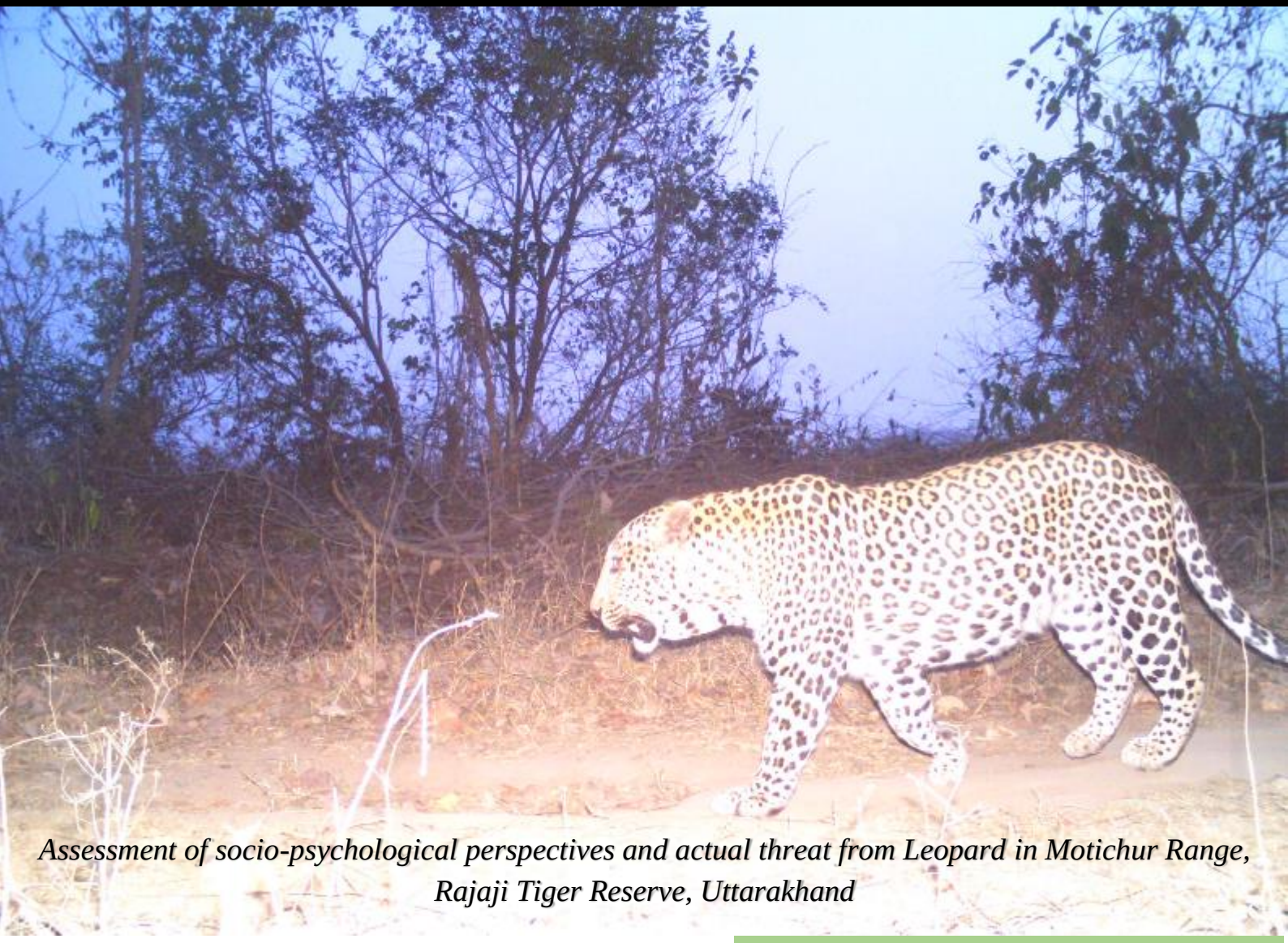
A TECHNICAL REPORT

December 2019

HUMAN-WILDILFE CONFLICT



Assessment of socio-psychological perspectives and actual threat from Leopard in Motichur Range, Rajaji Tiger Reserve, Uttarakhand

Principal Investigator: Dr. K. Ramesh

Researchers: Shashank Yadav, Manu Mohan Disha Sandilaya & Pallabi Boro.

Collaborators: Aditi Sharma & Sanatan Sonkar

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

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Citation: Yadav S., Mohan M., Sandilaya D., Boro P., Sharma A., Sanatan S. & Ramesh. K. 2019: ***Human-Wildlife Conflict:*** *Assessment of socio-psychological perspectives and actual threat from leopard in Motichur Range, Rajaji Tiger Reserve.* Technical Report. Wildlife Institute of India and Uttarakhand Forest Department.

An assessment of Landscape level changes & Human-Wildlife Conflict, including human-leopard conflict in Motichur range, around Rajaji Tiger Reserve, Uttarakhand.

(*Implemented as a part of the project 'Tiger Translocation and Recovery in Western Rajaji Tiger Reserve'*)

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Funding Agency: National Tiger Conservation Authority, New Delhi

Technical Report

Decemeber 2019

भारतीय वन्यजीव संस्थान
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Acknowledgments

We acknowledge the Uttarakhand Forest Department & National Tiger Conservation Authority for funding and supporting the project activities all through the period. We thank the Principal Chief Conservator of Forests (Wildlife)-cum-Chief Wildlife Warden of Uttarakhand, the Director and Dean of WII, for enabling this research in Rajaji Tiger Reserve. We are grateful to the National Tiger Conservation Authority specially ADG and Member Secretary, IG and DIG and Uttarakhand Forest Department for the funding support through the project "Tiger Translocation and Recovery in Western Rajaji Tiger Reserve, Uttarakhand" as this was the linked activities to create enabling environment for tiger augmentation. We thank the officers and staff of Uttarakhand Forest Department and specifically Rajaji Tiger Reserve with special mention of Mr. Mahinder Giri and his team for technical, logistic and administrative support in carrying out the fieldwork. We also thank our field assistants for their support.

Summary

As the proverbs go, *"the deeper the roots, the greater the fruits"* & *"the devil is in the details"*, for conservation management to be successful, one must look at multiple aspects and require comprehensive approach. Human-wildlife conflict is not a singular issue of management since it has wider implications and more so, in cases where species restoration in the form of conservation is involved, because social acceptance and better preparations are keys for success of such programs. In this report, information gathered from three different but linked studies carried out under the larger and long-term framework are synthesized, providing an overview of (1) socio-economic conditions and Quality of Life of people, (2) temporal landscape change and people perception on the conflict and (3) comparative status of leopard behavior in the conflict *versus* non-conflict zones.

By studying "Quality of Life", one can assess the impact of forest resources on the living conditions of people and vice versa. Chapter 1 shows the results of "QOL" study conducted within the villages falling under the 1 km buffer in the Eco-sensitive zone villages of Rajaji Tiger Reserve, Uttarakhand from January 2019 to June 2019. This study evaluates the socio-economic dimension of people and focused on demographic status, human dependency on utilization of forest resources and the role of people in management actions. The utilization of forest resources was found to be high in the three districts and there is hardly any participation of the people in the management inputs. The qualitative wellbeing assessment revealed that people are less satisfied with their living condition.

The global environment change is increasingly forcing the already dwindled wildlife areas to be even more susceptible to disturbances. Localisation, shifting or disappearance of resources can severely impact wildlife and can even lead to local extinctions. There are many evidences to support this narrative. A study analysing the "changes in landscape" from 1995 to 2018 was also undertaken, which showed an increase in barrenness. Because "Human-Wildlife Conflict" explicitly revolves around the costs of sharing land with dangerous wild animals, it is important to understand the patterns of landscape change. While highlighting the landscape changes over a 20 years period, the second study also focused on the damages done by wild animals, the compensatory schemes, and most importantly the perception of people about wild animals.

Though one can never truly eradicate human-wildlife conflict completely, any conflict is a situation of paramount importance to be solved, because any conservation effort does require the support of public at large, particularly the local people who share the space with wildlife. Any spike or change in trend of conflict requires further investigation not for the sole reason saving human fatalities but also for building better human relationships between wildlife managers and public. Since 2014, Motichur range of Rajaji Tiger Reserve has experienced 31 attacks on humans by the resident leopard (*Panthera pardus*) population. It resulted in 19 human deaths and grievous injuries to 12 people. The epicenter of the conflict is the space surrounding national highway 58, connecting the cities of Rishikesh and Haridwar. Rajaji forest department has been deploying camera traps in the conflict space to reckon the leopard movement patterns and to circle out any suspect animals responsible for the conflict. We intensified the camera trap study focusing on entire Motichur range (excluding the conflict locations) from November 2018 to February 2019. In addition, we visited each conflict site with the forest department officials, and collected information on various attributes related to the site. We found an extremely high leopard count for the winters i.e. 47, with a very high density of 45 animals per 100 square kilometers. We listed down the most suspected leopards involved in conflict based on 3-point criteria. The results of our work will increase our understanding of the adaptability of leopards. The results also reiterate the imperative to shift from a PA centric to a landscape level conservation approach, analyzing the source and drivers of conflicts, including the carrying capacity analysis. There is also an urgent need to include engage communities more closely and develop a short-term and long-term conservation programs.

CONTENTS

CHAPTER 1

"Analysis of "quality of life" focusing on human-forest interdependency in the eco-sensitive zone of Rajaji Tiger Reserve, Uttarakhand"

DISHA SANDILAYA

1 INTRODUCTION

1.1 "Quality of Life" – The Meaning

As per Liu (1976), there are as many "quality of life" definitions as "there are people". "Quality of life" is a vast concept that includes interaction of objective and subjective dimensions, "Quality of life" is "an approach integrating opportunities, human needs, and subjective well-being", and is a, multi-scale multidimensional concept, that contains interacting subjective and objective elements (Costanza *et al.*, 2007). The notion of social, physical and natural capital is closely linked with "QOL" and human well-being, and these broadly concern human networks, shared values and understanding, that exist within and between groups, which are further supported by economic and environmental processes (Prakash *et al.*, 2016). According to Cummins *et al.* (2003), social, economic and health dimensions are at the heart of objective measurements of "quality of life". In essence, "Quality of life" is primarily a subjective sense of well-being (Haas 1999).

To fulfil human needs, policy plays an important role as it provides an opportunity that can help in improving one's "quality of life". Human, social and natural capital are considered as the basis for the categorization of opportunities (Costanza *et al.*, 1997). Baker and Intagliata (1982), explained some of the reasons for the need of focusing on "quality of life" in mental health programs, these reasons being: comfort rather than cure, as complex programs require measurements of complex outcome, resulting in re-emergence of a holistic perspective. The traditional factors and quality of life are considered to be an important factor for local economic development (Wong, 2001).

1.2 Human dependency on forest resources around a protected area

Livelihood of people in rural areas is dependent on, animal and plant products of forest, these products are the sources of various food items, fuel for cooking and wide range of traditional medicine (Warner, 2000; & Bahuguna, 2000). Inception of protected areas incorporate the trade-off between different types of values; use value and non-use value. Non-consumptive uses are encouraged while consumptive uses are prevented in national parks (Emerton, 2001; Dolan and Lindsey, 1988). Many studies have examined the importance that forests and/or protected areas play in the livelihood of people living in and around them (Bahuguna, 2000; Barham *et al.*, 1999; Cavendish, 2000; Dewi, 2005; Gunatilake, 1998; Reddy & Chakravarty, 1999; Masozera & Alavalapati, 2004; Panta, Kim, & Lee, 2009; Takasaki, Barham, & Coomes, 2001; Mamo, Sjaastad, & Vedeld, 2007; Tieguhong & Nkamgnia, 2012). The comprehension of the relationships among local communities and their resource use patterns plays important role in designing community-based management programs as well as conservation and development strategies (Gunatilake, 1998; Hough, 1988; Wells *et al.*, 1992).

The goal of sustainability can be achieved by maintaining the balance between social, economic and ecological dimensions of sustainable development. The economy supports the livelihood and employment, and the aim of ecological dimensions is to satisfy the material needs of human beings (Roberts, 2002; & Sirakaya *et al.*, 2001). The social dimensions facilitate the individuals need to live dignified and healthy lives (Choi & Sirakaya, 2005; Mitchell and Reid, 2001). To utilize the natural resources within the ecological limits is the main aim of environmental dimension (Swarbrokee, 1999; Valentin and Spansenberg, 2002).

1.3 Protected areas as a component of Social-Ecological System

Maintaining the natural qualities of the area and attaining socio-economic benefits should theoretically, be the main goal. According to Liu *et al.* (2007), social and ecological research has to consider both, human and ecological components, as most of the social-ecological systems perspective considered that the difference between social and natural systems as artificial. Usually, ecological research debars human from system, while social research excludes the ecological repercussion of human activities (Berkes, 2007; Folke *et al.*, 2005). Emergence of resilience helps in understanding change and the multiple cross-scale interactions in social-ecological system (Plummer and Armitage, 2007). Resilience is an important attribute as it determines the potential of social-ecological system to adapt, and benefit from the change (Walker *et al.*, 2004). To generate benefits for local communities, different projects that connect development and conservation have been implemented around protected areas (Wells *et al.*, 1992). The balance should be between social, economic and environmental dimensions that attain sustainable management of national park (Kunz, 2006; Redclift, 2005; Spangenberg, 2002; Wood *et al.*, 1999).

1.4 People-Park conflicts - management implications

India has a substantial human population living in close proximity to forests. It has been found that 173,000 villages are located in and around the forests (MOEF,2006). Though, there is no official census figures, different estimates put the figures between 275 million (World Bank, 2006) to 350- 400 million (MoEF, 2009). Currently, there are 166 national parks and 515 wildlife sanctuaries in India. For decades, conflict between forest management and local communities, has been observed in India, which escalates when access to local resources is prohibited for the local communities (Mishra, 1992; Wells, Brandon, & Hannah, 1992). The people-park conflicts are the result of enforcing legislative measure without understanding the intricate connections between people and their surrounding environment (Keleman *et al.*, 2010). The exclusion of people has led to complex legal, historical, management as well as livelihood issues of forest communities and is one of the main reasons for local extinctions e.g. extinction of tiger from Sariska Tiger Reserve in 2004 (Rastogi *et al.*, 2012). Jain & Sajjad (2016), studied the factors influencing household forest dependency within the Sariska Tiger Reserve (STR) in Rajasthan and drew the policy implications for the management. Harihar *et al.* (2014), evaluated the coexistence of Gujjar and wildlife, with it being included in the "Gujjar" relocation as policy in Western Terai-Arc Landscape.

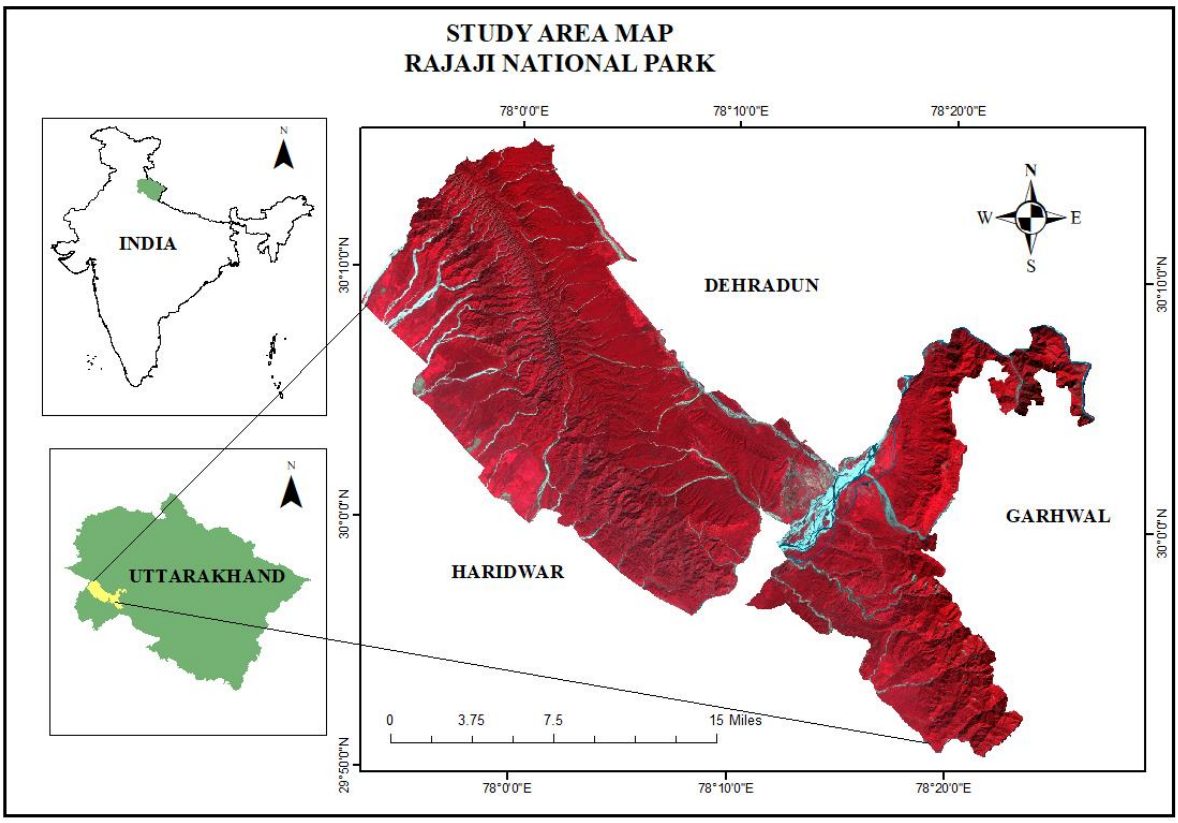
The exclusion of human-use has been highly controversial approach as it has forced 1,00,000- 6,00,000 people to be displaced from their original place (Lasgorceix and Kothari, 2009). According to Saberwal *et al.*, (2001), establishment of state controlled protected areas, lacking in the participatory decision of local communities has adversely impacted their livelihood which is based primarily on natural resources. Forest resources plays an important role in improving social, economic and cultural aspect of people life (Tewari, 1989). The reason behind conflicts between local communities and management authorities in the tropics is the conventional management strategies such as the fencing and fining approach, to prohibiting local access to protected areas (Wells *et al.*, 1992).

2 STUDY AREA

Rajaji Tiger Reserve (Map 2.1), located in Uttarakhand, first emerged in the year 1983, as Motichur and Chilla wildlife Sanctuaries, later named after Sri Rajagopalachari, also known as "Rajaji". The National Park was first declared as a wildlife sanctuary in the year 1983, and later on as a "Tiger Reserve" on 15 April 2015. The reserve lies between latitudes: 29°45' to 30°15' N, and, Longitudes: 77°52' to 78°33'. It comes under three districts of Uttarakhand i.e. Dehradun, Pauri Garhwal and Haridwar. The total area of the reserve is 1075.17 km^2. The core zone and the buffer zone encompass the area of 819.54 km^2. and 255.63 km^2 respectively. The buffer zone of the National Park covers Reserve forest block, part of Shyampur range of Haridwar forest division and Laldhang and Kotdwar ranges of Lansdowne forest division (MoEFCC, 2018).

The National Park falls within the Gangetic Plains Biogeographic Zone and the Upper Gangetic plains zone (Rodgers and Panwar, 1988). The Ganga River bisects the national park into two, the eastern and the western, parts. The Eastern part consist of Chilla and Ghori Range which covers an area of about 250 sq.km. The Western Part consist of Haridwar, Dhaulkhand, Beriwara, Chillawala, Motichur, Kansrao and Ramgarh range which covers an area of about 569.54 sq.km. The National Park enclosed by different forest division: Dehradun Forest Division, Lansdowne Forest Division, Haridwar Forest Division, Narendra Nagar Forest Division and Shivalik Forest Division of Uttar Pradesh. Some Salient Wildlife Corridors exist between Rajaji National Park and the forest division: Kansrao-Balkot, Chilla-Motichur, Motichur-Ghori and Rawasan-Sonanadi (MoEFCC, 2018).

The Stretch of Eco-Sensitive Zone ranges from 0 to 10 km around the reserve. The Eco-Sensitive zone encompasses area of 372.18 km^2 of which 255. 63 km^2 is forest land and 116. 55 km^2 is non-forest land (MoEFCC, 2018).



Map 2.1 Geopolitical location of Rajaji Tiger Reserve.

3 RATIONALE & OBJECTIVES

The heart of biological conservation are the protected areas (Hoyt, 2004; Prato & Fagre, 2005). India has the largest population of tigers worldwide and to maintain protected areas, the exclusion of human-use has been acknowledged as the central focus of tiger conservation policy (Karanth, 2003; Rastogi *et al.*, 2012). The securing inviolate habitats, and the possibility of co-existence between tigers and human is the hot topic for debate in context to tiger conservation (Carter *et al.*, 2012; Goswami *et al.*, 2013; Harihar *et al.*, 2013). As there have been less cases reported with respect to the benefits to both, the resettled communities and the wildlife in vacated domains (Karanth, 2007; Harihar *et al.*, 2009), studying the "Quality of Life" becomes even more important.

Human beings live in an environment which is defined objectively and at the same time perceived which is defined subjectively, as they respond to psychological life space (Campbell *et al.*, 1976). Enhancing "quality of life" is considered as important policy and lifestyle goal because understanding it has potential implications (Schuessler & fisher, 1985).

Protected area management should be done by identification of factors influencing dependency and by formulation of innovative strategies to reduce dependency (Gunatilake 1998; Hedge & Enters 2000). A case study from Nyungwe forest reserve, in Rwanda, shows that households with higher average income are less dependent on natural forest resources (Masozera & Alavalapati, 2010). It is crucial to identify the factors that influence forest dependency in order to formulate management policies to reduce such dependency (Beckley, 1998; Gunatilake, 1998; Hedge & Enters, 2000). Alternative sources of income or livelihood can in some instances reduce dependency on forests (Gunatilike, 1998).

Different approaches have been used for the assessment of "quality of life". To derive "QOL" in Russia, a simple regression model and ranking has been used (Kolenikov, 1998). Pandey (2009), classified forest resource utilization by economic function into 3 categories: "Consumption goods", "input" and "stocks".

For securing the future of wildlife, we need large habitats. Reducing the dependency to secure these habitats first, we need a baseline information of how much they are dependent on forests. "QOL" study fulfills this gap. For this, we list the following objectives for our study

1. To assess the socio- economic dimensions of the people's life living in the wildlife protected area.
2. To assess the human dependency on forest resources of Rajaji Tiger Reserve.
3. To analyze the role of people in conservation or management of forest of Rajaji Tiger Reserve.

4 METHODOLOGY

4.1 Materials

Data- For the analysis on "quality of life" of people in the eco-sensitive zone of the Rajaji National Park, census data on villages of Uttarakhand has been used. Specifically, the census data on villages of 3 districts of Uttarakhand has been used viz; Pauri Garhwal, Haridwar and Dehradun. The census data incorporates following information: district name, village name, demographic status and resource availability. The secondary data (census data) have been downloaded through Census of India.

1. **Questionnaire** – Questionnaire was designed to analyze the attributes of "quality of life" of people living in the eco-sensitive zone of Rajaji National Park and their role in conservation or management of protected area.

2. **Software:** Software acts as a processor which helps in processing of data to end result. For the study, the following software were used:

- **Google Earth Pro –** used to locate exact position of the villages falling under eco-sensitive zones of Rajaji national park.
- **Arc GIS –** used to create shape files and maps for the study.
- **MS-Excel and R-software** – used for the statistical analysis of the data produced by the survey and to create graphs.

4.2 Methods

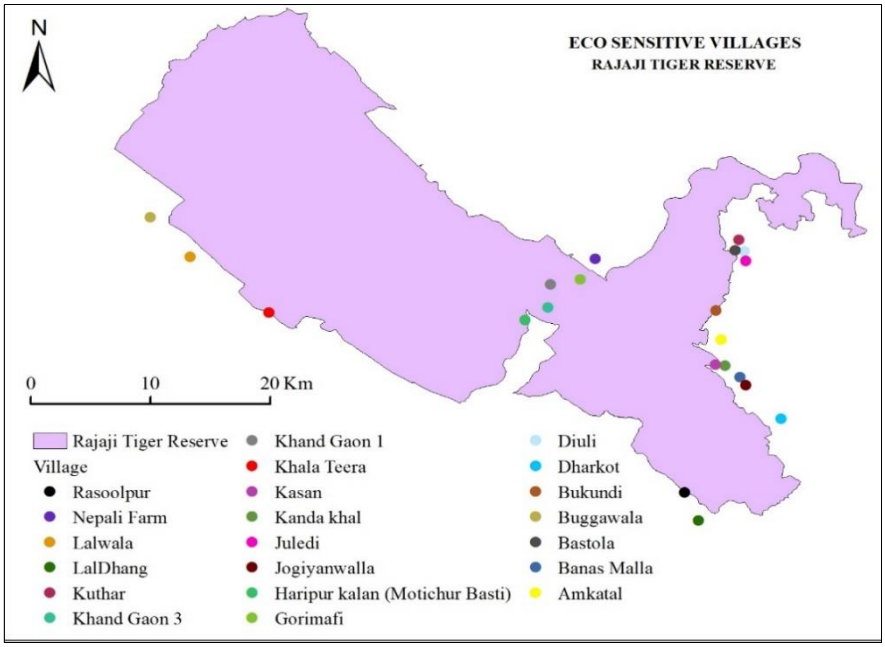
All the villages falling in and around the 1 km buffer of eco-sensitive zone of Rajaji National Park (Map 4.1) were surveyed. Village surveys were found to be best and cost-effective way to get information, namely on:

1. assessment of Socio-Economic Dimensions of local people.

2. the dependency of local people on forest resources of Rajaji Tiger Reserve, and

3. the role of people in management/ conservation of Rajaji Tiger Reserve.

Using questionnaire survey method (a standard set of questions which included both open and close-ended questions), information on demographic status, household characteristics, income sources was obtained. Only one person per household was surveyed at a time and the households were randomly selected. A total of 289 households were surveyed in 21 villages during the study period. Among 289 households, 68 households in Haridwar district, 82 households in Dehradun district and 139 household in Pauri-Garhwal district were surveyed.



Map 4.1 Eco-Sensitive Zone Villages of Rajaji Tiger Reserve.

5 RESULTS

5.1 Assessment of Socio-Economic Dimensions of local people.

The results are presented on the assessment of demographic classes, household characteristics, livestock holding, agriculture practices, and income sources. The data was gathered exclusively from the questionnaire.

5.1a Demographic Information

Our research began by a general analysis of the demographic data, from the respondents which included the gender and qualification of each family member in the 3 districts.

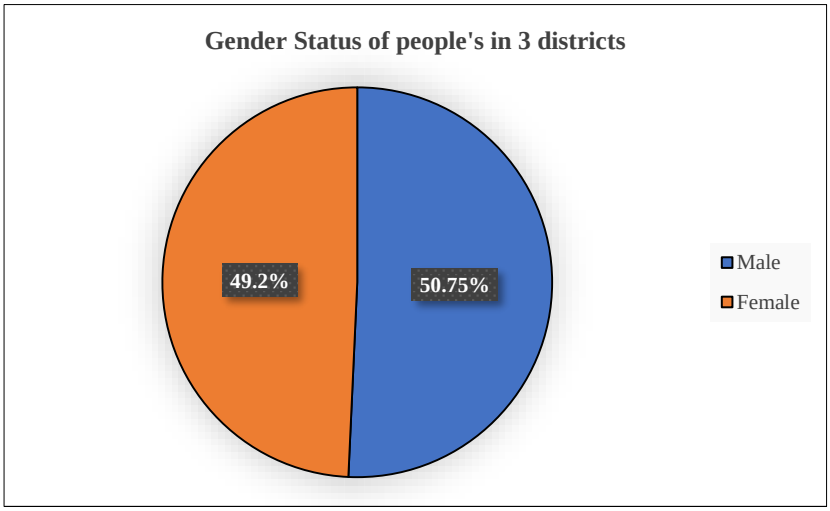


Fig. 5.1 Pie chart representing the gender percentage of the people in all the 3 districts.

46% (n=233) and 54% (n=156) of the respondents were males & females, respectively. The findings indicate that there were 49.2% (n=812) were females and 50.75% (n=837) were males, a fairly even sex ratio in the population, in the 3 districts (Fig 5.1).

5.1b Education

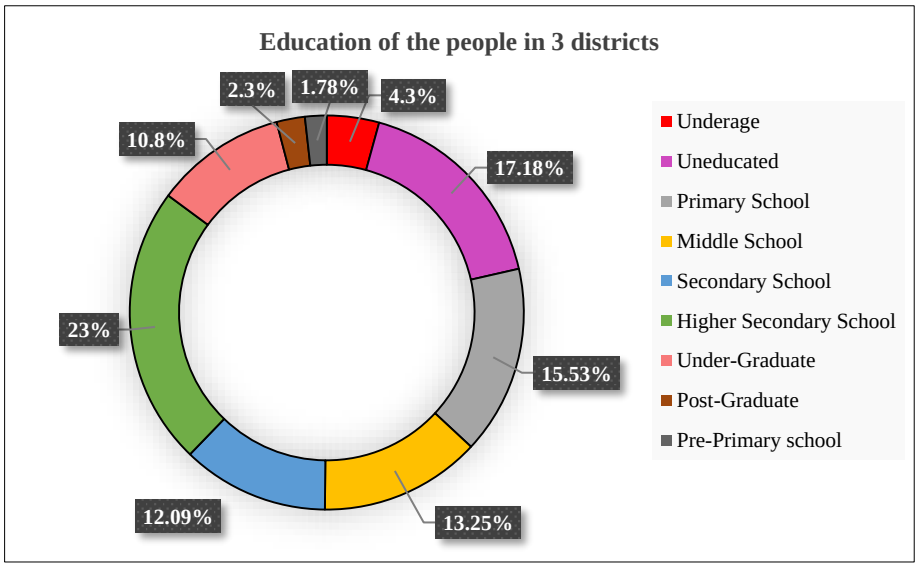


Fig. 5.2 Doughnut pie chart representing the education level of the people in all the 3 districts.

Our education level assessment resulted in 2.3% (n=68) underaged, 17.18% (n=279) uneducated, 15.53% (n=253) Primary school, 13.2% (n=215) Middle School, 12.09% (n=197) Secondary School, 23 % (n=374) Higher secondary school, 10.8% (n=176) under graduate, 2.3% (n=38) Postgraduate and 1.7% (n=29) Pre-primary school. About 78.3% (n=1282) are literate and remaining 21.7% (n= 347) are under the category of illiterate (Fig 5.2).

5.1c Livelihood or source of income of the local people in all the 3 districts

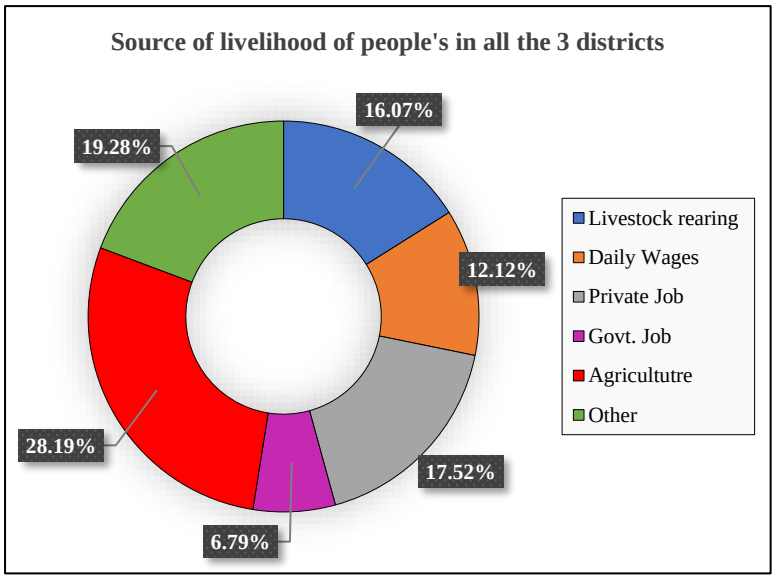
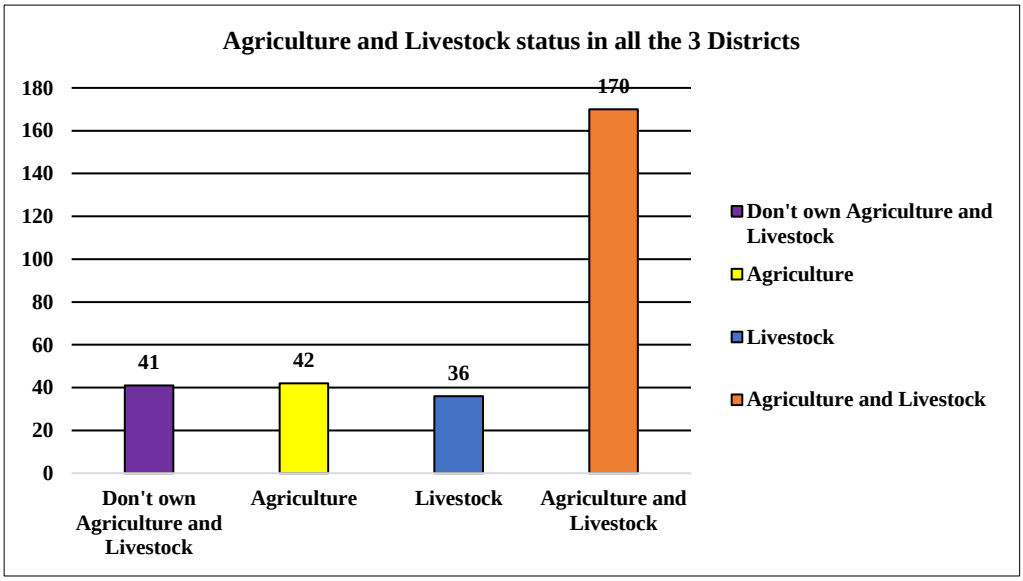


Fig. 5.3 Doughnut pie chart representing the source of livelihood of the people in all the 3 Districts.

The major profession of the people was agriculture i.e. 28.19% (n=465). About 16.07% (n=265) of the people were involved in livestock rearing, 6.79% (n=112) of the respondents were working in government sectors, 17.52% (n=289) of the people were working in private sectors, 12.12% (n=200) of the respondents rely on the daily wage schemes of the government, while the remaining 19.28% were housewife's, students, underaged children and unemployed people, who rely on other family members for financial support (Fig. 5.3).

5.1d Agriculture land and livestock status of households in all the 3 districts.

Fig. 5.4 Graph representing the Agriculture land and Livestock status in all the 3 districts: Dehradun, Haridwar and Pauri Garhwal.



The findings indicated that 42 & 36 households exclusively have agriculture land and own livestock respectively, while 170 households own both land for agriculture & livestock, in 3 districts (Fig. 5.4).

5.1e Population of Various livestock in all the 3 districts

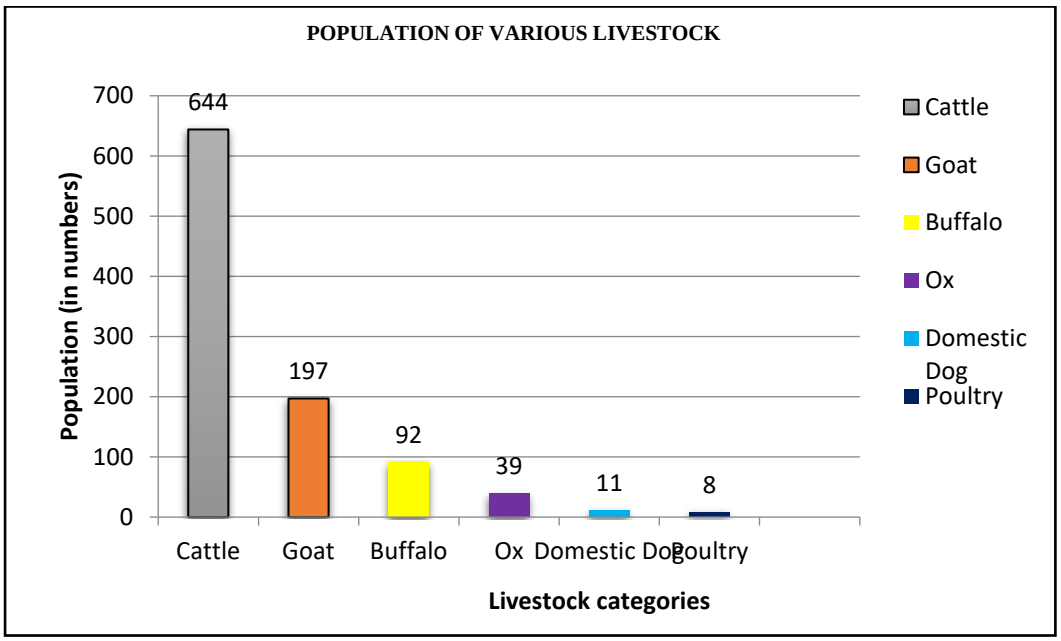


Fig. 5.5 Graph representing the Agriculture land and Livestock status in all the 3 districts: Dehradun, Haridwar and Pauri Garhwal.

The findings indicated that number of cattle found in all the 3 districts are n=644, number of goat are n= 197, number of buffalo are n= 92, number of ox are n=39, number of domestic dog are n=11 and number of poultry are n= 8 in numbers (Fig. 5.5).

5.1f Types of crops cultivated in all the 3 districts

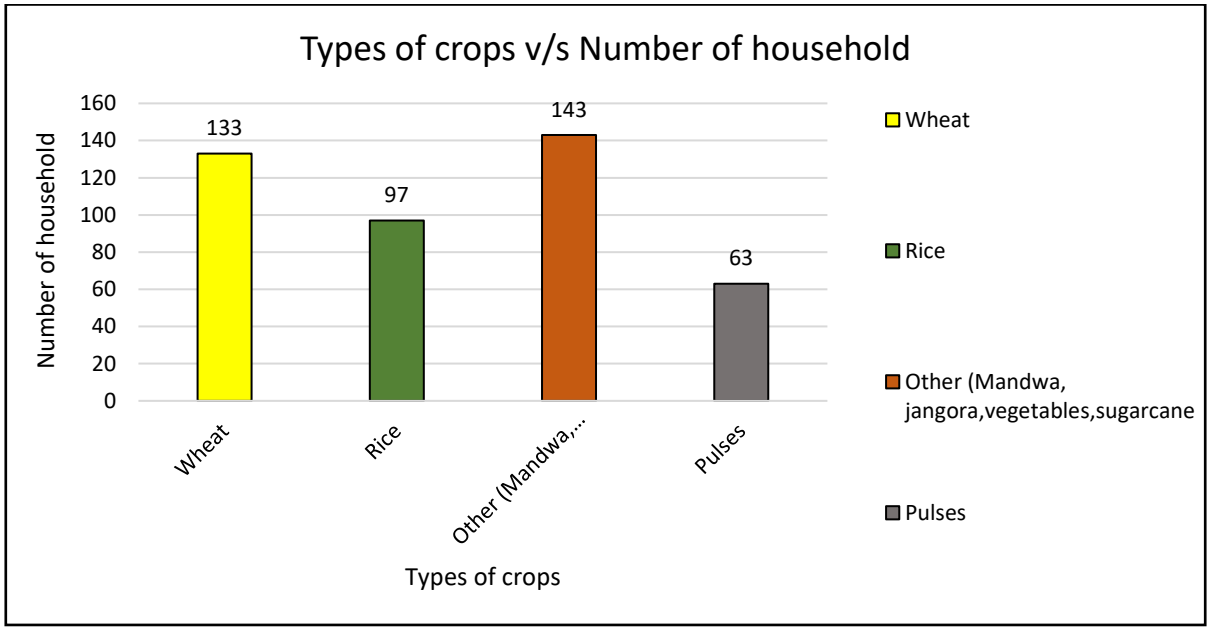


Fig 5.6 Graph representing the types of crops cultivated by number of households in all the 3 districts.

The findings indicate that n=143 household cultivated Mandwa, Jangora, Vegetable and Sugarcane crops, n= 63 households cultivated pulses, n= 133 household cultivated Wheat and n=97 household cultivated rice (Fig. 5.6).

5.2 Assessment of human dependency on forest resources of Rajaji Tiger Reserve

Here we categorized the forest resources in 3 different categories: Consumption goods (Wild Fruits, Wild Medicinal Plants and Firewood), Inputs (Livestock Grazing and Browsing, Grass and bark) and Durables (Animal Shelter, Doors and Windows and Hut wall/roofs).

5.2a Utilization of Consumption Goods by households.

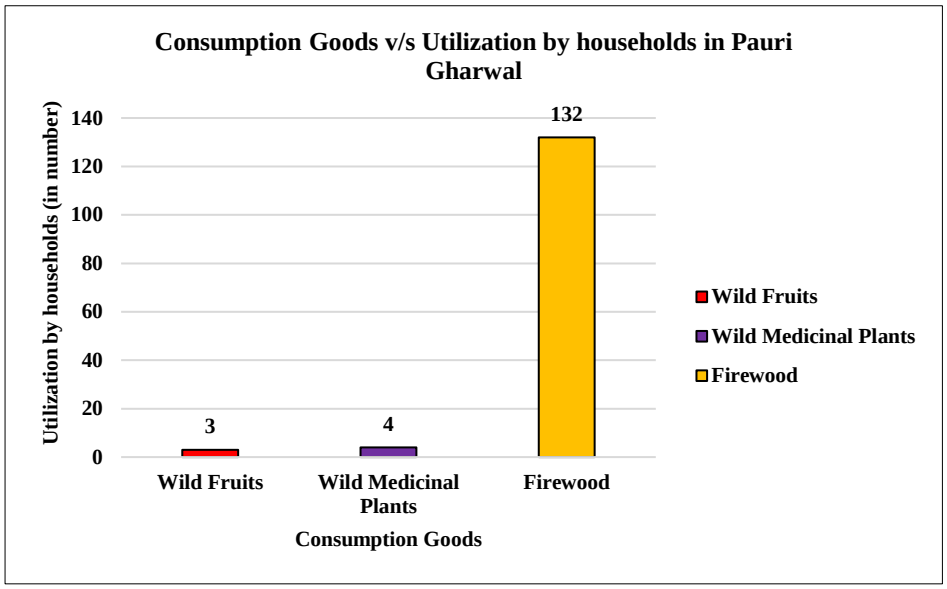


Fig. 5.7 Graph representing the Utilization of Consumption Goods (Wild Fruits, Wild Medicinal Plant and Firewood) by households in Pauri Garhwal.

Our Consumption goods assessment resulted in n= 3 household utilize wild fruits (Mango, Jamun, Amla, Ber), n=4 household utilize wild medicinal plants (Harad-Behada, Haldu), n=132 household utilize firewood for cooking and heating in Pauri Garhwal (Fig. 5.7).

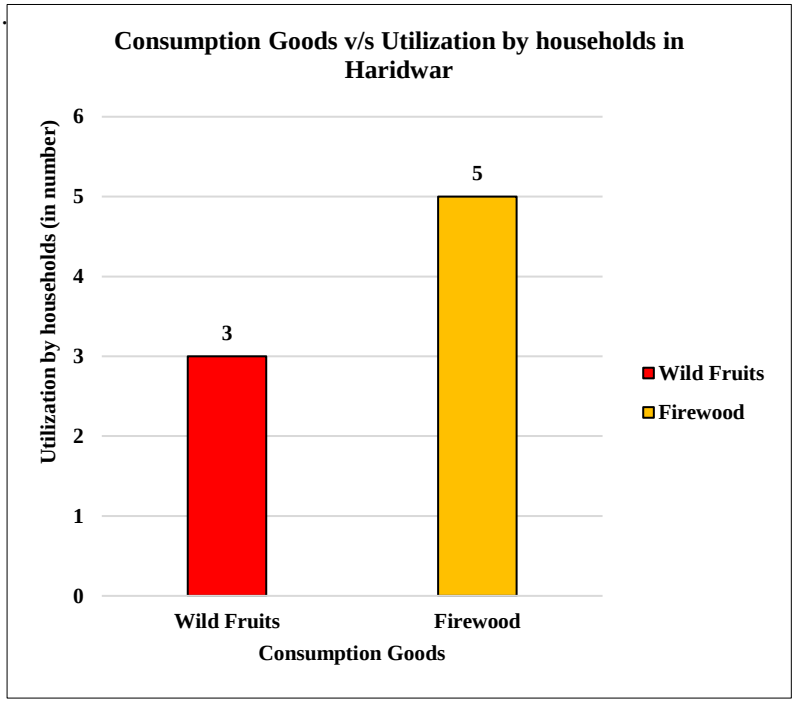


Fig. 5.8 Graph representing the Utilization of Consumption Goods (Wild Fruits, Wild Medicinal Plant and Firewood) by households in Haridwar.

Our Consumption goods assessment resulted in n= 3 household utilize wild fruits (Mango, Jamun, Amla, Ber), n=5 household utilize firewood for cooking and heating in Haridwar (Fig. 5.8).

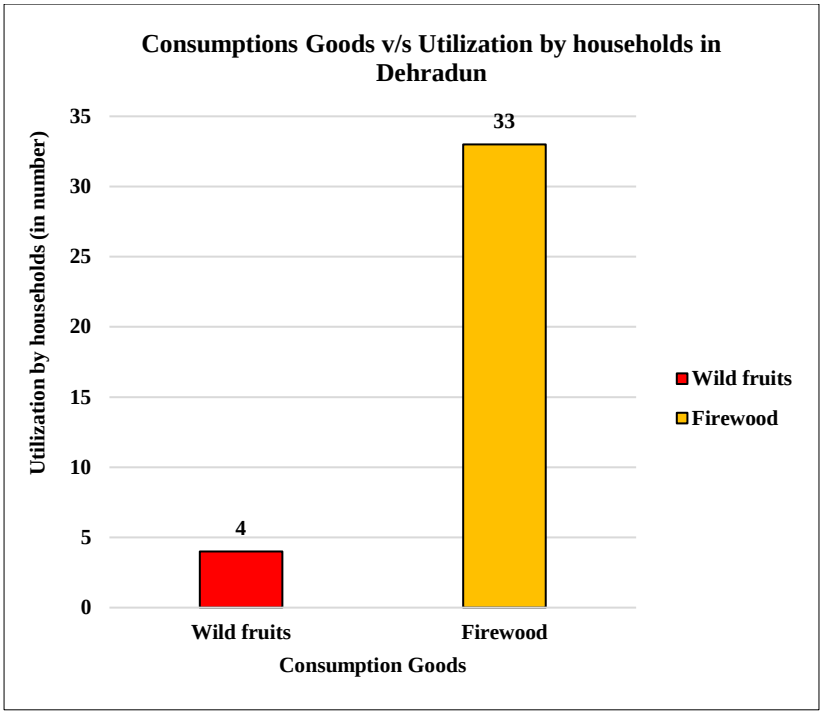


Fig. 5.9 Graph representing the Utilization of Consumption Goods (Wild Fruits, Wild Medicinal Plant and Firewood) by households in Dehradun.

Our Consumption goods assessment resulted in n= 4 household utilize wild fruits (Mango, Jamun, Amla, Ber), n=33 household utilize firewood for cooking and heating in Dehradun (Fig. 5.9).

5.2b Utilization of Utilization of Inputs by households in Pauri Garhwal, Haridwar and Dehradun.

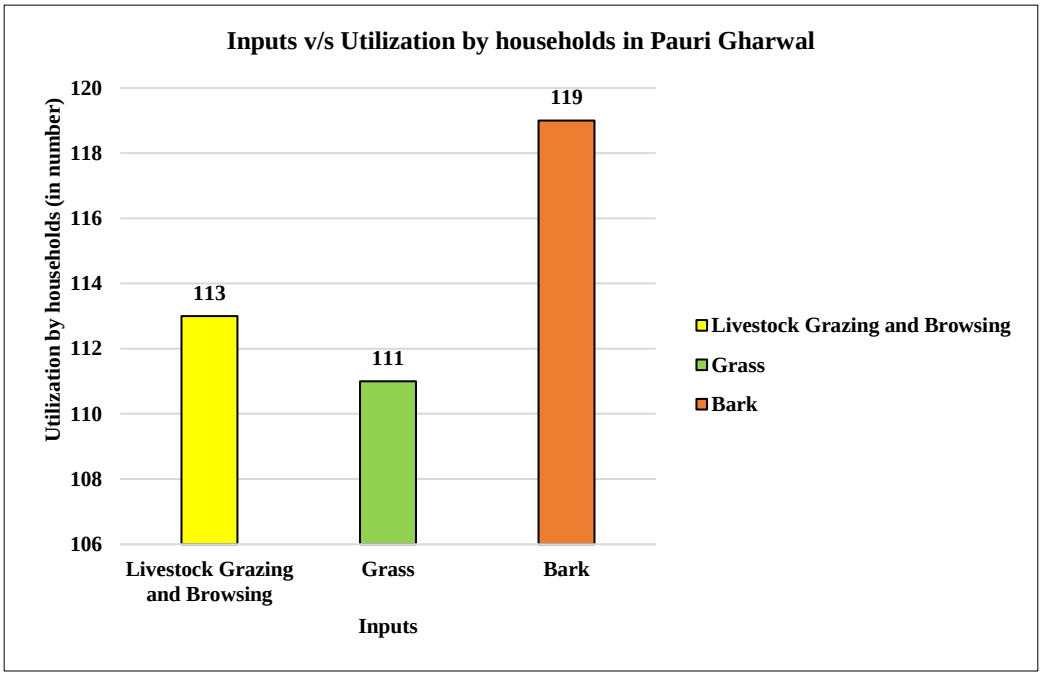


Fig. 5.10 Graph representing the Utilization of Inputs (Livestock Grazing and Browsing, Grass and bark) by households in Pauri Garhwal.

Our Inputs assessment resulted in n=113 household utilize forest land for Livestock Grazing and Browsing, n=111 household utilize Grass (phus grass, Brum grass, elephant grass), n=119 household utilize bark (bheemal bark) in Pauri Garhwal (Fig. 5.10).

Fig. 5.11 Graph representing the Utilization of Inputs (Livestock

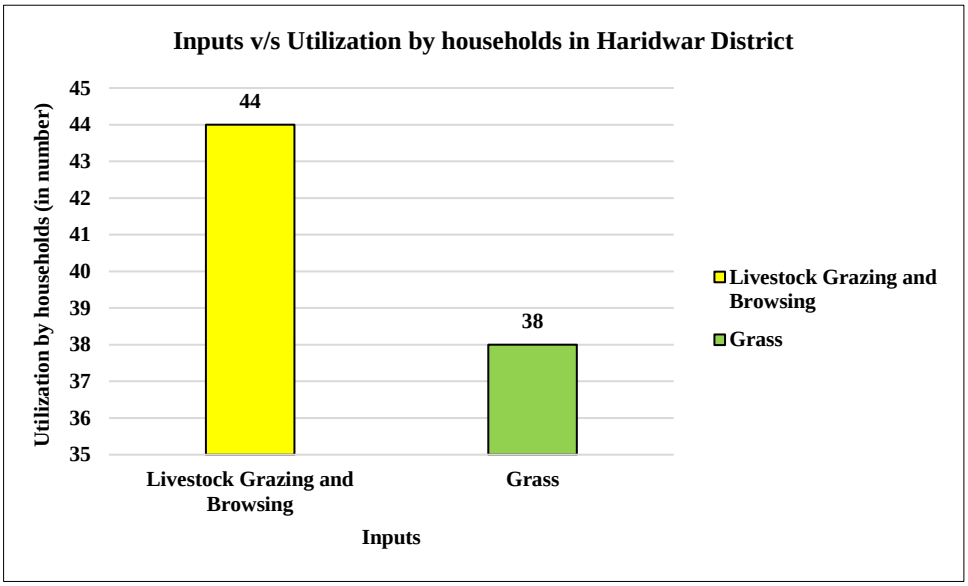


Fig. 5.11 Graph representing the Utilization of Inputs (Livestock Grazing and Browsing, Grass and bark) by households in Haridwar.

Our Inputs assessment resulted in n=44 household utilize forest land for Livestock Grazing and Browsing, n=38 household utilize Grass (phus grass, elephant grass) in Haridwar (Fig. 5.11).

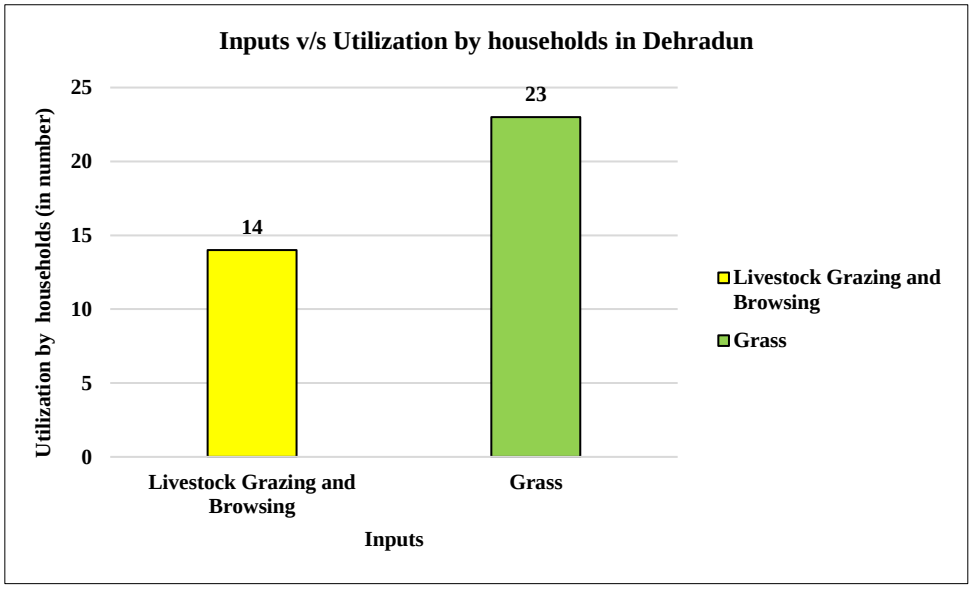


Fig. 5.12 Graph representing the Utilization of Inputs (Livestock Grazing and Browsing, Grass and bark) by households in Dehradun.

Our Inputs assessment resulted in n=14 household utilize forest land for Livestock Grazing and Browsing, n=23 household utilize Grass (phus grass, elephant grass) in Dehradun (Fig. 5.12).

5.2 c Utilization of Durables by households in Pauri Garhwal, Haridwar and Dehradun

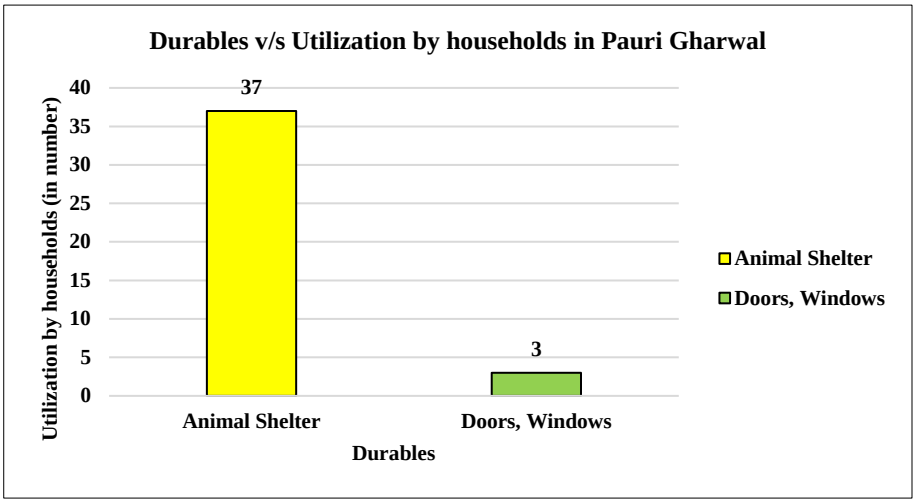
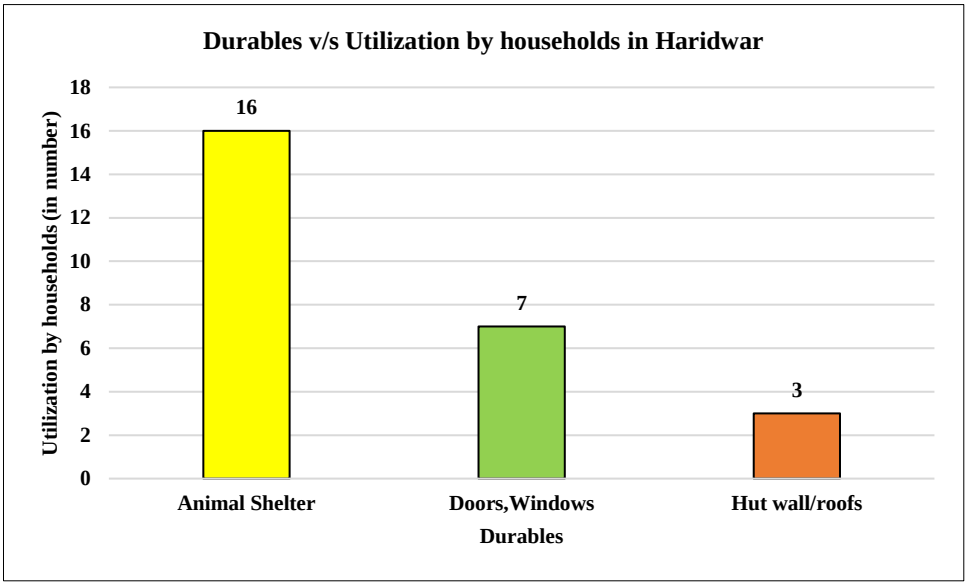


Fig. 5.13 Graph representing the Utilization of Durables (Animal Shelter, Doors/windows and Hut wall/roof) by households in Pauri Garhwal.

Our Durables assessment resulted in n=37 household utilize forest resources for construction of Animal Shelter, n=3 household utilize forest resources for making doors, windows in Pauri Garhwal (Fig. 5.13).

Fig. 5.14 Graph representing the Utilization of Durables (Animal Shelter, Doors/windows and Hut wall/roof) by households in Haridwar.



Our Durables assessment resulted in n=16 household utilize forest resources for construction of Animal Shelters, n=7 household utilize forest resources for making doors, windows, n= 3 household utilize forest resources for hut wall/roof in Haridwar (Fig. 5.14).

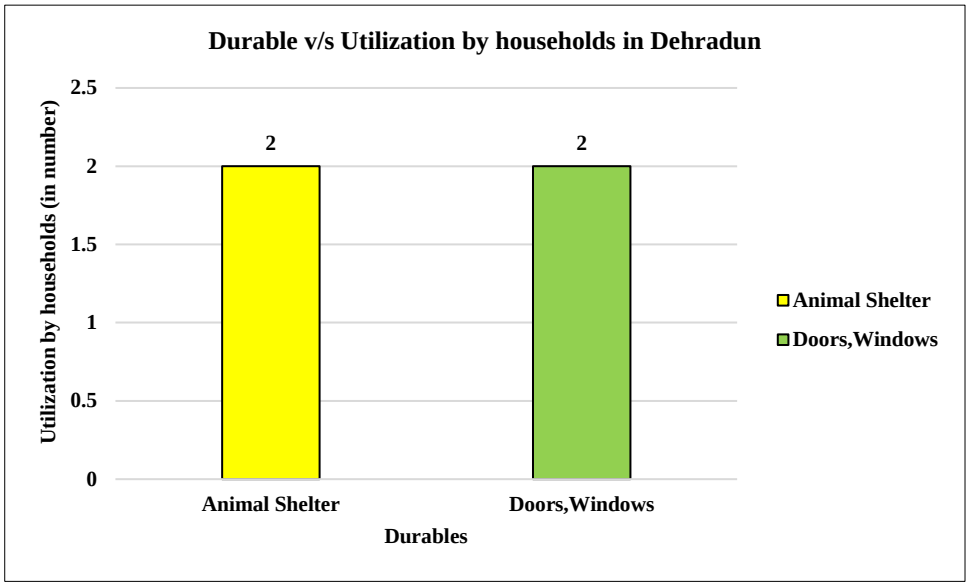


Fig. 5.15 Graph representing the Utilization of Durables (Animal Shelter, Doors/windows and Hut wall/roof) by households in Dehradun.

Our Durables assessment resulted in n=2 household utilize forest resources for construction of Animal Shelter, n=2 household utilize forest resources for making doors, windows in Dehradun (Fig. 5.15).

5.3 Assessment of the role of people in management/ conservation of Rajaji Tiger Reserve.

5.3. a Awareness among people (by household) about rules/laws regulated for forest management

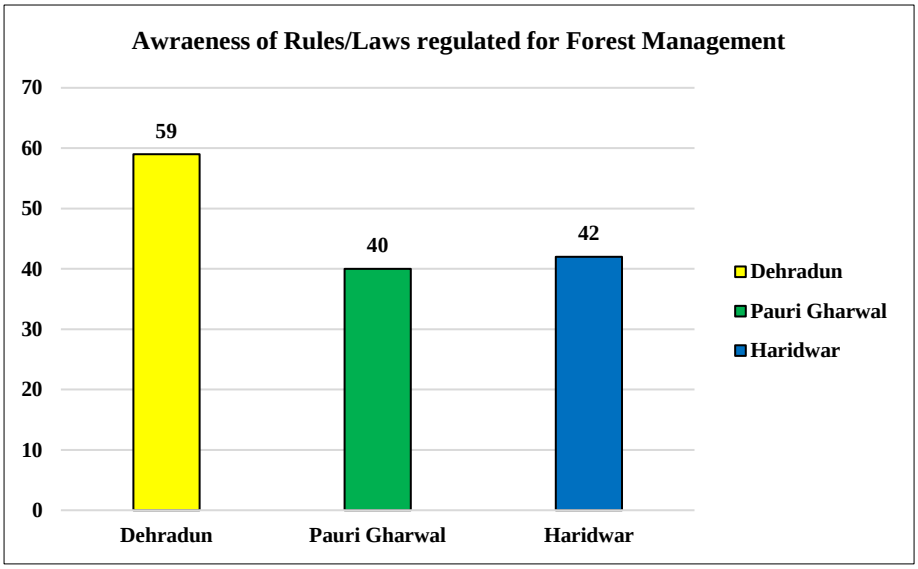


Fig. 5.16 Graph representing the awareness among people (by household) about rules/laws regulated for forest management in all the 3 districts.

The statistics shows that the percentage of household who were aware about rules/laws regulated for forest management in Dehradun, Haridwar and Pauri Garhwal are n=59, n=42 and n=40 respectively (Fig. 5.16).

5.3 b Awareness among people (by household) about programs/strategies adopted for forest management

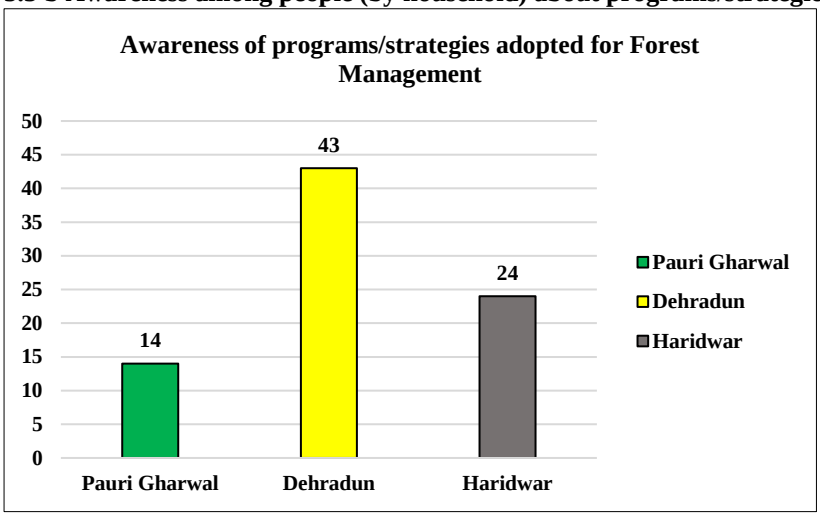


Fig. 5.17 Graph representing the awareness among people (by household) about programs/strategies adopted for forest management in all the 3 districts.

The statistics shows that the percentage of household who were aware programs/strategies regulated for forest management in Haridwar, Dehradun and Pauri Garhwal are n=24, n=43 and n=14 respectively (Fig. 5.17).

5.3 c Participation in programs/strategies adopted for forest management

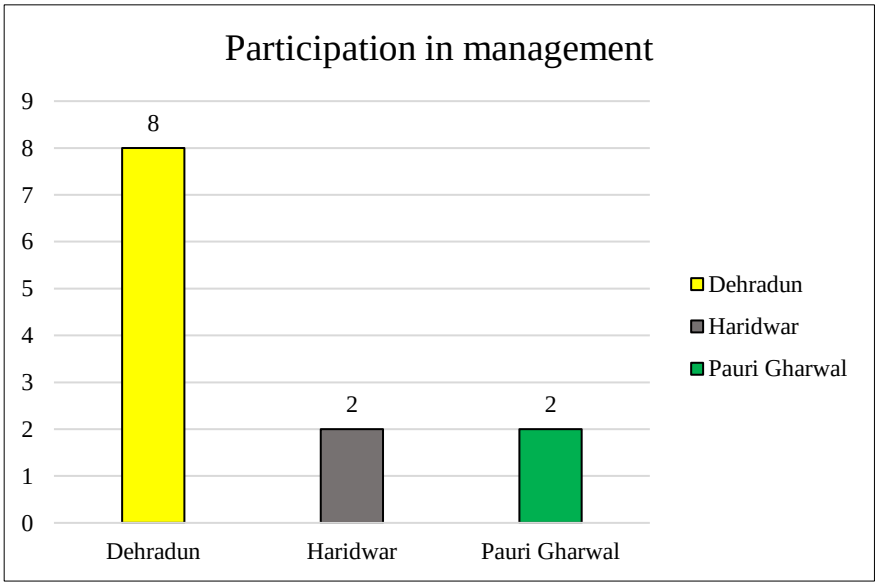


Fig. 5.18 Graph representing the participation of households in programs/strategies adopted for forest management in all the 3 districts: Dehradun, Haridwar and Pauri Garhwal.

The statistics shows that the percentage of household who were participated in programs/strategies regulated for forest management in Pauri Gharwal, Dehradun and Haridwar are n=2, n=8 and n=2 respectively (Fig. 5.18).

5.4 Quality of Life

Quality of life Index

S.No	Opportunities	Human Needs				Subjective well-being	
1.	Forest Resources	Consumption goods	Utilization by household in each district (%)			Haridwar(68)	
			Pauri Gharwal (139)	Haridwar (68)	Dehradun (82)	Not Satisfied	Satisfied
						73%	27%
		Wild fruits	2%	4%	nil		
		Wild Medicinal plants	3%	nil	nil		
		Firewood	95%	73%	40.2%		
		Inputs					
		Livestock browsing and Grazing	81.2%	64.7%	17.07%		
		Grass	80%	56.05%	28.05%		
		Bark	86%	nil	nil		
		Durable goods				Pauri Gharwal (139)	
		Animal Shelter	26.6%	23%	3%	Not Satisfied	Satisfied
		Doors, windows	2%	10%	3%	77%	23%
		Hut wall/roof	nil	5%	nil		
S.No	Opportunities	Human Needs				Subjective well-being	
2.	Participatory Decisions in Management/ Conservation	Awareness	Awareness and Participation in each district (%)				
			Pauri Gharwal (139)	Haridwar (68)	Dehradun (82)		
		Knowledge about Rules/Laws	29%	62%	72%		
		Knowledge about programs/Strategies	17%	20%	52%	Dehradun (82)	
						Not Satisfied	Satisfied
		Participation				75%	25%
		Eco-Samiti	2%	3%	9%		

Table 5.1 Quality of life Index representing Utilization of forest resources by household and Participation in Management of Forest by household in all the 3 districts: Dehradun, Haridwar and Pauri Garhwal (Left).

The above table 5.1, shows the dependency and participation of households in forests of Rajaji. Here the "quality of life" index is categorized into "opportunities", "human needs" and "subjective well-being". The ability of humans to satisfy their basic needs come from available opportunities. As we look at the dependency of humans on forests, the opportunities are the natural resources available from them. Opportunities are further categorized into "Forest Resources" and "Participatory Decision-making in Management/Conservation".

In terms of Utilization of Forest Resources, human needs are further categorized into "Consumptive goods", "Inputs", and "Durable goods".

Firewood is the maximum utilized consumptive goods amongst the three classes surveyed from the households, with decreasing order of use, district-wise as follows: Pauri Garwal (95%), then Haridwar (73%), and least in Dehradun (40.2%). Firewood is predominantly utilized as fuel of for cooking and heating. Wild-fruits and medicinal plants though used minimally; they are used maximally in Pauri Garhwal i.e. 2% & 3% respectively.

While consumption goods from forests are minimally used, except for firewood. Amongst the "inputs" class, all the three subcategories "Livestock grazing and browsing", "grass", & "bark" are highly used. The decreasing order of use for "Livestock grazing and browsing" is as follows: 81.2%, 64.7%, & 17.07%, from Pauri Garhwal, Haridwar & Dehradun respectively. Of the households surveyed, 80%, 56.05% & 28.05% households surveyed,

from Pauri Garhwal, Haridwar & Dehradun respectively, utilize grass. But bark is only utilized in Pauri Garhwal, by 86% households, its utilization is nil in Haridwar & Dehradun.

The last category of consumption goods is “Durable goods”, only animal shelters can be said to be used, made from materials from forests. Only utilized by 26.6%, 23% & 3%, of the households surveyed in Pauri Garwal, Haridwar and Dehradun respectively. Other than animal shelter, “doors/windows” & “hut wall/roof”, are utilized by, 2% 10% & 3%, and, nil 5% & nil, by households of Pauri Garhwal, Haridwar & Dehradun, respectively.

The opportunities in “participatory decision in management/conservation”, are classed in to “awareness” and “participation”.

There seems to be fair amount of “awareness” of both “rules/laws” and “programs/strategies” around Rajaji. 29%, 62% & 72%, of the households surveyed, acknowledge of having knowledge about “rules/laws” about forests. While knowledge about “programs/strategies”, comparatively is low. Only 17%, 20%, & 52% of the households surveyed, in Pauri Garhwal, Haridwar & Dehradun, respectively, acknowledge of having awareness about various “programs/strategies” in & around Rajaji.

The “opportunities” of “participation” in an Eco-Samiti program, in comparison, is considerably low. Only 2%, 3% & 9%, of households surveyed from, Pauri-Garhwal Haridwar & Dehradun respectively, acknowledge having a participatory role in an Eco-Samiti program.

6 DISCUSSION

6.1 Socio-Economic dimensions of local people

The demographic data collected during the survey shows that population of males is higher as compared to females in all the 3 districts. But a very low difference, of just 2.5%, the sex ratio is 1.03 male to 1 female, which is fairly even. It could be due to more awareness in people towards gender equality or the outcome awareness programs towards gender equality by the governments in the region.

The literacy percentage shows that about 78.3% are literate and remaining, 21.7% are illiterate. Of the percent of illiterate people, only 4.3% of the illiterate people were underaged, while adult illiterate population was 17.18%. The study revealed that the majority of the people (by household) depended on agriculture for their livelihood. The livestock population data collected during the survey shows that population of cattle is high compared to the other livestock.

6.2 Human dependency on forest resources

The forest resources are categorized into 3 different categories: Consumption goods (Wild Fruits, Wild Medicinal Plants and Firewood), Inputs (Livestock Grazing and Browsing, Grass and bark) and Durables (Animal Shelter, Doors and Windows and Hut wall/roofs).

From "consumption goods" data, if can be seen that utilization of firewood for cooking purposes is still very highly prevalent in all the three districts, while utilization of wild fruits (Mango, Jamun, Amla, and Ber) and wild medicinal plants (Harad-Behada, Haldu), is insignificantly low.

Under "Inputs", the use of forest land for "Livestock Grazing and browsing" is significantly higher in comparison to utilization of grass. While the use of bark (*"bheemal"*) is only prevalent in Pauri Garhwal. The grass taken from forests is used only for construction purpose or as fodder ("*chara"*) for livestock.

In "durable goods" assessment of eco-sensitive zones, show that the utilization forest resources for construction of "Animal Shelter" is maximum. In comparison, utilization of forest resources for construction of "doors and windows" is significantly lower.

6.3 Role of people in management/conservation

The role of people in "management/conservation of forest" data, collected during the survey, shows that the awareness of "rules/laws", "programs/strategies" & "participation" is highest in Dehradun district, and lowest in Pauri Gahrwal district.

The "quality of life" index shows that people are less satisfied by living around the protected area. While the proportion of "dependencies" and "opportunities", to local from Rajaji, may vary differently in three districts. Almost 75% of the households are unsatisfied, while only around 25% are satisfied by living around the Rajaji Tiger Reserve.

7 CONCLUSIONS

The study shows that people are, more or less, not concerned about the management of forests of "Rajaji Tiger Reserve". Whatever the utilization of forest resources is, harvesting is not legal. For the improvement of the "people-park relationship", between the managers and local people, participatory meetings should be organized, with opportunities for the people to tell their problems. With only around 25% of people satisfied with their living conditions, because as a majority, they are still dependent on traditional agriculture or on daily wages, which offers meagre income. The development of Eco-tourism or the idea of generating income from natural resources from the forest would significantly improve their living conditions. The study also shows how ill-informed people are, so local people still need to be educated in planning and management and conservation.

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CHAPTER 2

"Study of "Human-Wildlife Conflict" in the eco-sensitive zones & analysis of Landscape level changes of Rajaji Tiger Reserve, Uttarakhand"

PALLABI BORO

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1 INTRODUCTION

1.1 "Human-Wildlife Conflict"

Human–wildlife conflict is a major issue that occurs *"when the needs and behaviour of wildlife impact negatively on the goals of humans or can adversely impact the needs of wildlife, while sharing the landscape"* (Madden, 2004). The extent of HWC can vary, from grain-eating rodents to man eating tigers (Pimentel, Zuniga & Morrison, 2005). According to Nyahongo (2007), there are ways and means by which people tend to affect the wildlife by lethal methods, such as shooting, poisoning, trapping or snaring, habitat modification, encroachment or disease exchange between wildlife and livestock.

In Asia, the major flagship species involved in conflict with humans include snow leopard (*Panthera uncia*), with conflict in India and Mongolia; Asiatic lion (*Panthera leo persica*), Bengal tiger (*Panthera tigris tigris*) Indian leopard (*Panthera pardus fusca*), and Asian elephant (*Elephus maximus indicus*) with conflicts in India (Anwar *et al.*, 2015). Hundreds of human-wildlife conflict incidents occur annually in the Uttarakhand's protected areas that include livestock predation by leopards and tigers, and crop raiding by wild pigs, elephants, and various ungulates (Badola, 1998; Johnsingh *et al.*, 2002; Bhardwaj *et al.*, 2002; Johnsingh and Negi, 2003). In context of "Rajaji National Park", there are over 100 villages, within 1-5 km radius of Rajaji national park, dependent primarily upon nearby forest resources such as fuelwood, fodder, grazing land, thatch grass, medicinal plants, fruits, etc. (Badola, 1997). Overlapping use of resources is amongst the primary reason that increases the interactions between humans and wildlife leading to high number of conflicts (Treves *et al.*, 2006).

High incidences of crop raiding have been observed by Asian elephants (Sukumar, 1989; Balasubramanian *et al.*, 1995), where elephant raiding intensifies during ripening of paddy and millet, others species of crop raiding by animals is wild pig (*Sus scrofa*) (Linkie *et al.*, 2007). Around Uttarakhand's protected areas, attacks by elephants, tigers, bears, and leopards between 1994 and 1999, documented in and around Corbett National Park numbered to 18 (GOI, 2001), 11 people were injured by elephants near Rajaji National Park from 1993-1999 (Williams, 2002). Between 1982–1993, elephants killed 85 people in the corridor between the two parks (Badola, 1997).

1.2 Change detection analysis

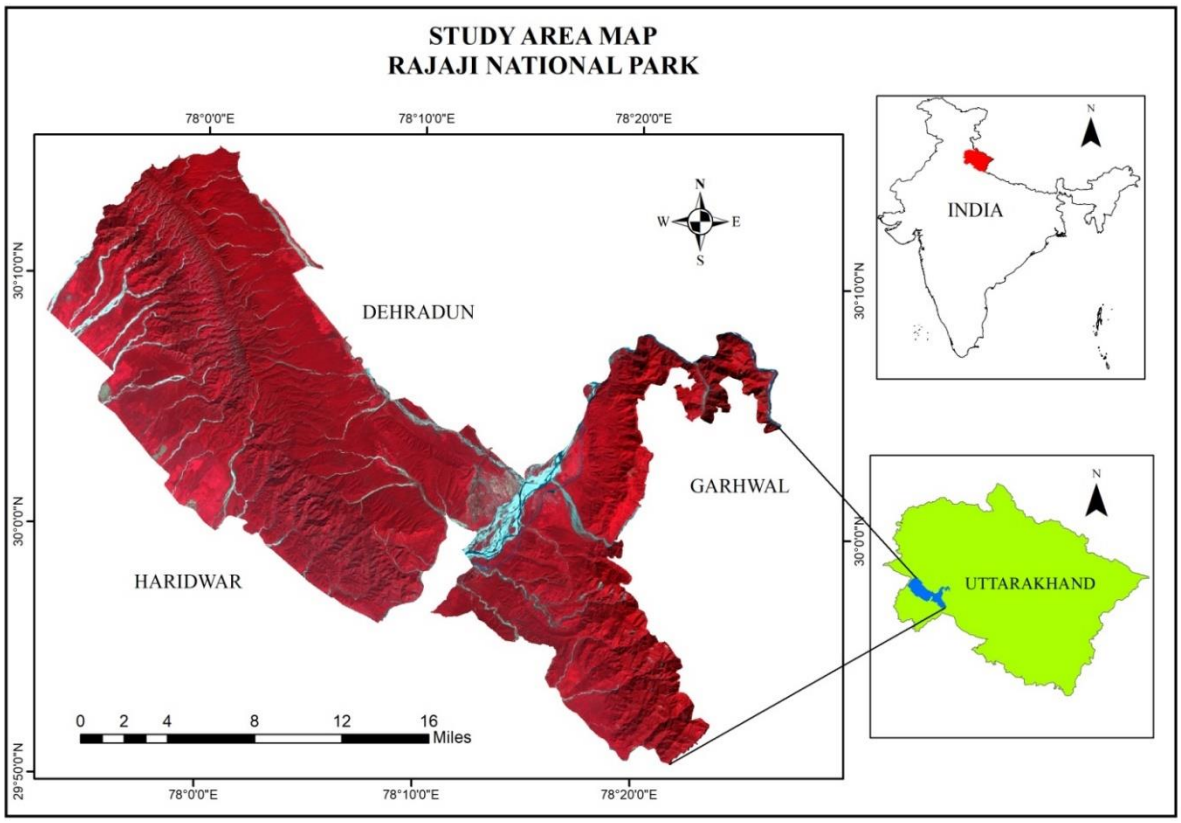
For a prolonged time, changes in a landscape results in the elimination of various species and disturbs the ecosystem functioning and services (Priess *et al.*, 2007; Martínez *et al.*, 2009). Simultaneous reduction and fragmentation of large forest tract into smaller non-contiguous fragments are defined as "fragmentation", and can further lead to human-wildlife conflict (Laurance, 2000; Midha & Mathur, 2010). Invasive species, intensive agriculture, infrastructure development, over-exploitation of natural resources, & pollution, are all related to the habitat loss and causes of fragmentation (Semwal 2005). Therefore, "NDVI" or "Normalized Difference Vegetation Index", - a spectral index, one of the well-known techniques of Remote Sensing and GIS technology, is used to detect spatio-temporal changes in vegetation cover for micro-regions over the earth's surface (Agone *et al.*, 2012). The technique is widely used for detecting the green plants canopy from multispectral remote sensing data. Example of land use classification map of Rajaji NP shows the analysis of water bodies, showing an overall change in area from 83.60 to 87.59 km^2 (from 1990 to 2000), and subsequent, decline to 85.47 km^2 (in 2009) (Singh *et al.*, 2016). Among the other modelling tools and techniques, the commonly used models are the modelling techniques embedded in IDRISI, with techniques like Land Change Modeler (LCM), Cellular Automata, Markov Chain, CA Markov, GEOMOD and STCHOICE (IDRISI, 2006).

Agone *et al.* (2012) did a change detection of vegetation cover using Geospatial technique, focussing on NDVI (Normalized Differential Vegetation Index). The NDVI was also used for detection of spatiotemporal change in vegetation cover for "Tittur" basin and found that bare land increased from the year 1990 to 2010.

2 STUDY AREA

The study was conducted in the "Rajaji National Park" (Map 2.1), first declared wildlife sanctuary in the year 1983, and later on declared as a "Tiger Reserve" on 15 April 2015. It is located in the state of Uttarakhand, formerly known as Uttaranchal, in northern India. The tiger reserve lies between latitudes 29º45' North to 30º15' North and longitudes 77º52' East to 78º33' East. The total area of the reserve is 1075.17 km^2. The core zone and the buffer comprise an area of 819.54 km^2. and 255.63 km^2 respectively.

"Rajaji Tiger Reserve" inherited its name from Rajaji Sanctuary. In 1983, three wildlife sanctuaries in the area namely, Chilla, Motichur and Rajaji, were merged into Rajaji National park, in a total area of 820.4219 km^2. The park was acknowledged after Late Shri C. Rajagopalachari also known as "Rajaji", who was the first Governor General of independent India.



Map 2.1 Geopolitical location of Rajaji Tiger Reserve.

Faunal components – The Park is the north-western limit of distribution of Bengal tigers and Asian elephants in India, with a large population of elephants and leopards. The Reserve has rich diversity of fauna with nearly 23 species of mammals and 315 avifauna species of birds. Chital **(***Cervus axis*), barking deer (*Muntiacus muntjak*), sambar (*Rusa unicolor*) are the principal species of cervids, while the goral (*Nemorhaedus goral*) & nilgai (*Boselaphus tragocamelus*) are the chief bovids. Wild pig (*Sus scrofa*) is very common. Asian elephant (*Elephas maximus*) is the chief main attraction of the Reserve. Bengal tiger (*Panthera tigris tigris*) and common leopard (*Panthers pardus fusca*) are the top carnivores, along with the sloth bear (*Melursus ursinus*) and the Asiatic black bear (*Ursus thibetanus*) and striped hyena (*Hyaena hyaena*). Small carnivores, such as, jungle cat (*Felis chaus*),

leopard cat (*Prionailurus bengalensis*) and small Indian civet (*Viverricula indica*), rusty-spotted cat (*Prionailurus rubiginosus*), golden jackal (*Canis aureus*), and Himalayan yellow-throated marten (*Martes flavigula*) are also found. The Zoological Survey of India (ZSI) has reported nine species of bats from the region. Rajaji has a number of snakes including the Indian rock python (*Python molurus*), king cobra (*Ophiophagus hannah*), common krait (*Bungarus caeruleus*), and spectacled cobra (*Naja naja*). The Indian monitor lizard (*Varanus bengalensis*) is also a common species (Rasaily, 2012).

Floral components - The vegetation belongs to northern tropical dry deciduous forest and sub-tropical forest. The main species of plants in the park are sal (*Shorea robusta*), baki *(Anogeissus latifolia*), sain (*Terminalia tomentosa*), haldu (*Adina cordifolia*), baheda (*Terminalia bellerica*), jhingan (*Lannea coromandelica*), kharpat (*Garuga pinnata*), phauri (*Lagerstroemia parviflora*), bula (*Kydia calycina*), badal (*Stereospermum chelonoides*), tun (*Toona ciliata*), gutel (*Trewia nudiflora*), and gular (*Ficus glomerata*). The under growth consists karaunda (*Carissa opaca*), gandhala (*Murraya koenigii*), marorphali (*Helicteres isora*). Grasses include gorla (*Chrysopogon fulvus*), kummeeria (*Heteropogon contortus*) (Champion and Seth, 1968).

3 RATIONALE & OBJECTIVES

"Human-wildlife conflict" is a very critical and major threat or issues to the survival of many endangered wildlife species or their habitat as well as on the people or their resources. This issue can be seen usually in and around the protected areas, such as national parks or villages, that are in eco-sensitive zones. Due to several factors such as forest dependency or habitat fragmentation of various species in the areas, human or local communities come in contact with the wild animals resulting in human as well as animal fatalities. Many cases of human deaths by leopards (*Panthera pardus fusca*) and tigers (*Pantheras tigris tigris*) have occurred around Rajaji Tiger Reserve. Hence, local level identification and categorization of different types of conflict in the eco-sensitive villages around are necessary for conservation and management of the forest resources and the wildlife populations. Moreover, these categorizations can also be used to prevent the loss of human life and property.

Due to climate change, as well the ever-changing nature of ecology itself, monitoring changes on the level of landscapes is a fairly good idea. Because of small sizes of protected areas in India, scarcity or reduction of resources can increase the conflict, from local to regional levels. To monitor the health of the system, and provide management suggestions, GIS and remote sensing tools and techniques were used to analyze landscape level changes through the years.

Therefore, this study was undertaken in Rajaji tiger Reserve's eco-sensitive zone villages with the following objectives:

1. To show the landscape changes of Rajaji National Park (now Rajaji Tiger Reserve) of time period from the year 1995-2010, 2010-2015, 2015-2018.

2. Analysis of human-wildlife conflict types and its vulnerability in the eco-sensitive villages of Rajaji National Park.

4 METHODOLOGY

4.1 Materials

4.1a. Change detection analysis

For the study of spatiotemporal detection of changes in forest vegetation cover, during 1995, 2010, 2015 and 2018 of Rajaji National Park, multi-spectral cloud free satellite imagery of Landsat series "LANDSAT 5, LANDSAT 7, LANDSAT 8" (WRS path row of 146, 39) were downloaded from the USGS "earth explorer" and was used for image processing for estimation of NDVI, to detect vegetation changes.

Seen ID	***Satellite/Sensor***	***Path Row***	***Date***	***Band***	***Resolution***
LT51460391995308ISP01	Landsat5/TM	146, 39	04/11/1995	3, 4	30m
LE71460392000330SGS00	Landsat7/ETM+	146, 39	25/11/2000	3, 4	30m
LT51460392010317KHC00	Landsat5/TM	146, 39	13/11/2010	3, 4	30m
LC81460392015315LGN01	Landsa8/OLI	146, 39	11/11/2015	4, 5	30m
LC81460392018275LGN00	Landsa8/OLI	146, 39	10/02/2018	4, 5	30m

Table 4.1 Data Source and Acquisition

4.1b. Questionnaire survey

Designing of questionnaire for the field survey was prepared, followed by sample selection of the number of households of each villages to be surveyed around 1km buffer zone from Rajaji tiger reserve under eco-sensitive areas.

4.1c. Software used

Following software were used during the study, for calculation of NDVI, change detection and prediction for the future.

- **Erdas imagine** is used for pre-processing of the satellite images.
- **Arc GIS** is used for the post processing that includes techniques of classifying NDVI taxonomy map, calculating area for each class using tools such zonal statistics
- **Tersset (IDRISI)** is used for prediction of conflict intense area using the changes of the time period taken.
- **Ms. Excel** is used for the statistical analysis of the cumulative change and survey.

4.2 Methods

This study is based on the remotely sensed data (aerial photographs and satellite images) and ground surveys in the villages located in the eco-sensitive zone of Rajaji National Park.

4.2a. Landscape Change Detection using Terrset Software.

The first objective of the study is to detect the vegetation changes of Rajaji Tiger Reserve landscape, followed by the calculating the time series analysis. First steps include the pre-processing of the imageries for further processing. Hence, cloud free Landsat imageries i.e., Landsat 5, Landsat 8 images of (WRS path row of 146, 39) of Rajaji National Park of the year 1995, 2010, 2015 and 2018 time period were acquired from the USGS earth explorer, for landscape change detection analysis of the study area, respectively.

Next, pre-processing of the chosen satellite imageries included defining projection i.e. WGS 1984, followed by calculating the reflectance of two bands i.e., Band 4 (Red Band) and Band 5 (Near Infrared Band) of Landsat 8 image of 2015 and 2018 which was processed in model maker tool in Erdas Imagine which results in high value as 255 and low value 0 using the formula: $\boldsymbol{\rho\lambda = M\rho * Qcal + A\rho}$

where: **ρλ** = TOA planetry,

Mρ = Reflectance multiplicative scaling factor for the band,

Aρ = Additive band, and

Qcal = Level/Pixel value in DN.

Next pre-processing of the Landsat 5 imagery of the year 1995 and 2010 is done by calculating radiance of band 3 i.e., Red Band and band 4 i.e., Near Infrared Band, using the following formula:

$$\boldsymbol{L\lambda = ((Lmax\lambda - Lmin\lambda)/(QcalMax - Qcalmin)) * (Qcal - Qcalmin) + Lmin\lambda.}$$

where**:**

Lλ = Spectral Radiance at the sensor's aperture in watts/(meter squared * ster * μm),

Qcal = the quantized calibrated pixel value in DN,

Lminλ = the spectral radiance that is scaled to QCALMIN in watts/(meter squared),

Lmaxλ = the spectral radiance that is scaled to QCALMAX in watts/(meter squared),

Qcalmin = the minimum quantized calibrated pixel value (corresponding to **Lminλ)** in DN, and

Qcalmix = the maximum quantized calibrated pixel value (corresponding to Lmaxλ) in DN = 255.

and then conversion of atmospheric reflectance from the radiance of both the band 3 and band 4 i.e. was computed using the following formula:

$$\boldsymbol{\rho = \pi * L\lambda * d^2 \div Esun\lambda * \cos\theta}$$

where:

P = Unitless planetary reflectance,

Lλ = Spectral radiance at the sensor's aperture,

d = Earth-Sun distance in astronomical units,

Esunλ = Mean solar exo-atmospheric irradiances, and

θ = Solar zenith angle in degrees.

Then taking the output reflectance image of bands 4 and 5 of Landsat 8 of the year 2015 and 2018, band 3 and 4 of Landsat 5 of year 1995 and 2010 were taken to calculate the NDVI for the chosen years using the formula: **NIR – R/NIR+R.**

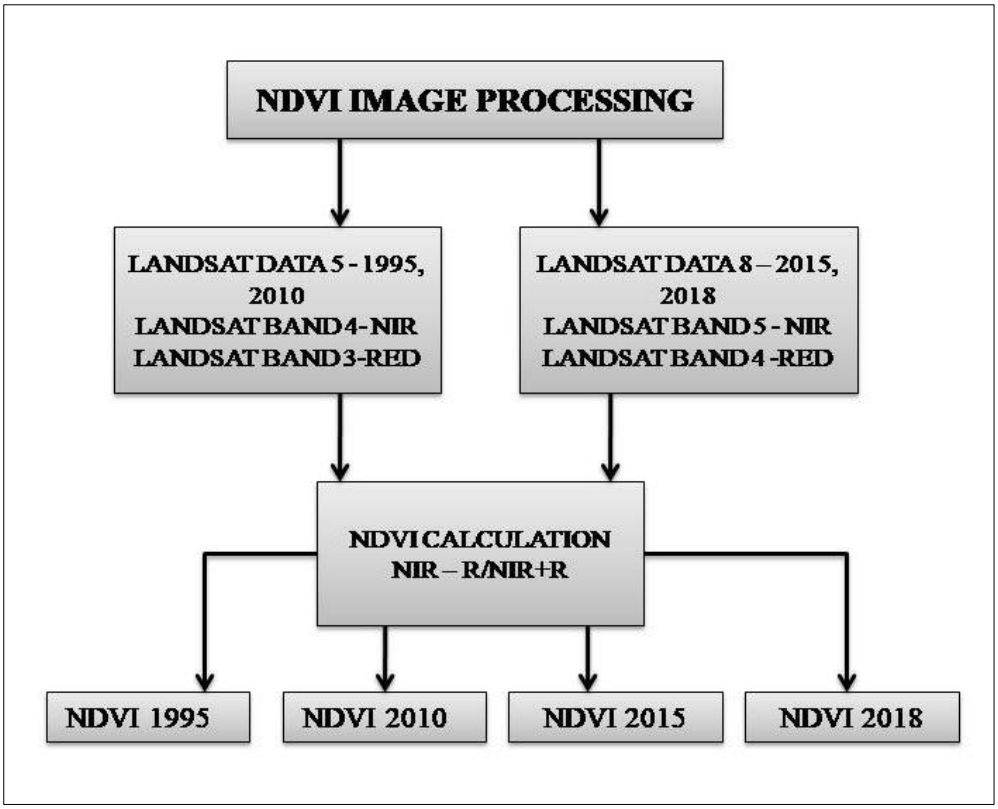


Fig 4.1: NDVI image processing flow chart.

By setting a threshold value for different classes, classification of the NDVI images was done for each year into 5 classes. 1. **Water Body**, 2. **Barren land**, 3. **Agriculture**, 4. **Scrubland and grassland**, and 5. **Dense Forest Cover,** with certain threshold value for each class, as follows - Water Body- (-0.74 to 0.0), Barren land – (0.0 to 0.3), Agriculture (0.3 – 0.46), Scrubland and Grassland- (0.46 – 0.6), & Dense Forest (0.6 – 0.81). Accuracy was assessed, followed by classifying the image using the above threshold. The respective classified imageries were then reclassified using the new highest and lowest threshold values of the NDVI classified image in Arc GIS. Followed by calculating the areas of each raster layer in Zonal Statistics tool, using both NDVI map and the reclassified map for each year. Zonal statistics is a geo processing tool that summarizes the values of a raster within the zones of another dataset and reports the results to a table. Cumulative change of areas of each class are then calculated and statistically represented. Lastly, the change analysis of the reclassified map of Rajaji land cover images were converted into .rst format for time period of 1995-2010, 2010-2015, 2015-2018 as an input in the land change modeler. The later was processed and the output maps were generated.

4.2b. Human-Wildlife Conflict questionnaire survey

The data collection methods included field observation, household survey and field interview. The following methods were adopted in order to collect information on types of human conflict and its vulnerable consequences

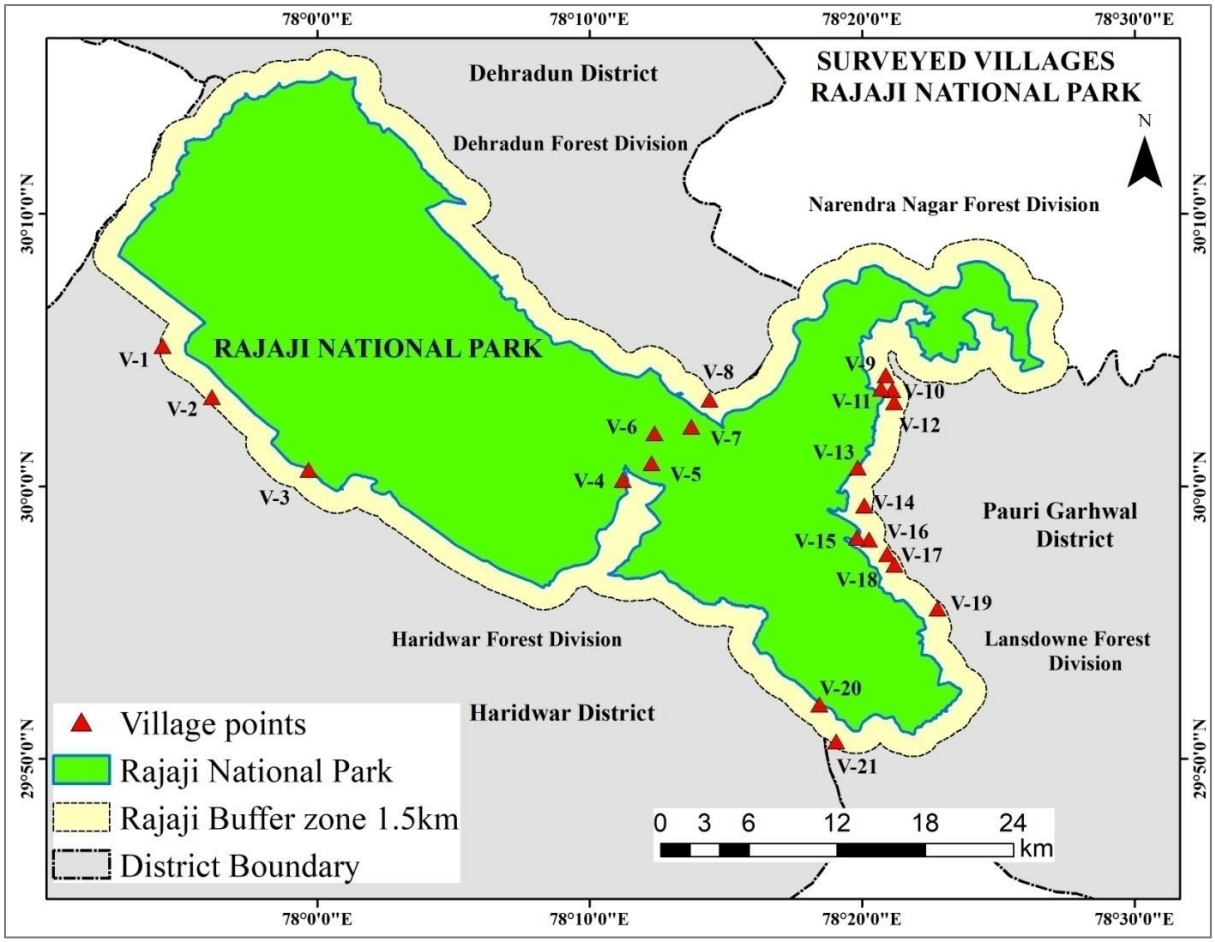
affecting both on locals and wildlife habitat in and around villages of the selected protected area Rajaji Tiger Reserve.

Questionnaire Formats - Questionnaire was designed and developed to collect information from the respondents. It was conducted with both open-ended questions and closed-ended questions, where a total of 288 households in 21 villages (Table 4.2 & Map 4.1) were involved. Broadly the questionnaire format was divided into nine sections, each section comprising of unbiased questions which aimed to collect information about respondent's livelihood loss from the wildlife and their perception. The study is mainly focused and aims on the conflict issues and its consequences upon the people living in and around Rajaji. Broad sections divided included questions that collected information on type of agriculture practices, agricultural and crop damage by herbivores, type of livestock owned, livestock depredation by carnivores, compensation schemes, local perception towards wildlife.

Table 4.2 Name and GPS locations of selected eco-sensitive village of Rajaji for survey

District	ID	Villages	GPS Location	
Haridwar	V-1	Buggawala	77.9055	30.08598
Haridwar	V-2	Lalwala	77.93553	30.05462
Haridwar	V-3	Khala Teera	77.99463	30.01018
Dehradun	V-4	Haripur kalan (Motichur Basti)	78.187	30.004
Dehradun	V-5	Khand Gaon 3	78.20453	30.01423
Dehradun	V-6	Khand Gaon 1	78.20628	30.03263
Dehradun	V-7	Gorimafi	78.22895	30.03653
Dehradun	V-8	Nepali Farming	78.24015	30.05305
Pauri Garhwal	V-9	Kuthar	78.348	30.068
Pauri Garhwal	V-10	Diuli	78.35188	30.05893
Pauri Garhwal	V-11	Bastola	78.345	30.05982
Pauri Garhwal	V-12	Juledi	78.35303	30.05148
Pauri Garhwal	V-13	Bukundi	78.3307	30.01163
Pauri Garhwal	V-14	Amkatal	78.33468	29.98842
Pauri Garhwal	V-15	Kasan	78.33035	29.9687
Pauri Garhwal	V-16	Kanda khal	78.33773	29.9676
Pauri Garhwal	V-17	Banas Malla	78.34882	29.95863
Pauri Garhwal	V-18	Jogiyanwalla	78.35318	29.95228
Pauri Garhwal	V-19	Dharkot	78.37958	29.92535
Haridwar	V-20	Rasoolpur meethi Beri	78.3072	29.86665
Haridwar	V-21	LalDhang	78.31743	29.84422

Field Survey - Prior to conducting the survey in the villages of Rajaji National Tiger Reserve, human-wildlife conflict issues and consequences in and around Rajaji, were discussed with the supervisor and coordinator. Based on their information and with the help of the list of eco-sensitive villages mentioned by **Ministry of Environment, Forest and Climate and Changes (MoEFCC) website,** methods of sorting and selecting the eco-sensitive villages to be surveyed in and around 1km of Rajaji boundary were done. The villages lie in Dehradun, Haridwar, Garhwal districts and in conflict hotspot zones.



Map 4.1 Map showing 1.5 km Buffer zone of Rajaji National Park and surveyed village locations.

From 24th march, 2019 household surveys were carried out in selected villages for the study area based on the research objectives. The selected villages were visited and questionnaire survey were conducted, to collect information on area profile, nature and extent of wildlife problem. Information on human killing by carnivore and mammal, livestock predation by tiger and leopard, agriculture and crop damage, people perception towards wildlife was collected. Before entering into Forest Division such as Haridwar forest division, Shyampur Range, Langdhang Division, Lansdowne range, permission from respective range officers were taken and one guard was provided by the officers for easy communication with the locals. Wherever necessary spot verifications were done, also with the help of GPS, ground truth coordinates were collected. Twelve household from each village was targeted and completed per day. Respondent was interviewed regarding their demographic information, source of livelihood, land-use practices inside forest and crop damage, human killings, livestock loss, causes of livestock death, etc. The collected information or data was then entered in the excel sheet. Data so generated were analyzed statistically and presented in the form of tables, graph, charts etc.

5 RESULTS

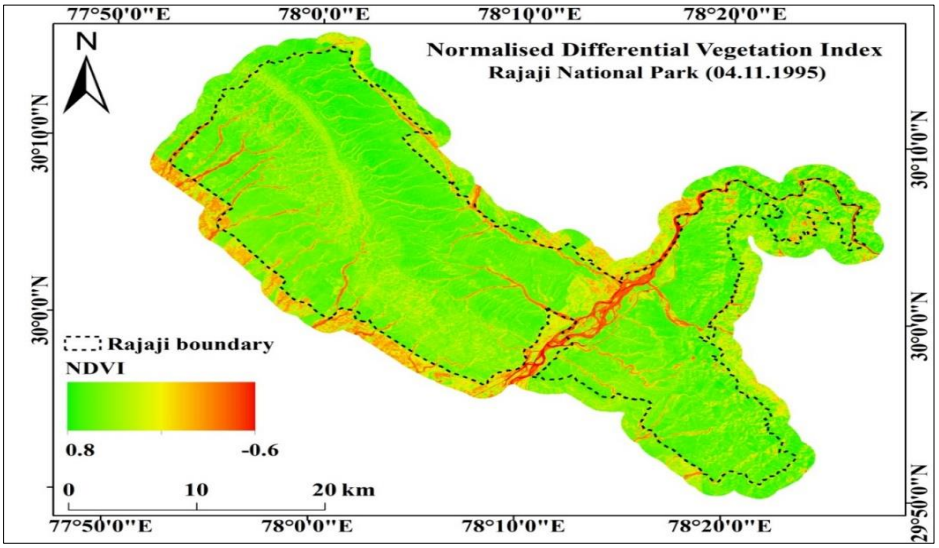
5.1 Landscape Level Changes in Rajaji Tiger Reserve from the year 1995-2018.

5.1a. NDVI

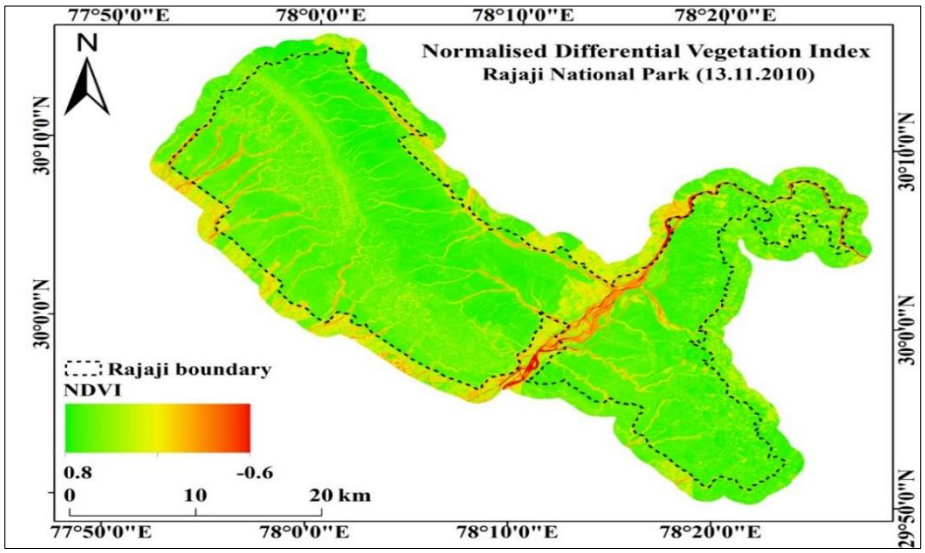
NDVI maps of "Rajaji Tiger Reserve" for the years 1995, 2010, 2015, & 2018, have been shown below. The value of NDVI ranges between 1 & -1, where values around 1 represent dense forests, around 0 represents barren land, and around -1 represents water (table 5.1). The NDVI classification maps for Rajaji Tiger Reserve for four years represent following five classes of land cover types- (i) Water bodies, (ii) Barren land, (iii) Agricultural Land, (iv) Scrub & grassland, and (v) Dense vegetation. NDVI values for each class of vegetation cover are detected, as shown in table 5.1.

NDVI values	**1**	**0**	**-1**
Land cover type	Dense vegetation ⟷	Barren Land ⟷	Water

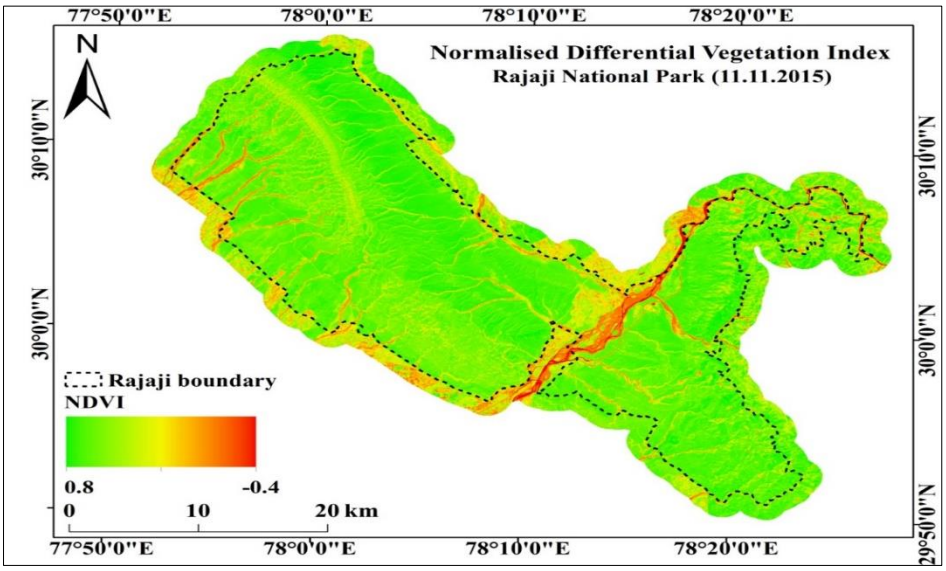
Table 5.1 Value depiction table of NDVI values.



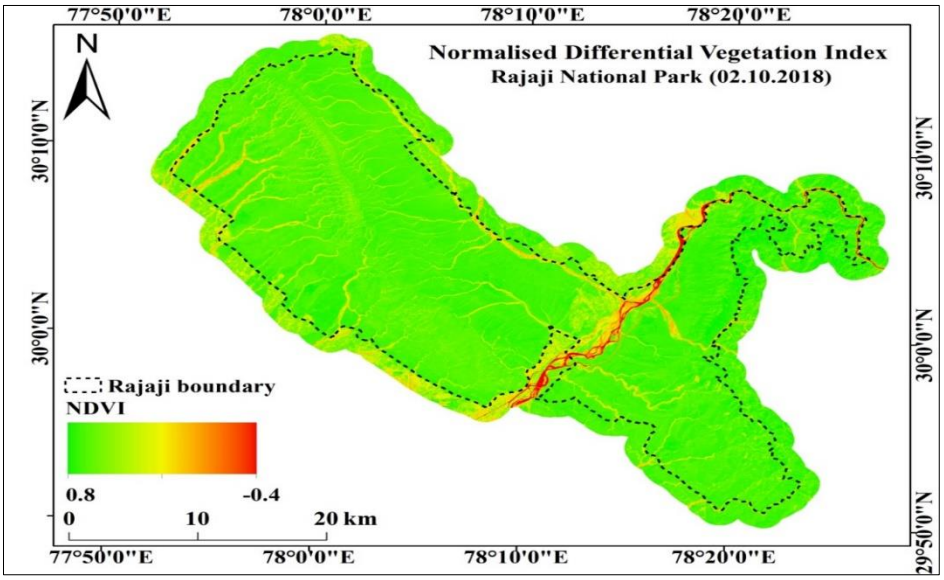
Map 5.1 NDVI Map for the year 1995.



Map 5.2 NDVI Map for the year 2010.



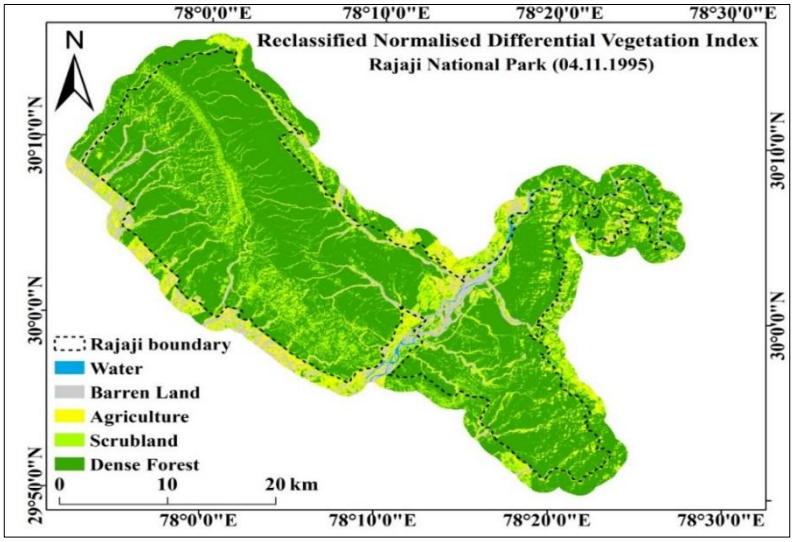
Map 5.3 NDVI Map for the year 2015.



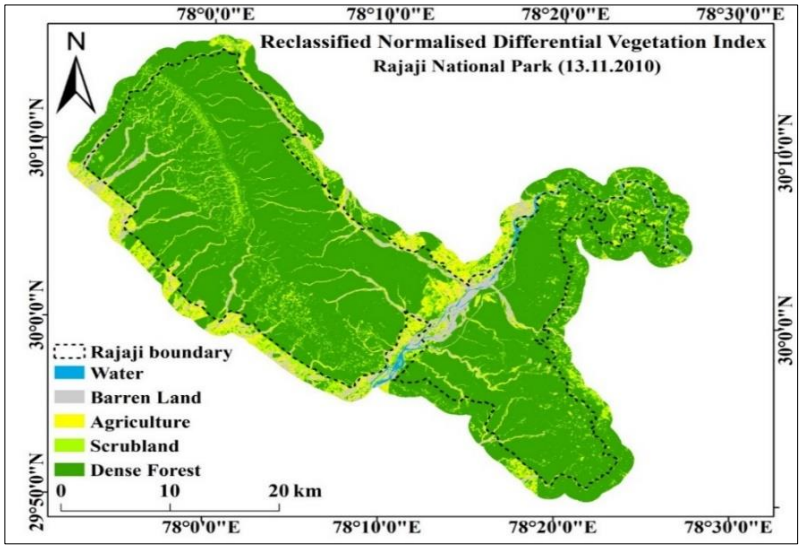
Map 5.4 NDVI Map for the year 2018.

The lowermost NDVI value for "Rajaji Tiger Reserve" is –0.6 (Map 5.1 & 5.2) for the years 1995 & 2010, which decreased to -0.4 for the years 2015 & 2018 (Map 5.3 & 5.4), indicating a decrease in riverine vegetation or water content. On the opposite end of the scale, the highest value remained stable at 0.8 (Map 5.1-5.4), which indicates no major change in the dense vegetation.

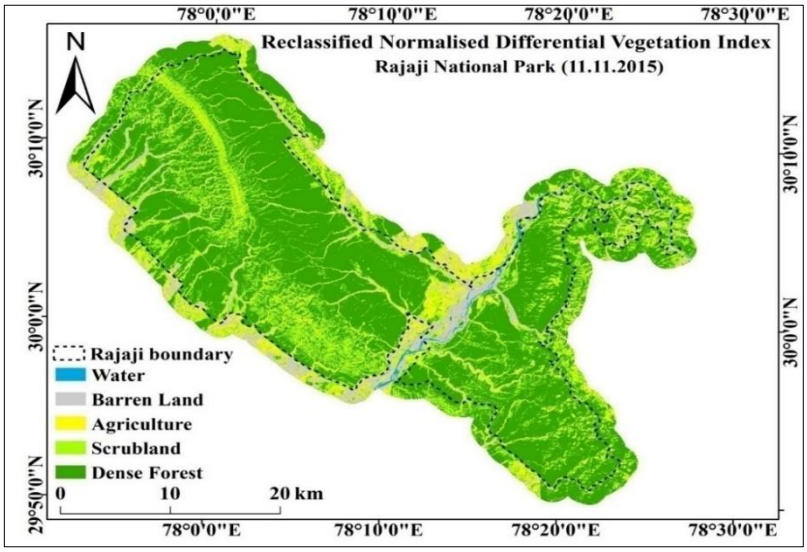
5.1 b. Spatiotemporal distribution of Vegetation Cover of Rajaji Tiger Reserve.



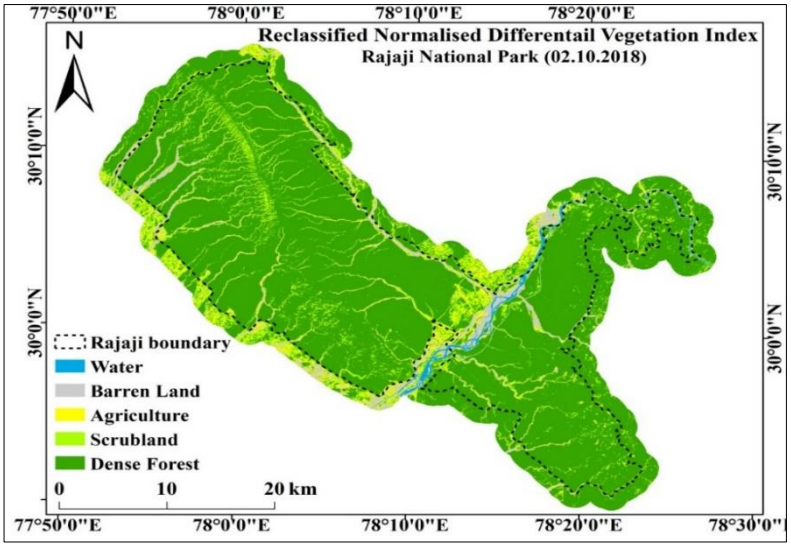
Map 5.5 Map showing reclassified NDVI image 1995.



Map 5.6 Map showing reclassified NDVI image 2010.



Map 5.7 Map showing reclassified NDVI image 2015.



Map 5.8 Map showing reclassified NDVI image 2018.

Years	*1995*			*2010*		
Vegetation Cover	**NDVI Values**	**Area (km^2)**	**% Area**	**NDVI**	**Area (km^2)**	**% Area**
Water	-0.6	5.0337	0.41	-0.6	7.8138	0.64
Barren Land	0.00 - 0.3	79.6932	6.57	0.0 - 0.3	65.9133	5.43
Agriculture	0.3 - 0.46	106.511	8.78	0.3 - 0.46	86.1039	7.10
Scrubland	0.46 - 0.6	206.647	17.04	0.46 - 0.6	118.933	9.81
Dense Forest	0.6 - 0.82	814.281	67.17	0.6 - 0.9	933.401	77.00

Table 5.2 Spatiotemporal distribution of Vegetation Cover of Rajaji of 1995 and 2010.

Years	*2015*			*2018*		
Vegetation Cover	**NDVI Values**	**Area (km^2)**	**% Area**	**NDVI**	**Area (km^2)**	**% Area**
Water	-0.4	7.2081	0.59	-0.4	11.3256	0.93
Barren Land	0.00 - 0.3	105.286	8.68	0.0 - 0.3	57.2139	4.72
Agriculture	0.3 - 0.46	110.066	9.08	0.3 - 0.46	57.7584	4.76
Scrubland	0.46 - 0.6	254.933	21.03	0.46 - 0.6	117.0387	9.66
Dense Forest	0.6 - 0.8	734.672	60.6	0.6 - 0.81	968.8293	79.93

Table 5.3 Spatiotemporal distribution of Vegetation Cover of Rajaji of 2015 and 2018.

From the findings (Tables 5.2 and 5.3), it can be concluded that % water area (NDVI value 0.6) increased by 0.23% of the total reserve area. An increase of 56.09% in area, from 1995-2010. Followed by subsequent decrease in water content (NDVI value 0.4) and an increase in this water deficient area to .93% in 2018, from an initial 0.59% in 2015, an overall 57.63% increase in water deficient area, from 2015-2018. This indicates increase in water deficiency.

Barren land has decreased, from an initial 6.57% to 4.72% from 1995-2018, an overall decrease of 28.15%. Similarly, scrubland decreased by 17.04% to 9.66% from 1995-2018, an overall decrease of 43.30%. And dense forest has increased overall to 18.99%, from an initial 67.17% in 1995 to 79.93% in 2018.

5.2 Analysis of "Human-wildlife Conflict" or "HWC" types & its vulnerability in the eco-sensitive villages of Rajaji Tiger Reserve.

A total of 288 villagers, across 21 sampled villages with 12 households per village, were interviewed, during the one and half months of study period from 24 March to 5th May. The analysis was focused on answered research questions. The following data was gathered exclusively from the questionnaire as a research instrument along with the ground truth verification. Results from the collected ground truth data are presented on the assessment of different aspects of human-wildlife conflict such as demographic, human death, livestock holdings and its loss, agricultural practices and its loss, and local perception towards wildlife in the conflict zones of Haridwar, Pauri Garhwal and Dehradun in and around Rajaji National Tiger reserve.

5.2 a. "Human-Wildlife conflict" and its effect on agriculture.

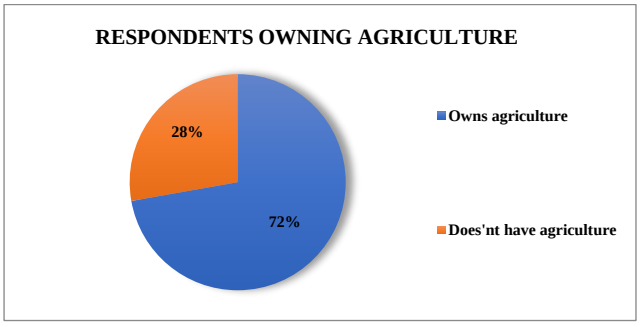
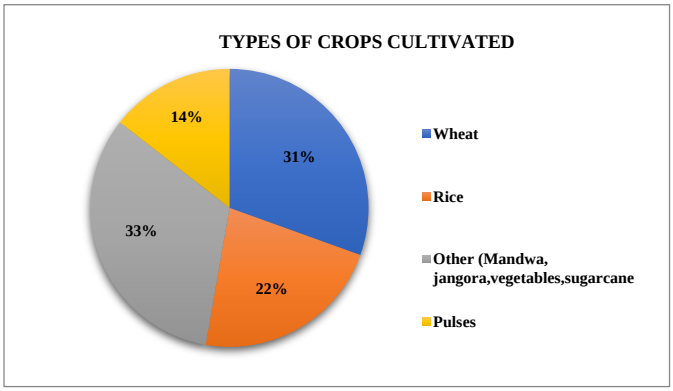


Fig. 5.1 Pie chart showing respondents owning agriculture.

The data represented, above, depicts that **72% (n=208)** of the households in the villages, in and around, Rajaji Tiger Reserve own agriculture, while only **28% (n= 80)** households don't own agriculture.

Fig. 5.2 Pie chart showing types of crops cultivated by the respondents.



Through the above findings (Fig. 5.2), it can be concluded that **33% (n=143)** of the households, that cultivate a **mixture of crops,** that include mandawa, jangora, vegetables and sugarcane etc., cultivated during the monsoons and summers, are the highest in proportion, among the villagers that depend on agriculture. Followed by **31% (n=141)** households that cultivate **wheat,** during winters, are second in line**.** Third are the **Rice** cultivators, about **22% (n=97)** households**.** Lastly, the least grown crops are the **pulses** which is **14% (n=63).**

In the villages of Dehradun, Pauri Garhwal, Haridwar districts, that fall inside the boundaries of Rajaji tiger reserve, rice, pulses are the least grown crop. Instead, wheat is grown highly except in Pauri Garhwal region. Alongside mandwa, jangora and plantation are highly cultivated in all the three districts. In the lower regions of Dehradun and Haridwar districts, sugarcane and banana, were cultivated earlier, but local people have stopped growing these crops now. According to locals, since this time, crop raiding by elephants has decreased than earlier. In the regions of Garhwal cultivation is gradually decreasing due to wild animals, though dry farming still prevails.

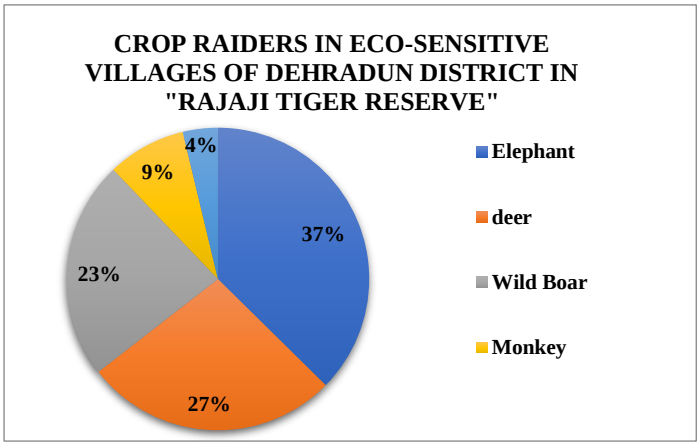


Fig. 5.3 Pie chart showing major kind of crop raiders in the villages of Dehradun district in and around boundary of Rajaji National Tiger Reserve.

The above findings show **37 % (n=40)** households claim that **elephant,** is the species that mostly raid crops in Dehradun district. Followed by **27% (n=29)** of the respondents who claimed **deer** as the second highest crop raider. **23% (n=25)** household claim **wild pig** and **9% (n=9)** household said **monkey** to be responsible for crop damage. **Others (feral cows, buffaloes & birds**) are only mentioned by **4% (n=4)** of the households.
Selected eco-sensitive villages of Dehradun include **Haripur Kalan, Khand Gaon 1, Khand Gaon 2, Gori Mafi,** & **Nepali Farm.** Therefore, it can be concluded that as these village of Dehradun district are adjacent to Rajaji, lying in the plain area, wild animals find easy invade to the farms and agricultural land for foraging, which often leads to “human-wildlife conflict”.

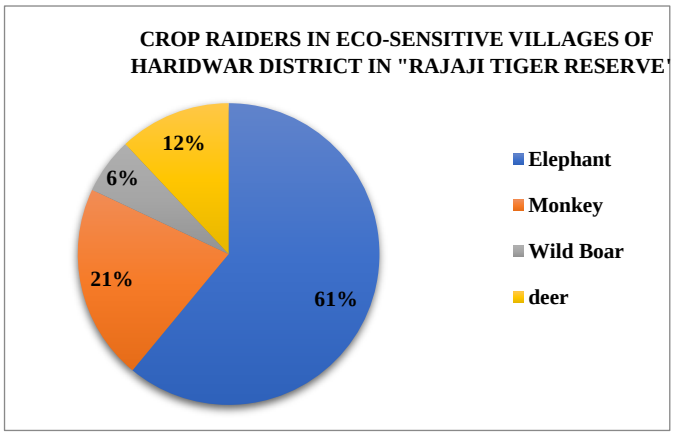


Fig. 5.4 Pie chart showing major kind of crop raiders in the villages of Haridwar district in and around the boundary of Rajaji Tiger Reserve.

The highest crop raiding animal remained the same i.e. **elephants**, in Dehradun district, as claimed by **61% (n=61)** of the households surveyed. However, **21% (n=21)** of the respondents claimed **monkey**, as the second highest crop raider.

While only **12% (n=12)** households claimed **deer**, and remaining **6% (n=6**) households claimed **wild pig** to be responsible for crop damage.

Selected eco-sensitive villages of Haridwar district include **Rasoolpur Meethi Beri, Landhang, Khala Teera, Buggawala, Lalwala.** These villages lie near the boundary of Rajaji, falling under Haridwar Range and Shyampur Range. According to villagers, improper fencing and boundaries and agriculture land inside and close to boundary attracts mammals, especially elephants that often mow down walls and even destroy houses.

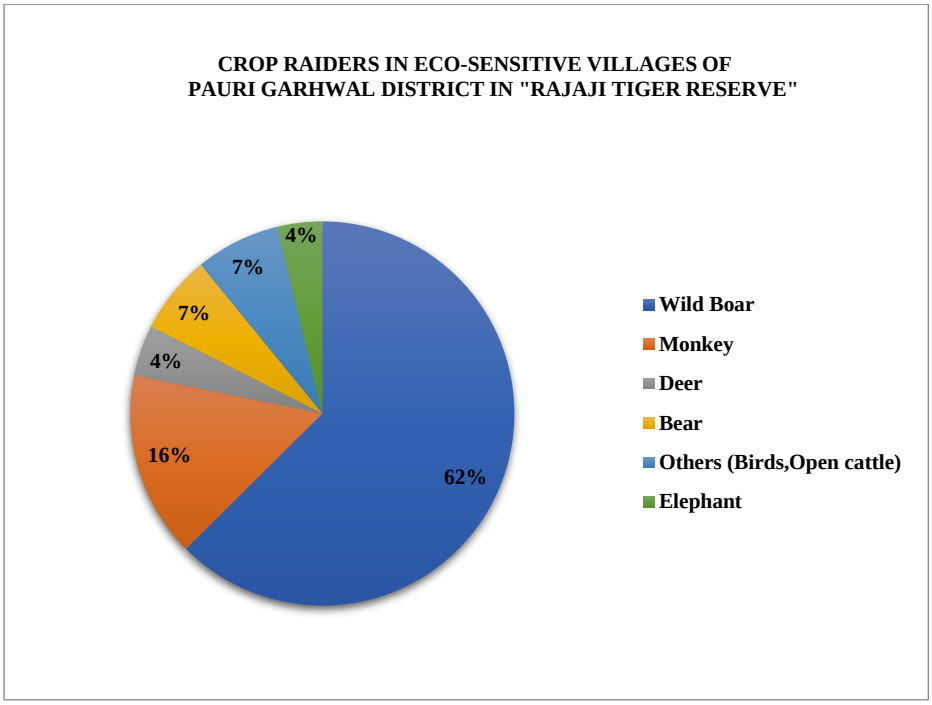


Fig. 5.5 Pie chart showing major kind of crop raiders in the villages of Pauri Garhwal district in and around boundary of Rajaji Tiger Reserve.

The above finding represents that **62% (n=132)** household claimed **wild pig** to be responsible for highest crop damage in the Garhwal district. Followed by **monkey** as the second highest crop raider, by **16% (n=33)** households. Whereas **7% (n=14)** households claimed **bear** to be responsible, another equal number i.e. **7% (n=15)** household claimed **others** (birds, cattle) as crop raiders. Lastly, **deer** and **elephant** the least mentioned, only by **4% (n=9)** and **4% (n=8)** households, respectively.

Villages of Garhwal Districts included **Kanda Khal**, **Kasan**, **Dharkot**, **Banasmalla**, **Jogianwala**, **Diuli**, **Juledi**, **Bastola**, **Kuthar**, **Bukundi** and **Amkatal**. It can be discussed and observed that Pauri Garhwal is comparatively very hilly and maximum of the selected villages, lie in this district. Due to the very steep terrain and high altitude, large mammals like elephants are comparatively, very rare, as only terrace farming is practiced here. Only smaller mammals like wild pig mostly, are comfortable in such a steep terrain, raiding crops during the night. Monkeys and birds like bee-eater, parakeets, and babbler often destroy crop during the day time. Asiatic black bear (*Ursus thibetanus*) was also found to be a crop raider in the Garhwal district.

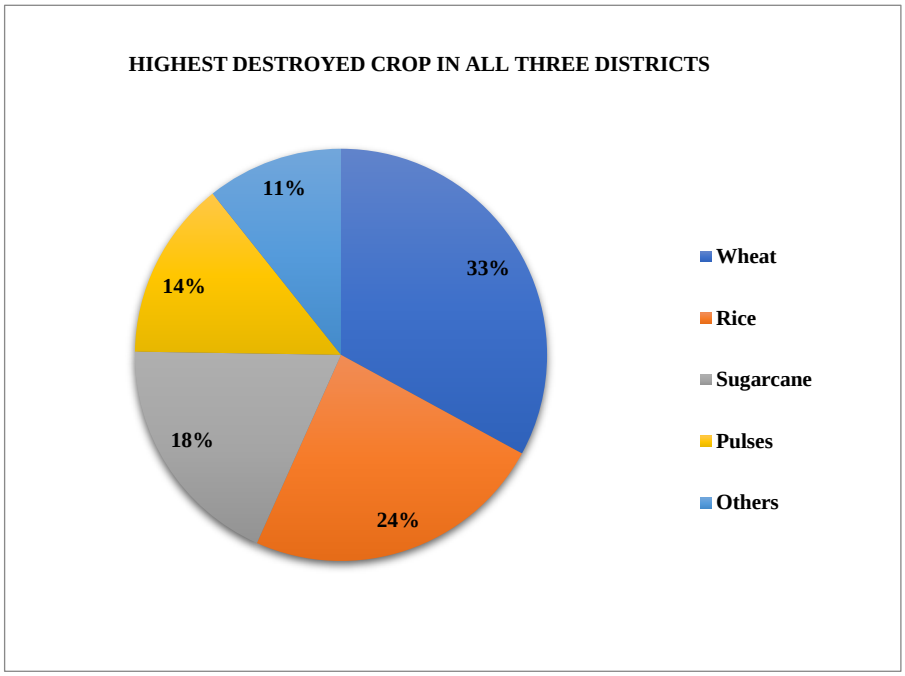


Fig. 5.6 Pie chart showing highest destroyed crop in the villages of Pauri Garhwal, Dehradun and Haridwar districts lying in and around Rajaji Tiger Reserve.

The findings depict that **wheat**, as per **33% (n=197)** households, is the highest damaged crop around Rajaji. Followed by **rice**, mentioned by **24% (n=142)** respondents, **sugarcane** by **18% (n=111)** households, **14% (n=84)** mentioned **pulses**. **11% (n=64)** said **others** category. As wheat is the second highest crop cultivated in huge amount by the locals, mammals and other animals find it easier to reach and access.

5.2 b. "Human-Wildlife conflict" and its effect on livestock.

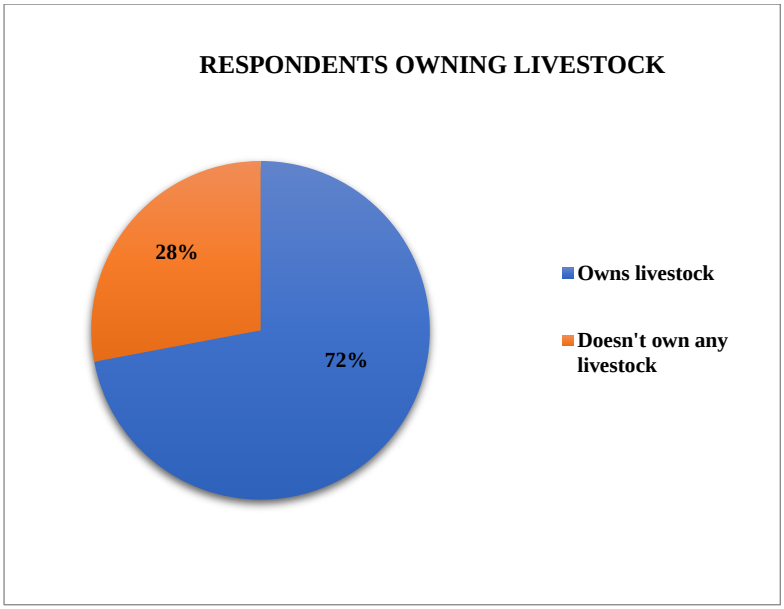


Fig. 5.7 Pie chart showing percent households, who own livestock vs who don't.

The above chart shows that in the eco-sensitive villages of Rajaji most of the people own livestock, i.e. around **72% (n= 206)** households, while only **28% (n=82)** households don't own any kind of livestock.

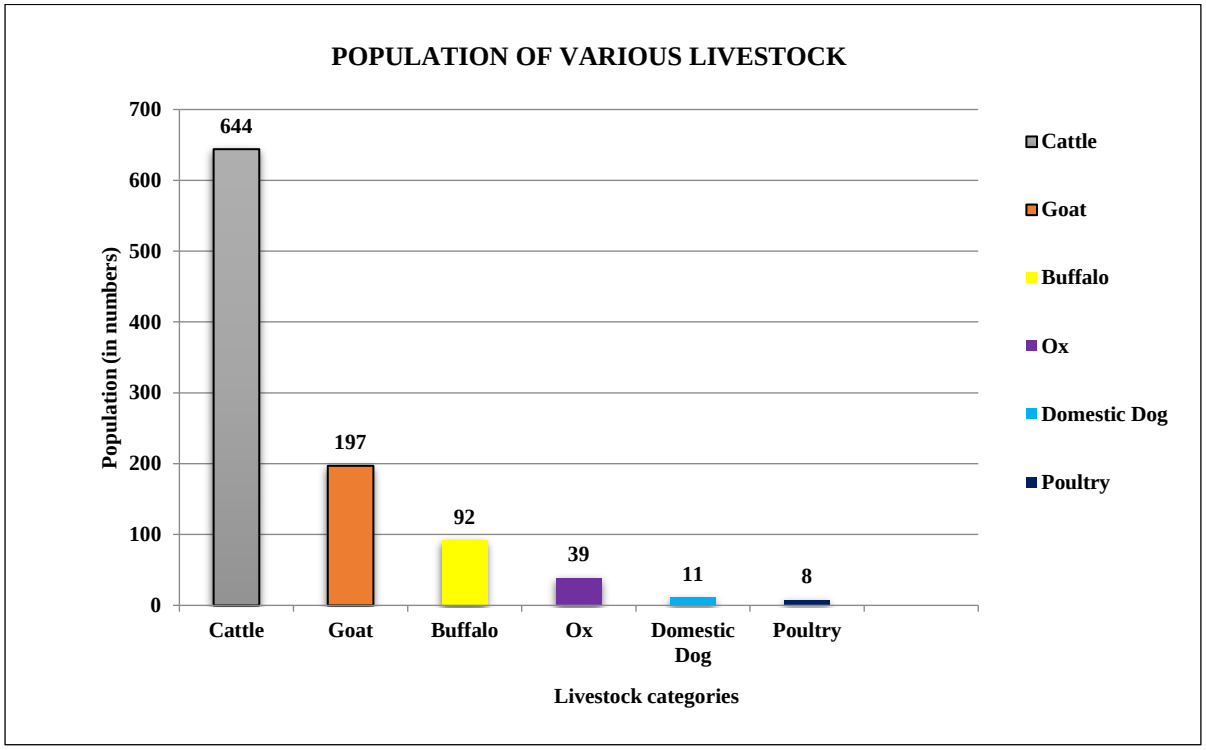


Fig. 5.8 Bar graph showing, population of different types of livestock owned in all the three districts.

The findings indicated that cattles were found in the highest numbers, in the three districts, n=644, number of goats n= 197, number of buffalo are n= 92, number of ox are n=39, number of domestic dogs are n=11, while the number of poultry are n= 8.

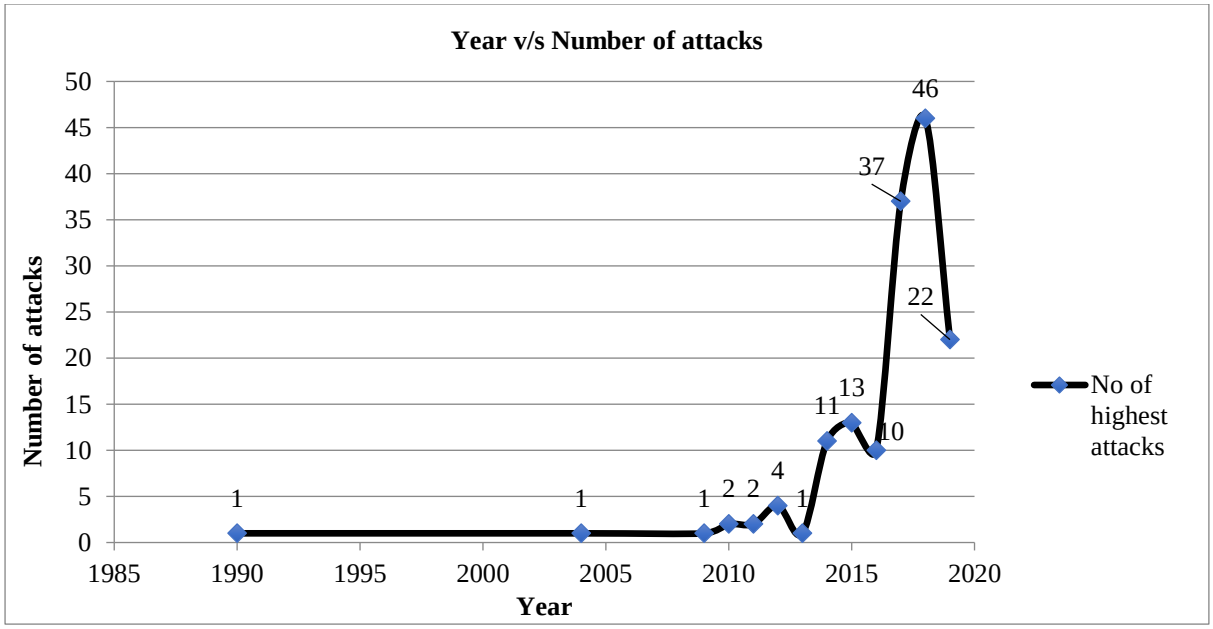


Fig. 5.9 Graph representing the number of attacks in different year in the 3 districts.

The above graph represents **2018** as the year, where highest number of attacks and loss of livestock occurred in the selected 21 eco-sensitive village of Rajaji NP. The graph also shows **increasing** pattern of livestock **predation** since the **year 2015**.

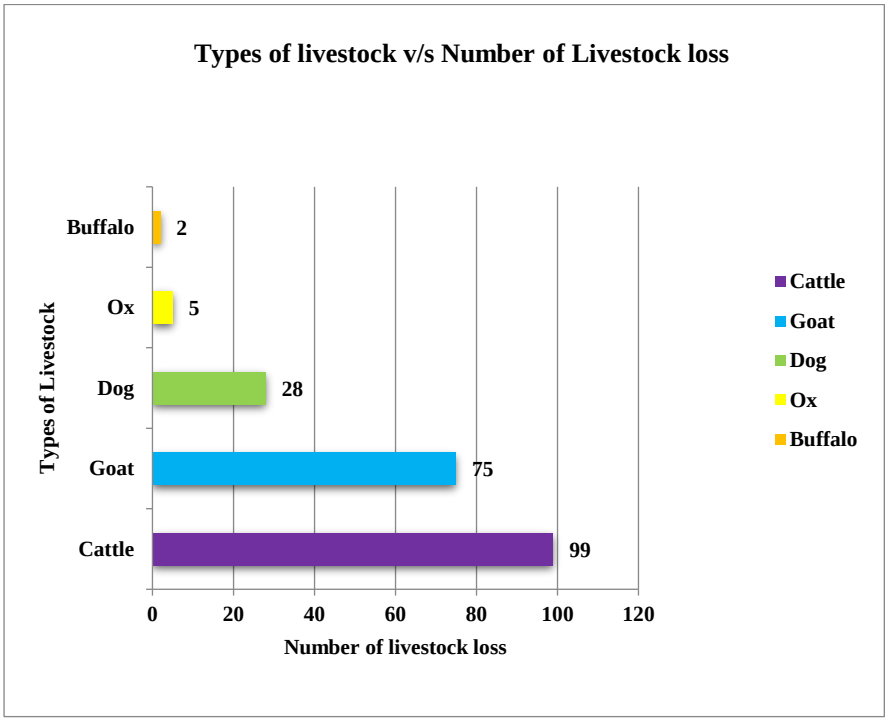


Fig. 5.10 Graph representing the number of livestock deaths in all the 3 districts.

The previous bar graph represents **cattle (n=99)** as the most killed domestic animal followed by **goats (n=75)** by carnivores. While fewer **dogs (n=28)** have been predated upon, the number of **oxen (n=5)** and **buffaloes (n=2)**, remain the least in number, attacked by carnivores.

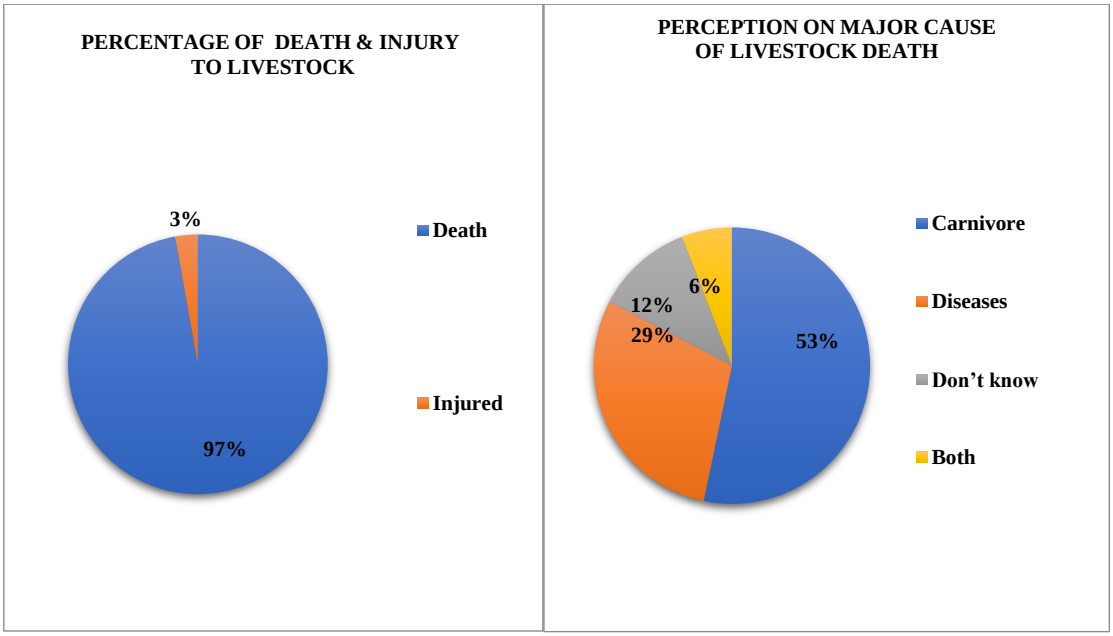


Fig. 5.11 Pie charts showing (a) percentage of death and injured livestock (left), & (b) local perception on the causes of livestock death (right).

The above findings (pie chart on the left) represent that **97% (n=209)** livestock have been **killed**, while only **3% (n=6)** livestock have been **injured**. These facts may indicate most animals attacked by carnivores are mostly for meat, only few domestic animals are able to escape such attacks.

The pie chart on the right of fig. 5.11 represents that **53% (n=154)** respondents mentioned **carnivores** as the main cause of livestock death. Whereas **29% (n=85)** respondents said **disease**, **12% (n=23)** respondents **didn't know** and weren't able to ascertain the cause of livestock death. Only about **6% (n=7) respondents** said both **carnivore and diseases,** lead to livestock death.

5.2 c Local perception towards wildlife.

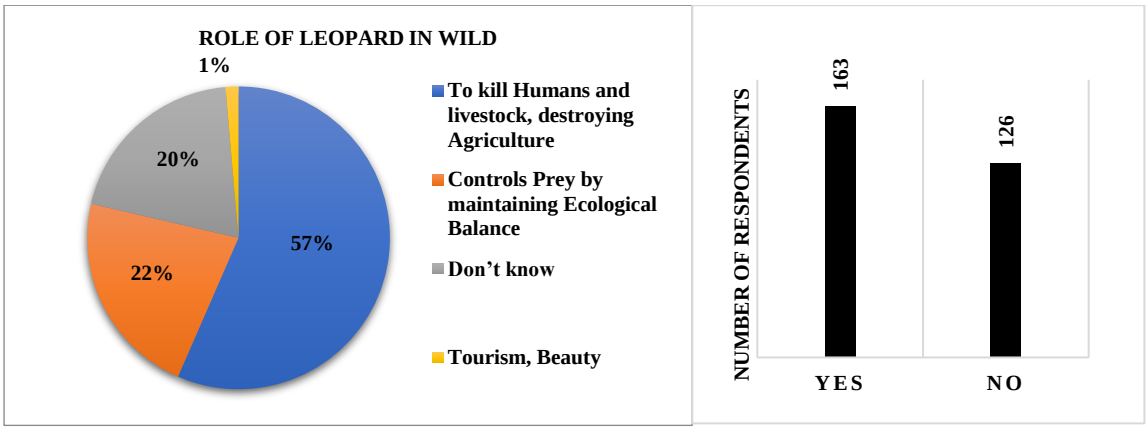


Fig. 5.12 Pie chart showing local perception of leopard in the wild (left); & bar graph showing respondent perception on people being responsible for increasing human-wildlife conflict (right).

During the survey (fig. 5.12, left), locals were asked questions about the role of leopards in the wild. The results indicate about **57% (n=164)** of the respondents said that leopards, only **creates nuisance for them by killing humans and livestock** whereas, only **22% (n=64)** of the respondents understood that they have an **ecological value for a healthy ecosystem**. While **20% (n=58)** of the respondents remained neutral, as they **didn't know** about their role in the wild, while only **1% (n=4)** respondents said leopards plays a major role in **tourism and attraction.**

About the role of human in "HWC" (fig. 5.12, right), a total of **163** respondents said **yes**, local people are responsible for increasing human-wildlife conflict, whereas **126** respondents said **no,** local people are not responsible.

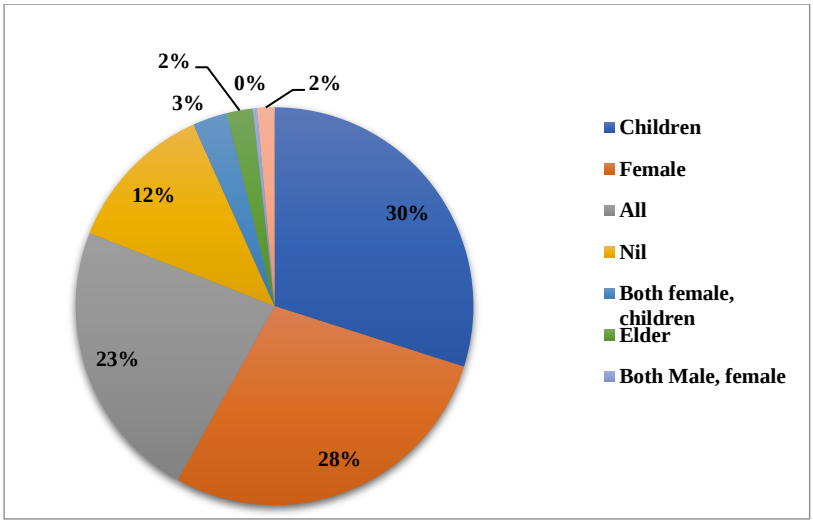


Fig. 5.13 Pie chart, showing classes of people most vulnerable in carnivore attacks.

30% (n=85) respondents said **children** have the highest chances of being attacked by carnivores, whereas **28% (n=80)** said **women**, **23% (n=65)** said **everybody** can be a victim, **12% (n=35)** are unaware and neutral. **3% (n=8**) mentioned both **women and children** have chances of being attacked. **2% (n=6)** said **elder**, another **2% (n=4)** mentioned **men**. And only **1** respondent said both **women and men.**

6 DISCUSSION

6.1 Landscape Level Changes in Rajaji Tiger Reserve from the year 1995-2018.

The findings (table 5.2 & 5.3) of the study indicate that the landscape of Rajaji has changed significantly since 1995. As of 2018, the wilderness of Rajaji is mostly covered by dense Forest, amongst any other class, occupying about 79.93% (968.8293 Km^2). On the hand, water covers the least surface area of about 1% (11.3256 km^2).

The dense forest has increased consistently, from 67% in 1995, to 77% in 2005. Then declined, to around 61% in 2015, and then again increasing to about 80% of the area of the park in 2018. On the other hand, amount of water or moisture content has decreased significantly, the NDVI value remained stable to -0.6 from 1995 to 2010, after which it decreased to -0.4 in 2015, then remaining stable up to 2018. The area under NDVI value of -0.6 increased from 0.41% to 0.64%, from 1995 to 2010, respectively. After which the value NDVI value decreased to -0.4, but area kept on increasing from, 0.59% to 0.93%, from 2015 to 2018, respectively. Barren land shows a downward trend of decrease in 2018 to 4.72%, from 6.57% in 1995.

The trend of agriculture went down from the year 1995 (8.78%) to 2010 (7.10%), which then again increased in 2015 (9.08%), and subsequently decreased in 2018 (4.76%). Scrubland has also decreased from 1995 (17.04%) to 2010 (9.81%), respectively, then increasing sharply up to 2015 (21.03%), and then decreasing in 2018 (9.66%), respectively, for the second time.

6.2 Analysis of "Human-wildlife Conflict" or "HWC" types & its vulnerability in the eco-sensitive villages of Rajaji Tiger Reserve.

In "human-wildlife conflict" or "HWC" survey, maximum respondents (72%) stated, agriculture being the mainstay of their livelihoods, and a mixed bag of cultivation (including vegetables & sugarcane etc.), cultivated by the majority (33%), as compared to single monoculture of wheat (31%) or rice (22%). The respondents further stated of experiencing highest number elephant raids on their crops, being highest in Haridwar district (61%), and then Dehradun district (37%). Crop raids by elephants were lowest in Pauri Garhwal district (4%), which might be attributed to high steep hilly terrain of Pauri Garhwal, where highest crop raiding is perpetuated by wild pig. The majority of households surveyed (72%) had livestock, with cattle (n=644) & goat (n=197), in terms of numbers, being the most owned animals. While it is difficult to ascertain, the trend of cattle lifting by carnivores, from more historical times in this region. The trends seem to be increasing from 2015, with highest number of cattle deaths attributed to carnivores, is from 2015, with cattle (99) and goat (75), being the most common species of livestock being killed.

As local population in villages perceive, most livestock attacked by carnivores (97%), die, while only very few (3%) are able to survive these attacks. Among the causes of cattle deaths, highest number of deaths are attributed to carnivore attacks (53%), diseases being the second reason (29%). The common leopard (*Pathers pardus fusca*) is by far, the most common large predator, attributed to human & cattle killing. Most respondents (57%) considered it a harmful species, a danger to human lives and cattle. While a lesser number of respondents (22%), indicated of it having any ecological value, i.e. killing prey and maintaining ecological balance. Only 1% had a

vague idea of its role in tourism. The remaining (20%) respondents, had no idea. Amongst the human casualties, respondents reported the classes of people being vulnerable to leopard attacks in the following order- children (30%) > females (28%) > all (23%) > unaware (12%) > both female & children (3%) > elderly people (2%) > men (2%) > men & women (1%).

The highest vulnerable area, as informed by the locals and forest department was the Motichur Range because of the corridors and high number of settlements at park-human interface that had led to many human killings by leopards and elephants, as recorded in the past years. Females and children had a higher chance of being the victims, as females go to the forests along with their livestock to graze them, and work in farms. Children are more or less most vulnerable to leopard attacks, because of their small size and the ease with which they can be killed.

In the villages of Dehradun and Haridwar districts, conflict was more intense as they have more proportion human-wildlife habitats interface, along with large number of settlements in the plains, as compared to the hilly regions of Pauri Garhwal. Due to crop raiding by, elephants during afternoon in the plain areas of Rajaji, by wild pigs in the nights in the hilly regions, people in both types of terrains have minimized crop cultivation. Though there are certain amount of compensation for all types of loss perpetuated by wildlife, approximately 94% of the households who had lost their livestock, didn't received any kind of compensation money.

7 CONCLUSIONS

The sustained increase in aridity or decrease in moisture content, which may be a result of "climate change" on the local level, or a result of ecological succession, as area under dense forest, has increased continuously. Nonetheless, dependence of wildlife on water, is a chief attribute, that determines their survival on a day to day basis. For long ranging mammals, like elephants, this may change their ranging patters & movement patters. And may bring to them even in closer proximity to people. Hence, the issue of water, is of primary importance. Artificial water holes that are more evenly distributed throughout the park, may keep this problem at bay.

While the problem of "human-wildlife conflict" can never be truly eradicated, it can be kept under check. A primary issue, is the lack of awareness amongst the local people. Though, they are aware of what animals cause the most damage to livelihood, but definitely neither are aware why animals do it and how it can be kept under check. Another issue was found to be payments of compensation, in cases of due damages. The process seems to be slow & ineffective. Most villagers complained of getting no compensation in either cases of crop damage or predation on cattle. Elephant and deer seem to perpetuate maximum damage in flat terrain, while wild pig has replaced them in hills.

The cases of leopard attacks on cattle seem to have increased. This may be due to better conservation strategies adopted by park management and subsequent increase in their numbers, which causes many to stray out in search of food. More research is needed to address the issue of increasing wild animals, in better protected areas. As in many cases, the lack of awareness is one of the drivers of "Human-wildlife conflict", if addressed in an efficient manner, it could be managed under controllable levels.

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CHAPTER 3

"An assessment of "Human-Leopard Conflict" in Motichur Range of Rajaji Tiger Reserve, Uttarakhand"

SHASHANK YADAV & MANU MOHAN

1 INTRODUCTION

1.1 "Human-Wildlife Conflict"

Inskip & Zimmermann (2009), defined "Human-Wildlife Conflict" (HWC) as "*a situation that arises when behaviour of a non-pest, wild animal species poses a direct and recurring threat to the livelihood or safety of a person or a community and, in response, persecution of the species ensues. It results most commonly from crop damage or livestock predation, and occasionally, attacks on people. They are of particular concern when the animal persecuted in retaliation for these events is a threatened species".*

"HWC" has always been an important management issue and it is only increasing around the globe, especially at the interface zone of protected areas (e.g., Bagchi & Mishra 2006; Gehrt *et al.* 2010; Loveridge *et al.* 2010). Tiger (*Panthera tigris*), Indian leopard (*Panthera pardus fusca*) and Asian elephant (*Elephas maximus*) are three large and threatened mammal species, reported to cause extensive damage/loss in the form of livestock and property, and also human fatalities (Treves & Karanth 2003; Sillero-Zubiri *et al.* 2007). Areas with high human population densities along with carnivore presence, outside the protected areas, are the most frequent sites of human carnivore conflicts (Karanth & Madhusudan 2002). In India, almost all species of large carnivores are known to attack on people which either result in a fatality or grievous injuries (Karanth & Gopal 2005; Jhala & Sharma 1997; & Saberwal *et al.* 1994). "HWC" is more frequent in areas adjoining protected areas (e.g. Athreya et al. 2011, Singh *et al.* 2010; & Jhala *et al.* 2009) and is known to occur in both urban & semi-urban areas (e.g. Gehrt *et al.* 2010; Murphy& Macdonald 2010; & Moyer *et al.* 2008).

Currently rising, is the public demand to use more humane, non-lethal methods in comparison to lethal methods, mostly used in the past (Shivik *et al.* 2003). Large home ranges and dietary requirements, make carnivores more susceptible to conflict (e.g. Macdonald & Sillero-Zubiri 2002; & Linnell *et al.* 2001). However, despite the recent change, in the trends to deal with the problem animals, the conflict appears to be increasing in frequency in many areas (Treves & Karanth, 2003).

The most major felid conservation matter is solving the human-felid conflict, but efforts have been few and far between to synthesize knowledge about conflict problem-solving. A systematic knowledge of the dynamics of human-felid conflicts is necessary to form and implement effective management policies. Conflict affects over 75% of the world's felid species with severity of conflict increasing with felid body mass, and is of utmost conservation significance to following nine species: caracal, Eurasian lynx, cheetah, snow leopard, leopard, cougar, jaguar, lion, and tiger. Tiger and leopard have been categorized with the most severe level of conflict (Inskip & Zimmermann, 2009). The most common cause of human-carnivore conflict is livestock predation (Inskip & Zimmermann 2009; Miller *et al.* 2016), hence, the resulting mitigation methods have primarily focused on safety of owned livestock i.e. sheep, goats and cattle (Hazzah, *et al.* 2014).

1.2 Human-Leopard Conflict

In India, the line separating wilderness and civilization is mostly a blur. The leopard has evolved itself to live in this blurred continuum, mostly near peripheries of human dwellings, adjacent to natural systems. Behavioral flexibility coupled with a wider prey base, and adaptability to survive in a range of novel ecosystems, makes the leopard often, the most implicated in attacks on people (Athreya *et al.* 2013). Human-leopard conflicts are reported throughout India with major hotspots being Uttarakhand, Maharashtra, West-Bengal, Gujarat and Himachal Pradesh (Athreya *et al.* 2007). The largest number of attacks on humans, amongst large felid species is perpetrated by the leopard (Goyal *et al.* 2000; & Singh 2005).

Just a brief snapshot, about the severity of human-leopard conflict in India, between 1999-2005, over a thousand people were attacked by leopards in the state of Maharashtra. Leopard attacks spiked up in Junnar, after large-scale translocations to unacquainted habitats were carried out (Athreya *et al.* 2011).

1.3 Drivers of Human-Felid Conflict

Kaushik *et al.* (2015), attributed major causes of intensification of conflicts in the recent years to: habitat loss, fragmentation, degradation due to increasing anthropogenic activities, particularly development, reduction in tolerance levels towards wildlife and lastly, local abundance of problem species.

Research on dynamics of large mammal ecology is often only restricted to protected areas, while knowledge about them in anthropogenic ecosystems are few (e.g. Miller *et al.* 2016; Odden *et al.* 2014; & Karanth *et al.* 2012).

The most common cases of conflict linked with increased risk of attack that results into either human injury or fatality occur when: (i) people venture into felid habitat (e.g. Reza *et al.* 2002; & Mukherjee 2003), (ii) while hunting of felids (e.g. Maddox 2003), and (iii) sleeping outside or in makeshift huts during summer months (e.g. Vijayan & Pati 2002; & Packer *et al.* 2005)

While there are multiple theories on animal behavior involving conflict, scientific studies are few. The best correlations between attacks and other events that occurred at the times, such as: (i) droughts (Saberwal *et al.* 1994), (ii) translocation (Athreya *et al.* 2011), and (iii) low prey base (Packer *et al.* 2005).

Except for the study by Goodrich *et al.* (2011), which involved tracking of radio-collared tigers, it was found that most tiger attacks happened largely due to human provocation.

Globally, conversion of land and anthropogenic activities has resulted in increased encroachment on natural habitats (DiMinin, *et al.* 2016). In some areas, wildlife has reclaimed historical ranges, where quite recently they had been absent (Gehrt *et al.* 2010), increasing the conflict intensity, derived from the ecology and human dimensions in the landscape (Carter & Linnell 2016). Most carnivore attacks are clustered spatio-temporally, with dozens of victims, over time, ranging between weeks to months (Saberwal *et al.* 1994; Peterhans & Gnoske 2001; Packer *et al.* 2005; Gurung *et al.* 2008; Goodrich *et al.* 2010; Athreya *et al.* 2011; Dhanwatey *et al.* 2013). This pattern has resulted from identification of humans as prey, by certain individuals, coupled with further attacks, before finally, the animal is killed or captured (e.g., "serial human-killers," Gurung, *et al.* 2008). However, humans are mostly attacked after sunset or with few witnesses (Packer *et al.* 2011), resulting in inference of attacks by a single individual, mostly assumed than confirmed, because people fail to recognize individual animals.

1.4 Human-Felid co-existence

There are studies on leopards conducted in Maharashtra, where animals have successfully adapted to living in human landscapes (e.g. Odden *et al.* 2014; & Athreya *et al.* 2013). For instance, Athreya *et al.* (2013), estimated density of large carnivores in agro-rural landscape with a human density of >300 people/km^2 in western Maharashtra, India. Both, Indian leopard (*Panthera pardus fusca*) and striped hyena (*Hyaena hyaena*) occurred at relatively high density of 4.8±1.2 (s.d.) adults/100 km^2 and 5.03±1.3 (s.d.) adults/100 km^2, respectively. Such a situation has never been reported before where 10 large carnivores/100 km^2 share space with a dense human population in a completely modified landscape. Attacks by leopards were rare despite a volatile situation, meanwhile there were conflicts including human deaths in adjoining areas.

Even a more extra-ordinary co-existence scenario has been observed at Jawai in Pali district of Rajasthan. While the rocky village is estimated to have 40 leopards, there has been practically no instance of leopard attack on humans. Moreover, the Jawai leopards have no issues in taking rest on big rocks, exposing themselves to humans and providing a spectacular visual feast to visitors and tourists, occasionally preying on livestock. However, these attacks are considered by the villages not as loss, but as their sacrificial offering (Sulphey, 2017).

1.5 Human-Leopard conflict in Uttarakhand

"Man-eating" has been made infamous by hunter turned naturalists like Jim Corbett, 1944. Sondhi *et al.* (2016) compiled a list of attacks on humans by leopards by Forest Divisions between 1998 and 2012 (Figure 1). Between 1998 and 2012, there are reports of 286 attacks on human from leopards in and around Rajaji viz. Pauri Garwal (183), Lansdowne (54), Dehradun (18), upper Yamuna Barkot (17), Haridwar (11) forest divisions and Rajaji (3) national park.

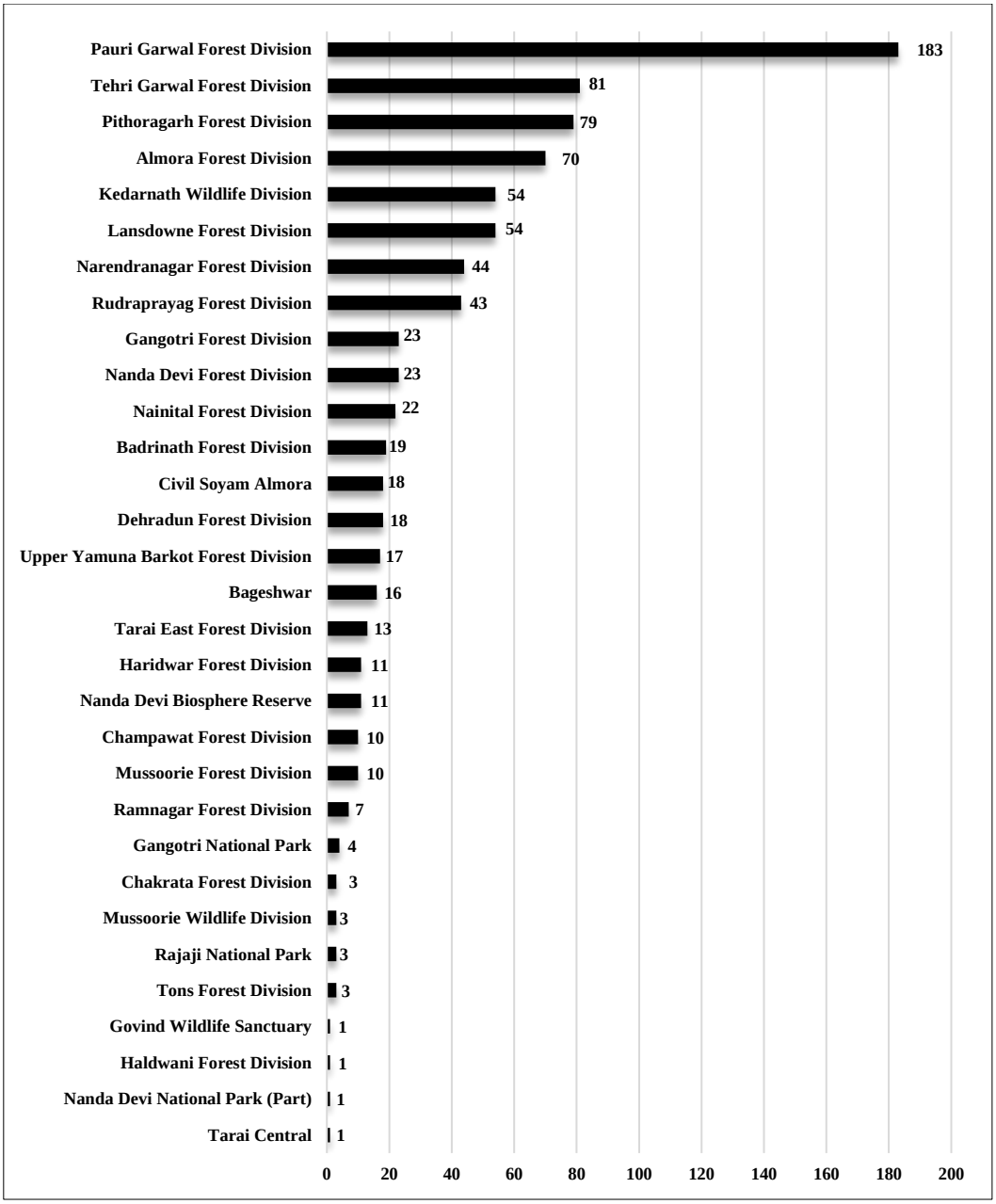
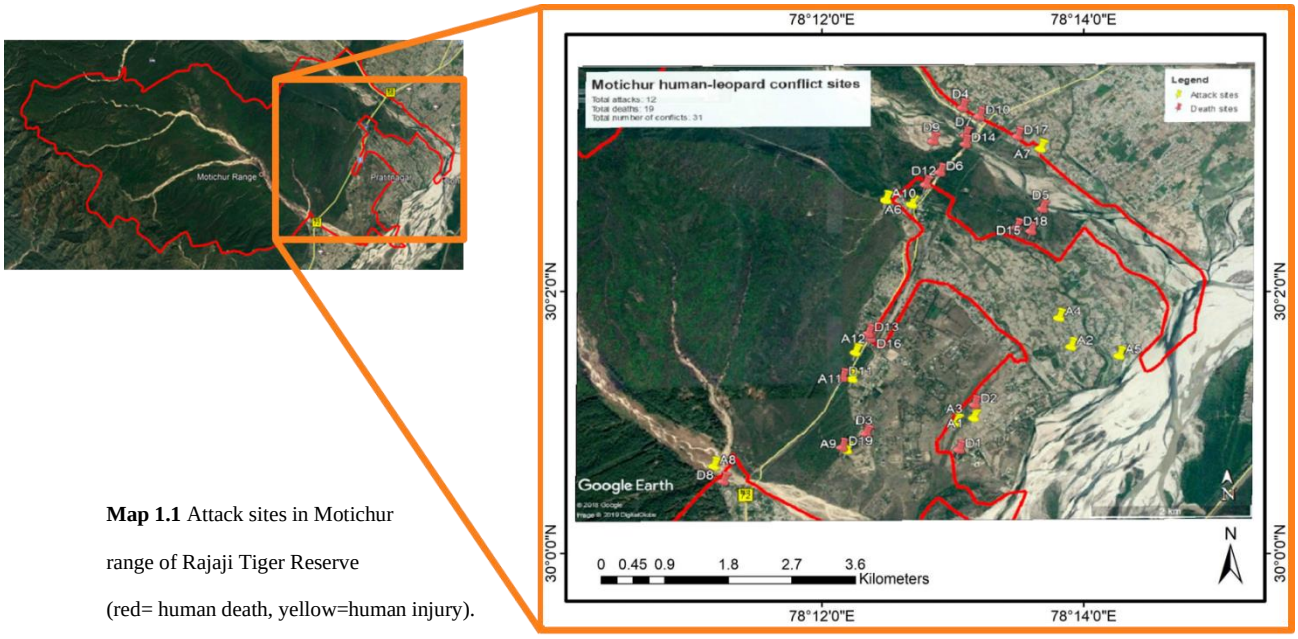


Fig.1.1 Leopard attacks on humans by Forest Division between 1998 and 2012 (Sondhi *et al.* 2016)

1.6 Human-Leopard conflict in "Rajaji Tiger Reserve"

The Tiger Reserve is divided into the western and eastern parts by the river Ganges. In addition to the Ganges, it is virtually bisected by national highway 58, and a railway track, connecting the cities of Haridwar and Rishikesh along with Dehradun. Haridwar, Rishikesh and Dehradun lie very close to the south-eastern, north-eastern and north-western edges of the western half respectively. Between the 2 former cities, the urban sprawl has virtually covered the riverine tracks along the western banks the Ganges giving rise to mosaic of farmland and semi-urban localities like Motichur, Haripur Kalan, Pratitnagar and Khandraiwala.

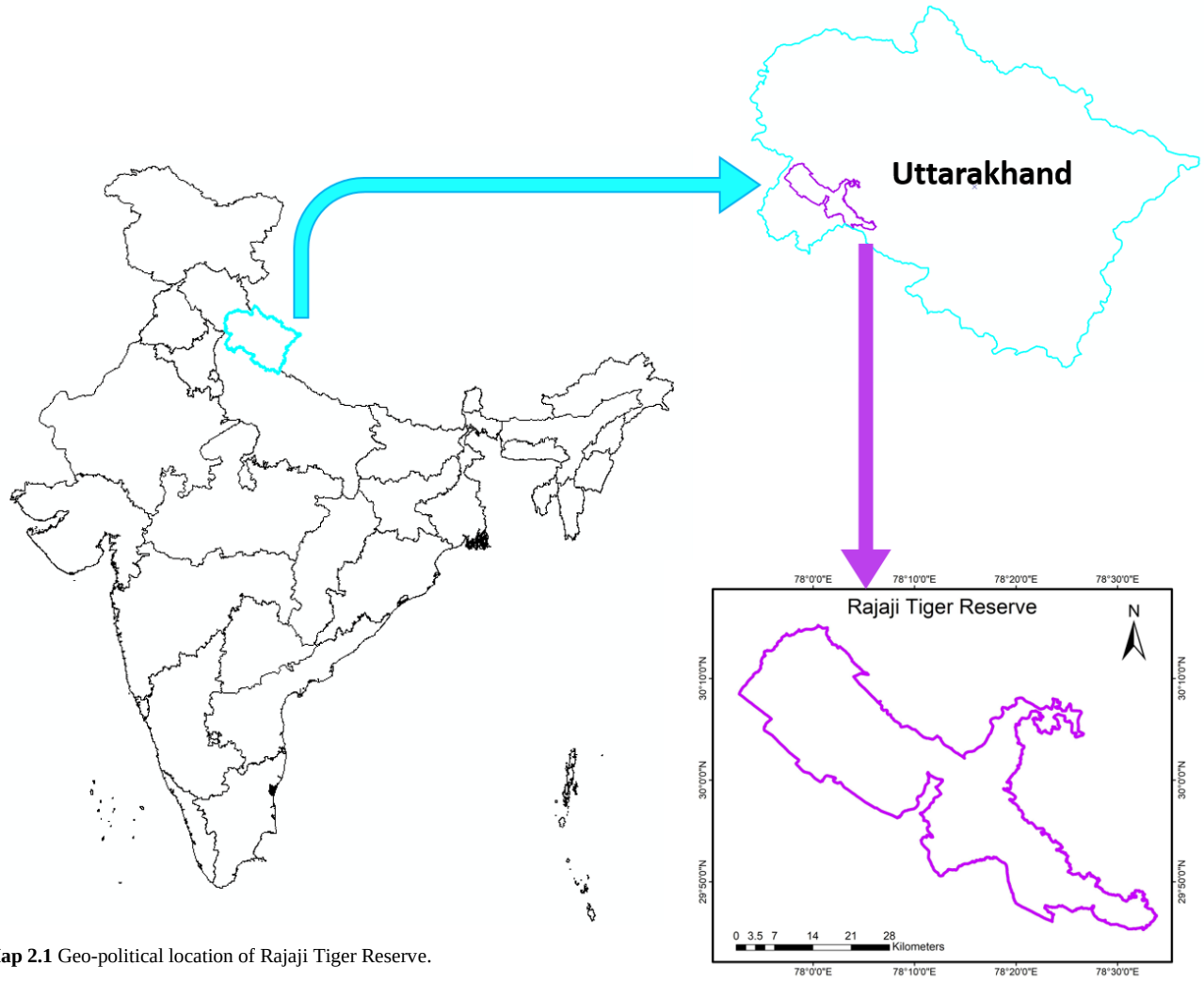


Map 1.1 Attack sites in Motichur range of Rajaji Tiger Reserve (red= human death, yellow=human injury).

Since 2014, the tiger reserve erstwhile national park, has become a hotspot for human-leopard conflict. The map above shows the attack sites in Motichur range of Rajaji Tiger Reserve. The hotspot of the conflict is near the north-eastern and eastern boundary of Motichur range (latitude: 29°59'-30°04' and longitude: 78°04'-78°14'). The area of the range is 84.9 Km^2. Since March 2014, 19 people were killed and 12 people were seriously injured by leopards. The map 1.1 depicts the site of leopard attacks during the period, both death and attack sites separately.

2 STUDY AREA

Rajaji Tiger Reserve (Map 2.1) (latitude: 29°45' to 30°15' N and longitude: 77°52' to 78°33') lies in the foothills of Sivaliks outspreading into the Gangetic Plains, located near the south-western boundary, of the state of Uttarakhand. The area of the reserve is 1075.17 Km^2 (core - 819.54 Km^2 and buffer – 255.63 Km^2).



Map 2.1 Geo-political location of Rajaji Tiger Reserve.

There are three distinct seasons, i.e., the winter (from November to February), the summer (from March to June) and the monsoon/rainy season (from July to October). Month of June records the hottest period but maximum shade temperature rarely exceeds 44°C. There is a wide variation in annual rain fall with change in altitude and topography. It varies from 400 mm. in outer hills to 2800 mm. in the upper hills.

The vegetation in the park is moist-deciduous, with sal (*Shorea robusta*) as the climax species, with 8 types of communities - (i) Moist Siwalik Sal, (ii) Moist Bhabar Dun Sal, (iii) Western Gangetic moist mixed deciduous, (iv) Low Alluvial Savannah woodland, (v) Dry Siwalik Sal, (vi) Northern dry mixed deciduous, (vii) Khair -sissoo forest and (viii) Lower Siwalik chir pine forest. The altitude varies from 302 to 1000 metres above sea level (Ghosh, 1995).

Principal Carnivores include tiger (*Panthera tigris)*, leopard (*Panthera pardus*), sloth bear (*Melursus ursinus*), Asiatic black bear (*Ursus thibetanus*), striped hyena (*Hyaena hyaena*), golden jackal (*Canis aureus*), leopard cat (*Prionailurus bengalensis*), Asian palm civet (*Paradoxurus hermaphroditus*) and small Indian civet (*Viverricula indica*). The common ungulates are – sambar (*Rusa unicolor*), chital (*Axis axis*), wild pig (*Sus scrofa*), barking deer (*Muntiacus muntjak*), nilgai (*Boselaphus tragocamelus*) and goral (*Naemorhedus goral*), along with the mega-herbivore Asian elephant (*Elephas maximus*). The park also has 2 species of primates - rhesus macaque (*Macaca mulatta*) and the Terai langur (*Semnopithecus entellus*).

3 RATIONALE & OBJECTIVES

Conflict between people and felids is one of the most urgent wild cat conservation issues worldwide. Yet efforts to scientifically evaluate knowledge about these conflicts have been few. For management strategies to be effective, a thorough understanding of the dynamics of human-felid conflicts is necessary. Worldwide only 31% of implemented management strategies having been evaluated scientifically (Inskip & Zimmermann 2009), there is a need for greater and more rigorous evaluation and a wider dissemination of results.

In Europe and North America, it has long been understood that the conservation of highly mobile wildlife species, especially the large carnivores, will require significant populations to range across multi-use landscapes outside protected areas that are simply not large enough to support viable populations. Under supportive legislation and the recovery of forest habitats and wild prey, both continents have seen dramatic recoveries of species as iconic as wolves (*Canis lupus*), mountain lions (*Puma concolor*), brown bears (*Ursus arctos*) and Eurasian lynx (*Lynx lynx*) (Linnell *et al.* 2009; Boitani & Ciucci 2009; and LaRue *et al.* 2012).

Conservationists in tropical countries have been much slower to see the conservation value of multi-use landscapes. In India, protected areas cover roughly 5% of the country's geographical area and in the case of wide-ranging large carnivores, human use landscapes will function as important habitats that are required for gene flow to occur between protected areas. Leopards (*Panthera pardus*) are among the most successful of the large tropical carnivores in terms of abundance and geographic distribution. They appear to be better able to tolerate humans, and their foraging habits are highly flexible (Hayward 2006), thus allowing leopards to persist in areas of low wild prey availability (by consuming domestic animals) and high human pressure (Athreya *et al.* 2013). The adaptability of leopards is therefore coupled with a high potential for conflicts with humans, a problem that is currently regarded as one of the greatest threats to the conservation of large carnivores worldwide (Saberwal & Rangarajan 2003; and Woodroffe *et al.* 2005). Hence, it is important to improve our understanding of how leopards interact with people, in order to minimize the inevitable conflicts that follow their sympatry with humans.

In the context of Rajaji, it is the western limit of tiger distribution in Shivalik-Gangetic Plain Landscape Complex with continuous occupancy of elephants (Jhala *et al.* 2015). It was elevated to the status of Tiger Reserve in 2014, but with only two tigresses in its western part. As a part of preparatory strategy to establish a potential source population of tigers in western Rajaji, solving the human-leopard conflict is of pronounced importance, before further efforts should be carried out for the recovery of the tiger. It is also of scientific importance to study the cause of leopard conflict, despite the absence of tigers.

We conducted the study with following objectives**:**

1) To discern the pattern of human-leopard conflict with focus on potential factors and problem animals.

2) To estimate leopard density and movement patterns.

4 DATA COLLECTION METHODOLOGY

4.1 Survey of conflict sites.

All 31 conflict locations were visited with forest department officials. The GPS coordinates were recorded for each site, along with the data of 11 type of characteristics associated to each conflict site, namely:

1) Euclidean distance to Railway line,
2) Euclidean distance to National Highway (NH 58),
3) Euclidean distance to nearby roads other than NH 58,
4) Euclidean distance to nearby settlements,
5) NDVI (March)
6) NDWI (Mar)
7) NDVI (Oct),
8) NDWI (Oct),
9) Slope,
10) Elevation, and
11) Approximate time of attacks.

Euclidean distances for first 3 features was generated with the "Near" tool in ArcGIS (ESRI 2011). Euclidean distance to settlements was recorded manually in Google Earth Pro.

For mean seasonal NDVI and NDWI, pre- and post-monsoon (i.e. March and October resp.), Landsat-8 images were used in ERDAS IMAGINE (ERDAS 2014). 100m buffer around conflict location was created and the mean value in the buffer were calculated for each site.

The slope and elevation data were generated from SRTM DEM and further processing in ArcGIS.

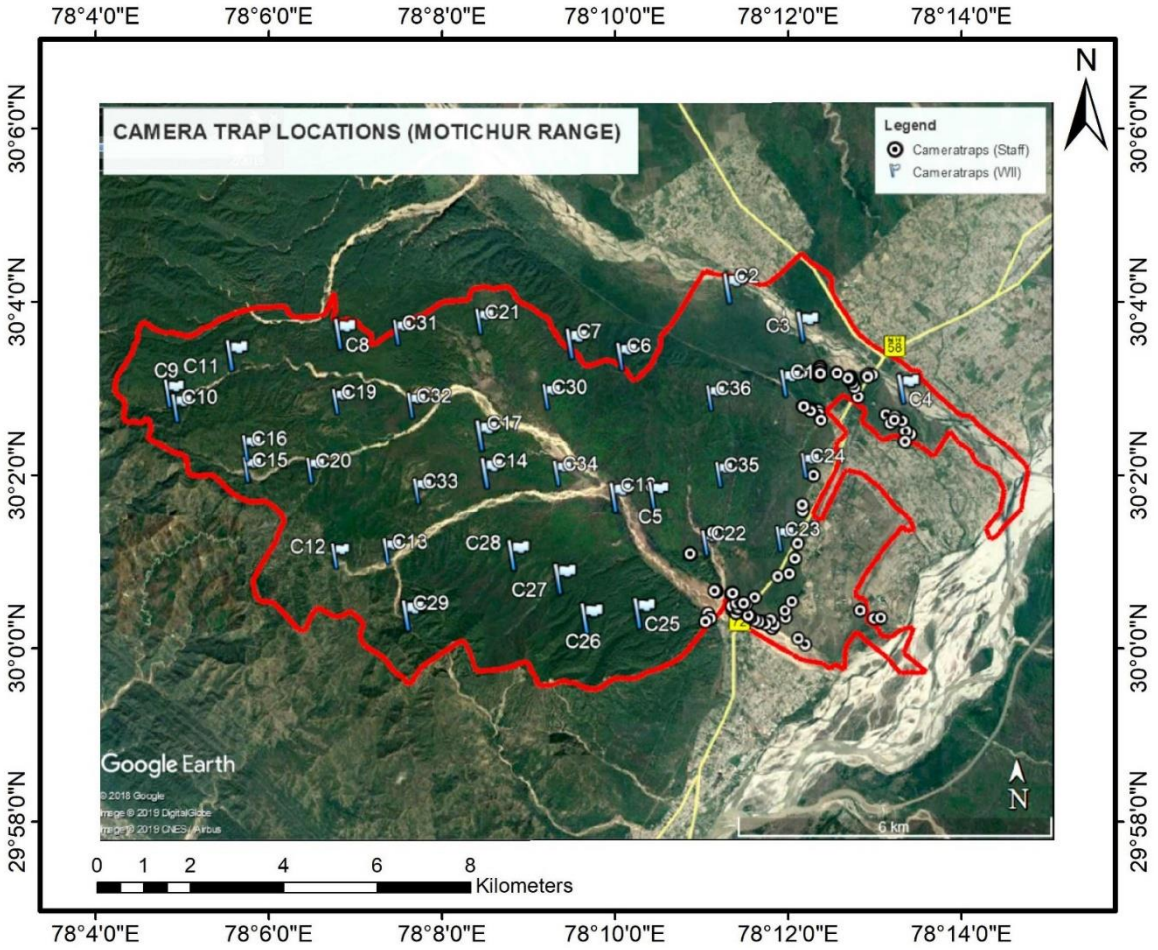
4.2 Survey of forests adjoining conflict sites

For conflict zone (near NH 58 and railway line)

Rajaji forest department deployed single cameras at various points in the conflict zone since 2017, on the trails most frequented by leopards with the aim of recording temporal movement and for individual identification purposes.

For non-conflict zone (adjoining Motichur range)

Using systematic random sampling approach, we deployed a pair of cameras in square grid of 2 km^2 (1.4 km ×1.4 km) across the Motichur range. The cameras were deployed during the winter months i.e. November 2018 to February 2019, and were placed on the most suitable animal trail nearest to the centroid of each square in the grid. The cameras were deployed in 36 such locations (Map 6.1). The duration of sampling period was kept to a minimum of 21 days for each trap station. Average distance between camera traps was 1085.255 metres ± 393.5222 metres. Each station comprised a pair of traps Cuddeback® Blue Series with an active white flash to maximize capture probability of an animal.



Map 4.1 Camera trap locations in Motichur range.

5 DATA ANALYSIS

5.1 Pattern in conflicts.

5.1a. Deriving conflict and non-conflict zone - 500 metres buffer around all the 31 conflict locations were synthesized, and the total range area was physically separated from the buffered sites.

5.1b. Conflict zone summary - We listed the range of each characteristic associated with conflict sites.

5.1c. Spatially potential conflict area - To evaluate spatially important potential conflict sites, we performed hotspot analysis. Based on the occurrence of conflict points on map, an Optimized Hotspot Analysis was done in ArcGIS. The tool assesses incident intensity rather than spatial clustering, associated with the conflict incident point.

Given incident points (GPS locations, in this case), hotspot analysis creates a map of statistically significant hot (extremely highest chance of occurrence or on positive side of the scale) and cold spots (absolutely no chance of occurrence or on negative side of the scale) using the Getis-Ord Gi* statistic. It evaluates the characteristics of the input feature class to produce optimal results.

The Hot Spot Analysis tool calculates the Getis-Ord Gi* statistic for each feature in a dataset. The resultant z-scores and p-values tell you where features with either high or low values cluster spatially. This tool works by looking at each feature within the context of neighboring features. A feature with a high value is interesting but may not be a statistically significant hot spot. To be a statistically significant hot spot, a feature will have a high value and be surrounded by other features with high values as well. The local sum for a feature and its neighbors is compared proportionally to the sum of all features; when the observed local sum is very different from the expected local sum, or when that difference is too large to be the result of random chance, a statistically significant spatial cluster in the form of z-score results.

The tool was executed in a pre-determined grids of cell size 501 meters. The optimal fixed distance band was based on peak clustering found at 1832.4962 meters. Red output features represent hot spots where high incident counts cluster.

5.1d. Influence of behavioral and physical factors in conflict - We conducted Fisher's exact test, by constructing appropriate contingency tables (shown below), to check any statistical association (i.e. whether trend visible is statically significant or just due to random chance alone):

(1) between, trend of increasing deaths and decreasing injury from leopard attacks as apparent in the contingency table below (Table 5.1). With Null hypothesis, that the attacks resulting in deaths & injury are equally likely to happen.

	2014	**2015**	**2016**	**2017**	**2018**
ATTACKS	5	2	3	1	1
DEATHS	2	5	3	3	6

Table 5.1 2×5 Contingency table for association between attacks and deaths.

(2) between the 3 seasons through the successive years, for which the overall order of decreasing trend of attacks was- summer (14), monsoon (10), and winters (7) respectively (Table 5.2). With Null hypothesis, that the attacks equally likely to happen in any season.

	2014	**2015**	**2016**	**2017**	**2018**
SUMMERS	5	4	0	1	4
WINTERS	0	1	3	2	1
MONSOON	2	2	3	1	2

Table 5.2 3×5 Contingency table for association between attacks and season.

And lastly, (3) the influence of sunlight or time of the day on attacks. For this case, we constructed our time class intervals during different seasons to observe any statistical influence of sunlight on time of attacks (Table 5.3).

	SUMMER	MONSOON	WINTER
DAWN (CREPUSCULAR HOURS)	*04:00 - 06:00*	*05:00 - 07:00*	*06:00 - 08:00*
DAY LIGHT HOURS	*06:00 - 18:00*	*07:00 - 17:00*	*08:00 - 16:00*
DUSK (CREPUSCULAR HOURS)	*18:00 - 20:00*	*17:00 - 19:00*	*16:00 - 18:00*
AFTER DARK HOURS	*20:00 - 04:00*	*19:00 - 05:00*	*18:00 - 06:00*

Table 5.3 Time class intervals for different seasons.

We further combined dawn and dusk hours to time class crepuscular hours, to account the influence of sunlight on attacks (table 5.4). With Null hypothesis, that the attacks are equally likely to happen at all times of the day.

	Summer	Monsoon	Winter
After Dark hours	7	1	0
Day light hours	4	4	3
Crepuscular hours	4	4	4

Table 5.4 2×3 Contingency table for association between Influence of sunlight & attacks.

We conducted fisher's exact test in R using **fisher.test** function.

5.2 Influence of spatial characteristics in conflict.

To see influence of spatial characteristics collected at all conflict sites, we conducted a bivariate analysis for each pair of characteristics (except for the approximate time of attacks) in Statistical Software R (package ggpubr).

5.3 Temporal Behavior of Leopard.

To quantify activity and temporal behavior of both, leopards and humans in both the conflict and non-conflict zones, we quantified activity patterns, activity classification and circular statistics.

5.3a. Activity Pattern - The activity pattern can be quantified in two ways. Activity patterns can be estimated separately, either non-parametrically, using kernel density estimation (Ridout and Linkie 2009) or by fitting a distribution from the flexible class of non-negative trigonometric sum distributions (Fernández-Durán 2004). To quantify diel activity-pattern we used Statistical Software R (package Overlap) using kernel density analysis (Ridout and Linkie 2009), which is a non-parametric method for evaluating the probability density function of a random variable (Worton 1989), which in this case was temporal activity. The default smoothing parameter was used. The method depends on the key assumption that all individuals in the sampled population are active at the peak of the daily activity cycle (Rowcliffe 2014). In cases where animals repeatedly triggered cameras without leaving the field of view, only the time of the initial trigger was used (Rowcliffe 2014) to avoid pseudoreplication.

5.3b. Activity Classification - We defined classification of activity as per (Lynam 2013) but altered it further to account for influence of seasonal change in sunlight duration on animal activity. We defined seasonal diel as in table 5.5 -

	SUMMER	MONSOON	WINTER
DAY LIGHT HOURS	05:00 – 19:00	06:00 – 18:00	07:00 – 17:00
AFTER DARK HOURS	19:00 – 05:00	18:00 – 06:00	17:00 – 07:00

Table 5.5 Classification of time of different seasons.

And classified animal activity as in table 5.6 -

ACTIVITY	PERCENT OF ACTIVITY
STRONGLY NOCTURNAL	≥85% of observations between after dark hours
MOSTLY NOCTURNAL	61–84% of observations between after dark hours
CATHEMERAL	40–60% of activity during day or night
MOSTLY DIURNAL	61–84% of observations between daylight hours
STRONGLY DIURNAL	≥85% of observations between daylight hours

Table 5.6: Classification of animal activity.

5.3c. Circular Statistics - From each independent time record, the mean activity of leopards and humans was calculated using the program Oriana 4.0 (Kovach, 2011). In addition, for each season, we performed Rao's spacing test of uniformity at alpha = 0.05, to check for uniformity of data under the null hypothesis that our data is evenly spaced or is unimodal (Rao 1969), which is applicable for time series data (Levitin 1994).

5.4 Leopard Population Indices.

5.4a. Leopard Count – Coupled alongside WII camera trap data we used Rajaji forest dept. data, and classified individual leopards based on gender (male and female) and age class (adult and cub).

5.4b. Relative Abundance Index (RAI) - To account for spatial variation of leopards within and between the conflict and non-conflict zone, we calculated relative abundance index (RAI) (Carbone *et al*., 2001; O'Brien, Kinnaird & Wibisono, 2003) by dividing the total number of independent records by the total trap nights. Photographic rate is the relative index of the animal's spatial use and a crude abundance estimate (Carbone *et al*., 2001); hence, we considered simply by treating each camera trap station as an independent spatial point.

From the conflict zone, we did this at two levels, (1) to calculate gross photographic capture rate of leopards at each trap site; i.e. average number of leopard images captured per day at a trap station; and (2) photographic capture rate of individual leopards at each trap station from forest department data i.e. gross number of individual leopards captured per day at a trap station. We did this for the winter season (Nov 2018- Feb 2019). We followed the same procedure for non-conflict zone.

5.4c. Density - We used Statistical Software R (package SPACECAP) (Gopalaswamy *et al.* 2012) to estimate leopard density, which uses a Bayesian approach and Markov chain Monte Carlo simulation to generate samples from the posterior distribution of each parameter, as described by Royle *et al*. (2009).

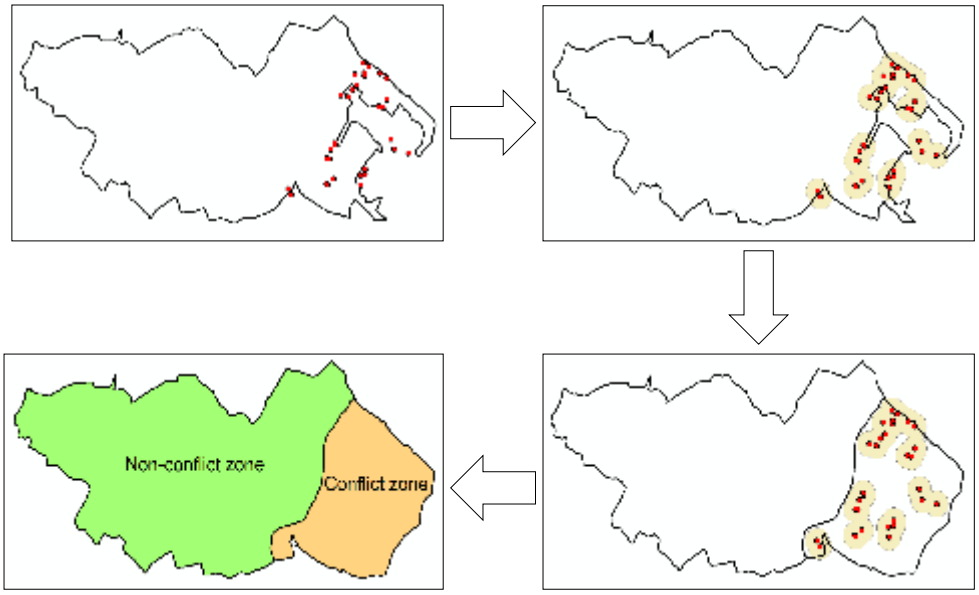
5.5 Leopard Movement Patterns.

We used ArcMap to derive the movement patterns of individual leopards, in and around the conflict zone, with the location data obtained from the cameratraps. A simple polygon enclosing all the capture locations, of an individual leopard was derived.

6 RESULTS

6.1 Pattern in conflicts.

6.1a. Deriving conflict and non-conflict zone – 500 metres buffer around all the 31 conflict locations were synthesized, and the total Range area was physically separated from the buffered sites. This resulted in conflict (yellow) and non-conflict zones (green) with areas of 24.5 km^2 and 70 km^2 respectively (Map 6.1).



Map 6.1 Conflict (24.5 Km^2) and non-conflict zone (70 Km^2) created with an addition of 500 metre buffer around each conflict site.

6.1b. Conflict Zone Summary - Distance from National highway (NH 58) was the most important characteristic of the conflict as 8 attacks occurred within 50 metres of the highway. The second one is the distance to human settlements as 7 attacks occurred within 20 meters and 4 within the human settlements. See, table 6.1 below, for the range of all characteristics of conflict sites.

S. NO.	CHARACTERISTIC	RANGE
1	Euclidean distance to NH 58	4.5-2900 (Metres)
2	Euclidean distance to roads other than NH 58	0-365 (Metres)
3	Euclidean distance to Railway line	18-2820 (Metres)
4	Euclidean distance to Settlements	0-515 (Metres)
5	Mean NDVI within 100m buffer (March)	0.166 to 0.387
6	Mean NDVI within 100m buffer (March)	0.201 to 0.428
7	Mean NDWI within 100m buffer (October)	0.152 to 0.345
8	Mean NDWI within 100m buffer (October)	0.169 to 0.37
9	Slope	0-8.564 (degrees)
10	Elevation	312-361 (MSL)

Table 6.1 Range of all characteristics of conflict sites.

Almost all incidents have occurred within 500m distances of the settlements and roads other than NH 58, while the distances from other two characteristics, NH 58 and railway line vary to a much greater extent (Fig. 6.1).

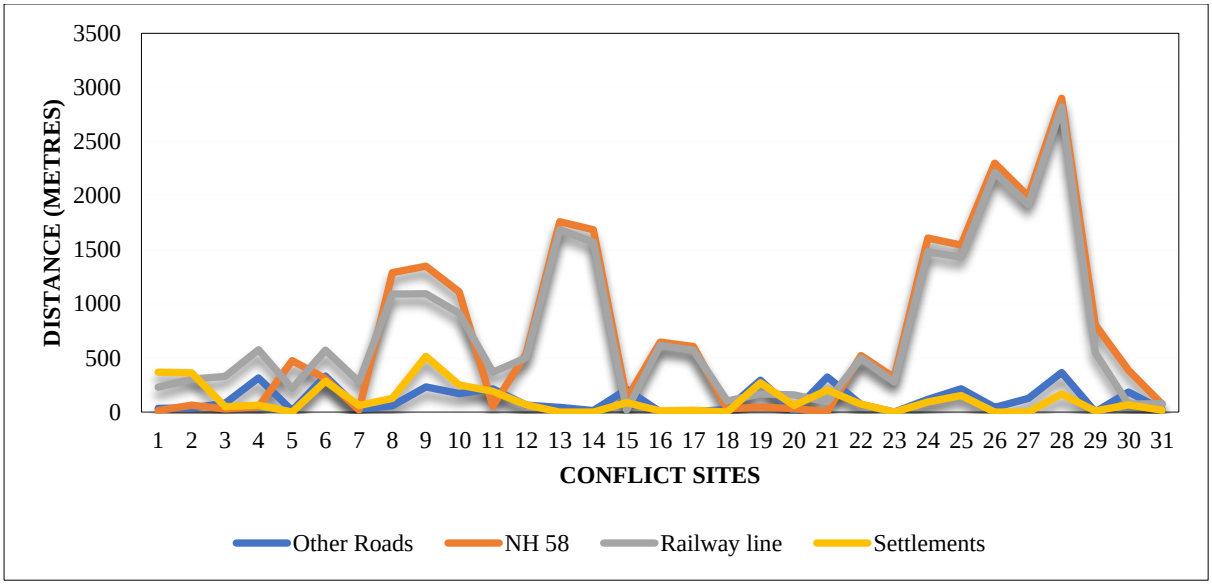


Fig. 6.1 Euclidean distances to NH 58, railway line, settlements and roads other than NH 58.

The NDVI and NDWI values showed that most of the attacks happened in moderate to open vegetation and shrubby areas coupled with moderate moisture content (Fig. 6.2) (NDVI Map 6.2).

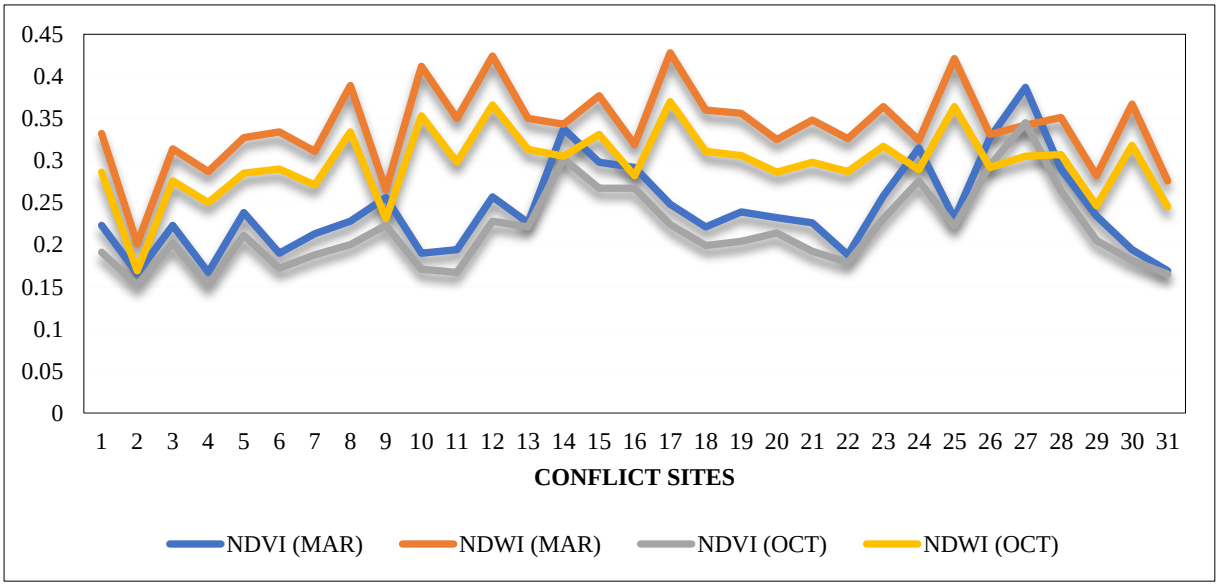
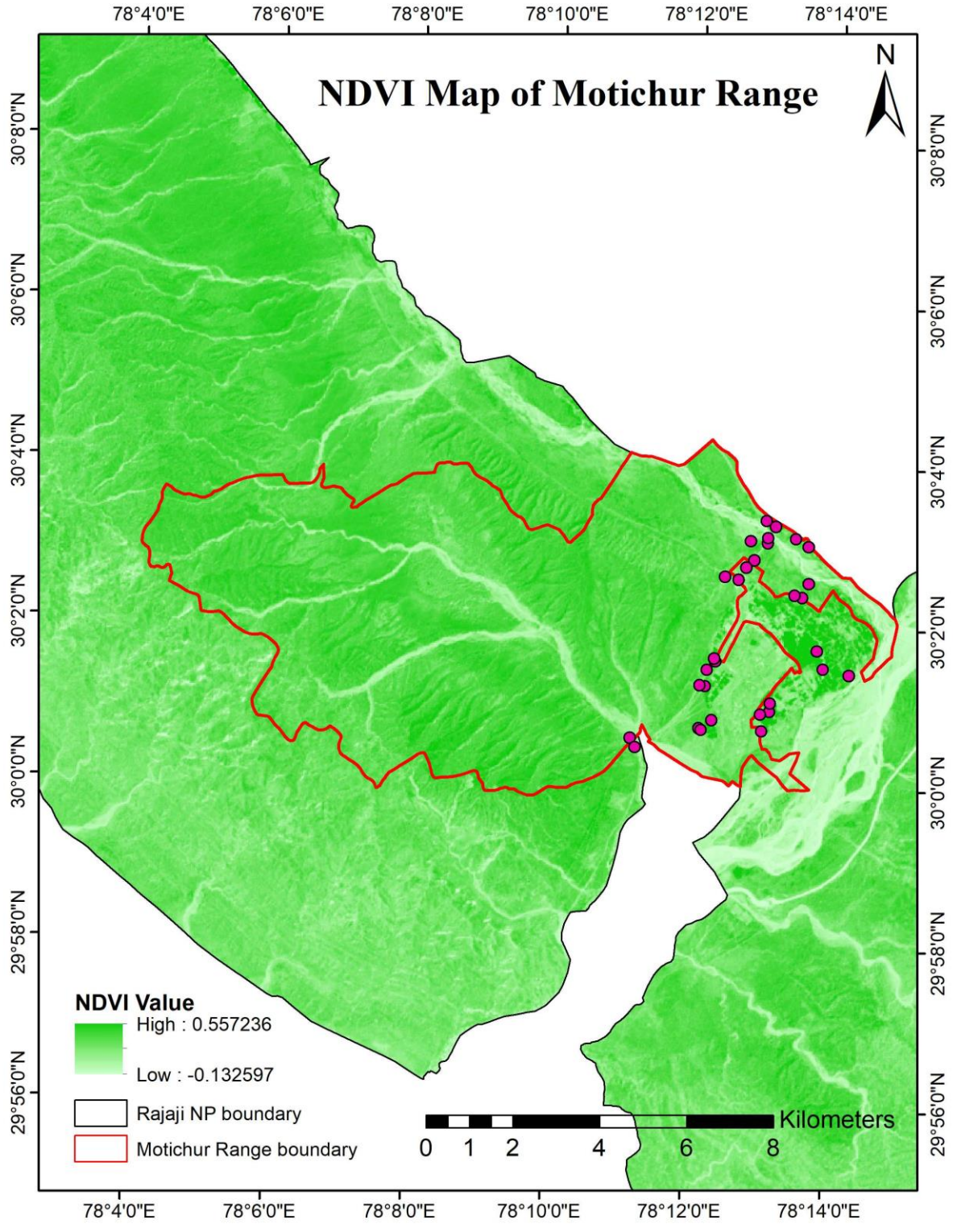


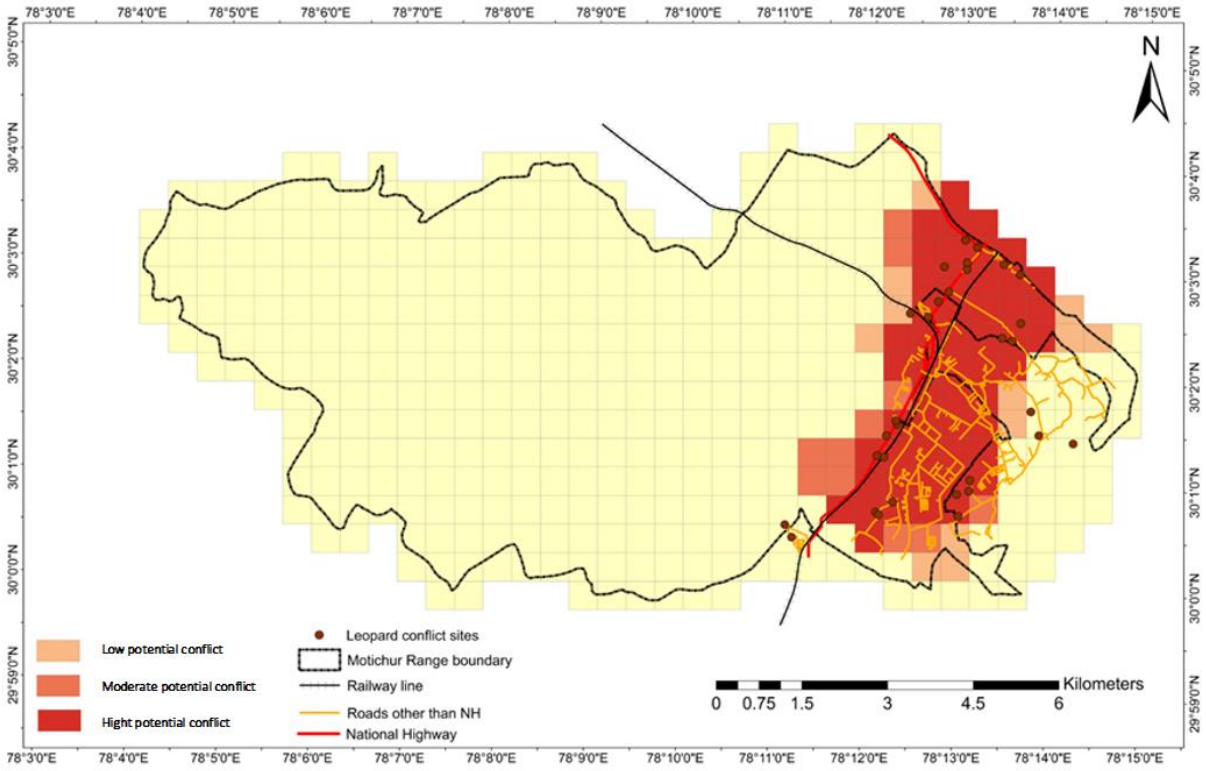
Fig. 6.2 NDVI and NDWI values from March and October from each conflict site.



Map 6.2: NDVI map with the conflict sites.

The map above shows the locations of attack sites, they are localized primarily around water bodies and streams, in moderately dense to open habitats.

6.1 **b. Spatially Potential conflict area -** Areas with dark red were most prone to attacks based on spatial clustering of incident intensity (Map 6.3). They are concentrated mainly around national highway and railway track.



Map 6.3 Incident intensity map based on spatial clustering.

6.1c. Influence of behavioral and physical factors in conflict - In all 3 cases, obtained p value was higher than our α level of 0.05, i.e. (i) between trend of increasing deaths and decreasing injury from leopard attacks (p value = 0.2297) (fig 6.3, left); (ii) between the 3 seasons through the successive years (p value = 0.1842), for which the order of decreasing trend of attacks was summer (14), monsoon (10), and winters (7) respectively (influence of fluctuations of temperature and water availability) (fig 6.3, right). Though these p values are not significant, but the data does represent a trend.

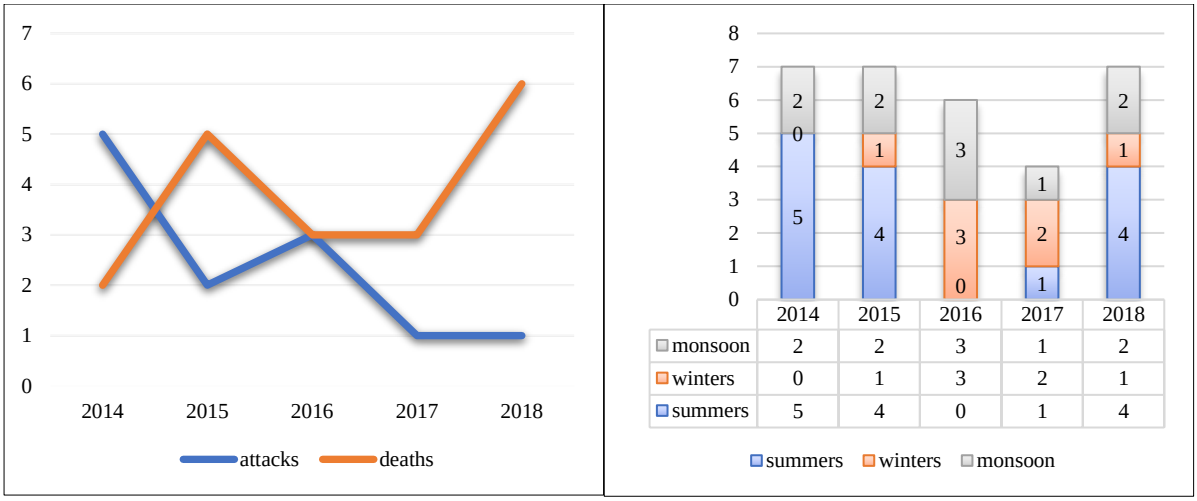


Fig 6.3 Annual count of leopard attacks resulting in either injury or death (left); & the yearly seasonal count of leopard attacks (right).

And lastly, (iii) The influence of sunlight on leopard attacks (p value = 0.1614). We observed that majority of the attacks occurred during crepuscular hours, both in number (12) & percentage (38.7%) (Fig. 6.4) and least during day light hours (8 in number, & 25%).

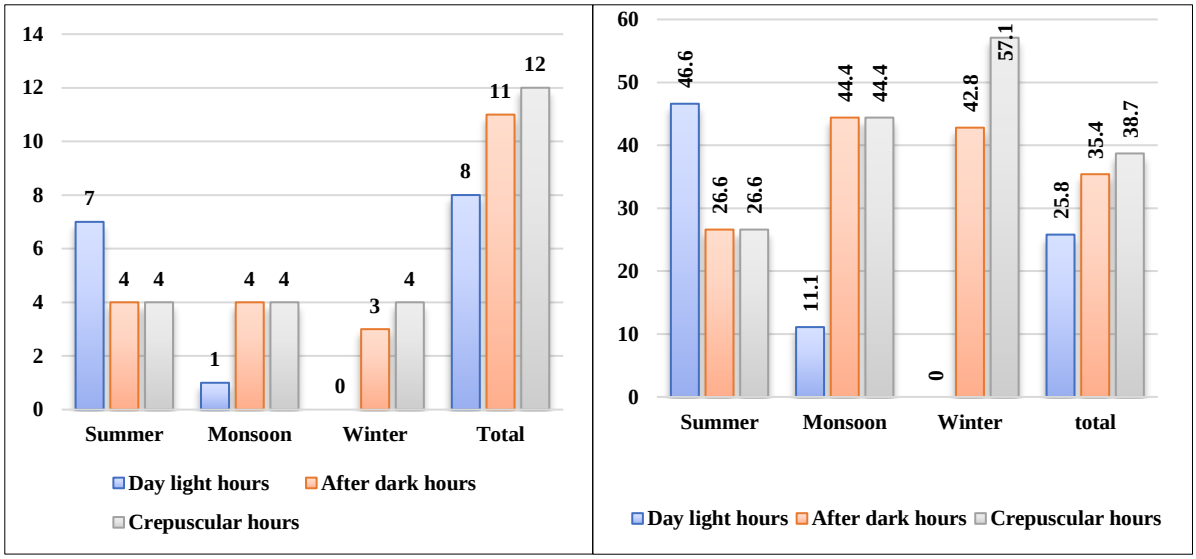


Fig. 6.4 Attack count based on time classes (left); Attack percentage based on time classes (right).

In terms of daylight most attacks occurred in summer, 7 in number around 46.6%; while, exactly the opposite was observed in both monsoons (1 in number around 3.2%) and winter (0). Both during the after dark and crepuscular hours, the trend is almost constant in number, throughout the seasons. Semi-lit to dark conditions, seemed to increase the attacks. Where dawn and dusk were the most sensitive. Taken together, they would account for 71% of the attacks.

6.2 Influence of spatial characteristics in conflict.

There was a statistically significant strong positive correlation (rho = 0.824) between the distances of conflict sites to NH58 and the railway line (p=1.211e-08) as compared to (p = 0.0001) distance from settlements and other roads other than NH58 (rho = 0.640) (Fig. 6.5).

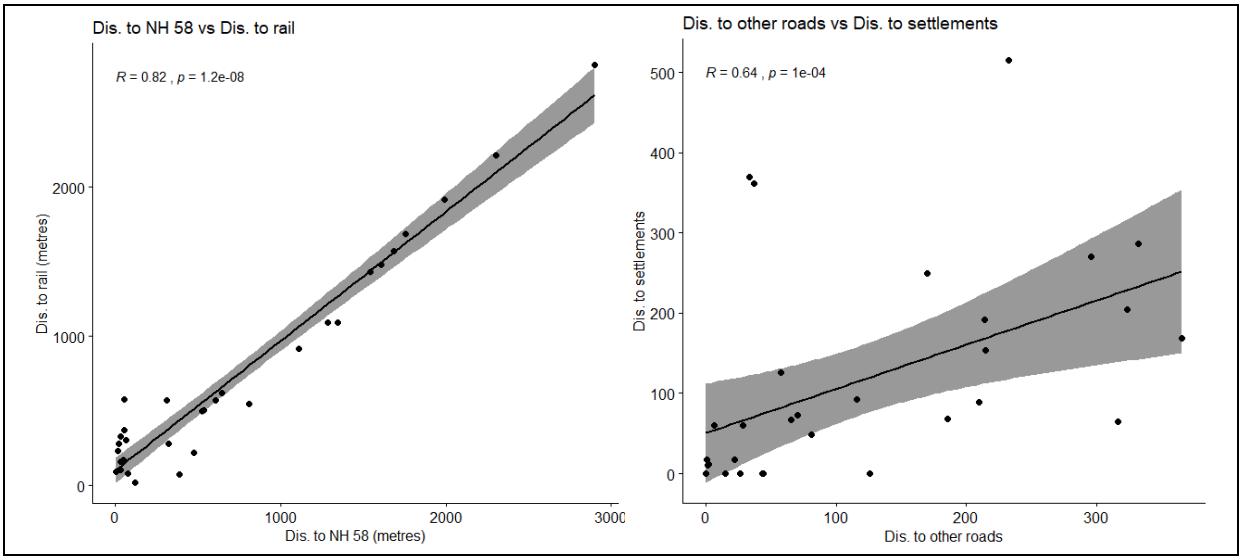


Fig. 6.5: Correlation between distance to rail vs distance to NH 58 (left); & distance to settlements vs distance to roads other than NH58 (right).

There was a statistically significant (p = 2.2e-16) strong positive correlation (rho = 0.974) between NDVI and NDWI values of March. Exactly same results (p = 2.2e-16) obtained for correlation (cor. = 0.995) between NDVI and NDWI values of October (Fig. 6.6). (For full results of bivariate correlation, see appendix)

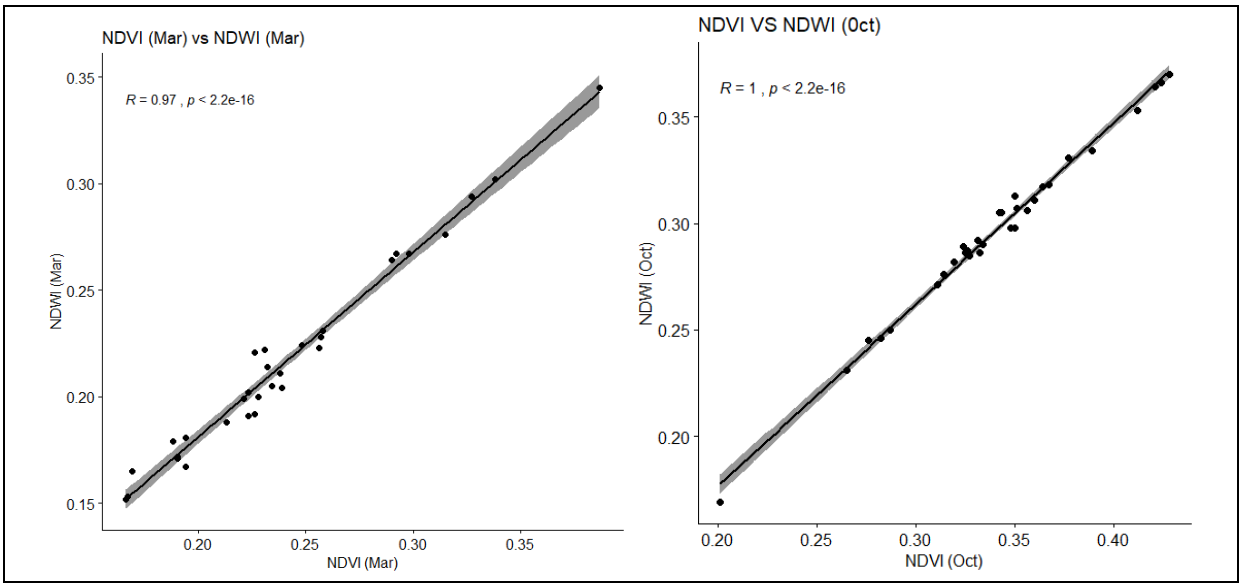


Fig. 6.6 Correlation between NDVI and NDWI for the month of March (left); & NDVI and NDWI for the month of October (right).

6.3 Temporal behavior of Leopard.

Activity patterns, Activity classification and Circular Statistics - We classified a total of 721 images from March 2018 to February 2019, belonging to individually identifiable leopards from the conflict zone from Forest Dept. camera traps. We classified the images on seasonal basis: 69, 322 and 330 belonging to summer (Mar-June 2018), monsoon (July-Oct 2018) and winters (Nov 2018 - Feb 2019) respectively. We further obtained 61 images belonging to individually identifiable leopards from the non-conflict zone for the winter season (Nov 2018-Feb 2019) from WII camera traps. To obtain any temporal relationship between human and leopards, we extracted and classified all images of human activity on foot from WII camera traps. We obtained 50 such photographic captures. We calculated circular statistics (Table 6.1), and also classified their activity (Table 8.4) along with their activity patterns.

For our conflict zone in summer, the mean activity was at 23:05 (95% C.I. 22:16 - 23:55) with the highest concentration length (1.8). The leopard activity peaked around 21:00 hrs (Fig8.6) and is absent around mid-day. Though the activity was strongly nocturnal (82.6% photographic captures between 19:00-05:00), percent photographic captures during the night remained lowest in all the three seasons. Summers recorded the highest level of daylight activity (17.4% photographic captures between 05:00-19:00).

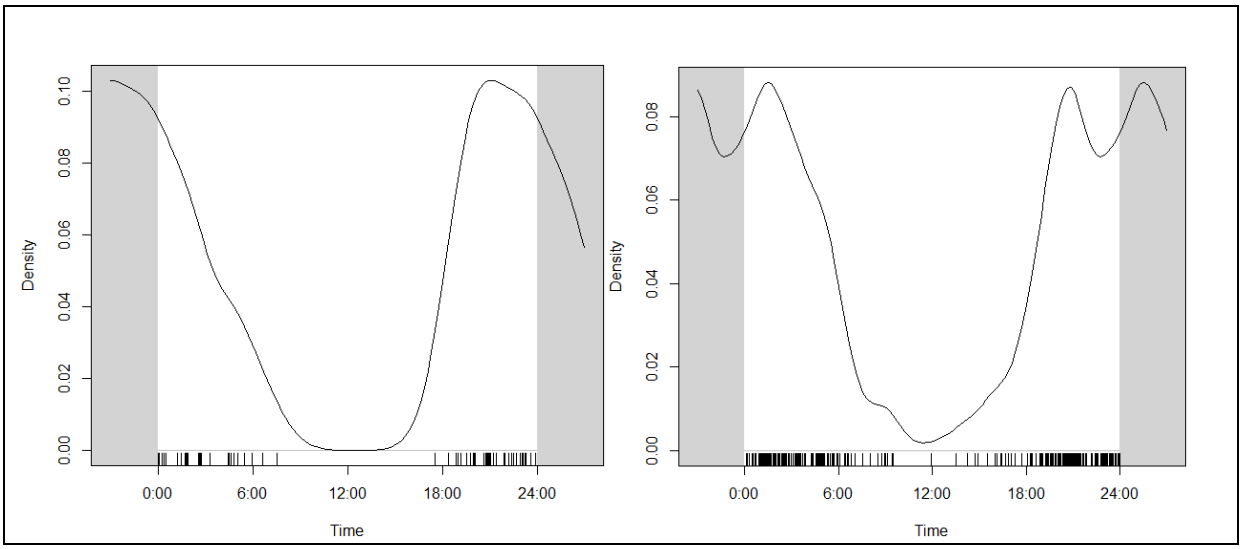


Fig. 6.7 Leopard activity patterns from the conflict zone (Left; Summers; Mar 18 – Jun 18) (Right; Monsoon; Jul 18 – Oct 18)

Conversely, for monsoon season leopards had the lowest level of daylight activity (10.5% photographic captures between 06:00-18:00) and highest level of nocturnal activity (89.4% photographic captures between 18:00-06:00). The mean activity was at 23:57 (95% C.I. 23:27 - 00:26) with an intermediate concentration length (1.299). Activity was bimodal, peaking around 20:00 and 01:00 hours (Fig 6.7).

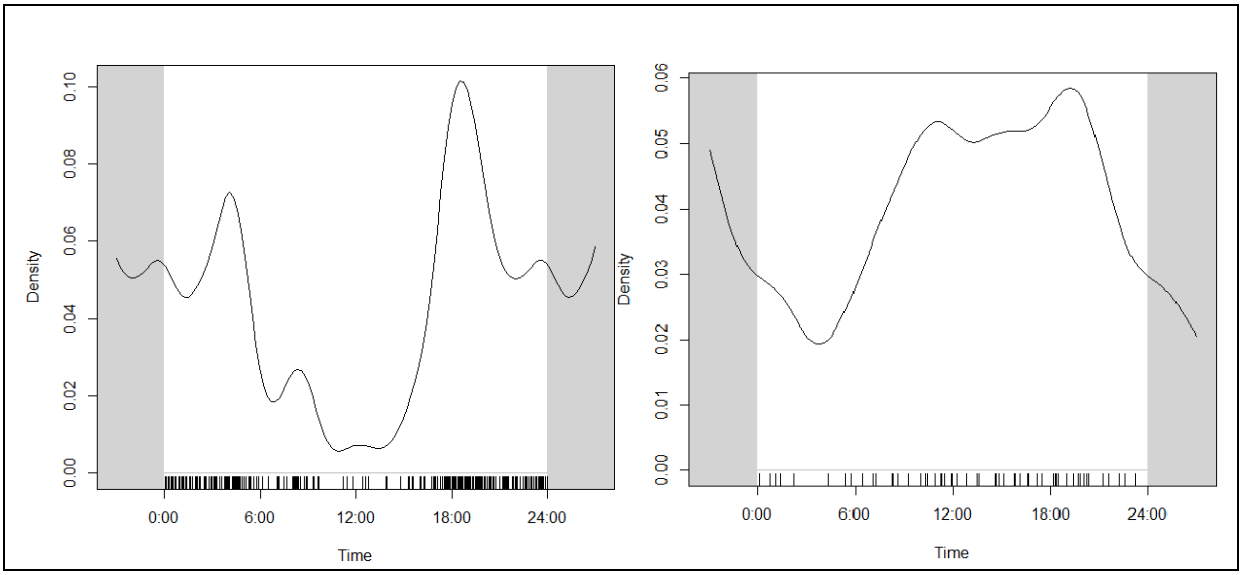


Fig 6.8 Leopard activity patterns from the conflict zone (Left; winters; Nov 18 – Feb 19) and from the non-conflict zone (Right; Winters; Nov 18 – Feb 19).

For winters, the activity was multimodal. Peaking roughly around 18:00, 24:00, 04:00 and 09:00 (Fig. 8.7). The mean activity was at 22:21 (95% C.I. 21:34 - 23:07) with the lowest concentration length 0.778. The Leopard activity remained strongly nocturnal (85.1 % photographic captures between 17:00-07:00), with the night time percent photographic captures remaining intermediate between the monsoon (highest) and summer season

(lowest). In comparison for adjacent non-conflict zone, leopard activity was cathemeral (50.8% photographic captures between 07:00-17:00, and 49.1% photographic captures between 17:00-07:00). The mean activity was at 15:20 (95% C.I. 12:17 - 18:23) with the lowest concentration length (0.449) amongst any class. The activity was roughly clumped, with rough peaks (11:00, 15:00 and 20:00), while the activity dropping considerably around 04:00 hrs (Fig 6.8).

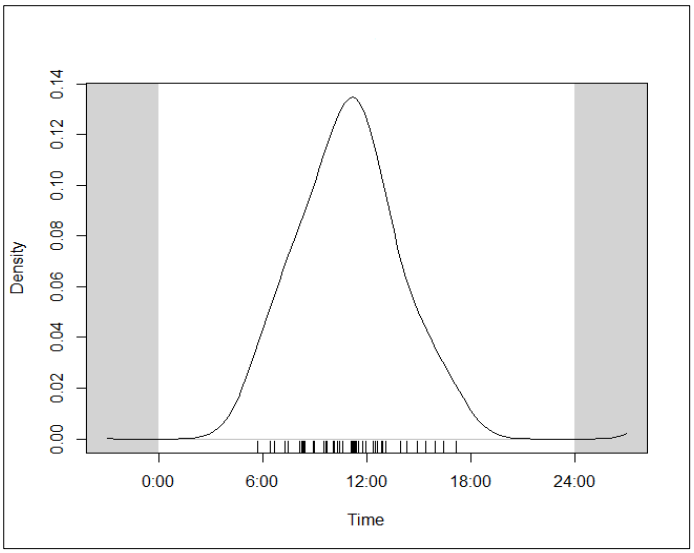


Fig. 6.9 Activity pattern for human movement on foot on the trails in the Motichur range; (Winters; Nov 18 - Feb 19) (left).

We included photographic captures of any human on foot to estimate human activity in the reserve. The mean human activity was at 10:51 (95% C.I. 10:05 - 11:36) with the highest concentration length amongst all classes (2.519). The human activity was strongly diurnal (88% photographic captures during 07:00-17:00) with a strong unimodal peak peaking at 12:00 hours (Fig. 6.9).

	n	***Rao's Spacing Test (U)***	***Rao's Spacing Test (p)***
Conflict summers	69	201.319	< 0.01
Conflict monsoon	322	181.877	< 0.01
Conflict winters	330	173.439	< 0.01
Non-conflict winters	61	122.209	0.90 > p > 0.50
Human activity winters	50	203.3	< 0.01

Table 6.1 Rao's spacing test

	n	***Mean vector***	***Length of mean vector***	***Concentration***	***Circular variance***	***Standard error of mean***	***95% confidence interval***	***Circular Standard deviation***
Conflict summers	69	23:05	0.664	1.8	0.336	00:25	22:16 - 23:55	03:27
Conflict rainy	322	23:57	0.544	1.299	0.456	00:15	23:27 - 00:26	04:12
Conflict winters	330	22:21	0.363	0.778	0.637	00:23	21:34 - 23:07	05:26
Non-conflict winters	61	15:20	0.219	0.449	0.781	01:33	12:17 - 18:23	06:39
Human activity winters	50	10:51	0.768	2.519	0.232	00:23	10:05 - 11:36	02:46

Table 6.2: Circular statistics of leopard & human.

Leopards in the conflict zone had a multimodal or non-evenly spaced distribution of time in the diel cycles from all the three seasons (P < 0.01 for all 3 seasons). However, leopards from the non-conflict zone had a unimodal or evenly spaced distribution of time (0.90 > p > 0.50). Human activity was also non-evenly spaced (p<0.01) (Table 8.2).

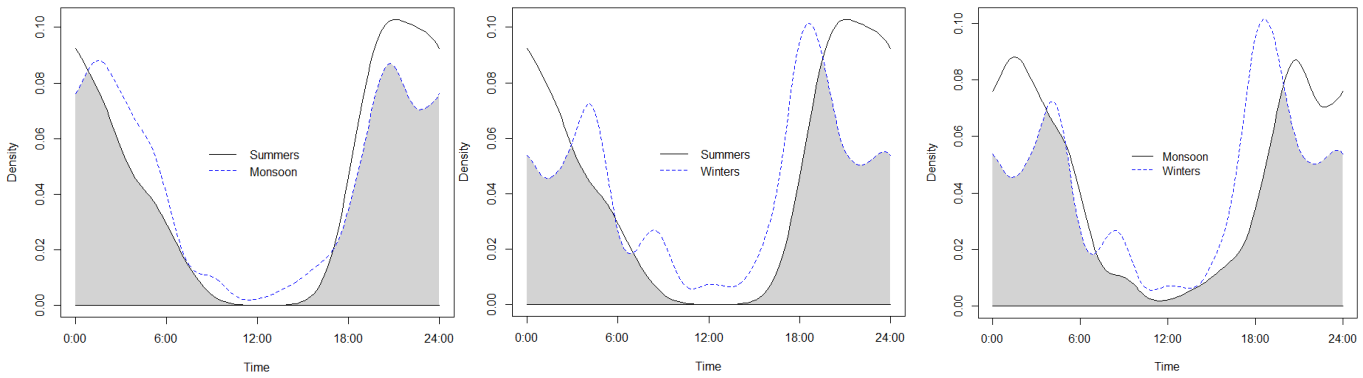


Fig. 6.10 Seasonal overlap of leopard activity pattern from conflict zone: summer 2018 vs monsoon 2018 (Left); summer 2018 vs winter 2018 (Centre); & monsoon 2018 vs winters 2018 (Right).

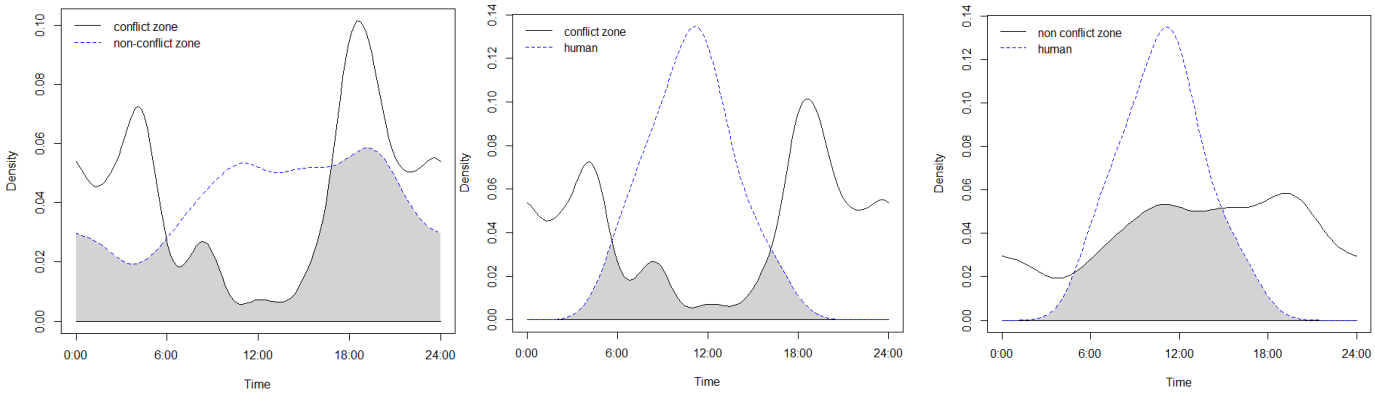


Fig. 6.11 Overlap of activity patterns (i) between leopards from conflict zone vs non-conflict zone in Winters (left); (ii) between leopards from conflict zone vs for human movement from non-conflict zone in winters (centre); (iii between leopards vs human movement, both from non-conflict zone in winters (right).

The diel overlap in the conflict zone, between leopard activity throughout the 3 seasons (Fig. 6.10) was very high. Summers vs monsoon and winters vs monsoon experience almost had the same overlap of leopard activity (0.80), which was somehow lower in summer vs winters (0.75), which may be due to large differences in light hours. The overlap of leopard activity from both the conflict and non-conflict zone for winters was a bit lower (0.67) which may indicate behavioral adaptation to anthropogenic disturbances in fringe areas. We estimated the diel overlap of temporal activity between human and leopards from both the conflict and non-conflict zones for the winter season (Fig 6.11). Even though the overlap of activity between leopards and human activity was high (0.57), there was never a potential attack on a human inside the reserve. In comparison, the non-conflict zone which had a very low overlap (0.28) but high incidences of attacks.

Species, Season, Zone & Total Pictures	Hour Class	Light Availability	Total Pictures	Percent	Activity
Leopard, Conflict winters (330)	07:00-17:00	Daylight	49	14.9	strongly, nocturnal
	17:00-07:00	Dark	281	85.1	
Leopard,Conflict monsoon (322)	06:00-18:00	Daylight	34	10.5	strongly, nocturnal
	18:00-06:00	Dark	288	89.4	
Leopard,Conflict summers (69)	05:00-19:00	Daylight	12	17.4	Strongly nocturnal
	19:00-05:00	Dark	57	82.6	
Leopard,Non-conflict winters (61)	07:00-17:00	Daylight	31	50.8	Cathemeral
	17:00-07:00	Dark	30	49.1	
Human, both zones winters (50)	07:00-17:00	Daylight	44	88	Strongly diurnal
	17:00-07:00	Dark	6	12	

Table 6.3 Activity classification of leopard & human.

6.4 Leopard population indices.

6.4a. Leopard Count – To obtain the total leopard count. We used the data of pre-identified animals from the forest department. And also identified individuals with data from non-conflict zone.

We also halved the total unidentified single flanked animals from forest department data to account for the pseudo-replication arising due horizontal flipping of images, when actual placement of the single camera on the ground is not known.

Season	M. BF I.D.	F. BF I.D.	SF I.D.	M (NO.)	F (NO.)	SF (NO.)	Exact total	Approx. Total
Sum	L1, L3, L5	L10, L13, L16, L19	F (L31, L43)	3	4	2/2 = 1	7	8
Mon	L1, L2, L3,	L10, L11, L12, L13, L16	F (L32, L33, L43, L53, L54)	3	5	5/2 = 2.5~2	8	10
Win	L1, L2, L3, L4	L10, L11, L12, L13, L15, L44, L55	F (L34, L35, L36, L37, L38, L39, L40, L45)	4	7	8/2 = 4	11	15

Table 6.4 Leopard count obtained from conflict area (M.= Male; F.=Female; BF=both flanks; SF=single flank; I.D.=Identification; NO.=Number)

From the forest department data, we obtained photographic captures of both flanks of 7 individuals, and a gross single flanked animal for summer season (Mar-June) of 2018. For monsoon (July-Oct) we obtained 8 animals and 2 gross single flanked animals. For winters (Nov-Feb) we obtained 11 animals, and 4 gross single flanked animals (Table 6.4).

From the non-conflict zone, we obtained a total of 32 individual animals (Table 6.5). (For individual leopard identification patterns see appendix)

S.NO.	GENDER	I.D.	NO.
1	Male (both flanks)	L1, L2, L4, L6, L7, L8, L9	7
2	Female (both flanks)	L10, L17, L18, L19, L20, L21, L52, L22, L23, L24, L25, L26, L27, L28, L29	15
3	Cub (both flanks)	L45, L46, L47	3
4	Male (single flank)	L51	1
5	Female (single flank)	L41, L42, L30	3
6	Cub (single flank)	L48, L49, L50	3
		TOTAL	**32**

Table 6.5 Leopard count obtained from non-conflict zone from winters 2018-19 (I.D.=Identification; NO.=Number)

6.4b. Relative Abundance Index (RAI) - For summers (Fig. 6.12), we observed a high RAI for just male leopards. A single individual with high RAI was L1 (0.38).

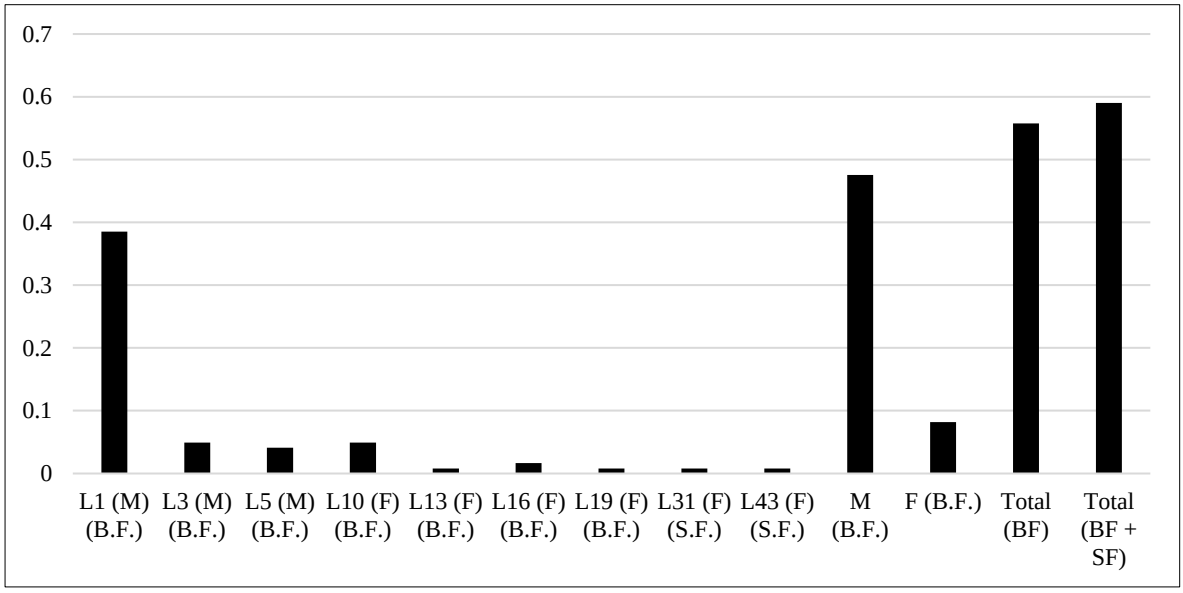


Fig. 6.12 RAI for summers 2018, conflict zone (M = male; F = female; B.F. = both flanks; S.F. = single flanks)

For monsoons (Fig. 6.13), we observed a high RAI for two individuals; L1 (1.31) and L10 (0.84). The trend remained the same for winters (Fig. 6.14), L1 (1.3) and L10 (1.07) being the only two relatively abundant individuals in the conflict zone as compared to other animals.

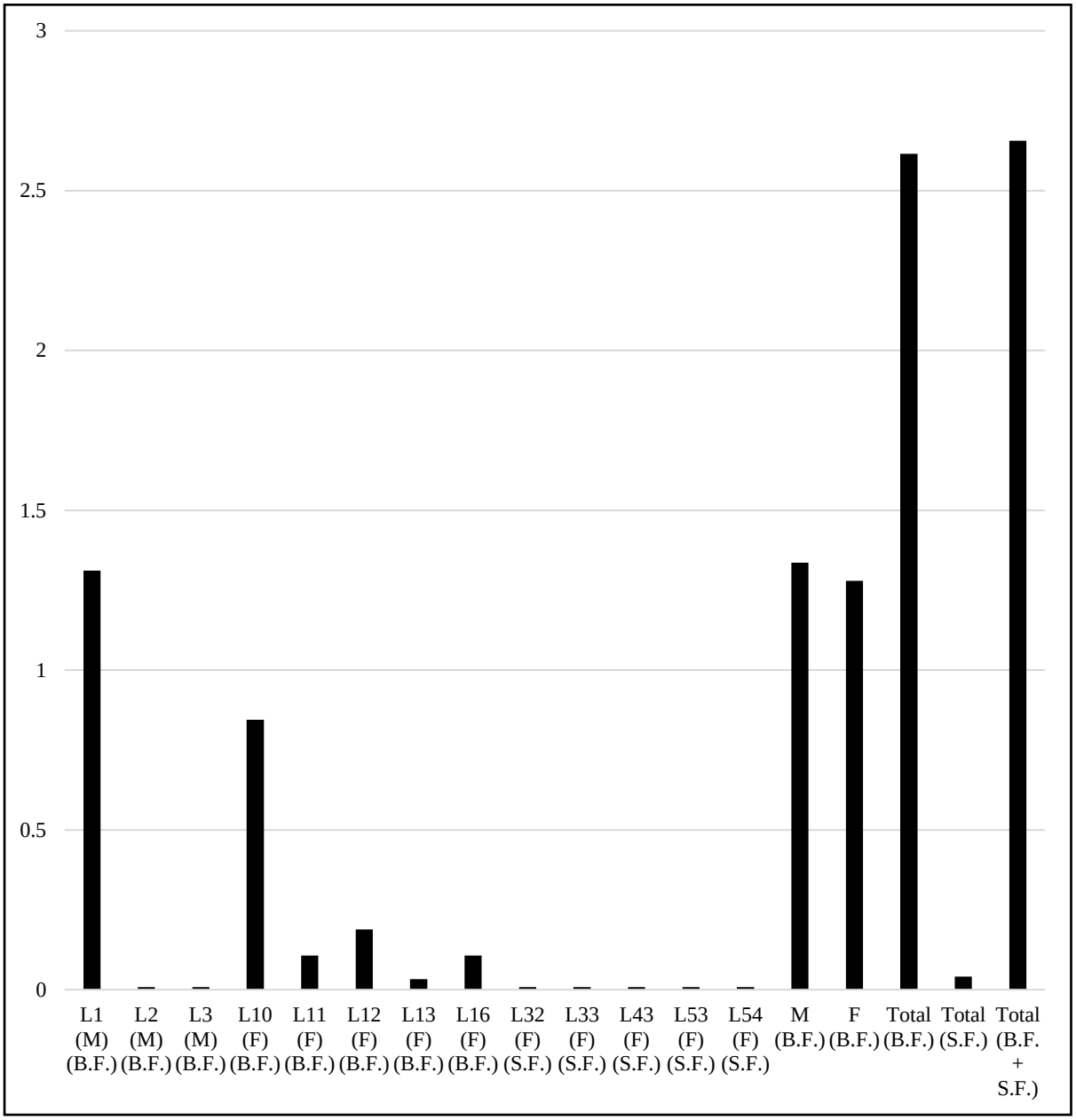


Fig. 6.13 RAI for monsoons 2018, conflict zone (M = male; F = female; B.F. = both flanks; S.F. = single flanks)

The other individual male leopards common in the conflict sites, but with a relatively low RAI are L2 and L3; L3 were common throughout the 3 seasons, while L2 being absent only in summers. Female leopards L13 and L16 are present in the conflict area throughout the year but with a relatively low RAI as compared to L10. Other females L11 and L12 were also present in monsoons and winters but were absent in summers.

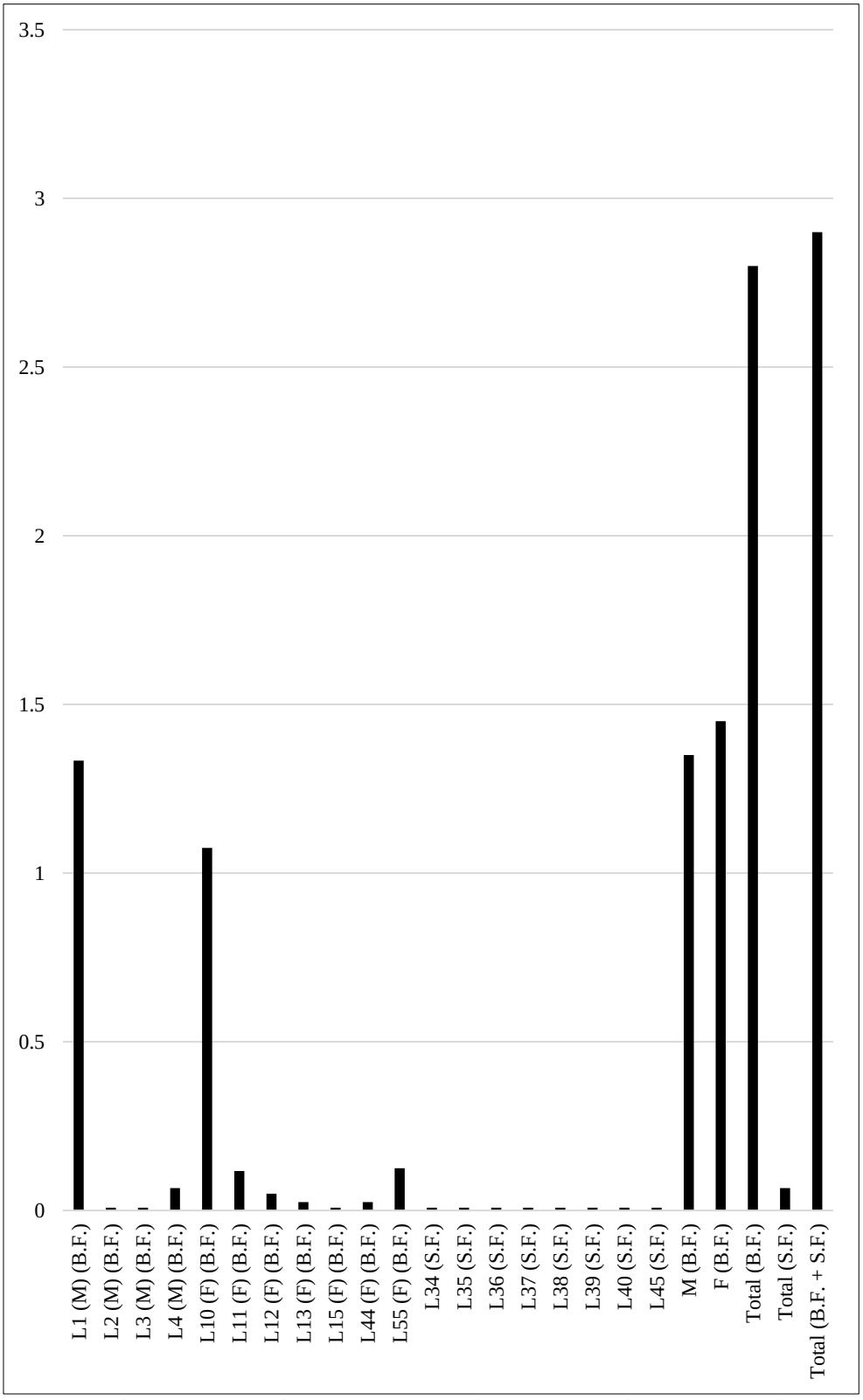


Fig. 6.14 RAI for winters 2018, conflict zone (M = male; F = female; B.F. = both flanks; S.F. = single flanks)

Male leopards (summers (0.47), monsoons (1.33), winters (1.35)) had a more relatively higher RAI in comparison to females (summers (0.07), monsoons (1.27), winters (1.45)) in all the three seasons, except for winters. The combined RAI for leopards was higher for the winters in comparison to others (summers (0.55), monsoons (2.6) and winters (2.9)). Single flanked animals were relatively low for all three seasons (summers (0.02), monsoons (0.04) and winters (0.06)).

For the non-conflict zone (Fig. 6.15), four individual leopards were photo captured, that were also common in the conflict zone, namely L1 (0.23), L2 (0.23), L4 (0.09) and L10 (0.09). Along with L7 and L19, the former was present in the conflict zone in 2017, while the latter was present in the conflict zone in summer 2018.

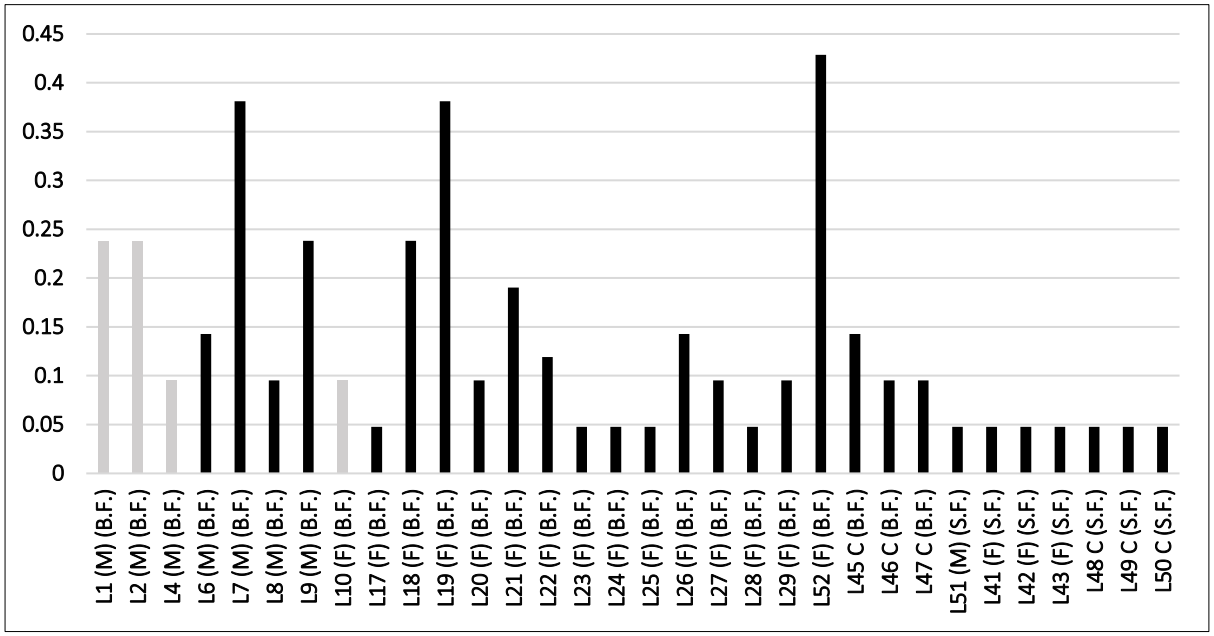
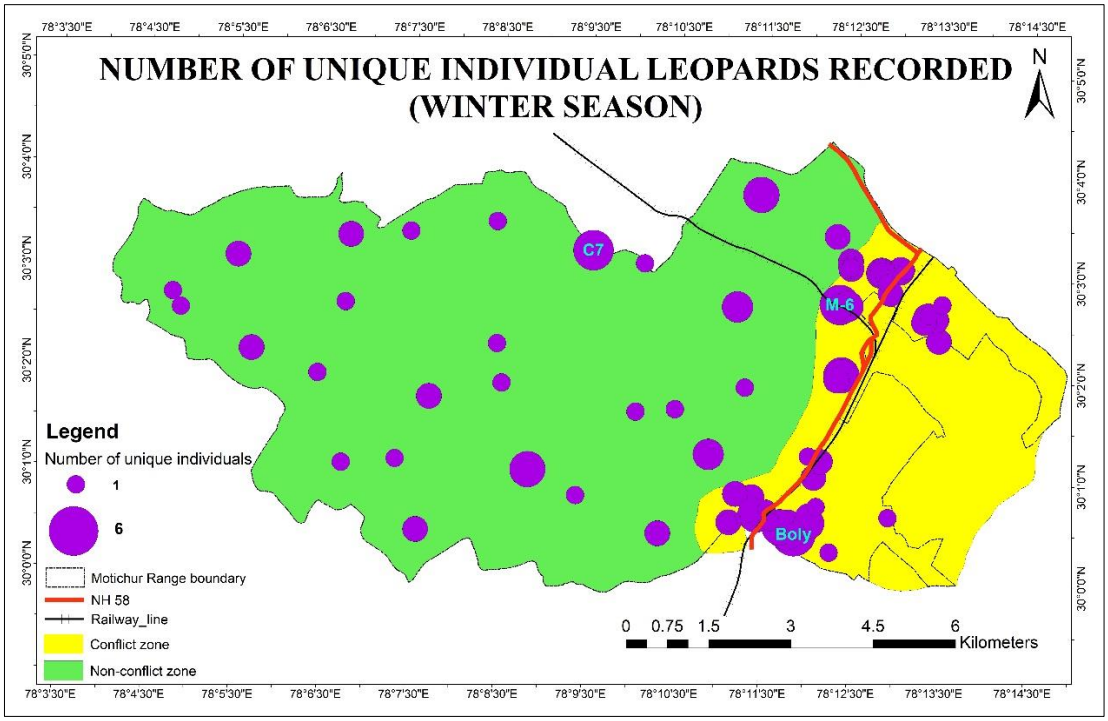


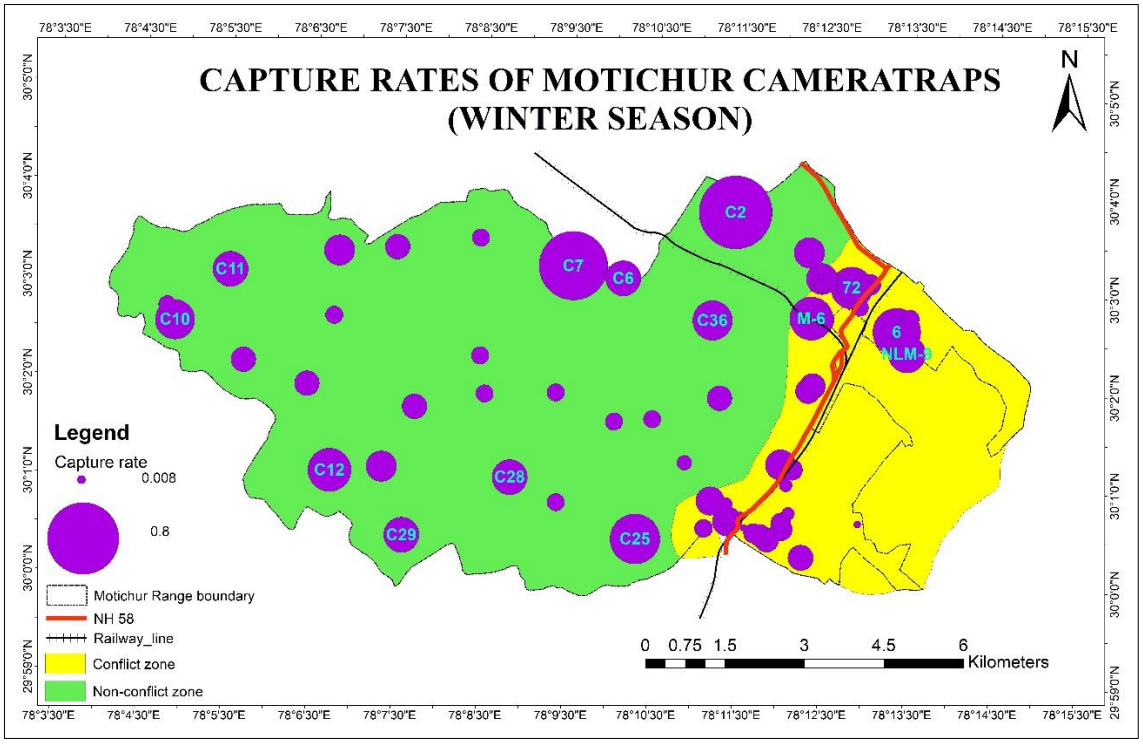
Fig. 6.15: RAI for winters 2018, non-conflict zone; grey colour indicates animals from conflict zone (M = male; F = female; B.F. = both flanks; S.F. = single flanks)

Gross individual capture rate of leopards (Map 6.4) is recorded from just at the northern and southern boundary of the Motichur range. Camera ID's Boly (0.05), M-11 (0.042), M-6 (0.042), and 552 (0.03) recorded the maximum capture rate.



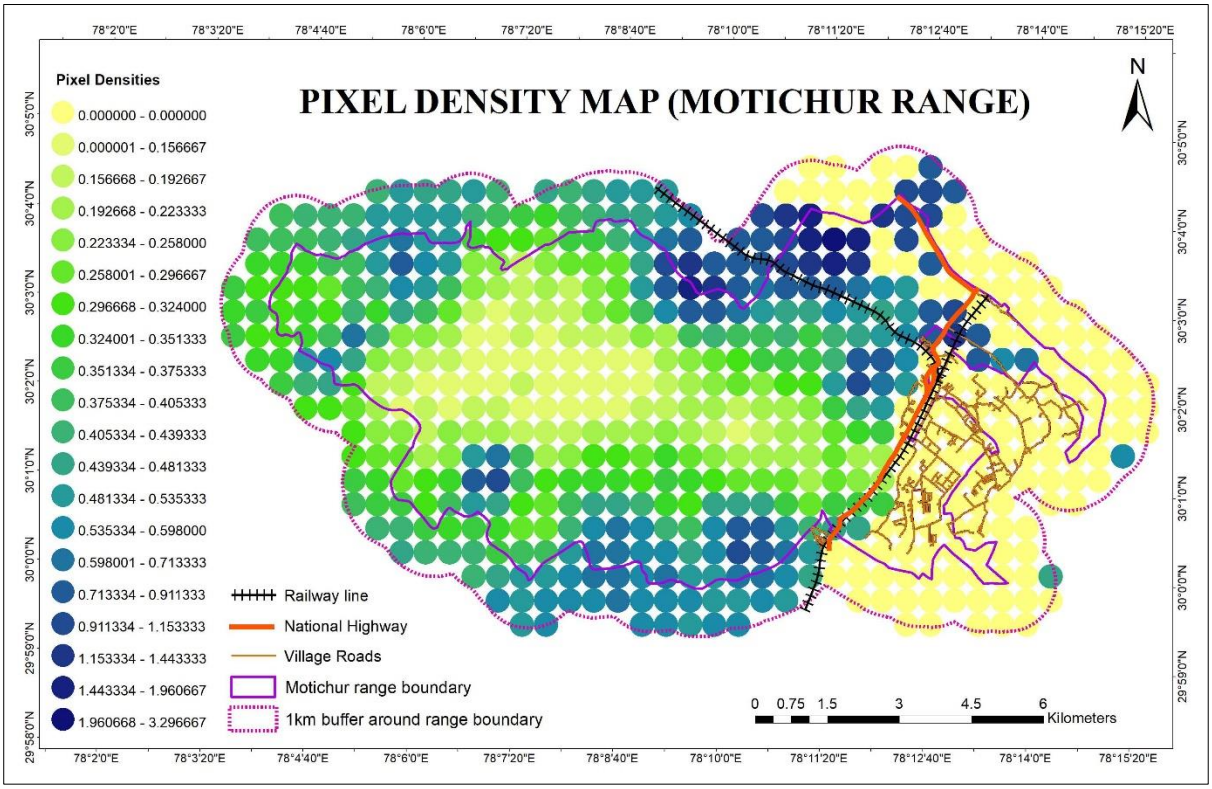
Map 6.4 Gross individual capture rate of leopards at each camera station for winter season (size of the spot is proportional to capture rate).

Gross leopard capture rate (Map 6.5) was seen at 6 (0.35), M6 (0.28), 72 and NLM-9 (0.21) in the conflict zone. C2 and C7 recorded the maximum gross capture rate at C2 (0.8), and C7 (0.7) from non-conflict zone.



Map 6.5 Gross leopard Capture rate of leopards at each camera station for winter season (size of the spot is proportional to capture rate).

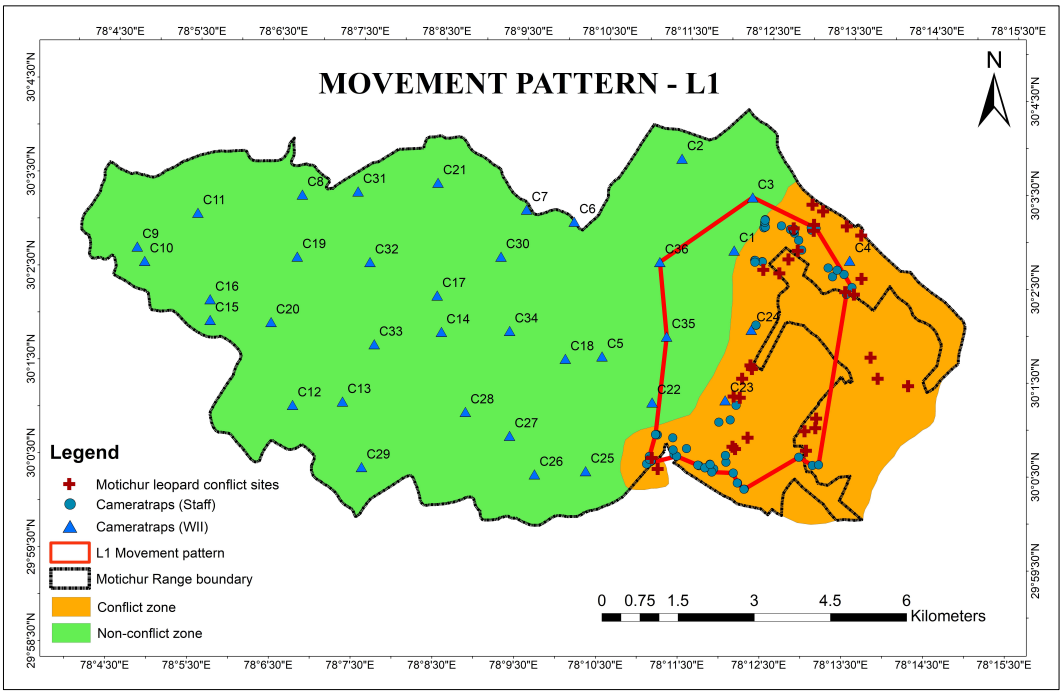
6.4c. Density - We observed a density of 45 animals (35-56 95% HPD level) per 100 square kilometers (for full results of density see appendix). See leopard density per pixel of 0.25 km^2 below (Map 6.6).



Map 6.6 A pixelated density map showing leopard densities per pixel of size 0.25 km^2.

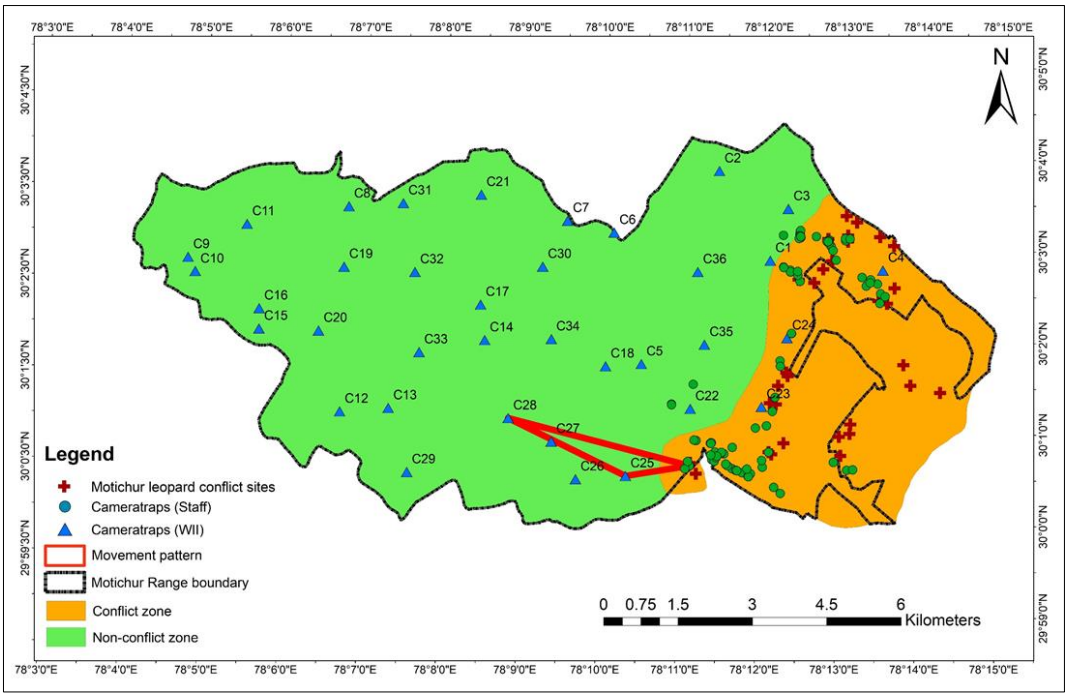
6.5 Leopard Movement Patterns.

Based on 2 factors i.e., a high RAI (relative to other leopards) and, movement in the conflict zone, we mapped the movement patterns (Map 6.7- Map 6.14) of 8 individual leopards common throughout the three seasons. The eight individual leopards had the following ID's - L1, L3, L10, L11, L12, L13, L15 and L16.

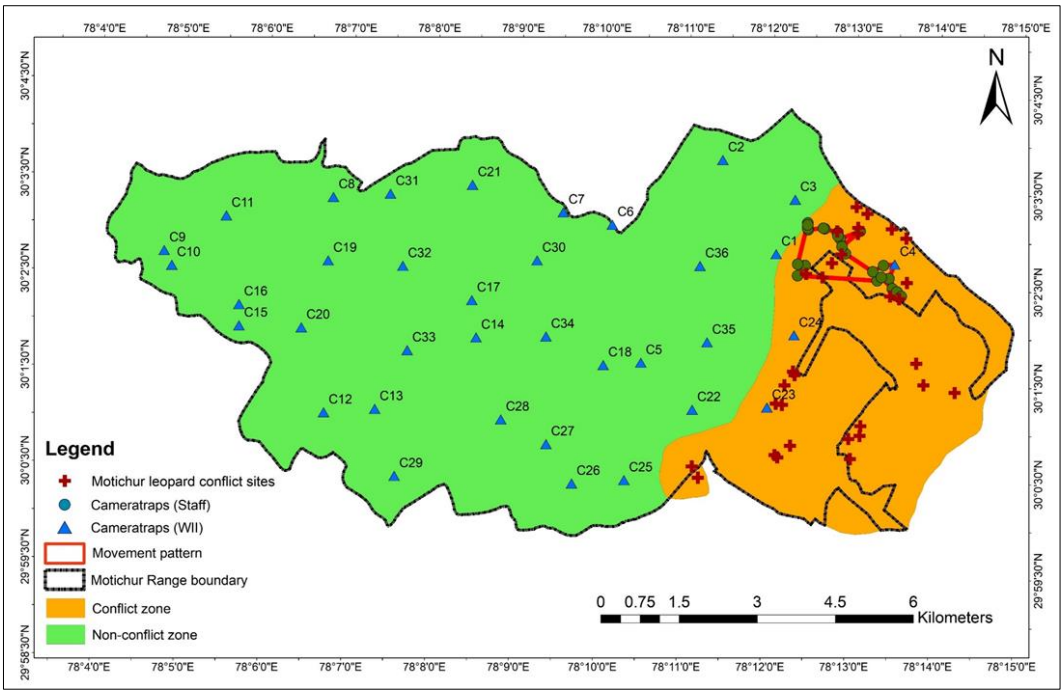


Map 6.7: Movement pattern of L1

L1, a male leopard, was observed to have the widest ranging animal. It was recorded throughout the three seasons from the entire conflict zone as well from more than 6 km inside the reserve (Map 6.7). In contrast, male L3, was had a very restricted movement to the south-eastern boundary of the conflict zone (Map 6.8).

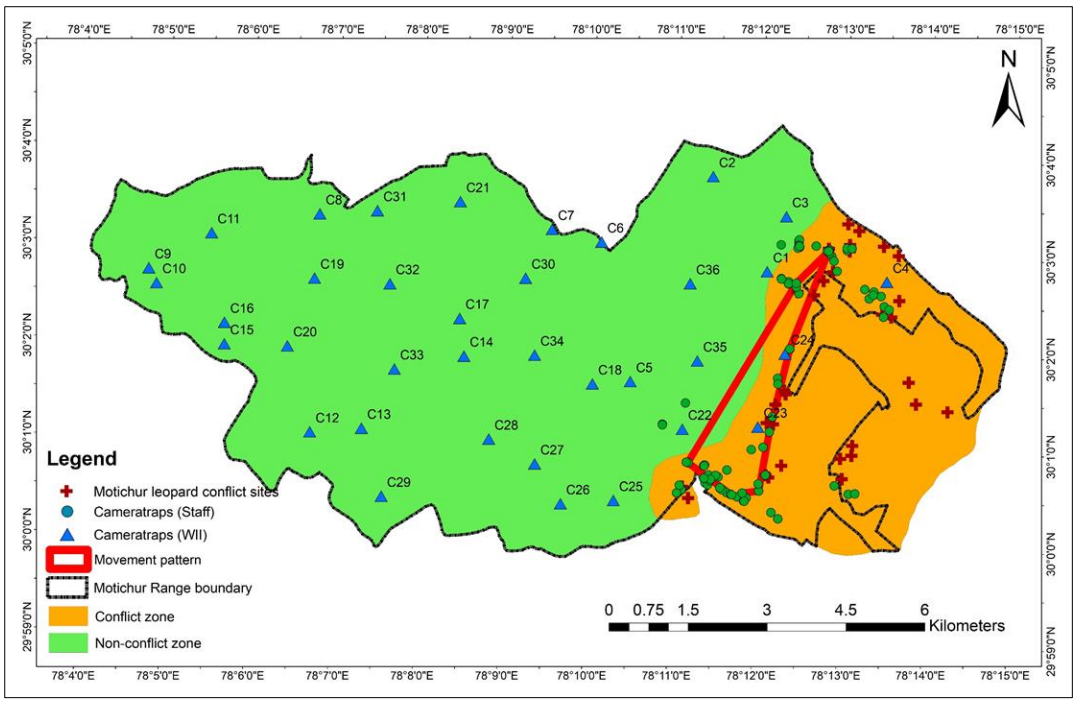


Map 6.8: Movement pattern of L3



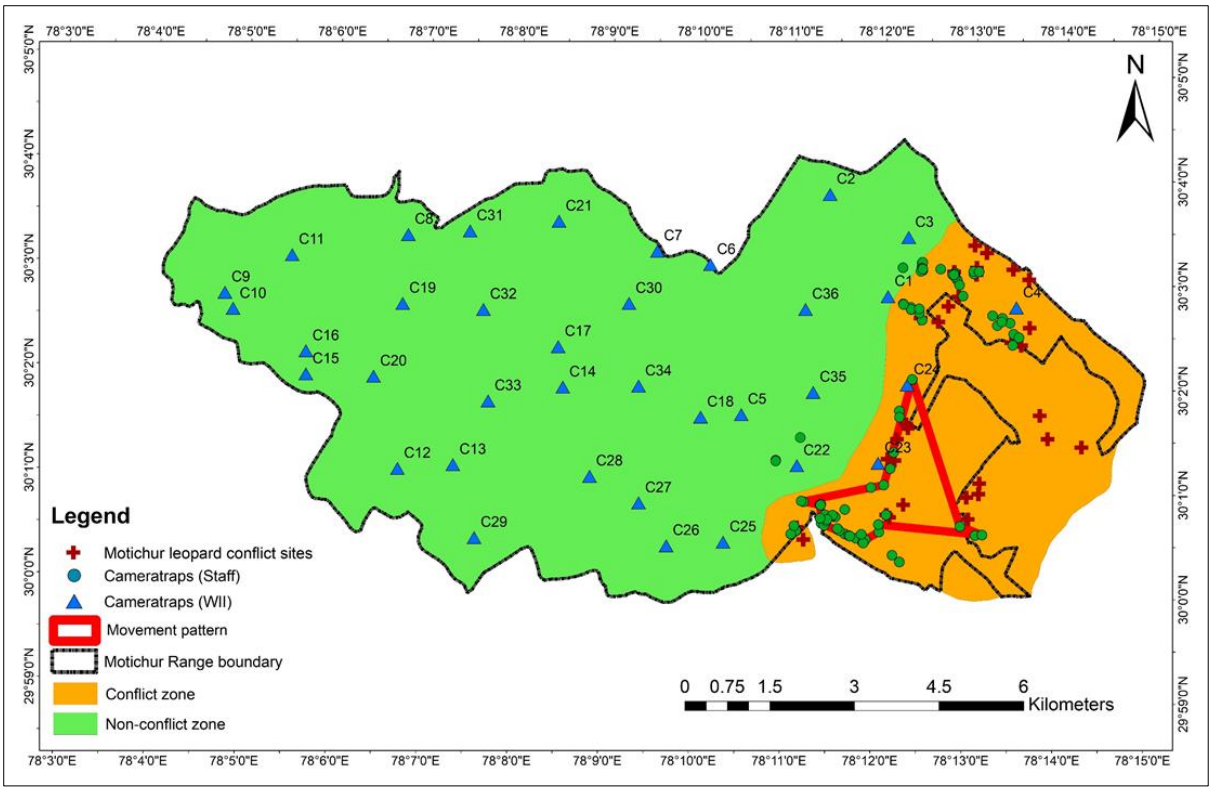
Map 6.9 Movement pattern of L10

In contrast, a female L10, was solely restricted her movement the northeast boundary of the Motichur range, inside the conflict zone (Map 6.9).

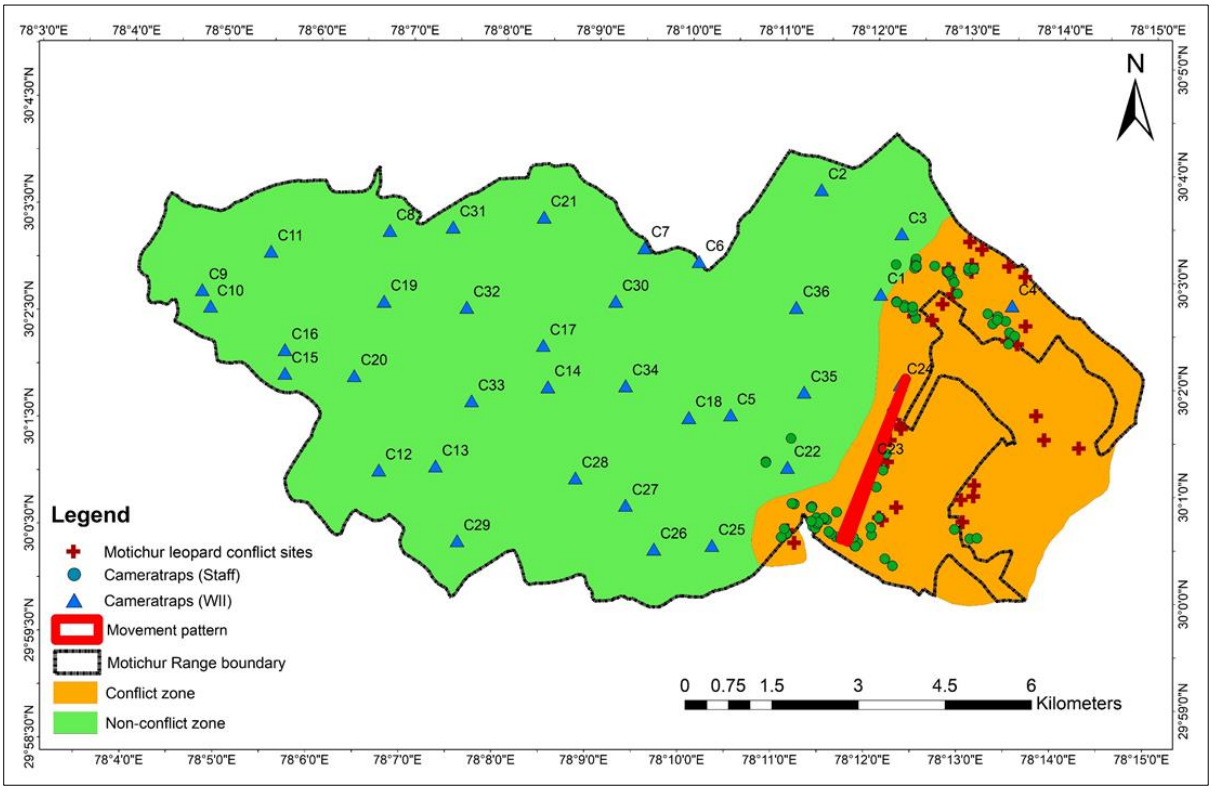


Map 6.10 Movement pattern of L11

Female L11, was also seen traversing the entire conflict zone (Map 6.10), while Female L12 was only present in the southern part of the conflict zone (Map 6.11).

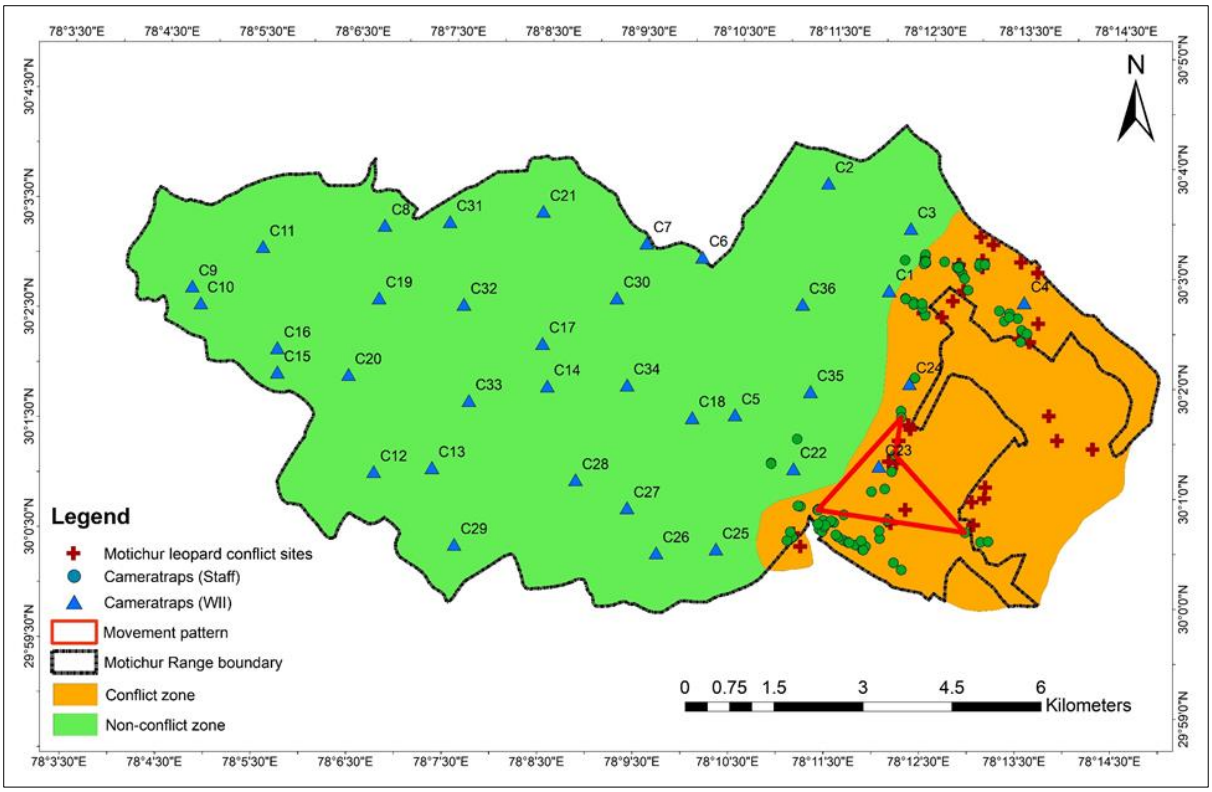


Map 6.11 Movement pattern of L12.



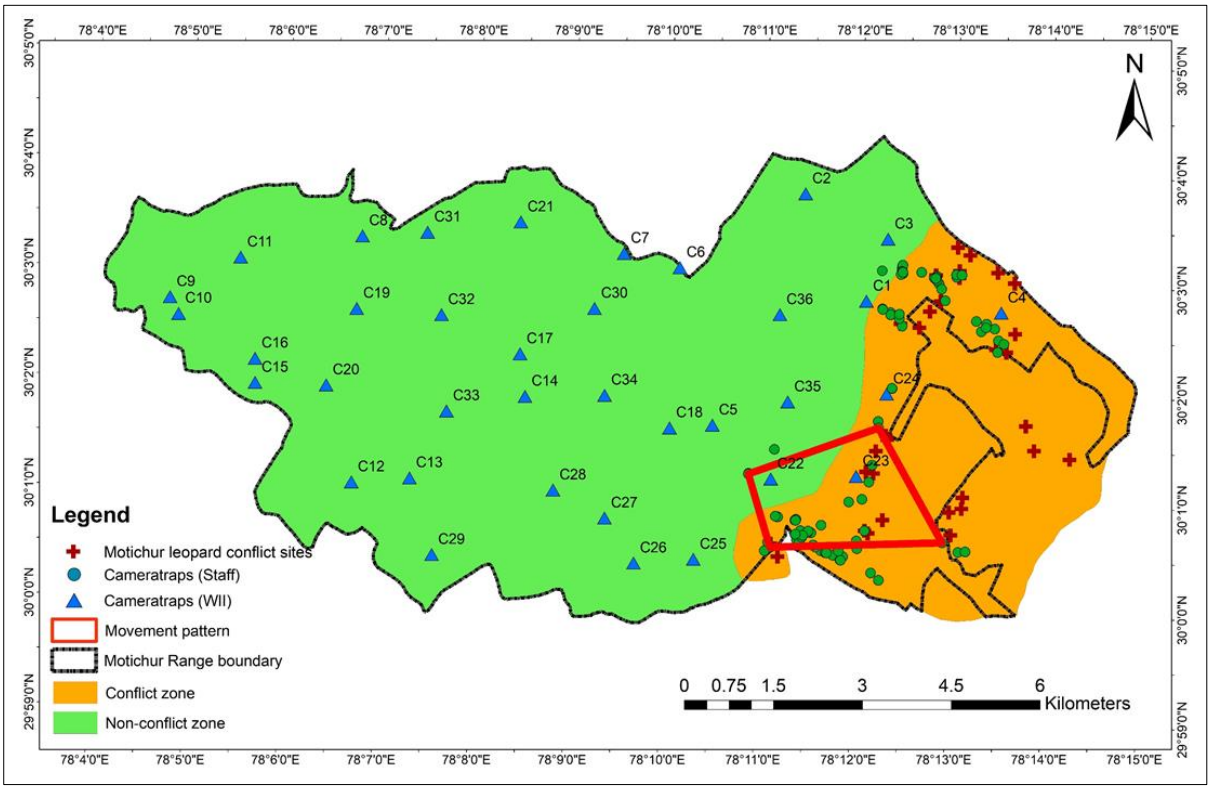
Map 6.12 Movement pattern of L13

The last 2 animals common throughout the 3 seasons were also females, L13 & L15, but had highly restricted movements in the south of the conflict zone (Map 6.12 & Map 6.13).



Map 6.13 Movement pattern of L15

Another female L16, only had relatively seasonal movement (Map 6.14).



Map 6.14 Movement pattern of L16.

7 DISCUSSION

7.1 Summary

Almost all incidents occurred within 500 metre distances from the settlements and roads other than NH 58. While the distances from other two characteristic, NH 58 and railway line vary to a maximum of 3 kilometers. In comparison even though the patrolling on foot is common in the interior forests, no attack ever happened there. The highway and the settlements were the key spatial characteristic driving the conflict, as evident in spatial hotspot analysis (Map 6.3).

Temporal factor was another key factor i.e. the time and season of attack. While maximum daylight attacks happened in summer season, in general the night and crepuscular hours, taken together accounted to about 71% of the attacks. It is highly probable that leopards were more active in summer because of highly localized water availability during daytime, while low lighting conditions were the usual ideal time for a nocturnal predator to be active and about moving. The latter case was apparent in the activity classification which was nocturnal for conflict zone leopards for all the three seasons. In comparison, leopards in the non-conflict zone were highly cathemeral i.e. active both during day and night. This indicated high versatility of the leopard, which adapted itself to night movement in the periphery to avoid detection.

Most of the attacks happened in moderate to open vegetation and shrubby areas coupled with moderate moisture content. Attacks happened in places where there is some water content, irrespective of the season.

There is a trend is of increasing deaths from leopard attacks. While many of the initial attacks happened near the highway, either due to lack of awareness or indifference on the part of the trespassing victims, were probably chance encounters between leopards and trespassing people. Due to these encounters, few individuals could have lost their fear and later started seeing human as a prey.

The leopards did not necessarily solely become man-eaters, as no successive attacks ever happened one after the other. Interaction with villagers and records from forest departments showed that a minimum of 9 attacks happened while the victims were performing open defecation. Many other attacks happened in poorly lit situation and while villagers ventured into the forests for firewood and fodder collection. In many places, tall grasses and bushes had gone profusely very close to human habitations where attacks happened.

Although the human-wildlife conflict has existed since times immemorial, but in the 21st century, where wild animals have small and isolated populations with fragmented geographical ranges, solving human-wildlife conflict has more merits for wildlife rather than people because the long-term conservation will not just depend on ecological merits and ethos of science but also on public perception of wild animals. In the following section we list out the most suspected leopards for conflict and potential causes of the conflict in Rajaji tiger reserve.

7.2 Most Suspected Leopards

To list out the most suspected leopards, we constructed our list on 3 factors –

i) Presence throughout the year.
ii) A relatively high RAI as compared to other leopards.
iii) Movement pattern maps across the conflict sites.

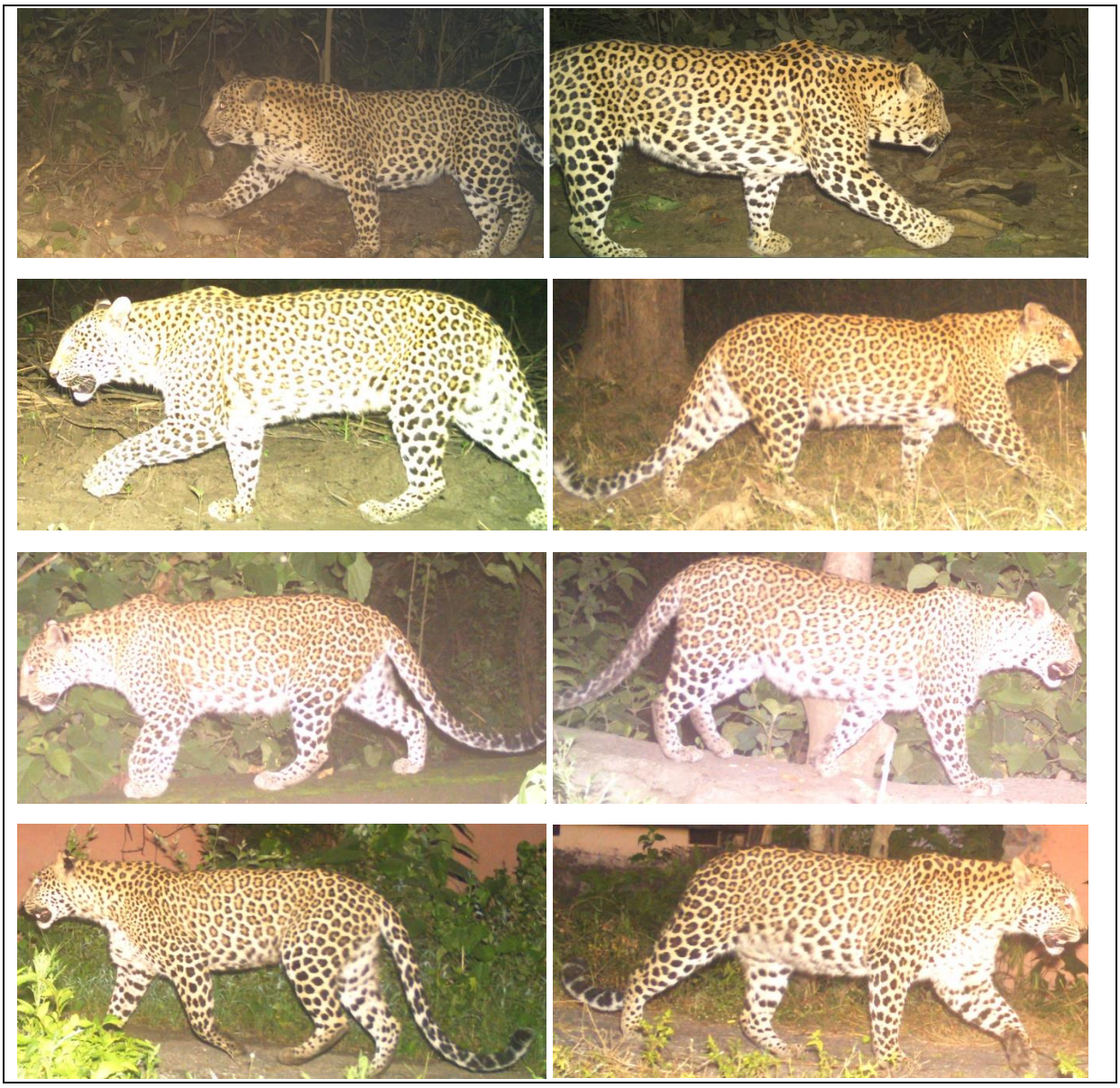
	MALES	**FEMALES**
PRESENCE THROUGHOUT THE YEAR	L1, L3	L10, L13
RAI	L1, L3	L10, L11, L12, L13, L16
MOVEMENT IN THE CONFLICT ZONE	L1	L10, L11, L12, L13, L15

Table 7.1 List of most suspected animals based on 3 criteria

Based on RAI alone, leopards L1 and L10 were the most suspected leopards for attacks, along with L3, L11, L12, L13 and L16. Although L13 was common throughout the three seasons, it had relatively low RAI, and L16 was only present in summers & monsoon, so both were excluded from the suspect list. We were left only with L1, L3, L10, L11, L12 and L15 based on RAI.

We further made ranging patterns maps of the most suspected leopards in order to visualize their movement of leopards in the conflict zone. Our suspects were L1, L3, L10, L11, L12, and L15. Based on movement patterns,

we ruled out L3 and L15. L3 had very limited to almost no movement in the conflict zone. While L15, though widely covering the conflict sites, had a relative seasonal movement and was absent throughout the monsoon and winters. Hence, we considered L1, L10, L11 and L12 to be likely involved in conflict cases, based on movement patterns (Fig 7.1).



Left flank	Right flank

Fig. 7.1 Left and right flanks of the most suspected leopards (top to bottom ⟶ L1, L10, L11 and L12)

7.3 Causes of Human-Leopard conflict

7.3a. Ecological Causes

Trophic Cascade – Interspecific killing has been recorded, and appears to be common in communities of mammalian carnivores of North America, Africa, and Europe, and may account for up to 68% of known mortalities in some species (Palomares & Caro, 1999). Currently there are only two tigresses in the western Rajaji tiger reserve. Tigers frequently kill leopards to reduce competition (Johnsingh 1992). Besides historical presence of dhole (*Cuon alpinus*) in Dholkhand and Malowala forests in 1967 (Joshi and Kumar 1970), there are only occasional occurrences of sloth bears and hyenas. Absence of other co-predators results in dramatically increased populations of a single species. Absence of other large carnivores on same or higher trophic level may be one of

the reasons for such a high leopard count and density, which increases the probability of human-leopard encounter with more young and old animals being pushed to the peripheral forests.

Dominance Hierarchy – Motichur range is connected to Barkot forests through a corridor in the north, and to Haridwar and Kansrao ranges to the west. It also linked to the eastern Rajaji through narrow corridors. As a result, it is a hotspot for all kinds of migratory and dispersing mammals from almost all directions especially long ranging animals, such as leopards, resulting in very high density. In such scenarios the dispersing younger and older animals are pushed out by more dominant animals inside the reserve towards the periphery of the forests. These animals often search more easy prey like feral dogs and cattle. Though a leopard would generally avoid people, but a chance encounter can go wrong.

7.3b. Anthropological Causes

Open defecation, fuel wood collection and or a leisurely venture into an area with resident large predator population can and often does leads to human-wildlife conflict. A more dangerous situation would be to do these activities during night-time hours. Selling and consuming alcohol is restricted in both cities of Haridwar and Rishikesh. Khandraiwala (between the two cities and present on NH-58), is the only venue which has a liquor shop. Humans under the influence of, or to consume alcohol, venture into the forest, where predators might attack such easy prey.

A general apathy for signages and warning messages of "prohibition of entry into the forest" has become one of the major causes of human fatalities. Some of the victims were outsiders who ventured into the forest just for leisure or for defecation. Another cause is improper disposal of garbage, which might directly attract leopards or leopard prey which may attract a leopard and their prey.

The only genuine cases where the wild animals could be considered partly at fault was observed in incidences where dense undergrowth had grown profusely near a human-habitations which provides cover for the felid, perhaps looking for dog or cattle. Often the victims in such type of cases are young children.

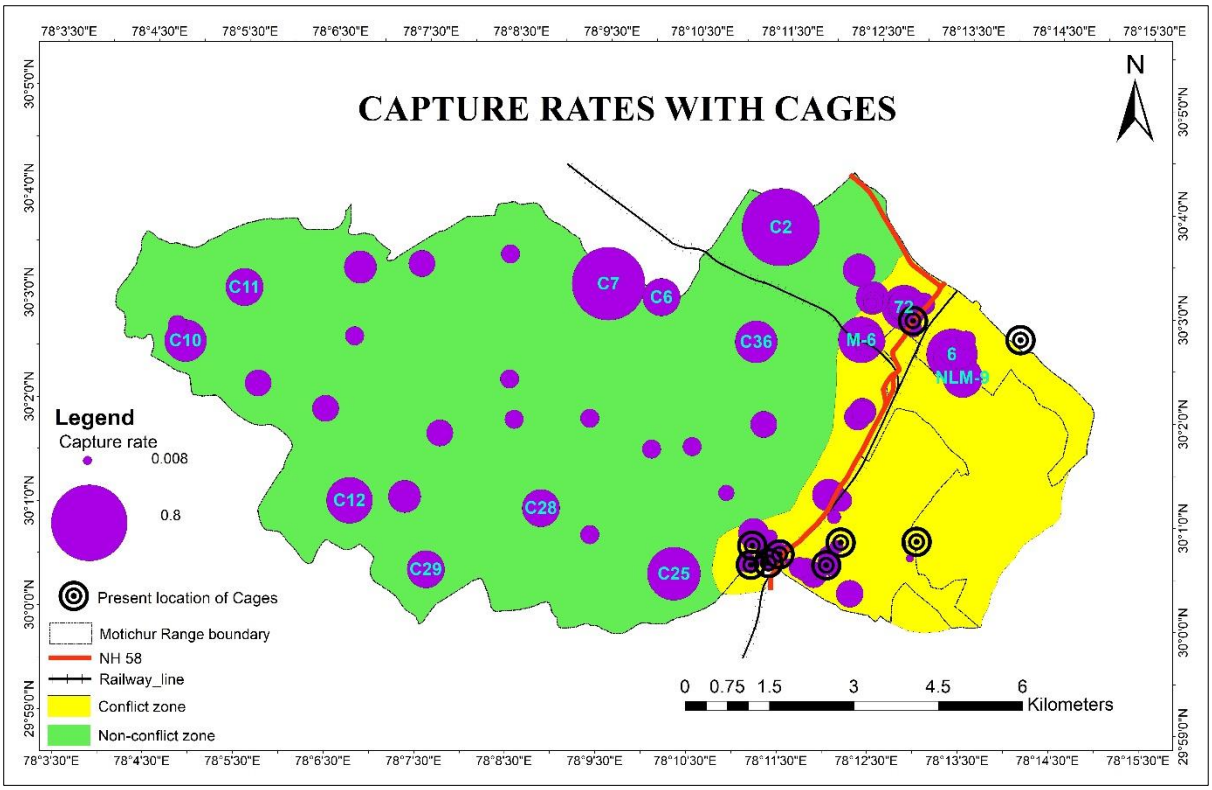
7.4 Recommendations

We list the following recommendations, for effectively dealing with human-wildlife conflict ergo human leopard conflict in Motichur range of Rajaji Tiger Reserve

7.4a. Short-Term Recommendations

1) Translocation – We do not recommend translocation as translocated leopards generally do not stay at the release sites, and translocation induces more attacks on people. Leopards either return to the trap site or show extensive roaming behaviour after release, which apparently can be a consequence of being released into an area already occupied by territorial conspecifics. Translocation increases aggression induced by stress of the translocation process, movement through unfamiliar human-dominated landscapes following release, and loss of fear of humans due to familiarity with humans acquired during captivity (Weilenmann *et al.* 2010; & Athreya *et al.* 2011). Moreover, out of 11 leopards removed 9 leopards have already been translocated to other areas from Motichur range since 2014 but it did not seem to have an effect, moreover conflict has increased successively during the years.

2) Research and monitoring – Radio collaring of resident leopards is more effective tool in monitoring leopard movement, can indicate which areas are to be focused first as for a site-specific management strategy indicated by individual leopard movement. A similar strategy could be employed with the camera trap data by deployment of strategies that would deter leopard movement in highly sensitive areas. Baited cages can be set in accordance pixelated density map (Map 6.6), individual capture rate of leopards for winters at each camera station (Map 6.4), and gross capture rate of leopards for winters at each camera station (Map 6.5). For e.g. map 7.1 shows Gross Capture rate of leopards at each camera station with location of baited cages by forest department, cages can be adjusted to areas with more leopard movement.



Map 7.1 Gross Capture rate of leopards for winters at each camera station with location of baited cages.

3) Rigorous Patrolling – Since most of the incidents occurred alongside NH 58, a regular patrolling team should monitor the highway, especially during the night, with jurisdiction to fine and prosecute any trespassers or offenders, would circumvent any further events of conflict alongside the national highway, especially in areas with moderate to open forest with perennial water sources.

4) Construction of Hedges – Construction of hedges alongside national highway that would discourage or prevent any trespassers to enter the forest. Along with cyclic pruning of ground vegetation that could offer cover to any predator, interior to the hedges.

7.4b. Long-Term Recommendations

5) Eco-development communities or EDCs – Dissemination of knowledge and awareness, and creating a general acceptance about the risks of living alongside large predators, with local communities would go a long way in solving current as well as future scenarios of human-wildlife conflict.

6) Garbage and refusal disposal – Proper disposal of food or refusal that would attract wildlife near human habitation would lessen the activity of wildlife near human habitations.

7) Continued Research – Extension of research activities in surrounding Haridwar and Barkot forests, such as camera trapping, and prey base estimation that would create a more all-inclusive comprehension about dynamics of leopard behavior and dispersal patterns.

8) Establishment of connectivity – Establishment and maintenance of connectivity to the forests of Haridwar, Barkot and Eastern Rajaji, along development of suitable prey base in the surrounding forest divisions would alleviate existing pressure on resources in the western Rajaji, arising from dispersing animals from surrounding forests.

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4 APPENDIX

4.1 "Quality of Life" questionnaire

Quality of life attribute Survey of People in the Eco-Sensitive Zone of Rajaji National Park, Uttarakhand

Date: _____ **Name of the Interviewer:** _____
Time: _____
Name of the Village: _____
Questionnaire Number: _____

Part 1- Demographic Status

S.NO	Name of the family members(Specify respondent/head in brackets)	Age	Gender	Marital Status	Education Status	Occupation

2. What is your relationship with head of the family?

3. What mode of transportation is being used?
(a) Car
(b) Motorbike
(c) None
(d) Other (Specify) ……..

4. Mode of communication you have access to:
(a) T.V.
(b) Radio
(c) Land phones
(d) Computer

5. Religion and Caste……

Part 2- Household Characteristics

1. **What type of house do you have?**
   - **(a)** Pucca ☐
   - **(b)** Kutcha ☐
   - **(c)** Wood/Bamboo ☐
2. **What is the main source of drinking water?**
   - **(a)** Tap Water ☐
   - **(b)** Tube well / borehole ☐
   - **(c)** River/Canal ☐
   - **(d)** Tank/pond/lake ☐
   - **(e)** Other Specify ……..
3. **How long does it take to collect the water?**
   - **(a)** Home Supply ☐
   - **(b)** 0-5 minutes' walk ☐
   - **(c)** 5- 10 minutes' walk ☐
   - **(d)** 10-15 minutes' walk ☐

4. **What type of fuel do you use for cooking purpose?**
   - **(a)** LPG ☐
   - **(b)** Firewood ☐
   - **(c)** Kerosene ☐
   - **(d)** Biogas ☐
   - **(e)** Other Specify……..
5. **Do you have facility of toilets?**
   - **(a)** Yes
   - **(b)** No
6. **Please mark the 3 major sources of income (from 1 to 3, where 1 most important and 3 is least important) and specify the income generate from these sources.**

Source of Income	Per month	Per year
Govt. Job		
Pvt. Job		
Farming land		
Livestock		
Forest Resources/NTFP		
Other Specify ( )		

Part 3- Origin and Migration

1. **Ethnicity**
   - **(a)** Gujjar ☐
   - **(b)** Gothia ☐
   - **(c)** Taungya ☐
   - **(d)** None ☐
   - **(e)** Other Specify……
2. **How long do you lived here?**
   - **(a)** First Generation
   - **(b)** Second Generation
   - **(c)** More than 2 generation
3. **Do you people migrate from Rajaji?**
   - **(a)** Yes ☐
   - **(b)** No ☐
4. **If yes, in which season you people migrate?**
   - **(a)** Summer ☐
   - **(b)** Winters ☐
   - **(c)** Rainy ☐
5. **What is the purpose behind migration and for how long do you stay at different place?**

Part- 4: Dependency on Forest Resources/Utilization of forest Resources

1. **How far is the forest from your house?**
   - **(a)** 0- 3 km away ☐
   - **(b)** 3-5 km away ☐
   - **(c)** More than 5 km ☐
2. **Is forest land/Forest resources is/are useful for your livelihood or for income generation?**
   - **(a)** Very useful ☐
   - **(b)** Slightly useful ☐
   - **(c)** Less Useful ☐
   - **(d)** No useful ☐
3. **What do you use the forest for?**
   - **(a)** Collection of fruits ☐
   - **(b)** Collection of medicinal and aromatic herbs and plants ☐
   - **(c)** Grazing of livestock on pasture of forest ☐
   - **(d)** Growing Crops of forestry lands ☐
   - **(e)** Collection of fuel and dry wood ☐
   - **(f)** Other Use (Specify)……..
4. **Do you know what natural resources your forest has?**
   - **(a)** I don't know ☐
   - **(b)** I know very well ☐
   - **(c)** I know about some resources
5. **Please mark (✔) the natural resources used by the villagers.**

Natural Resources	Mark (✔)
Fruits	

Vegetables	
Honey	
Wax	
Nut	
Gum	
Leaves/Roots/bulbs	
Medicinal Plants	
Grass	
Use of bark (dye/ ropes/hunting nets)	
Other Specify	

6. Do you use forest wood/ grass for the construction purposes? If yes, mark the given option below.

Construction wood/ grass	**Mark (✔)**
Hut wall/roof	
Doors	
Windows	
Household Furniture	
Cattle hut	
Pots for animal feed	
Pots for water storing	
Stools	
Woven mats	
Baskets	
Other Specify	

7. Do you use tree for ritual or festival purpose? If yes, specify the ritual or festival.

8. Do you use forest resources/land for commercial purposes or for your own consumption?

(a) Yes ☐

(b) No ☐

9. Do you pay for forest resources?

(a) Yes

(b) No

10. If yes, how much do you pay for forest resources and for what resources do you pay?

11. To whom you pay the amount money?

(a) To the forest department people

(b) To the mediators

(c) Other (Specify)

12. **Do you know about NTFPs?**

(a) Yes ☐

(b) No ☐

13. What type of NTFPs your forest has? Are they useful for your livelihood?

Part 5- People attitude towards management/ Conservation

1. Do you know about laws or rules regulated for forest management?

(a) Yes ☐

(b) No ☐

(c) Some ☐

2. Do you think these rules examine the villagers or community interest?

(a) Yes ☐

(b) No ☐

(c) Some ☐

3. Do you know about programs or strategies adopted by forest department for forest management?

(a) Yes ☐

(b) No ☐

(c) Some (Specify)……

4. Do you play any role in these kind of management/ conservation programs?

(a) Yes ☐

(b) No ☐

(c) Some (Specify)……

5. Would you like to participate in management/conservations programs?

(a) Yes ☐

(b) No ☐

(c) Not sure ☐

6. If yes, in which plans would you like to participate (Specify 2)?

(a) Improvement of forest resources ☐

(b) Maintenance of forests ☐

(c) Conservation of species ☐
(d) Eco-tourism ☐
(e) None ☐

7. Do you know about eco-tourism?

(a) Yes ☐
(b) No ☐

8. Do you find eco-tourism beneficial for your livelihood?

(a) Yes ☐
(b) No ☐

9. If yes, how much you earn from eco-tourism (Per year)?

Part -8: Agriculture

1. Do you have agriculture land?
- **(a)** Yes ☐
- **(b)** No ☐

2. If yes, is it irrigated?
- **(a)** Yes ☐
- **(b)** No ☐

3. What kind of irrigation system do you have?
- **(a)** Open well ☐
- **(b)** River/Stream ☐
- **(c)** Bore hole ☐
- **(d)** Other (Specify) ☐

4. How many crops do you cultivated in your land and specify their names?
- **(a)** 0 ☐
- **(b)** 1 ☐
- **(c)** 2 ☐
- **(d)** More than 2 ☐

5. What kind of land is it?
- **(a)** Leased land ☐
- **(b)** Owned ☐
- **(c)** Leased and Owned ☐

6. Where is your agricultural land located?
- **(a)** Near house ☐
- **(b)** Near to the forest ☐
- **(c)** In other village ☐

7. Do women work in agriculture land?
- **(a)** Yes ☐
- **(b)** No ☐

8. Do you have any conflicts with other people for the land?
- **(a)** Yes ☐
- **(b)** No ☐

9. How much you earn from agriculture (per year)?

Part-9: Livestock

1. Do you own livestock?
- **(a)** Yes ☐
- **(b)** No ☐

2. How many livestock do you have? (Specify in numbers)
- **(a)** Cattle ☐
- **(b)** Buffalo ☐
- **(c)** Sheep ☐
- **(d)** Goat ☐
- **(e)** Poultry ☐
- **(f)** Other (Specify)

3. What is the purpose behind owing livestock?
- **(a)** Milk ☐
- **(b)** Agriculture ☐
- **(c)** Source of income ☐
- **(d)** Personal Consumptions ☐

4. Do you lose livestock due to carnivore attack (Specify Number)?
- **(a)** Yes ☐
- **(b)** No ☐

5. Is livestock important for your income generation and how much you earn from livestock (per year)?

6. Are you satisfied with the current living condition inside the forest?

(a) Satisfied ☐

(b) Less Satisfied ☐
(c) Not Satisfied ☐

7. What changes do you desire to improve your well-being?

4.2 “Human-Wildlife Conflict” questionnaire

Questionnaire Survey
Household Surveys for Human and Wildlife Conflict.

Date: **Time:**
Name of the interviewer:
Name of the village:
Questionnaire Number:

SECTION-1 INTERVIEWER ASSESSMENT

1.1 Information about the interviewee and member of his/her household?

Name of the other members	Head of the house	Gender	Age	Marital status	Education	Religion Caste	Occupation

1.2 What is the source of livelihood?

(a) Service (government/private) (b) Agriculture
(c) Livestock farming (d) Daily wages
(e) Hotel/ Tourism (f) Other

SECTION- 2 TRANSPORT AND COMMUNICATION

2.1 What mode of transportation is being used by the interviewee?

(a) Cycle (b) Two wheeler
(c) None (d) Others (specify)

2.2 Modes of communication you have access to:

(a) T.V. (b) Radio
(c) Mobiles (d) Land phones
(e) Computer

SECTION – 3 HOUSEHOLD CHARACTERISTICS

3.1 What type of house do you live in?

(a) Pucca. (b) Semi-pucca.
(c) Kutcha. (d) Bamboo/wood.

3.2 What type of roof does it have?

(a) Thatch (b) Tinned/cement sheets
(c) Mud baked tiles (d) Concrete

3.3 How many generation of your family have lived here?

(a) First generation (b) Second generation
(b) Other

3.4 What is the origin of your family?

(a) Himachali (b) Garhwal

(b) Kumaoni (d) Nepal

3.5 Do you have electricity connection?

(a) Yes (b) No

3.6 Which is the primary source of fuel do you use for cooking purpose?

(a) LPG gas (b) Kerosene
(c) Bio-gas (d) Fuel wood
(e) All the above.

3.7 What is the primary source of water in your house?

(a) Tap (b) Stream/river
(c) Bore well (d) Open well
(e) Other (specify).....

3.8 How far do you go to fetch water?

(a) Home supply (b) 0-5 minute walk
(c) >5-15 minute walk (d) >15 minute walk

SECTION-4 AGRICULTURE

4.1 Do you own any Agricultural land?

(a) Yes (b) No

4.2 How much agricultural land do you own?

4.3 What type of crops do you owe?

(a) Jute (b) Rice
(c) Wheat (d) Pulses
(e) Other type (f) All the above

4.4 Do you have irrigation facility available for agriculture?

(a) Yes (b) No

4.5 What type of irrigation facility you use for agriculture?

(a) River (b) Bore Well
(b) Open well (d) Other type

4.6 What is the main purpose of doing agricultural practice?

(a) Commercial (b) Personal utility.

4.7 How many types of crops do you get from your land per year?

(a) 1 (b) 2
(c) 3 (d) Or More

SECTION-5 LIVESTOCK

5.1 Do you own livestock?

(a) Yes (b) No

5.2 What is the major purpose for keeping the livestock?

(a) Agriculture (b) Commercial
(c) Meat (d) Dairy

(e) Personal Consumption (f) All of the above

5.3 What kind of livestock do you own?

(a) Sheep (b) Buffalo
(c) Goats (d) Cattle
(e) Poultry (f) All of the above.

5.4 What is the major cause of livestock death?

(a) Carnivore attack
(b) Dieasese

5.5 How much livestock do you lose per year due to carnivore attack?

SECTION-6 HUMAN-WILDLIFE CONFLICT

6.1 What type of animal conflict occur the most in your village?

(a) Leopard (b) Tiger
(c) Elephant (d) Other

6.2 How many killing has occurred so far by conflict in the past years in your village? Any report.

(a) 6 (b) 10
(c) 12 (d) More then 12.

6.3 Who is more often attacked by the carnivore?

(a) Male (b) Female
(c) Children (d) Elder

6.4 During which season carnivore attack is high?

(a) Summer (b) Winter
(c) Monsoon (d) Springs

6.5 Which type of livestock is mostly attacked?

(a). Sheep (b) Buffalo
(c) Goat (d) Cattle
(e) Poultry

6.6 Did government compensate any kind of loss through conflict in your village or households?

(a) Yes (b) No

6.7 If yes, then how much amount of compensation did you get (In rupees)?

6.8 How do you prevent the carnivore or the animal from attacking?

6.9 Do you practice some forms of rituals to ward off animal attacks? If yes how?

(a) Yes (b) No

SECTION- 7 LEOPARD CONFLICT

7.1 Have leopard conflict incidents increased in the 10 years?

(a) Increased (b) Decreased

7.2 Which month/s or season/s is the leopard conflict at its peak?

(a) Monsoon (b) Spring

(b) Summer (d) Winter

7.3 Any recent or past records or cases of incidents of leopard attack in your village or household? If yes sp

(a) Yes (b) No

Name of the victim	Name of the village	Injury Type	Time of the incident	Year of the incident	GPS Location

7.4 According to you what would be the two top most reasons for increase or decrease of leopard conflict leading to livestock predation in your village

Causes of livestock	**Livestock predation**
1. Availability of suitable leopard habitat	
2. Availability of wild prey	
3. Increase in human population/settlement	
4. Increase in livestock population	
5. Increase in stray dogs	
6. Increase in the lantana growth	
7. Frequent visits to the forest area by the local	
8. Decrease in the forest/ or fragmentation	

7.5 Do you think conversion of forest areas into scrublands has intensified leopard attacks? If yes then why? If no then why?

7.6 Does government compensate any kind of loss through leopard conflict? If yes How?
7.7 How do you prevent the leopard from attacking you or your household?

SECTION – 8 CROP RAIDING

8.1 Have crop raiding incidents increased in the 10 years?

(a) Increased (b) Decreased

8.2During which month or season does the crop raiding occurs?

(a) Monsoon (b) Spring

(c) Summer (d) Winter

8.3 During which time does the crop raiding incident occur?

(a) Afternoon (b) Sunset

(c) Evening (d) Dawn

8.4. Which type of crops is often seen under attacked or consumed frequently by the large mammal?

(a) Rice (b) Pulses

(c) Jute (d) Wheat

(e) Sugarcane (e) Others

8.5 Any recent incidents of crop raiding in your village or household? If yes specify

(a) Yes (b) No

Year	Name of the village	No of farms raided	Total area of the farms raided	Distance of the farm from park	No of times raided

8.6 Does government compensate the loss due to destroyed crop? If yes How?

(a) Yes (b) No

8.7 How do you prevent the mammals from attacking the fields?

8.8 According to you what would be the top most reasons for increasing and decreasing of the crop raiding incident in your village?

Causes of crop raiding	**Crop raiding**
1. Availability of the suitable habitat	
2. Easy access to the Field	
3. Increase in Human Population/settlement	
4. Increase in the farm lands/fields	
5. Decreasing the forest cover	
6. Decline quality and nutritive value of the natural forage	
7. Types of crops	

SECTION- 9 LOCALS PERCEPTION TOWARD WILDLIFE

9.1 What should be done with the carnivore after the conflict?

(a) Kill (b) Relocate

9.2 Do you think people are the main reason behind the increase of the animal conflict?

(a) Yes (b) No

.

9.3 According to you what is the role of leopard or tiger or elephant in the wild?

(a) To control prey abundance / to keep the ecological balance
(b) To destroy, subdue or eat other animals
(c) To destroy forests and damage agriculture/ food resources/ human habitation
(d) Other (specify)
(e) None
(f) Don't know.

9.4 Do you consume wild meat? If yes, then what is the source?

(a) Yes (b) No

9.5 What could be the top 3 solutions to reduce leopard incident in your area?
solutions leopard incident?

Solutions	Leopard incident Human death/human injury	Leopard incident Livestock depredation	Remarks
Increased education and awareness			
Better designed animal shelters			
Decrease human dependence on forests			
Reduce forest entry at night			
Speedier and appropriate compensation measures			
Better media reporting			
Better quality forest habitat for leopards			
Increased prey availability for leopards			

4.3 “Human-leopard conflict” assessment - Bivariate correlation

	Other Roads	*Nh 58*	*Railway Line*	*Settlements*	*Mean NDVI (Mar)*	*Mean NDVI (Oct)*	*Mean NDWI (Mar)*	*Mean NDWI (Oct)*	*Slope*	*Elevation*
Other Roads		4870	4226	1784.4	5785.3	4255.9	5950.1	4332.8	4375.6	4693.6
Nh 58	4870		872	6133.9	2212.9	4024.9	1931.7	3465.5	5999.6	9049.8
Railway Line	4226	872		5412.7	3002.2	4896	2707.8	4392.8	6399.9	4392.8
Settlements	1784.4	6133.9	5412.7		6723	4899.6	7115.9	5241.2	3889.1	4001
Mean NDVI (Mar)	5785.3	2212.9	3002.2	6723		3879.5	127.56	3565.5	4923.5	7132.9
Mean NDVI (Oct)	4255.9	4024.9	4896	4899.6	3879.5		3828.8	55.037	1.3632	0.11899
Mean NDWI (Mar)	5950.1	1931.7	2707.8	7115.9	127.56	3828.8		3403.4	4984	7300
Mean NDWI (Oct)	4332.8	3465.5	4392.8	5241.2	3565.5	55.037	3403.4		1.256	0.27939
Slope	4375.6	5999.6	6399.9	3889.1	4923.5	1.3632	4984	1.2562		2.676
Elevation	4693.6	9049.8	4392.8	4001	7132.9	- 0.11899	7300	-0.2794	2.676	

Table 4.1 S and T values for bivariate correlation (S = Blue colour, t = Red colour).

	OTHER ROADS	NH 58	RAILWAY LINE	SETTLEMENTS	MEAN NDVI (MAR)	MEAN NDVI (OCT)	MEAN NDWI (MAR)	MEAN NDWI (OCT)	SLOPE	ELEVATION
OTHER ROADS		0.9232	0.4253	0.0001	0.3710	0.4462	0.2816	0.4979	0.5279	0.7742
NH 58	0.9232		1.211e-08	0.1999	0.0012	0.3098	0.0003	0.0995	0.2578	1.179e-08
RAILWAY LINE	0.4253	1.211e-08		0.6254	0.0280	0.9451	0.0103	0.5402	0.1131	8.768e-10
SETTLEMENTS	0.0001	0.1999	0.6254		0.0497	0.9482	0.0145	0.7619	0.2434	0.2974
MEAN NDVI (MAR)	0.3710	0.0012	0.0280	0.0497		0.2391	< 2.2e-16	0.1255	0.9686	0.0137
MEAN NDVI (OCT)	0.4462	0.3098	0.9451	0.9482	0.2391		0.2172	< 2.2e-16	0.1833	0.9061
MEAN NDWI (MAR)	0.2816	0.0003	0.0103	0.0145	< 2.2e-16	0.2172		0.0855	0.9794	0.0073
MEAN NDWI (OCT)	0.4979	0.0995	0.5402	0.7619	0.1255	< 2.2e-16	0.0855		0.2191	0.7819
SLOPE	0.5279	0.2578	0.1131	0.2434	0.9686	0.1833	0.9794	0.2191		0.0121
ELEVATION	0.7742	1.179e-08	8.768e-10	0.2974	0.0137	0.9061	0.0073	0.7819	0.0121	

Table 4.2 P values for the bivariate correlation (p values ≤ 0.05 shown in blue colour).

	OTHER ROADS	NH 58	RAILWAY LINE	SETTLEMENTS	MEAN NDVI (MAR)	MEAN NDVI (OCT)	MEAN NDWI (MAR)	MEAN NDWI (OCT)	SLOPE	ELEVATION
OTHER ROADS		*0.018*	*0.148*	*0.640*	*-0.166*	*0.142*	*-0.200*	*0.126*	*0.118*	*0.054*
NH 58	*0.018*		*0.824*	*-0.237*	*0.554*	*0.188*	*0.610*	*0.301*	*-0.210*	*-0.824*
RAILWAY LINE	*0.148*	*0.824*		*-0.091*	*0.395*	*0.013*	*0.454*	*0.114*	*-0.290*	*-0.855*
SETTLEMENTS	*0.640*	*-0.237*	*-0.091*		*-0.355*	*0.012*	*-0.435*	*-0.057*	*0.216*	*0.193*
MEAN NDVI (MAR)	*-0.166*	*0.554*	*0.395*	*-0.355*		*0.218*	*0.974*	*0.281*	*0.007*	*-0.438*
MEAN NDVI (OCT)	*0.142*	*0.188*	*0.013*	*0.012*	*0.218*		*0.229*	0.995	0.245	-0.022
MEAN NDWI (MAR)	*-0.200*	*0.610*	*0.454*	*-0.435*	*0.974*	*0.229*		*0.314*	*-0.005*	*-0.472*
MEAN NDWI (OCT)	*0.126*	*0.301*	*0.114*	*-0.057*	*0.281*	0.995	*0.314*		0.227	0.052
SLOPE	*0.118*	*-0.210*	*-0.290*	*0.216*	*0.007*	0.245	*-0.005*	0.227		0.445
ELEVATION	*0.054*	*-0.824*	*-0.855*	*0.193*	*-0.438*	-0.022	*-0.472*	0.052	0.445	

Table 4.3 Correlation values (rounded off to 3 decimal places) for the bivariate correlation (Rho values in italics, cor. Values non-italics) (Strong correlation (±0.5 – ±1) = in red colour,Moderate correlation (±0.2 – ±0.5) = in blue colour,Weak correlation in black colour (0 - ±0.2) = in black colour).

S. No.	Gender	Animal I.D.	Right	Left	Total	Days	RAI
			Both flanks				
1	Male	L1	18	29	47	122	0.385245902
2	Male	L3	2	4	6	122	0.049180328
3	Male	L5	2	3	5	122	0.385245902
	Male	**Total**	22	36	58	122	0.475409836
4	Female	L10	3	3	6	122	0.049180328
5	Female	L16	1	1	2	122	0.008196721
6	Female	L13	0	1	1	122	0.016393443
7	Female	L19	0	1	1	122	0.008196721
	Female	**Total**	4	6	10	122	0.081967213
			Single flank				
8	Female	L31 (F) (S.F.)	1			122	0.008196721
9	Female	L43 (F) (S.F.)	1			122	0.008196721
	Total	**B.F.**	26	42	68	122	0.557377049
	Total	**S.F.**	2			122	0.016393443
	Total	**B.F. + S.F.**	72			122	0.590163934

Table 4.4 RAI in non-conflict zone - Summer 2018

S. No.	Gender	Animal I.D.	Right	Left	Total	Days	RAI
			Both flanks				
1	Male	L1	77	83	160	122	1.3114754
2	Male	L2	0	1	1	122	0.0081967
3	Male	L3	1	0	1	122	0.0081967
	Male	**Total**	78	84	162	122	1.3278689
5	Female	L10	55	48	103	122	0.8442623
6	Female	L11	8	5	13	122	0.1065574
7	Female	L12	15	8	23	122	0.1885246
8	Female	L13	3	1	4	122	0.0327869
9	Female	L16	6	7	13	122	0.1065574
	Female	**Total**	87	69	156	122	1.2786885
			Single flank				
10	Female	L32	1			122	0.008196721
11	Female	L33	1			122	0.008196721
12	Female	L43	1			122	0.008196721
13	Female	L53	1			122	0.008196721
14	Female	L54	1			122	0.008196721
	Total	**B.F.**	165	153	318	122	2.6065574
	Total	**S.F.**	5			122	0.0409836
	Total	**B.F. + S.F.**	323			122	2.647541

Table 4.5 RAI in conflict zone - Monsoon 2018.

S. No.	Gender	Animal I.D.	Right	Left	Total	Days	RAI
			Both flanks				
1	Male	L1	98	62	160	122	1.333333
2	Male	L2	1	0	1	122	0.008333
3	Male	L3	0	1	1	122	0.008333
4	Male	L4	3	5	8	122	0.066666667
	Male	**Total**	104	66	162	122	1.35
4	Female	L1	79	50	129	120	1.075
5	Female	L2	1	0	1	120	0.008333
6	Female	L12	13	1	14	120	0.116667
7	Female	L14	5	1	6	120	0.05
8	Female	L15	2	1	3	120	0.025
9	Female	L44	5	2	7	120	0.058333
10	Female	L55	10	5	15	120	0.125
	Female	**Total**	115	60	173	120	1.458333333
			Single flank				
11	Female	L34	1			120	0.008333
12	Female	L35	1			120	0.008333
13	Female	L36	1			120	0.008333
14	Female	L37	1			120	0.008333
15	Female	L38	1			120	0.008333
16	Female	L39	1			120	0.008333
17	Female	L40	1			120	0.008333
18	Female	L45	1			120	0.008333
	Total	**B.F.**	219	126	337	120	2.808333333
	Total	**S.F.**	8			120	0.066666667
	Total	**B.F. + S.F.**	345			120	2.875

Table 4.6 RAI in conflict zone – Winters 2018/19

S. No.	Gender	Animal I.D.	Total	Days	RAI
1	Male	L1 (B.F.)	5	21	0.238095238
2	Male	L2 (B.F.)	5	21	0.238095238
3	Male	L4 (B.F.)	2	21	0.095238095
4	Male	L6 (B.F.)	3	21	0.142857143
5	Male	L7 (B.F.)	8	21	0.380952381
6	Male	L8 (B.F.)	2	21	0.095238095
7	Male	L9 (B.F.)	10	42	0.238095238
8	Female	L10 (B.F.)	2	21	0.095238095
9	Female	L17 (B.F.)	1	21	0.047619048
10	Female	L18 (B.F.)	5	21	0.238095238
11	Female	L19 (B.F.)	8	21	0.380952381
12	Female	L20 (B.F.)	2	21	0.095238095
13	Female	L21 (B.F.)	4	21	0.19047619
14	Female	L52 (B.F.)	9	21	0.428571429
15	Female	L22 (B.F.)	5	42	0.119047619
16	Female	L23 (B.F.)	1	21	0.047619048
17	Female	L24 (B.F.)	2	42	0.047619048
18	Female	L25 (B.F.)	1	21	0.047619048
19	Female	L26 (B.F.)	6	42	0.142857143
20	Female	L27 (B.F.)	2	21	0.095238095
21	Female	L28 (B.F.)	1	21	0.047619048
22	Female	L29 (B.F.)	2	21	0.095238095
23	Cub	L45 (B.F.)	3	21	0.142857143
24	Cub	L46 (B.F.)	2	21	0.095238095
25	Cub	L47 (B.F.)	2	21	0.095238095
26	Male	L51 (S.F.)	1 (left only)	21	0.047619048
27	Female	L41 (S.F.)	1 (right only)	21	0.047619048
28	Female	L42 (S.F.)	1 (left only)	21	0.047619048
29	Female	L43 (S.F.)	1 (right only)	21	0.047619048
30	Cub	L48 (S.F.)	1 (left only)	21	0.047619048
31	Cub	L49 (S.F.)	1 (right only)	21	0.047619048
32	Cub	L50 (S.F.)	1 (right only)	21	0.047619048

Table 4.7 RAI in non-conflict zone – Winters 2018/19.

S.No.	Camera I.D.	Lattitude	Longitude	Gross Captures	Individuals Captured	Days	Gross Capture Rate	Individual Capture Rate
1	C01	30° 2'50.30"N	78°12'5.00"E	0	0	21	0	0
2	C02	30° 3'48.18"N	78°11'25.14"E	17	4	21	0.80952381	0.19047619
3	C03	30° 3'24.52"N	78°12'17.70"E	3	2	21	0.142857143	0.095238095
4	C04	30° 2'45.60"N	78°13'30.00"E	1	1	21	0.047619048	0.047619048
5	C05	30° 1'40.52"N	78°10'29.91"E	1	1	21	0.047619048	0.047619048
6	C06	30° 3'6.14"N	78°10'7.12"E	4	1	21	0.19047619	0.047619048
7	C07	30° 3'13.15"N	78° 9'31.87"E	15	5	21	0.714285714	0.238095238
8	C08	30° 3'19.17"N	78° 6'46.95"E	3	2	21	0.142857143	0.095238095
9	C09	30° 2'43.30"N	78° 4'46.74"E	1	1	21	0.047619048	0.047619048
10	C10	30° 2'34.27"N	78° 4'52.41"E	5	1	21	0.238095238	0.047619048
11	C11	30° 3'5.88"N	78° 5'30.60"E	4	2	21	0.19047619	0.095238095
12	C12	30° 1'4.62"N	78° 6'43.68"E	6	1	21	0.285714286	0.047619048
13	C13	30° 1'7.62"N	78° 7'20.20"E	3	1	21	0.142857143	0.047619048
14	C14	30° 1'53.71"N	78° 8'31.57"E	1	1	21	0.047619048	0.047619048
15	C15	30° 1'57.60"N	78° 5'41.55"E	0	0	21	0	0
16	C16	30° 2'10.85"N	78° 5'41.18"E	2	2	21	0.095238095	0.095238095
17	C17	30° 2'16.88"N	78° 8'27.85"E	1	1	21	0.047619048	0.047619048
18	C18	30° 1'38.47"N	78°10'3.05"E	1	1	21	0.047619048	0.047619048
19	C19	30° 2'39.46"N	78° 6'44.36"E	1	1	21	0.047619048	0.047619048
20	C20	30° 1'57.25"N	78° 6'26.31"E	2	1	21	0.095238095	0.047619048
21	C21	30° 3'28.90"N	78° 8'26.35"E	1	1	21	0.047619048	0.047619048
22	C22	30° 1'11.91"N	78°11'7.52"E	0	0	21	0	0
23	C23	30° 1'14.44"N	78°12'1.06"E	3	1	21	0.142857143	0.047619048
24	C24	30° 1'59.85"N	78°12'19.05"E	2	2	21	0.095238095	0.095238095
25	C25	30° 0'26.96"N	78°10'19.96"E	8	2	21	0.380952381	0.095238095
26	C26	30° 0'24.12"N	78° 9'42.48"E	0	0	21	0	0
27	C27	30° 0'48.31"N	78° 9'23.51"E	1	1	21	0.047619048	0.047619048
28	C28	30° 1'2.93"N	78° 8'50.64"E	4	4	21	0.19047619	0.19047619
29	C29	30° 0'26.03"N	78° 7'35.40"E	4	2	21	0.19047619	0.095238095
30	C30	30° 02'42.53"N	78° 09'13.68"E	0	0	21	0	0
31	C31	30° 03'22.05"N	78° 07'27.9"E	2	1	21	0.095238095	0.047619048
32	C32	30° 02'36.8"N	78° 7'37.82"E	0	0	21	0	0
33	C33	30° 01'44.84"N	78° 7'42.63"E	2	2	21	0.095238095	0.095238095
34	C34	30° 01'55.50"N	78° 09'21.80"E	1	0	21	0.047619048	0
35	C35	30° 01'54.23"N	78° 11'17.02"E	2	1	21	0.095238095	0.047619048

36	C36	30° 02'41.77"N	78° 11'10.71"E	5	3	21	0.238095238	0.142857143
37	1	78°12'48.200004"E	30°3'3.700008"N	0	0	120	0	0
38	3	78°12'15.3"E	30°2'45.999996"N	0	0	120	0	0
39	4	78°11'51.100008"E	30°0'33.400008"N	0	0	120	0	0
40	6	78°13'20.600004"E	30°2'37.299984"N	42	3	120	0.35	0.025
41	7	78°11'23.660016"E	30°0'49.569984"N	0	0	120	0	0
42	8	78°12'52.120008"E	30°2'57.829992"N	2	1	120	0.016666667	0.008333333
43	10	78°12'48.499992"E	30°3'4.100004"N	0	0	120	0	0
44	15	78°11'10.899996"E	30°0'51.599988"N	0	0	120	0	0
45	19	78°12'11.099988"E	30°1'20.799984"N	0	0	120	0	0
46	21	78°12'15.199992"E	30°2'46.299984"N	0	0	120	0	0
47	23	78°12'48.200004"E	30°3'3.6"N	0	0	120	0	0
48	24	78°12'48.899988"E	30°3'2.499984"N	11	2	120	0.091666667	0.016666667
49	28	78°12'7.139988"E	30°0'44.780004"N	3	1	120	0.025	0.008333333
50	31	78°11'23.700012"E	30°0'42.000012"N	5	2	120	0.041666667	0.016666667
51	33	78°11'35.130012"E	30°0'36.330012"N	0	0	120	0	0
52	42	78°11'6.45"E	30°0'37.400004"N	0	0	120	0	0
53	49	78°11'36.499992"E	30°0'35.200008"N	0	0	120	0	0
54	51	78°12'50.500008"E	30°3'0.699984"N	2	1	120	0.016666667	0.008333333
55	52	78°11'36.499992"E	30°0'35.200008"N	1	1	120	0.008333333	0.008333333
56	56	78°12'25.819992"E	30°2'43.62"N	16	3	120	0.133333333	0.025
57	58	78°11'35.300004"E	30°0'36.100008"N	0	0	120	0	0
58	60	78°12'14.500008"E	30°1'41.199996"N	0	0	120	0	0
59	62	78°12'27.500004"E	30°3'6.500016"N	6	1	120	0.05	0.008333333
60	63	78°12'26.399988"E	30°3'5.299992"N	2	1	120	0.016666667	0.008333333
61	65	78°11'43.599984"E	30°0'32.199984"N	0	0	120	0	0
62	66	78°11'28.299984"E	30°0'41.4"N	0	0	120	0	0
63	67	78°10'53.330016"E	30°1'14.279988"N	4	3	120	0.033333333	0.025
64	69	78°11'27.800016"E	30°0'40.5"N	0	0	120	0	0
65	72	78°12'48.200004"E	30°3'3.700008"N	32	3	120	0.266666667	0.025
66	73	78°12'14.4"E	30°3'7.099992"N	0	0	120	0	0
67	81	78°11'42.9"E	30°0'32.500008"N	0	0	120	0	0
68	91	78°13'4.71"E	30°3'5.749992"N	2	1	120	0.016666667	0.008333333
69	93	78°12'27"E	30°3'6.900012"N	2	1	120	0.016666667	0.008333333
70	94	78°11'23.300016"E	30°0'49.700016"N	0	0	120	0	0
71	97	78°11'39.810012"E	30°0'47.360016"N	0	0	120	0	0
72	99	78°11'39.900012"E	30°0'33.400008"N	0	0	120	0	0
73	100	78°12'47.199996"E	30°3'3.800016"N	0	0	120	0	0

74	552	78°11'43.000008"E	30°0'32.299992"N	7	4	120	0.058333333	0.033333333
75	07h	78°12'25.970004"E	30°2'41.219988"N	0	0	120	0	0
76	12h	78°12'20.409984"E	30°2'43.239984"N	0	0	120	0	0
77	13h	78°11'23.930016"E	30°0'50.13"N	0	0	120	0	0
78	28a	78°11'9.300012"E	30°1'28.099992"N	0	0	120	0	0
79	62a	78°13'32.099988"E	30°2'28.5"N	0	0	120	0	0
80	67a	78°11'26.400012"E	30°0'38.000016"N	0	0	120	0	0
81	6a	78°12'48.200004"E	30°3'3.700008"N	0	0	120	0	0
82	7a	78°13'14.400012"E	30°2'40.700004"N	0	0	120	0	0
83	93a	78°12'26.899992"E	30°3'6.980004"N	0	0	120	0	0
84	Boly	78°11'52.500012"E	30°0'28.400004"N	11	6	120	0.091666667	0.05
85	Case-1	78°11'4.499988"E	30°0'32.600016"N	0	0	120	0	0
86	Case-4	78°12'27.299988"E	30°3'10.500012"N	0	0	120	0	0
87	Dk11	78°10'53.339988"E	30°1'14.689992"N	0	0	120	0	0
88	Dk111	78°13'10.800012"E	30°0'34.599996"N	0	0	120	0	0
89	Dk11a	78°13'6.200004"E	30°0'34.2"N	0	0	120	0	0
90	Dk41	78°10'53.330016"E	30°1'14.679984"N	0	0	120	0	0
91	Dk410	78°11'7.89"E	30°0'34.620012"N	4	1	120	0.033333333	0.008333333
92	Dk61	78°11'52.199988"E	30°0'28.500012"N	0	0	120	0	0
93	Dk610	78°12'56.099988"E	30°0'39.200004"N	1	1	120	0.008333333	0.008333333
94	Dk71	78°11'12.400008"E	30°0'51.320016"N	0	0	120	0	0
95	Dk81	78°12'14.209992"E	30°1'44.749992"N	0	0	120	0	0
96	Dk810	78°12'11.7"E	30°0'21.800016"N	0	0	120	0	0
97	Dnd-15	78°11'12.040008"E	30°0'51.320016"N	15	2	120	0.125	0.016666667
98	I-14	78°11'23.930016"E	30°0'50.13"N	0	0	120	0	0
99	M-1	78°11'8.000016"E	30°0'34.499988"N	6	2	120	0.05	0.016666667
100	M-10	78°12'48.499992"E	30°3'4.100004"N	19	2	120	0.158333333	0.016666667
101	M-11	78°11'47.600016"E	30°0'30.999996"N	9	5	120	0.075	0.041666667
102	M-12	78°12'22.299984"E	30°2'3.009984"N	12	3	120	0.1	0.025
103	M-13	78°11'26.400012"E	30°0'38.000016"N	6	3	120	0.05	0.025
104	M-14	78°11'33.600012"E	30°0'42.999984"N	1	1	120	0.008333333	0.008333333
105	M-15	78°11'12.040008"E	30°0'51.320016"N	0	0	120	0	0
106	M-2	78°12'48.809988"E	30°3'4.809996"N	18	2	120	0.15	0.016666667
107	M-3	78°12'27.500004"E	30°3'5.799996"N	6	2	120	0.05	0.016666667
108	M-6	78°12'20.310012"E	30°2'44.400012"N	34	5	120	0.283333333	0.041666667
109	M-7	78°12'26.939988"E	30°3'8.750016"N	18	2	120	0.15	0.016666667
110	M-8	78°12'20.400012"E	30°2'43.100016"N	4	2	120	0.033333333	0.016666667
111	M-9	78°11'23.300016"E	30°0'49.700016"N	3	2	120	0.025	0.016666667

112	Nlm-1	78°12'2.199996"E	30°0'39.200004"N	7	2	120	0.058333333	0.016666667
113	Nlm-11	78°12'9.200016"E	30°1'11.499996"N	8	2	120	0.066666667	0.016666667
114	Nlm-12	78°12'22.399992"E	30°2'2.900004"N	8	4	120	0.066666667	0.033333333
115	Nlm-13	78°11'24.500004"E	30°0'39.099996"N	16	3	120	0.133333333	0.025
116	Nlm-14	78°13'20.899992"E	30°2'39.3"N	12	1	120	0.1	0.008333333
117	Nlm-15	78°12'54.500004"E	30°2'51.600012"N	5	2	120	0.041666667	0.016666667
118	Nlm-16	78°13'1.2"E	30°3'5.900004"N	8	2	120	0.066666667	0.016666667
119	Nlm-17	78°13'1.400016"E	30°3'4.5"N	4	2	120	0.033333333	0.016666667
120	Nlm-18	78°13'17.699988"E	30°2'35.099988"N	13	2	120	0.108333333	0.016666667
121	Nlm-2	78°12'5.100012"E	30°1'1.999992"N	3	2	120	0.025	0.016666667
122	Nlm-20	78°13'26.100012"E	30°2'36.700008"N	11	2	120	0.091666667	0.016666667
123	Nlm-28	78°12'27.100008"E	30°3'10.199988"N	8	2	120	0.066666667	0.016666667
124	Nlm-4	78°12'2.7"E	30°0'34.899984"N	9	3	120	0.075	0.025
125	Nlm-5	78°12'16.700004"E	30°0'18"N	12	1	120	0.1	0.008333333
126	Nlm-6	78°11'53.900016"E	30°0'30.399984"N	4	1	120	0.033333333	0.008333333
127	Nlm-9	78°13'28.2"E	30°2'24"N	26	2	120	0.216666667	0.016666667

Table 4.8 Gross capture rate and individual capture rate (Blue = Wii camera traps; and red = forest department camera traps for winters 2018/19).

4.5 “Human-Leopard Conflict” assessment - Density

Area of habitat pixel: **0.25 km^2**

Model selected:

Trap response present,

Spatial Capture-Recapture,

Negative Exponential detection function,

Bernoulli detection process

MCMC simulation settings:

Iterations: 16000

Burn-in: 4000

Thinning: 2

Number of values saved: 6000

Data augmentation: 400 Total size of dataset: 435

Starting values:

sigma = 1412.78636251023, lam0 = 0.018, beta = 0, psi = 0.6

	Posterior Mean	***Posterior S.D.***	***95% Lower HPD Level***	***95% Upper HPD Level***
Sigma	1407.082901	113.0722	1199.254	1644.01
lam0	0.035225691	0.012389	0.01209	0.057165
Beta	1.710432274	0.360923	1.094592	2.442986
Psi	0.114869674	0.021142	0.076434	0.158895
N	49.18116667	6.446596	38	61
Density	0.451203364	0.059143	0.348624	0.559633
p1	0.034538559	0.011926	0.012017	0.055562
p2	0.169162605	0.030714	0.112756	0.228944

Table 4.9 Summary of results of density (The derived parameters Sigma is the range parameter’ of an animal if the animal movement about its activity centre has a distribution similar to the detection function used; Lam0 is the expected encounter rate of an individual i in trap location j at sampling occasion k, whose activity centre is exactly at the trap location; Beta is regression coefficient which measures the behavioural response; Psi = ratio of the number of animals present within the space S to the maximum allowable number; N = number of activity centres located in S; Density is N divided by S; P1 is encounter probability of an individual before initial encounter; P2 is encounter probability of an individual after initial encounter).

Fraction in 1st window = 0.1				
Fraction in 2nd window = 0.5				
sigma	lam0	beta	Psi	N
-0.3519	***0.4232***	***-0.1051***	***0.3478***	***0.3108***
Effective posterior sample size:				
sigma	lam0	beta	Psi	N
51.72014	***52.32356***	***45.69606***	***972.00723***	***450.93384***
Bayesian p-value based on individual encounters: 0.7635				

Table 4.10 Results of the Geweke Diagnostic.

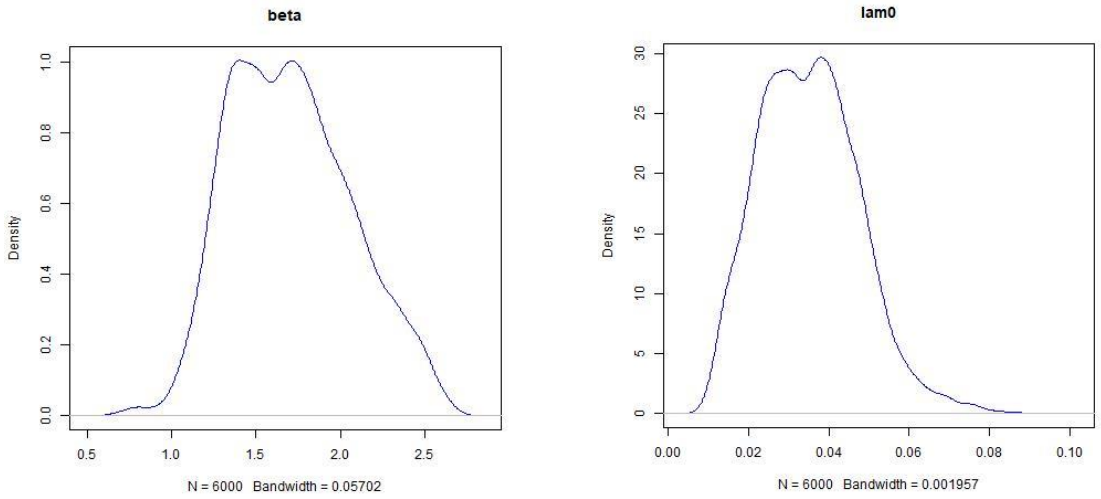


Fig. 8.1 Density plots for beta (Left), & lamb0 (Right).

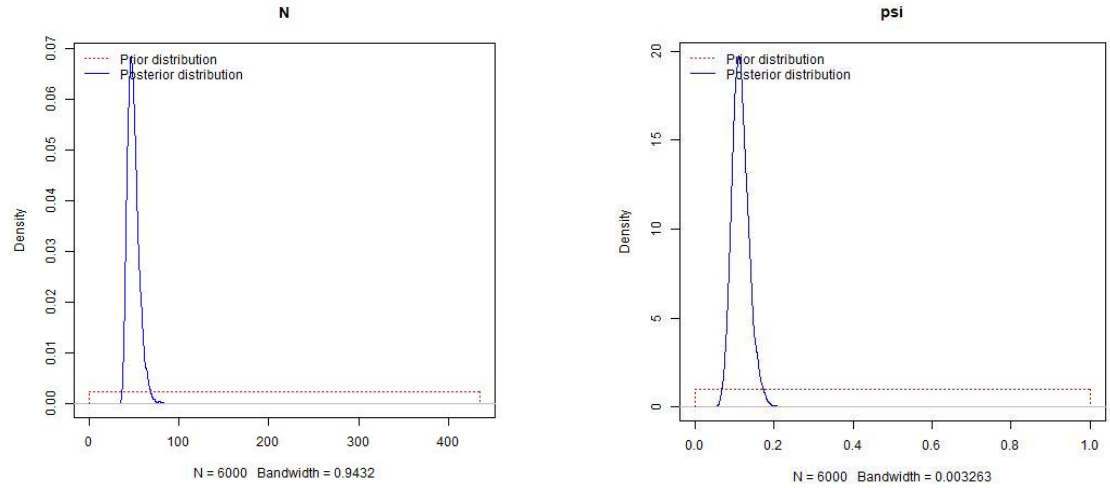


Fig. 8.2 Density plots for N (Left), & psi (Right).

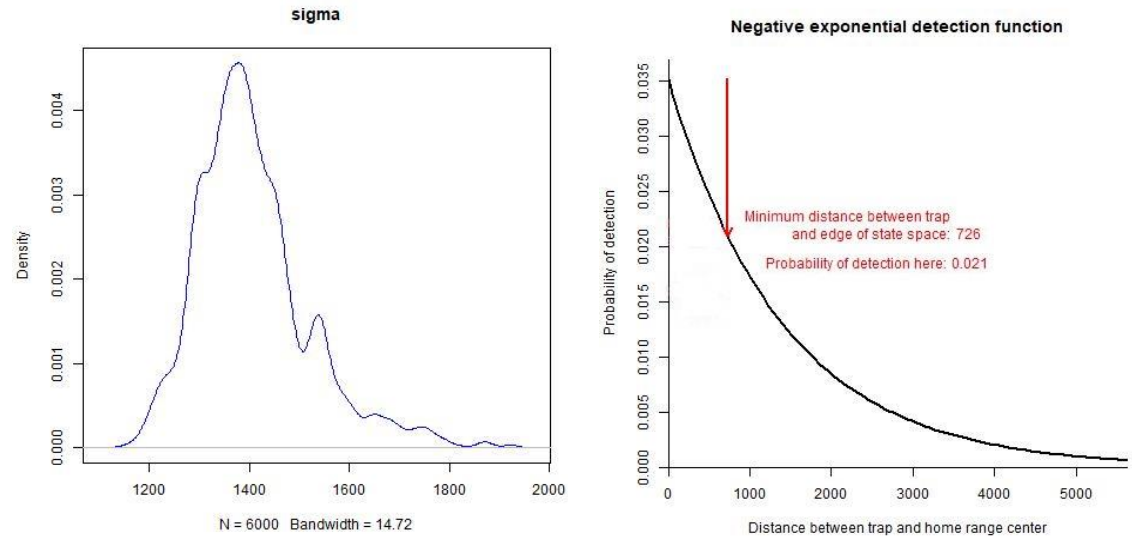


Fig. 8.3 Density plot for sigma (Left), & detection function plot (Right)

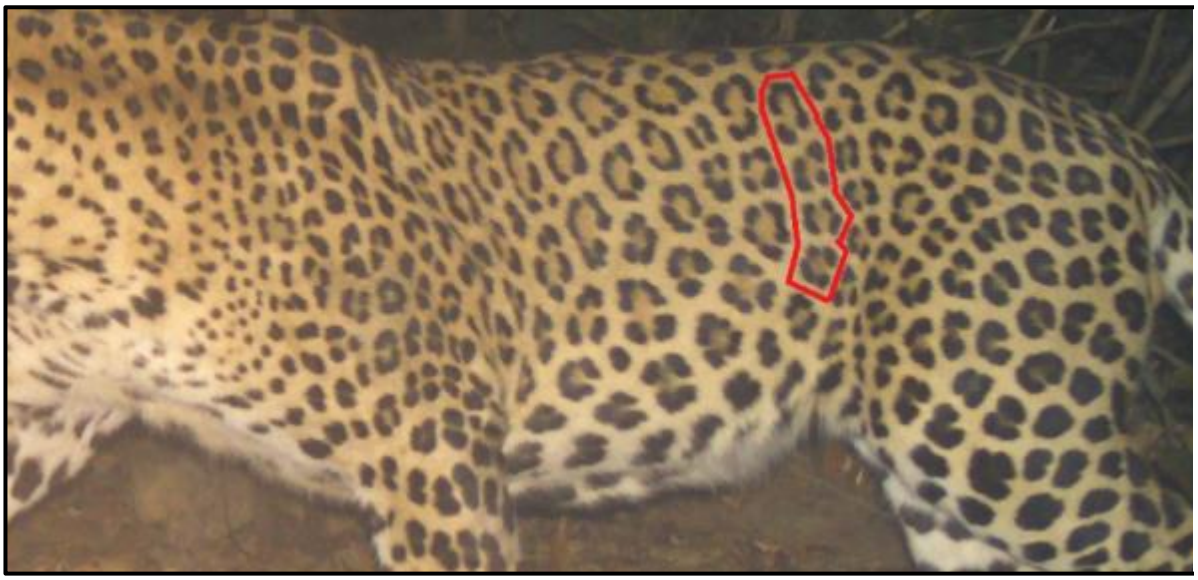
4.6 “Human Leopard Conflict” assessment - Individual Leopard Identification

Note (there is no leopard I.D. as L14 & “probable” depicts single leopard flank with unknown camera placement).

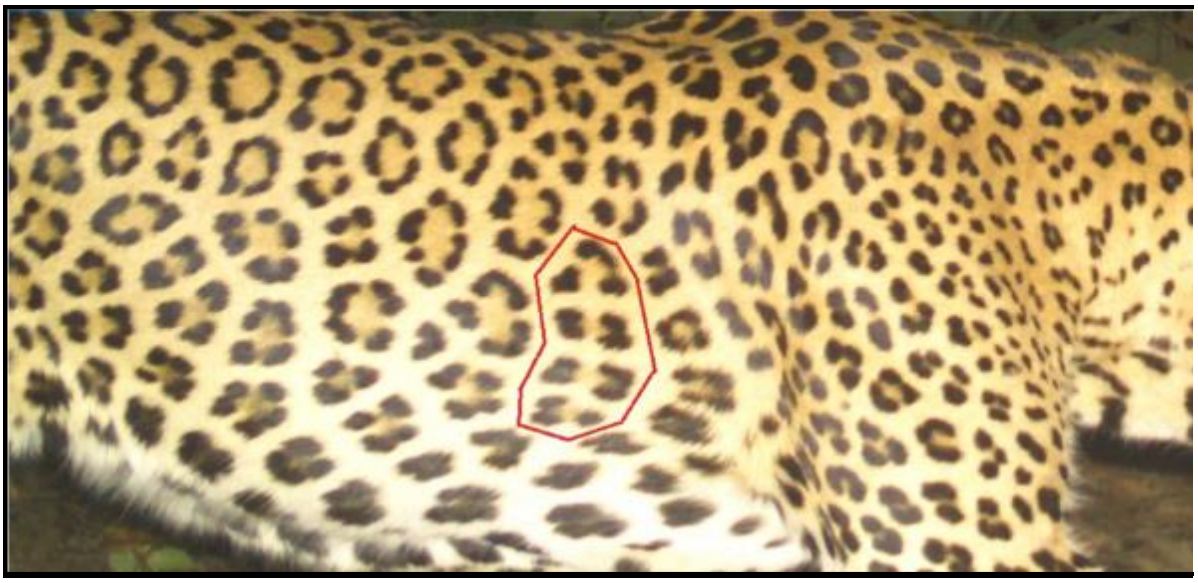
Leopard I.D. - L1 (Gender - Male)

Left Flank

Right Flank



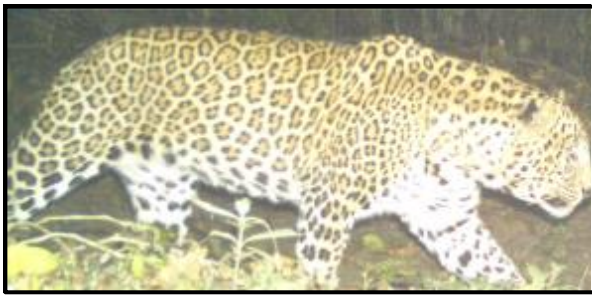
Left Flank Identification



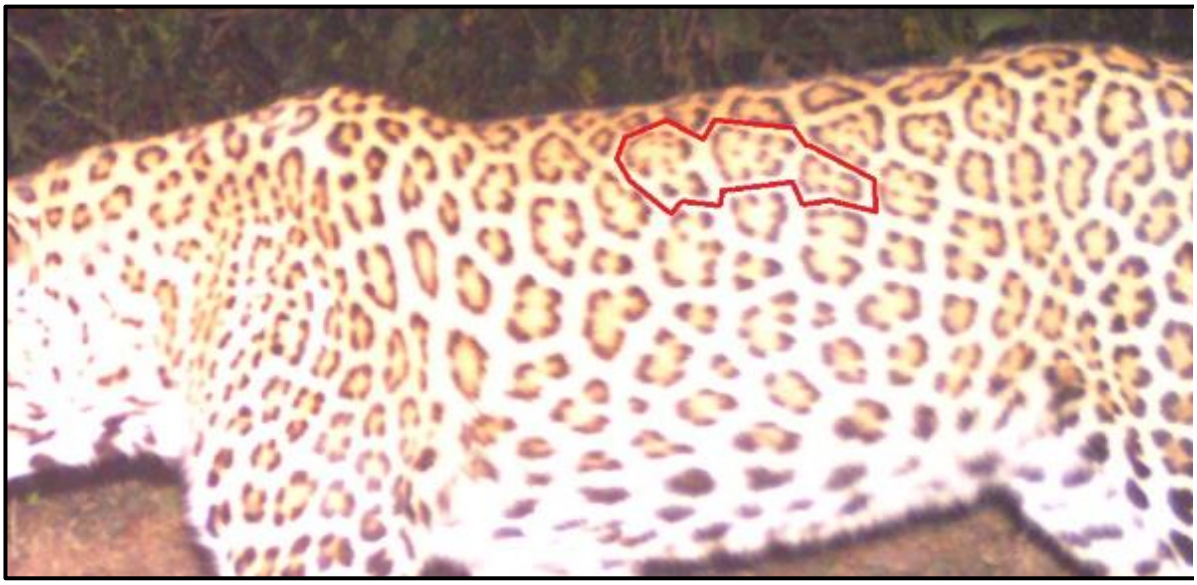
Right Flank Identification

Leopard I.D. – L2 (Gender - Male)

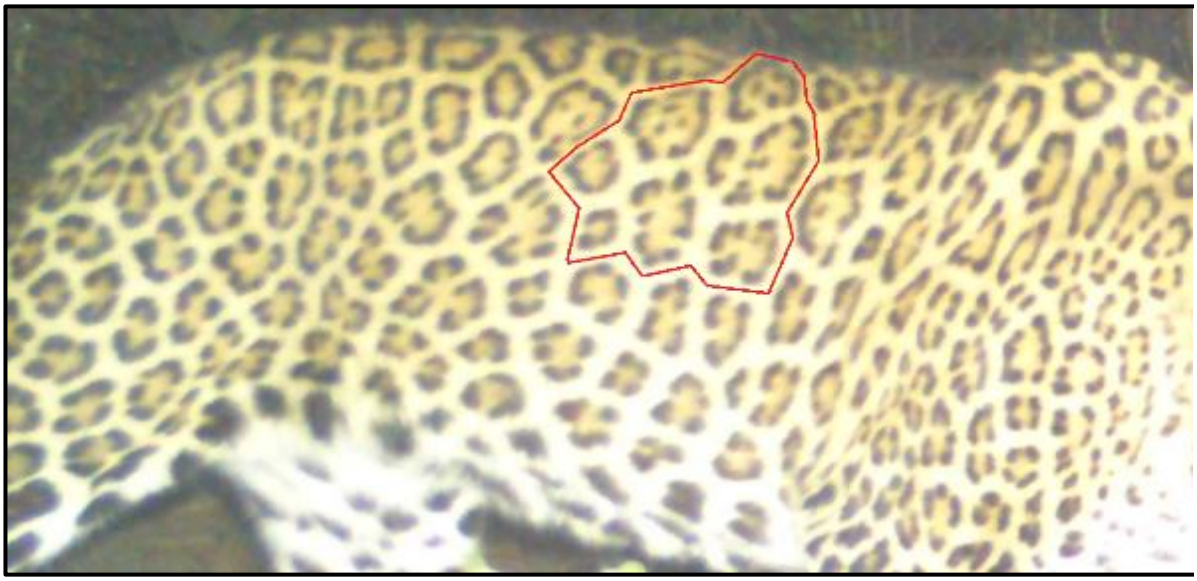
Left Flank



Right Flank



Left Flank Identification

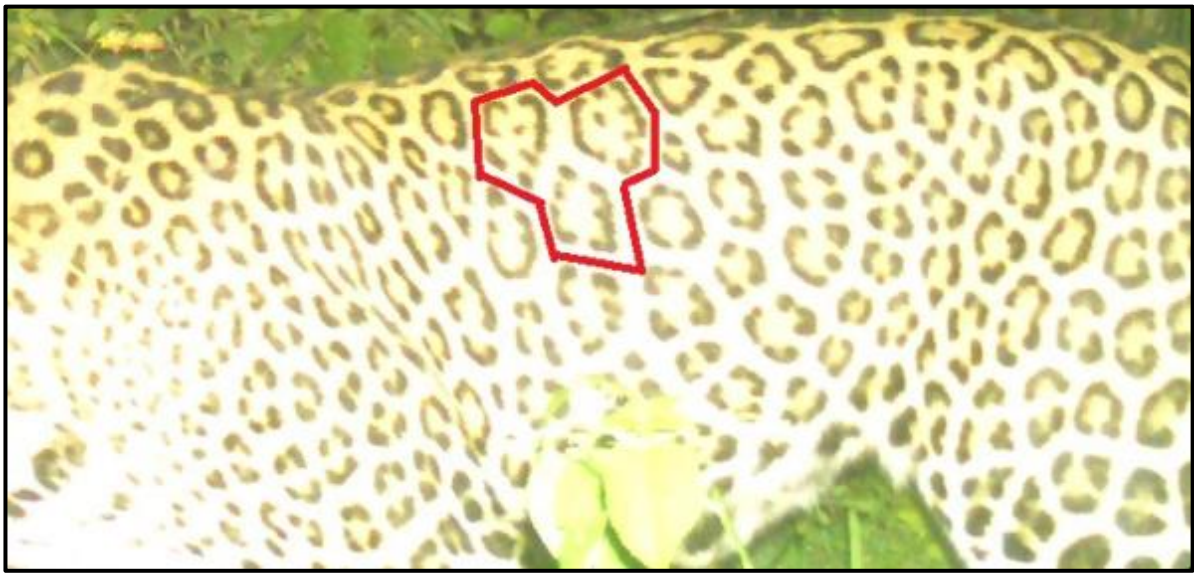


Right Flank Identification

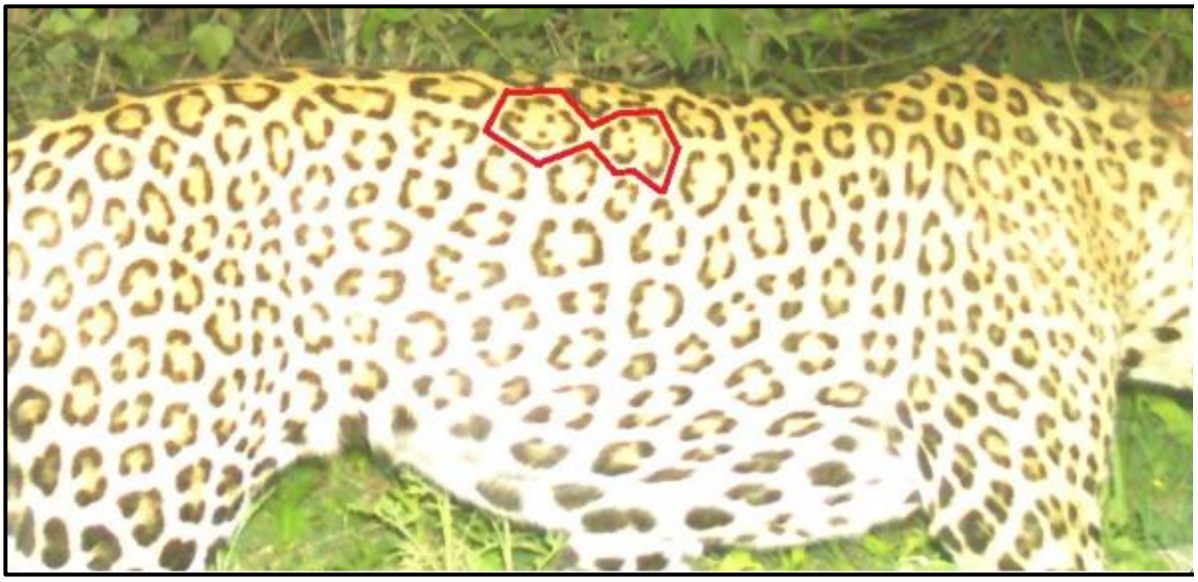
Leopard I.D. – L3 (Gender - Male)

Left Flank

Right Flank



Left Flank Identification

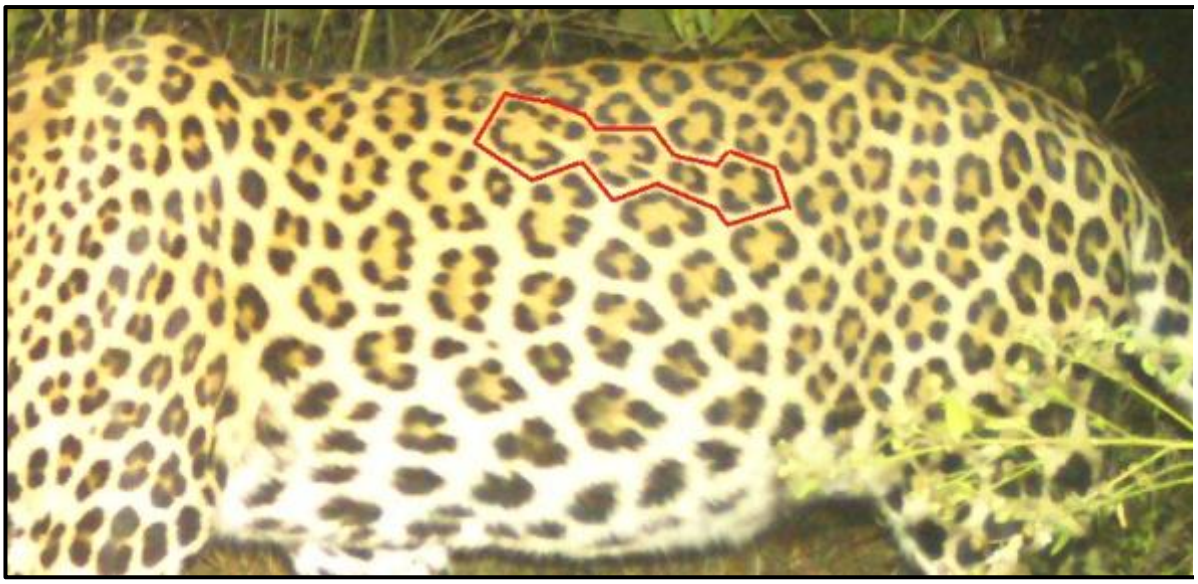


Right Flank Identification

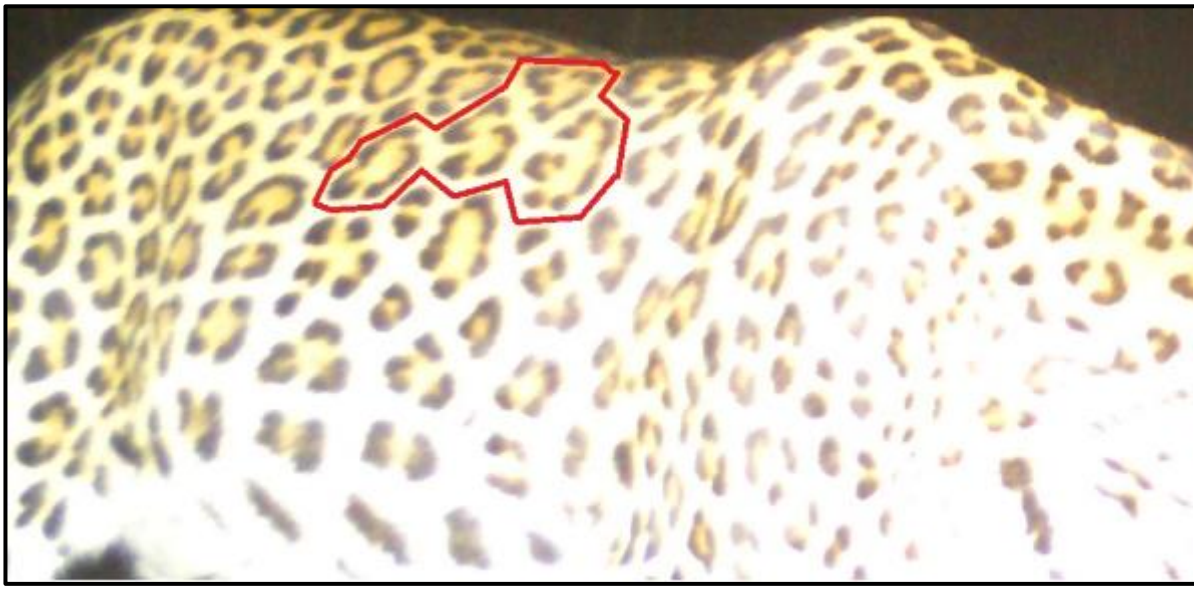
Leopard I.D. – L4 (Gender - Male)

Left Flank

Right Flank

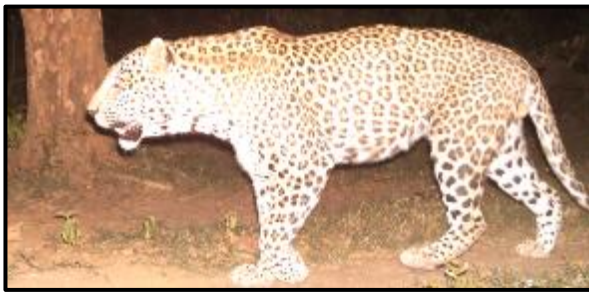


Left Flank Identification



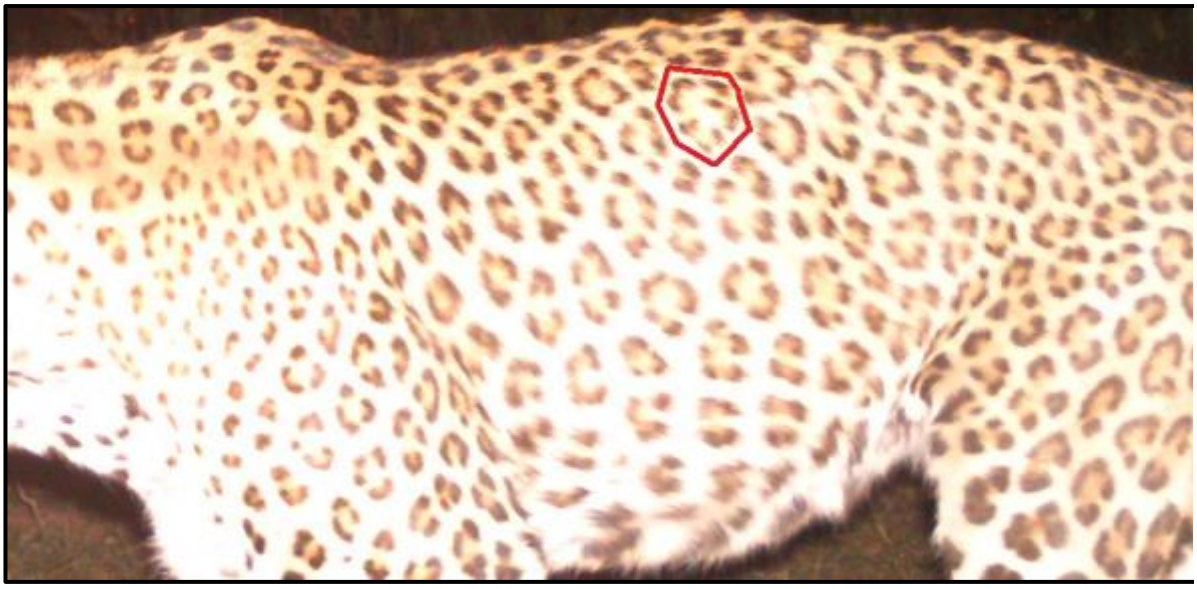
Right Flank Identification

Leopard I.D. – L5 (Gender - Male)



Left Flank

Right Flank



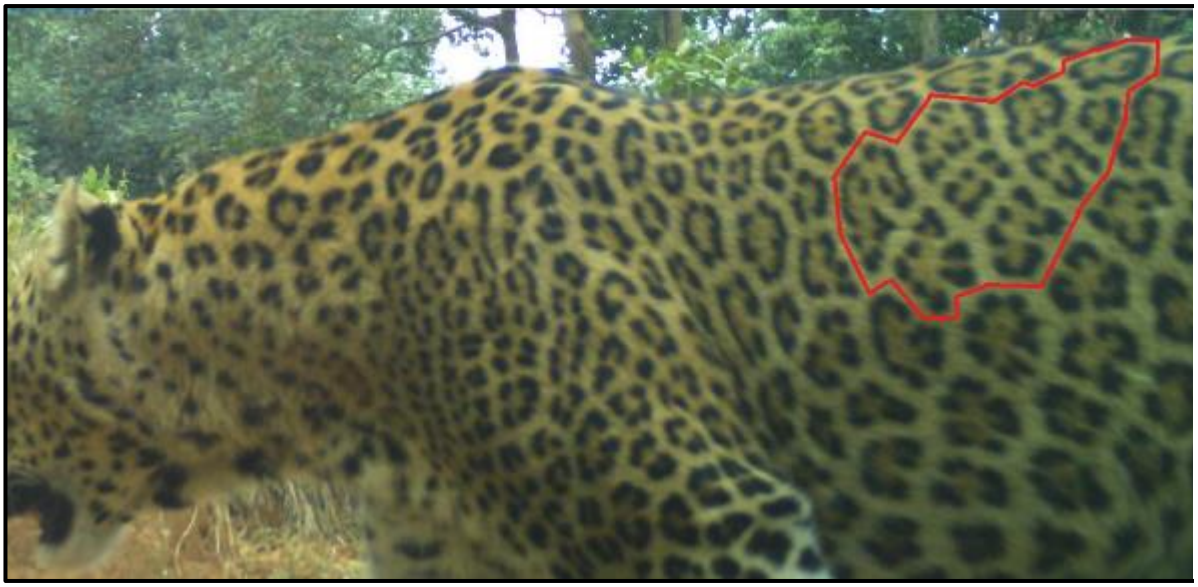
Left Flank Identification

Right Flank Identification

Leopard I.D. – L6 (Gender - Male)

Left Flank

Right Flank



Left Flank Identification

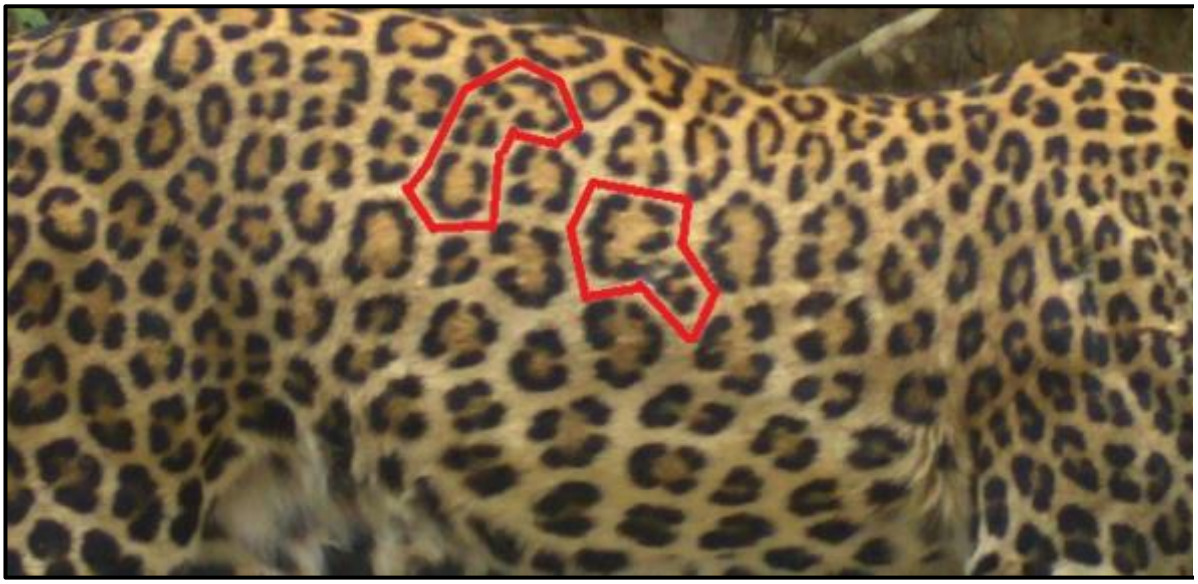
Right Flank Identification

Leopard I.D. – L7 (Gender - Male)

Left Flank

Right Flank

Left Flank Identification

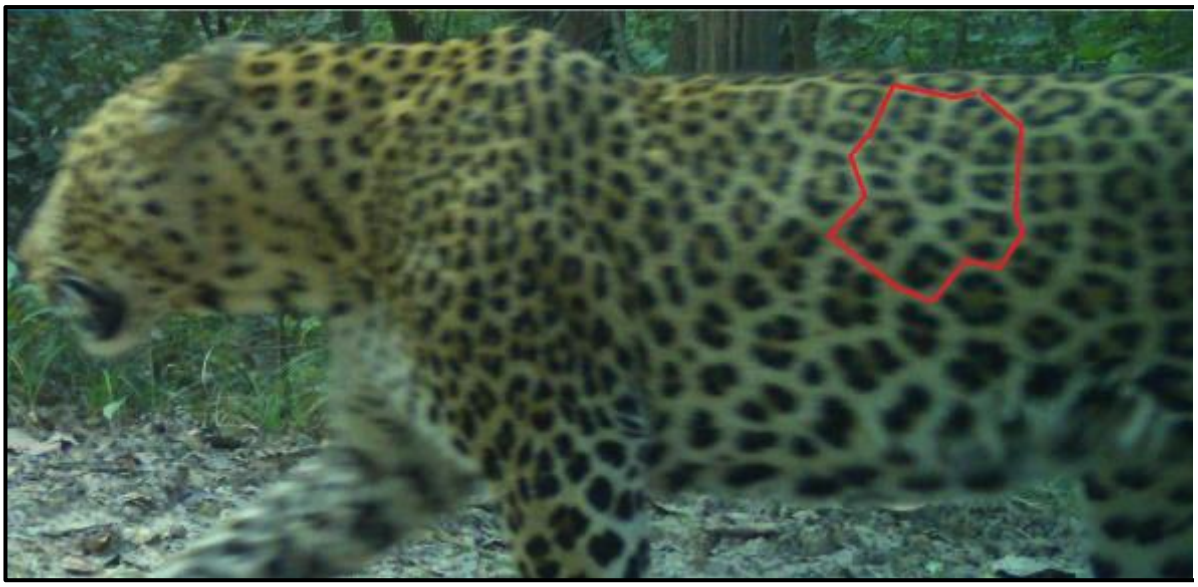


Right Flank Identification

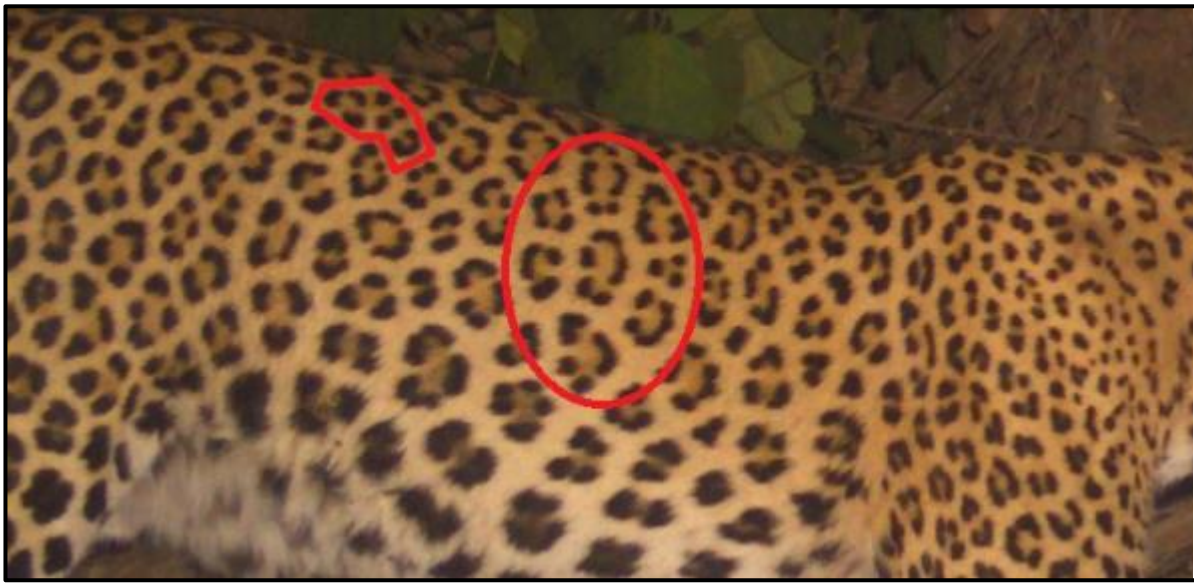
Leopard I.D. – L8 (Gender - Male)

Left Flank

Right Flank



Left Flank Identification

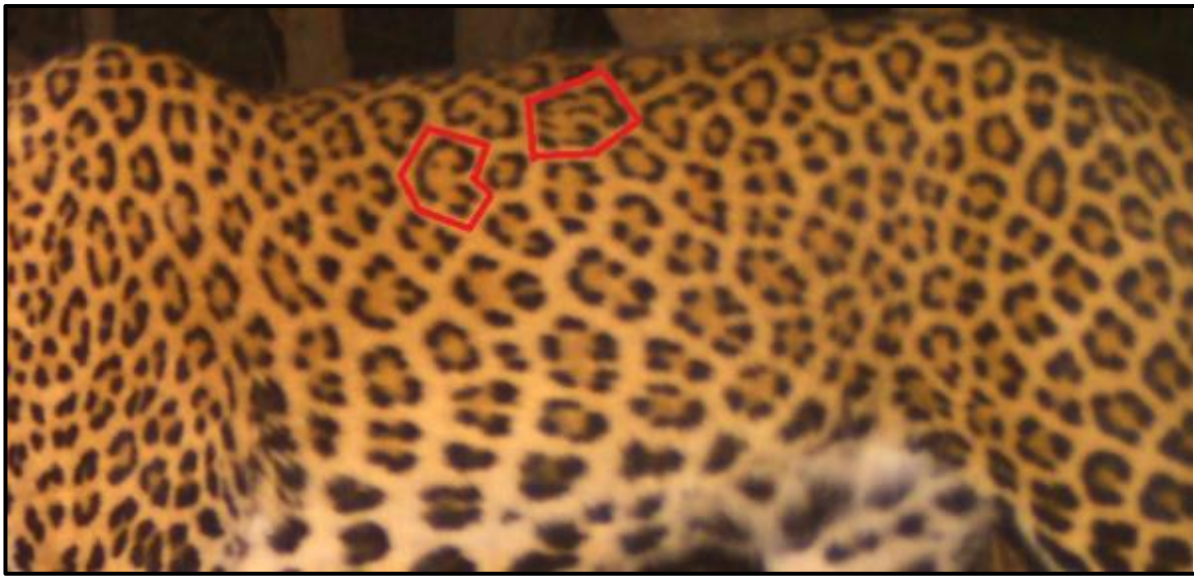


Right Flank Identification

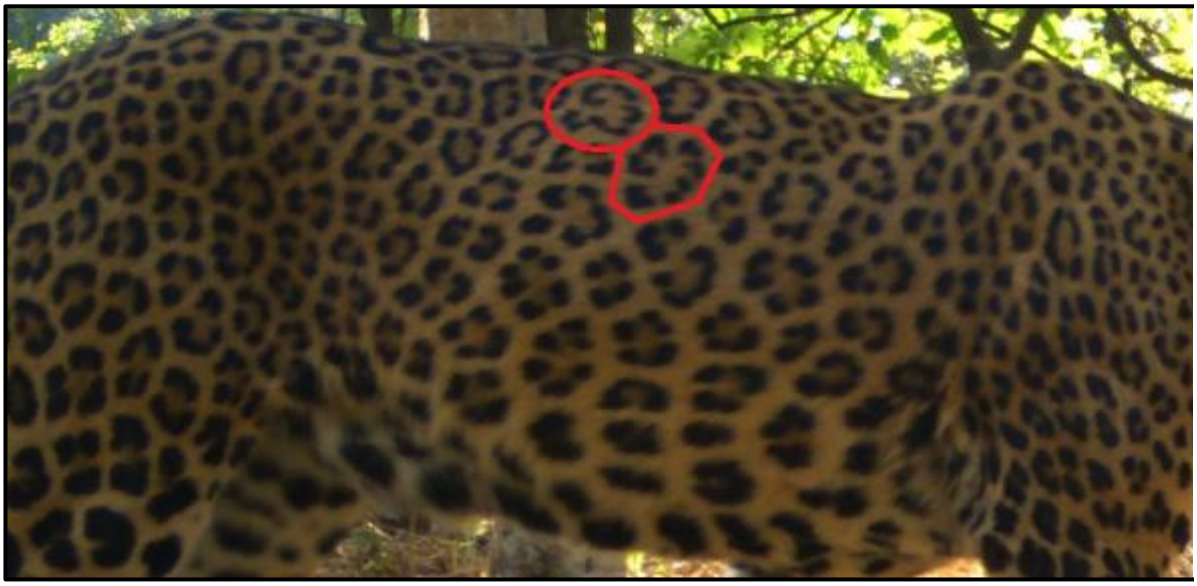
Leopard I.D. – L9 (Gender - Male)

Left Flank

Right Flank

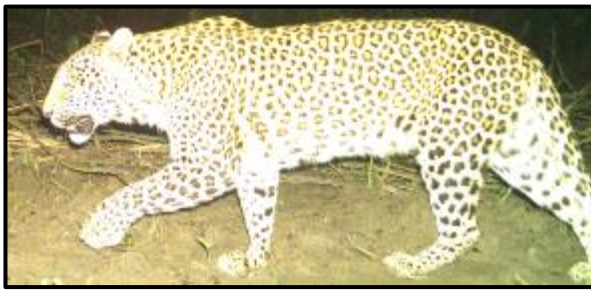


Left Flank Identification



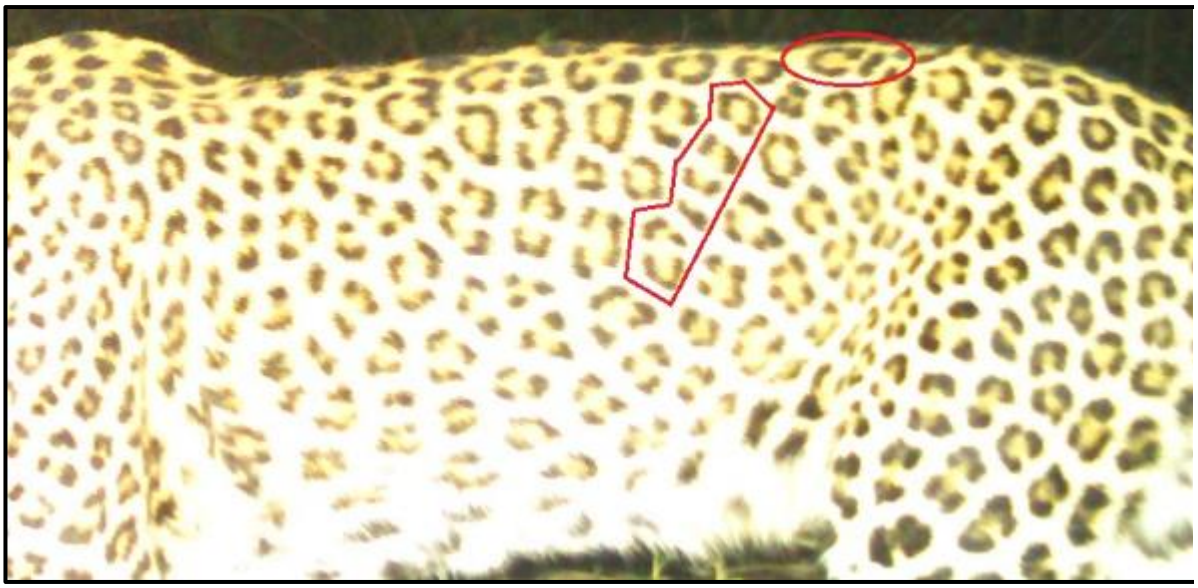
Right Flank Identification

Leopard I.D. – L10 (Gender - Female)

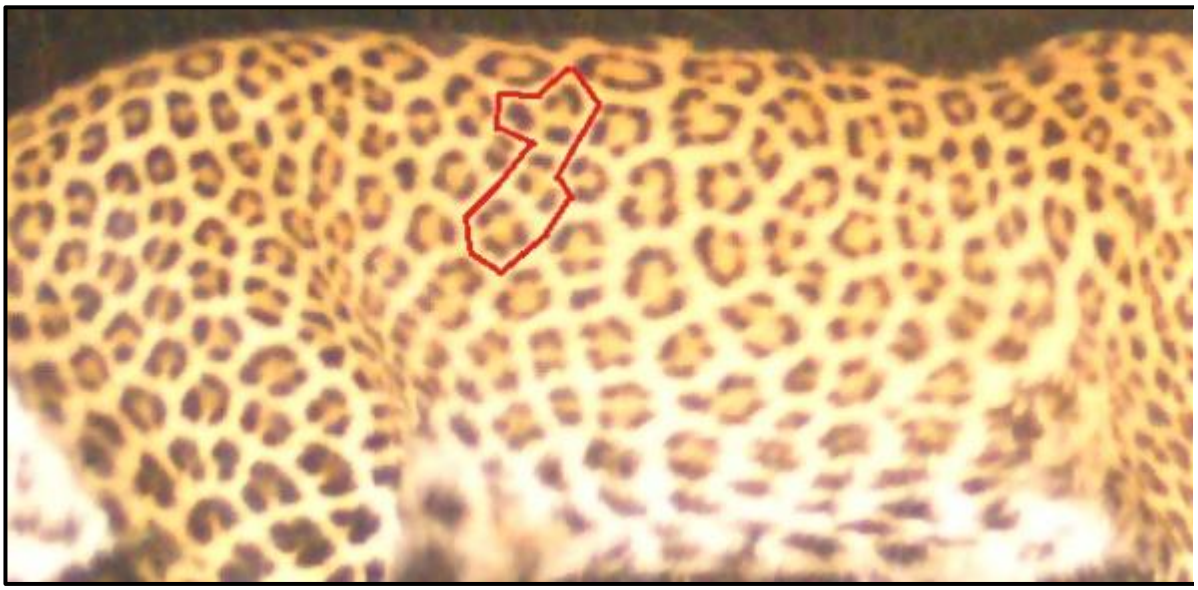


Left Flank

Right Flank



Left Flank Identification

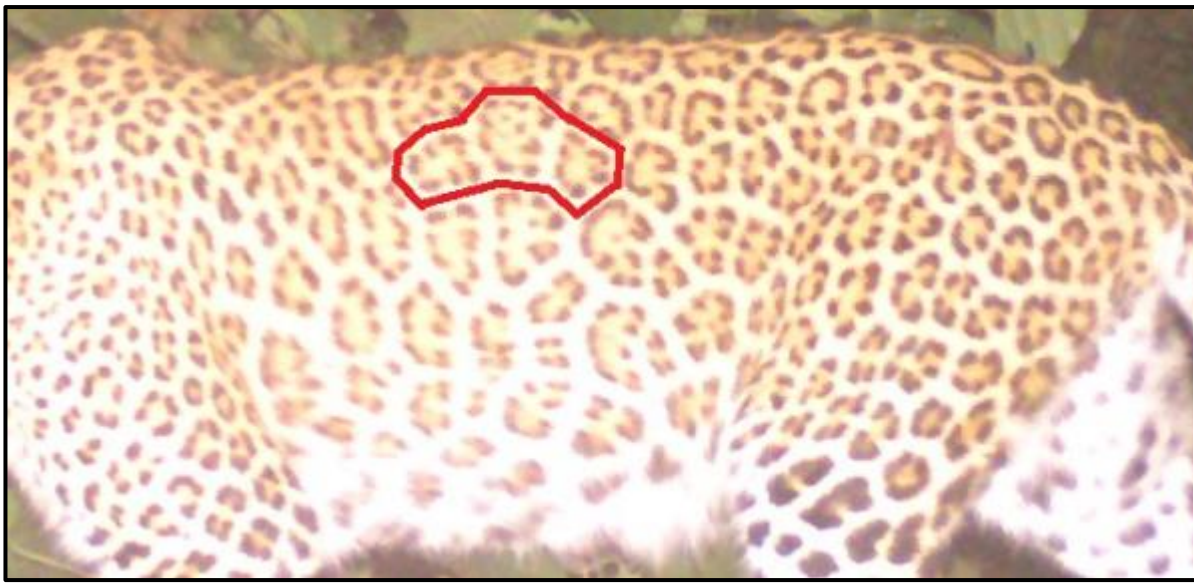


Right Flank Identification

Leopard I.D. – L11 (Gender - Female)

Left Flank

Right Flank



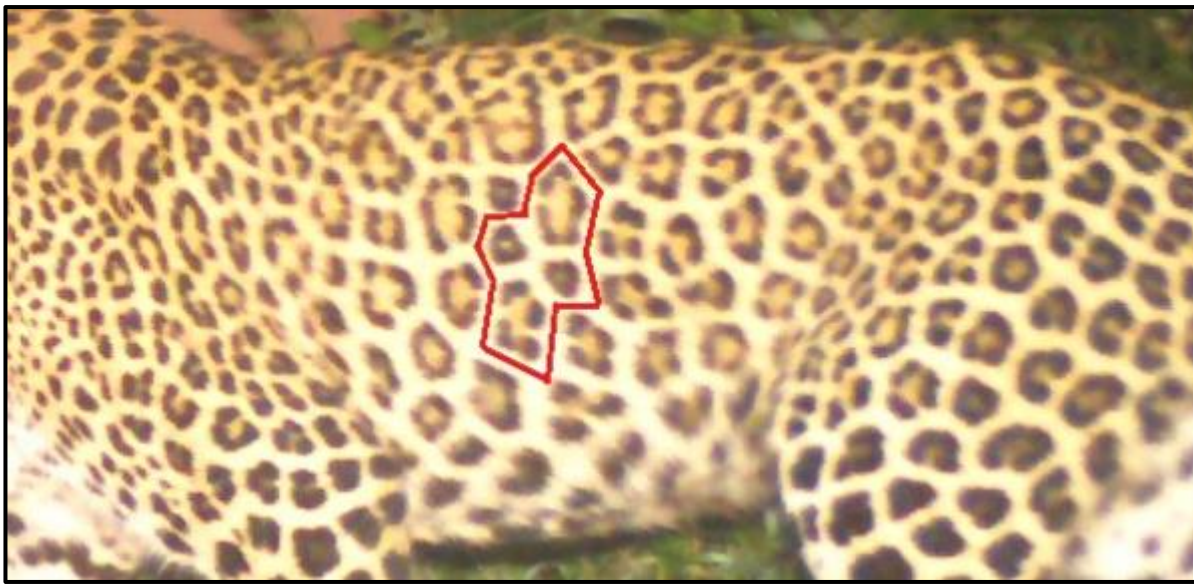
Left Flank Identification

Right Flank Identification

Leopard I.D. – L12 (Gender - Female)

Left Flank

Right Flank



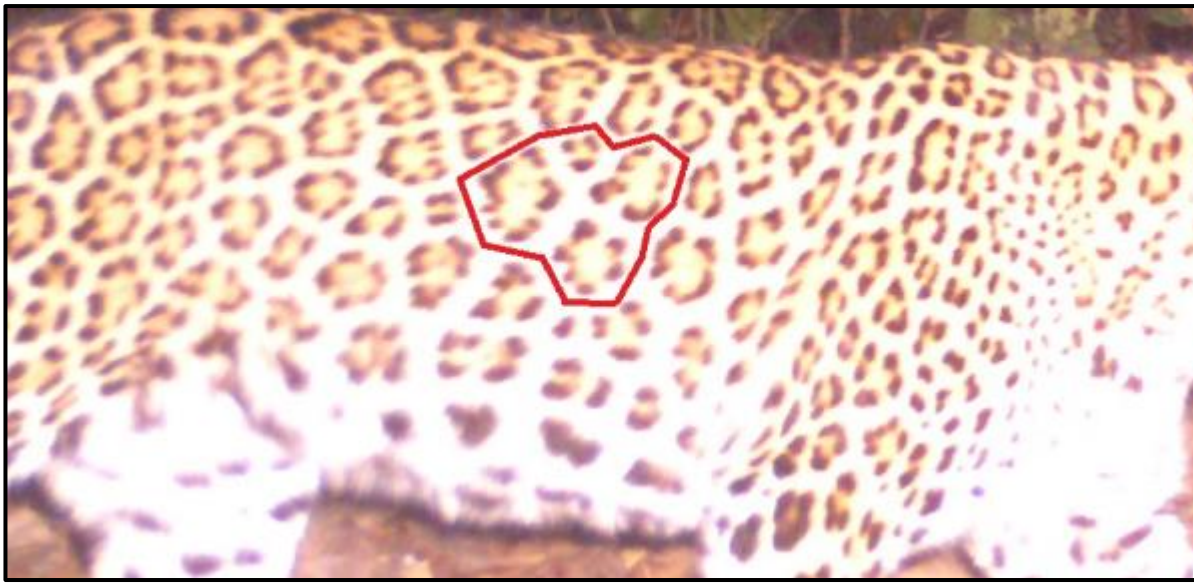
Left Flank Identification

Right Flank Identification

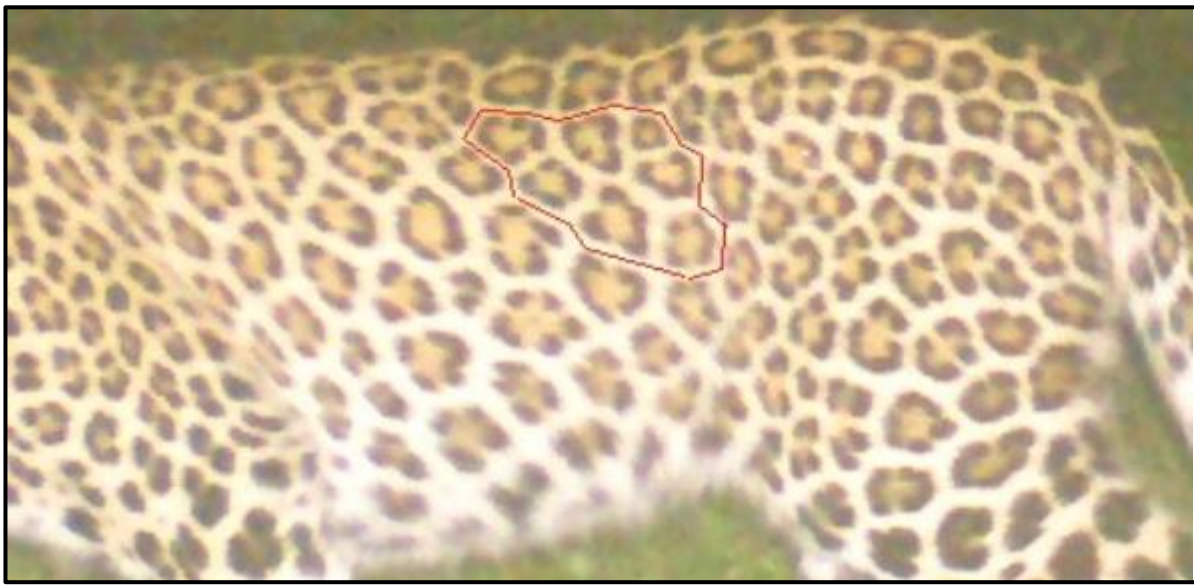
Leopard I.D. – L13 (Gender - Female)

Left Flank

Right Flank



Left Flank Identification

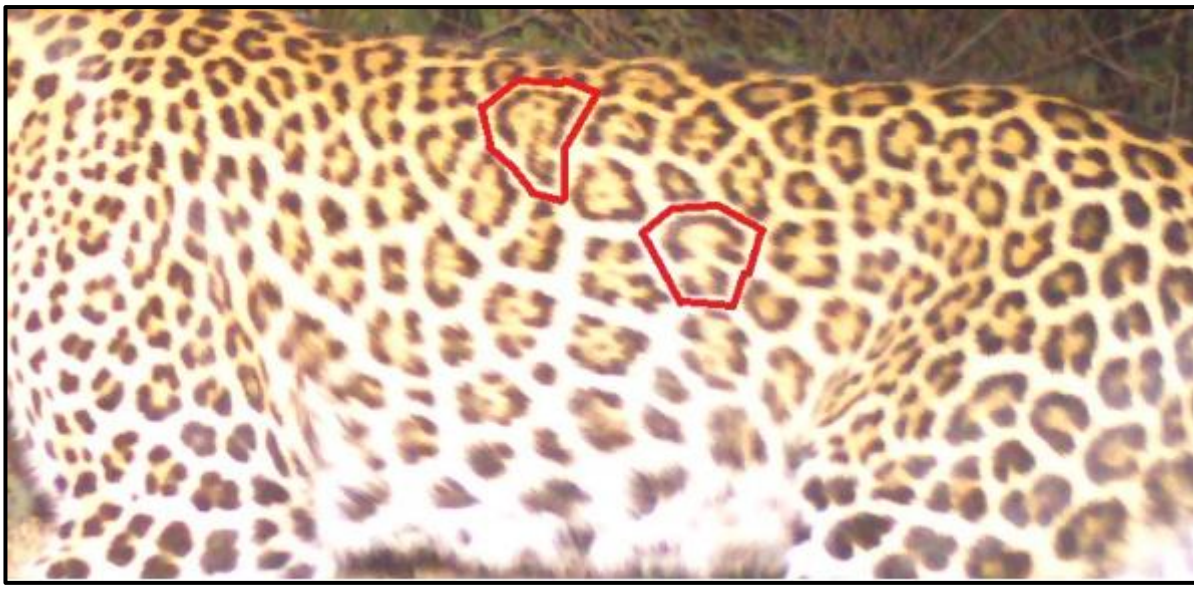


Right Flank Identification

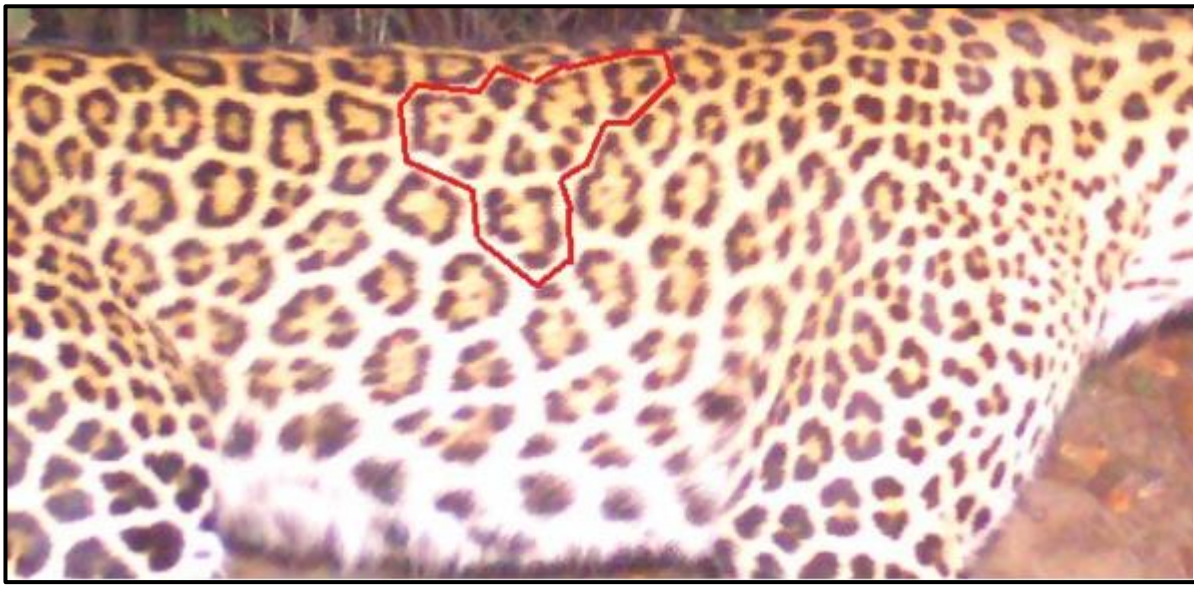
Leopard I.D. – L15 (Gender - Female)

Left Flank

Right Flank



Left Flank Identification



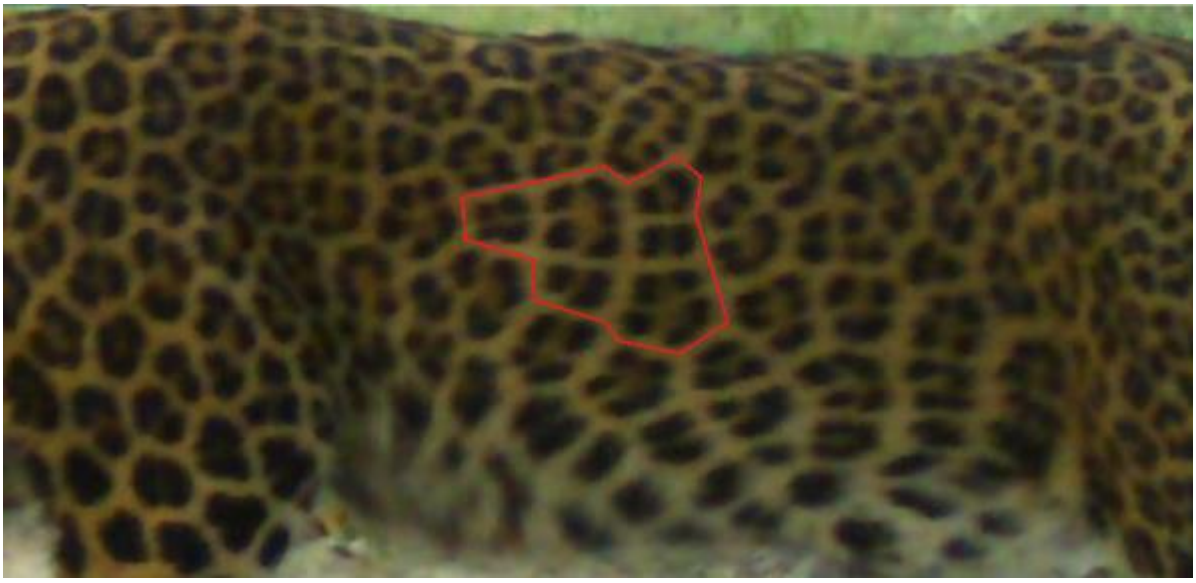
Right Flank Identification

Leopard I.D. – L16 (Gender - Female)

Left Flank

Right Flank

Left Flank Identification

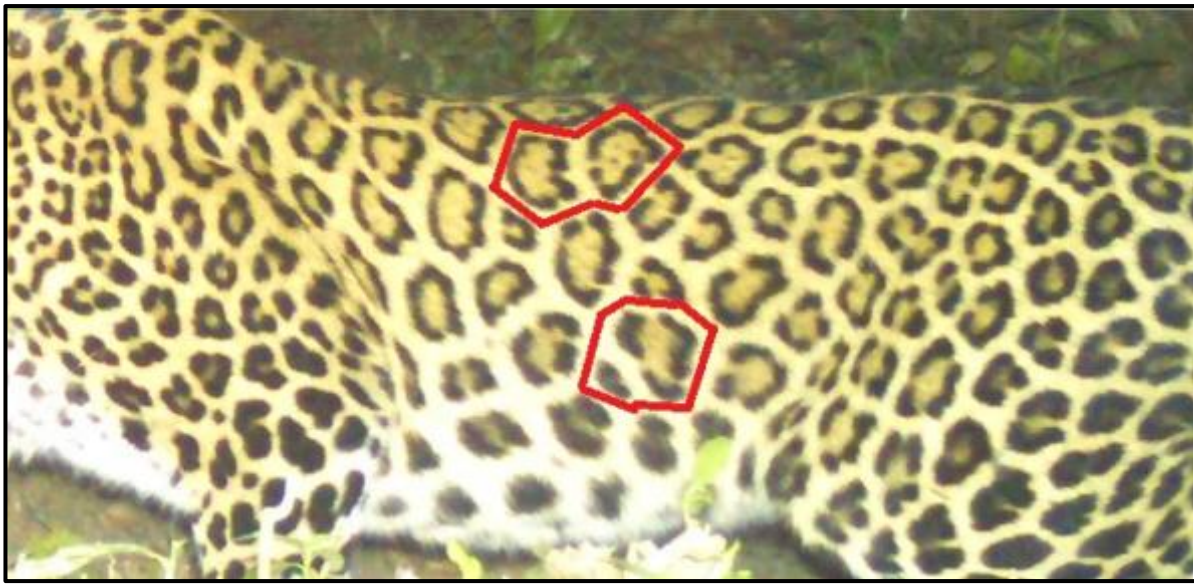


Right Flank Identification

Leopard I.D. – L17 (Gender - Female)

Left Flank

Right Flank



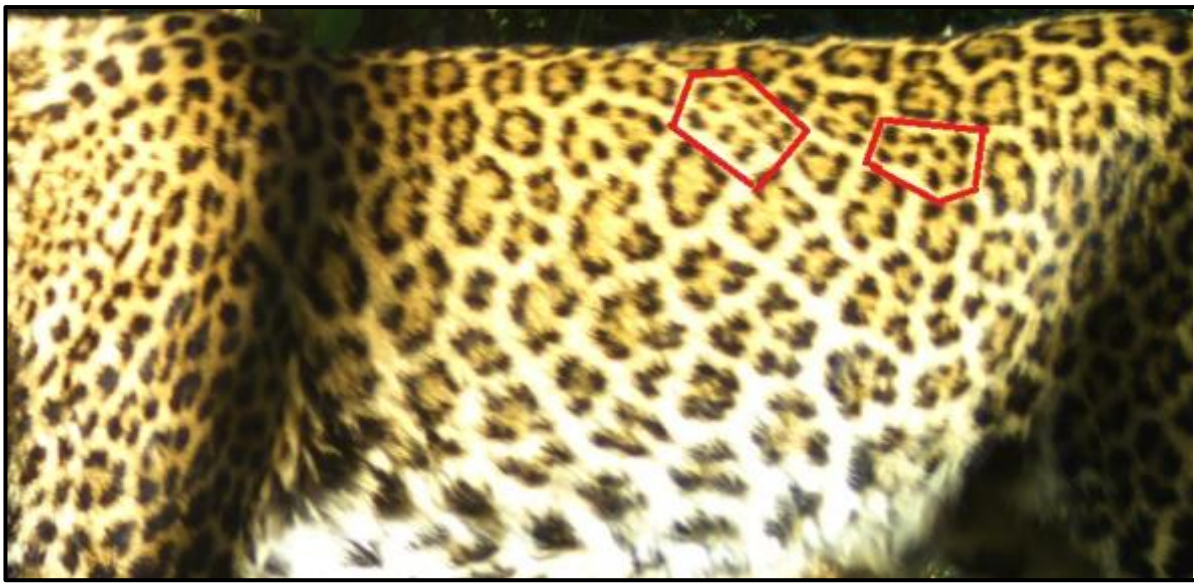
Left Flank Identification

Right Flank Identification

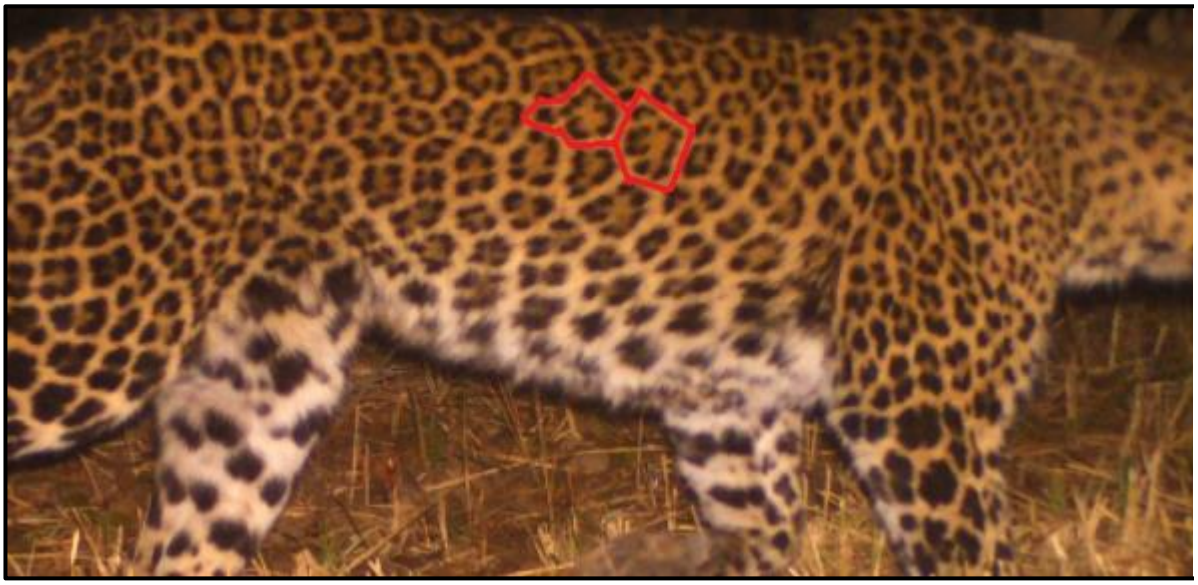
Leopard I.D. – L18 (Gender - Female)

Left Flank

Right Flank



Left Flank Identification

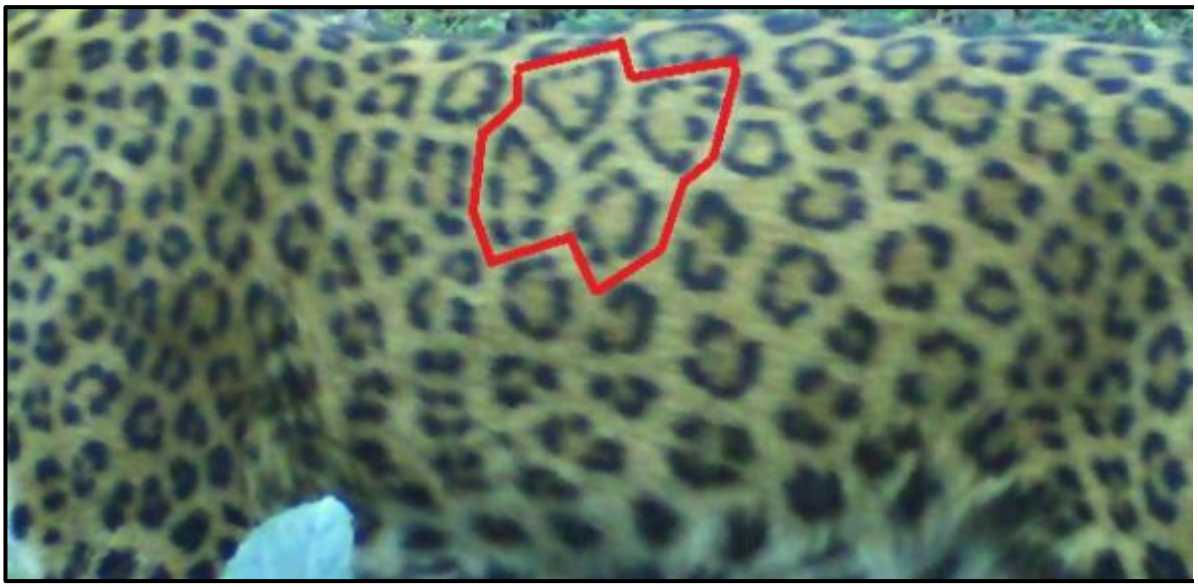


Right Flank Identification

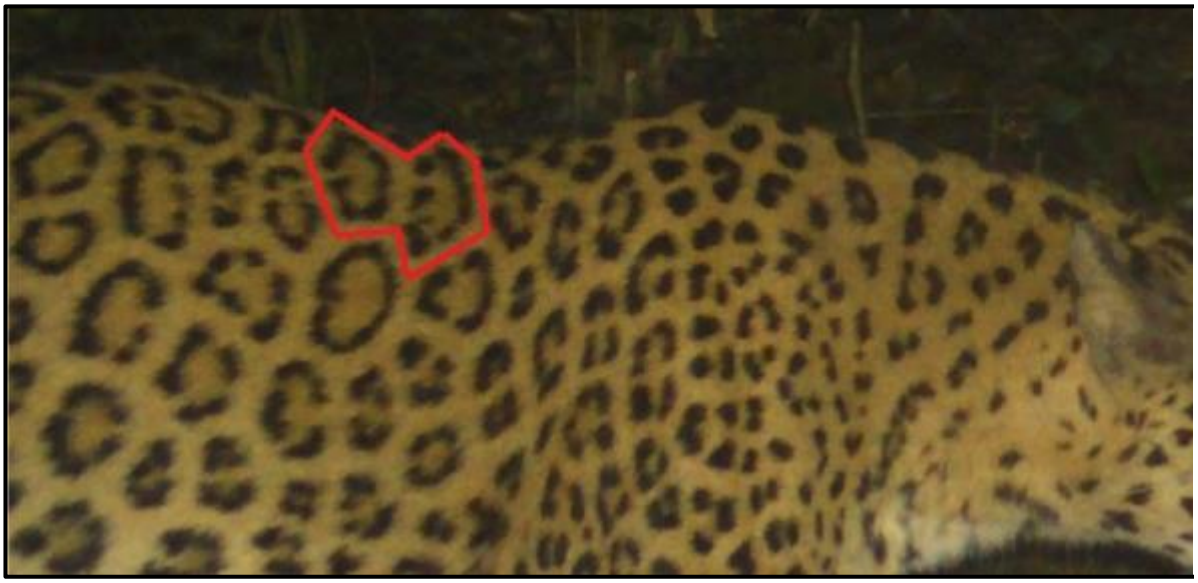
Leopard I.D. – L19 (Gender - Female)

Left Flank

Right Flank



Left Flank Identification

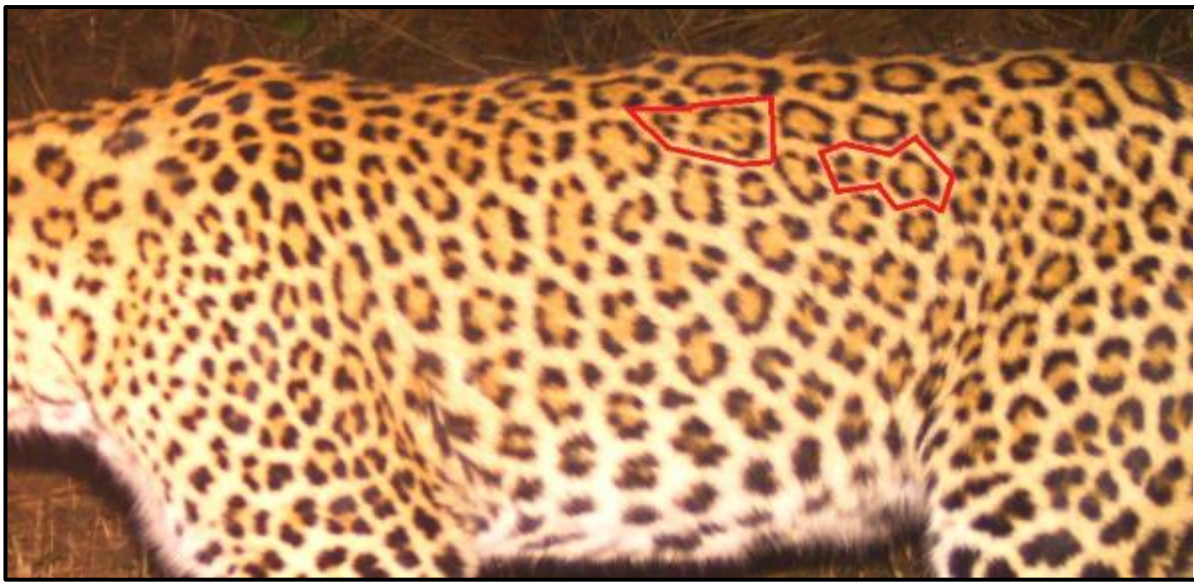


Right Flank Identification

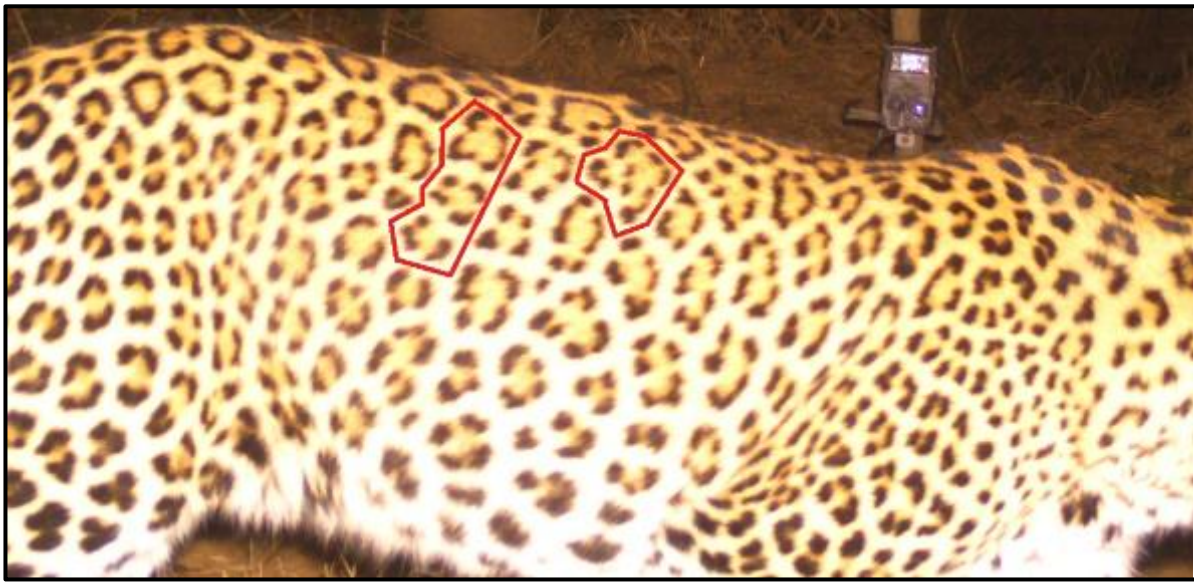
Leopard I.D. – L20 (Gender - Female)

Left Flank

Right Flank



Left Flank Identification

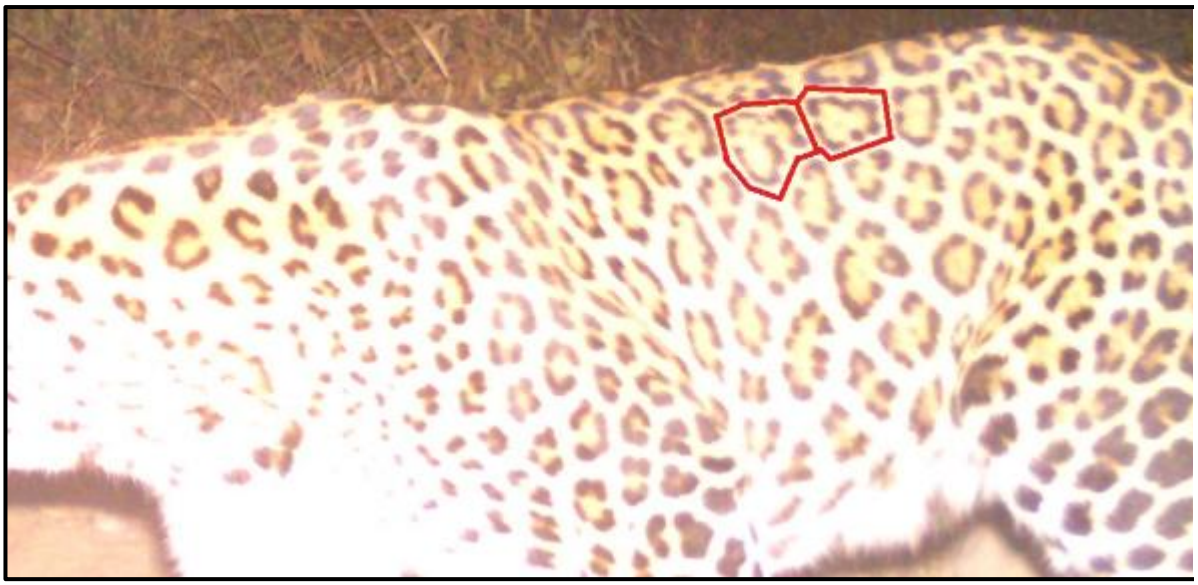


Right Flank Identification

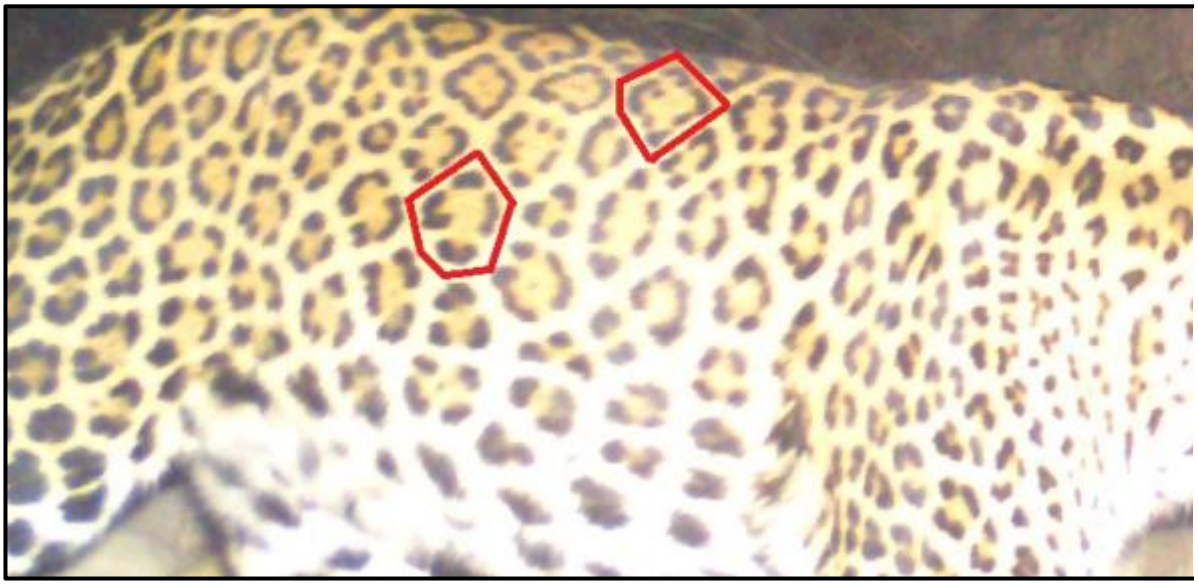
Leopard I.D. – L21 (Gender - Female)

Left Flank

Right Flank



Left Flank Identification

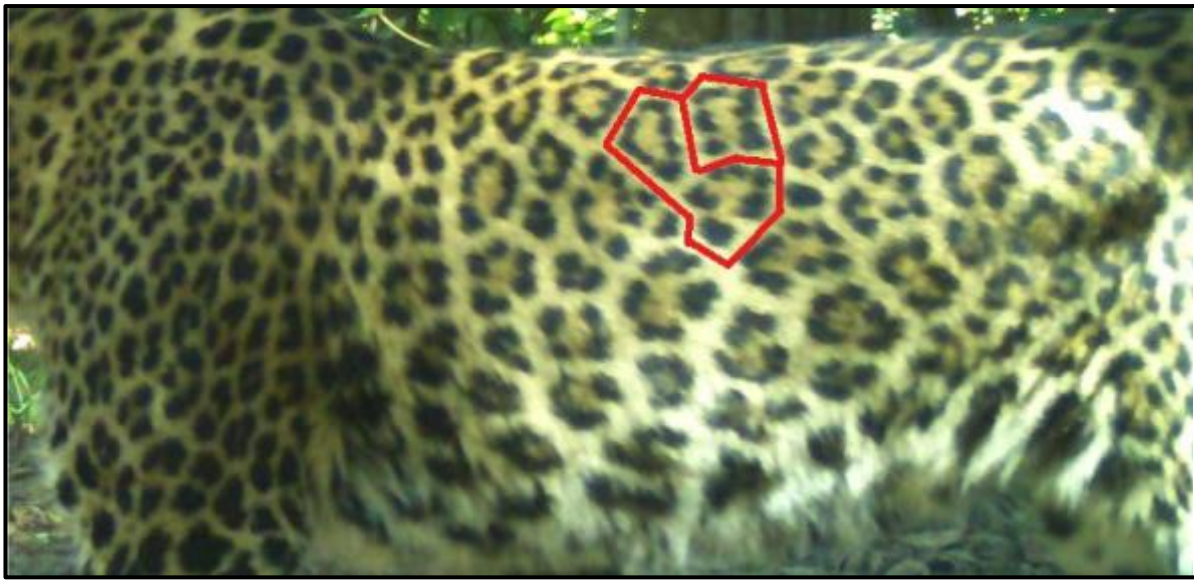


Right Flank Identification

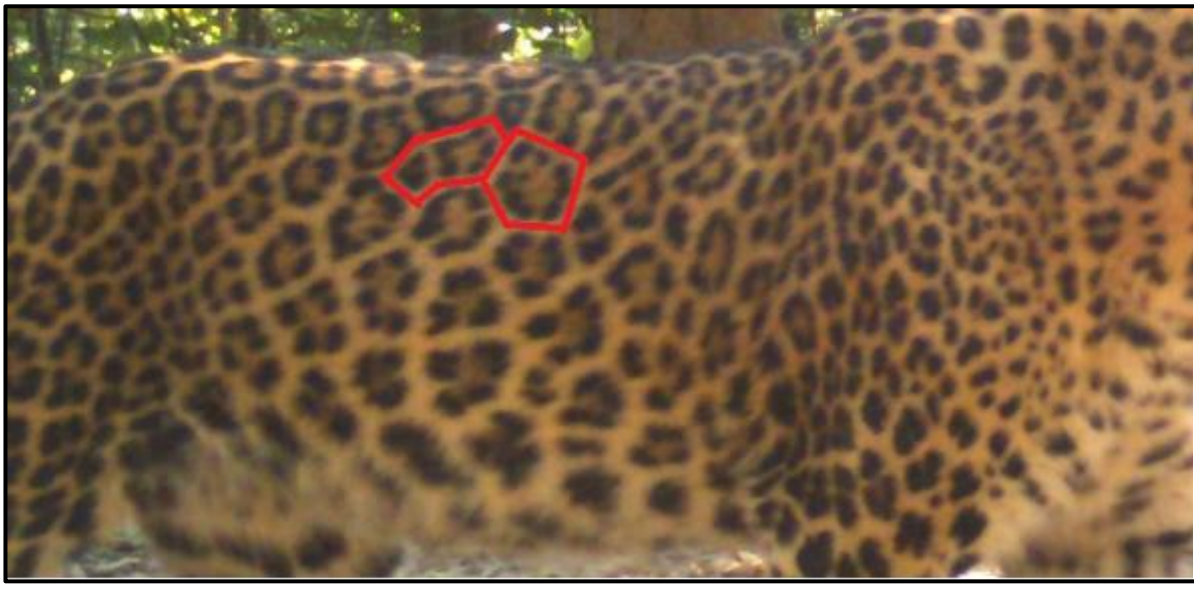
Leopard I.D. – L22 (Gender - Female)

Left Flank

Right Flank



Left Flank Identification

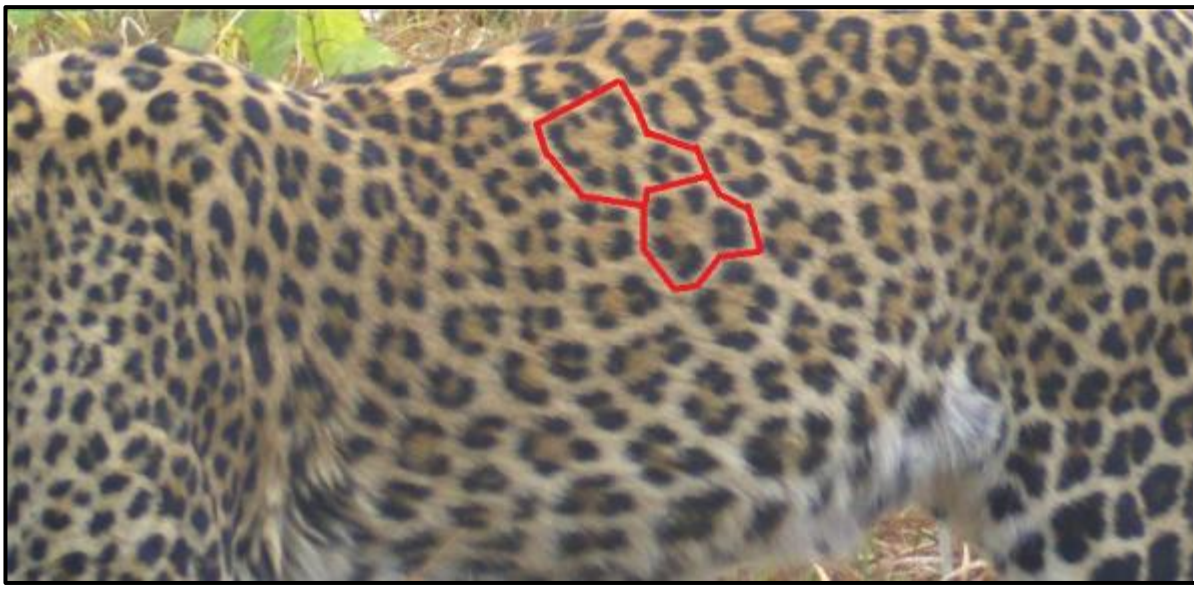


Right Flank Identification

Leopard I.D. – L23 (Gender - Female)

Left Flank

Right Flank

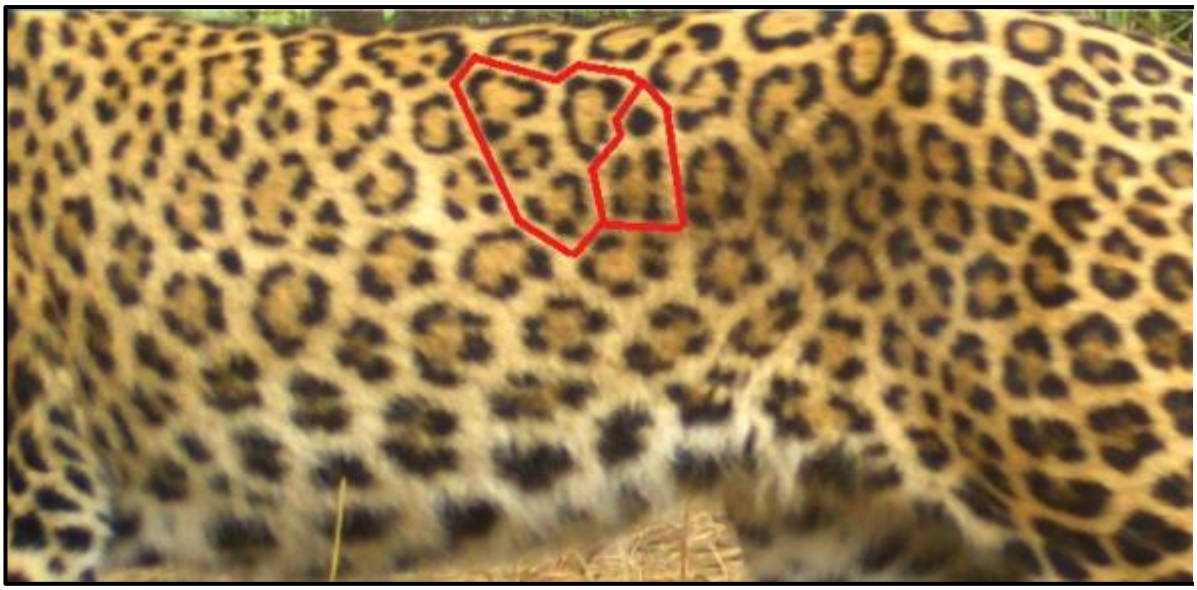


Left Flank Identification

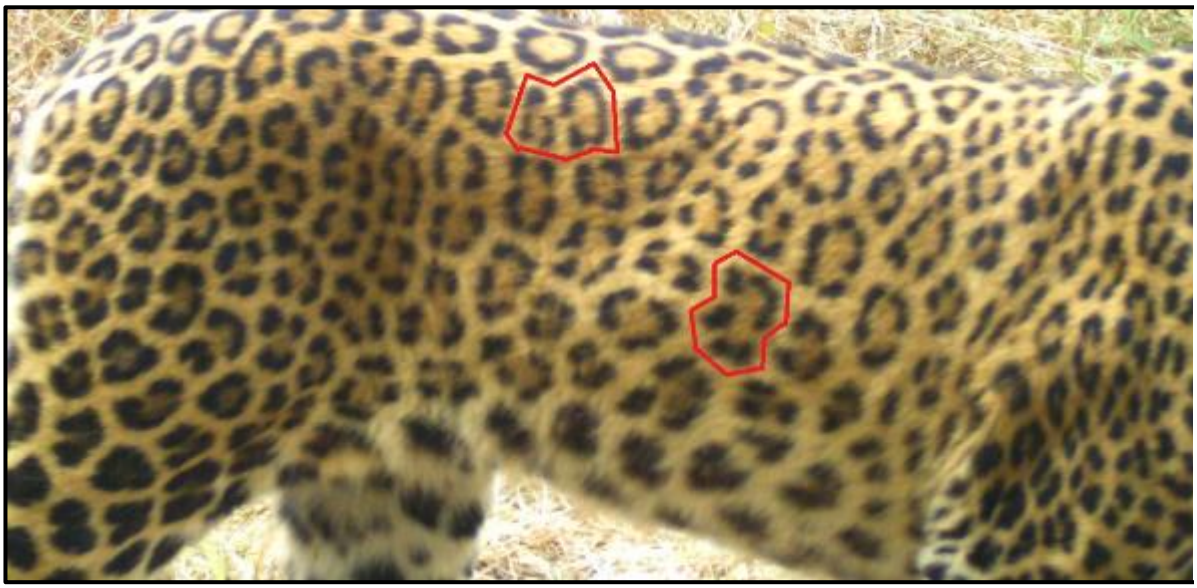
Leopard I.D. – L24 (Gender - Female)

Left Flank

Right Flank



Left Flank Identification

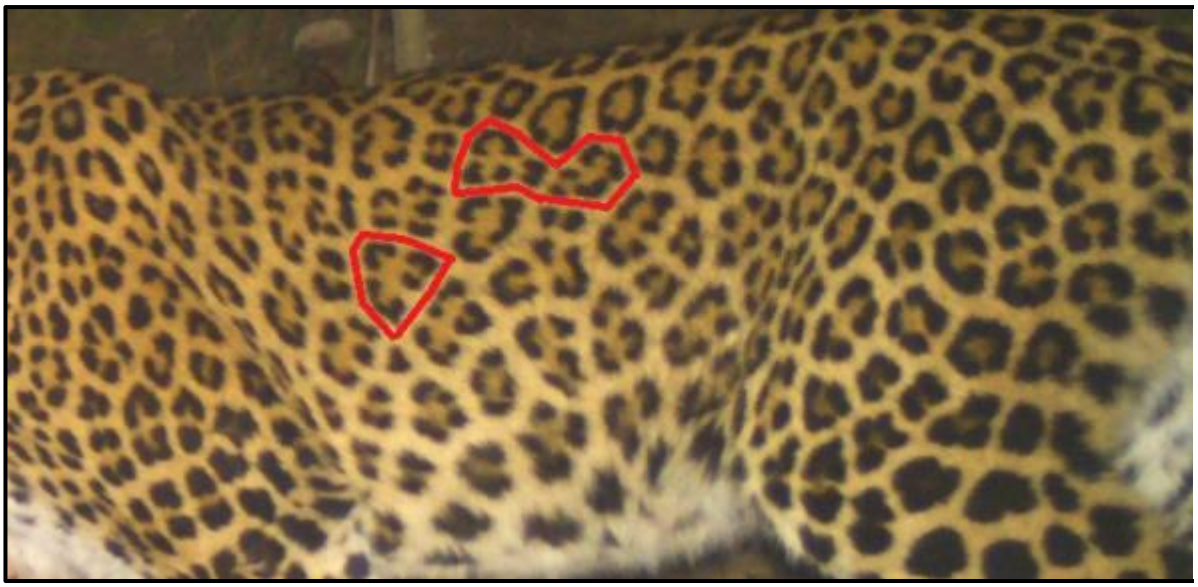


Right Flank Identification

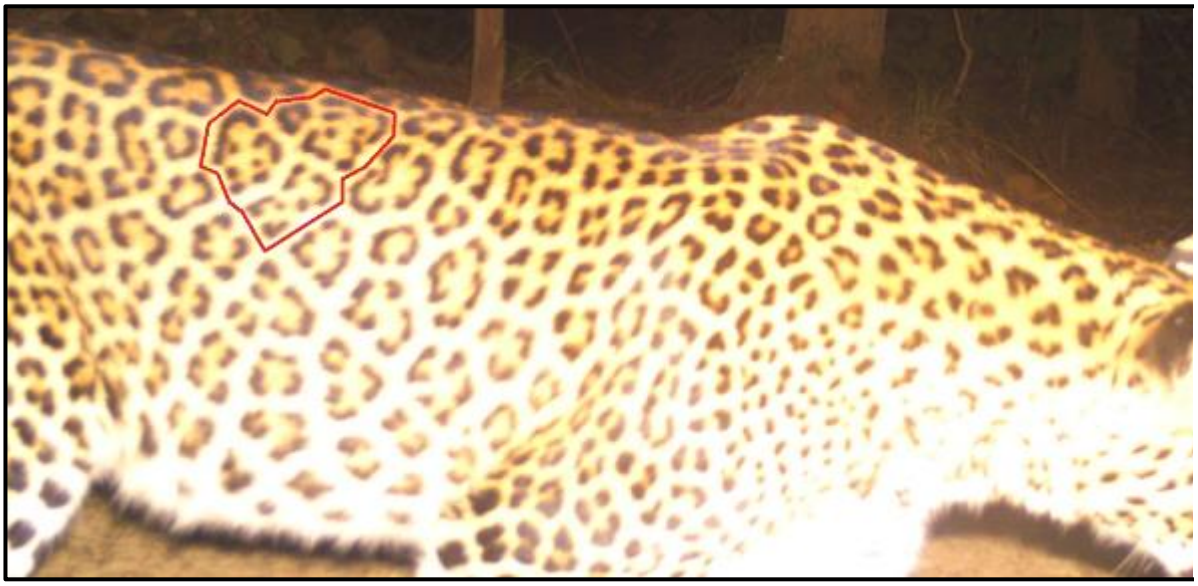
Leopard I.D. – L25 (Gender - Female)

Left Flank

Right Flank



Left Flank Identification

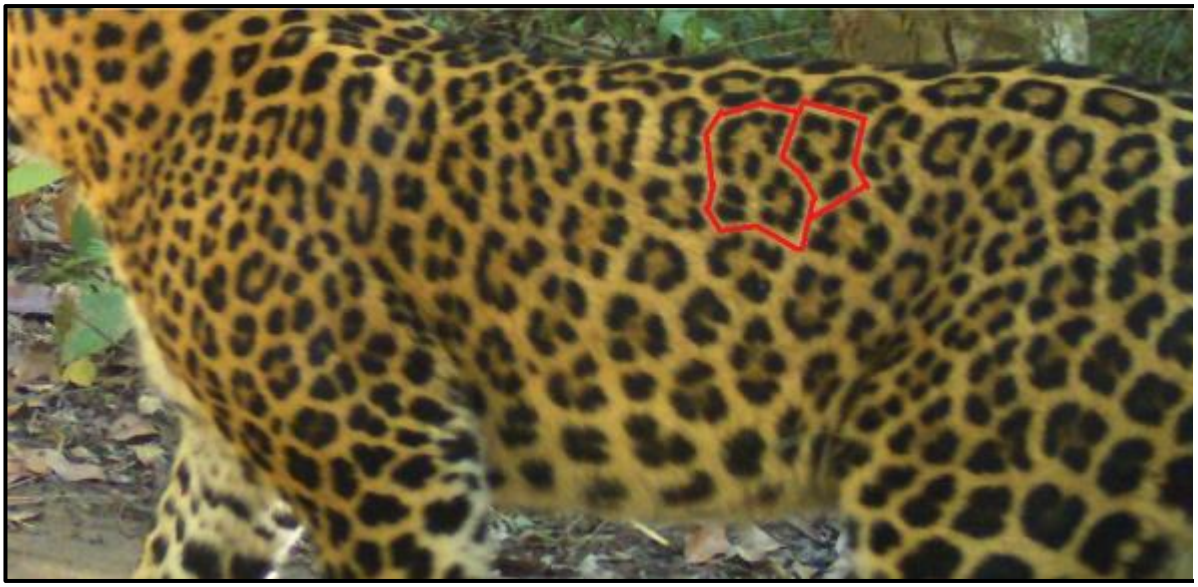


Right Flank Identification

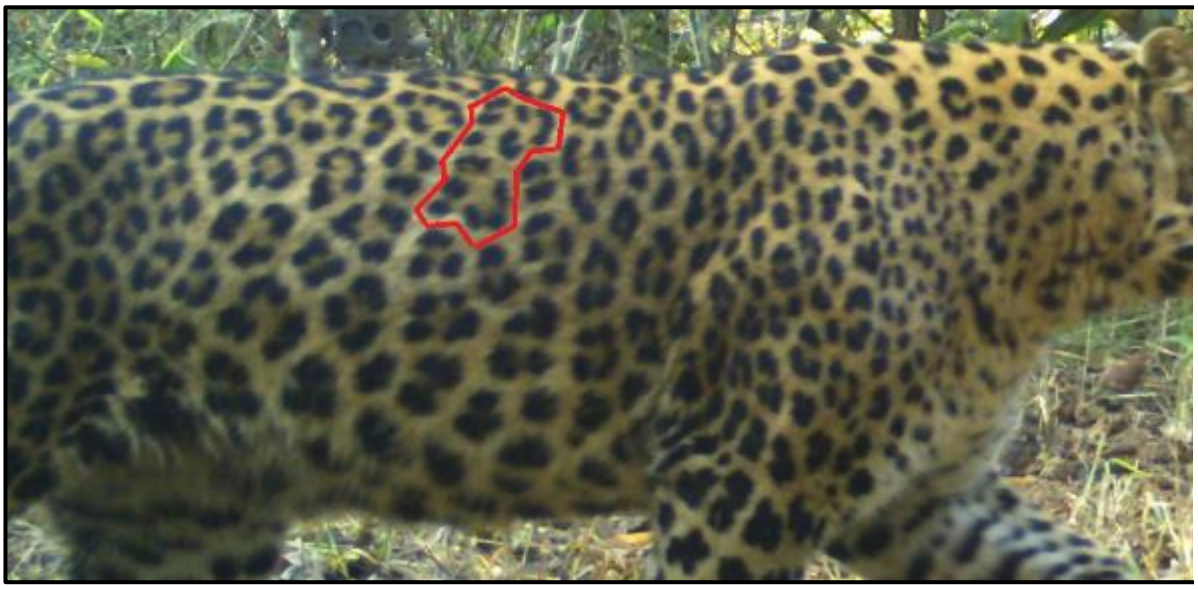
Leopard I.D. – L26 (Gender - Female)

Left Flank

Right Flank



Left Flank Identification

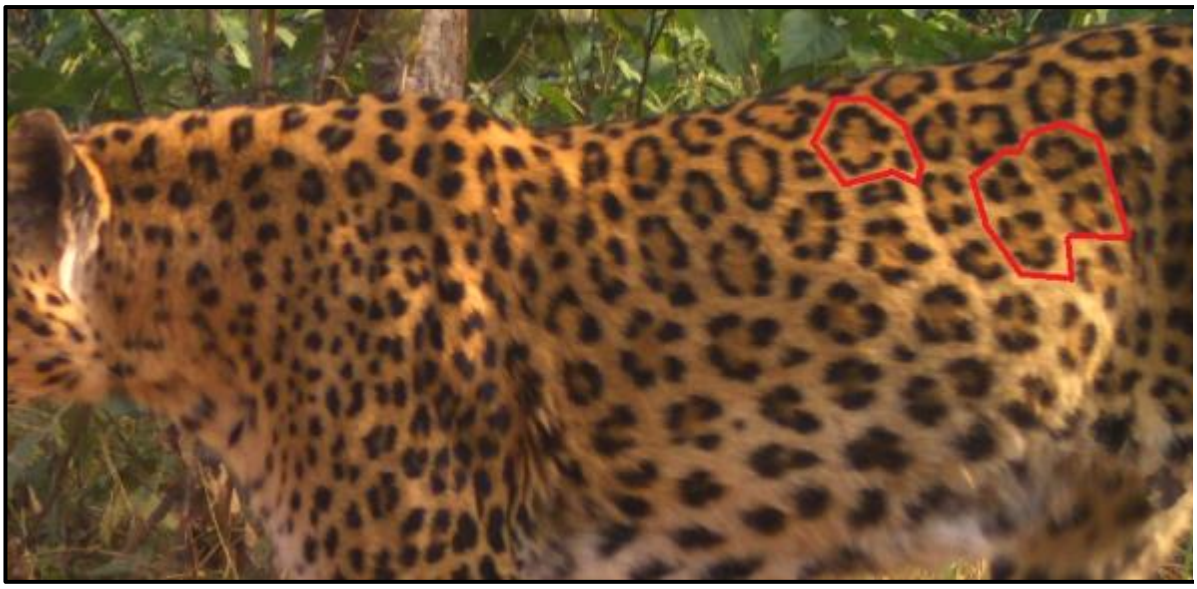


Right Flank Identification

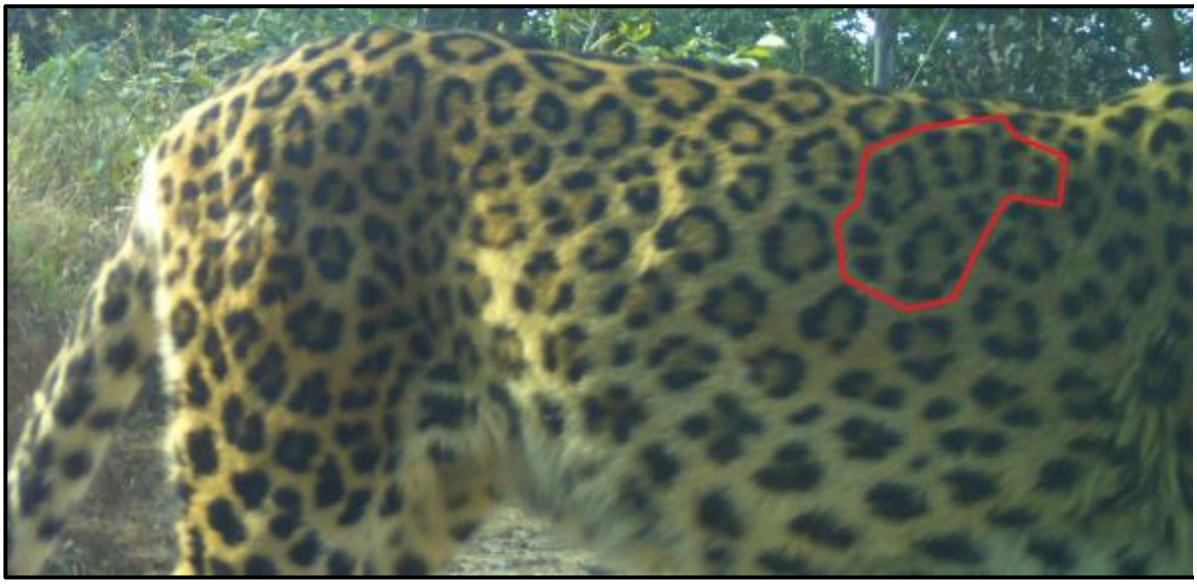
Leopard I.D. – L27 (Gender - Female)

Left Flank

Right Flank



Left Flank Identification



Right Flank Identification

Leopard I.D. – L28 (Gender - Female)

Left Flank

Right Flank

Left Flank Identification

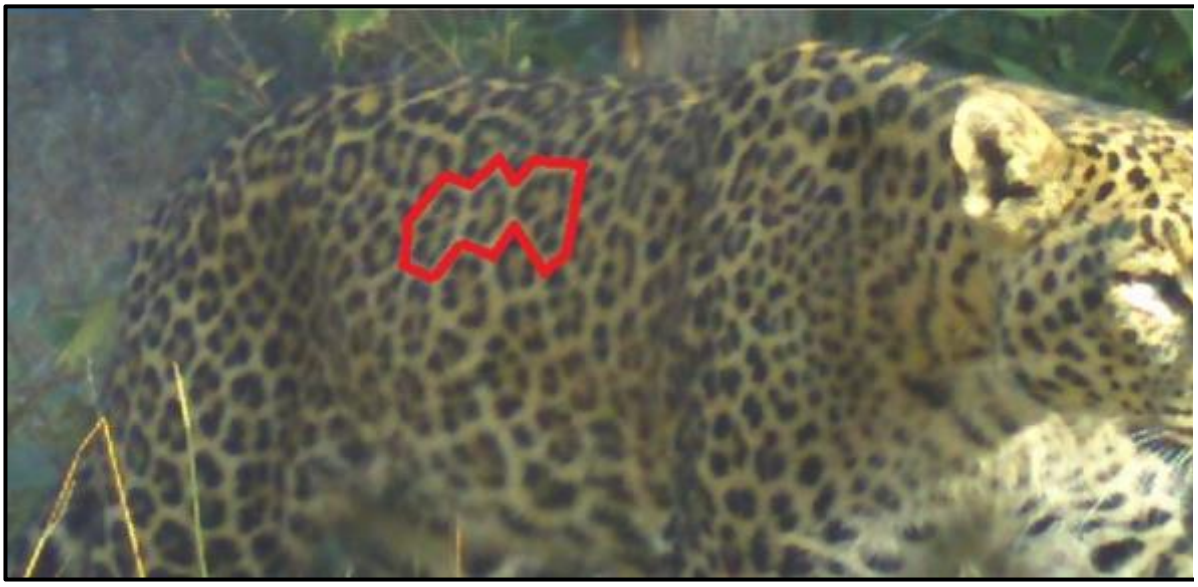
Right Flank Identification

Leopard I.D. – L29 (Gender - Female)

Left Flank

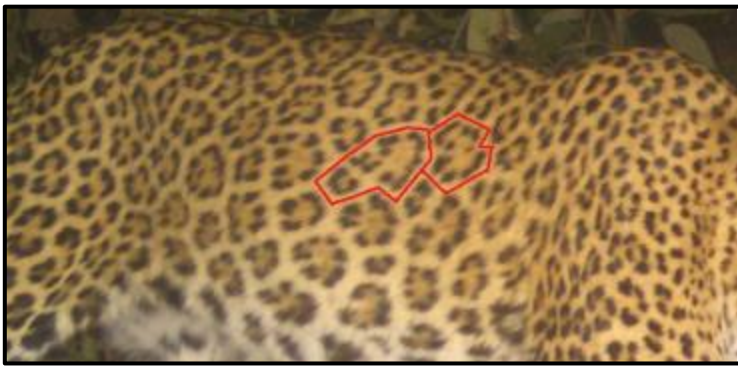
Right Flank

Left Flank Identification



Right Flank Identification

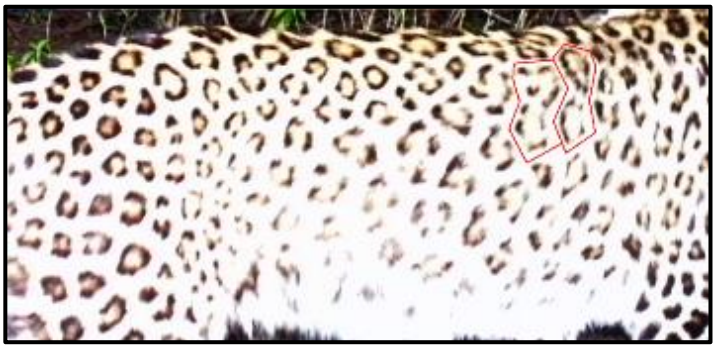
Leopard I.D. – L30 (Gender – Female)



Right Flank

Right Flank Identification

Leopard I.D. – L31 (Gender – Female)



Uncertain Right Flank

Uncertain Right Flank Identification

Leopard I.D. – L32 (Gender – Female)

Uncertain Right Flank

Uncertain Right Flank Identification

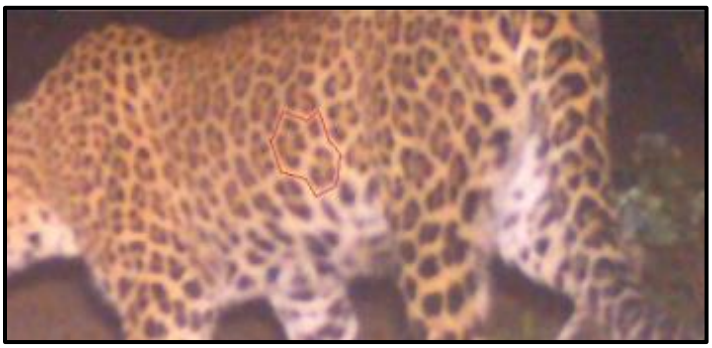
Leopard I.D. – L33 (Gender – Female)

Uncertain Right Flank

Uncertain Right Flank Identification

Leopard I.D. – L34 (Gender - Female)

Uncertain Left Flank



Uncertain Left Flank Identification

Leopard I.D. – L35 (Gender - Female)

Uncertain Left Flank

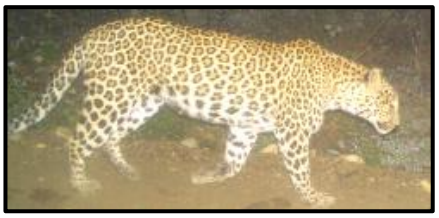
Uncertain Left Flank Identification

Leopard I.D. – L36 (Gender - Female)

Uncertain Right Flank

Uncertain Right Flank Identification

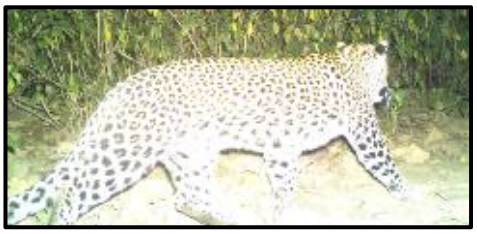
Leopard I.D. – L37 (Gender - Female)



Uncertain Right Flank

Uncertain Right Flank Identification

Leopard I.D. – L38 (Gender - Female)



Uncertain Right Flank

Uncertain Right Flank Identification

Leopard I.D. – L39 (Gender - Female)

Uncertain Right Flank

Uncertain Right Flank Identification

Leopard I.D. – L40 (Gender - Female)

Uncertain Right Flank

Uncertain Right Flank Identification

Leopard I.D. – L41 (Gender - Female)

Uncertain Right Flank

Uncertain Right Flank Identification

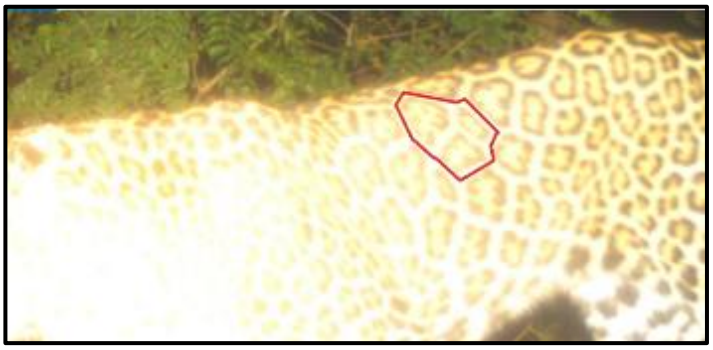
Leopard I.D. – L42 (Gender - Female)

Uncertain Left Flank

Uncertain Left Flank Identification

Leopard I.D. – L43 (Gender - Female)

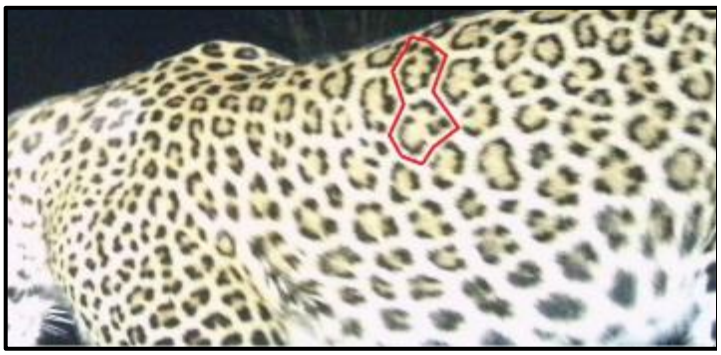
Uncertain Left Flank



Uncertain Left Flank Identification

Leopard I.D. – L45 (Gender - Female)

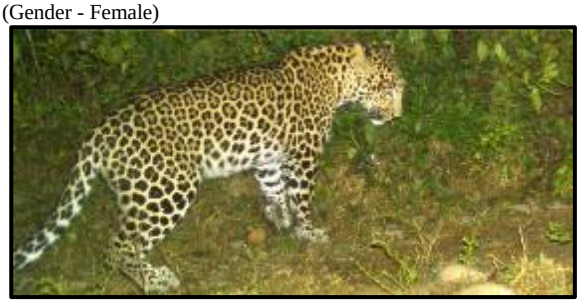
Uncertain Left Flank



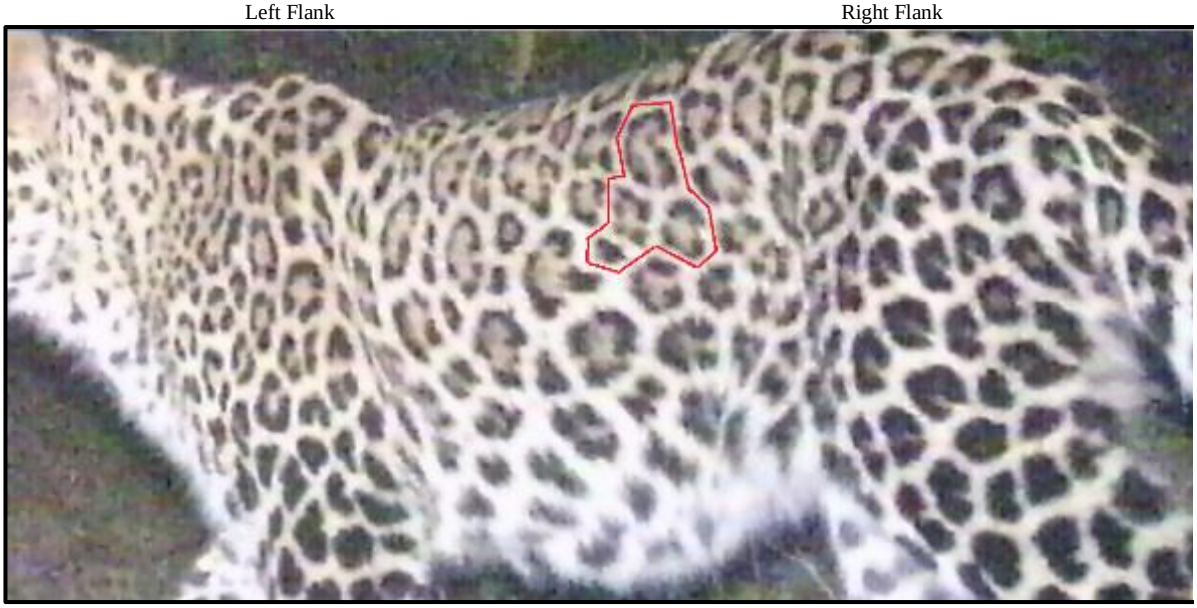
Uncertain Left Flank Identification

Leopard I.D. – L44 (Gender - Female)

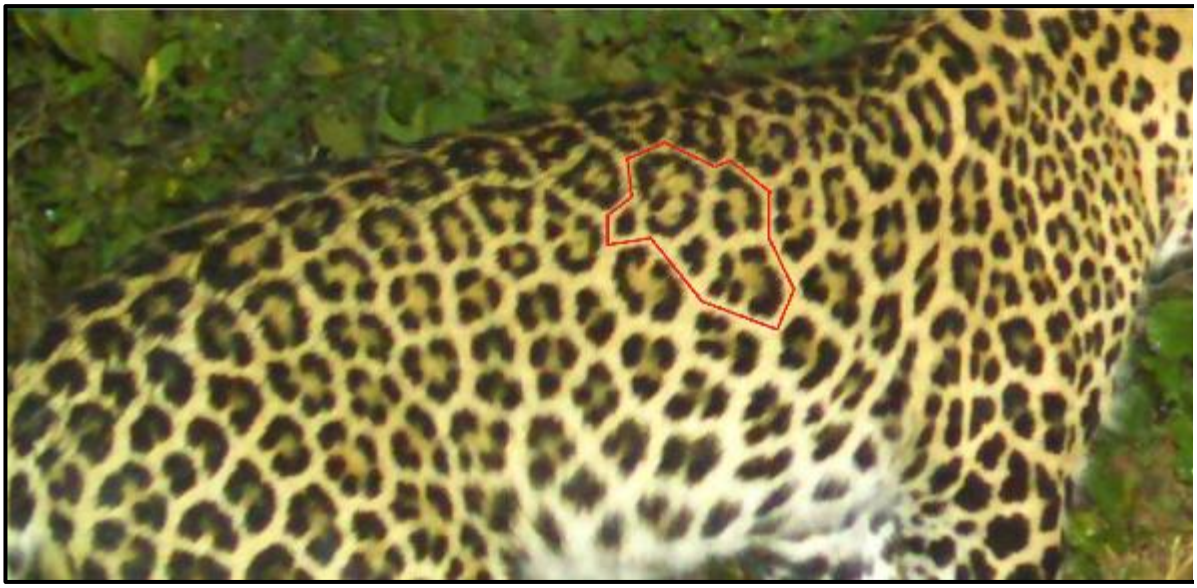
Left Flank



Right Flank



Left Flank Identification



Right Flank Identification

Leopard I.D. – L45 (Cub)

Leopard I.D. – L45 (Cub)

Left Flank

Right Flank

Leopard I.D. – L46 (Cub)

L46 along with L45

Leopard I.D. – L47 (Cub)

Left Flank

Right Flank

Leopard I.D. – L48 (Cub)

Left Flank

Leopard I.D. – L49 (Cub)

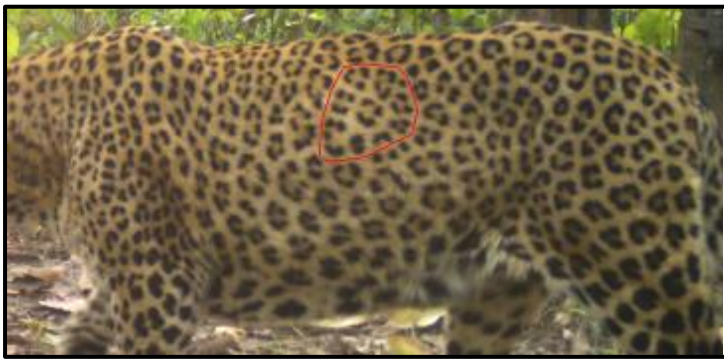
Left Flank

Leopard I.D. – L50 (Cub)

Left Flank

Leopard I.D. – L51 (Gender - Male)

Left Flank

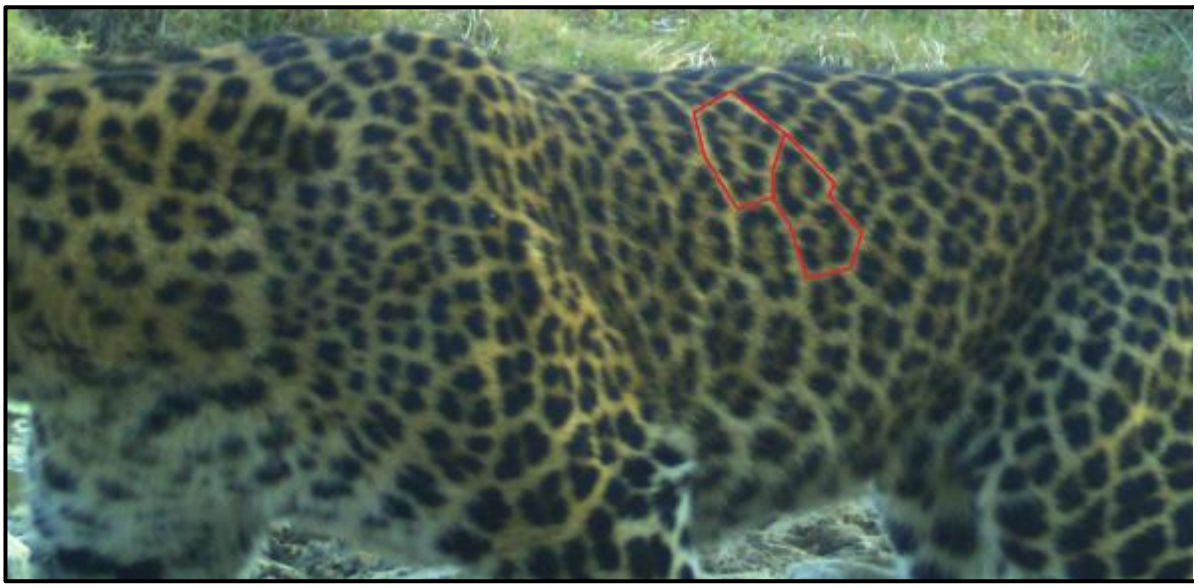


Left Flank Identification

Leopard I.D. – L52 (Gender - Female)

Left Flank

Right Flank



Left Flank Identification

Right Flank Identification

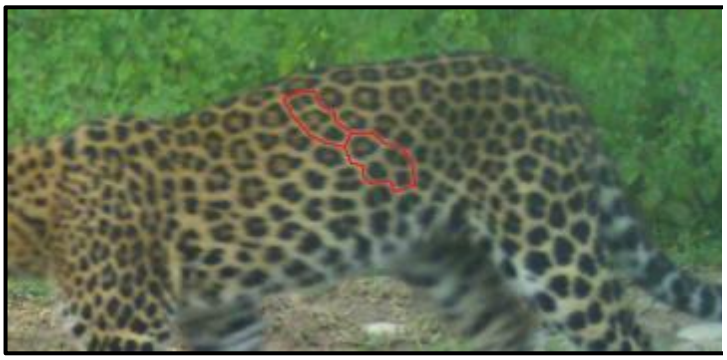
Leopard I.D. – L53 (Gender - Female)

Uncertain Left Flank

Uncertain Left Flank Identification

Leopard I.D. – L54 (Gender - Male)

Uncertain Left Flank

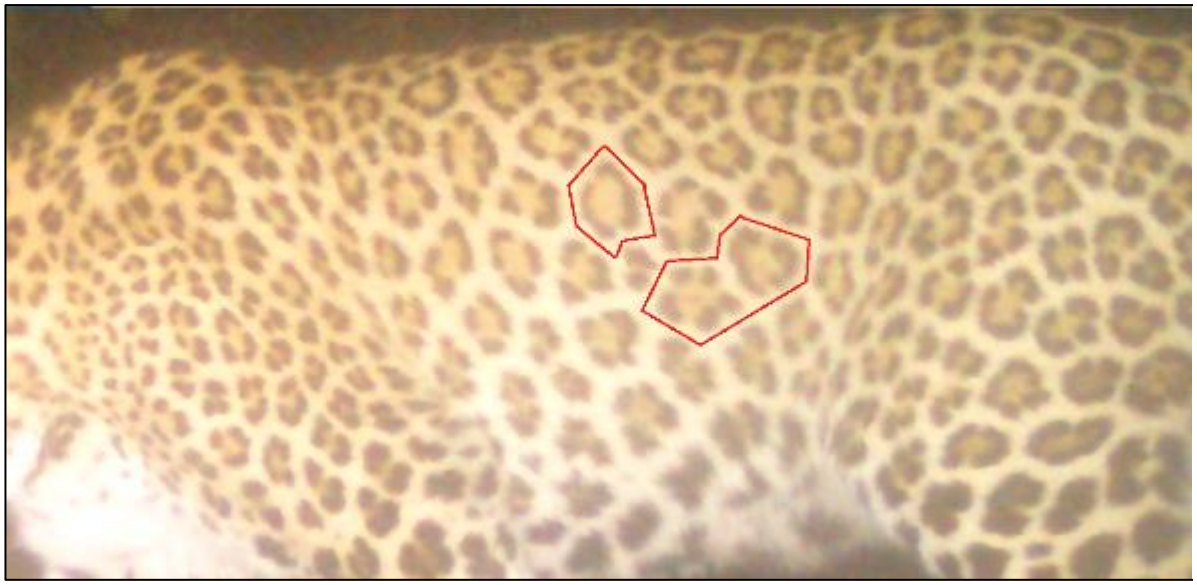


Uncertain Left Flank Identification

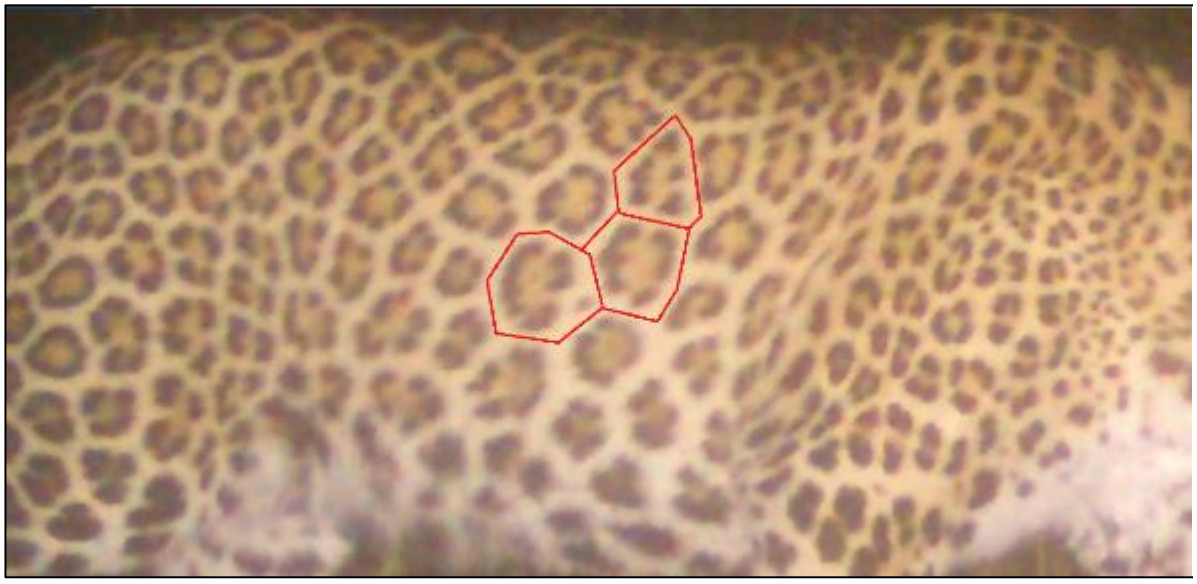
Leopard I.D. – L55 (Gender - Female)

Left Flank

Right Flank



Left Flank Identification



Right Flank Identification

4.7 “Human Leopard Conflict” assessment – conflict locations

S. no.	Name	Dept code	Time	Date	Month	Year	Order of occurrence	GPS
1	001	D14	16:00:00	15	4	2018	25	30°03’06.0” N 078°13’05.1” E
2	002	D7	06:00:00	6	9	2015	14	30°02’05.5” N 078°13’01.3” E
3	003	D10	04:00:00	18	11	2016	20	30°03’15.8” N 078°13’08.5” E
4	004	D4	06:30:00	29	3	2015	9	30°03’17.2” N 078°13’04.9” E
5	005	D17	19:00:00	14	6	2018	28	30°03’08.6” N 078°13’25.5” E
6	006	D9	17:00:00	28	9	2016	18	30°03’04.0” N 078°12’48.4” E
7	007	D6	04:00:00	15	6	2015	11	30°02’50.6” N 078°12’52.5” E
8	008	D15	10:30:00	9	5	2018	26	30°02’39.2” N 078°13’17.0” E
9	009	D5	15:00:00	8	6	2015	10	30°02’34.8” N 078°13’37.8” E
10	010	D18	16:30:00	9	7	2018	29	30°02’24.5” N 078°13’27.9” E
11	012	D12	18:30:00	18	5	2017	23	30°02’45.4” N 078°12’45.2” E
12	013	D19	18:00:00	26	7	2018	30	30°00’44.6” N 078°12’07.2” E
13	014	D1	18:00:00	29	3	2014	4	30°01’28.8” N 078°13’23.8” E
14	015	A1	19:30:00	6	3	2014	1	30°00’58.0” N 078°13’07.6” E
15	016	A11	06:00:00	5	1	2017	21	30°02’00.5” N 078°12’23.2” E
16	017	D3	18:30:00	12	2	2015	8	30°00’51.2” N 078°12’16.0” E
17	018	A9	18:00:00	11	9	2016	17	30°00’45.0” N 078°12’11.2” E
18	019	D16	15:30:00	21	5	2018	27	30°01’34.9” N 078°12’20.2” E
19	020	A12	10:30:00	6	12	2018	31	30°01’28.3” N 078°12’13.5” E
20	021	D13	02:00:00	19	12	2017	24	30°01’36.7” N 078°12’19.0” E
21	022	D11	13:30:00	3	5	2017	22	30°01’18.9” N 078°12’08.6” E
22	023	A8	07:00:00	19	1	2016	15	30°00’35.5” N 078°11’10.6” E
23	024	D8	18:00:00	25	2	2016	16	30°00’34.0” N 078°11’10.3” E
24	025	D2	20:00:00	24	10	2014	7	30°01’37.7” N 078°13’18.9” E
25	026	A3	22:30:00	23	3	2014	3	30°01’21.8” N 078°13’28.2” E
26	027	A2	20:30:00	7	3	2014	2	30°01’30.4” N 078°13’52.5” E
27	028	A4	17:30:00	24	4	2014	5	30°01’43.9” N 078°13’47.2” E
28	029	A5	19:00:00	28	8	2014	6	30°01’26.2” N 078°14’15.8” E
29	030	A7	19:30:00	21	8	2015	13	30°02’46.4” N 078°14’05.9” E
30	031	A10	18:00:00	25	10	2016	19	30°02’43.6” N 078°12’31.0” E
31	032	A6	23:30:00	19	6	2015	12	30°02’36.9” N 078°12’38.2” E

Table 4.11 Conflict locations in Rajaji Tiger Reserve since 2014.

S. No.	Nearest FC	Nearest dist	Dis_other_road	Dis_NH	Dis_Rail	Dis Settlements	Mean NDVI (Mar)	Mean NDVI (Oct)	Mean NDWI (Mar)	Mean NDWI (Oct)	Slope	Elevation
1	NH	14.85	33.35	14.85	231.22	370	0.223	0.332	0.191	0.286	2.957	344
2	roads except NH	37.04	37.04	63.13	302.80	362	0.166	0.201	0.152	0.169	4.343	339
3	NH	29.22	81.12	29.22	331.34	48	0.223	0.314	0.202	0.276	2.771	343
4	NH	50.74	316.65	50.74	576.24	65	0.167	0.287	0.153	0.25	1.945	341
5	roads except NH	14.61	14.61	475.40	217.06	0	0.238	0.327	0.211	0.285	0.344	336
6	NH	308.45	332.34	308.45	571.87	287	0.19	0.334	0.172	0.29	6.064	346
7	NH	20.53	28.39	20.53	279.12	60	0.213	0.311	0.188	0.271	0	343
8	roads except NH	57.62	57.62	1287.46	1091.15	126	0.228	0.389	0.2	0.334	3.093	330
9	roads except NH	232.72	232.72	1348.00	1092.41	515	0.256	0.265	0.223	0.231	3.841	329
10	roads except NH	169.90	169.90	1109.91	913.31	249	0.19	0.412	0.171	0.353	1.945	333
11	NH	54.29	214.29	54.29	369.27	192	0.194	0.35	0.167	0.298	6.318	343
12	roads except NH	65.15	65.15	537.22	502.89	67	0.257	0.424	0.228	0.366	8.564	335
13	roads except NH	43.74	43.74	1758.32	1686.09	0	0.226	0.35	0.221	0.313	2.431	329
14	roads except NH	14.51	14.51	1686.10	1569.31	0	0.338	0.343	0.302	0.305	2.063	332
15	railway line	18.21	210.08	121.40	18.21	89	0.298	0.377	0.267	0.331	6.259	346
16	roads except NH	1.03	1.03	646.63	617.44	11	0.292	0.319	0.267	0.282	2.917	334
17	roads except NH	0.54	0.54	605.55	570.95	17	0.248	0.428	0.224	0.37	3.169	331
18	roads except NH	26.33	26.33	29.46	103.78	0	0.221	0.36	0.199	0.311	7.219	358
19	NH	46.82	295.83	46.82	169.01	270	0.239	0.356	0.204	0.306	4.768	361
20	roads except NH	6.35	6.35	30.37	159.34	60	0.232	0.325	0.214	0.286	2.503	360
21	NH	4.53	323.71	4.53	92.37	204	0.226	0.348	0.192	0.298	2.771	360
22	roads except NH	70.00	70.00	521.98	500.00	73	0.188	0.326	0.179	0.287	5.655	353
23	roads except NH	0.03	0.03	319.17	277.23	0	0.258	0.364	0.231	0.317	8.27	353
24	roads except NH	116.00	116.00	1608.48	1482.10	93	0.315	0.324	0.276	0.289	4.854	335
25	roads except NH	214.90	214.90	1541.74	1430.85	154	0.231	0.421	0.222	0.364	2.202	335
26	roads except NH	43.35	43.35	2301.57	2214.67	0	0.327	0.331	0.294	0.292	0	320
27	roads except NH	125.87	125.87	1992.74	1915.77	0	0.387	0.342	0.345	0.305	4.135	322
28	roads except NH	365.51	365.51	2900.45	2820.41	169	0.29	0.351	0.264	0.307	0	312
29	roads except NH	1.90	1.90	806.56	547.90	12	0.234	0.282	0.205	0.246	1.032	332
30	railway line	73.83	185.64	387.75	73.83	68	0.194	0.367	0.181	0.318	4.463	356
31	roads except NH	21.56	21.56	73.24	79.41	17	0.169	0.276	0.165	0.245	1.459	344

Table 4.12 Data of Spatial features of Conflict locations in Rajaji Tiger Reserve since 2014.