in last 5 years (2012 to 2016) within the Greater Gir Landscape of Saurashtra



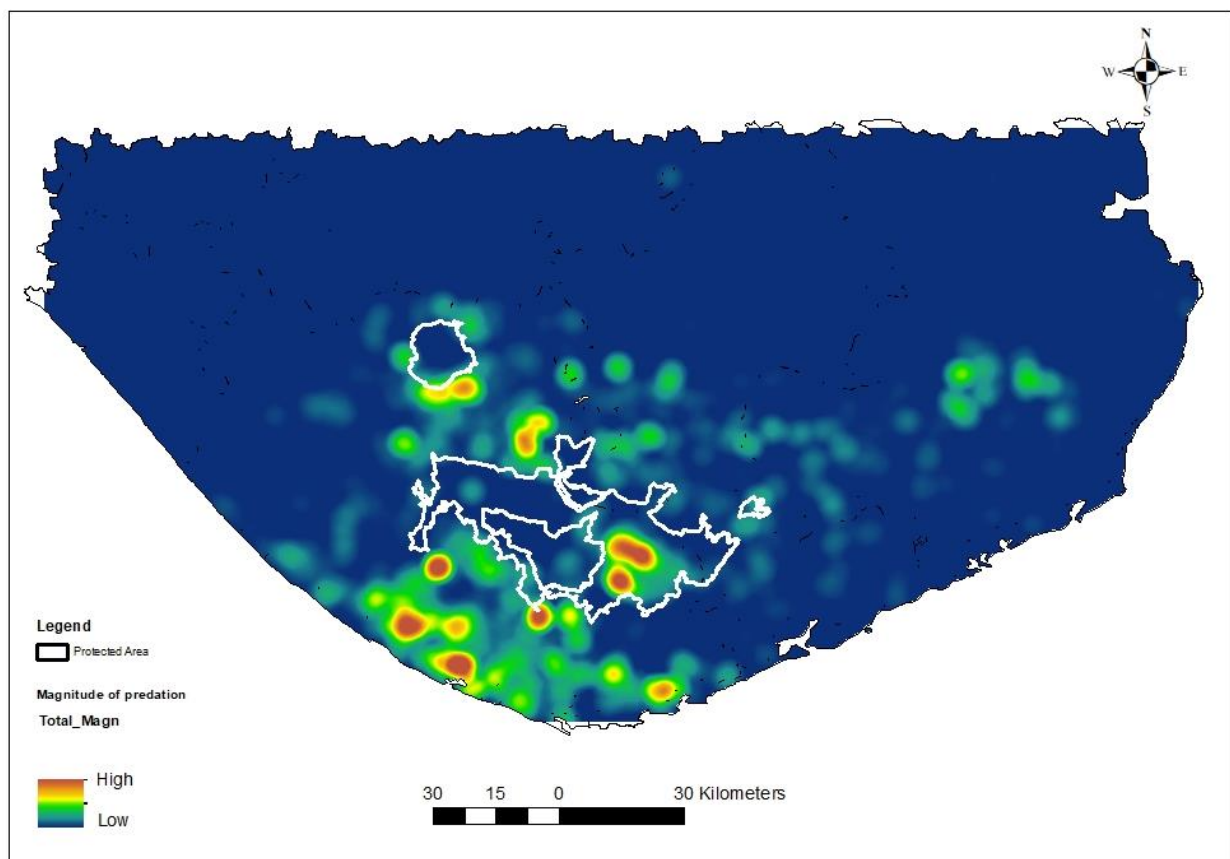
High predation was recorded from villages bordering the protected areas and in the coastal region (Fig 4). There seems to be no spatial relation between intensity of nightlight and predation magnitude. This shows that leopards killed livestock across the landscape irrespective of the size of human and livestock population at a site.



**Fig 4:** Distribution and intensity of livestock predation by leopard between the years 2012 to 2016 overlaid on night-light intensity within the Saurashtra landscape.



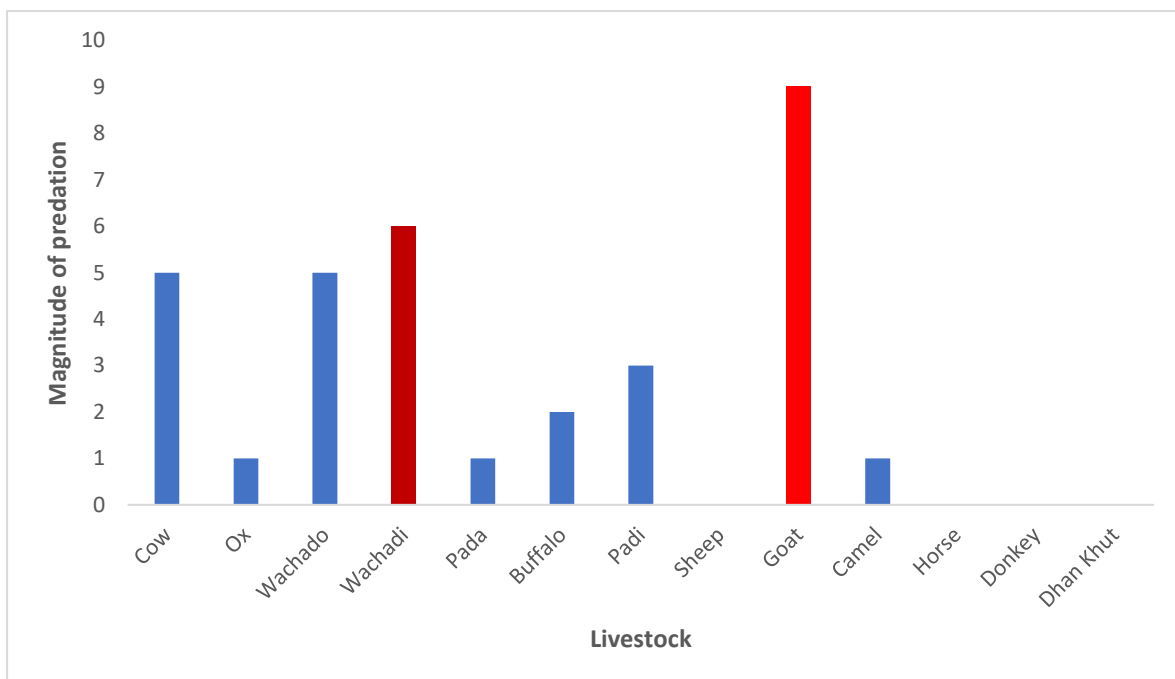
The kernel utilization distribution (Fig 5) shows a clear pattern of livestock predation with high intensity recorded along Girnar Sanctuary, Mendarda, Visavadar, Talala, Tulsishyam, coastal regions of Veraval, Sutrapada, Kodinar and Una as well as areas of Palitana and Shihor (Fig 5). Temporal patterns of livestock predations across years were suggestive that the both intensity and spatial extant of livestock predation was on the rise in the areas like Talala, Mendarda, Visavadar, Girnar, coastal villages of Mangrol, Veraval, Sutrapada and Una, as well as villages of Dhari, Amreli and Shiror-Palitana areas. However, not much change in spatio-temporal extant of livestock predation by leopard is observed in vilages around Shetrunji, Savarkundla and Eastern coastline vilages of the Greater Gir Landscpae. (Fig S1, S2, S3, S4, S5).



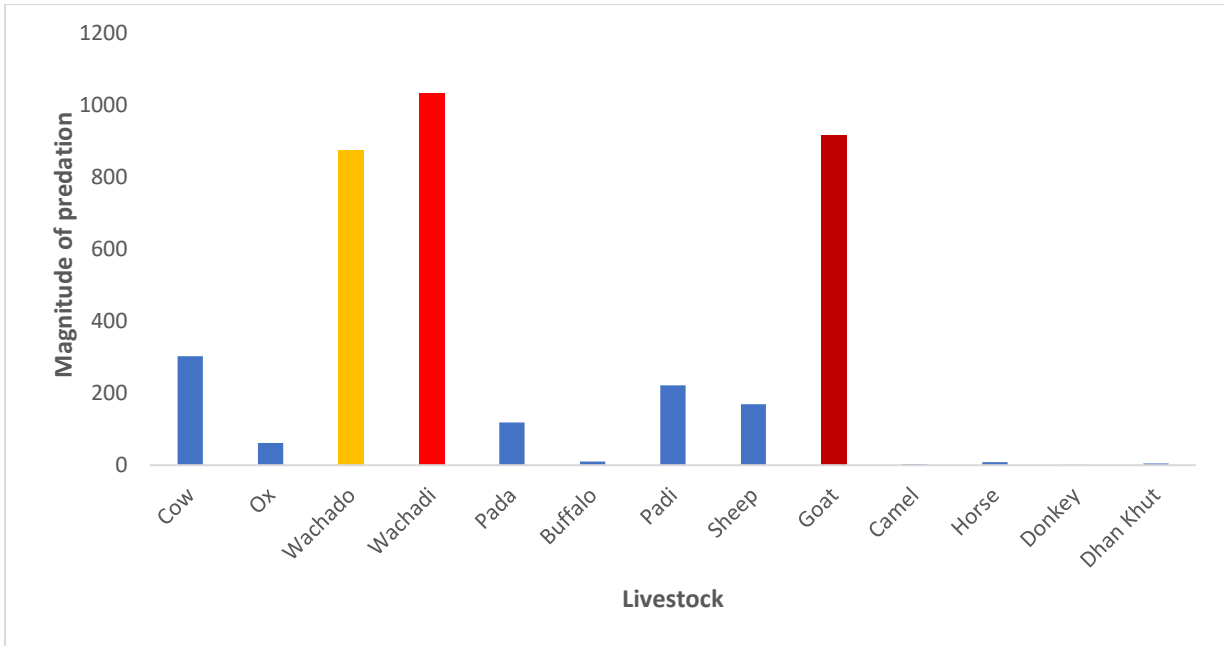
**Fig 5:** Kernel density of livestock kill intensity by lions within the Greater Gir Landscape between 2012-2016



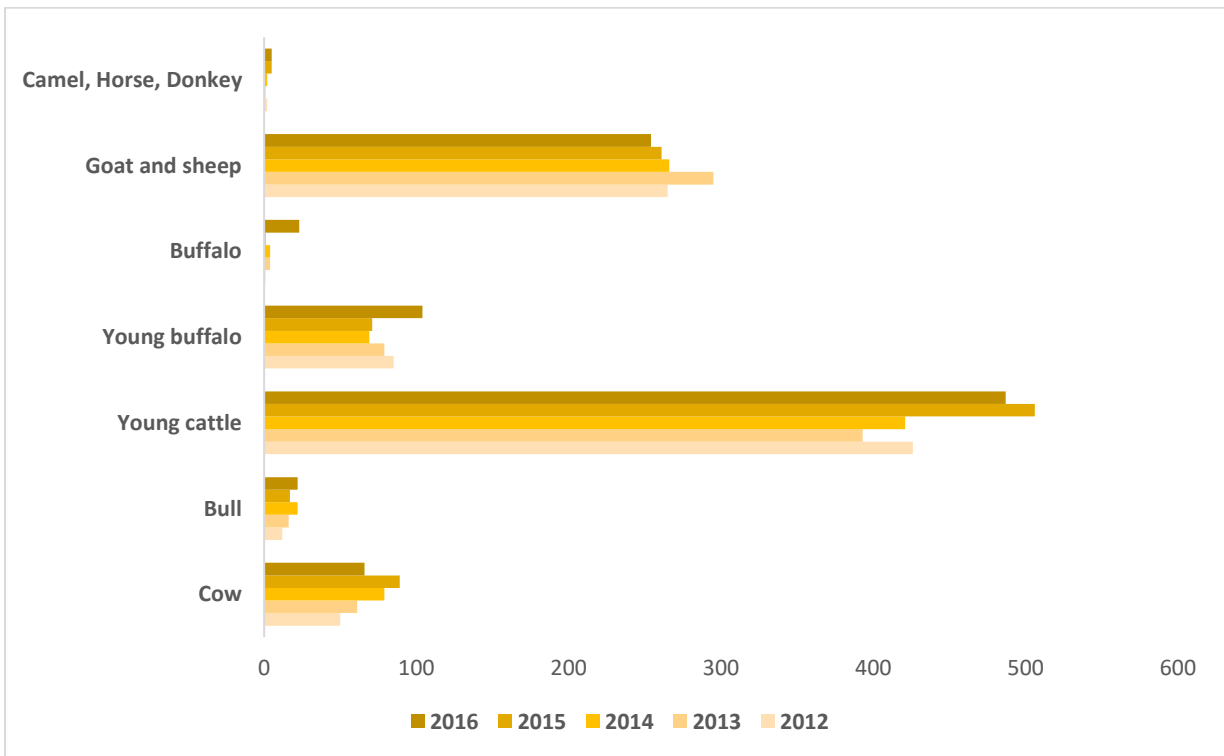
Leopards were observed to predate maximum on goat followed by young cattle inside the protected area (Fig 6), whereas leopard predation was more on young cattle, followed by goat and cow outside the protected area (Fig 7). There is not much difference in the array of livestock predation by leopards across the landscape (Fig 6 and Fig 7). An increasing trend was observed in the number of cattle killed by leopard while predation on goat and sheep has a declining trend, buffalo and other livestock did not show a temporal trend (Fig 8).



**Fig 6:** Graph showing the number of depredated livestock by leopard inside the protected area.



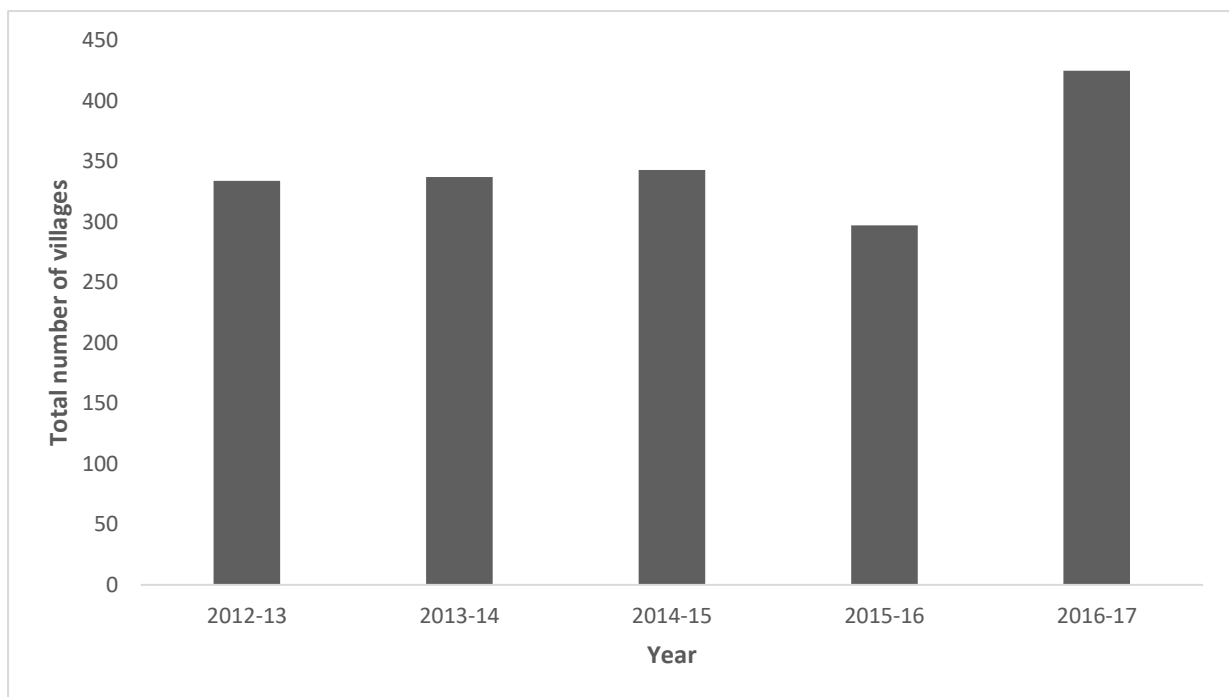
**Fig 7:** Graph showing the number of depredated livestock by leopard outside the protected area.



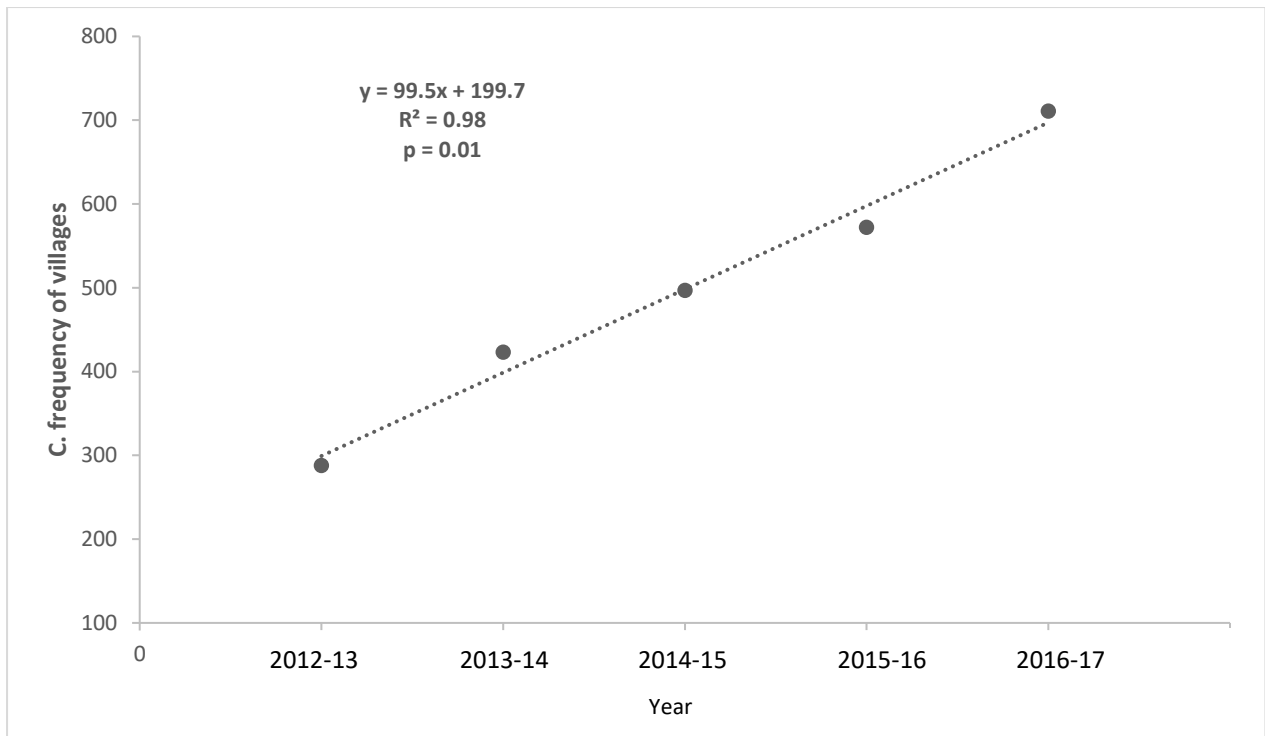
**Fig 8:** Number of different livestock preyed upon by leopard between 2012 to 2016.



There was no significant increase in the number of villages that registered predation on livestock by leopards, however there is a small spurt in year 2016-17 (Fig 9). The cumulative number of villages that reported leopard kills of livestock increased linearly ( $R^2 = 0.98$ ), with an addition of over 99 new villages each year. This is indicative of an expanding leopard population across the landscape (Fig 10), although the total number of villages reporting livestock predation by leopard is stable.

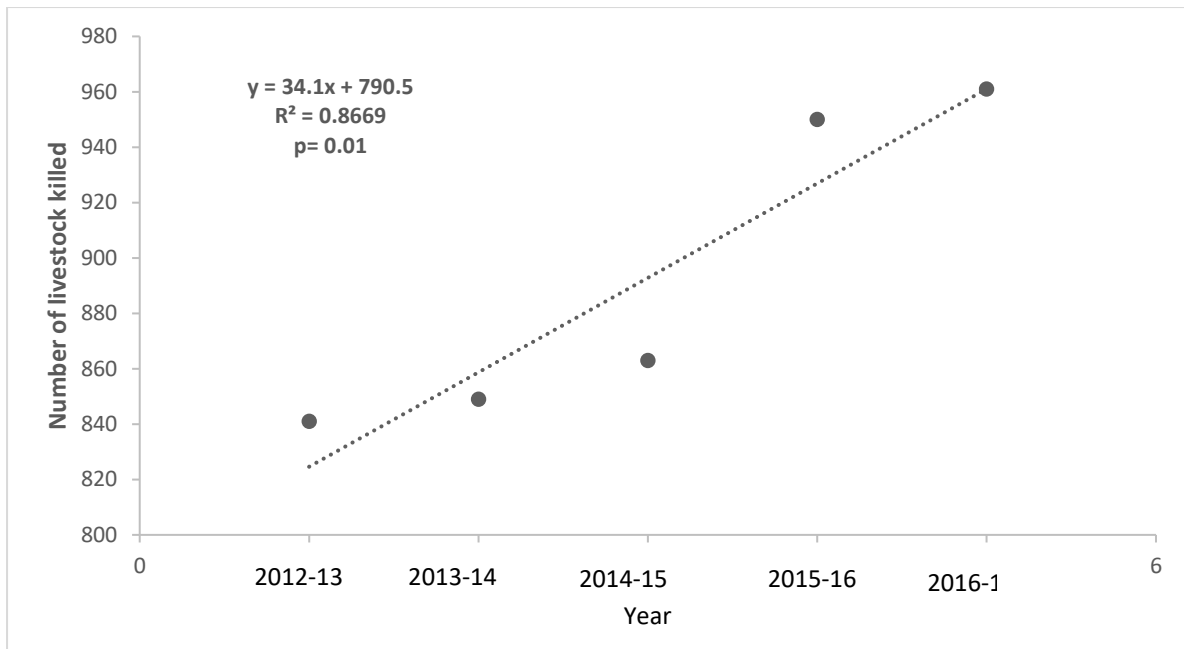


**Fig 9:** Graph showing the total number of villages under predation by leopards in last 5 years from 2012 to 2016.

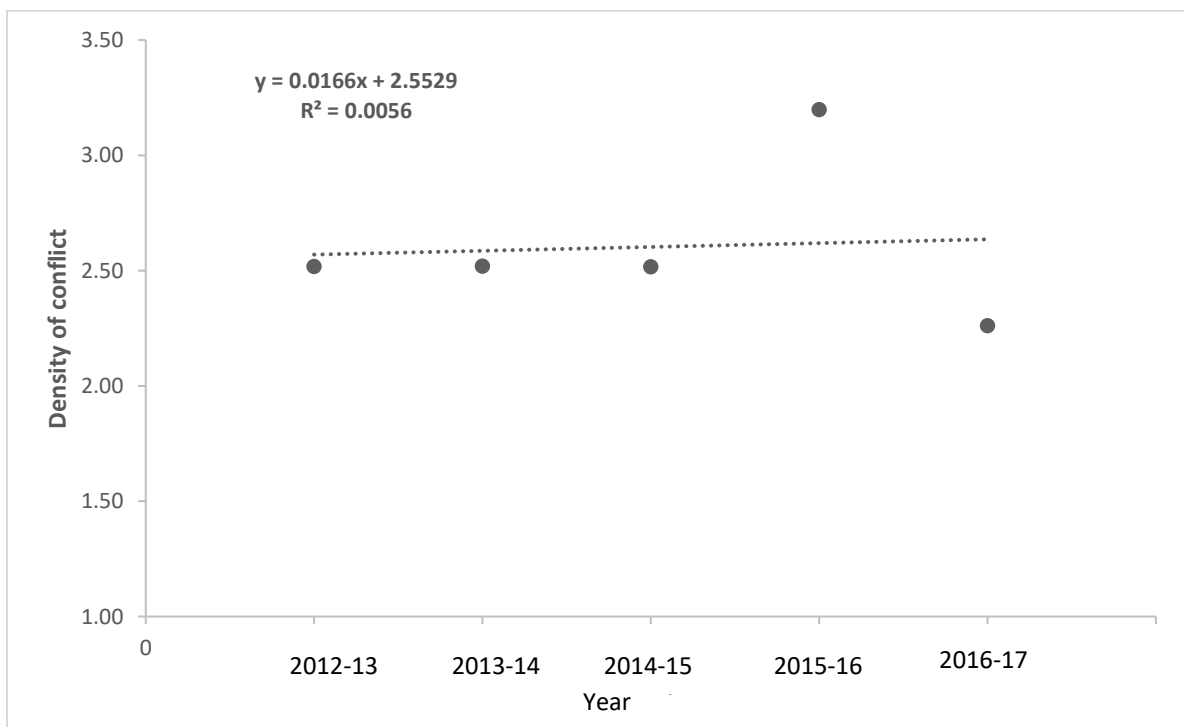


**Fig 10:** Cumulative number of villages where leopard depredated livestock in the last 5 years (2012 to 2016).

The number of livestock killed by leopard showed an increasing trend between 2012 to 2016, with an predation increment of more than 34 livestock per year in the landscape ( $R^2=0.86$ ,  $p=0.01$ ) (Fig 11). This could be a result of increasing population of leopards in the landscape. Intensity of conflict, indexed through number of conflicts/number of villages did not show any trend (Fig 12). This shows that in the passing years with an expanding leopard and human population, the magnitude of conflict is not increasing but has remained stable. However the increasing number of livestock predated by the expanding leopard population in the human dominated landscape is a matter of serious concern.



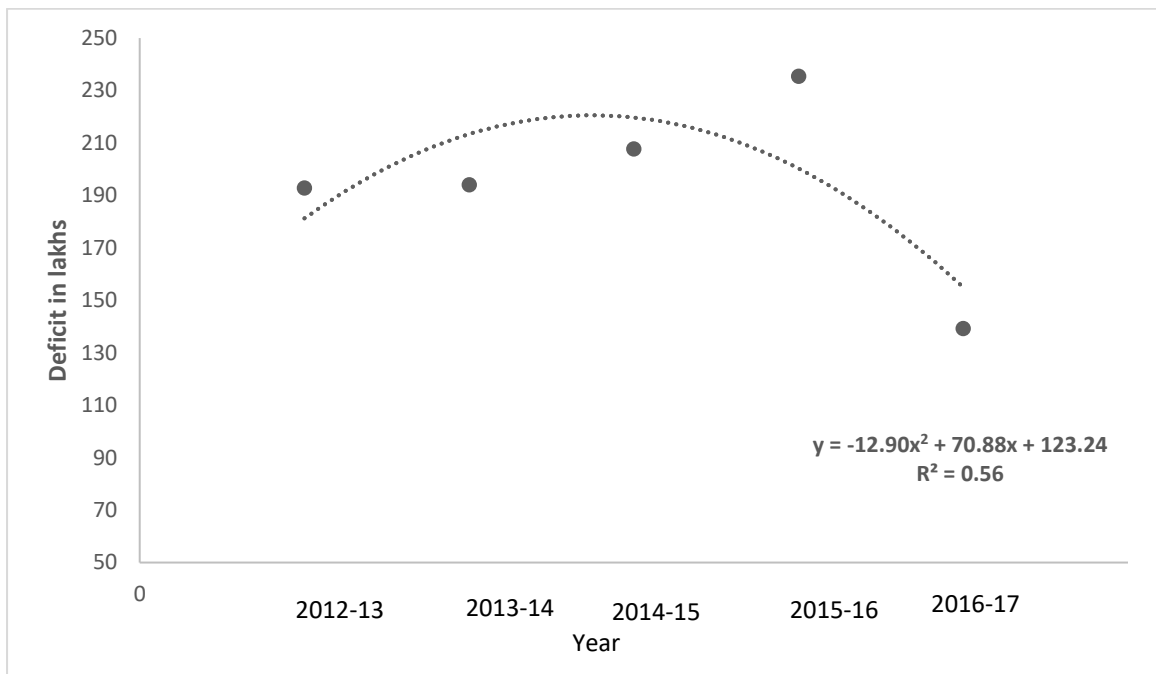
**Fig 11:** Graph showing the trend of livestock killed by leopard in the last 5 years (2012 to 2016) within the Greater Gir Landscape.



**Fig 12:** Graph showing the intensity of livestock predation by leopard (number of predation events / number of villages with predation per year) by leopard in the last 5 years (2012 to 2016) within the Greater Gir Landscape.



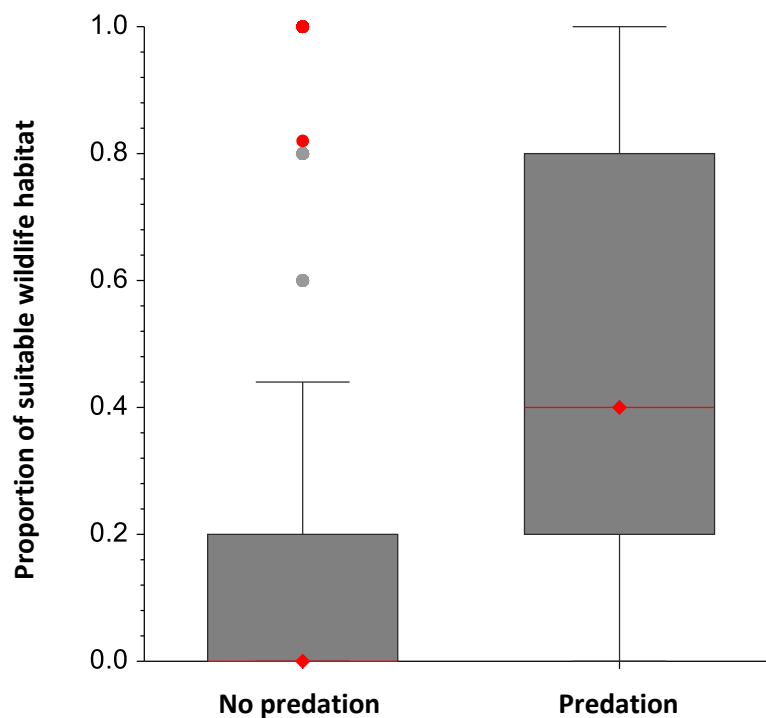
The Gujarat Forest Department has a good livestock compensation scheme and mechanisms for payment in India. Yet, an analysis of the magnitude of market rate economic loss incurred by leopard predation with potential and actual compensation paid showed a significant deficit. After the revision of compensation scheme by the forest department in 2015-16 the margin has comedown, however the deficit is still significant, about one hundred and twenty-three lakh of rupees a year (Fig 13). Such an increasing deficit is likely to result in increasing resentment by local communities towards leopards living in their backyards.



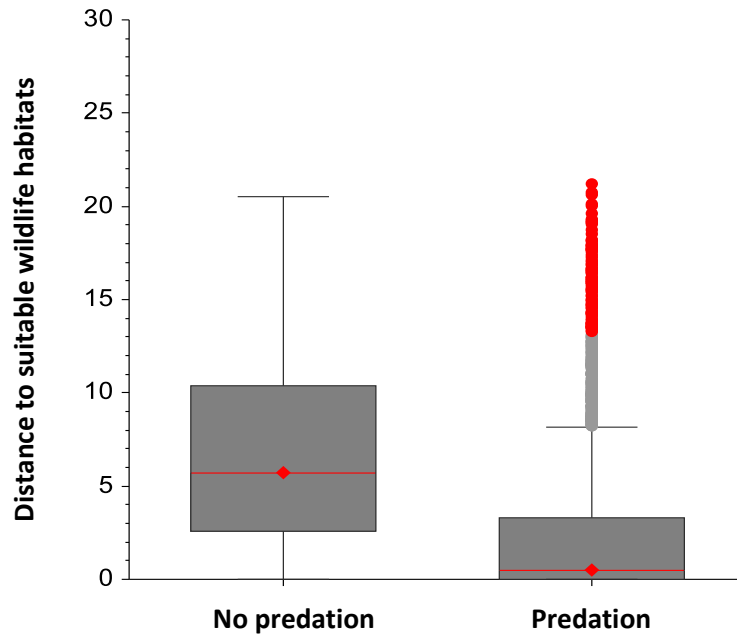
**Fig 13:** Graph showing yearly differences in compensation paid by the Forest Department and actual market value of the livestock. This shows economic loss to the locals to predation by leopard in last five years (2012 to 2016) despite claiming of compensation.



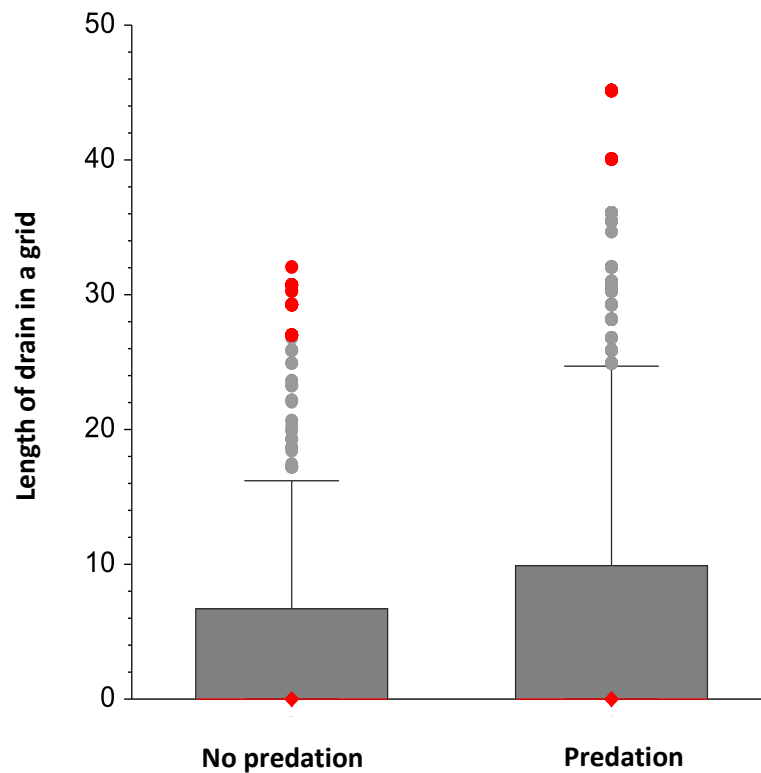
It was found that grids where livestock predation has occurred was associated with high proportion of suitable habitats within it (Fig 14). Similarly, grids with livestock predation were also found to be close to forest patches and highly suitable wildlife habitats (Fig 15). We also found that areas with higher drainages had a greater chance of predation by leopard (Fig 16). Drainage act as natural movement corridors for large carnivores in human dominated landscapes. Our results show that leopard attacks on livestock had no relation with distance from and size of human settlement (Fig 17).



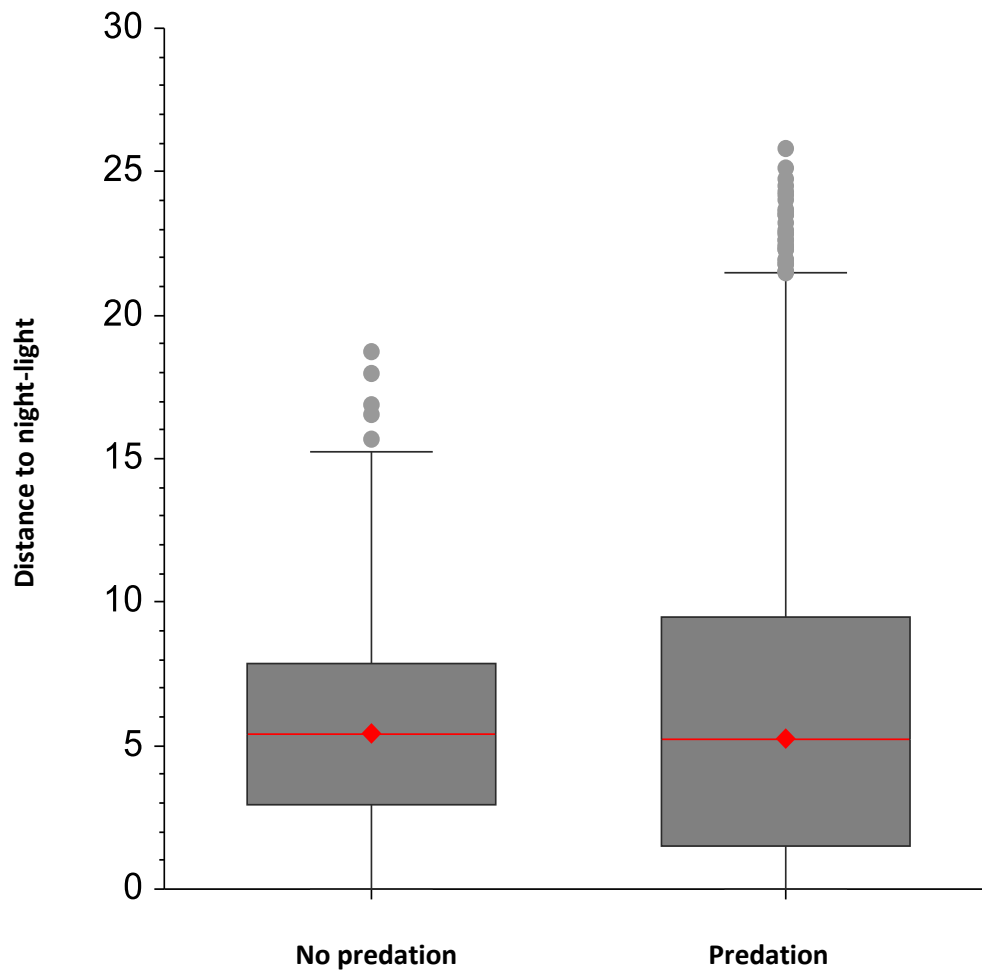
**Fig 14:** Box-whisker plot showing distribution of livestock predation with proportion of lion habitat present in the respective grids. This shows that presence of livestock predation was high in grids with high lion habitats.



**Fig 15:** Box-whisker plot showing distribution of livestock predation categorized into no-predation and predation with distance of the respective grids from suitable wildlife habitats which were mapped through a habitat suitability analysis using long-term information of lion locations in the landscape. Presence of livestock predation was higher in grids near to such suitable wildlife habitats.



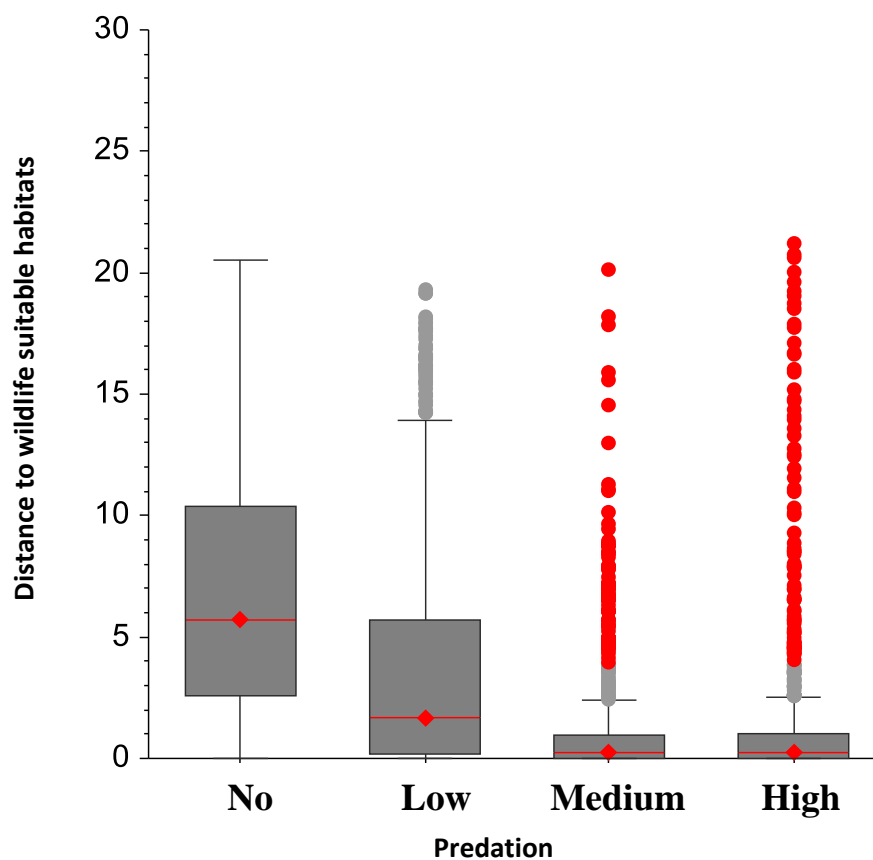
**Fig 16:** Box-whisker plot showing distribution of livestock predation chategorised into no-predation and predation with the total length of drainages present in the grids. Presence of livestock predation was higher in grids with greater lengths of drainages.



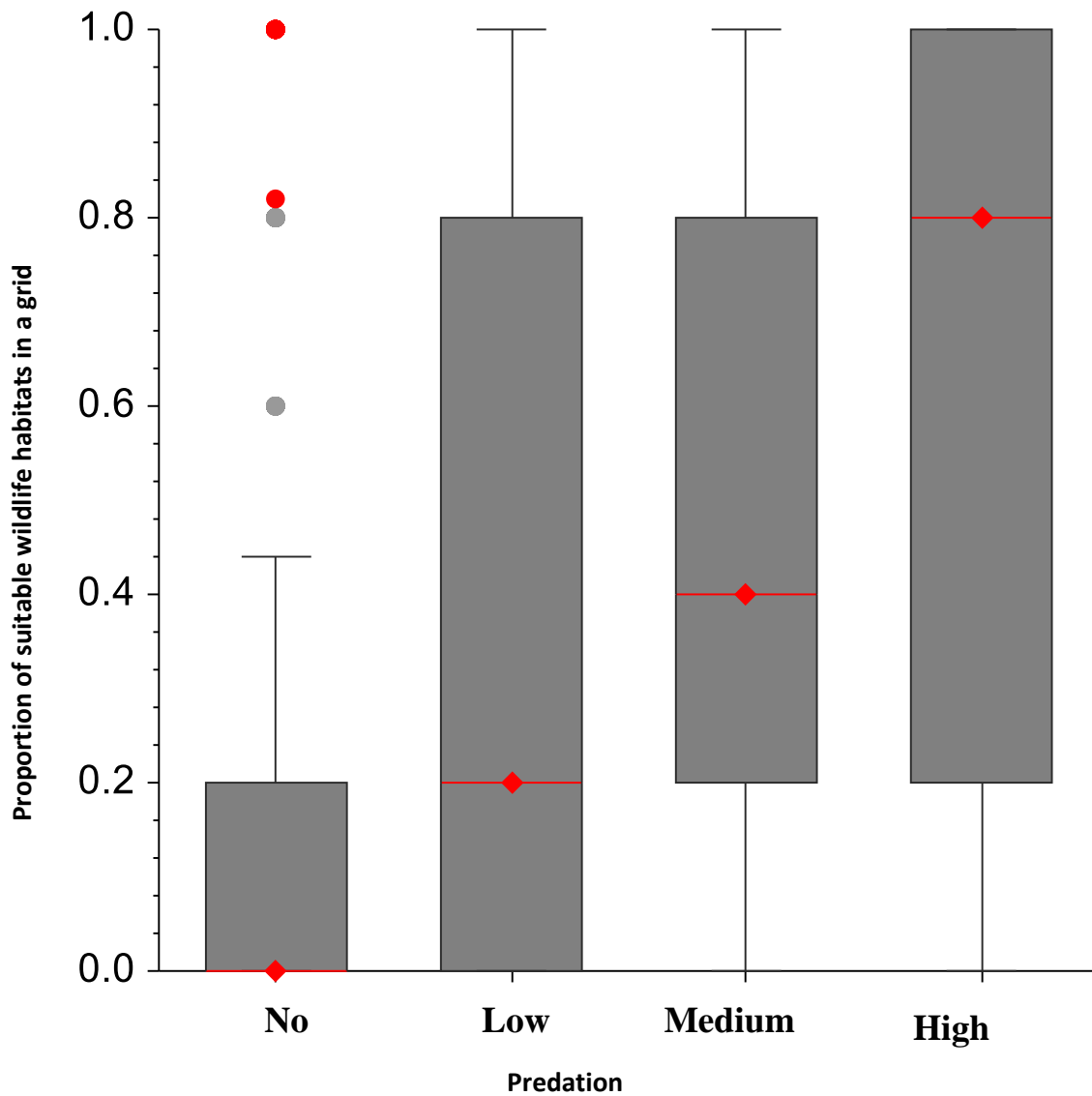
**Fig 17:** Box-whisker plot showing distribution of livestock predation categorized into no-predation and predation with the distance to built-up areas, surrogated by the intensity of nightlights. Livestock predation was found to be present both in areas near and far from such built-up areas, however, the magnitudes were higher away from urban centres.



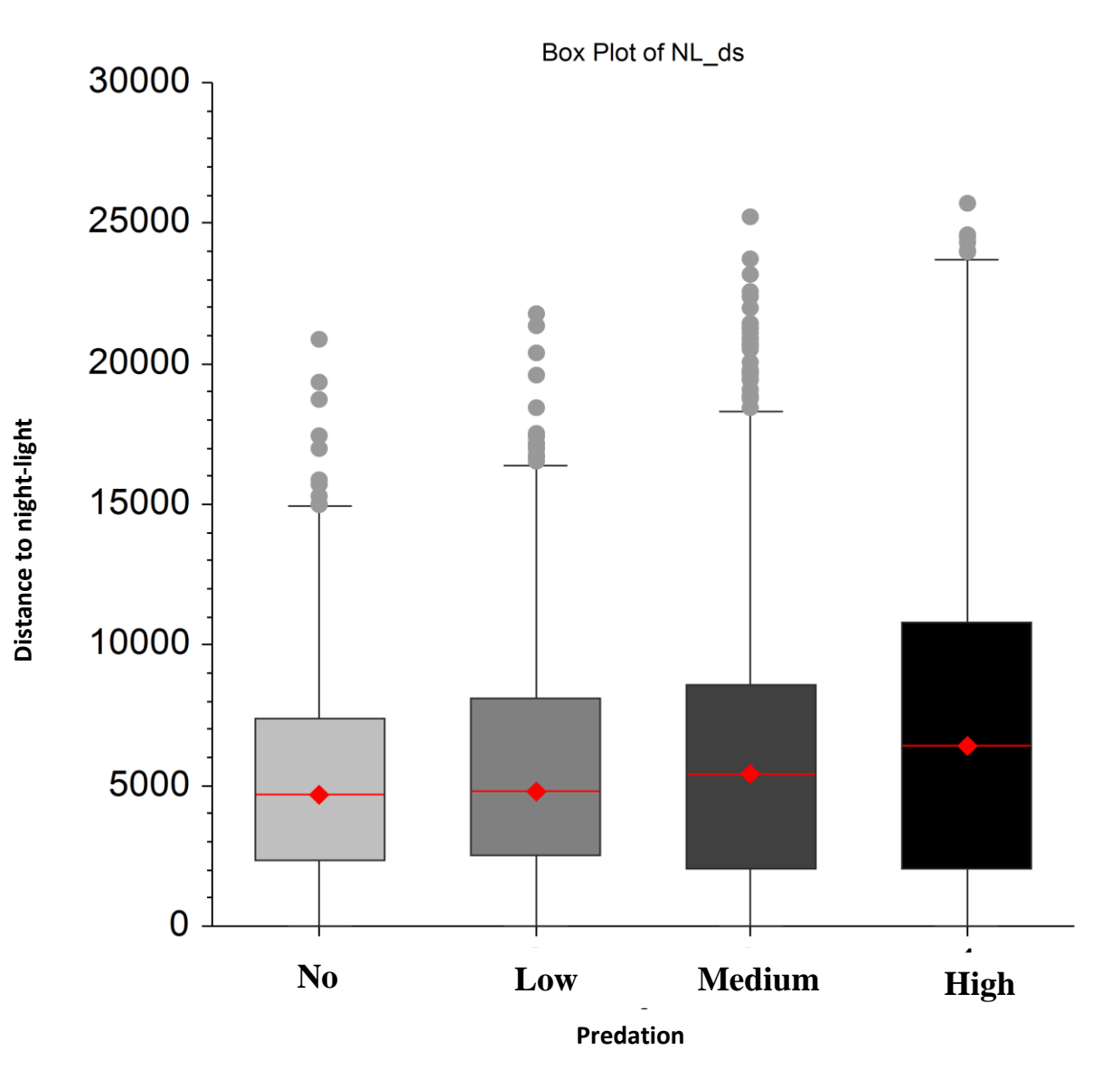
Categorization of magnitudes of livestock predation further indicated that areas which are closer to suitable wildlife habitats suffered higher predation, and leopard conflict progressively declined with increasing distance from such habitats (Fig 18). Areas with high proportion of suitable wildlife habitats were found to have higher predation (Fig 20). Urbanization surrogated by intensity of nightlight had no effect on the livestock predation by leopard (Fig 23).



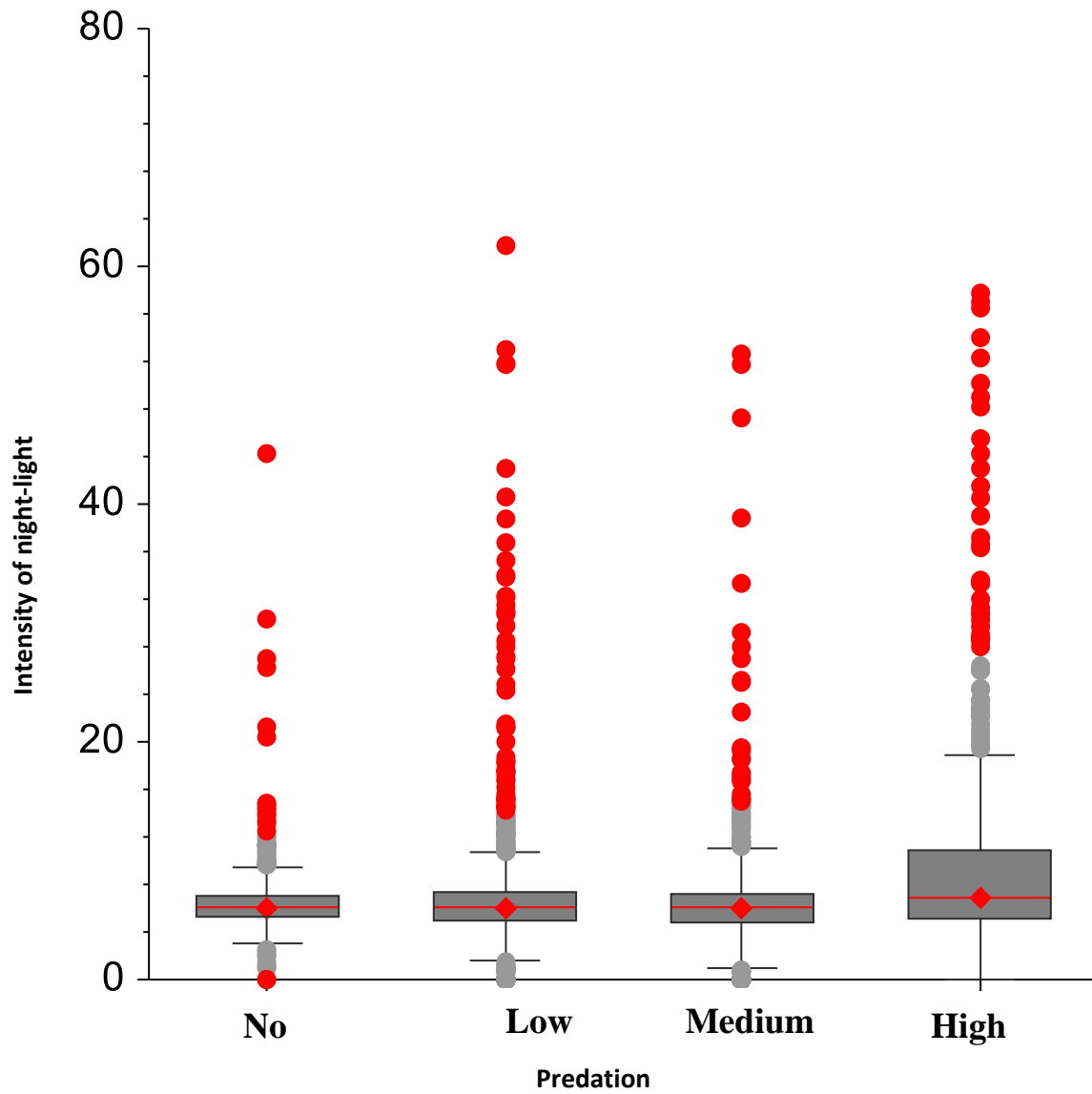
**Fig 18:** Box-whisker plot showing distribution of livestock predation by leopard (categorized into four classes of no (1), low (2), medium (3) and high (4)) with the distance to suitable wildlife areas. This shows that high livestock predation was found in areas closed to such suitable wildlife habitats which progressively decline with increasing distance from such habitats.



**Fig 19:** Box-whisker plot showing distribution of livestock predation by leopard (categorized into four classes of no (1), low (2), medium (3) and high (4)) with the proportion of suitable wildlife areas in the respective grids. This shows that high livestock predation was found in grids with greater proportion of lion habits, which decline with decrease in such habitats in a grid.



**Fig 20:** Box-whisker plot showing distribution of livestock predation by leopard (categorized into four classes of no (1), low (2), medium (3) and high (4)) with the distance from night-light, surrogates urbanization. This shows no relation of livestock predation by leopard with distance to urbanisation.



**Fig 21:** Box-whisker plot showing distribution of livestock predation by leopards (categorized into four classes of no (1), low (2), medium (3) and high (4)) with the intensity of night-light surrogating urban and built-up areas in a grid. This shows that leopards were predated livestock all across the landscape irrespective of urbanisation.



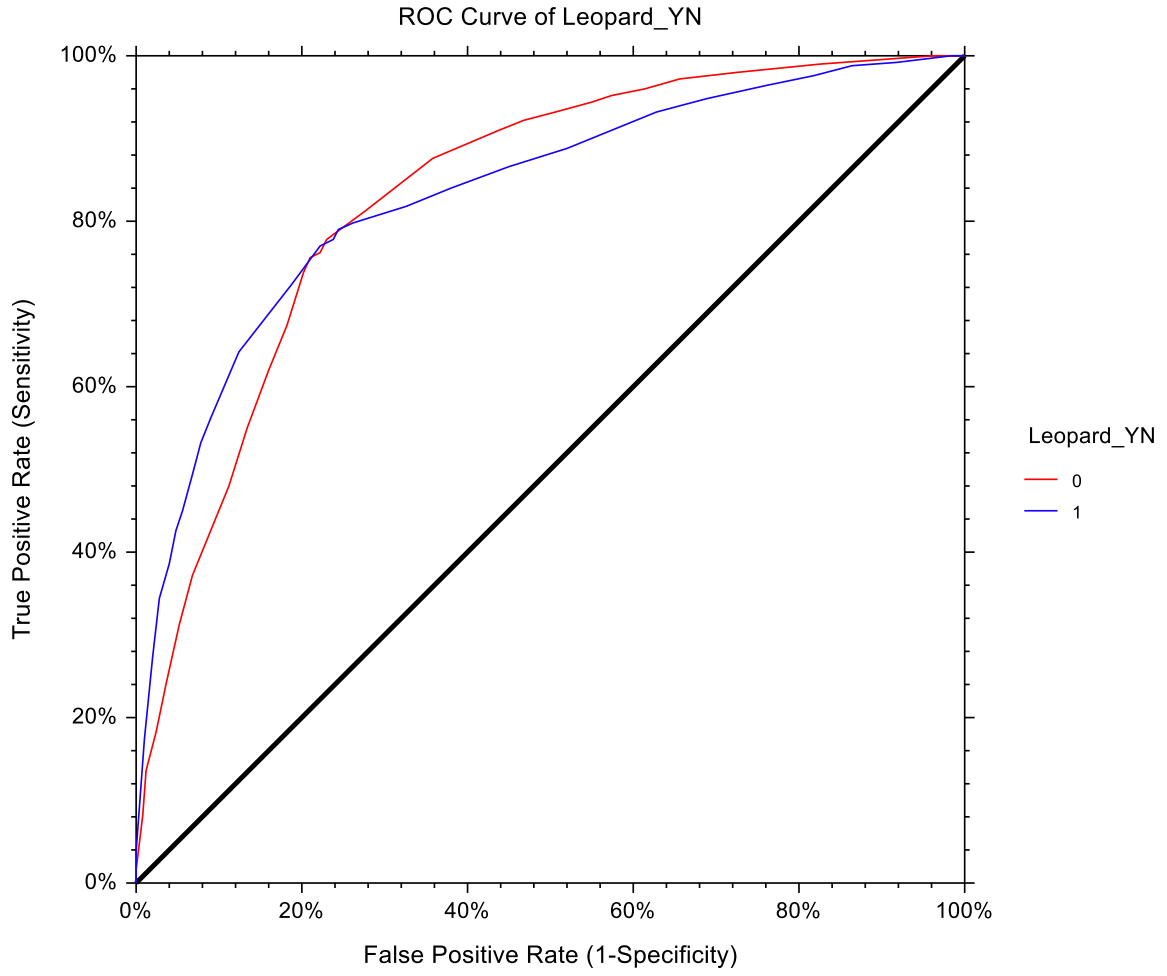
The magnitude of livestock predation by leopards at any given village in the study area was best explained by a model having the additive effect of proximity to suitable wildlife areas (Dist\_Whab), proportion of wildlife habitat in a grid (Prp\_Whab) and intensity of urbanization (NL) (Table 1) given by:

$$\text{Model: } \log \left( \frac{\text{conflict grids}}{\text{no conflict grids}} \right) = 0.48 - 0.81 * \text{Dist\_Whab} + 0.98 * \text{Prp\_Whab} + 23 * \text{NL}$$

For the above model we used the predictor variables mentioned in the method section, which explains that villages or townships those are closer to high wildlife suitable areas, with significant urbanisation and contains wildlife habitats within, are prone to high cattle predation by leopards.

**Table 1:** Logistic regression table

<b>Independent Variable</b>	<b>Regression Coefficient</b>	<b>Standard Error</b>	<b>Wald Z-Value</b>	<b>Wald p value</b>
Intercept	0.48	0.04	11.19	0
Prp_Whab	0.98	0.05	16.49	0
Dist_Whab	-0.81	0.04	-18.04	0
NL	0.23	0.06	3.58	0.0003



**Fig 22:** Model fit of the logistic regression as assessed by Receiver Operator Curve



### **Villages with high livestock predation:**

Based on the magnitude of livestock predation by leopard a list of villages which are of utmost priority for mitigation measures are listed below. Villages with magnitude of conflict more than 20 incidents in the last 5 years are listed in table 2. Other villages with magnitude of 19-10 livestock predation in the last 5 years are categorized as moderate priority villages (Table A1) and villages with magnitude of <10 predations were listed as low priority villages (Table A2).



**Table 2:** Villages with magnitude of conflict more than 20 between 2012 to 2016.

<b>Village</b>	<b>Taluka</b>	<b>District</b>	<b>Total_Magn</b>
Talala	Talala	Junagadh	77
Lodhva	Sutrapada	Junagadh	72
Ghantvad	Kodinar	Junagadh	71
Visavadar	Visavadar	Junagadh	57
Umej	Una	Junagadh	46
Una	Una	Gir Somnath	45
Bhutdi	Visavadar	Junagadh	43
Harmadiya	Kodinar	Junagadh	40
Bilkha	Junagadh	Junagadh	39
Dhamlej	Sutrapada	Junagadh	39
Navadra	Veraval	Junagadh	38
Mendarada	Mendarada	Junagadh	30
Jaliya	(blank)	Bhavnagar	29
Prashnavda	Sutrapada	Gir Somnath	29
Gir Gadhada	Gir Gadhada	Gir Somnath	29
Dhari	Dhari	Amreli	28
Chhara	Kodinar	Junagadh	28
Khadiya	Junagadh	Junagadh	27
Bagasara (M)	(blank)	Amreli	27
Junagadh	Junagadh	Junagadh	27
Manekvada	(blank)	Amreli	26
Mandavad	Visavadar	Junagadh	25
Savni	Veraval	Junagadh	24
Bhacha	Gir Gadhada	Gir Somnath	24
Bhadiyadar	Una	Amreli	24
Alidar	Kodinar	Junagadh	23
Patan	Veraval	Junagadh	23
Sutrapada	Sutrapada	Gir Somnath	23
Jamanvada	Kodinar	Junagadh	22
Meghapura	Veraval	Junagadh	22
Vavadi	Sutrapada	Gir Somnath	22
Rakhej	Sutrapada	Gir Somnath	22
Kanek	Gir Gadhada	Gir Somnath	22
Nathej	Una	Gir Somnath	22
Dolasa	Una	Gir Somnath	21
Velan	Kodinar	Junagadh	21
Samter	Una	Gir Somnath	20



## Discussion:

The leopard, one of the most widely distributed large felid in India, found across different ecosystems with a significant number existing outside of protected areas (Athreya *et al.*, 2010, Daniel, 1996). They are well adapted to a variety of climatic regions, prey bases and diverse landscapes including human habitats (Daniel, 1996, Edgaonkar and Chellam, 2002, Johnsingh Panwar and Rodgers, 1991). In Saurashtra, leopard population is thriving under the umbrella of protection measures taken for lion conservation in the multi-used human dominated landscape. Inter-specific competition in carnivores usually increases when the diet and adaptations of morphological features are similar (Morin 1999). The coexistence of morphologically alike species and avoidance of interspecific competition is attained by behavioral mechanisms like spatially and temporally segregating their activities (Pianka 1974, Schoener 1974, Durant 1998, Linnell and Strand 2000, Harrington *et al.* 2009). Information on the spatial distribution and densities of leopards are not known for the protected areas or the human dominated Greater Gir Landscape, however due to their ecological niche segregation it is expected to have different spatio-temporal pattern of livestock predation by leopards and lions in the landscape. Dominance by lions might also cause leopards to live in suboptimal habitats of human modified environments or in habitats where they can escape from lions enhancing the interface and conflict between human and leopards.

Our results indicate that the chances of livestock predation by leopards occurring in an area was positively affected by the amount and proximity of suitable wildlife habitats in a village with moderate level of urbanization, proximity to suitable wildlife habits and distance to forest patches. However, the conflict information presented here represents data that has been reported to the forest department. Thus, such information represents two important facets:



1. **Ownership of livestock:** The kill data comes from livestock that are owned. The landscape also comprises of a high density of feral livestock which are significantly cropped by leopards (Banerjee 2012, Chakrabarti et al. 2016). However, such livestock losses are not reported for compensation claim. However, such losses are unlikely to cause resentment in local communities as feral livestock are a serious problem for crop damage.
2. **Compensation claim:** Also, the information comes from only those cases which have been reported to the department for a compensation claim. Many cases are not reported. Thus, the data presented here also signify the level of awareness people have towards a government policy of compensating losses of livestock to leopard.

Based on our results, we propose the following mitigation strategies:

1. In areas with recent colonization by leopards, pastoral community should be educated about husbandry practices that minimize leopard-livestock interaction. An approach could be to make them visit Maldhari ness and with Maldhadhai who have mastered local methods to minimize conflict with carnivores in Gir and exchange information on husbandry practices.
2. A landscape level understanding of spatial density of both leopard, lion and their both domestic and wild prey population is necessary to findout site specific mitigation measures for the Greater Gir Landscape.



3. Compensation for livestock losses should be continued. A prompt and fair compensation would ameliorate the losses and build up the social carrying capacity for leopards in the landscape. Also, the compensation paid by the forest department should be revised as per the market rates and should cover the lost opportunity cost of the livestock killed (Banerjee et al. 2013).
  
4. Prompt action is required in the priority villages (Table 2) to mitigate high livestock kills by providing pulsating electric fencing to livestock pens.
  
5. In the long term some form of management mechanism will be needed to regulate the density of large carnivores in human dominated landscapes. This could be in the form of reproductive control through either immuno, chemical or hormonal contraception. Since there are no habitats where leopards could be captured and translocated within Gujarat without increasing human-leopard conflict.



## **Conclusion:**

Our report analyses information on livestock predation by leopard between 2012 to 2016 and provides insight into spatial and non-spatial pattern that would be useful for the management of negative interaction between leopards and humans.

It was found that the extent and intensity of leopard-livestock conflict is on the increase and can reach a tipping point if not addressed with innovative, proactive management interventions. Villages with heightened conflict have been identified for priority investments in mitigation measures. Drivers of leopard-livestock conflict were (a) Proximity to suitable wildlife habitats (b) proportion of wildlife habitat within a village, and (c) intensity of urbanisation. There seemed to be no relation to the size of villages with leopard predation. We propose a revised compensation scheme that reflects market reality and lost opportunity cost, as well as better husbandry practices to reduce livestock-leopard conflict. A landscape level density estimation of the large carnivores (lion and leopard), their prey (both domestic and wild) and assessment of habitats availability is the fundamental requirements to understand the conflicted situations in a more robust way and formulate site specific management strategies. A policy decision may soon be required on the social carrying capacity of leopards in the Greater Gir Landscape. Discussion and policy on how leopard population should be managed below this carrying capacity so as to continue to foster the co-existence between leopards and humans in this unique landscape is urgently required.

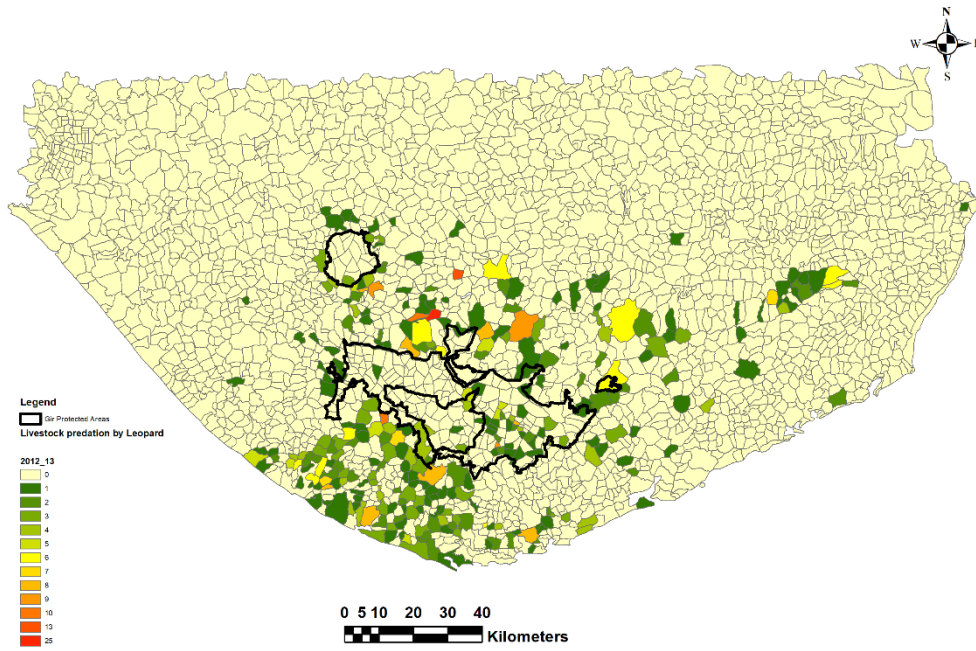


### **Acknowledgement:**

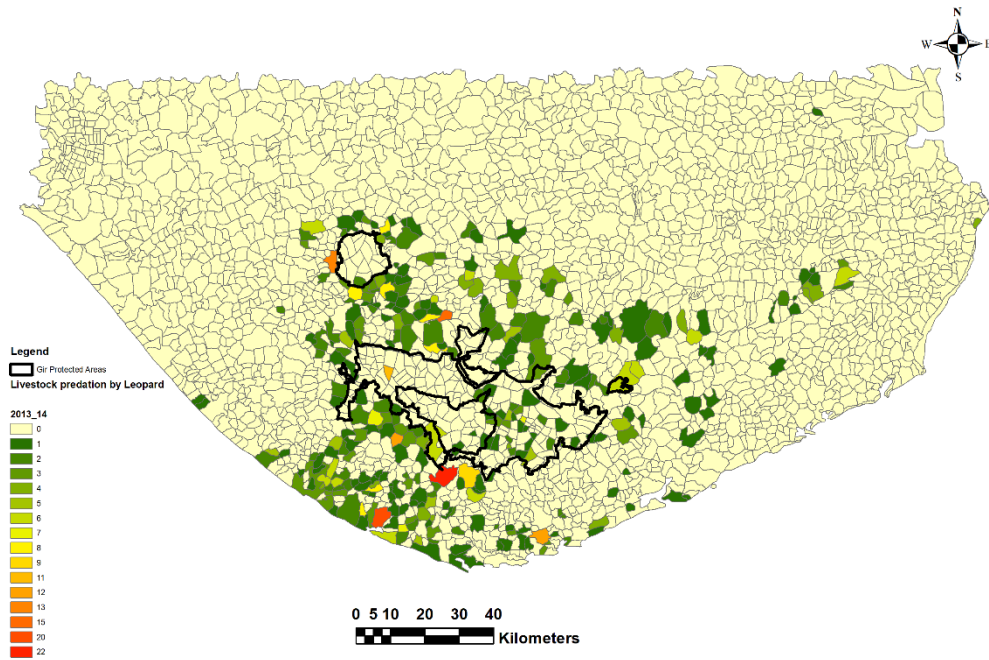
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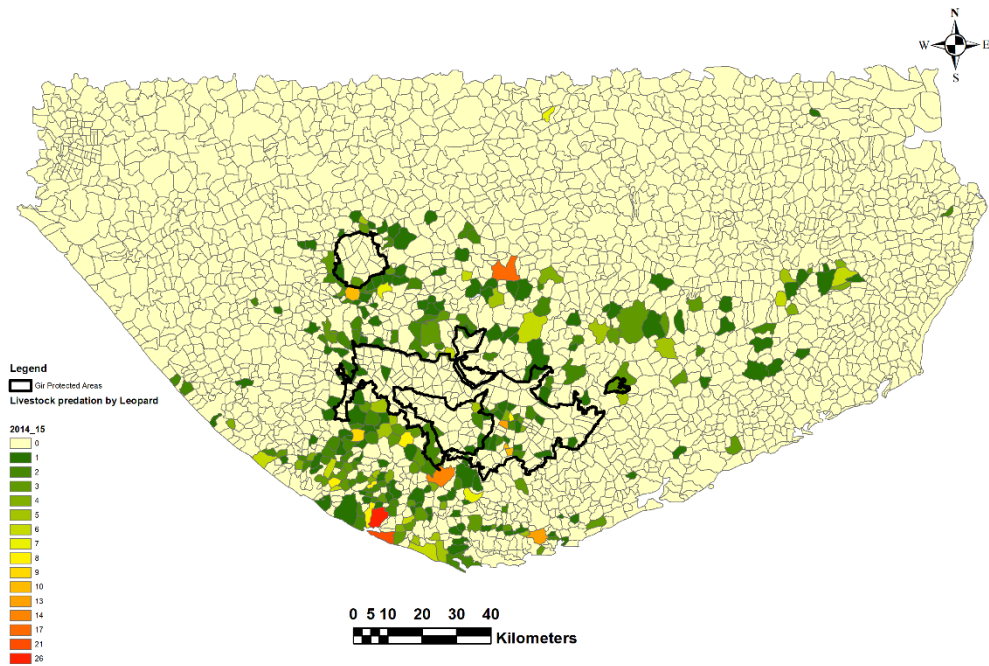
## Appendix



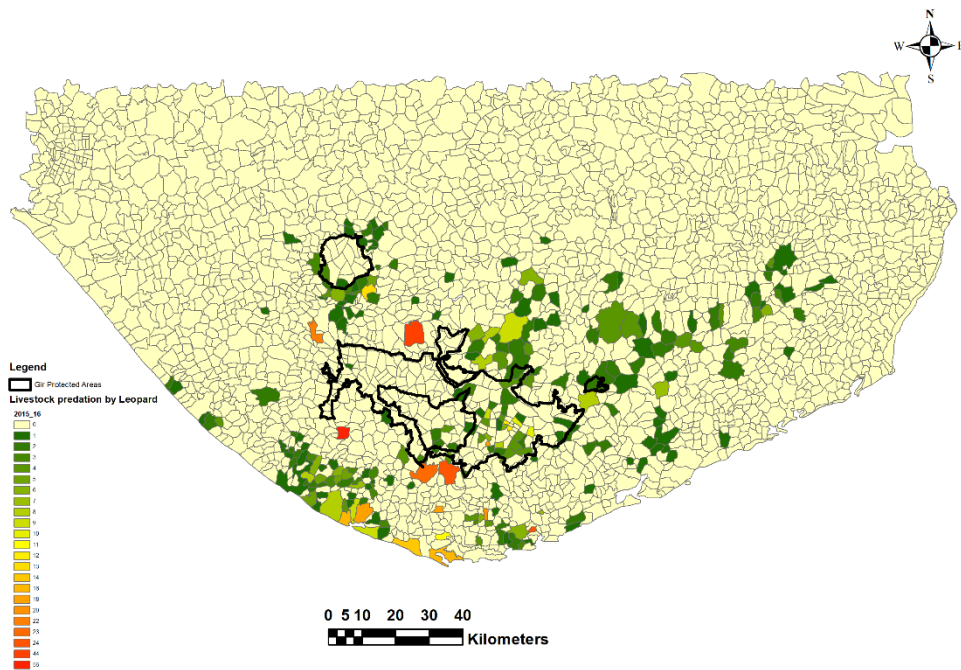
**Fig S1:** Map showing the villages with livestock predation by leopards in the year 2012-13



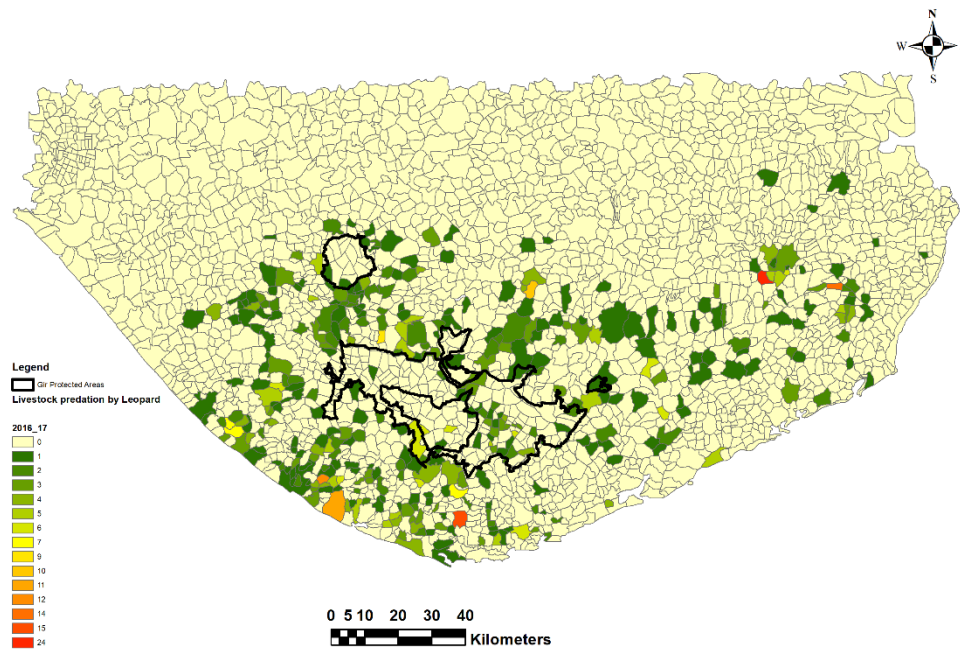
**Fig S2:** Map showing the villages with livestock predation by lions in the year 2013-14



**Fig S3:** Map showing the villages with livestock predation by lions in the year 2014-15



**Fig S4:** Map showing the villages with livestock predation by lions in the year 2015-16



**Fig S5:** Map showing the villages with livestock predation by lions in the year 2016-17



**Table S 1:** List of villages with the magnitude of livestock predation by leopard in Saurashtra

<b>Village</b>	<b>Taluka</b>	<b>District</b>	<b>Total Magnitude</b>
Talala	Talala	Junagadh	77
Lodhva	Sutrapada	Junagadh	72
Ghantvad	Kodinar	Junagadh	71
Visavadar	Visavadar	Junagadh	57
Umej	Una	Junagadh	46
Una	Una	Gir Somnath	45
Bhutdi	Visavadar	Junagadh	43
Harmadiya	Kodinar	Junagadh	40
Bilkha	Junagadh	Junagadh	39
Dhamlej	Sutrapada	Junagadh	39
Navadra	Veraval	Junagadh	38
Mendarada	Mendarada	Junagadh	30
Jaliya	(blank)	Bhavnagar	29
Prashnavda	Sutrapada	Gir Somnath	29
Gir Gadhada	Gir Gadhada	Gir Somnath	29
Dhari	Dhari	Amreli	28
Chhara	Kodinar	Junagadh	28
Khadiya	Junagadh	Junagadh	27
Bagasara (M)	(blank)	Amreli	27
Junagadh	Junagadh	Junagadh	27
Manekvada	(blank)	Amreli	26
Mandavad	Visavadar	Junagadh	25
Savni	Veraval	Junagadh	24
Bhacha	Gir Gadhada	Gir Somnath	24
Bhadiyadar	Una	Amreli	24
Alidar	Kodinar	Junagadh	23
Patan	Veraval	Junagadh	23
Sutrapada	Sutrapada	Gir Somnath	23
Jamanvada	Kodinar	Junagadh	22
Meghapura	Veraval	Junagadh	22
Vavadi	Sutrapada	Gir Somnath	22
Rakhej	Sutrapada	Gir Somnath	22
Kanek	Gir Gadhada	Gir Somnath	22
Nathej	Una	Gir Somnath	22
Dolasa	Una	Gir Somnath	21
Velan	Kodinar	Junagadh	21
Samter	Una	Gir Somnath	20
Virodar	Sutrapada	Gir Somnath	19
Vadodara Jhala	Sutrapada	Junagadh	19
Jasapur	Talala	Junagadh	19
Vavarada	Una	Amreli	19
Sarambhda	Amreli	Amreli	18



Panandar	Kodinar	Junagadh	18
Nakhada	Veraval	Gir Somnath	18
Nani Rajasthali	(blank)	Bhavnagar	18
Hathasani	(blank)	Bhavnagar	18
	Savar		
Mitiyala	Kundala	Amreli	18
Ankolvadi	Talala	Junagadh	18
Jamawala	Una	Junagadh	18
Ayavej	(blank)	Bhavnagar	17
Amrapur	Sutrapada	Junagadh	17
Surva	Talala	Junagadh	17
Rajpara	Visavadar	Junagadh	17
Vekariya	Dhari	Amreli	17
Malshika	Dhari	Amreli	16
Navagam	Junagadh	Junagadh	16
Kadvasan	Kodinar	Junagadh	16
Ambaliyala	Veraval	Gir Somnath	16
Sanjanasar	(blank)	Bhavnagar	16
Mendha	(blank)	Bhavnagar	16
Gangda	Una	Gir Somnath	16
Delwada	Una	Gir Somnath	16
Bhalgam	Junagadh	Junagadh	15
Khambha	Khambha	Amreli	15
Shevadivadar	(blank)	Bhavnagar	15
Prempara	Visavadar	Junagadh	15
Savarkundla	Savarkundala	Amreli	15
Toraniya	Junagadh	Junagadh	14
Bolas	Sutrapada	Gir Somnath	14
Vadodara Dodiya	Sutrapada	Junagadh	14
Sasan	Talala	Junagadh	14
Ambada	Gir Gadhada	Gir Somnath	14
Bhakha	Gir Gadhada	Gir Somnath	14
Dhokadva	Gir Gadhada	Gir Somnath	14
Mendpara	Bhesan	Junagadh	13
Chidivav	Kodinar	Junagadh	13
Vadnagar	Kodinar	Junagadh	13
Umba	Veraval	Junagadh	13
Lati	Sutrapada	Junagadh	13
Borvav	Talala	Junagadh	13
Javantri	Talala	Junagadh	13
Mota Desar	Gir Gadhada	Gir Somnath	13
Kodiya	Gir Gadhada	Junagadh	13
Ishvariya	Visavadar	Junagadh	13
Halariya	Bagasara	Amreli	12
Dalkhaniya	Dhari	Amreli	12
Dungarpur	Junagadh	Junagadh	12



Nanavada	Kodinar	Gir Somnath	12
Panswala	Una	Gir Somnath	12
Anjar	Una	Gir Somnath	12
Sultanpur	Una	Gir Somnath	12
Ishapur	Junagadh	Junagadh	11
Dungarpur	(blank)	Bhavnagar	11
	Savar		
Nani Vadal	Kundala	Amreli	11
Dhava	Talala	Junagadh	11
Umrethi	Talala	Junagadh	11
Kandhi	Una	Gir Somnath	11
Khapat	Una	Gir Somnath	11
Kariya	Bhesan	Junagadh	10
Navagam	Junagadh	Junagadh	10
Jamaka	Junagadh	Junagadh	10
Gohil ni Khan	Kodinar	Junagadh	10
Devli	Kodinar	Junagadh	10
Moraj	Sutrapada	Junagadh	10
Rampara	Una	Gir Somnath	10
Arena	Mangrol	Junagadh	10
Maljinjava	Talala	Junagadh	10
	Savar		
Mota Zinzuda	Kundala	Amreli	10
	Savar		
Gadhakda	Kundala	Amreli	10
Bhojde	Talala	Junagadh	10
Moruka	Talala	Junagadh	10
Semarvav	Talala	Junagadh	10
Gabha	Talala	Junagadh	10
Patapur	Gadhada	Gir Somnath	10
Nathal	Una	Gir Somnath	10
Amodra	Una	Gir Somnath	10
Varsingpur	Una	Gir Somnath	10
Sokhada	Una	Gir Somnath	10
Vajdi	Una	Gir Somnath	10
Jambudi	Visavadar	Junagadh	10
Malida	Bhesan	Junagadh	9
Dhargani	Chalala	Amreli	9
Shivad	Dhari	Amreli	9
Choravadi	Junagadh	Junagadh	9
Singhaj	Kodinar	Junagadh	9
Kadodara	Kodinar	Junagadh	9
Chamoda	Veraval	Junagadh	9
Sonariya	Veraval	Junagadh	9
Jhinjhuda	Junagadh	Junagadh	9
Satana Nes	(blank)	Bhavnagar	9
Kukarash	Veraval	Junagadh	9



Simar	Veraval	Gir Somnath	9
	Savar		
Bhamar	Kundala	Amreli	9
Vansavad	Sutrapada	Junagadh	9
Khambha	Sutrapada	Gir Somnath	9
Motha	Gir Gadhada	Gir Somnath	9
Paldi	Una	Gir Somnath	9
Sanvav	Gir Gadhada	Gir Somnath	9
Sukhpur	Dhari	Amreli	9
Sarasiya	Dhari	Amreli	8
Khicha	Dhari	Amreli	8
Dedan	Khambha	Amreli	8
Dadhiyali	Khambha	Amreli	8
Indroi	Veraval	Gir Somnath	8
Mithapur	Sutrapada	Gir Somnath	8
Rohishala	(blank)	Bhavnagar	8
Badalpara	Sutrapada	Gir Somnath	8
	Savar		
Senjal	Kundala	Amreli	8
Abhrampara	Savarkundala	Amreli	8
Ghantiya	Sutrapada	Junagadh	8
Mahobatpara	Sutrapada	Junagadh	8
Ghunsiya	Talala	Junagadh	8
Sanakhda	Una	Gir Somnath	8
Garal	Una	Gir Somnath	8
Manandiya	Visavadar	Junagadh	8
Sarsai	Visavadar	Junagadh	8
Thorkhan	(blank)	Amreli	7
Hulariya	(blank)	Amreli	7
Bordi	Dhari	Amreli	7
Khisri	Dhari	Amreli	7
Bandhala	Junagadh	Junagadh	7
Mandanpara	Junagadh	Junagadh	7
Patapur	Junagadh	Junagadh	7
Malgam	Kodinar	Junagadh	7
Sarkhadi	Kodinar	Junagadh	7
Pandava	Veraval	Gir Somnath	7
	Maniya		
Kukasvada	Hatina	Junagadh	7
	Maniya		
Langodra	Hatina	Junagadh	7
	Maniya		
Maliya Hatina	Hatina	Junagadh	7
Dhareshvar	Rajula	Amreli	7
Bhutiya	(blank)	Bhavnagar	7
Gandhol	(blank)	Bhavnagar	7
Bhandariya	(blank)	Bhavnagar	7
Maludha	Veraval	Junagadh	7



Solaj	Sutrapada	Gir Somnath	7
Zadkala	Jesar	Amreli	7
Ghandala	Savarkundla	Amreli	7
Kanjotar	Sutrapada	Junagadh	7
Vadala	Talala	Junagadh	7
Rameshvar	Gir Gadhada	Gir Somnath	7
Yajpur	Una	Gir Somnath	7
Itvaya	Gir Gadhada	Gir Somnath	7
Hadmatiya khakhra	Bhesan	Junagadh	6
Majevdi	Junagadh	Junagadh	6
Prabhatpura	Junagadh	Junagadh	6
Valadar	Kodinar	Junagadh	6
Pichhvi	Kodinar	Junagadh	6
Anandpur	Kodinar	Junagadh	6
Chhachhar	Kodinar	Junagadh	6
Adpokar	Kodinar	Junagadh	6
Tantaniya	(blank)	Bhavnagar	6
	Maniya		
Vadala	Hatina	Junagadh	6
Gundiya	Mendarada	Junagadh	6
Gorakh madhi	Sutrapada	Gir Somnath	6
Bosan	Sutrapada	Gir Somnath	6
Tobra	Sutrapada	Junagadh	6
Vadala	Talala	Junagadh	6
Revad	Una	Gir Somnath	6
Moti Moli	Una	Gir Somnath	6
Jhudvadali	Gir Gadhada	Gir Somnath	6
Rampara	Una	Gir Somnath	6
	└áGir		
Ghodavadi	Gadhada	Gir Somnath	6
Rasulpara	Talala	Junagadh	6
Monpari Nani	Visavadar	Junagadh	6
Dudhala	Visavadar	Junagadh	6
Samdhiyala	(blank)	Amreli	5
Samatpara	Junagadh	Junagadh	5
Chanaka	Bhesan	Junagadh	5
Nava Vaghaniya	Bhesan	Junagadh	5
Hudli	Dhari	Amreli	5
Kubda	Dhari	Amreli	5
Mithapur	Dhari	Amreli	5
Padariya	Junagadh	Junagadh	5
Mandlikpur	Junagadh	Junagadh	5
Anandpur	Junagadh	Junagadh	5
Mevasa	Junagadh	Junagadh	5
Balana	Jafrabad	Amreli	5
Raningpara	Khambha	Amreli	5
Inchvad Nani	Kodinar	Gir Somnath	5



Arnej	Kodinar	Junagadh	5
Mota Khuntvada	(blank)	Bhavnagar	5
Nani Khodiyar	Mendarada	Junagadh	5
Itali	Mendarada	Junagadh	5
Kenadipur	Mendarada	Junagadh	5
Inaj	Veraval	Junagadh	5
Adapur	(blank)	Bhavnagar	5
Juna Padar	(blank)	Bhavnagar	5
Kindarva	Veraval	Junagadh	5
Chanch	Rajula	Amreli	5
Nana Zinzuda	Savarkundla	Amreli	5
Padruka	Sutrapada	Gir Somnath	5
Lakhapara	Sutrapada	Junagadh	5
Juna Sangana	(blank)	Bhavnagar	5
Gundaran	Talala	Junagadh	5
Vithalpur	Kodinar	Junagadh	5
Vadviyala	Gir Gadhada	Gir Somnath	5
Naliyeri Moli	Una	Gir Somnath	5
Rajput Rajpara	Gir Gadhada	Amreli	5
Vansoj	Una	Gir Somnath	5
Naliya Mandvi	Gir Gadhada	Gir Somnath	5
Bediya	Dhari	Amreli	5
Padapadar	Una	Junagadh	5
	Maniya		
Sukhpur	Hatina	Junagadh	5
Bhalgam	Visavadar	Junagadh	5
Lunghiya	Visavadar	Junagadh	5
Chavand juni	Visavadar	Junagadh	5
Veraval	Veraval	Gir Somnath	5
Kagdadi	(blank)	Amreli	4
Hathab	(blank)	Bhavnagar	4
Mandva	Bhesan	Junagadh	4
Ranpur	Bhesan	Junagadh	4
Mota Gujariya	Bhesan	Junagadh	4
Karamdadi	Dhari	Amreli	4
Nagadara	Kodinar	Gir Somnath	4
Dahida	Dhari	Amreli	4
Ambaradi	Dhari	Amreli	4
Ditla	Dhari	Amreli	4
Amaratpur	Dhari	Amreli	4
Govindpur	Dhari	Amreli	4
Trambakpur	Dhari	Amreli	4
Nava Pipadiya	Junagadh	Junagadh	4
Umarala	Junagadh	Junagadh	4
Manekavada	Keshod	Junagadh	4
Bamanasa (Ghed)	Keshod	Junagadh	4



Dervan	Junagadh	Junagadh	4
Vadal	Junagadh	Junagadh	4
Baliyavad	Junagadh	Junagadh	4
Taliyadhar	Junagadh	Junagadh	4
Vangadhara	Khambha	Amreli	4
Visavadar Nana	Khambha	Amreli	4
Jamka	Bagsara	Amreli	4
Panch Pipalava	Kodinar	Junagadh	4
Devalpur	Kodinar	Junagadh	4
Fafni Moti	Kodinar	Junagadh	4
Dudana	Kodinar	Junagadh	4
Damali	Kodinar	Junagadh	4
Ajotha	Veraval	Gir Somnath	4
Govindpara	Veraval	Gir Somnath	4
Kalsari	Visavadar	Junagadh	4
	Maniya		
Ambecha	Hatina	Junagadh	4
Karla	(blank)	Bhavnagar	4
	Maniya		
Dhanej Moti	Hatina	Junagadh	4
	Maniya		
Gotana	Hatina	Junagadh	4
	Maniya		
Kanek	Hatina	Junagadh	4
Gheti	(blank)	Bhavnagar	4
Bhalapara	Veraval	Junagadh	4
Nava Sangala	(blank)	Bhavnagar	4
Chhapri	(blank)	Amreli	4
Hindorna	(blank)	Amreli	4
Hadmatiya	Talala	Junagadh	4
BHONKARVA	Savarkundla	Amreli	4
Juni Kamrol	(blank)	Bhavnagar	4
Navagam	Sutrapada	Junagadh	4
Anandapara	Sutrapada	Junagadh	4
Rangpur	Sutrapada	Junagadh	4
Pransli	Sutrapada	Gir Somnath	4
Shingsar	Sutrapada	Junagadh	4
Bamanasa	Talala	Junagadh	4
Lushala	Talala	Junagadh	4
Pipalava	Talala	Junagadh	4
Nagadiya	Una	Gir Somnath	4
Sanosri	Gir Gadhada	Gir Somnath	4
Bodidar	Gir Gadhada	Gir Somnath	4
Kesariya	Una	Gir Somnath	4
Chikhli	Una	Gir Somnath	4
Simar	Gir Gadhada	Junagadh	4
Kothari	Una	Junagadh	4



Mandvi	Gir Gadhada	Gir Somnath	4
Thordi	Una	Junagadh	4
Sendarda	Vanthali	Junagadh	4
Pindakhai Nani	Visavadar	Junagadh	4
Shobhavadla Gir	Visavadar	Junagadh	4
Rajula (M)	(blank)	Amreli	4
Palitana (M)	(blank)	Bhavnagar	4
Hamapur	Kunkavav	Amreli	3
Galath	Bhesan	Junagadh	3
Sardarpar	Bhesan	Junagadh	3
Gigasan	Dhari	Amreli	3
Monvel	Dhari	Amreli	3
Samadhiyala Nana	Dhari	Amreli	3
Khambhaliya	Dhari	Amreli	3
Kaner	Dhari	Amreli	3
Jira	Dhari	Amreli	3
᳚Gadhiya	Dhari	Amreli	3
Shemaradi	Dhari	Amreli	3
Vijapur	Junagadh	Junagadh	3
Rameshvar	Junagadh	Junagadh	3
Kathrota	Junagadh	Junagadh	3
Patrapasar	Junagadh	Junagadh	3
Bamangam	Junagadh	Junagadh	3
Bela	Junagadh	Junagadh	3
Bagadu	Junagadh	Junagadh	3
Badalpur	Junagadh	Junagadh	3
Sakhadavadar	Junagadh	Junagadh	3
Pipalava	Khambha	Amreli	3
Shergadh	Keshod	Junagadh	3
Dhari Nani	Dhari	Amreli	3
Lasa	Khambha	Amreli	3
Chakrava	Khambha	Amreli	3
Trakuda	Khambha	Amreli	3
Pachapachiya	Khambha	Amreli	3
Arithiya	Kodinar	Junagadh	3
Jagatiya	Kodinar	Junagadh	3
Navagam	Kodinar	Junagadh	3
Ronaj	Kodinar	Junagadh	3
Advi	Kodinar	Junagadh	3
Velva	Kodinar	Junagadh	3
Kaj	Kodinar	Gir Somnath	3
Jambuda	(blank)	Bhavnagar	3
Supasi	Veraval	Junagadh	3
Mandor	Veraval	Junagadh	3
Ishvariya	Veraval	Gir Somnath	3
Bordi	(blank)	Bhavnagar	3



Bhadrod	(blank)	Bhavnagar	3
Dhanej Nani	Maniya	Junagadh	3
	Hatina		
Pikhor	Maniya	Junagadh	3
Jalondhar	Hatina	Junagadh	3
	Maliyahatina		
Ghunghati	Maniya	Junagadh	3
	Hatina		
Khambhaliya	Maniya	Junagadh	3
Shil	Hatina	Junagadh	3
Shapur	Mangrol	Junagadh	3
Moti Khodiyar	Mangrol	Junagadh	3
Samadhiyala	Mendarada	Junagadh	3
Najapur	Mendarada	Junagadh	3
Amargadh	Mendarada	Junagadh	3
Malanka	Mendarada	Junagadh	3
Virpur (Chok)	(blank)	Bhavnagar	3
Deda	Veraval	Junagadh	3
Kathivadar	Una	Gir Somnath	3
Khera	Veraval	Junagadh	3
Piparadi	Jesar	Amreli	3
Vanda	Savarkundla	Amreli	3
Kantrodi	Jesar	Amreli	3
Dedkadi	Savarkundla	Amreli	3
Gorakh madhi	Veraval	Junagadh	3
Barula	Sutrapada	Junagadh	3
Timbdi	Sutrapada	Junagadh	3
Chagiya	Sutrapada	Junagadh	3
Morasa	Sutrapada	Junagadh	3
Navi Kamrol	(blank)	Bhavnagar	3
Khirdhar	Talala	Junagadh	3
Sangodra	Talala	Junagadh	3
Chitravad	Talala	Junagadh	3
Ramarechi	Talala	Junagadh	3
Virpur	Talala	Junagadh	3
Sonpura	Una	Gir Somnath	3
Madhgam	Una	Gir Somnath	3
Dodhi	Dhari	Amreli	3
Dudhala	Kodinar	Junagadh	3
Bhebha	Una	Gir Somnath	3
Sanjavapur	Una	Gir Somnath	3
Kob	Una	Gir Somnath	3
Khajudra	Una	Gir Somnath	3
Nandrakh	Una	Gir Somnath	3
Men	Una	Gir Somnath	3
Sondardi	Una	Gir Somnath	3



Sondarda	Una	Gir Somnath	3
Damasa	Gir Gadhada	Gir Somnath	3
Tad	Una	Gir Somnath	3
Jaragli	Dhari	Junagadh	3
Lamdhar	Una	Gir Somnath	3
Gadoi	Vanthali	Junagadh	3
Umatvada	Vanthali	Junagadh	3
Shapur	Junagadh	Junagadh	3
Khijadiya	Visavadar	Junagadh	3
Virpur	Junagadh	Junagadh	3
Jetalvad	Visavadar	Junagadh	3
Ravani Kuba	Visavadar	Junagadh	3
Kalavad	Visavadar	Junagadh	3
	Maniya		
Chorvad	Hatina	Junagadh	3
Thordi	Kunkavav	Amreli	2
Patla	Bhesan	Junagadh	2
Kharchiya	Bhesan	Junagadh	2
Sukhpur	Bhesan	Junagadh	2
Gorviyali	Bhesan	Junagadh	2
Umarali	Bhesan	Junagadh	2
Vandarvad	Bhesan	Junagadh	2
Padargadh	Dhari	Amreli	2
Gopalgram	Dhari	Amreli	2
Dangavadar	Dhari	Amreli	2
Kotha Pipariya	Dhari	Amreli	2
Chhatradiya	Dhari	Amreli	2
Madhupur	Talala	Gir Somnath	2
Hirava	Dhari	Amreli	2
Rajavadar	(blank)	Bhavnagar	2
Ivanagar	Junagadh	Junagadh	2
Palasava	Junagadh	Junagadh	2
Bhada	(blank)	Amreli	2
Intala	Junagadh	Junagadh	2
Kotda	Khambha	Amreli	2
Nanudi	Khambha	Amreli	2
Kodiya	Gir Gadhada	Gir Somnath	2
Talda	Khambha	Amreli	2
Barman Mota	Khambha	Amreli	2
Kantala	Khambha	Amreli	2
Sedhaya	Kodinar	Junagadh	2
Morvad	Kodinar	Junagadh	2
Girdevli	Kodinar	Junagadh	2
Fachariya	Kodinar	Junagadh	2
Sayajirajpura	Kodinar	Junagadh	2
Mitiyaj	Kodinar	Junagadh	2



Kodidra	Veraval	Junagadh	2
Chhatroda	Veraval	Gir Somnath	2
Dabhor	Veraval	Gir Somnath	2
Katrasa	Maniya	Junagadh	2
	Hatina		
Gadu	Maniya	Junagadh	2
	Hatina		
Chhapariyali	(blank)	Bhavnagar	2
Kalmodar	(blank)	Bhavnagar	2
Shantinagar	(blank)	Bhavnagar	2
Bhankharvad	Maniya	Junagadh	2
	Hatina		
Matarvaniya	Maniya	Junagadh	2
	Hatina		
Devgam	Maliyahatina	Junagadh	2
Ladudi	Maliyahatina	Junagadh	2
	Maniya		
Budhecha	Hatina	Junagadh	2
Pipalva	Sutrapada	Junagadh	2
Sangavala	Mangrol	Junagadh	2
Divasa	Mangrol	Junagadh	2
Sheriyaj	Mangrol	Junagadh	2
Chiroda	Mendarada	Junagadh	2
Gundala	Mendarada	Junagadh	2
Devghadh	Mendarada	Junagadh	2
Rajesar	Mendarada	Junagadh	2
Khijadiya	Mendarada	Junagadh	2
Chok	(blank)	Bhavnagar	2
Thorali	(blank)	Bhavnagar	2
Barbatana	(blank)	Amreli	2
Chotra	Rajula	Amreli	2
Vadal	(blank)	Bhavnagar	2
Panderiya	(blank)	Bhavnagar	2
Lapaliya	(blank)	Bhavnagar	2
Chiroda	(blank)	Bhavnagar	2
Chhapari	Savarkundala	Amreli	2
Bhegali	(blank)	Bhavnagar	2
Dantrad	(blank)	Bhavnagar	2
Vavera	(blank)	Amreli	2
Khakhbai	Rajula	Amreli	2
Luvava	Savarkundla	Amreli	2
Kadavar	Sutrapada	Junagadh	2
Mota Bhamodra	Savarkundla	Amreli	2
Jira	Savarkundala	Amreli	2
Thavi	Savarkundla	Amreli	2
Likhala	Savarkundala	Amreli	2
Bagoya	Savar	Amreli	2
	Kundala		



Gangetha	Sutrapada	Junagadh	2
Untwala	Una	Gir Somnath	2
Thareli	Sutrapada	Junagadh	2
Moradiya	Sutrapada	Junagadh	2
Pasavi	(blank)	Bhavnagar	2
Timana	(blank)	Bhavnagar	2
Haripur	Talala	Junagadh	2
Mandorna	Talala	Junagadh	2
Anida	Talala	Junagadh	2
Ratidhar	Talala	Junagadh	2
Semaliya	Talala	Junagadh	2
Saiyad Rajpara	Una	Gir Somnath	2
Kanakbarda	Una	Gir Somnath	2
Lerka	Una	Junagadh	2
Simasi	Gir Gadhada	Gir Somnath	2
Mahobatpara	Una	Gir Somnath	2
Olvan	Una	Gir Somnath	2
Fulka	Una	Gir Somnath	2
Nandan	Una	Gir Somnath	2
Mota Mindha	Gir Gadhada	Amreli	2
Motisar	Gir Gadhada	Gir Somnath	2
Fareda	Una	Junagadh	2
Gundala	Una	Gir Somnath	2
Ugala Juna	Gir Gadhada	Gir Somnath	2
Chaparda	Visavadar	Junagadh	2
Pipali	Kodinar	Junagadh	2
Haripur	Visavadar	Junagadh	2
Khumbhadi	Vanthali	Junagadh	2
Lushala	Vanthali	Junagadh	2
Hadmatiya Mota	Visavadar	Junagadh	2
Kuba(ravani)	Visavadar	Junagadh	2
Leriya	Visavadar	Junagadh	2
Kotada Mota	Visavadar	Junagadh	2
Kotda Nana	Visavadar	Junagadh	2
Rabarika	Visavadar	Junagadh	2
Bhat vavdi	Visavadar	Junagadh	2
Miya vadla	Visavadar	Junagadh	2
Moniya	Visavadar	Junagadh	2
Lalpur	Visavadar	Junagadh	2
Monpari Moti	Visavadar	Junagadh	2
Piyava	Visavadar	Junagadh	2
Chalala (M)	Dhari	Amreli	2
Khodiyarpara	Visavadar	Junagadh	2
Jaliya	(blank)	Bhavnagar	1
Mandavda Mota	Amreli	Amreli	1
Vaghaniya	Bhesan	Junagadh	1



Haliyad Navi	(blank)	Amreli	1
Gundi	(blank)	Bhavnagar	1
Dudhala	Bhesan	Junagadh	1
Khajuri Hadmatiya	Bhesan	Junagadh	1
Khambhaliya	Bhesan	Junagadh	1
Kathirvadar	Dhari	Amreli	1
Nava Charkha	Dhari	Amreli	1
Mithapur	Dhari	Amreli	1
Juna Charkha	Dhari	Amreli	1
Rajsthali	Dhari	Amreli	1
Fategadh	Dhari	Amreli	1
Chanchai	Dhari	Amreli	1
Fachariya	Dhari	Amreli	1
Jaljivadi	Dhari	Amreli	1
Dudhala	Dhari	Amreli	1
Paniyala	(blank)	Bhavnagar	1
Chhaya	(blank)	Bhavnagar	1
Varahsvarup	(blank)	Amreli	1
Avatadiya	Junagadh	Junagadh	1
Thumbala	Junagadh	Junagadh	1
Balagam	Keshod	Junagadh	1
Mangalpur	Keshod	Junagadh	1
Magharvada	Keshod	Junagadh	1
Agatrai	Keshod	Junagadh	1
Handala	Keshod	Junagadh	1
Fagali	Keshod	Junagadh	1
Khara	Liliya	Amreli	1
Kanthariya Koli	(blank)	Amreli	1
Kagvadar	Jafrabad	Amreli	1
Ebhalvad	Girgadhada	Junagadh	1
Jikadri Navi	(blank)	Amreli	1
Babarkot	(blank)	Amreli	1
Kerala	Junagadh	Junagadh	1
Rupavati	Junagadh	Junagadh	1
Vadhavi	Junagadh	Junagadh	1
Kaneri	Keshod	Junagadh	1
Bhad	Dhari	Amreli	1
Babarpur	Khambha	Amreli	1
Rangpur	Keshod	Junagadh	1
Borala	Khambha	Gir Somnath	1
Tantaniya	Dhari	Amreli	1
Sarakadiya Divan	Khambha	Amreli	1
Pati	Savarkundla	Amreli	1
Samadhiyala No-2	Khambha	Amreli	1
Hanumanpur	Khambha	Amreli	1
Kantala	Khambha	Amreli	1



Chauhan ni Khan	Kodinar	Junagadh	1
Sandhnidhar	Kodinar	Junagadh	1
Pavti	Kodinar	Junagadh	1
Sugala	Kodinar	Junagadh	1
Pichhva	Kodinar	Junagadh	1
Bodva	Kodinar	Junagadh	1
Fafni Nani	Kodinar	Gir Somnath	1
Pipalava Bavana	Kodinar	Gir Somnath	1
Adri	Veraval	Junagadh	1
Chanduvav	Veraval	Gir Somnath	1
Bhetali	Veraval	Gir Somnath	1
Sarera	(blank)	Bhavnagar	1
	Maniya		
Kalimbhada	Hatina	Junagadh	1
Moti Vadal	(blank)	Bhavnagar	1
Karjala	(blank)	Bhavnagar	1
Bagdana	(blank)	Bhavnagar	1
Kotiya	(blank)	Bhavnagar	1
Karmadiya	(blank)	Bhavnagar	1
Kotamoi	(blank)	Bhavnagar	1
Galthar	(blank)	Bhavnagar	1
Moda	(blank)	Bhavnagar	1
Nana Khuntvada	(blank)	Bhavnagar	1
	Maniya		
Virdi	Hatina	Junagadh	1
	Maniya		
Kerala	Hatina	Junagadh	1
	Maniya		
Janadi	Hatina	Junagadh	1
	Maniya		
Vadiya	Hatina	Junagadh	1
	Maniya		
Ghumli	Hatina	Junagadh	1
	Maniya		
Achhidra	Hatina	Junagadh	1
	Maniya		
Lathodra	Hatina	Junagadh	1
Rahij	Mangrol	Junagadh	1
Makatupura	Mangrol	Junagadh	1
Manpur	Mendarada	Junagadh	1
Nataliya	Mendarada	Junagadh	1
Dedakiyal	Mendarada	Junagadh	1
Babar tirath	Mendarada	Junagadh	1
Ambala	Mendarada	Junagadh	1
Karsangadh	Mendarada	Junagadh	1
Ranidhar	Mendarada	Junagadh	1
Amrapur	Mendarada	Junagadh	1
Mathasuriya	Veraval	Junagadh	1



Jivapur	(blank)	Bhavnagar	1
Dedarda	(blank)	Bhavnagar	1
Hathsani	Savarkundla	Amreli	1
Vijana Nes	(blank)	Bhavnagar	1
Morchupana	(blank)	Bhavnagar	1
Tantivela	Veraval	Gir Somnath	1
Paldi	Veraval	Junagadh	1
Umarala	Veraval	Junagadh	1
Bij	Veraval	Junagadh	1
Veraval(Rural Area) (Part)	Veraval	Gir Somnath	1
Royal	(blank)	Bhavnagar	1
Devaliya	(blank)	Bhavnagar	1
Kherali Moti	(blank)	Amreli	1
Mandardi Navi-Juni	Rajula	Amreli	1
Kherali Nani	Rajula	Amreli	1
Dantardi	(blank)	Amreli	1
Chhatadiya	Dhari	Amreli	1
Bhachadar	(blank)	Amreli	1
Haranasa	Sutrapada	Junagadh	1
Borala	Khambha	Amreli	1
Juna Savar	Gir Gadhada	Gir Somnath	1
Simaran	Savarkundla	Amreli	1
Khada	Una	Gir Somnath	1
Dadhiya	Savarkundla	Amreli	1
Nesdi	Savarkundla	Amreli	1
Pithvadi	Savarkundla	Amreli	1
Vanshiyali	Savar Kundala	Amreli	1
Mevasa	Savarkundla	Amreli	1
Nal	Savar Kundala	Amreli	1
Bhenkra	Kundala	Amreli	1
Badhada	Savarkundla	Amreli	1
Madhda	Savarkundla	Amreli	1
Ramgadh	Savar Kundala	Amreli	1
Chikhali	Una	Gir Somnath	1
Ambardi	Dhari	Amreli	1
Thoradi	Savarkundla	Amreli	1
Khodiyana	Savarkundla	Amreli	1
Sundarpara	Sutrapada	Gir Somnath	1
Sanosara	(blank)	Bhavnagar	1
Malvan	(blank)	Bhavnagar	1
Alidhra	Sutrapada	Junagadh	1
Pingali	(blank)	Bhavnagar	1
Rojiya	(blank)	Bhavnagar	1



Madhuvan	(blank)	Bhavnagar	1
Bhalchhel	Talala	Junagadh	1
Amrutvel	Talala	Junagadh	1
Rasulpara	Una	Gir Somnath	1
Galiyawad	Talala	Junagadh	1
Bhimdeval	Talala	Junagadh	1
Hadala	Gir Gadhada	Gir Somnath	1
Ankolali	Una	Junagadh	1
Bandhada	Una	Gir Somnath	1
Sonariya	Gir Gadhada	Junagadh	1
Vadli	Una	Gir Somnath	1
Shahdesar	Una	Gir Somnath	1
Vankiya	(blank)	Amreli	1
Kanakiya	Una	Junagadh	1
Chanchakvad	Una	Gir Somnath	1
Ambavad	Una	Junagadh	1
Kansari	Una	Junagadh	1
Kheda	Una	Gir Somnath	1
Hadala	Gir Gadhada	Gir Somnath	1
Nitli	Gir Gadhada	Junagadh	1
Khilavad	Kodinar	Gir Somnath	1
Dron	Gir Gadhada	Junagadh	1
Nana Samadhiyala	Una	Gir Somnath	1
Kanjadi	Vanthali	Junagadh	1
Khambhaliya	Visavadar	Junagadh	1
Khambha Gir	Visavadar	Junagadh	1
Selra	Vanthali	Junagadh	1
Dhanfuliya	Vanthali	Junagadh	1
Tinmas	Vanthali	Junagadh	1
Akha	Vanthali	Junagadh	1
Khorasa	Vanthali	Junagadh	1
Navaniya	Visavadar	Junagadh	1
Jhankhiya	Una	Junagadh	1
Mahudi	Visavadar	Junagadh	1
Kankchiyala	Visavadar	Junagadh	1
Shapar	Visavadar	Junagadh	1
Pipaliya Hajani	Visavadar	Junagadh	1
Sudavad	Visavadar	Junagadh	1
Mangnath Pipli	Visavadar	Junagadh	1
Ambala	Gir Gadhada	Gir Somnath	1
Vadala Shetranj	Visavadar	Junagadh	1
Govindpara	Visavadar	Junagadh	1
Limadhra	Visavadar	Junagadh	1
Javaldi	Visavadar	Junagadh	1
Vanthli	Vanthali	Junagadh	1
Kalipat	Gir Gadhada	Gir Somnath	1



Lilapani	Dhari	Amreli	1
Jafrabad (M)	(blank)	Amreli	1
Mangrol	Mangrol	Junagadh	1
Sihor	(blank)	Bhavnagar	1
Talaja (M)	(blank)	Bhavnagar	1
Mahobatpara	Kutiyana	Junagadh	0
Dhruvala	Kutiyana	Junagadh	0



## References:

- Andelt, W.F. and Hopper, S.N., 2000. Livestock guard dogs reduce predation on domestic sheep in Colorado. *Journal of Range Management*, pp.259-267.
- Ayres, L.A., Chow, L.S. and Graber, D.M., 1986. Black bear activity patterns and human induced modifications in Sequoia National Park. *Bears: Their Biology and Management*, 6, pp.151-154.
- Banerjee, K. & Jhala, Y. V. (2012) Demographic parameters of endangered Asiatic lions ( *Panthera leo persica* ) in Gir Forests, India. *Journal of Mammalogy*, 93, 1420–1430.
- Banerjee, K., Jhala, Y. V, Chauhan, K.S. & Dave, C. V. (2013) Living with Lions : The Economics of Coexistence in the . , 8, 1–11.
- Bangs, E., and J. Shivik. 2001. Managing wolf conflict with livestock in the northwestern United States. *Carnivore Damage Prevention News* 3:2–5.
- Basu, P. 2013. Assessment of landscape pattern for modelling habitat suitability for Lions and Prey species in Gir protected area, Gujarat. Ph.D. thesis, Forest Research Institute Deemed University, Dehradun. India, 288 pp.
- Bauer, H., Chapron, G., Nowell, K., Henschel, P., Funston, P., Hunter, L.T., Macdonald, D.W. and Packer, C., 2015. Lion (*Panthera leo*) populations are declining rapidly across Africa, except in intensively managed areas. *Proceedings of the National Academy of Sciences*, 112(48), pp.14894-14899.
- Chapron G, et al. (2014) Recovery of large carnivores in Europe’s modern human-dominated landscapes. *Science* 346(6216):1517–1519.
- Divyabhanusinh. (2005) The Story of Asia’s Lions. *Marg Publications*, 259.



- Graham, K., Beckerman, A.P. and Thirgood, S., 2005. Human–predator–prey conflicts: ecological correlates, prey losses and patterns of management. *Biological Conservation*, 122(2), pp.159-171.
- Gujarat Forest Department, 2015. 14th Lion Population Estimation Report– 2015.
- Hayward MW, O’Brien J, Kerley GIH (2007) Carrying capacity of large African predators: Predictions and tests. *Biol Conserv* 139(1):219–229.
- Herrero, S., Higgins, A., Cardoza, J.E., Hajduk, L.I. and Smith, T.S., 2011. Fatal attacks by American black bear on people: 1900–2009. *The Journal of Wildlife Management*, 75(3), pp.596-603.
- Inskip, C. and Zimmermann, A., 2009. Human-felid conflict: a review of patterns and priorities worldwide. *Oryx*, 43(1), pp.18-34.
- Massé, S., Dussault, C., Dussault, C. and Ibarzabal, J., 2014. How artificial feeding for tourism-watching modifies black bear space use and habitat selection. *The Journal of Wildlife Management*, 78(7), pp.1228-1238.
- McCullagh, P. & Nelder, J.A. (1989) *Generalized Linear Models*, 2nd ed. Chapman and Hall.
- Packer, C., Loveridge, A., Canney, S., Caro, T., Garnett, S.T., Pfeifer, M., Zander, K.K., Swanson, A., MacNulty, D., Balme, G. and Bauer, H., 2013. Conserving large carnivores: dollars and fence. *Ecology letters*, 16(5), pp.635-641.
- Singh, H.S. & Gibson, L. (2011) A conservation success story in the otherwise dire megafauna extinction crisis: The Asiatic lion (*Panthera leo persica*) of Gir forest. *Biological Conservation*, 144, 1753–1757.



Singh, H.S., 2017. Dispersion of the Asiatic lion *Panthera leo persica* and its survival in human-dominated landscape outside the Gir forest, Gujarat, India. *Current Science* (00113891), 112(5).

Stephens, P.A., 2015. Land sparing, land sharing, and the fate of Africa's lions. *Proceedings of the National Academy of Sciences*, 112(48), pp.14753-14754.

Sukumar, R (1994), Wildlife-Human conflict in India: An ecological and social perspective, in *Social Ecology* ed R. Guha, pp 303-317, Oxford University Press.

Woodroffe R, Lindsey P, Romanach S, Stein A, Ole Ranah SMK (2005) Livestock predation by endangered African wild dogs (*Lycaon pictus*) in northern Kenya. *Biol Conserv* 124:225–234.



Bongaarts, J. (2009). Human population growth and the demographic transition. *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, 364(1532), 2985-2990.

Meyer, W. B., & Turner, B. L. (1992). Human population growth and global land-use/cover change. *Annual review of ecology and systematics*, 23(1), 39-61.

Marker, L. A. U. R. I. E., & Sivamani, S. (2009). Policy for human-leopard conflict management in India. *CAT news*, 50(1), 23-26.

Athreya, V. I. D. Y. A., & Belsare, A. V. (2007). Human-leopard conflict management guidelines. *Unpublished Report. Kaati Trust, Pune, India.*