Akola Forest Division, Maharashtra

Status of Tigers, CoPredators & Prey

2021

Report Title:
Status of Tigers, Co-Predators and Prey in Akola Wildlife Division

Project Title:
Long-term monitoring of tigers, co-predators and prey in tiger bearing areas of Vidarbha, Maharashtra

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Executive Summary

Phase IV monitoring for Akola Wildlife Division was conducted from February – May 2021 covering an area of 300 sq. km. as a part of the project "Long-term Monitoring of Tigers, Co-Predators and Prey in Tiger Reserves and other Tiger bearing areas of Vidarbha, Maharashtra". The objective of the Phase IV Monitoring is to estimate the minimum number of tigers in the reserve using Capture-Recapture Sampling and density estimation of prey base using Distance Sampling.

A total of 103 camera traps (pairs) were placed in the 4 wildlife sanctuaries (viz. Dnyanganga WLS, Katepurna WLS, Karanja-Sohol WLS and Lonar WLS) of Akola Wildlife Division following a sampling grid of 2 sq. km. In each wildlife sanctuary, camera traps were active for 25-30 days. During 90 days of camera trapping survey with a sampling effort of 3,090 trap nights, 42 adult individual leopards were photographed in Akola Wildlife Division. 28 adult individual leopards were photographed in Dnyanganga WLS and population size (N) based on the best fit (SECR Heterogeneity) model was 28 (SE ± 1.0). 9 adult individual leopards were photographed in Katepurna WLS and population size (N) based on the best fit (SECR Null) model was 10 (SE ± 1.27). 3 and 2 adult individual leopards were photographed in Karanja-Sohol WLS and Lonar WLS respectively. Leopard density per 100 sq. km. based on the Spatially Explicit Capture-Recapture (SECR) model was 13.42 (SE ± 2.56) and 25.61 (SE ± 8.85) for Dnyanganga WLS and Katepurna WLS respectively.

To estimate prey density in Dnyanganga WLS, 42 line transects were sampled times 6-7 during the sampling period, with a total walking effort of 513 km. Overall during the sampling, 336 animal/bird observations were made. The overall density of major prey species (Wild Boar 14.90/sq. km., Nilgai 12.51/sq. km., Peafowl 2.79/sq. km., Chinkara 1.40/sq. km. and Four Horned Antelope 1.33/sq. km.) as estimated using distance sampling was 24.19 /sq. km.

A basic understanding of sympatric carnivore ecology with asymmetric competition enables us to hypothesize that to coexist and not just co-occur there must be niche segregation on at least one of the three axes: space, time, and/or diet. To understand how large sympatric predators co-occur in space and in time, camera trapping was carried out. Temporal activity overlaps were derived by using kernel density. Leopards were found in all 4 wildlife sanctuaries. There was a distinct difference in the space-use pattern observed for all three carnivores and a strong spatial segregation pattern found between Leopards, Hyenas and Dholes. It showed significant segregation and avoidance of each other's space. While leopards show a strong, bimodal, nocturnal activity pattern, Hyenas have a strong, unimodal activity pattern in Dnyanganga WLS. In Katepurna WLS, leopards show a strong unimodal, nocturnal activity pattern and dholes show a bimodal, crepuscular activity pattern.

1. Introduction

The tiger (*Panthera tigris*) is the largest extant cat species. 100 years ago it was easy to see a tiger in its natural habitat - around 100,000 of them roamed across Asia, including several sub-species that are now extinct. Today the number of tigers in the wild has declined exponentially. The remaining population of tigers is threatened by habitat destruction and habitat fragmentation. They require large patches of undisturbed territories to sustain their dietary needs. While tigers are generally found throughout Southeast Asia and China, India remains the most prolific home of these magnificent animals and also boasts of having the highest population.

Being a charismatic umbrella species, the tiger is also a crusader for the protection of other species. India is known to harbour the highest population of tigers amongst the 13 range countries in Asia; Central India is one of the last strongholds of the big cat. As an apex predator, the tiger shapes the community structure of the ecosystem. It also prevents over-grazing by limiting herbivore numbers and maintains the ecological integrity of the ecosystem.

The tiger bearing areas of Vidarbha (Fig. 1) include Melghat Tiger Reserve, Pench Tiger Reserve Maharashtra, Bor Tiger Reserve, Navegaon-Nagzira Tiger Reserve, Tadoba-Andhari Tiger Reserve, Umred-Pauni-Karhandla Wildlife Sanctuary, Tipeshwar Wildlife Sanctuary, Pandharkawada (Territorial) Forest Division, and Bramhapuri (Territorial) Forest Division. Vidarbha holds two-thirds of Maharashtra's mineral resources and three-quarters of its forest resources and is a net producer of power. It has a forest cover of 28% and a tiger number of 315 despite having a human population of more than 5.2 million.

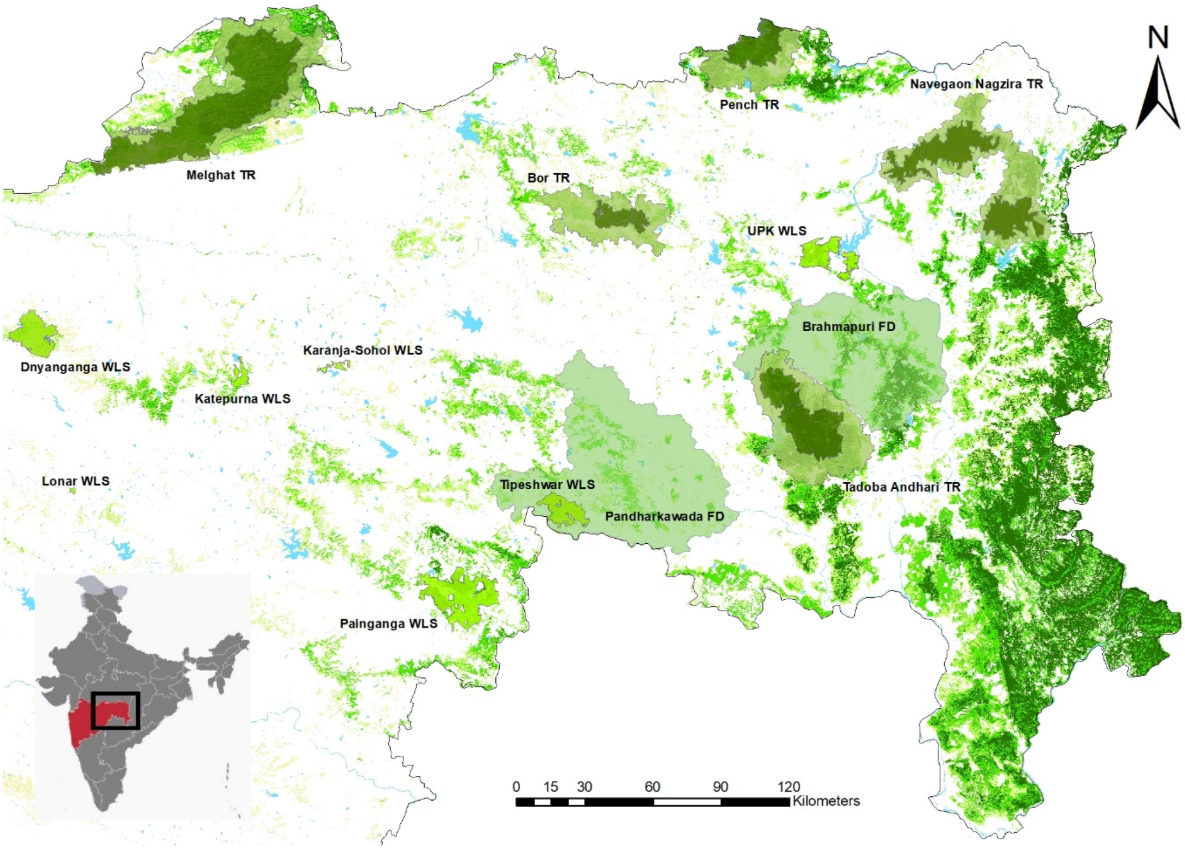

Figure 1: Map of study area showing study sites in Vidarbha Landscape, Maharashtra, India

Akola Wildlife Division lies in the Akola, Buldhana, and Washim districts of the Vidarbha region of Maharashtra. It has 4 wildlife sanctuaries (viz. Dnyanganga WLS, Katepurna WLS, Karanja-Sohol WLS, and Lonar WLS) and is an important leopard habitat in the Central Indian Landscape. The division has a unified area of 300 sq. km. (*Fig. 2*). Akola Wildlife Division is under the unified control of the Field Director - Melghat with the office located at Amravati. Administratively, Akola Wildlife Division has 4 wildlife sanctuaries viz. Dnyanganga WLS (205 sq. km.), Katepurna WLS (73.69 sq. km.), Karanja-Sohol WLS (18.32 sq. km.) and Lonar WLS (3.8 sq. km.).

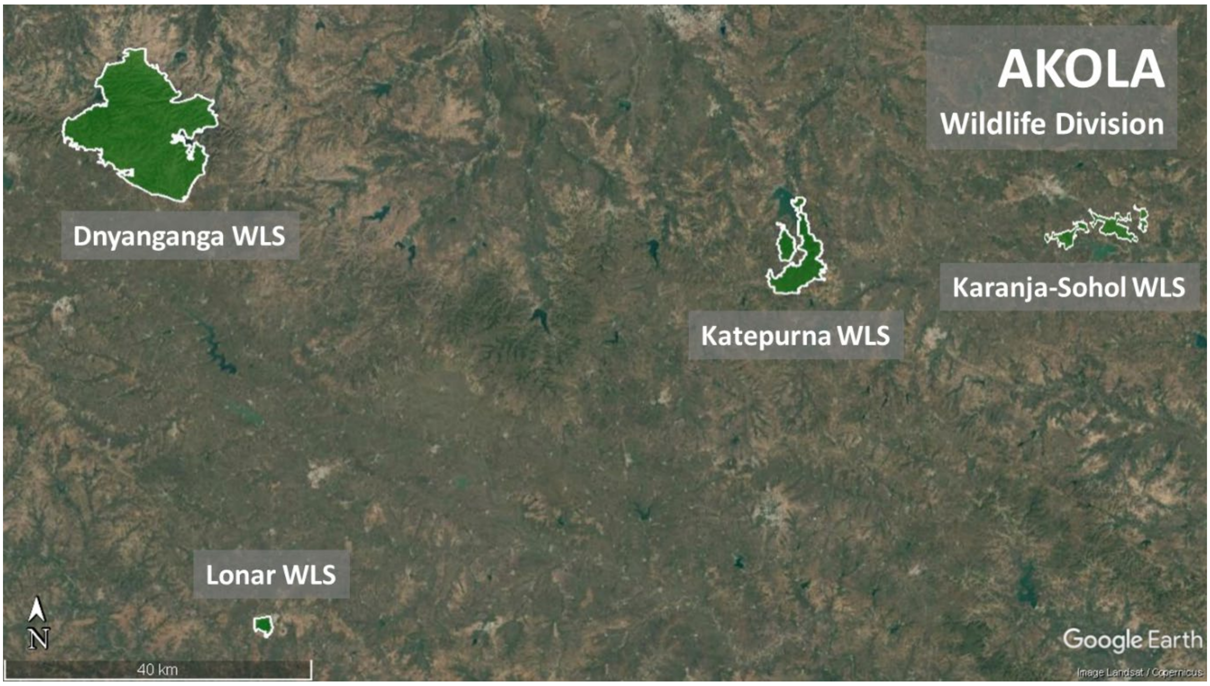

Figure 2: Map depicting different wildlife sanctuaries of Akola Wildlife Division

Dnyanganga Wildlife Sanctuary is situated between Buldhana and Khamgaon towns of Maharashtra. It derives its name from the River Dnyanganga which is a tributary of River Tapi. There are two lakes in the sanctuary which form the catchment area of Matargaon Dam and Paldhag Dam. The terrain is undulating, interspersed with hillocks having gentle slopes.

Katepurna Wildlife Sanctuary is situated in the Akola district of Maharashtra. It derives its name from the River Katepurna, which flows south to Northward almost through the central part of the sanctuary. This sanctuary is in the catchment area of the perennial Katepurna reservoir. The landscape is undulating with a combination of plateau and plains.

Karanja-Sohol Wildlife Sanctuary is situated in the Washim district of Maharashtra. It derives its name from Karanja town & Sohol village. The sanctuary is a part of the catchment area of the Aadan reservoir of River Aadan. The terrain is gently undulating with open grasslands and woodlands.

Lonar Wildlife Sanctuary is situated near Mehkar town in the Buldhana district of Maharashtra. It derives its name from the mythological demon '*Lonasura'*. The sanctuary surrounds the basaltic rock crater lake formed due to meteorite impact. The lake was declared a Ramsar site in 2020. The terrain is wetlands near the crater lake and steep basaltic outcrops surrounding it.

As a part of the research project titled "Long-term monitoring of Tigers, Co-predators and prey in Tiger reserves and other Tiger bearing areas of Vidarbha, Maharashtra", the Wildlife Institute of India has initiated this study in 2019 having the objectives that are as follows:

Objective 1: Status of tigers, co-predators and their prey in the landscape

a) Field surveys will be conducted to detect the presence of tigers, co-predators and prey species using animal signs (tracks, scats, direct sightings, calls etc) in occupancy-based framework. The data will be analysed in the occupancy framework to estimate the occupancy of the target species. Single season or multiple season occupancy models will be used depending on data collection approaches. These occupancy field surveys will be carried in all the tiger areas. The data collection will be followed by modelling and estimation approaches described in detail by Mackenzie et al., (2002, 2006).

b) Density, abundance and demography of tigers and co-predators will be carried by using camera traps in all the tiger areas followed by analysing the data in capture–recapture frame work. Rigorous field methods will be followed to achieve a small CV and high precision. These field surveys will be conducted in all the tiger areas.

c) Estimation of abundance and density of the key ungulate species will be conducted using distance sampling employing line-transect survey protocols. The survey protocols and analyses of this data set will be based on modelling and estimation approaches developed by Buckland et al. (2001, 2004).

d) Estimation of recruitment, survival, transience, temporary emigration, permanent emigration and dispersal rates of tigers and leopards will be based on data collected from camera trapping and radio-telemetry.

e) Scat analysis is indirect, non-invasive and unbiased technique for recording frequency of occurrence of prey in the diet of large carnivores and hence it is most widely used (Johnson et al., 1983; Leopold and Krausman, 1986; Jhala, 1993; Mukherjee et al., 1994a, b; Spaulding et al., 1997; Jethva, 2002; Biswas and Sankar, 2002). Scats will be collected at regular time intervals, generally every week. The scats will be collected in polythene bags, labelled and sun-dried in the field. Information on habitat, substratum where scat will be found and its GPS location will also be recorded.

Objective 2: Development of database on tigers across the landscape

a) The photo database generated by the methodology delineated in 1b above will be collated at every tiger area level. Identification of unique individuals will be done from these collated photographs and a database of identified tiger individuals will be generated. New photographs from every camera trapping session will be compared with the existing database, whereby recaptured individuals will be noted and any new individuals found will be added to the database.

Objective 3: Identification of tiger dispersal in the landscape

a) On an event when a previously captured individual goes missing in pictures from the current camera trapping exercise, or when a new individual is discovered, it will be cross-checked against tiger databases of adjoining areas. This will enable us to find out if a missing individual has dispersed to a new area.

Objective 4: Development of feedback for management intervention at reserve and landscape level

a) The outputs of the project will help in developing management feedback for the State of Maharashtra to effectively manage tiger populations.

2. Status of Prey Species in Akola Wildlife Division

Introduction:

The distribution and density of carnivores depend on the availability of wild ungulate prey in an area. Moreover, ungulates play an important role in maintaining ecosystems by influencing the vegetation structure, plant species composition and nutrient cycling (McNaughton 1979; Bagchi and Ritchie 2010). Maintaining and monitoring ungulate populations is, therefore, an important objective of conservation management. In this survey, prey species estimation was carried out using the line-transect based conventional distance sampling method (Buckland et al., 2004). Line transect sampling is a widely used technique to census wildlife populations.

The prey status survey was conducted in Akola Wildlife Division for Dnyanganga WLS which lies in Buldhana district in the Vidarbha region of Maharashtra. The River Dnyanganga flows through a forest that lies within the catchment area of the river system. According to Champion & Seth classification, the forests of Dnyanganga WLS belong to subgroup 5A-Southern tropical dry deciduous forest. Teak (*Tectona grandis*) is the most dominant species of these forests. There are open dry grassland areas as well in the sanctuary.

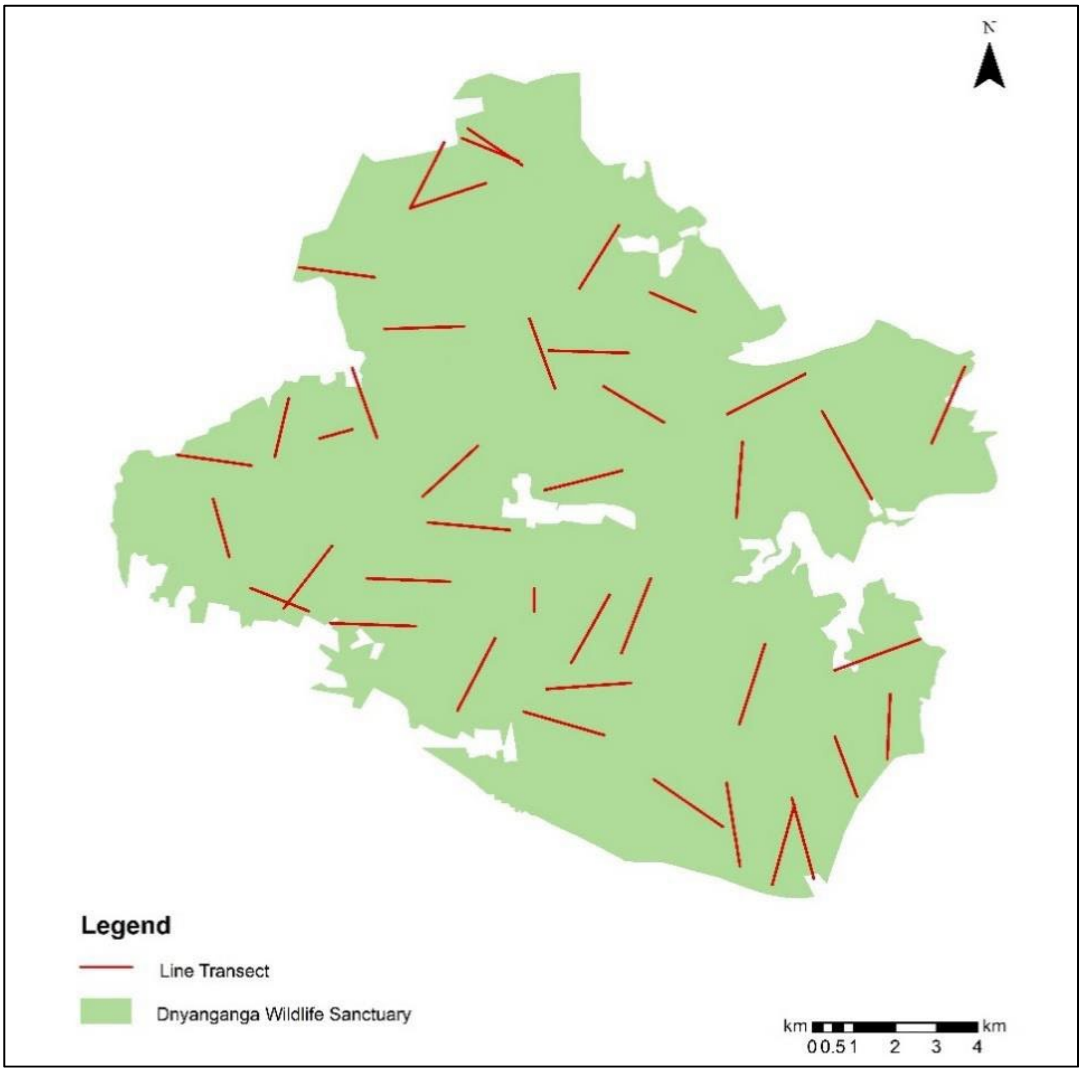

Figure 3: Location of line transects in Dnyanganga Wildlife Sanctuary, Maharashtra, India

Distance Sampling:

Distance sampling is the most established method to estimate the density of ungulates in an area using line-transect method. Line transects are laid randomly over the total forest area assuming that all vegetation types existing in the area are represented while marking these lines. Sightings of prey species observed while walking on these lines are recorded along with habitat and terrain features.

A total of 42 transects of 2 km length were marked and monitored in 20 beats of Dnyanganga Wildlife Sanctuary. Figure 3 shows the distribution of line transects across Dnyanganga WLS. Transects are well spread over an area of 205 sq. km. of Dnyanganga Wildlife Sanctuary covering almost all the vegetation types in the area. Each line transect was walked 6-7 times during the period from 7th – 12th March 2021 to record prey species across the whole area of Dnyanganga Wildlife Sanctuary. Thus, a total walking effort of 513 km (Table 1) was invested in line transect surveys which generated a total of 336 observations of all types of prey species. This includes the major prey species like Wild Boar (*Sus scrofa*), Nilgai (*Boselaphus tragocamelus*), Chinkara (*Gazella bennettii*) Four Horned Antelope (*Tetracerus quadricornis*), and Peafowl (*Pavo cristatus*). Langur (*Semnopithecus* spp.), Spotted Deer (*Axis axis*), Indian Hare (*Lepus nigricollis*), and Blackbuck (*Antelope cervicapra*) were also found in Dnyanganga Wildlife Sanctuary.

Table 1: Transect monitoring effort and species reported from Dnyanganga Wildlife Sanctuary, Maharashtra, India during Phase IV monitoring 2021

Survey Details	
Number of transects	42
Length of each transect	2 km
Number of replicates	6-7
Total distance covered	513
Beats	20
Number of species recorded	8

During the transect walk data on species, the number of animals seen, group composition, the bearing of the animal, and angular sighting distance was recorded by ocular estimation. To give spatial reference to every observation Global Positioning System (GPS) was used. The GPS coordinates of the transects were also recorded.

During the transect exercise of Dnyanganga Wildlife Sanctuary in 2021, a total of 336 sightings of 8 major prey species were recorded. Nilgai was the most frequently recorded species with 129 sightings. The maximum number of individuals was also recorded of Nilgai (Table 2). Moreover, during the transect survey carnivore species such as leopard, hyena, and sloth bear were also sighted. Due to the low number of sightings of Spotted Deer, Langur, Rhesus Macaque, and Indian Hare were excluded from distance analysis. Line transect data were analysed for Nilgai Four Horned Antelope, Chinkara, Wild Boar and Peafowl.

Table 2: Details of species recorded in the Dnyanganga Wildlife Sanctuary Phase IV 2021

Species Recorded	Number of Sightings	Individuals recorded
Nilgai	129	641
Rhesus Macaque	17	227
Four Horned Antelope	53	120
Chinkara	35	71
Indian Hare	26	27
Wild Boar	43	468
Langur	17	227
Peafowl	33	192

All prey (sum of all the individual prey species density) density estimated is 24.19 per sq. km. The density of Wild Boar (14.90±10.75) was highest followed by Nilgai (12.51±3.83), Peafowl (2.79±0.93), Chinkara (1.40±0.35) and Four Horned Antelope (1.33±0.28) respectively. The Individual Density, Group Density, Effective Strip Width, Average Group Size and Encounter Rate of 5 species reported during the Phase IV Monitoring 2021 in Dnyanganga Wildlife Sanctuary, Maharashtra, India is given in table 3.

Table 3: Individual Density, Group Density, Effective Strip Width, Average Group Size and Encounter Rate of various ungulate species reported from Dnyanganga Wildlife Sanctuary Phase IV 2021

Parameters	Chinkara	Wild Boar	Nilgai	FHA	Peafowl
Individual density (No of Animals/Km^2)	1.40	14.90	12.51	1.33	2.79
Standard error	0.35	10.75	3.83	0.28	0.93
Percent CV	24.80	72.18	30.64	21.46	33.45
95% confidence interval	0.86-2.28	4.06- 54.70	6.93 - 22.59	0.87-2.02	1.46-5.32
Group density (No of groups/Km2)	0.58	0.68	1.77	0.61	0.42
Standard error	0.13	0.48	0.51	0.12	0.11
Percent CV	23.01	70.08	29.02	20.06	27.47
95% confidence interval	0.37-0.92	0.19-2.42	1.00-3.10	0.41- 0.90	0.24- 0.72
Effective strip width	58.23	61.70	70.47	84.40	72.28
Standard error	7.83	42.27	19.63	10.43	10.54
Percent CV	13.45	68.52	27.86	12.36	14.58
95% confidence interval	44.34-76.47	17.63-215.97	41.02-121.06	65.91-108.07	53.75-97.19
Average group size	2.40	21.97	7.08	2.17	6.68
Standard error	0.22	3.80	0.69	0.17	1.27
Percent CV	9.25	17.28	9.81	7.64	19.09
95% confidence interval	1.99-2.90	15.54-31.06	5.83-8.59	1.86-2.5298	4.54-9.83
Encounter rate	0.07	0.08	0.25	0.10	0.06
Percent CV	18.67	14.72	8.13	15.79	23.29
95% confidence interval	0.05-0.10	0.06-0.11	0.21-0.29	0.08-0.15	0.04-0.96

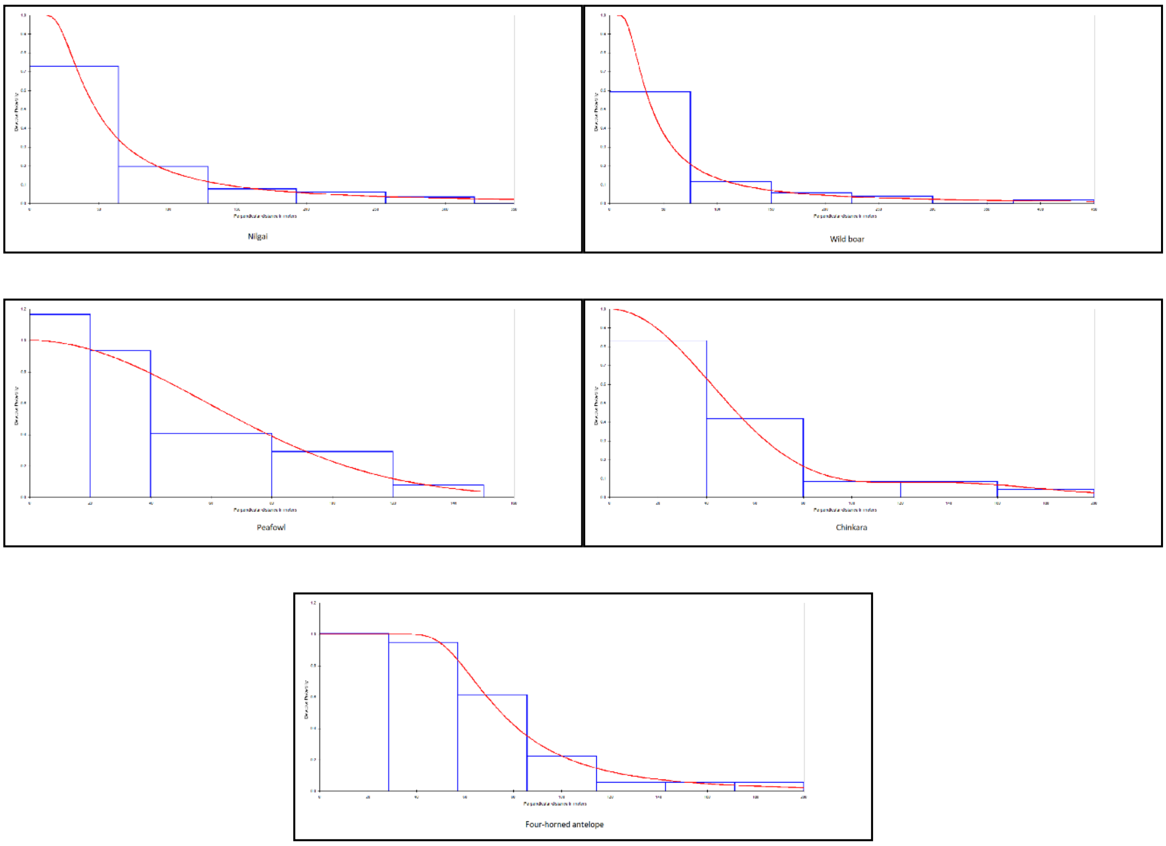

Figure 4: Detection functions of the best-selected model for prey species during prey estimation survey in Dnyanganga Wildlife Sanctuary 2021.

3. Status of Predators in Akola Wildlife Division

Introduction:

Monitoring of large carnivore populations is important to guarantee their survival, to adapt management practices to changing situations, and to fulfill obligations for the conservation of habitat. It is also a very demanding exercise because of the large scales over which it must be conducted, often stretching across huge areas. The combination of biological characteristics of leopards - extensive distributional range, low densities, elusiveness, wide-ranging behaviours, low chances of detection of leopard signs in most situations – poses major challenges to the task of monitoring leopard populations. Typically, over large regions, even results of the mere presence or absence surveys tend to be equivocal or indeterminate. In particular, it is difficult to infer the absence of leopards based on the absence of a leopard sign. The collection of quantitative data on the abundance of leopards or leopard signs is usually handicapped by small sample sizes, low detection probabilities, and numerous logistical and physical constraints. These species occur under a diversity of situations across Akola Wildlife Division and their monitoring hence represents a variety of challenges. The long term monitoring projects are effective in understanding population trends in great detail. The need for long term scientific monitoring of large carnivore populations arises from three considerations:

a) To objectively audit or evaluate the success or failure of earlier management measures and conservation interventions to react adaptively and solve problems (Walters, 1986; Nichols et al., 1995).

b) To establish benchmark data that can serve as a basis for specific objectives for management and conservation efforts and

c) To improve our basic understanding of tiger, co-predator, and prey ecology through rigorous field studies, to develop a body of theoretical knowledge that can generate the predictive capacity to deal with new situations and contributes to the general advancement of scientific knowledge.

Camera Trapping:

Potential locations of camera trap stations were mapped using ArcGIS 9.3 (ESRI, Redlands, CA, USA) based on crucial data provided by the frontline forest staff of Akola Wildlife Division. For Phase IV exercise a total of 103 camera traps (pairs) were deployed in the 4 wildlife sanctuaries (viz. Dnyanganga WLS, Katepurna WLS, Karanja-Sohol WLS, and Lonar WLS) of Akola Wildlife Division (Fig. 5 (a-d)) in a grid size of 2 sq. km. In each wildlife sanctuary, camera traps were active for 25 days. One pair of camera traps was deployed in each location for 25-30 days in the field that resulted in 3,090 trap nights. Five different models of camera traps (CuddeBack C1, CuddeBack Xchange Color, CuddeBack Ambush, CuddeBack Professional Color, and Moultrie 880-c) were used for the above exercise.

The cameras were active for the 24-h periods that accounted for one sampling occasion. Each camera was assigned a unique identification number. Grid and the locations of each station were recorded for spatial analysis. Every leopard photograph was given a unique identification number after examining the rosette pattern on the flanks, limbs, and forequarters (Schaller 1967; McDougal 1977; Karanth 1995). Individual capture histories of leopards were developed in a standard “X-matrix format” (Otis et al., 1978; Nichols 1995). One critical assumption for closed population estimate is that the population should be demographically and geographically closed; (Otis et al., 1978; Rexstad and Burnham 1991) and to follow our closure assumption the sampling duration was kept as a minimum. Capture histories were analyzed using the software R package ‘SECR’ (Efford M.G. 2015) using a model developed for closed populations. The appropriate model was selected based on the Akaike Information Criterion. The density was estimated with the maximum likelihood obtained from the model fitted with 'SECR'.

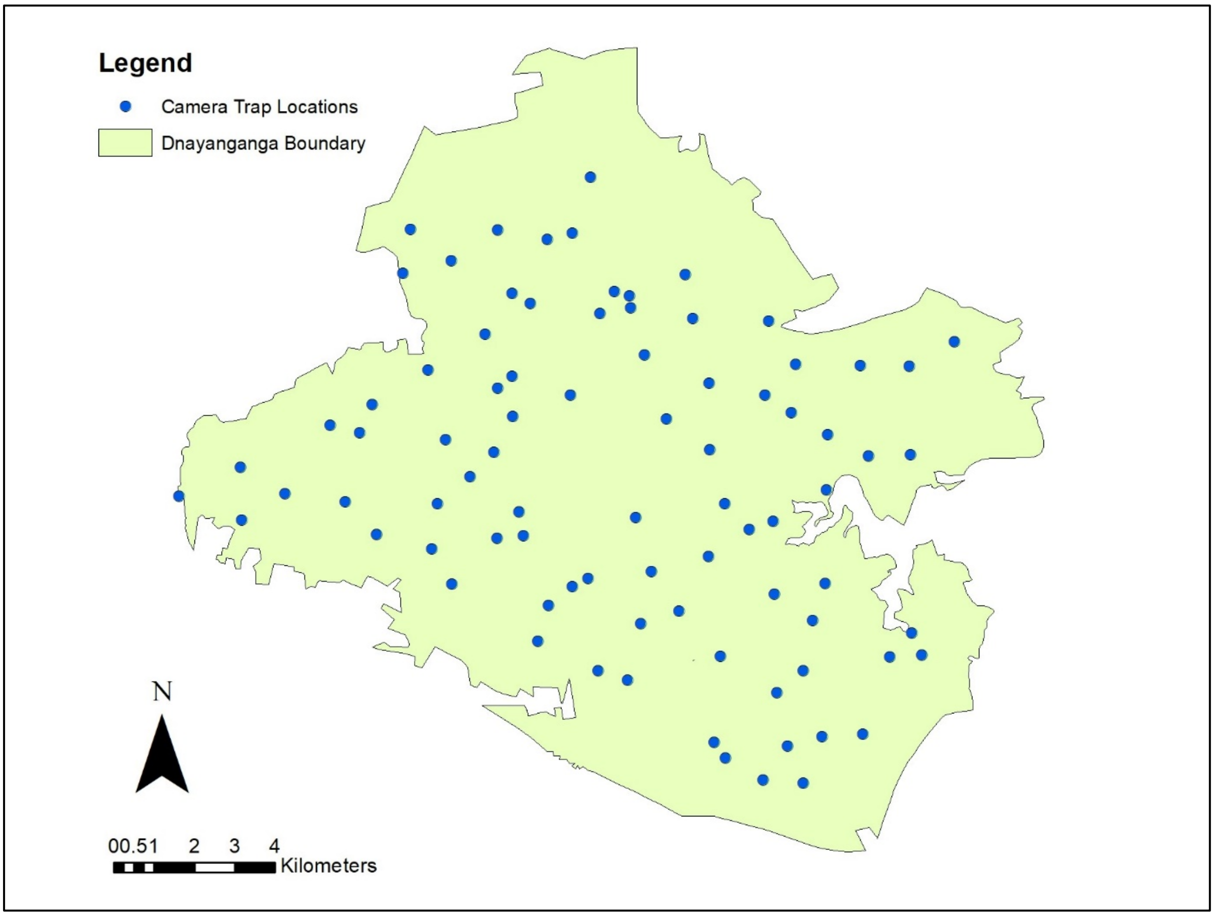

Figure 5 (a): Map depicting camera trap placement locations in Dnyanganga Wildlife Sanctuary 2021.

Figure 5 (b): Map depicting camera trap placement locations in Katepurna Wildlife Sanctuary 2021.

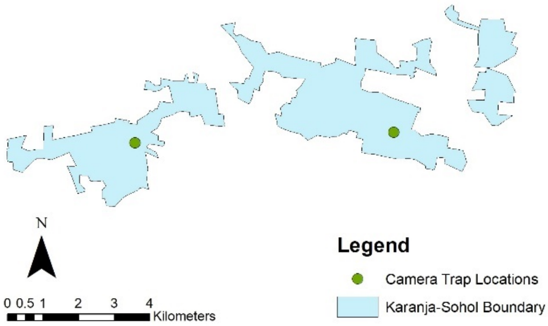

Figure 5 (c): Map depicting camera trap placement locations in Karanja-Sohol Wildlife Sanctuary 2021.

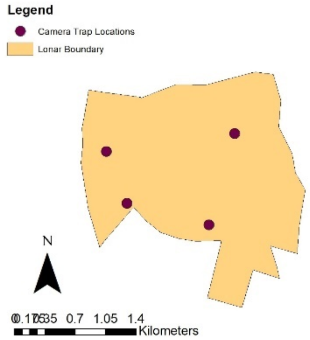

Figure 5 (d): Map depicting camera trap placement locations in Lonar Wildlife Sanctuary 2021.

Population Estimation for Tigers and Leopards:

During 30 days of camera trapping for leopards, a total sampling effort of 3,090 trap nights 42 adult individual leopards were photographed in Akola Wildlife Division. 28 adult leopards were identified based on the rosette pattern of the right flank in Dnyanganga WLS. 9 adult leopards were identified based on the rosette pattern of the left flank in Katepurna WLS. 3 adult leopards were identified in Karanja-Sohol WLS and 2 adult leopards were identified in Lonar WLS. For estimating the density and population, "SECR" instead of the conventional capture-recapture model was used for Dnyanganga WLS and Katepurna WLS. Due to the small sample size and area, the leopard data of Karanja-Sohol WLS and Lonar WLS was not considered for SECR analysis.

Spatially explicit capture-recapture (SECR) is a set of methods for modelling animal capture-recapture data collected with an array of 'detectors. The methods are used primarily to estimate population density and have advantages over non-spatial methods when the goal is to estimate population size (Efford and Fewster 2013). SECR methods overcome edge effects that are problematic in the conventional capture-recapture estimation of animal populations (Otis et al. 1978). Here detectors are camera traps that take photographs of tigers and leopards and they are recognized by their natural marks. Camera-traps are proximity detectors because they can detect multiple animals within an occasion, and they do not detain detected animals, which remain free to be detected by other camera traps within each occasion. Like other statistical methods for estimating animal abundance (Borchers et al. 2012), SECR also combines a state model and an observation model. The state model describes the distribution of animal home ranges in the landscape, and the observation model (a spatial detection model) relates the probability of detecting an individual at a particular detector to the distance of the detector from a central point in each animal's home range. Unlike the maximum-likelihood and Bayesian estimation methods, it is not based on an explicit likelihood function and does not have the same inference foundation as these methods. The key additional data that SECR analyses require, over and above the data used in non-spatial capture-recapture studies, are the locations of traps at which individuals were captured. Hence, to develop SECR models, some notation for trap location was needed. The MCP polygons of leopards of Dnyanganga WLS and Katepurna WLS are shown in Figure 6 (a - d) and 7 (a -b) respectively.

Leopard density per 100 sq. km. based on the SECR Heterogeneity model was estimated to be 13.42 (SE ±2.5) for Dnyanganga WLS. Leopard density per 100 sq. km. based on the SECR Null model was estimated to be 25.61 (SE ±8.8) for Katepurna WLS The best model for the density estimate is chosen according to the AIC (Akaike Information Criterion). The details for leopards of Dnyanganga WLS are provided in Table 4 and 5 and the details for leopards of Katepurna WLS are provided in Table 6 and 7. g_0 is the detection probability for the species, it is assumed to be constant or variable depending on the distribution. Sigma is the distribution of the average movement of the animal. It increases if the individuals are captured at very far away locations.

Table 4: Density estimates of leopards using Spatially Explicit Capture-Recapture Models in Dnyanganga WLS, Maharashtra, India for the year 2021

Parameters	Leopard 2021
Model	Heterogeneity
Detection Function	Half normal
Density Estimate	13.426
Density Standard Error	2.5
Density Confidence Interval	9.269 - 19.445
g0 Estimate	0.076
g0 Standard Error	0.007
g0 Confidence Interval	0.063 - 0.091
Sigma Estimate	1.508
Sigma Standard Error	0.059
Sigma Confidence Interval	1.396 - 1.628

Table 5: Density of leopards in Dnyanganga WLS for the year 2021

Year	No. of Individuals Captured	Estimate	Density per 100 sq. km.
2021	28	28 (±1.0)	13.42 (±2.5)

Table 6: Density estimates of leopards using Spatially Explicit Capture-Recapture Models in Katepurna WLS, Maharashtra, India for the year 2021

Parameters	Leopard 2021
Model	Null
Detection Function	Half normal
Density Estimate	25.611
Density Standard Error	8.853
Density Confidence Interval	13.256 – 49.480
g0 Estimate	0.027
g0 Standard Error	0.08
g0 Confidence Interval	0.015 – 0.048
Sigma Estimate	2.261
Sigma Standard Error	0.405
Sigma Confidence Interval	1.595 – 3.203

Table 7: Density of leopards in Katepurna WLS for the year 2021

Year	No. of Individuals Captured	Estimate	Density per 100 sq. km.
2021	9	10 (±1.27)	25.61 (±8.85)

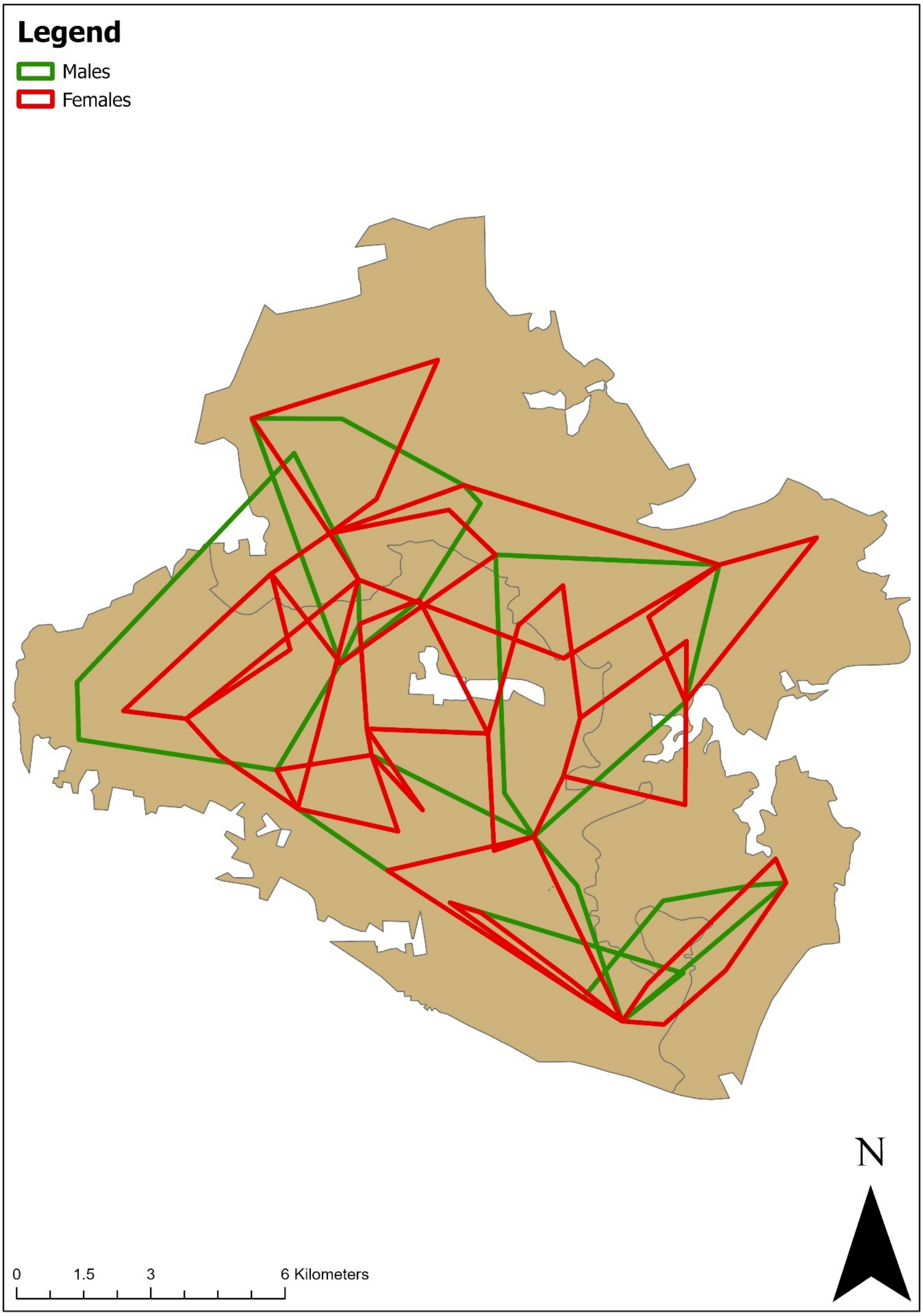

Figure 6(a): Minimum Convex Polygon of Leopards (Males & Females) in Dnyanganga WLS during the year 2021.

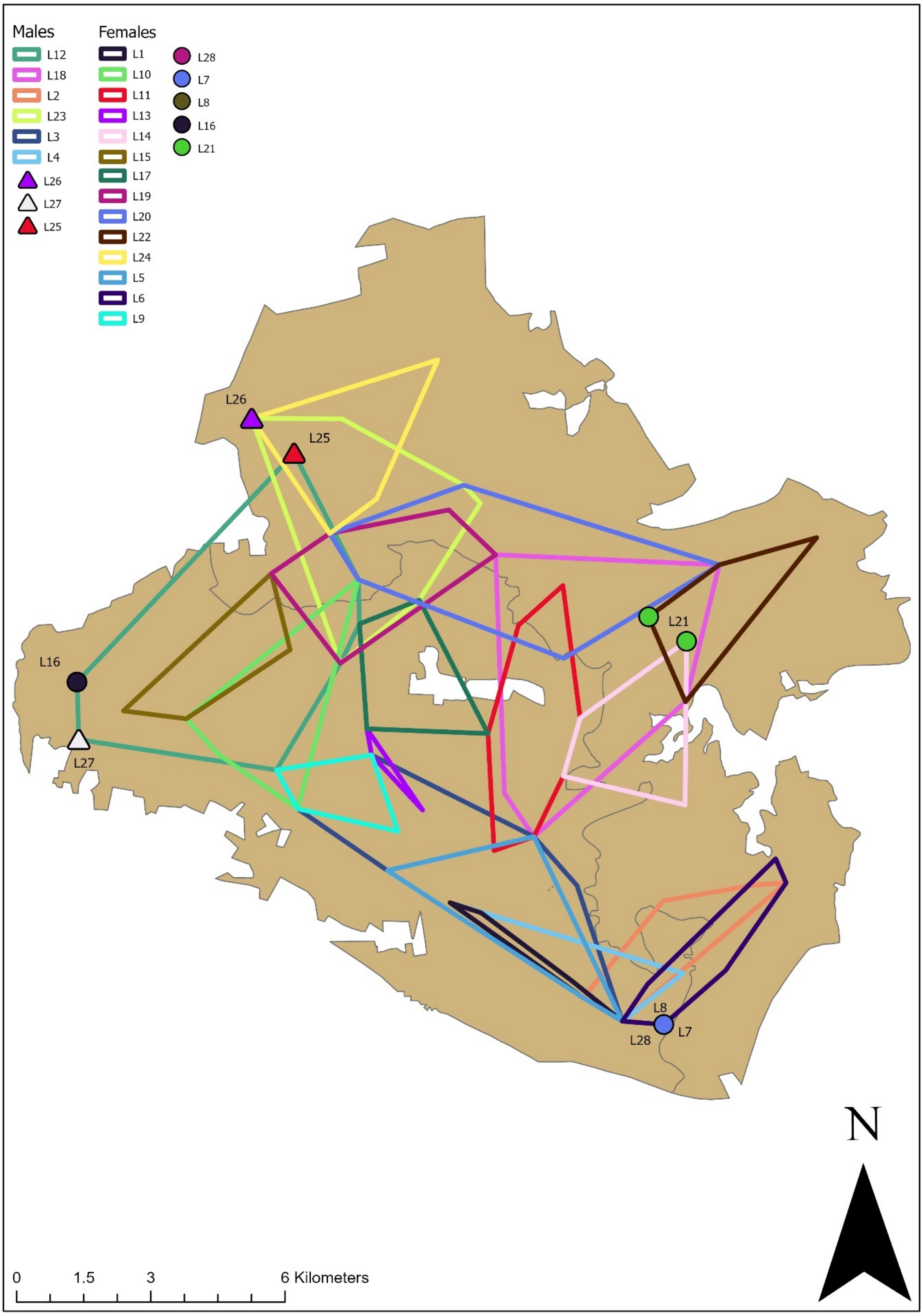

Figure 6(b): Minimum Convex Polygon of Leopards (Males & Females) in Dnyanganga WLS during the year 2021.

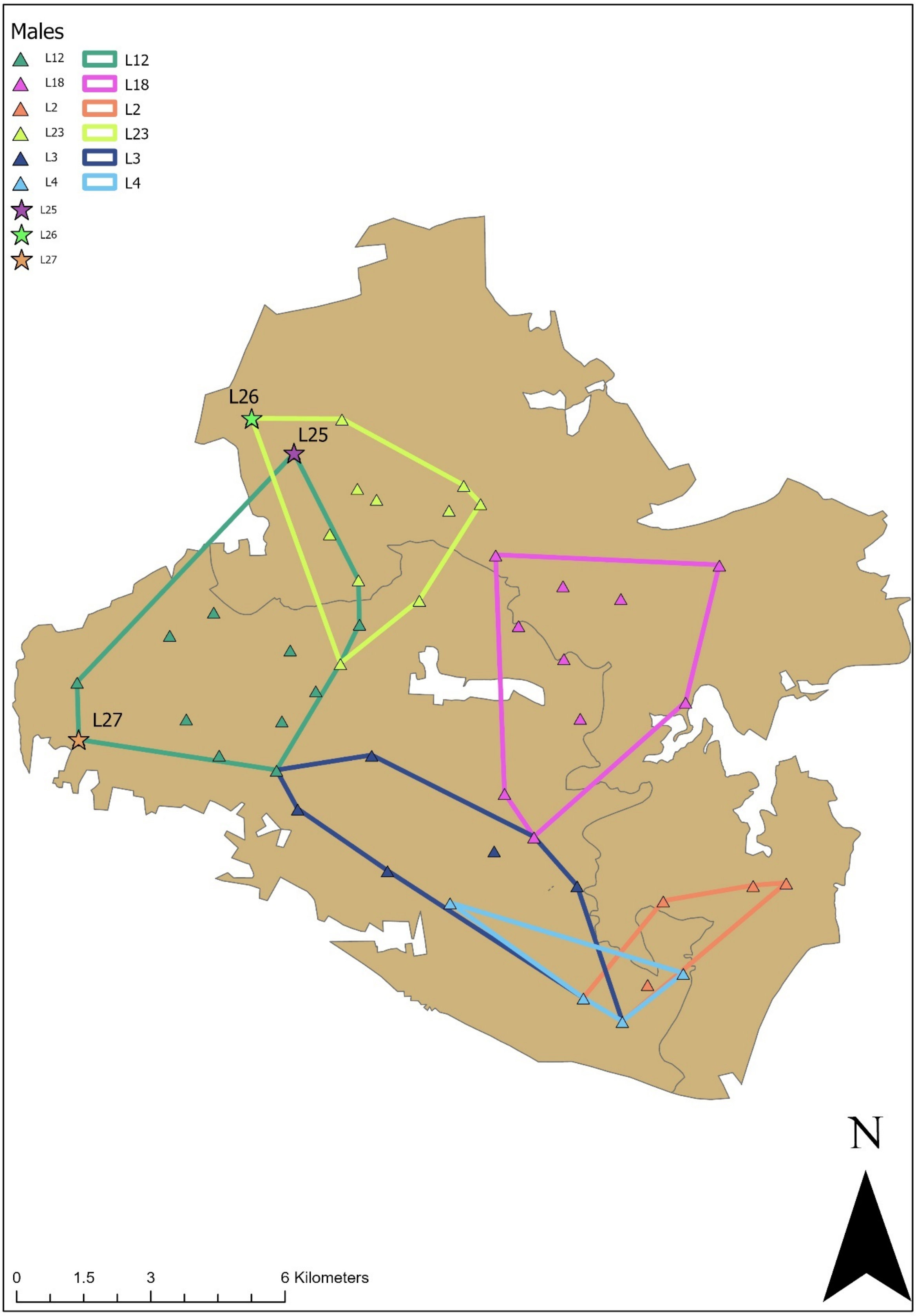

Figure 6(c): Minimum Convex Polygon of Leopards (Males) in Dnyanganga WLS during the year 2021.

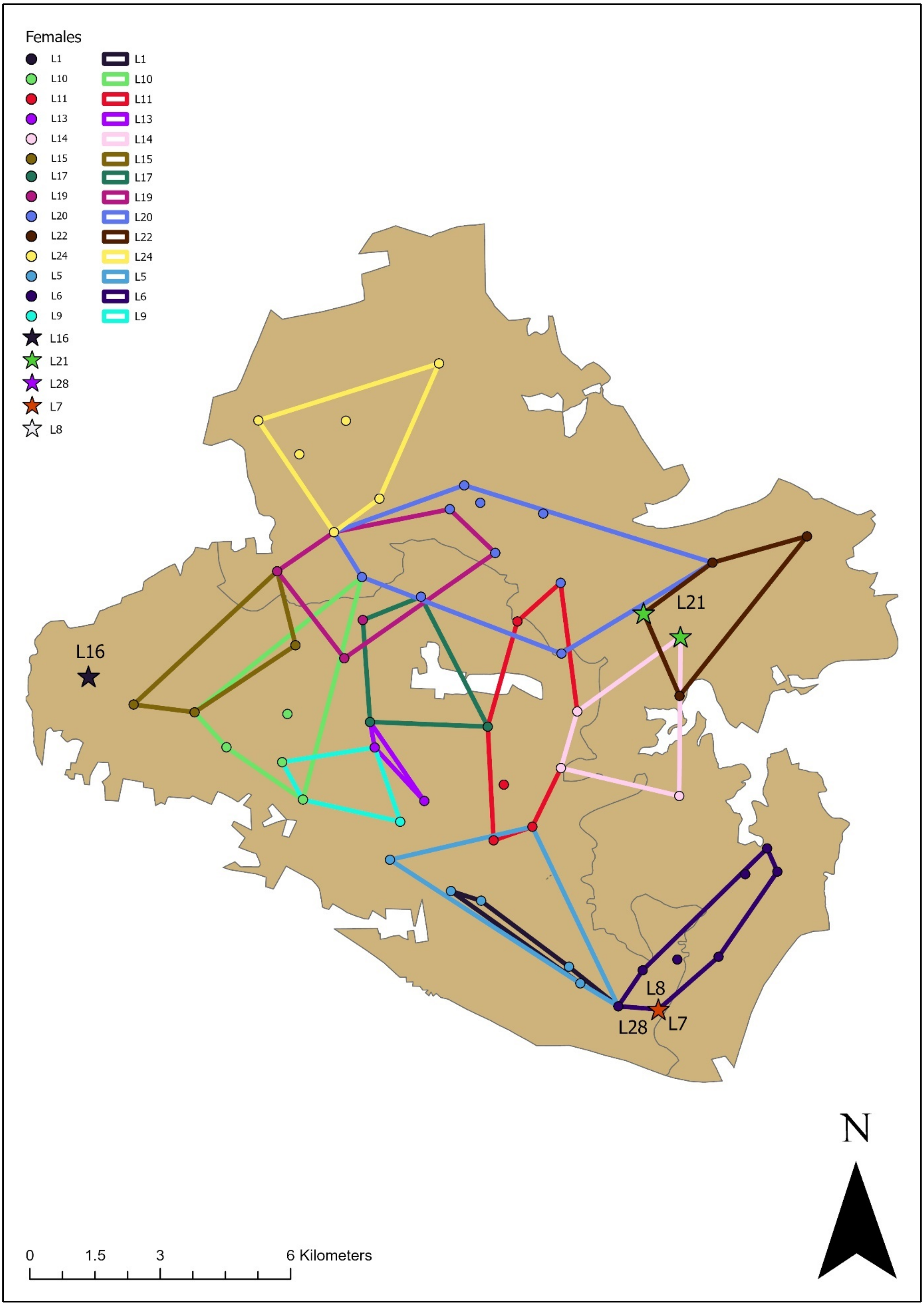

Figure 6(d): Minimum Convex Polygon of Leopards (Females) in Dnyanganga WLS during the year 2021.

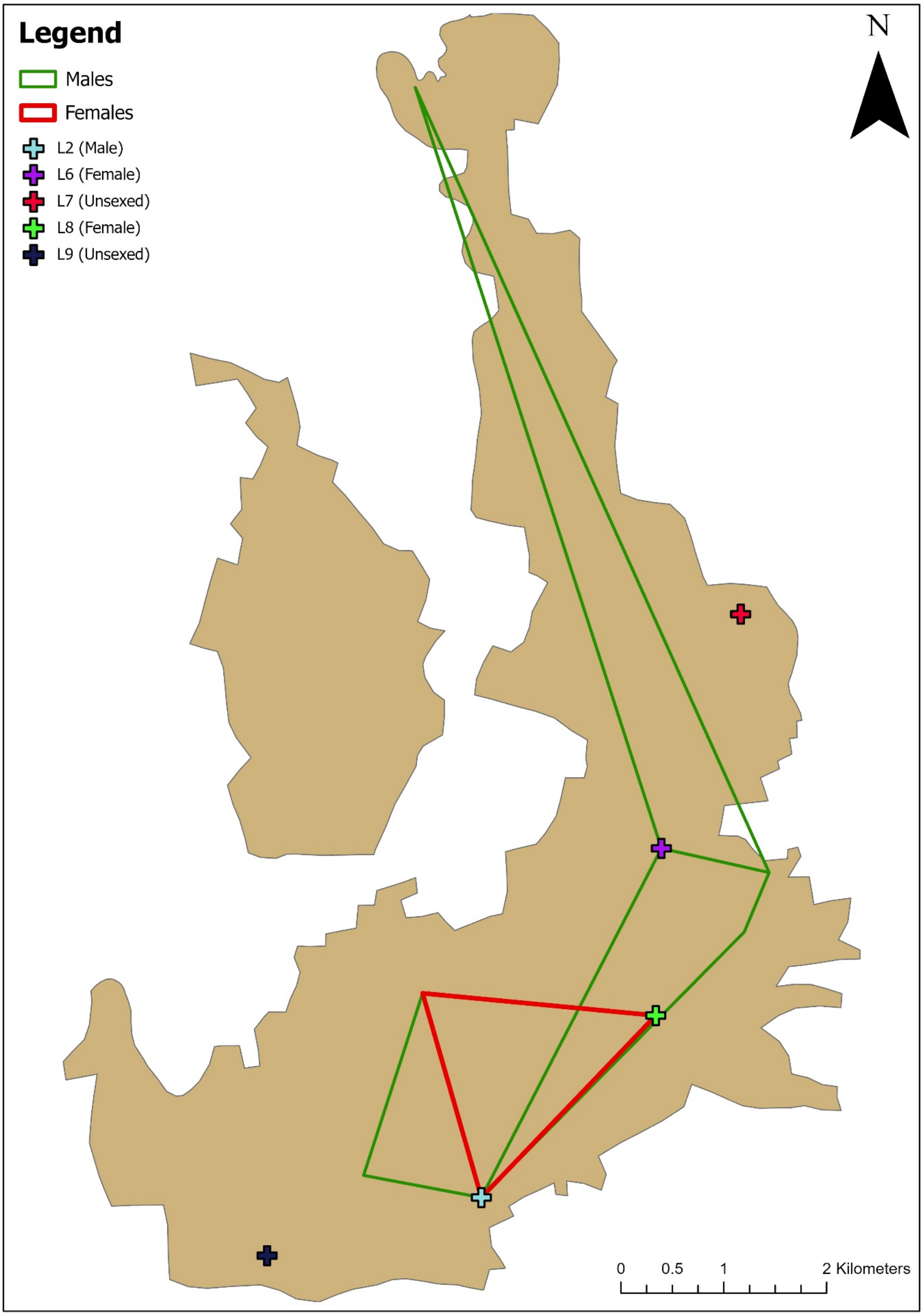

Figure 7(a): Minimum Convex Polygon of Leopards (Males & Females) in Katepurna WLS during the year 2021.

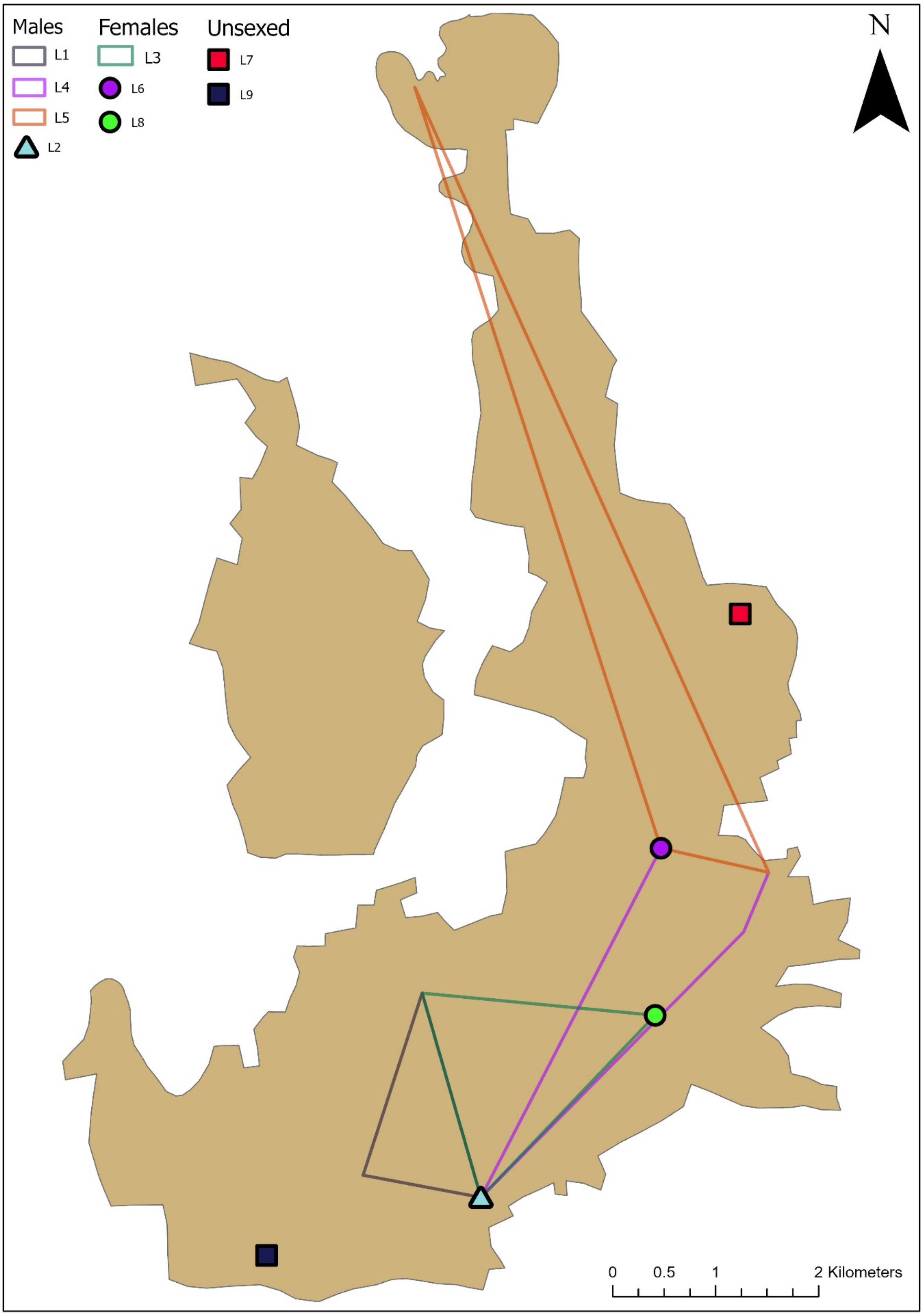

Figure 7(b): Minimum Convex Polygon of Leopards (Males, Females and Unsexed) in Katepurna WLS during the year 2021.

4. Temporal Activity of Predators and Prey Species in Akola Wildlife Division

Introduction:

To know how prey species, interact with each other over time and space, it is imperative to study their activity patterns as well as their overlap. Camera trap being an excellent tool provides capture timings that have been used to determine the peak activity period among sympatric predators and prey of the study area.

Methods and Results:

The temporal pattern of the predators and their prey was analysed using R Studio in R statistical software (version 3.6.2). The approach established by Linkie and Ridout (2009) was used to study temporal activity patterns and the package “overlap” which estimates the coefficient of temporal overlap non-parametrically using kernel density estimates was used. In the package ‘overlap’, data are regarded as a random sample from the underlying distribution that describes the probability of a photograph being taken within any particular interval of the day. The probability density function of this distribution is then referred to as the activity pattern, which assumes that the animal is equally likely to be photographed at all times when it is active (Ridout & Linkie 2009). It is a two-step process. In the first step, each activity pattern is estimated non-parametrically, using kernel density estimation. The kernel density estimates used a bandwidth parameter, which is selected following the procedure developed by Taylor (2008). For the second step, a measure of overlap between the two estimated distributions was calculated. Ridout and Linkie (2009) reviewed several alternative measures of overlap between two probability distributions, favouring the coefficient of overlapping, Δ (Weitzman 1970), which ranges from 0 (no overlap, e.g. one species entirely diurnal, the other entirely nocturnal) to 1 (complete overlap). This is defined as the area under the curve that is formed by taking the minimum of the two density functions at each time point. A useful interpretation of the coefficient of overlapping is that for any time during the day the proportion of activity that occurs during that period differs between the two distributions by <1–Δ. 1000 bootstrap samples are used to derive the confidence intervals.

These estimators use kernel density estimates fitted to the data to approximate the true density functions f(t) and g(t). Schmid & Schmidt (2006) propose five estimators of overlap:

$$\hat{\Delta}_1 = \frac{2\pi}{T} \sum^{T} \min\{\hat{f}(t_i) - \hat{g}(t_i)\}$$

Dhat1 is calculated from vectors of densities estimated at T equally-spaced times, t, between 0 and 2π:

For circular distributions, Dhat2 is equivalent to Dhat1, and Dhat3 is inapplicable. Dhat4 and Dhat5 use vectors of densities estimated at the times of the observations of the species, x, and y:

$$\hat{\Delta}_4 = \frac{1}{2}\left(\frac{1}{n}\sum_{i=1}^{n} \min\left\{1, \frac{\hat{g}(x_i)}{\hat{f}(x_i)}\right\} + \frac{1}{m}\sum_{j=1}^{m} \min\left\{1, \frac{\hat{f}(x_j)}{\hat{g}(x_j)}\right\}\right)$$

$$\hat{\Delta}_5 = \frac{1}{n}\sum_{i=1}^{n} \mathrm{I}\{\hat{f}(t_i) < \hat{g}(t_i)\} + \frac{1}{m}\sum_{j=1}^{m} \mathrm{I}\{\hat{f}(y_j) \geq \hat{g}(y_j)\}$$

Where n, m are the sample sizes and I is the indicator function (1 if the condition is true, 0 otherwise).

The Kernel density estimates of daily temporal activity patterns of different predator species are shown in Figure 8 – 9 and 10 – 11 for Dnyanganga WLS and Katepurna WLS respectively. Due to the small sample size and area of Karanja-Sohol WLS and Lonar WLS, the data was not considered for kernel density estimates of daily temporal activity patterns. From the kernel density estimators, leopard and sloth bear were observed to have a high degree (0.86 for Dnyanganga WLS and 0.76 for Katepurna WLS) of overlap as indicated by the estimated overlap coefficients in Table 8 and 9:

Table 8: Temporal activity overlap of predator and prey species in Dnyanganga WLS

Species	Leopard	Hyena
Blackbuck	0.24	-
Chinkara	0.42	0.21
Four Horned Antelope	0.52	0.29
Indian Hare	0.64	0.84
Langur	0.37	-
Nilgai	0.57	0.3
Peafowl	0.39	0.14
Porcupine	0.64	0.86
Sambar	0.76	0.73
Spotted Deer	0.49	0.44
Wild Boar	0.91	0.67
Jungle Cat	0.72	-
Leopard	-	0.69
Hyena	0.69	-
Sloth Bear	0.86	0.72

Table 9: Temporal activity overlap of predator and prey species in Katepurna WLS

Species	Leopard	Dhole
Chinkara	0.1	0.17
Indian Hare	0.84	0.3
Langur	0.07	0.1
Nilgai	0.24	0.27
Peafowl	0.21	0.55
Porcupine	0.81	0.11
Spotted Deer	0.25	0.38
Wild Boar	0.79	0.28
Jackal	0.51	0.07
Jungle Cat	0.84	0.18
Leopard	-	0.69
Dhole	0.21	-
Sloth Bear	0.76	0.2

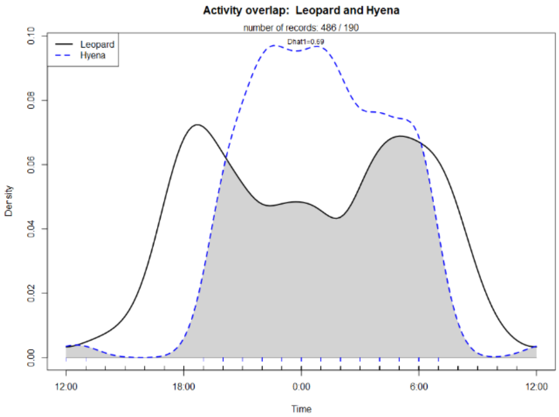

Figure 8(a): Leopard – Hyena

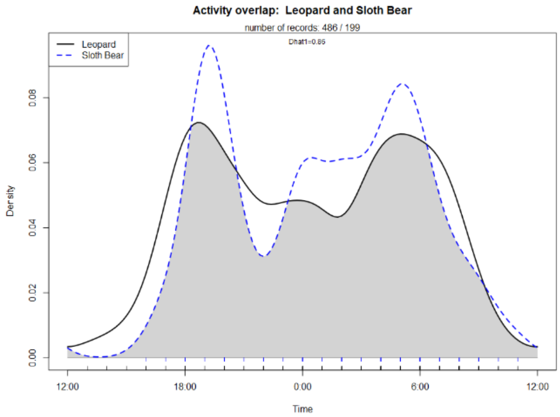

Figure 8(b): Leopard – Sloth Bear

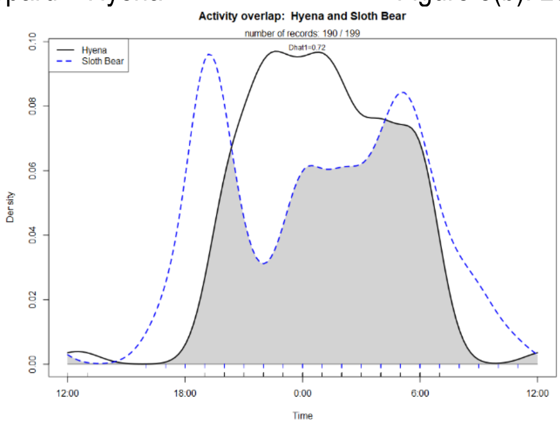

Figure 8(c): Hyena – Sloth Bear

Figures 8 (a-c): Daily temporal activity pattern overlap between co-predators. a) leopard vs. hyena; b) leopard vs. sloth bear; c) hyena vs. sloth bear in Dnyanganga WLS, India. The lines represent the kernel density estimates based on individual photograph times. The overlap is shown by the shaded area in each plot.

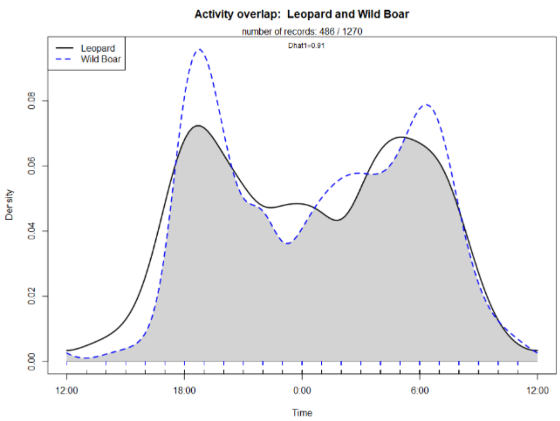

Figure 9(a): Leopard–Wild Boar

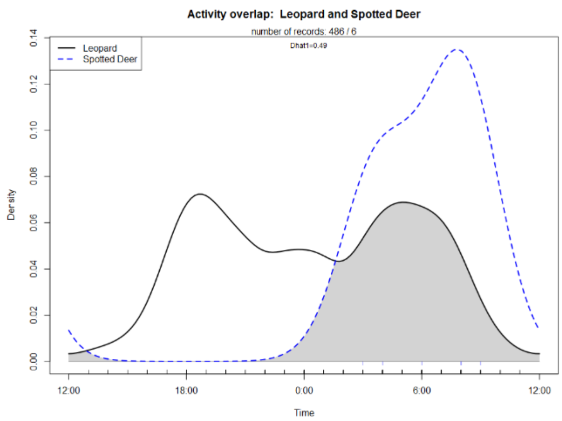

Figure 9(b): Leopard – Spotted Deer

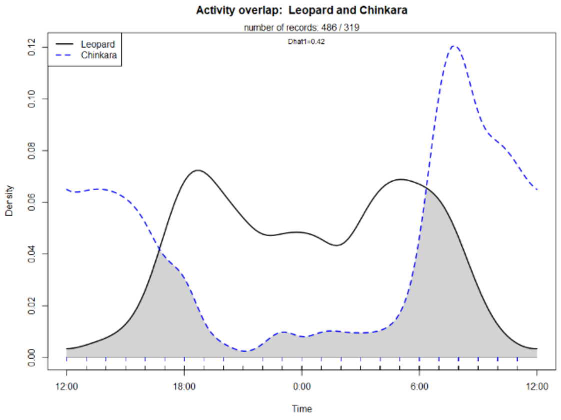

Figure 9(c): Leopard – Chinkara

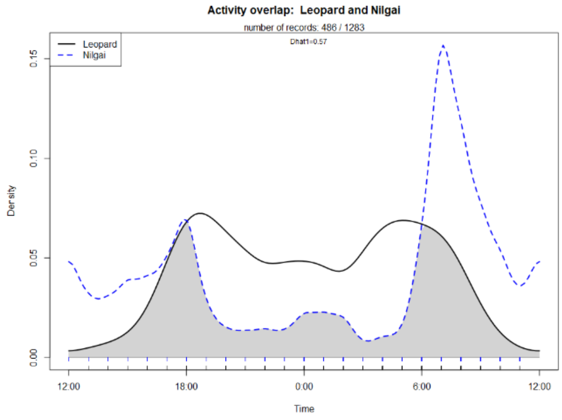

Figure 9(d): Leopard – Nilgai

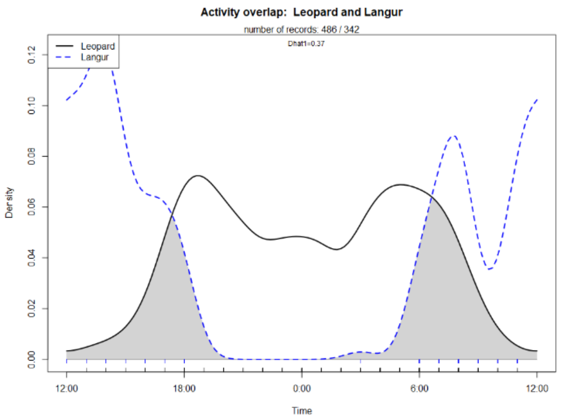

Figure 9(e): Leopard – Langur

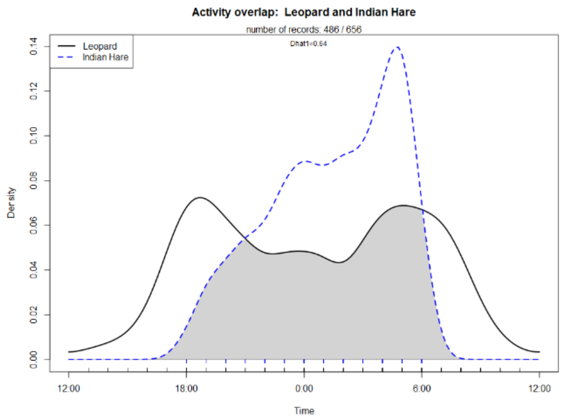

Figure 9(f): Leopard – Indian Hare

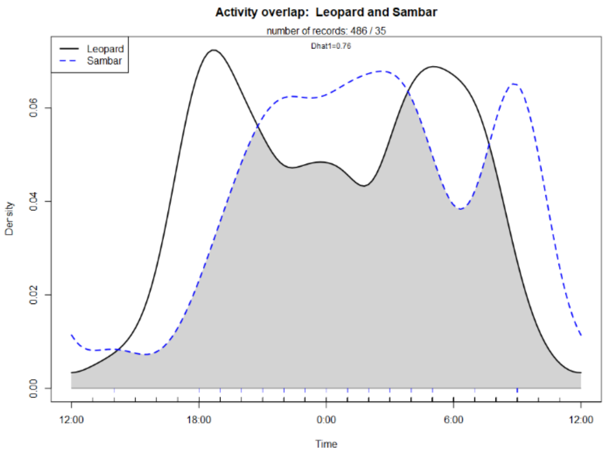

Figure 9(g): Leopard – Sambar

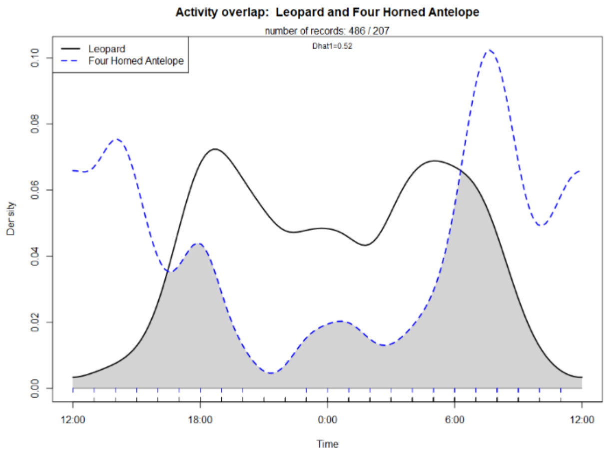

Figure 9(h): Leopard – Four-Horned Antelope

Figures 9 (a-h): Daily temporal activity patterns of the Leopard vs. prey species in Dnyanganga WLS, India during the year 2021. The lines represent the kernel density estimates based on individual photograph times. The overlap is shown by the shaded area in each plot.

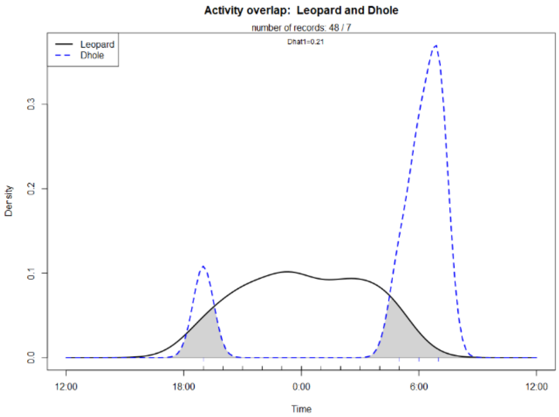

Figure 10(a): Leopard – Dhole

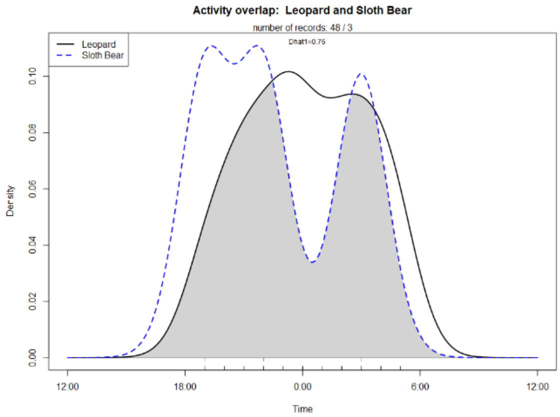

Figure 10(b): Leopard – Sloth Bear

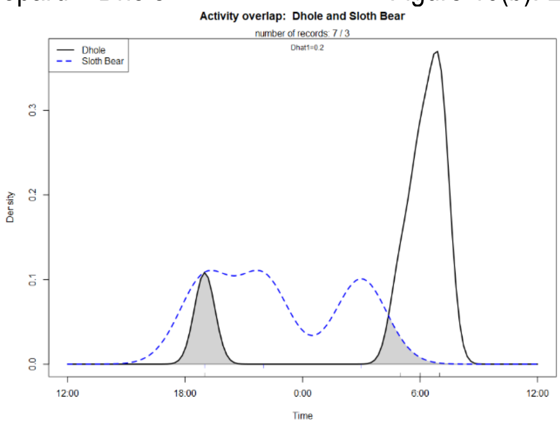

Figure 10(c): Dhole – Sloth Bear

Figures 10 (a-c): Daily temporal activity pattern overlap between co-predators. a) leopard vs. dhole; b) leopard vs. sloth bear; c) dhole vs. sloth bear in Katepurna WLS, India. The lines represent the kernel density estimates based on individual photograph times. The overlap is shown by the shaded area in each plot.

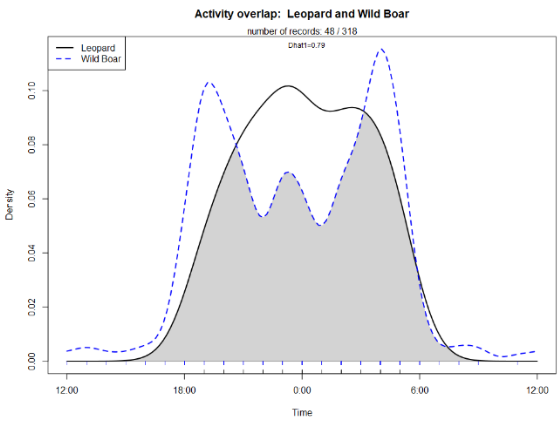

Figure 11(a): Leopard–Wild Boar

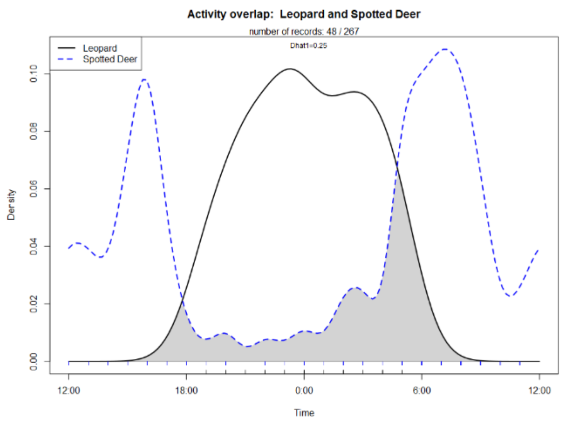

Figure 11(b): Leopard – Spotted Deer

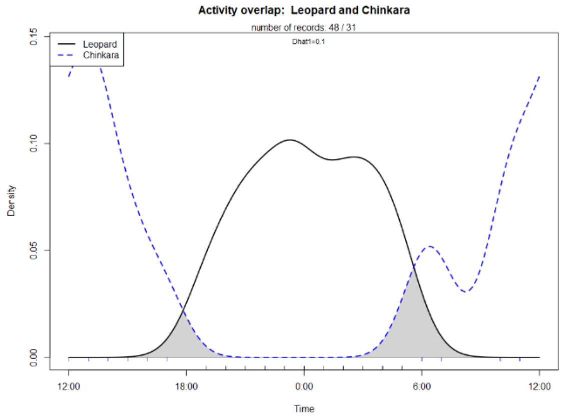

Figure 11(c): Leopard – Chinkara

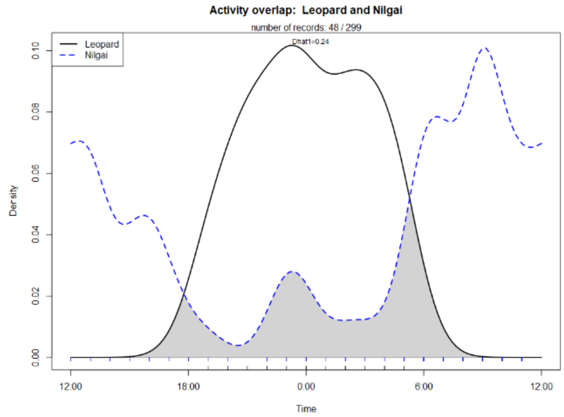

Figure 11(d): Leopard – Nilgai

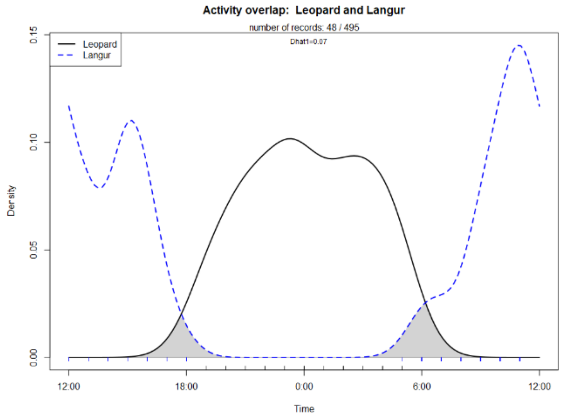

Figure 11(e): Leopard – Langur

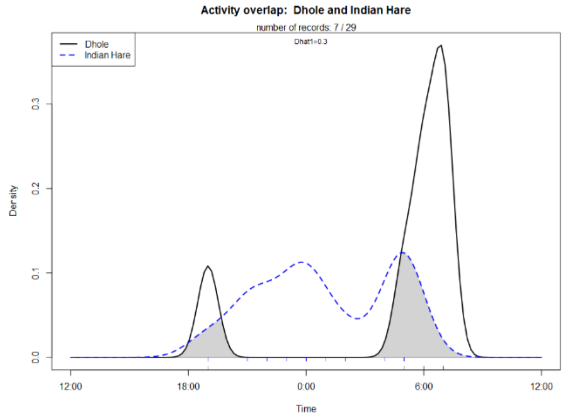

Figure 11(f): Leopard – Indian Hare

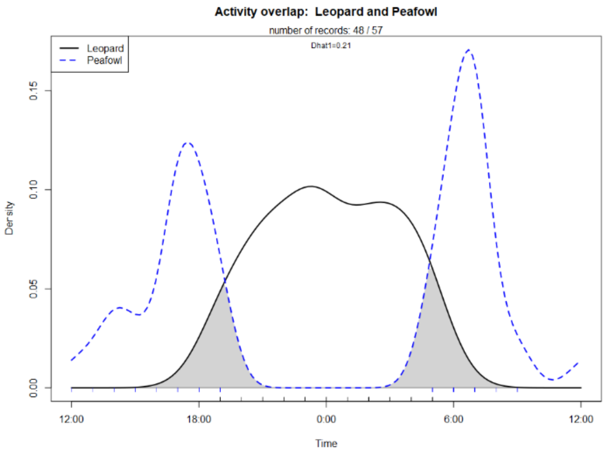

Figure 11(g): Leopard – Peafowl

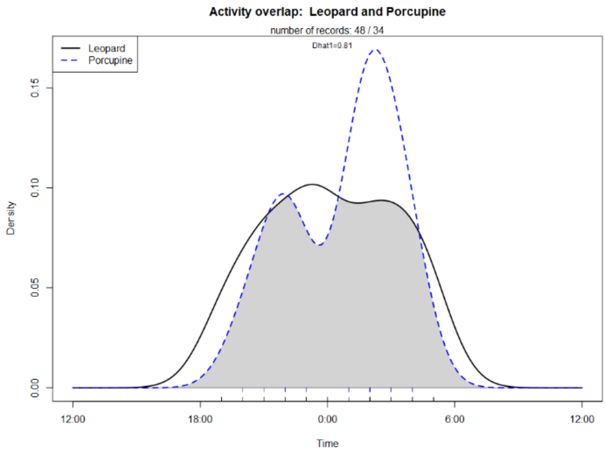

Figure 11(h): Leopard – Porcupine

Figures 11 (a-h): Daily temporal activity patterns of the Leopard vs. prey species in Katepurna WLS, India during the year 2021. The lines represent the kernel density estimates based on individual photograph times. The overlap is shown by the shaded area in each plot.

5. Modelling Spatially Explicit Intensive Use Areas: Predator & Prey Species

Introduction:

Camera trap locations with number of captures of each species were modelled in a GIS domain using IDW (Inverse distance weighted) interpolation technique to generate spatially explicit capture surfaces. Inverse Distance Weighting (IDW) interpolation is mathematical (deterministic) assuming closer values are more related than further values with its function. IDW function is used when a set of points is dense enough to capture the extent of local surface variation required for the analysis. IDW assumes that each measured point has a local influence that diminishes with distance. It gives greater weights to points closest to the prediction location, and the weights diminish as a function of distance, hence the name inverse distance weighted. IDW is an exact interpolator, where the maximum and minimum values (Fig. 12) in the interpolated surface can only occur at sample points. The output surface is sensitive to clustering and the presence of outliers. IDW assumes that the phenomenon being modelled is driven by local variation, which can be captured (modelled) by defining an adequate search neighbourhood.

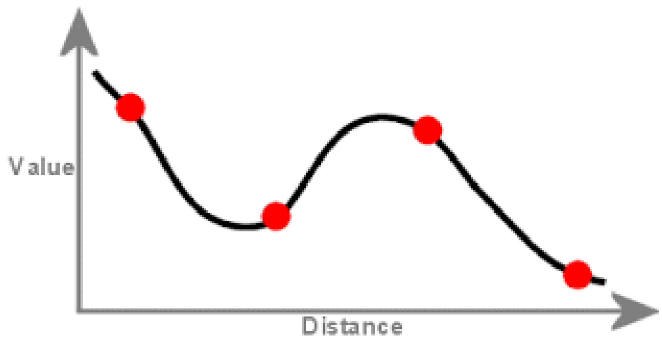

Figure 12: IDW (Inverse distance weighted) interpolation

Using IDW technique spatially explicit intensive use area maps (Based on camera trap location and number of photographs at each location) has been developed for predator and prey species, Fig.13 (a - u) shows intensive use areas by different species in Dnyanganga WLS of Akola Wildlife Division. Due to the small sample size and area of Karanja-Sohol WLS and Lonar WLS, the data were not considered for this analysis

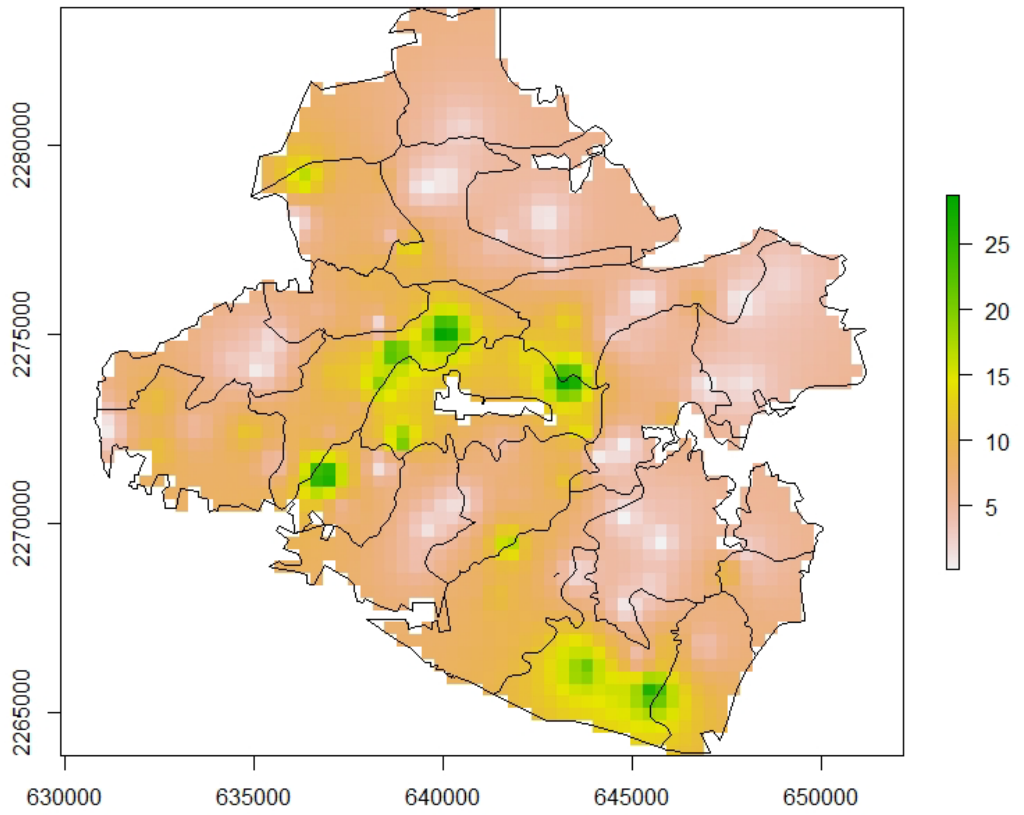

Figure 13(a): Intensive area use map for Leopard at Dnyanganga WLS

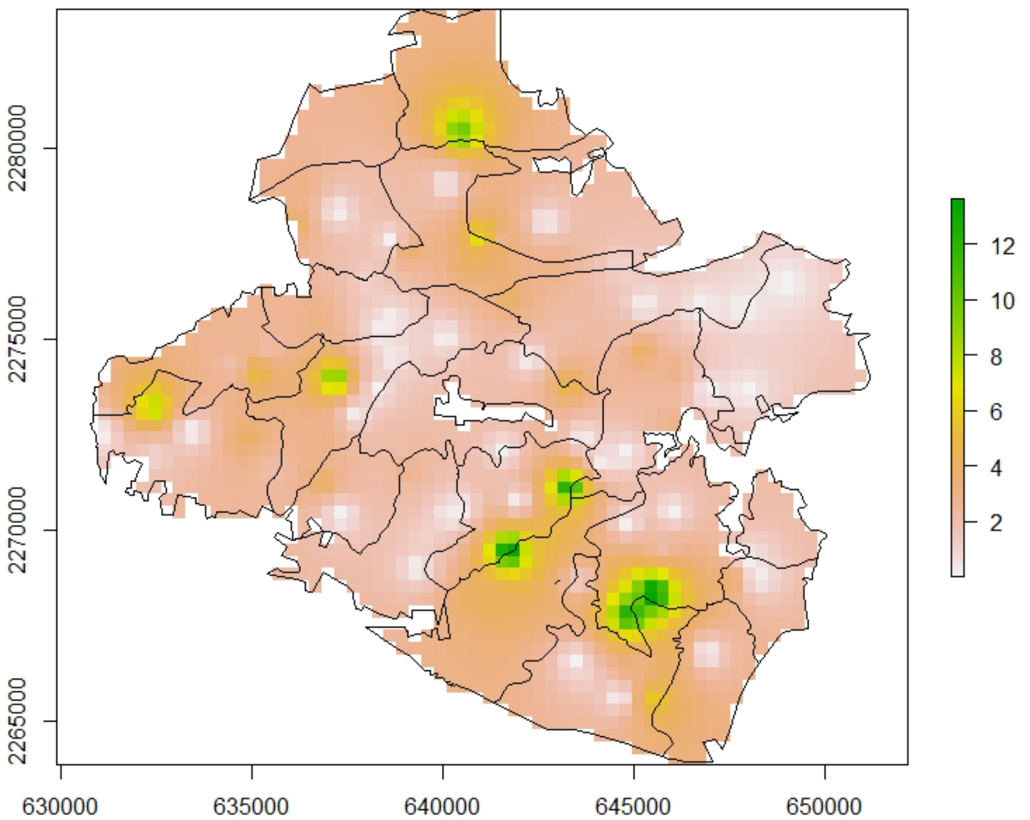

Figure 13(b): Intensive area use map for Hyena at Dnyanganga WLS

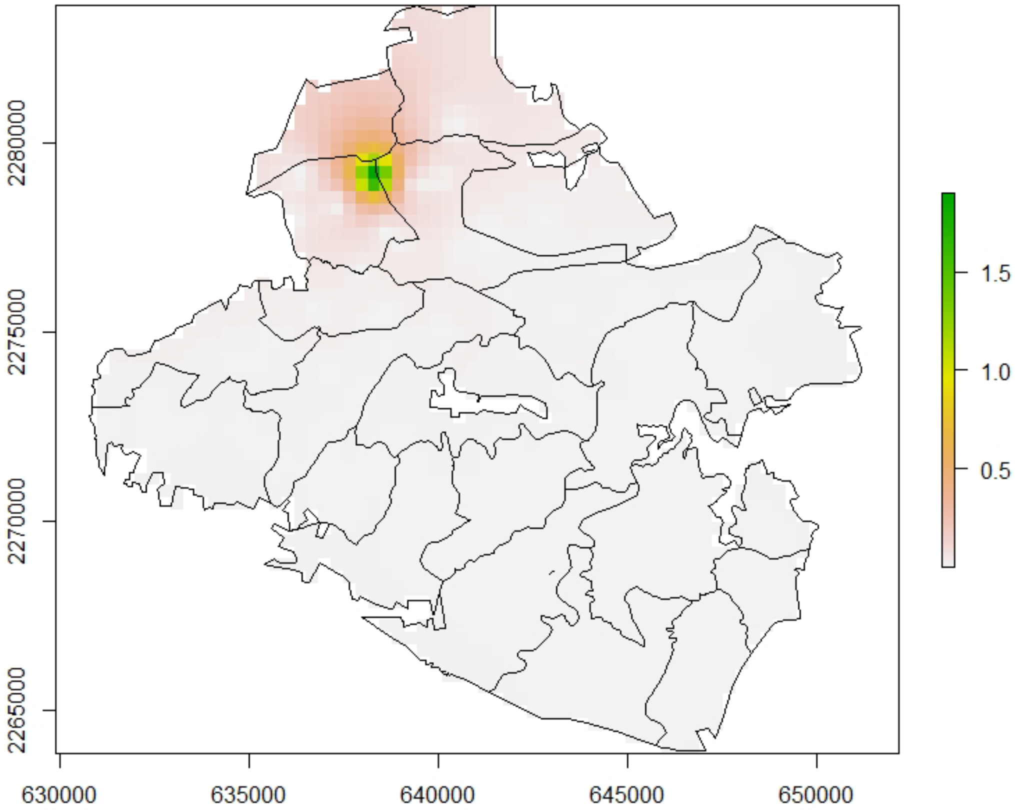

Figure 13(c): Intensive area use map for Wolf at Dnyanganga WLS

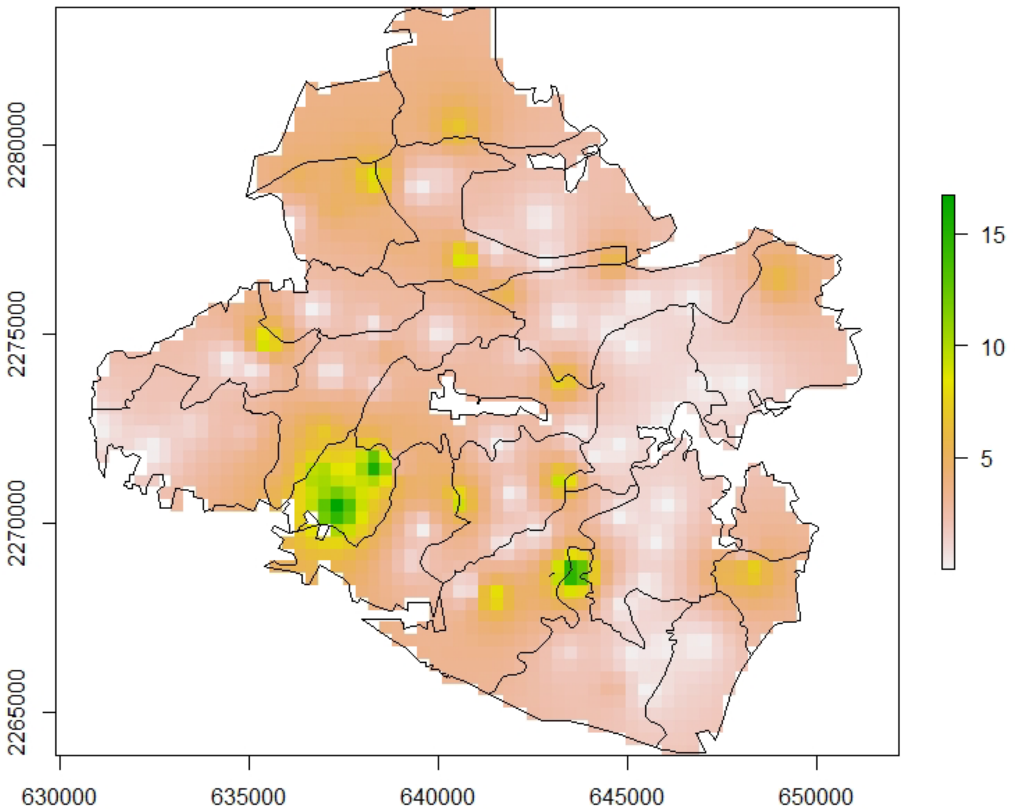

Figure 13(d): Intensive area use map for Sloth Bear at Dnyanganga WLS

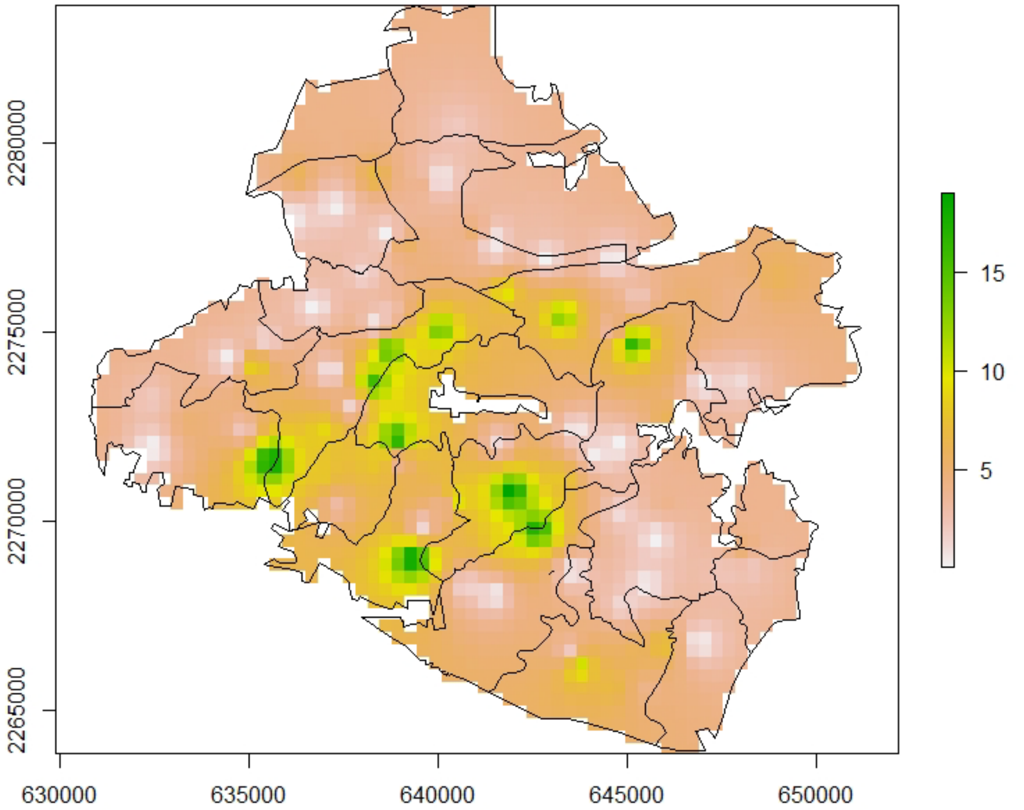

Figure 13(e): Intensive area use map for Jungle Cat at Dnyanganga WLS

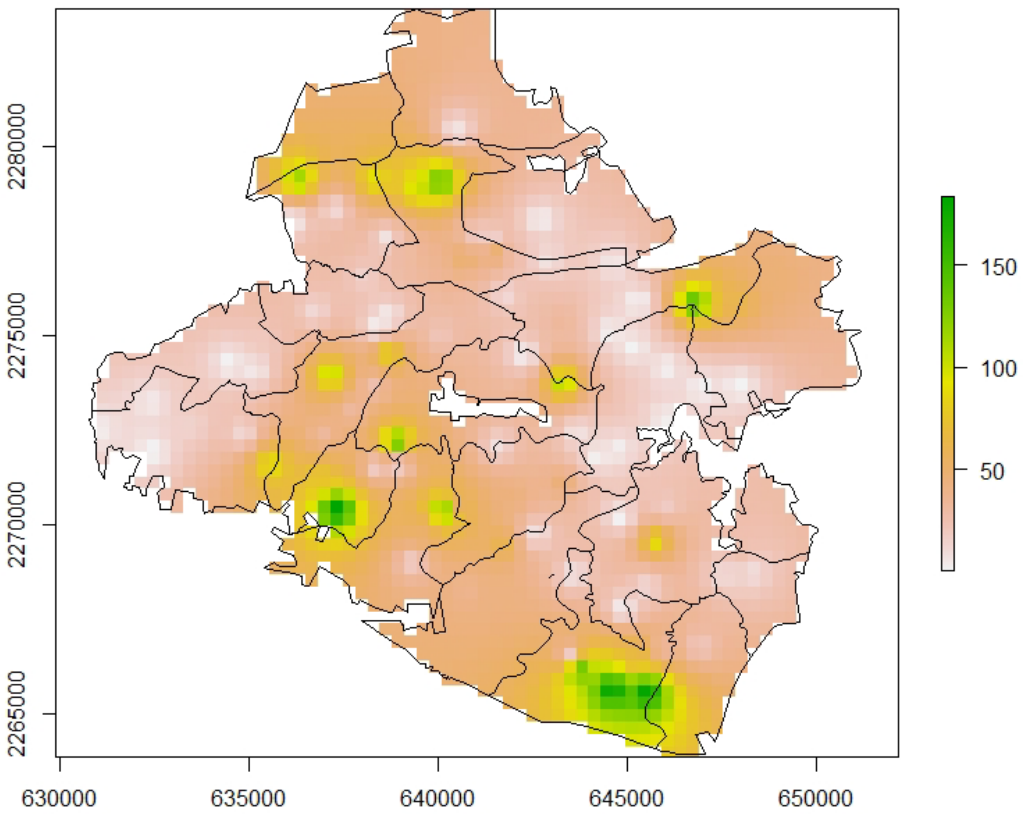

Figure 13(f): Intensive area use map for Nilgai at Dnyanganga WLS

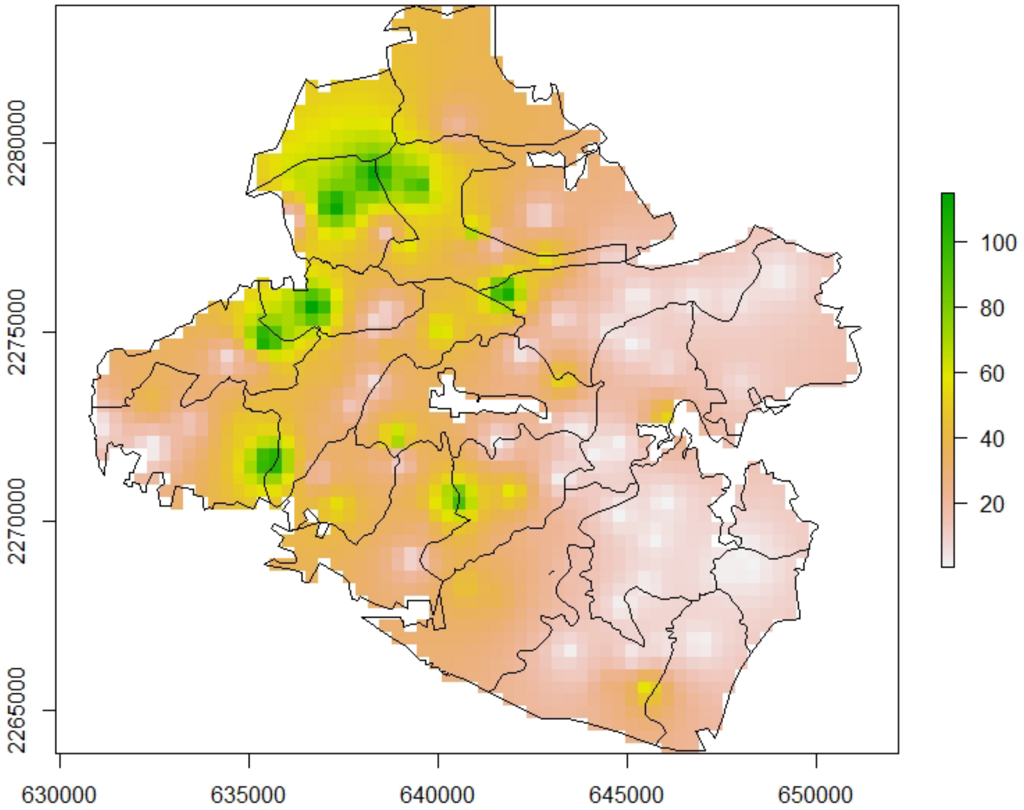

Figure 13(g): Intensive area use map for Wild Boar at Dnyanganga WLS

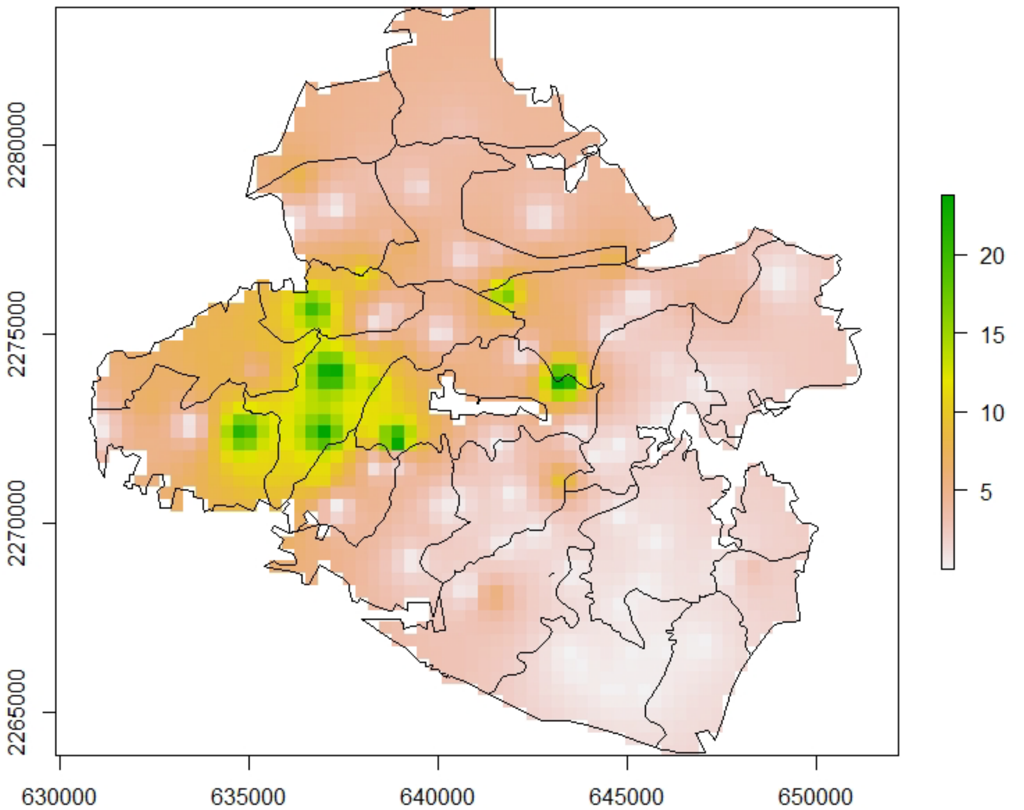

Figure 13(h): Intensive area use map for Four Horned Antelope at Dnyanganga WLS

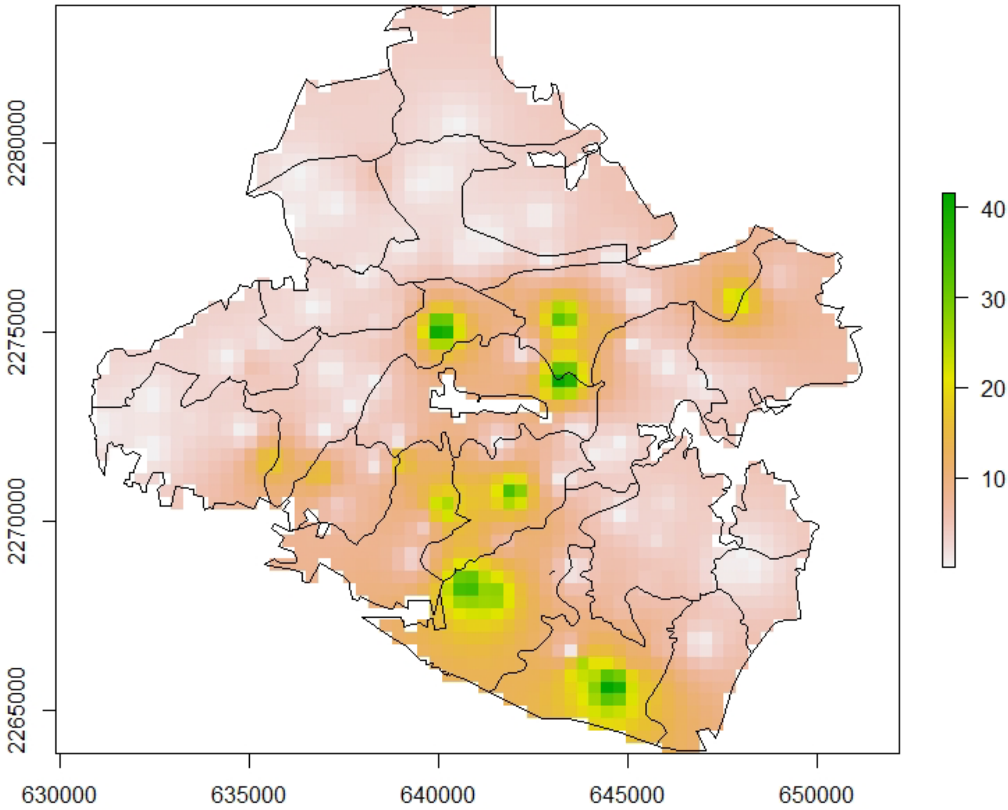

Figure 13(i): Intensive area use map for Chinkara at Dnyanganga WLS

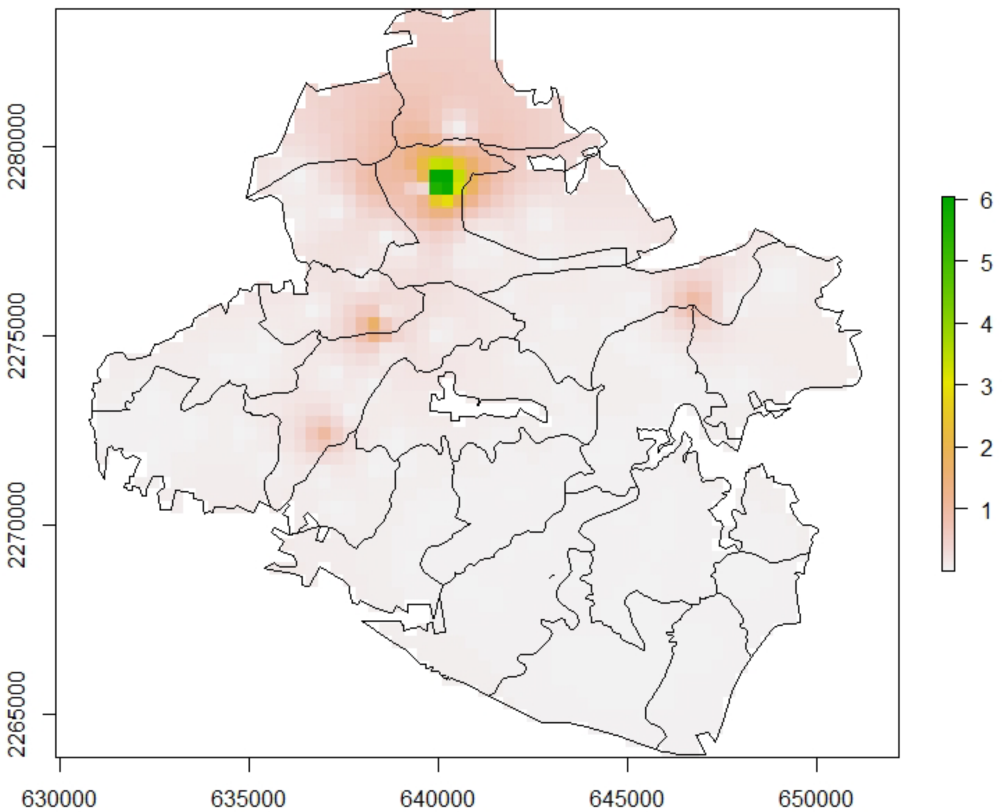

Figure 13(j): Intensive area use map for Spotted Deer at Dnyanganga WLS

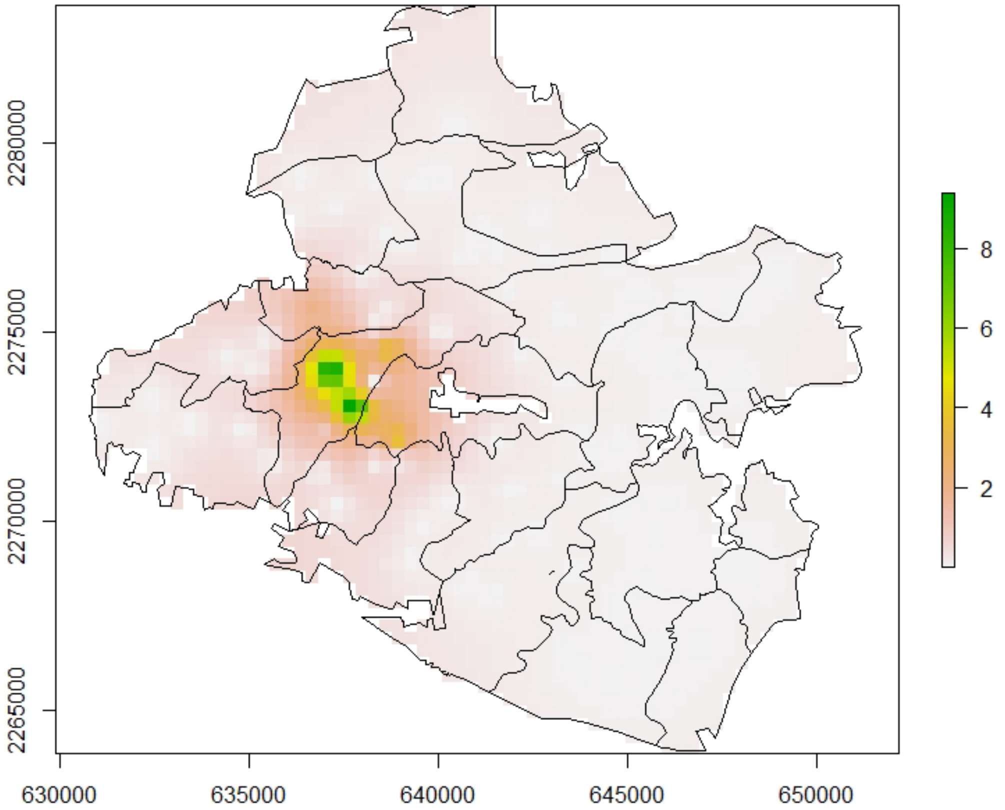

Figure 13(k): Intensive area use map for Sambar at Dnyanganga WLS

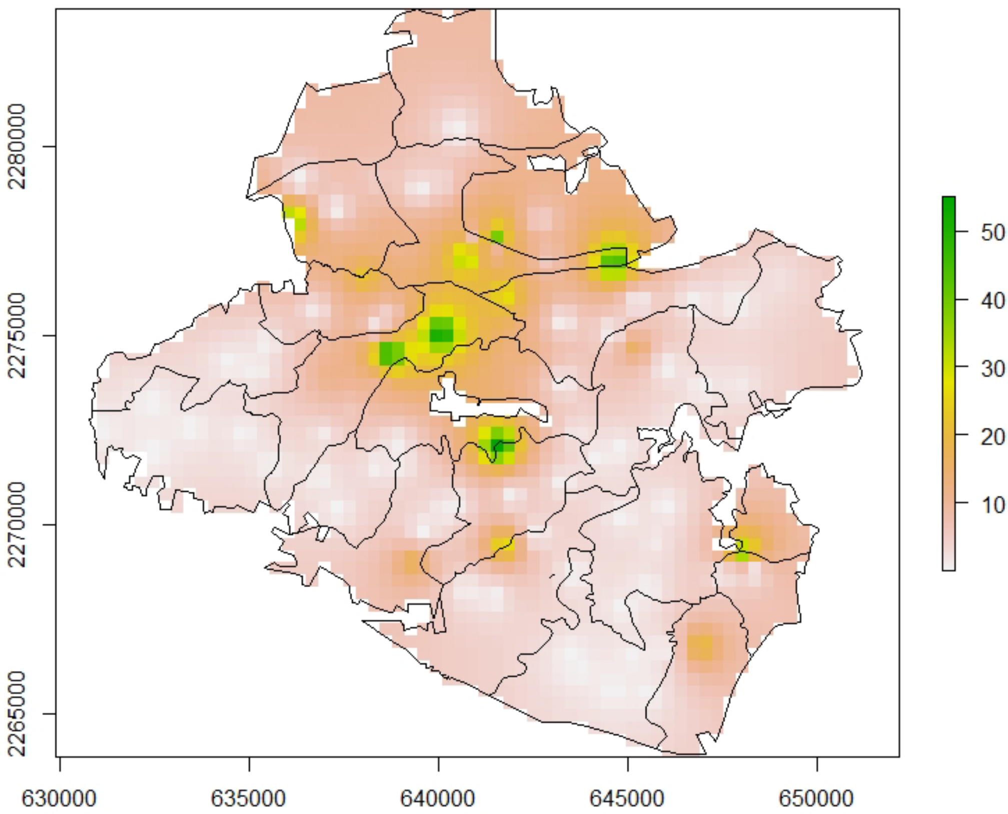

Figure 13(l): Intensive area use map for Langur at Dnyanganga WLS

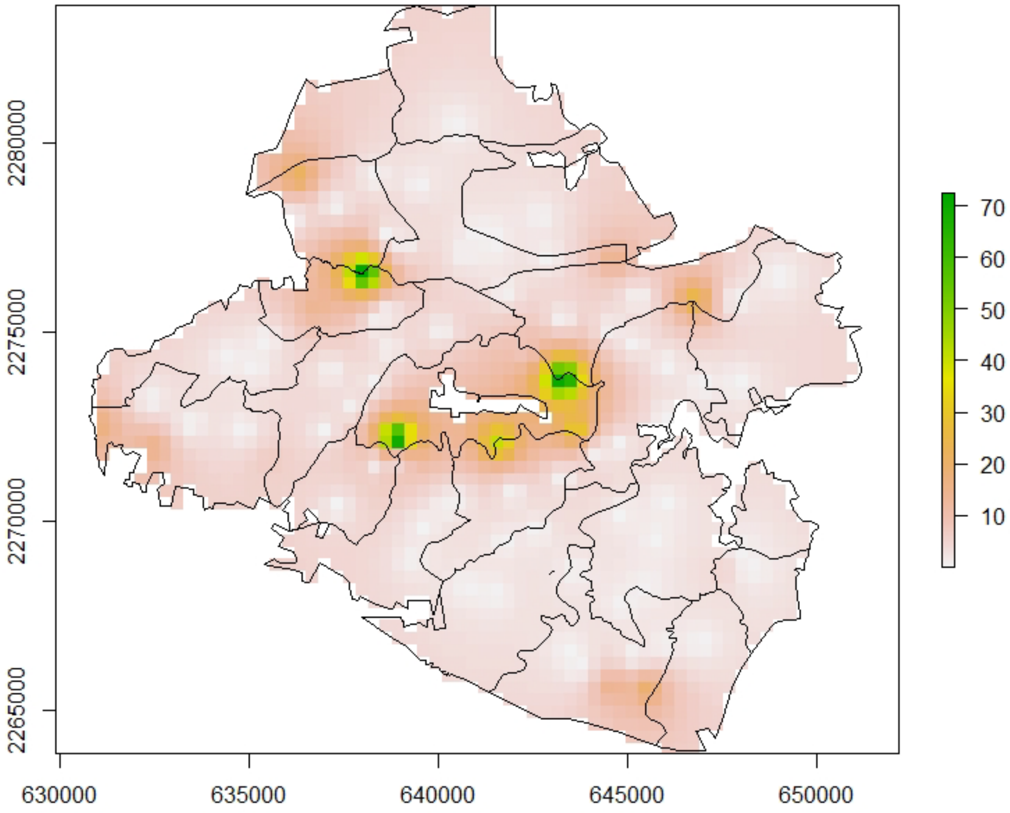

Figure 13(m): Intensive area use map for Peafowl at Dnyanganga WLS

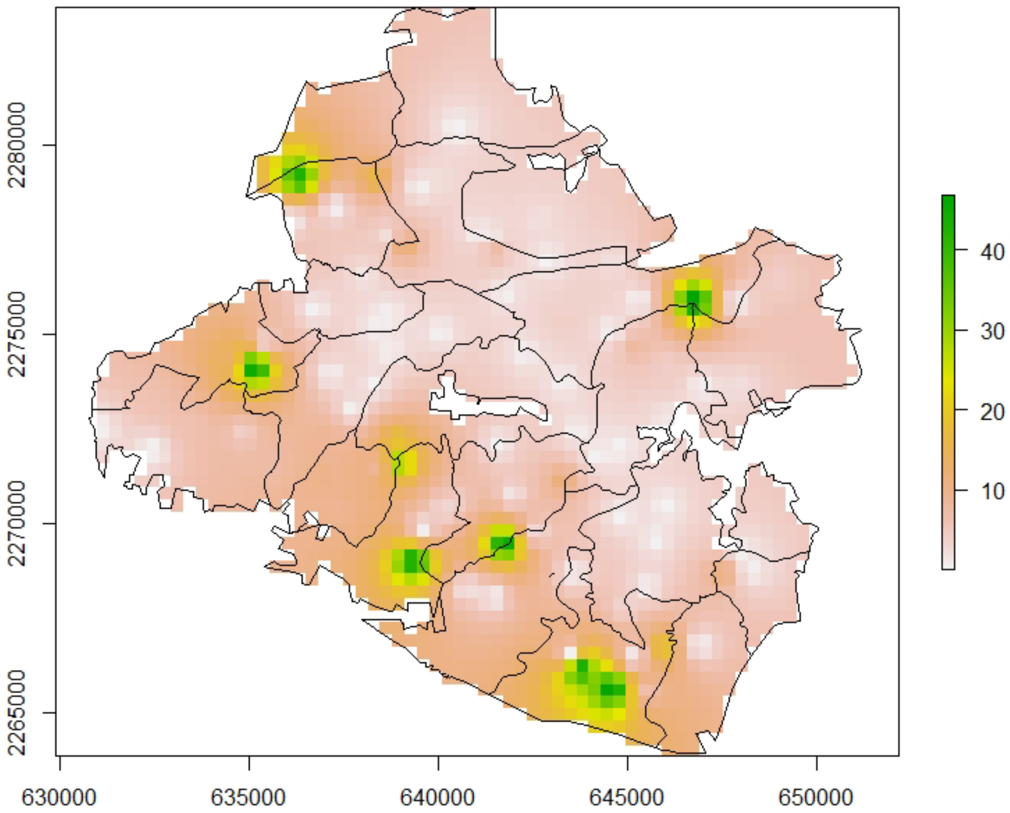

Figure 13(n): Intensive area use map for Indian Hare at Dnyanganga WLS

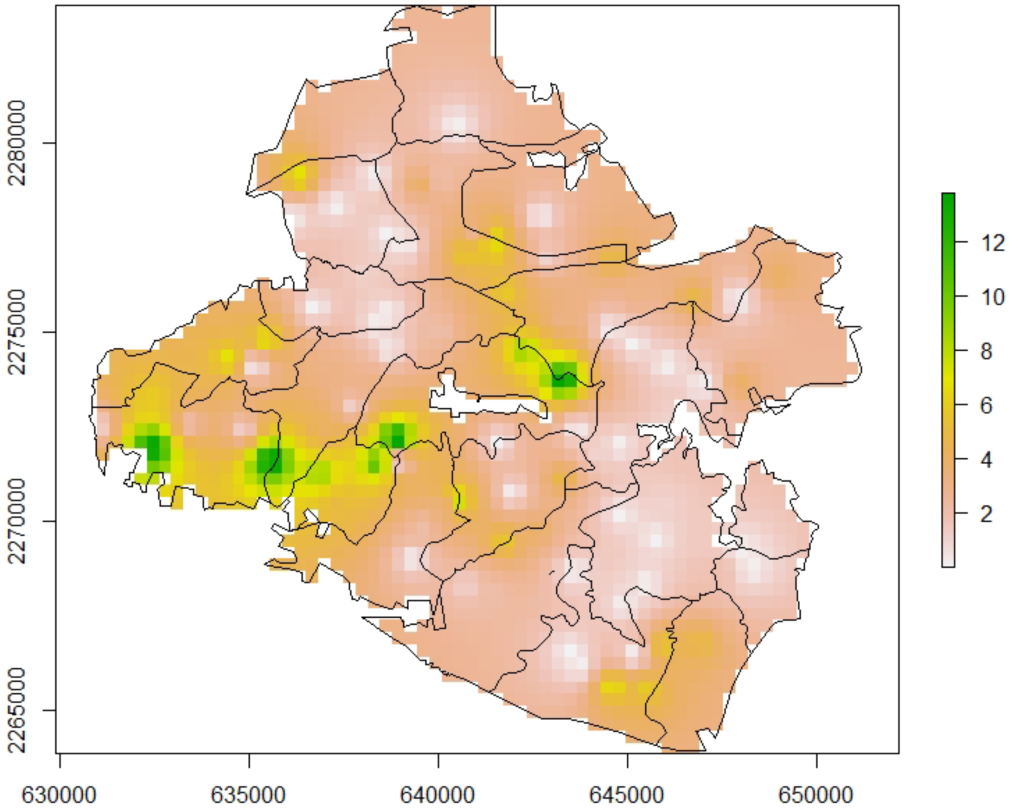

Figure 13(o): Intensive area use map for Porcupine at Dnyanganga WLS

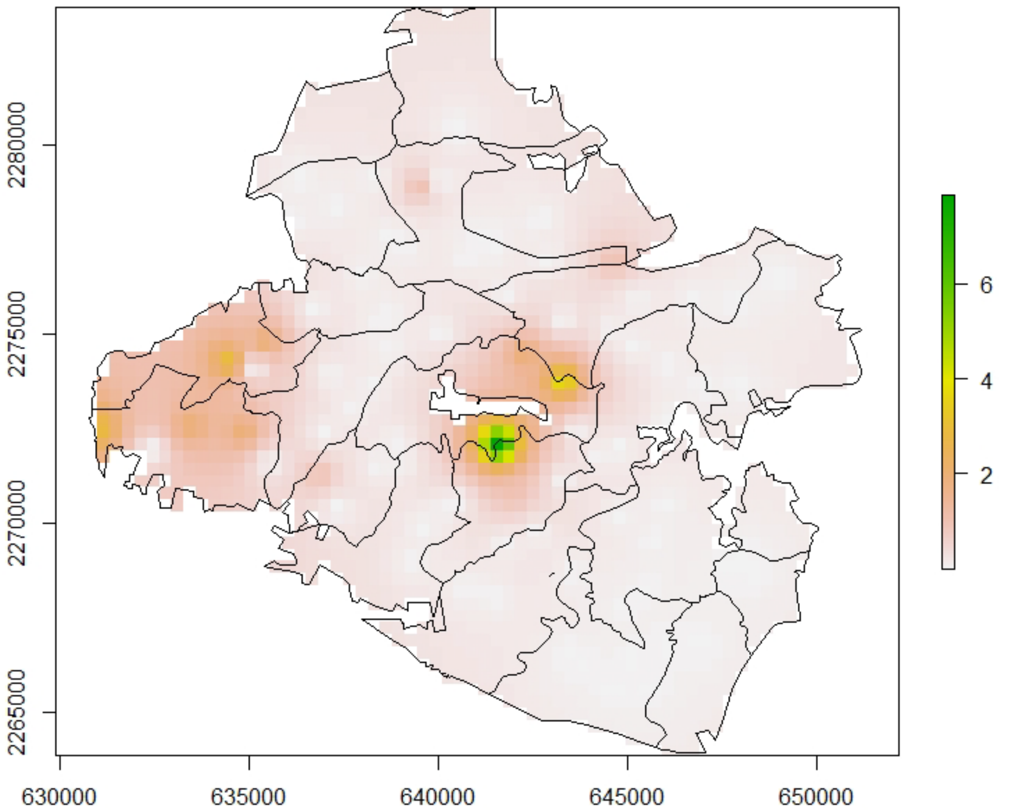

Figure 13(p): Intensive area use map for Common Palm Civet at Dnyanganga WLS

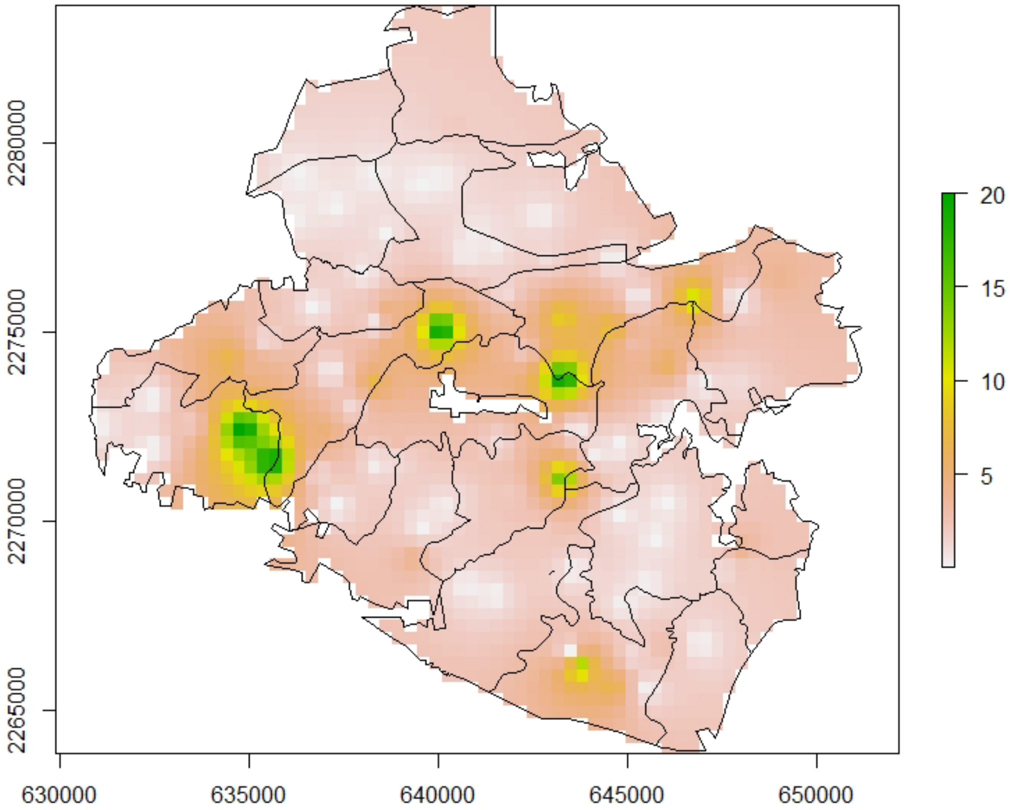

Figure 13(q): Intensive area use map for Small Indian Civet at Dnyanganga WLS

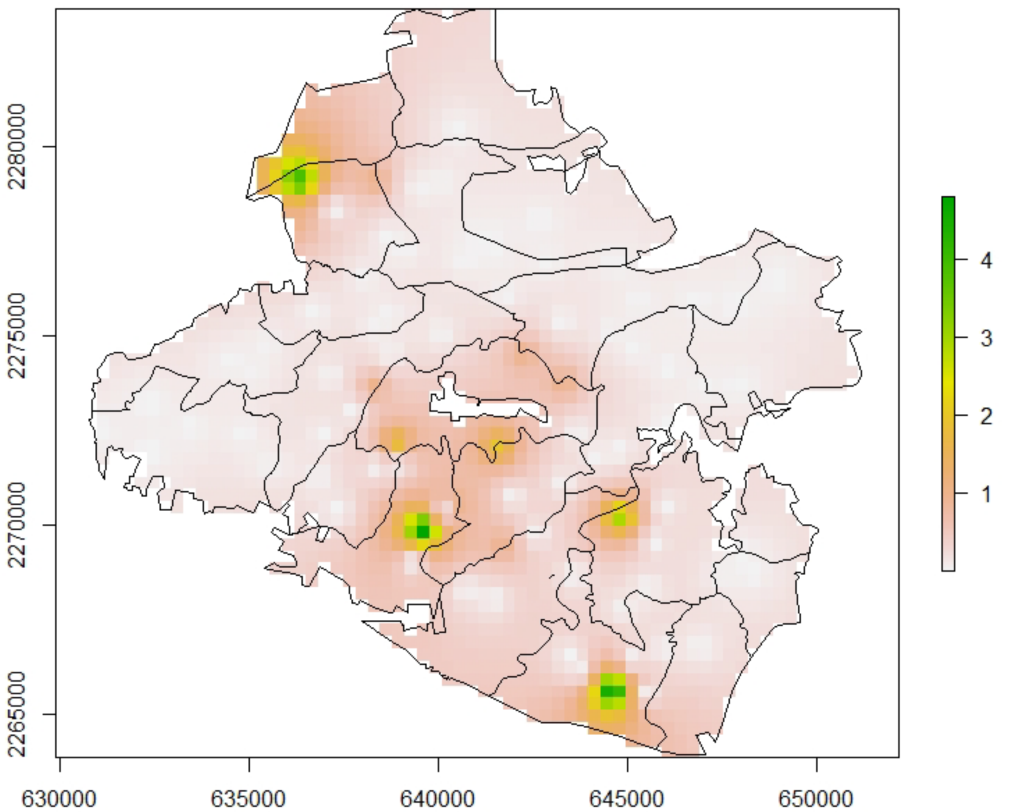

Figure 13(r): Intensive area use map for Grey Mongoose at Dnyanganga WLS

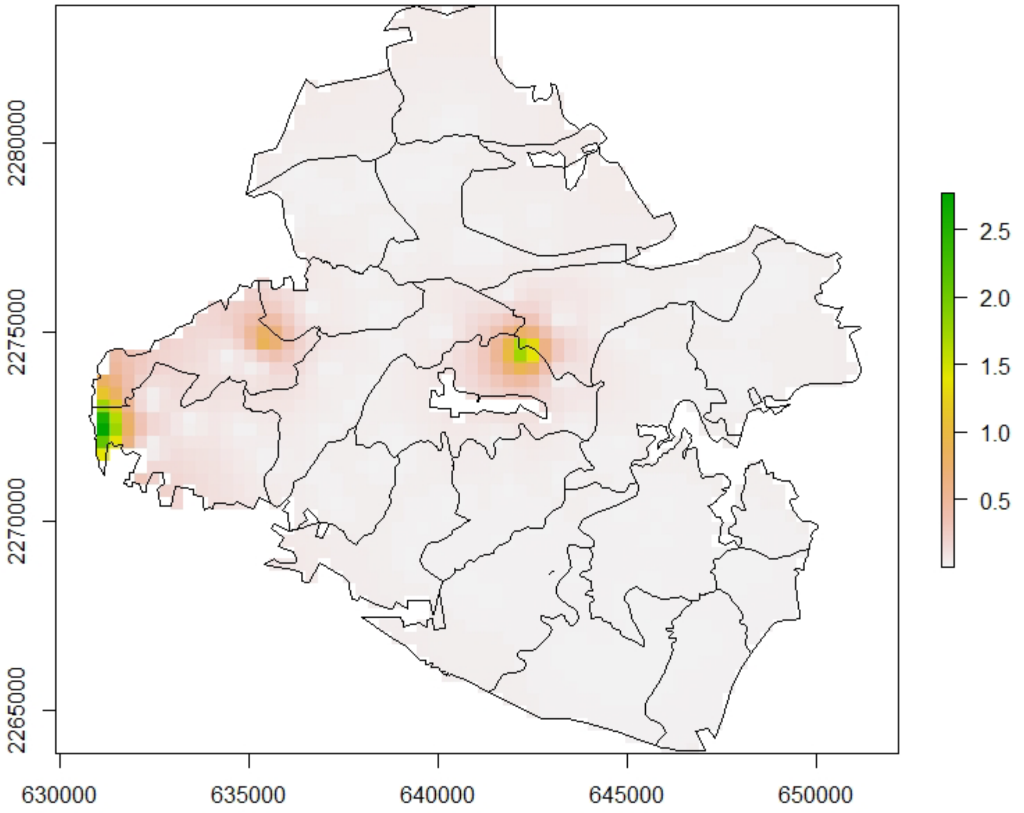

Figure 13(s): Intensive area use map for Ruddy Mongoose at Dnyanganga WLS

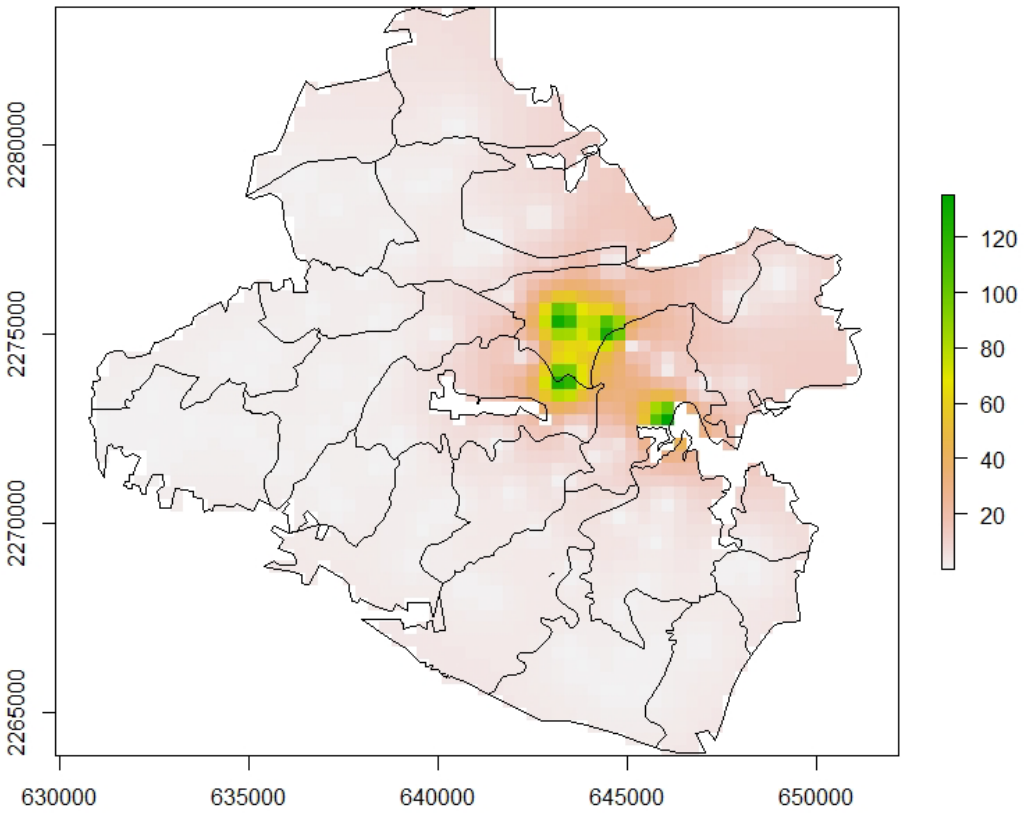

Figure 13(t): Intensive area use map for Cattle at Dnyanganga WLS

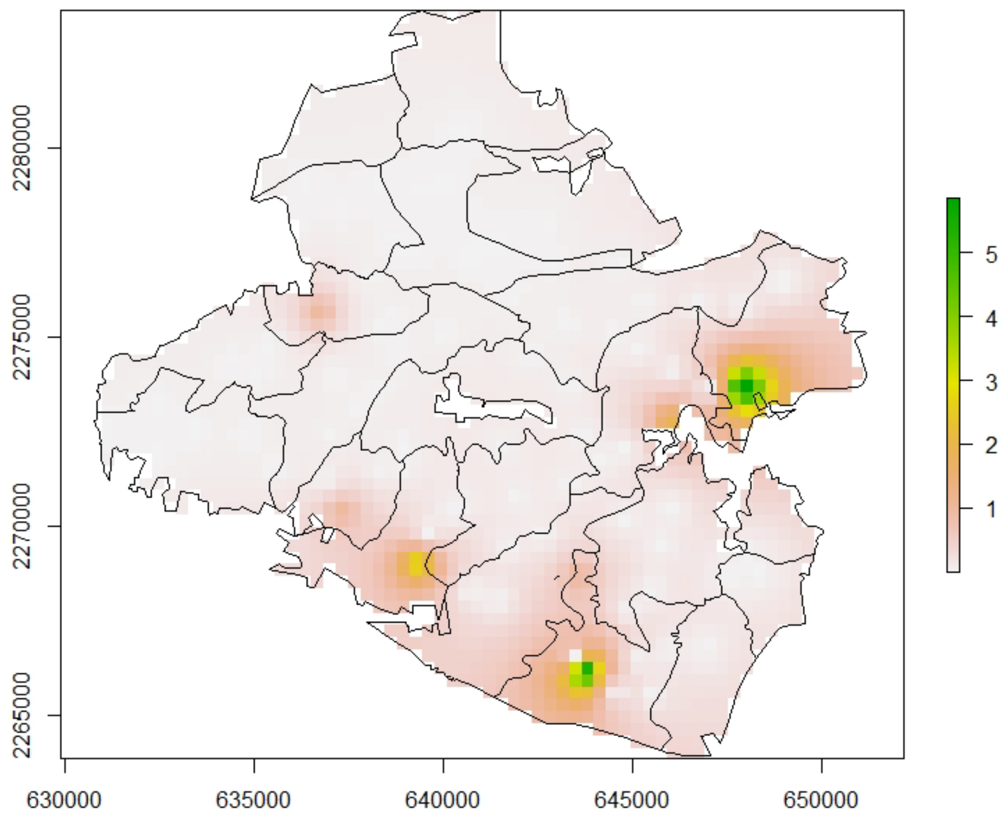

Figure 13(u): Intensive area use map for Stray Dog at Dnyanganga WLS

Figures 13 (a – u): Intensive area use of various species at Dnyanganga WLS, Maharashtra, India during the 2021 Phase IV Monitoring.

6. References

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