Final Report

Population Status, Habitat and its Use by Blackbuck (*Antilope cervicapra*) in and around Kaimoor Wildlife Sanctuary, with reference to proposed Coal-based Thermal Power Plant of 1320 MW, Mirzapur, Uttar Pradesh

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

March |2019

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Team Leader

Dr. V.B. Mathur, Director

Investigators

Dr. Bilal Habib, Scientist 'E'

Mr. Salvador Lyngdoh, Scientist 'D'

Dr. S.P. Goyal, Emeritus Scientist

Researchers

Khursid Alam Khan

Rahul De

Himanshu Kumar

Kumar Ankit

Other Contributors

Manoj Agrawal, Shahid A. Dar, Sougata Sadhukhan,
Nirmal Kumar and Vinay Kumar

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Photographs:

Khursid A. Khan (khan.khursheed.alam@gmail.com)

Corresponding authors:

Dr. Bilal Habib (bh@wii.gov.in)
Dr. S.P. Goyal (goyalsp@wii.gov.in)

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Blackbuck Project Team

Wildlife Institute of India, Dehradun

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List of Abbreviations and Acronyms

Abbreviations	*Expansions*
AF	Adult female
AM	Adult male
AR	Allelic richness
AUC	Area under curve
BEAST	Bayesian Evolutionary Analysis Sampling Trees
BIC	Bayesian information criteria
BSA	Bovine serum albumin
CAMPA	Compensatory Afforestation fund Management and Planning Authority
CI	Confidence Interval
CV	Coefficient of Variation
D	Estimate of density of animals
DAPC	Discriminant analysis of principal components
DN	Digital number
DNA	Deoxyribonucleic acid
DS	Estimate of density of clusters
E(S)	Estimate of expected value of cluster size
F	Fawn
FAO	Food and Agriculture Organization
FCC	False colour composite
FSI	Forest Survey of India
GBH	Girth at breast height
GIS	Geographic Information System
GPS	Global Positioning System
HA	Hectare
IBC	Individual based Bayesian clustering
IBD	Isolation by distance
ICFRE	Indian Council of Forestry Research and Education

IUCN	International Union for Conservation of Nature and Natural Resources
JAICA	Japan International Cooperation Agency
KM	Kilometre
KWLS	Kaimoor Wildlife Sanctuary
LULC	Land use land cover
MCM	Million cubic metres
MCMC	Markov-chain Monte Carlo
MoEF	Ministry of Environment and Forest
MP	Madhya Pradesh
mtDNA	Mitochondrial DNA
MW	Mega Watt
N	Estimate of number of animals in specified area
NCBI	National Centre for Biotechnology Information
NE	North East
NGS	Next generation sequencing
NH	National highway
NIR	Near infrared
NRSA	National Remote Sensing Agency
NUMT	Nuclear mitochondrial DNA segment
PCCF	Principal chief conservator of forest
PCR	Polymerase chain reaction
ROC	Receiver operating characteristic
RS	Remote sensing
RT	Radial transect
SAF	Sub-adult female
SAM	Sub-adult male
SDM	Species distribution model
SE	Standard Error
SE	South East

SH	State highway
SNP	Single nucleotide polymorphisms
sPCA	Spatial principal component analysis
SSR	Simple sequence repeat
STR	Short tandem repeat
TM	Thematic mapper
TPP	Thermal Power Plant
UP	Uttar Pradesh
USA	United states of America
VNTR	Variable number tandem repeat
WCMC	World Conservation Monitoring Centre
WEUPPL	Welspun Energy Uttar Pradesh Private Limited
WLS	Wildlife Sanctuary

Executive Summary

The Indian antelope (Antilope cervicapra) or Blackbuck is endemic to the Indian sub-continent and was widely distributed until recent past across a diverse range of habitats from semi-arid grasslands to scrublands and open forest. However, its most preferred habitat has always been open grassland throughout its distributional range. Moreover, such grasslands are considered as wastelands and have been heavily impacted due to different anthropogenic factors, e.g., livestock grazing, plantation, rapid urbanization, and industrialization. Such factors have caused a decline in habitat quality which resulted in local extinction across its range. Besides habitat degradation, hunting in the past has also caused in decline population. Majority of the Blackbuck populations are now small, and residing in human-dominated landscape or cropland except a few populations, which are still dwelling inside the protected areas, which may serve as the gene pool for long-term conservation if managed properly.

Of the different Blackbuck populations of Uttar Pradesh, one of the conservation importance population is of Kaimoor Wildlife Sanctuary (KWLS) in Mirzapur and Sonbhadra districts of Uttar Pradesh. Recently, a coal based Thermal Power Plant (TPP) of 1320 MW has been proposed by the M/S WELSPUN Energy UP Pvt. Ltd., Mirzapur, Uttar Pradesh within 30 km of KWLS. Given the likely conservation threats to the Blackbuck population due to TPP, Chief Wildlife Warden, Uttar Pradesh advised M/S WELSPUN Energy UP Pvt. Ltd., Mirzapur Uttar Pradesh for a need of a detailed study on the (i) status of Blackbuck, movements, habitat and its use and (ii) prepare a conservation plan for the species in the Reserved Forests of Mirzapur and Sonbhadra districts and KWLS from the Wildlife Institute of India, Dehradun. Given this, the institute proposed six months study (July to December 2018) and was funded by M/S WELSPUN Energy UP Pvt. Ltd., Mirzapur Uttar Pradesh.

Effective conservation plan requires information on species' ecology and biology such as population status, demography, resource requirements in relation to habitat quantity and quality, population connectivity and impacts of anthropogenic factors. We collected these information during our reconnaissance survey and intensive field work (September to December 2018) in KWLS and the territorial forest ranges of the Ghurma, Robertsganj, Ghorawal, and Halia covering an area of 1767 km^2. We observed that most of the Blackbuck populations congregated in small habitat patches in Halia, Ghorawal and Robertsganj ranges of the KWLS whereas they are locally extinct from the Ghurma range. In the different ranges, the Blackbuck populations were confined in and around the Blackbuck valley (Robertsganj), Visundhari (Ghorawal), Kusehra, Halia 3, Parsia and Chaura (Halia). These all populations

are fragmented and isolated from each other. Distribution pattern and population estimation have been one of the major tools for the species' conservation plan. Therefore, we randomly placed 53 line transects ranging 2 to 3.5 km in the intensive study area. Temporal replicates (n=4) for each transect were walked in different habitat types ranging from agriculture land, open scrub, dense scrub, barren land, and plantations. A total of 75 Blackbuck herds were sighted on transects which encompass of 259 individuals. The estimated density of Blackbuck was 4.42±2.00 with a mean cluster density of 3.35±0.40. The coefficient of variance was very high, i.e., 57.77. Our random survey within the study area also resulted in sighting of 226 individuals among which maximum individuals recorded were in Halia (127) followed by Ghorawal (58), and Robertsganj (41) ranges. During our transect surveys, we counted 226 different Blackbuck individuals within the sampled area of 811 km^2 determined based on minimum coverage polygon (MCP). Hence, the overall estimated population in the study area of 1767 km^2 could be between 450 and 500.

We classified encountered Blackbuck herds in different group size and age categories. During the entire survey, we visited different areas repeatedly to enumerate herd compositions in and around KWLS. During the study period, we noted a total of 289 groups which comprised 1500 individuals from the intensive study area. The male to female ratio of the overall encountered Blackbuck indicated that the population is female biased (1:2.37). Adult female comprised a maximum proportion of (42.6%) followed by sub-adult female (23.26 %), adult male (18.33%), sub-adult male (9.4%), and fawn were (6.4%). Adult female to fawn ratio was 1: 0.15. The proportion of the adult male was c. 20% of the total sightings across all forest ranges. However, the sub-adult male proportion was similar in Ghorawal and Halia ranges (c.11%), but it was only 4.6% in the Robertsganj range. This may be because of the low population size, and this range may have a greater chance of the poaching and predation by other carnivores when the sub-adult males disperse from the natal area.

The herd size is an indicator of habitat quality in several antelopes, and larger herds remained in better habitat quality. The herd size recorded from KWLS ranged from 1 to 28 individuals, and the majority of the herds (72.6%) were < 5 individuals. We observed a few herds (1.0%) which were larger than 26 individuals in the study area. Low adult female to fawn ratio and observed small group size indicate that the habitat quality of the study area is poor in terms of food resources.

During the present study, we did not find any lekking sites of the Blackbuck throughout the study area. Likewise, lekking was also not observed in the areas where the Blackbuck *substantial populations were observed in the restricted areas of Rajasthan, Gujarat and Madhya Pradesh (Ranjitsinh 1982).*

The Predators are one of the most influencing factors of any wild population. Therefore, information is crucial for understanding the ecology and biology of prey species. Predation by domestic dogs and wild carnivores are reported to be a major threat to species' conservation across the world. Therefore, we assessed the status of the domestic and wild carnivores inside the study area and data were collected during the line transect. A total effort of 298.7 km was made to estimate the predators (Golden jackal, Domestic dogs, and Fox) in and around KWLS. We found that the overall density of the predators (was estimated to be 1.96±0.69 per km^2. The average cluster size was 1.56 individuals. The predator especially the domestic dogs were distributed throughout the study area as most of the area is under village settlement or crop field. However, the wild carnivores were distributed either in barren land or inside the protected area.

For understanding the extent of predation by wild and domestic carnivores (Golden jackal, Fox, and Domestic dog) on Blackbucks, a total of 138 scats were collected from the study area. Analysed scats (n=122) indicate that 5.73% of scats contain Blackbuck hair. However, we also noted the presence of Blackbuck hair in domestic dog scat. The incidences of predation of Blackbuck by Jackal were maximum in Ghorawal followed by Robertsganj range. Hence, predation by domestic and wild carnivores may be a major threat for the small Blackbuck populations of KWLS. This may affect growth rate and requires long term monitoring to assess the extent of such predation on Blackbuck population.

Land use and land cover are two essential factors, explaining the terrestrial environment in connection with both natural as well as anthropogenic activities. We assessed the temporal changes in land use and land cover in the study area of KWLS from 2000 to 2018. Analysed data indicate that fallow and barren land, which are the key habitat for the Blackbuck have declined over a period. The maximum reduction was estimated in forestland, i.e., 47% to 6.54% (including open forest) followed by fallow land, 17% to 11%. However, the increase was recorded in agriculture land (29% to 44%) and shrub land 3% to 31%. The gain recorded in scrubland is due to increase of the Lantana (Lantana camara) and Parthenium (Parthenium hysterophorus) weeds. Most of the ideal Blackbuck habitats (fallow land and barren land) have been converted into the scrubland or agricultural land over eighteen years.

The vegetation of the study area is tropical dry deciduous forests, and are characterized by long dry and warm months and growth of vegetation resources are dependent on monsoonal rainfall. To assess the vegetation characteristic of the study area, the systematic sampling was *done along the line transects at every 200 meters. We recorded a total of 28 tree species, 33 shrub species, 17 herb species, and seven grass species in the study area. The overall tree density was 2.36/hectare and maximum was recorded for the Butea monosperma (0.58/ha) followed by Diospyros melanoxylon (0.41/ha), Acacia catechu (0.41/ha) and Acacia nilotica (0.18/ha). The overall shrub density was 381.32/hectare, and the maximum shrub density recorded was for the Lantana camara 163.8/ha followed by Diospyros melanoxylon 35.3/ha, Butea monosperma 34.8/ha, Holarrhena antidysentrica 23.4/ha and Acacia catechu (15.2/ha). Dominant grasses were Eragrostis tenella, Digitaria spp., Cynodon dectylon, Desmostichea spp. etc. and average grass height was relatively more in Halia than other ranges. Data indicates that high shrub cover in all the ranges and plantation undertaken during last ten years infests most of the preferred open grassland habitats.*

Among different anthropogenic factors, overexploitation of the resources by people, habitat loss due to destruction, fragmentation, or degradation of habitat, overgrazing are the primary threats to the survival of the species' in the human-dominated landscape. The extent of livestock grazing was quantified over 53 line transects. We encountered 51 sightings encompass 604 livestock individuals on transects throughout the study area. The estimated density of livestock was 132±16 individuals/km^2, and the mean cluster size was of 13.2±0.92. Estimated livestock dung density was in between 105 to 177/ha and was in the order of Halia > Robertsganj > Ghorawal > Ghurma. The intensity of the lopping was maximum in the Ghorawal and Halia in comparison to Robertsganj and Ghurma ranges.

Prosopis juliflora is one of the known threat to the Blackbuck throughout India. It has adversely impacted on Blackbuck population in Velavadar and other Blackbuck distributed areas in Rajasthan, Gujarat, Uttar Pradesh, and Madhya Pradesh. The Blackbuck population has been reduced drastically wherever Prosopis has encroached the open grasslands. Most of these encroachments have been due to high dispersal of the seeds by the livestock as pods of this species are palatable. We assessed the presence of the Prosopis juliflora in and around the KWLS, and it was recorded from Ghurma, and Robertsganj ranges having the density of 29.15/ha and 0.25/ha respectively. However they are found in less numbers, but having a broad ecological amplitude, excellent growth rate, and strategy of the seed dispersal by livestock and other wild animals, it could invade very fast in to the study area and could be a possible threat for the Blackbuck in the near future. Therefore, we suggest that the distribution of this species should be monitored regularly at least once in five years.

The government policies to improve green cover throughout the country are going to be the major threat for the grassland and open scrub species. Grassland and open scrub are always considered as wasteland, and it provides a suitable environment for enhancing the forest cover. So the whole Vindhyan range and especially the Kaimoor Wildlife Sanctuary was planted during the recent past under the different forest projects especially Compensatory Afforestation Fund Management and Planning Authority (CAMPA) and Japan International Cooperation Agency (JICA) which played a major role to reduce the crucial Blackbuck habitat. The tree species like Acacia catechu, Acacia benzamine, Ailanthus excelsa, Acacia nilotica, and Lagerstroemia parviflora were planted in and around the Blackbuck presence sites Blackbuck valley (Robertsganj), Visundhary (Ghorawal), Halia 3, Kusehra, Parsia 3, Parsia 5 and Chaura 5, forest blocks of (Halia) in KWLS to enhance the forest cover. This plantation caused a change in the habitat and forced the Blackbuck which is a grassland species to remain in the fragmented small grasslands/ open scrublands. We suggest a need to restore the grasslands in this landscape.

Habitat suitability based on the "Species Distribution Model" about environmental variables and landscape connectivity was assessed for the Blackbucks using presence data in 'Maximum Entropy' and 'Circuit Theory' framework respectively in and around KWLS. The current land use patterns reveal the presence of small suitable habitats and limited landscape connectivity among different populations and are available only at few places in spite of the short distance between Robertsganj and Ghorawal. This has been because of anthropogenic factors. The connectivity between the Ghorawal and Halia is through a narrow scrubland which has succumbed to human habitation and several other anthropogenic pressures.

Assessment of genetic variability has been a key issue in species' conservation planning for ensuring long term conservation goals. We document first time genetic variability and connectivity using mtDNA and microsatellite genetic markers for the Blackbuck populations in India using non-invasive genetic samples (n=112). We did not observe any distinct regional affinity among different populations of KWLS and adjoining areas in phylogeography examined using mtDNA cytochrome b sequences (c. 350 bp) originating from Pakistan, Madhya Pradesh, Rajasthan, Gujarat, and Maharashtra (Shukla et al. 2019). This may be because of the historic bottleneck, and population expansion might have taken place from the small parent stock. However, we still suggest the use of a few additional genes of the mtDNA genome to document geographic affinity, if any. We used neutral nuclear markers (bi-parental) or multi locus genotyping for understanding genetic fitness/diversity and connectivity among different populations within KWLS. We observed relative low heterozygosity (Ho=0.366) and *sub-structuring in the populations of KWLS. Our analysis of landscape, as well as genetic connectivity, has indicated that the Blackbuck population of Robertsganj is genetically homogenized and isolated. We need to minimize the anthropogenic factors on the identified connectivity landscape corridor areas through 'Circuitscape', so as the movement of animals may take place among different populations in and around KWLS. Besides, the Blackbuck population of Robertsganj needs introgression of the gene pool from animals of similar co-ancestry to maintain a viable population.*

We also assessed the extent of the suitability of Blackbuck habitat at the proposed Thermal Power Plant (TPP) using eight radial transects radiating from the site. Maximum sighted animals were livestock with an encounter rate of 44.12±8.19 per km. Among livestock species, sheep comprises maximum encounter rate followed by cattle and goat. However, the encounter rates of wild animals were found very low 0.40±0.12 per km. Nilgai comprised maximum encounter rate of 02.8±0.10 while the minimum encounter rate was found for the Indian hare. Vegetation quantification at TPP site indicates that dominate trees species were of Acacia catechu (15.20/ha), Butea monosperma (9.55/ha), Lagerstroemia parviflora (4.24/ha) whereas other trees with low-density were of Aegle marmelos, Eucalyptus hybrid, Cassia fistula. We recorded 20 shrub species, and most of the areas were dominated by Ziziphus nummularia (1.97/ha), Ziziphus mauritiana (0.50/ha), Acacia catechu (0.40/ha). The area was also heavily infested with the high density (116.18/ha) of the bamboo (Dendrocalamus strictus). The nearest population of Blackbucks of all the ranges of KWLS is around 24 to 49 km from the TPP site. We did not observe large areas of habitats preferred by the Blackbucks at TPP site such as short grassland and open scrub. Most of the areas in and around TPPs are surrounded by the moderate density of forests of Bamboo and other tree species which are not suitable Blackbuck habitats. We also examined the land use and land cover in areas between TPP site and boundary of KWLS. The majority of the areas are dominated with a high-density of human populations and under intense agriculture. Because of high anthropogenic factors including canal system, state highways, high-density road network and high vehicular traffic between areas of TPP site and KWLS, we visualize the least possibility of recolonization of the Blackbucks in this landscape from the populations of KWLS.

Based on the information collected on species' ecology and biology about population status and demography, existing LULC and anthropogenic factors, we suggest conservation plan for the Blackbuck of KWLS to ensure the long-term conservation goals under Chapter 12.

Chapter 1:

Introduction and context of this project

1.1.Introduction:

The Indian antelope (*Antilope cervicapra*) or Blackbuck is endemic to Indian sub-continent. Once distributed in India, Pakistan, Bangladesh and Nepal now has been extinct from the Pakistan and Bangladesh. However, the population in Pakistan was re-established by re-introduction of a small populations from USA. Blackbuck is widely distributed across a diverse range of habitats from semi-arid grasslands to scrublands and open forest. (Schaller 1967, Mungall et al. 1981, Prasad 1981, Ranjitsinh 1982, Ranjitsinh 1989, Rahmani 1991, Isvaran 2005). The Blackbuck occurs in high densities in semi-arid, open as well as short-grass plains. Taxonomically Blackbucks are classified under the subfamily Antilopinae, family Bovidae and the order Artiodactyla. A recent revised phylogeny of Antilopinae based on sequences from several nuclear and mitochondrial loci indicated that *Antilope* and *Gazella* to be sister genera distinct from the other sister genera of *Nanger* and *Eudorcas* (Fig 1.1) (Considine and Kulip 2008, Bärmann et al. 2013). There are two distinct sub species of Blackbuck documented in India. The north-western *Antilope cervicapra rajputanae* and the south-eastern *Antilope cervicapra cervicapra* (Groves 1980, Ranjitsinh 1989). Body size, horn length, and the darkness of male coats typically decrease in a gradient from north of the Blackbuck occurrence range to south as well as from west to east. (Dharmakumarsinhji and Gaekwad 1958, Krishnan 1972, Ranjitsinh 1989). *Antilope cervicapra cervicapra* is found in southern, eastern and central India and it has a white eye ring which is narrow above the eye while neck is black in case of the male; the white sections on the ventral region is largely restricted to the belly in both males and females. The black leg stripe is well defined and reaches all along the leg. The subspecies *Antilope cervicapra rajputanae* occurring in the north-western parts of India typically has broad white eye ring with the leg-stripe going down to the shanks. Males develop a grey sheen at the dark parts of the body during the mating season. The white portions on the ventral side extends up to half way on the sides whereas the lower base of the neck is white in case of males. (Groves 1980, Groves and Grubb 2011, Sontakke 2012).

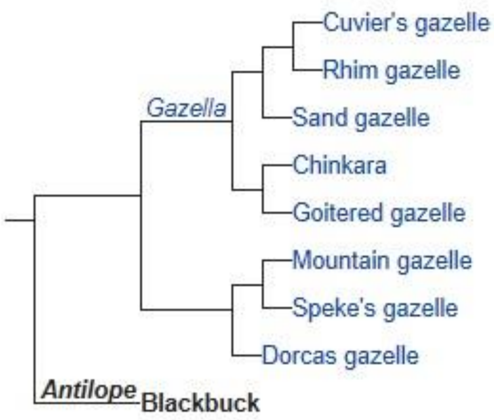

Figure 1.1 Phylogeny of Blackbuck

The Blackbuck is listed in the Schedule I in Wildlife (Protection) Act 1972, while IUCN Red list has listed this animal as “Least Concern” and is included in Appendix III of the

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Until recent past, Blackbuck was known to be widely distributed (Fig. 1.2.), but has been disappeared from numerous areas due to habitat destruction and anthropocentric development. Despite such threat Blackbuck are known to be increasing in many protected areas and community reserves in Rajasthan, Gujarat and Haryana (Rahmani 2001).

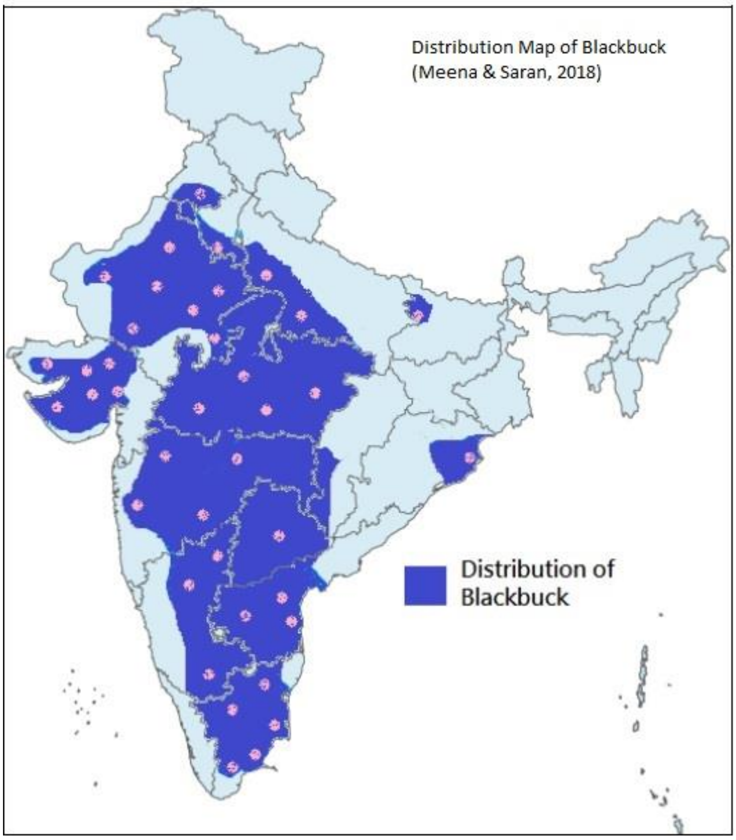

Figure 1.2. Distribution map of Blackbuck in India.

Blackbuck show prominent sexual dimorphism; males have black and white pelage and large spiralling horns. The brown areas at the back of males gradually darken with age finally becoming black (Prater 1971). Blackbucks rarely live in isolation, and are mostly found in herds. The Blackbuck is diurnal animal feeding on tender leaves of shrubs and trees, grass, crops and vegetables (Meena and Chourasia 2017). Blackbucks are often seen feeding in agriculture fields within distribution range or on the fringes of protected areas. They show a definite pattern of activities in the fixed hours of the day which may slightly vary with the seasons (Meena et al. 2017). Blackbuck has an important ecological role in grassland ecosystem (Sharma 1980, Meena et al. 2017). It shows a very unique mating system called ‘lekking’. Lekking is a mating system in which breeding males congregate in an open area defending tightly clustered small territories, and are visited by females for mating. The ‘lek’ territories typically do not have any other resources attracting the females except for the mates (Bradbury 1981). Lekking is an energy intensive strategy for the males often bear injuries. Therefore, it is typically adopted only by strong and dominant males (Ishvaran and Jhala 2000). The dominant male chases the female with the nose pointing upward showing a flehmen response towards the urine of the female. The female waves her tail and thumps the rear legs on the ground showing receptivity followed by mounting attempts leading to copulation, the whole process taking up to six hours. The territorial male may then move on to mate with another female following the same procedure.

The viability of small isolated populations is under constant threat from stochastic destabilising effects such as inbreeding, demographic changes as well as susceptibility to diseases (Lacy 2000). Maintaining meta-population structures by ensuring genetic connectivity, however, aids survival of patchily distributed small populations (Akçakaya et al. 2007). In drastic situations measures such as ‘genetic rescue’ i.e. introduction of alleles in population through managed immigration to increase the fitness of the population, has been shown to have positive impact (Whiteley et al. 2015).

1.2. Purpose of Study:

M/S WELSPUN Energy UP Pvt. Ltd., Mirzapur, Uttar Pradesh has proposed a Greenfield Coal based Thermal Power Plant (TPP) of 1320 MW comprising two units each of 660 MW using super-critical technology in an area of 354.11 ha in Mirzapur, Uttar Pradesh. The proposed TPP is planned to utilize domestic coal or imported coal from Indonesia. As per the Environmental Impact Analysis guidelines, company has prepared “Conservation and Management Plan” for the site and has also been approved by the Chief Wildlife Warden (CWLW), Forest Department, Lucknow. Closed to this TPP plant, there are areas of Reserved Forests mainly of dry deciduous and open scrub forests of Mirzapur and Sonbhadra districts. Besides this, there is Kaimoor Wildlife Sanctuary (KWLS), which is well known for the presence of the Indian antelope (Blackbuck) within 30 to 40 km of the proposed TPP. For conservation of this Schedule I species, CWLW, UP advised the M/s. WELSPUN Energy UP Pvt. Ltd. to undertake a detailed study on Blackbuck’s habitat, movements, habitat use and to prepare a conservation plan for the species in the Reserved Forests of Mirzapur and Sonbhadra districts and KWLS with reference to proposed TPP by the Wildlife Institute of India, Dehradun vide his letter dated 15th October, 2014 (Annexure I). Reference to this, WELSPUN Energy Pvt. Ltd, Mirzapur has requested Director, Wildlife Institute of India, Dehradun vide letter dated 23.04.2018 to submit proposal for undertaking study (Annexure II) and was funded by them for the same.

1.3. Study Area:

The study area (Kaimoor Wildlife Sanctuary and the territorial forest ranges of the Robertsganj, Ghurma, Ghorawal and Halia) lies between 24^0 27' 36.93" N, 83^0 9' 37.44" E to 24^0 54' 25.467"N, 82^0 15' 54.23"E. It extends from north to south is around 50 km and east to west is around 90 km with an area of 1767 km^2 (Fig. 1.3). The study area is situated in Mirzapur and Sonbhadra districts of Uttar Pradesh. To safeguard the fauna and flora of the Vindhyachal region, the KWLS was established in 1982. It covers an area of about 501 km^2. The KWLS is famous for huge diversity of flora and faunas. A variety of vegetation is found in KWLS, the forest type is mixed and dry deciduous that consist of primary tree vegetation like, Mahua (*Madhuca longifolia*), Dhaak (*Butea monosperma*) and Bamboo (*Dendrocalemus sp.*). The wildlife comprises of Blackbuck (*Antilope cervicapra*), Chinkara (*Gazella bennettii*), Four-Horned antelope (*Tetracerus quadricornis*), Bluebulls (*Boselaphus tragocamelus*), Sambar (*Rusa unicolor*), Chital (*Axix axis*), Sloth Bear *(Melursus ursinus)* and Leopard (*Panthera pardus*) etc. Amongst reptiles, crocodiles and different snake species are found. Migratory birds visit the wetlands in the study area. There are water holes and watchtowers at situated at vantage points providing the visitors a first-hand experience of watching wildlife in their natural habitat. The Son river and the Kaimur hills demarcate the southern boundary of the Wildlife Sanctuary.

1.4. Site visited for reconnaissance Survey:

In the first phase of the project, a reconnaissance survey was carried in July 2018 to collect the information on population status, habitat documentation and its use by Indian antelope in Sonbhadra and Mirzapur districts (Fig. 1.4). We collected information regarding the study area and Blackbuck, from four ranges of the KWLS i.e., Halia, Ghorawal, Ghurma and Robertsganj for systematic study design for the next phase (Fig 1.4). In relation to proposed TPP, the following approaches were used during the reconnaissance survey:

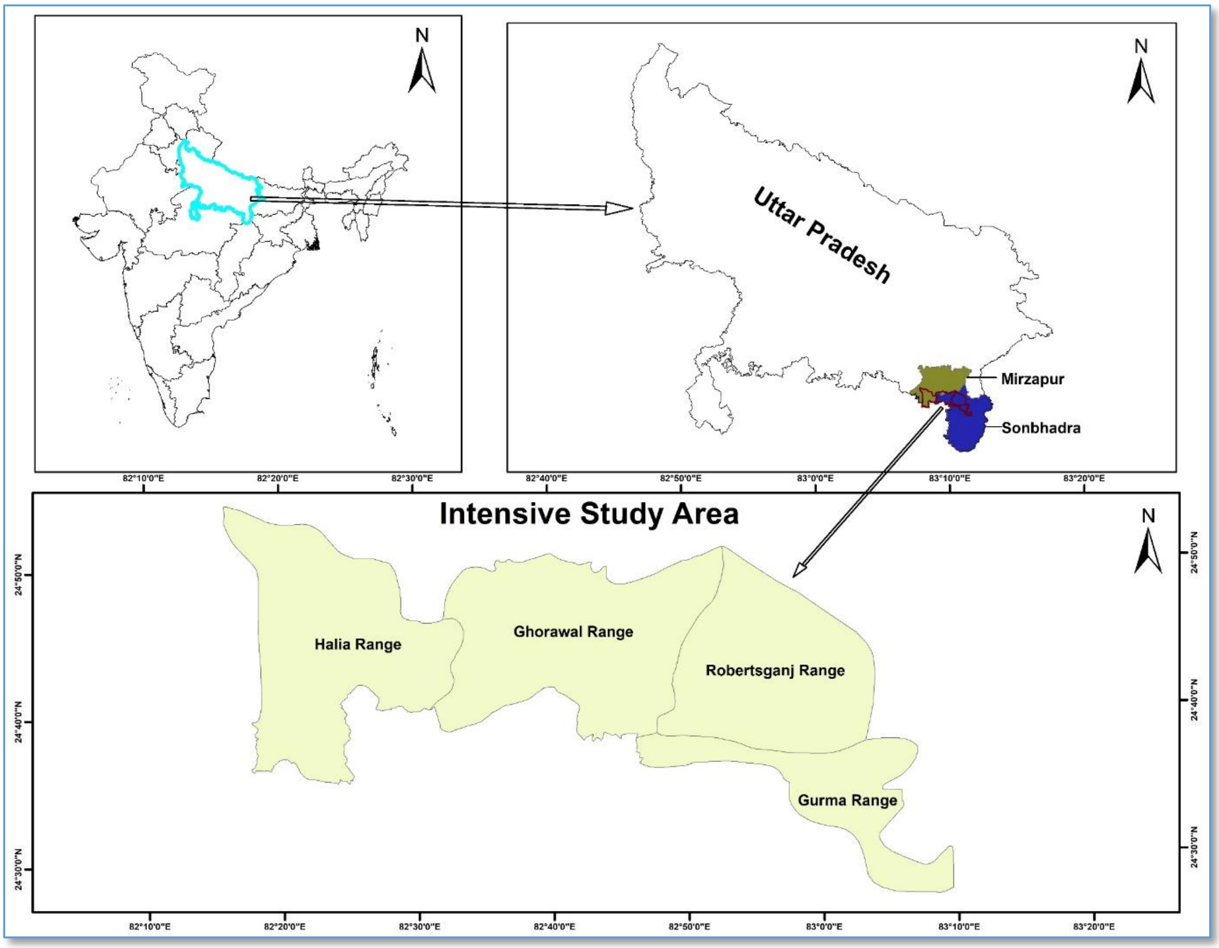

Figure 1.3. Map of intensive study Area.

A. Undertake reconnaissance survey to document habitat population status and its extent of use by the Indian antelope,

B. Examine secondary information available on Indian antelope populations in Sonbhadra and Mirzapur districts of Uttar Pradesh,

C. Examine secondary information available on Indian antelope populations in Sonbhadra and Mirzapur districts of Uttar Pradesh, and

D. Undertake habitat assessment of TPP site.

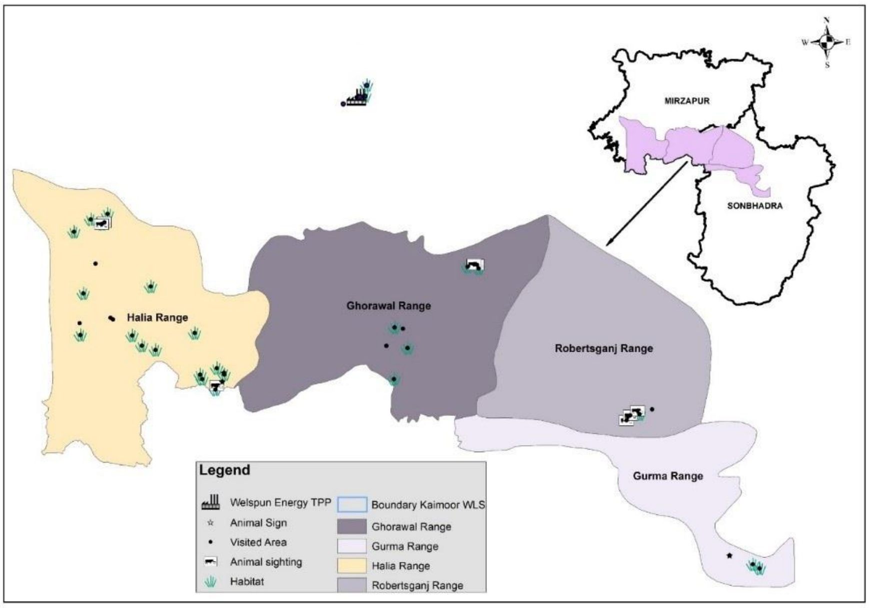

Figure 1.4. Map of study area visited during reconnaissance survey.

For preparing conservation plan information on species' population status, demography, resource requirements in relation to availability of habitat quantity and quality, population connectivity and anthropogenic factors are needed. Hence, we proposed collection of the information on the following aspect for preparing species conservation plan.

Figure 1.5. Information on different aspects of species ecology and biology collected for conservation plan.

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Chapter 2:

Distribution pattern and population estimation of Blackbuck

Summary

Estimating the status of wild animal population has very high importance in predicting, applying and verifying potential conservation and management initiatives for species and their habitat. The estimation of the Blackbuck population was one of the important aspects of the conservation plan and to safeguard this animal in KWLS. Therefore, we randomly placed 53 line transects ranging 2 to 3.5 km in the study area (1767 km2) to estimate the density of Blackbuck. The temporal four replicates (n=4) for each transect were done in different habitat types ranging from agriculture land, open scrub, dense scrub, barren land, and plantations. A total of 75 Blackbuck herds were sighted on transects which encompass 259 individuals. The estimated density of Blackbuck was 4.42 ± 2 with a mean cluster density of 3.35 ± 0.40. The coefficient of variance was very high, i.e., 57.77. Our random survey within the study area also resulted in sightings of 226 individuals. Estimated population within the study area could be 400 to 450. We have encountered maximum individuals of Blackbucks in Halia range (127) followed by Ghorawal (58) and Robertsganj (41) ranges.

2.1. Introduction:

Abundance estimation of the wild animals within as well as outside protected areas are important in order to monitor the wildlife value across a landscape (Buckland et al. 2000). A regular census permits predicting, applying and verifying potential management and conservation strategies for several species inhabiting the site (Blanco et al. 1996, Buckland et al. 2000). Accurate information on spatial and temporal distribution patterns is elementary to support species management, conservation and correctly assessing extinction risks (Gaston and Fuller 2009).

The Blackbuck is a group-living animal native to Indian sub-continent, designated as "Least Concern" in IUCN (Mallon and Kingswood 2001). The species was distributed throughout the Indian sub-continent (India, Pakistan, Bangladesh, and Nepal). Now, it has been confined in 80 to 100 isolated pockets of 13 states of India. It has been extinct (in the wild) from Pakistan and Bangladesh, however, the population was re-established in Pakistan through re-introduction. It has disappeared from its historical distribution due to several anthropogenic factors, habitat change, and hunting. Despite such threats, its population has been increased in several protected areas in Rajasthan, Gujarat, and Haryana (Rahmani 2001). However, habitat and overall population has shrunk throughout its distributional ranges. The Blackbuck population is reported from Odisha, West Bengal, Uttar Pradesh, Bihar, Punjab, Haryana, Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra, Madhya Pradesh, Rajasthan and Gujarat. In Nepal, Blackbuck Conservation Area south of the Bardia National Park holds the last surviving population of Blackbuck (200 individuals) (Bashistha et al. 2012). In Pakistan, Blackbuck sightings are rare along the border areas with India, which are perhaps reintroduced. They are also kept in the Lal Suhanra National Park enclosures for possible reintroduction (Mallon et al. 2001). The Indian antelope were also introduced to the grasslands of the United States of America (Texas) and Argentina (Mallon and Kingswood 2001).

2.2. Population estimates:

No systematic survey has been conducted to know the exact population of Blackbuck in India except a detailed study undertaken by Ranjitsinh (1982). The estimated population size was about four million 200 years ago which came down to around 80,000 individuals in 1947 (Ranjithsinh 1982). Subsequently, the effort was also made to assess the Blackbuck population in India and recorded an estimated population of 22500 – 24500 individuals (Ranjithsinh, 1982). It was estimated that the population had increased from 24500 to 50000 in between 1982 to 2000 (Rahmani 2001). The largest numbers were estimated in the states of Gujarat, Rajasthan, Punjab, Madhya Pradesh and Maharashtra (Rahmani 2001). Presence of Blackbuck in the Punjab state is confined only to Abohar Wildlife Sanctuary, Fazilka. The population of Blackbucks was 3500 in 2011 which has been reduced to 3273 in 2017. In Velavadar Blackbuck National Park, Gujarat, population of Blackbuck in 2001 was estimated to be around 25025 and now, it has reduced to 14281 in 2015.

In Odisha, according to the recent census that was conducted by the Forest Department in 2017, there are 3806 Blackbucks in the Ganjam district. During the 2011 census, the number was only 2194. Debata (2017) reported 7134 Blackbucks in a human-dominated area of Balipadar-Bhetnoi Blackbuck Conservation Area during 2012-2013. In Tamil Nadu, the population of Blackbuck seems to have seen a significant increase in the Moyar Valley pointing to increased protection of the species by the Forest Department. The Blackbuck population, believed to be anywhere between 800 to 1000 individuals in the Nilgiri Biosphere Reserve, parts of the lower Nilgiri, the Bhavani Sagar range in Erode and some parts of Coimbatore Forest Division. In Karnataka, the Blackbucks are found in highest number in Ranebennur Blackbuck Sanctuary which is located in Haveri district. This sanctuary had a population of over 6000. There are 886 Blackbucks in the Bidar district, the second largest population in Karnataka (Mohammed and Modse 2016).

Prasanna and Zutshi (2013) estimated Blackbuck in Jayamangali Blackbuck Conservation Reserve, Mydanahalli, and reported 454 Blackbuck during the census of 2009. Sagar and Antoney (2017) estimated 193 Blackbucks in Basur Amruth Mahal Kaval Conservation Reserve, Chikkamagaluru. The major increase in the Blackbuck population has been observed in Rajasthan state, where the Forest Department data suggest that the population has increased from 13457 in 2011 to 30530 in 2016. In Gajner Wildlife Sanctuary, Bikaner the total Blackbuck population was 86 individuals (Kumar and Niraj 2016). Hemsingh and Jakher (2007) reported that highest population density of Blackbuck in the Jodhpur district, followed by Nagaur district due to the availability of good habitat as well as protection provided by the local people. In some areas, the Blackbuck has become an agricultural pest due to overpopulation.

The Blackbuck was introduced in 1932 in Texas, USA. Reports suggest that the population proliferated and the Blackbuck was the second most populous introduced animal in Texas after the chital. The population size in the USA was estimated to be ca. 35,000 individuals in 2000. Blackbucks had also been introduced into Argentina in 1906, and it was estimated that there are 8,600 individuals in 2000 (Mallon et al. 2001). Bashistha et al. (2011) reported around 200 individuals of Blackbuck in Nepal.

Of the different Blackbuck populations nearby (Fig. 2.1) in the present study, field studies were conducted to estimate the status of the Blackbuck population in Kaimoor Wildlife Sanctuary and adjoining areas.

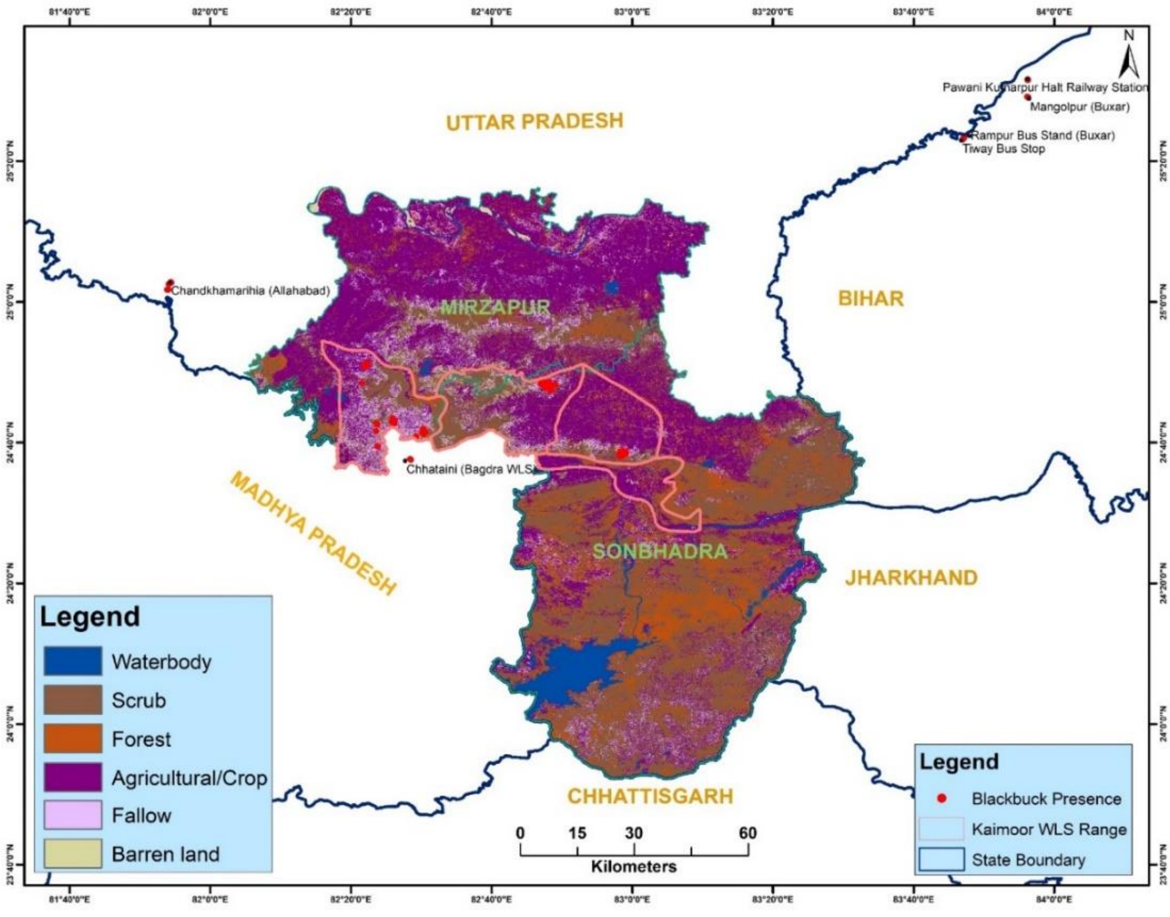

Figure 2.1. Distribution map of Blackbuck in and around KWLS.

2.3. Methodology:

The data for population estimation were collected from KWLS during the line transect survey. A total of 53 transects were laid (Fig. 2.2.) in different habitat types like agriculture land, open scrub, dense scrub, barren land, and plantations, to estimate the Blackbuck population in all the four ranges of the intensive study area. The length of the majority of transects varied from 2 km to 3.5 km (Annexure III). The temporal replicates (n=4) of the same was also done in the study area. Transects were walked during early morning and evening from 6:00 am to 10 am and 3:45 pm to 6:00 pm depending on locality, distance from the basecamp and terrain type. During the transect survey, we recorded the number of animals sighted, sighting distance, herd size, sex and age categories whenever the Blackbuck was sighted (Annexure IV). Other areas occupied by Blackbuck were also visited frequently to estimate the population and its demography. All encountered Blackbucks were classified in different age and sex categories. The animal within a distance of 50 meters from the centre of the herd was considered as a single group. However, the animal (territorial male) showed defending the territory was considered as a separate herd.

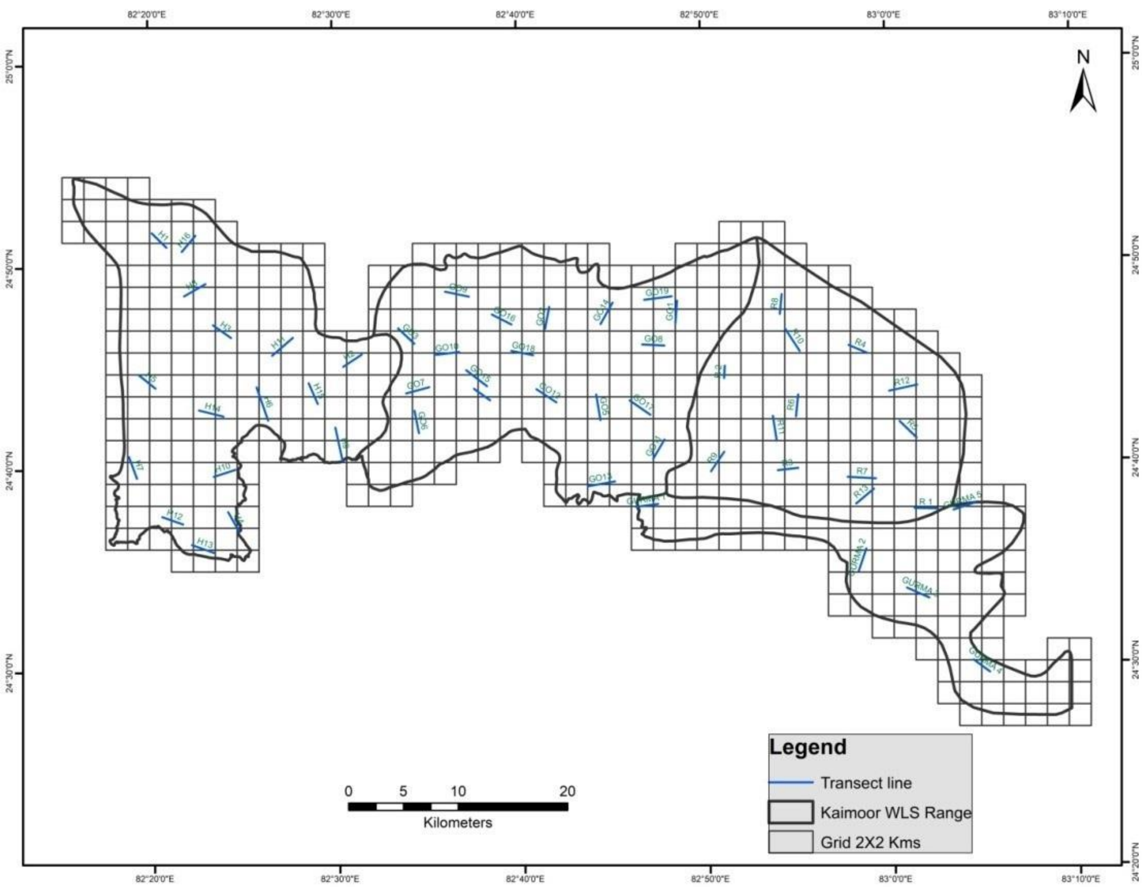

Figure 2.2. Transect placed in and around KWLS.

The age and sex were categorized into five categories according to Mungall (1978), i.e., adult male (AM), sub-adult male (SAM), adult female (AF), sub-adult female (SAF) and fawn (F). Further the herd size was classified into different group categories, i.e. (0-5, 6-10, 11-15, 16-20, 21-25, >26).

2.4. Results and Discussion:

Several studies have been carried out on status and aspect of the ecology of Blackbuck in the different part of the India (Daniel 1967, Nair 1976, Natarajan et al. 1978, Sharma 1980, Ranjitsinh 1982, Prasad 1983, Rahmani 1991, Singh 2005, Murmu et al. 2013, Kumar and Niraj 2016). But, most of the studies dealt with the ecological and biological aspect of the Blackbuck. None of the studies except the (Sagar and Antony 2017) has been conducted to estimate the population through the distance sampling method. We encountered 75 herds of the Blackbuck which includes 259 individuals on the transects. The animals encountered has been identified and classified in different group size and age structure.

The density of the Blackbuck was calculated 4.42 ± 2.00. The cluster density was recorded as 3.35 ± 0.40, though the coefficient of variance was high, i.e., 57.77 in the study area (Table 2.1). The effective strip width in this habitat was of 50 m (Fig. 2.3).

The estimated density was much less than the Sagar and Antony (2017) who estimated 26.23 individuals/km^2 in Basur Amruth Mahal Kaval Conservation Reserve. Most of the study carried out on Blackbuck was based on status (total count or block count), ecology, distribution, and behavioural aspects, expect the few which were based on detection probability of Blackbuck.

Our random survey within the study area resulted in sightings of 226 individuals. Estimated population within the study area could be 400 to 450. Observed sightings in different ranges were in the order of Halia (127) > Ghorawal (58) and >Robertsganj (41) (Table 2.2.) while Singh (2005) has estimated 595 and 534 individuals in the 2003-2004 and 2004-2005 in KWLS respectively (Table 2.2).

Table 2.1. Summary output of estimation of Blackbuck in the study area.

Parameter	Point Estimate	SE	% CV	95% CI	
DS	1.31	0.74	56.51	0.45	3.77
E(S)	3.35	0.4	11.97	2.64	4.25
D	4.42	2.55	57.77	1.51	12.92
N	4.00	2.31	57.77	2.00	13.00

DS= Estimate of density of clusters; E(S) = Estimate of expected value of cluster size; D=; N= Estimate of number of animals in specified area; SE= Standard error; CV= Coefficient of variation; CI= Confidence interval

Table 2.2 Population status of the Blackbuck in KWLS.

Range	Area, km^2	2003-2004*	2004-2005*	2018**	Projected Estimated No.
Ghurma	243	0	0	0	0
Robertsganj	440	201	179	41	76
Ghorawal	555	57	54	58	131
Halia	529	337	301	127	230
Total	**1767**	**595**	**534**	**226**	**437**

* Singh (2005)

** Present study

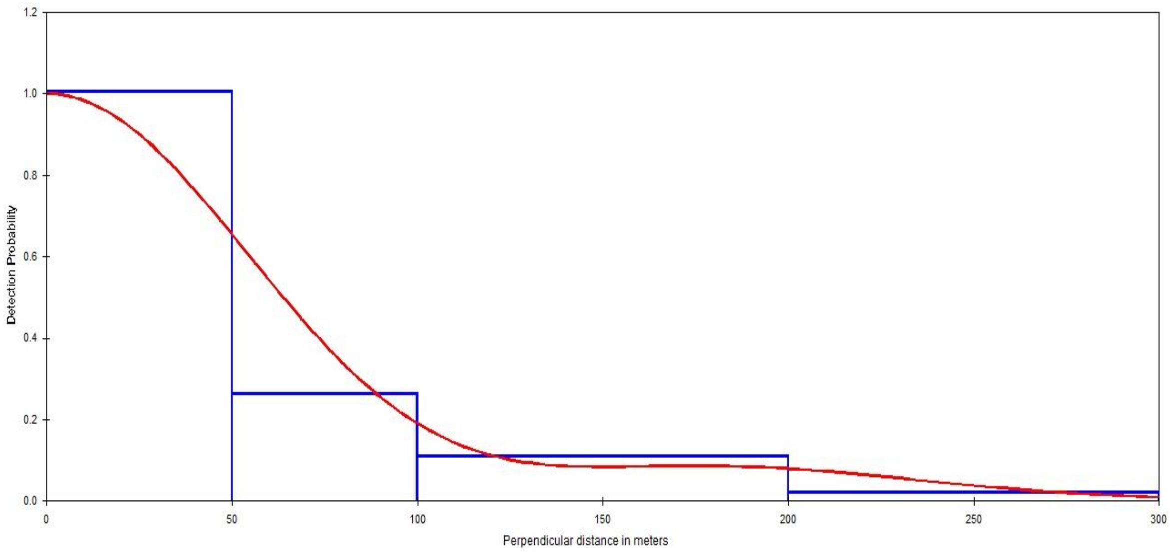

Figure 2.3. Detection probability curve of Blackbuck using "DISTANCE" program in KWLS.

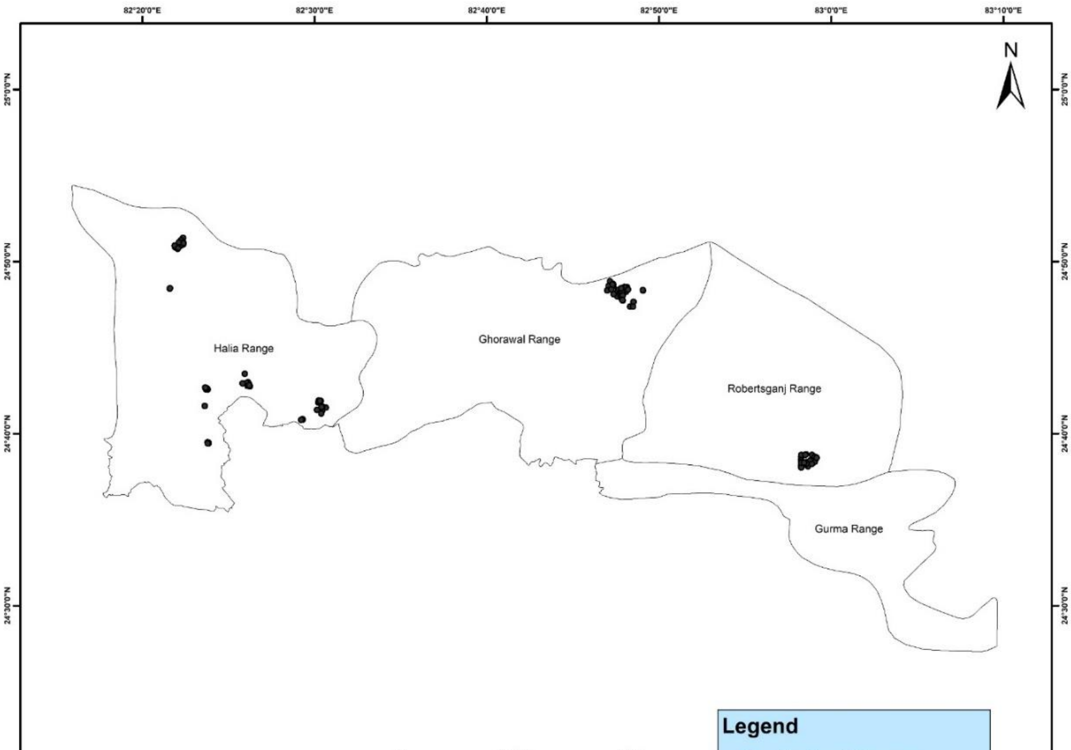

Figure 2.4. Distribution map of Blackbuck in KWLS.

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Chapter 3:

Population demography of Blackbuck

Summary

Estimation of the demographic parameters including age-sex composition and density indices is crucial for management and monitoring of wild populations and can also be used to predict population dynamics in the future. To document the demographic parameters, the encountered Blackbucks were identified and classified in different group size and age categories. During the entire survey, a total of 289 groups were encountered which comprises 1500 individuals from the intensive study area. The overall encountered Blackbuck indicated that the population is female biased, the adult female comprised maximum proportion (42.6%) followed by sub-adult female (23.26 %), adult male (18.33%), sub-adult male (9.4%) and was recorded minimum for the fawn (6.4%). The range wise population composition indicated that the proportion of adult male was 18.8%, 15.95% and 19.88% in Robertsganj, Ghorawal and Halia ranges respectively. While the sub-adult male proportion was found similar in Ghorawal and Halia ranges (c.a.11%) but was only 4.6% in the Robertsganj range. The female proportion was the maximum of 45.1% in Ghorawal range followed by Robertsganj 43.55% and Halia 40.48% ranges respectively. The proportion of fawn was 6% throughout all the ranges. The herd size is an essential parameter of habitat quality in several antelopes. The larger herd size is an indicator of the better habitat quality and vice versa. The h erd size recorded from KWLS were categorised in different group size categories and the majority of population found under (0-5) group size category (72.66%) whereas only 1.03% were recorded in>26 group size category. This indicates that the habitat quality of the study area is very poor in the terms of resources.

Sex ratios are one of the most fundamental demographic parameters indicating the relative survival of females and males as well as the future breeding potential of a population. The observed sex ratio is consequent of natural selection and anthropogenic effects of harvest on the sexes. Sex ratio also affects growth parameters and the evolutionary trajectories of wild populations. The sex ratio of the population is also a culmination of the birth, death, immigration, and emigration rates. The sex ratio (male: female) of the Blackbuck was estimated to be 1:2.37 in the study area. Means sex ratio is skewed towards the female and this is because of the natural selection as the male disperse and struggle for the resources and are also more vulnerable to poach/hunt and predate. The adult female to fawn ratio of the Blackbuck was 1: 0.15. This ratio is very low, and it is because of the small population size of Blackbuck in the intensive study area or could be poor habitat quality.

3.1. Introduction:

Estimation of the demographic parameters including age-sex composition and density indices is crucial for management and monitoring of wild populations and can also be used to predict population dynamics in the future. (Mysterud and Ostbye 2006, Coulson et al. 2001, Gaillard et al. 2003). Ungulates are K-selected long-lived animals with low litter size and high female parental investment. Demography and behavior in ungulates have evolved to accommodate of high population density reaching carrying capacity with their competitive ability important to individual success and inclusive fitness (Clutton-Brock et al. 1987, McCullough 1979). Competitive ability also plays a central role also in social behavior and organization (Geist 1974, Jarman 1974).

Anthropogenic harvest, predation, density-dependent competition for forage and climatic conditions significantly affect vital parameters of ungulates (Messier 1994, Sæther 1997, Gaillard et al. 1998, Patterson and Power 2002, Garrott et al. 2003). Though the effects climate variables on animal growth, body condition, and survival have earlier been studied (Pettorelli et al. 2007, Mysterud et al. 2008), a comprehensive analysis explicitly comparing the relative contributions of geographic, climatic, anthropogenic and biological variables is rare in the available literature. Understanding of the indicators as well as the drivers of population change can be informative for population status assessment and management decisions especially for managed populations spanning broad biogeographical gradients. Stochastic variability in climate is potentially important driver of population dynamics of ungulates (Saether 1997), affecting the seasonal forage quality (Chapin et al. 1995) having interactions with various limiting factors (Post et al. 1999). Ungulates inhabiting seasonally varying environments are usually adapted to give birth during high growth phase of vegetation to maximize nutritious forage access. Weather pattern variations in a climate regime affecting the timing of vegetation growth or delaying the decline in plant nutritional content may therefore affect juvenile growth and survival rates (Langvatn et al. 1996, Pettorelli et al. 2007).

Ascertaining the sex and age of an individual animals is the first step towards defining the sex ratio and age structure of a species population. These characteristic may provide important insight into a population's recent history, current status, and likely future range. Knowing age-specific natality is important for many population studies and wildlife management. Thus determining age classes becomes important. (Dimmick and Pelton 1996).

Aging is usually more difficult, and many methods for its determination have been developing. Some aging techniques place the animal into broad categories (adult male, sub-adult male, adult female, sub-adult female, and fawn) while others can be used to place individuals into specific year classes. The latter group of technique is considerably less common and generally more time-consuming. A few methods of age determination are of a more general in nature and can be broadly applied to several species, depending upon the question to be answered. Besides, it is extremely difficult to get a good reliable estimate of the age of the ungulates while walking transects and estimating abundance.

Actual estimate of age can be obtained by examination of teeth eruption and wear from the dead specimen or more accurately by cementum annuli on tooth sections (Dimmick and Pelton 1996). This would be desirous for analysis of demographic parameters and life tables (Caughley 1977). However, for monitoring, it would be relevant to distinguish the population into easily identifiable age and sex groups.

3.2. Methodology:

The data of herd size composition were collected from KWLS during the line transect and random survey. A total of 53 transects were laid in all four ranges of KWLS. We walked, and temporal replications of the same were done in different habitat to document the demography of the Blackbuck in all the four ranges of the intensive study area. During the transect survey we recorded the number of animal sighted, sighting distance, herd size, sex and age categories whenever the Blackbuck was sighted (Annexure IV). Other areas occupied by Blackbuck were also visited frequently to estimate the population and its demography. All encountered Blackbucks were classified into different age and sex categories. The animal within 50-meter distance from the centre of the herd was considered as a single group. However, the animal (territorial male) showed defending the territory was considered as a separate herd. Moreover, random surveys were also carried out throughout the study area to find out the lesser known population, and whenever the animal encountered the number of animals sighted, group size, sex and age categories were recorded through *Ad libitum* sampling. The age and sex were categorized into five categories according to Mungall (1978), i.e., adult male (AM), sub-adult male (SAM), adult-female (AF), sub-adult female (SAF) and fawn (F), further the herd size was classified into different group categories, i.e. (0-5, 6-10, 11-15, 16-20, 21-25, >26).

3.3. Results and Discussion:

3.3.1. Population demography:

Several studies (Daniel 1967, Nair 1976, Natarajan et al. 1978, Sharma 1980, Ranjitsinh 1982, Prasad 1983, Rahmani 1991, Singh 2005, Murmu et al. 2013, Kumar and Niraj 2016) have been conducted on the status and population composition of Blackbuck in India. A total of 1500 individuals in 289 groups were encountered during transect and random survey throughout the study area. The animals encountered has been identified and classified in different group size and age structure. Out of 289 groups encountered the proportion of the population shows that adult female comprises maximum, i.e., 42.6% followed by sub-adult female 23.26 % and was recorded minimum for the fawn 6.4% (Fig. 3.1). However, the study conducted in 2004 (Singh 2005) in the same study area suggested almost the same proportion of the population composition (Fig. 3.2). According to Singh 2005, the female proportion was 61.32% followed by male 26.82% and fawn 11.84%. Other studies carried out in a different part of India also indicate the Blackbuck population is female biased. Nair (1976) described the proportion of adult female 82.47% followed by adult male 17.52% in Point Calimare Tamil Nadu, Prasad (1982) recorded 57.2% adult female followed by 11.29% adult male in Mudmal, Andhra Pradesh, Singh (2005) recorded 61.32% female followed by 26.82% male in Kaimoor WLS, Uttar Pradesh, Murmu et al. (2013) recorded 42.44% adult female followed by adult male 20.19% in Orissa and Kumar and Niraj (2016) described 48.83% adult female followed by 9.3% female in Gajner, Rajasthan. The range wise population composition of the present study indicated that the proportion of adult male was 18.8%, 15.95% and 19.88% in Robertsganj, Ghorawal and Halia ranges. The sub-adult male proportion was found similar (c. 11%) in Ghorawal and Halia ranges but was lower in the Robertsganj range 4.6%. This is because of the low population size and greater the chance of poaching and predation (Fig. 3.4). Moreover, the female proportion was maximum (45.1%) in Ghorawal range followed by Robertsganj (43.55%) and Halia (40.48%). The proportion of fawn was around 6% throughout all the ranges.

The proportion of fawn indicated drastic change from 11.84% to 6.4% in comparison to 2004 (Singh 2005). This may be due to shrunken population size, the population of Blackbuck throughout its ranges in KWLS had been severely reducing due to habitat change, overgrazing, poaching, anthropogenic pressure and perhaps due to predation by the domestic dog, Jackal, fox and other predators. The sex ratio varied with the population size of the Blackbuck. Nair (1976) recorded sex ratio 1:4.7 in Point Calimere, Natarajan et al. (1978) recorded 1:5 in Point Calimere in Tamil Nadu, Schaller 1967 reported the sex ratio of Blackbuck 1:1.7 in Madhya Pradesh. While in the Rajasthan (Sharma 1980) recorded sex ratio different at different localities varied from 1:8, 1:11, and 1:14 respectively. The recent study by Meena and Saran (2018) recorded sex ratio 1:3 in Rajasthan. Ranjitsinh (1982) recorded adult male-female ratio 1:8 in Velavadar. The study carried out in KWLS (2005) documented sex ratio (1: 2.28) which is almost similar to the present study, i.e., 1:2.37. The reduction has been recorded in the female fawn ratio in compare to the previous study by Singh (2005). Estimated female fawn ratio by Singh (2005) was of 0.19 which is slightly greater than the present study, i.e., 0.15. The female fawn ratio is slightly less; this may be because of the population reduction (Fig. 3.4.).

The herd size of Blackbuck was ranging from (1- 28) in Kaimoor WLS. The herd size was recorded between (1-23) individuals in Robertsganj and Ghorawal ranges; while in Halia it was recorded (1-28) individuals.

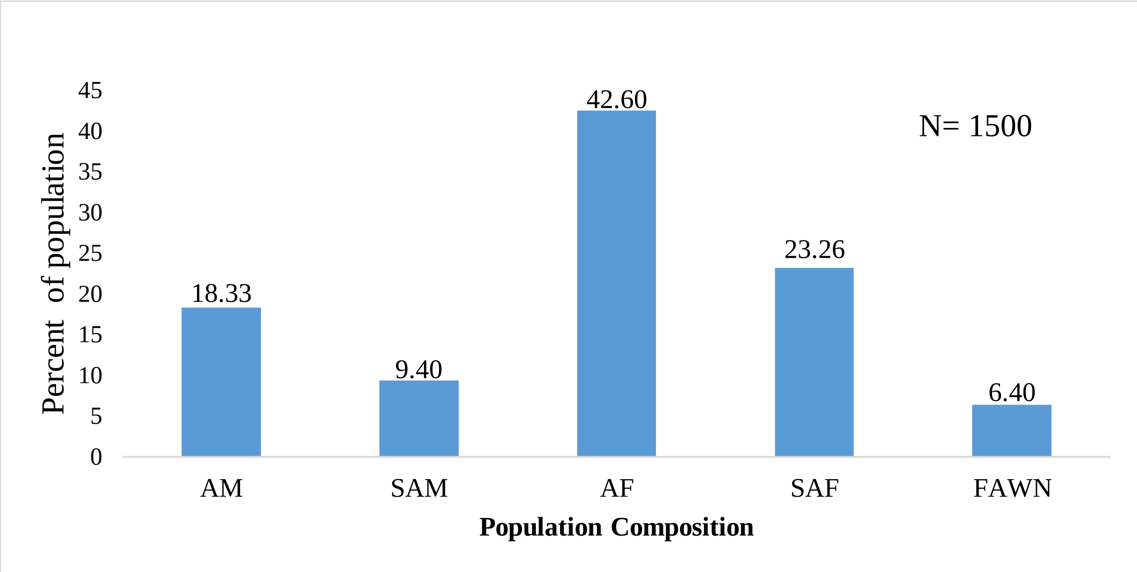
A total of 289 groups encountered during the study period indicated that 72.66% population found under (0-5) group size category followed by 11.41% (6-10) group size category and minimum 1.03% in (>26) group category (Fig. 3.3). The maximum proportion of the population was recorded under (0-5) group size category, but this was recorded maximum for the Halia range (80.39) and this may be due to the fragmented populations of this range (Fig. 3.5). The population in Halia was totally fragmented and has been resided in 5 isolated pockets. However no larger group >26 individuals were seen in Robertsganj and Ghorawal ranges, the largest group recorded was in Halia which comprised 28 individuals (Table 3.1).

3.4. *Lekking*

Blackbuck shows a unique mating system called ‘lekking’. Lekking is a mating system in which breeding males congregate in an open area defending tightly clustered small territories, and are visited by females for mating. The ‘lek’ territories typically do not have any other resources attracting the females except for the mates (Bradbury 1981). Lekking is an energy intensive strategy for the males often bear injuries. Therefore, it is typically adopted only by strong and dominant males (Ishvaran and Jhala 2000). The dominant male chases the female with the nose pointing upward showing a flehmen response towards the urine of the female. The female waves her tail and thumps the rear legs on the ground showing receptivity followed by mounting attempts leading to copulation, the whole process taking up to six hours. The territorial male may then move on to mate with another female following the same procedure.

During the present study, we did not find any lekking sites of the Blackbuck throughout the study area. The territoriality was not observed in the Blackbuck, adult males did not form lekking sites during the breeding season. Rather, the dominating male use to remain with the female groups and did not allow another adult buck to enter in this group. Moreover, sub-adult bucks were allowed to remain within the group. The other adult males seen near the group were chased out by the dominating male. The chased adult males either lives alone or form the male herds. We also observed that the chased males moved away from the group and were seen with the single female far from the dominating male. This phenomenon may be due to the small isolated habitat, lesser population size and lot of anthropogenic pressure.

Mungall (1978) has also reported that territorial male does not keep the harem in Texas. This situation was also noticed in the area where substantial Blackbuck population lived in a relatively restricted area in Rajasthan, Gujarat and Madhya Pradesh (Ranjitsinh 1982).



*AM= Adult male, SAM= Sub-adult male, AF= Adult female, SAF= Sub-adult female

Figure 3.1. Population composition of Blackbuck in KWLS during study period.

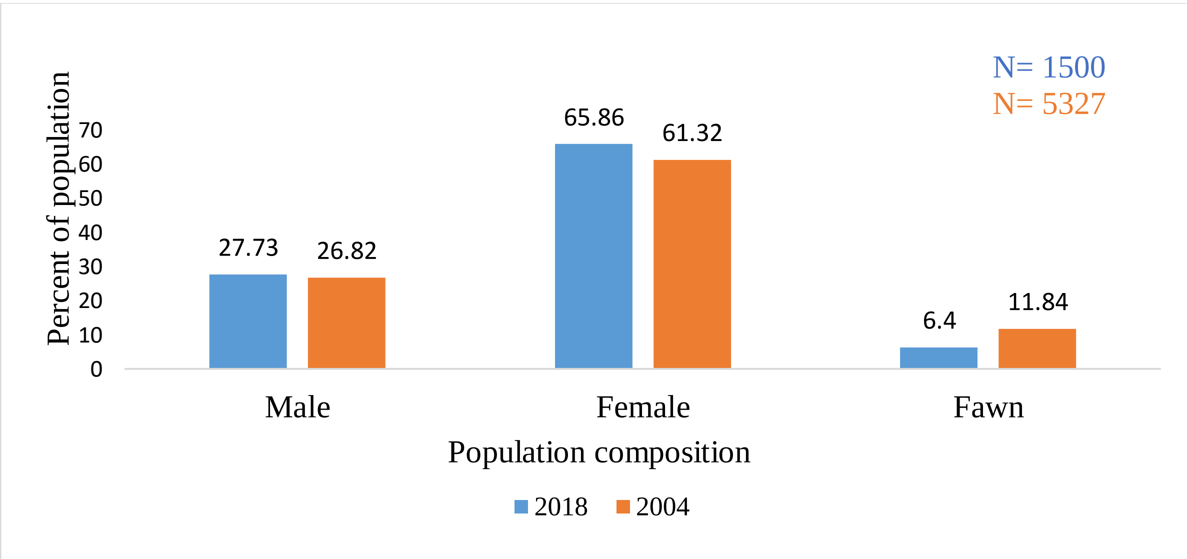


Figure 3.2. Comparison of population composition of Blackbuck in KWLS in 2018 and 2004. (Source: Singh 2005)

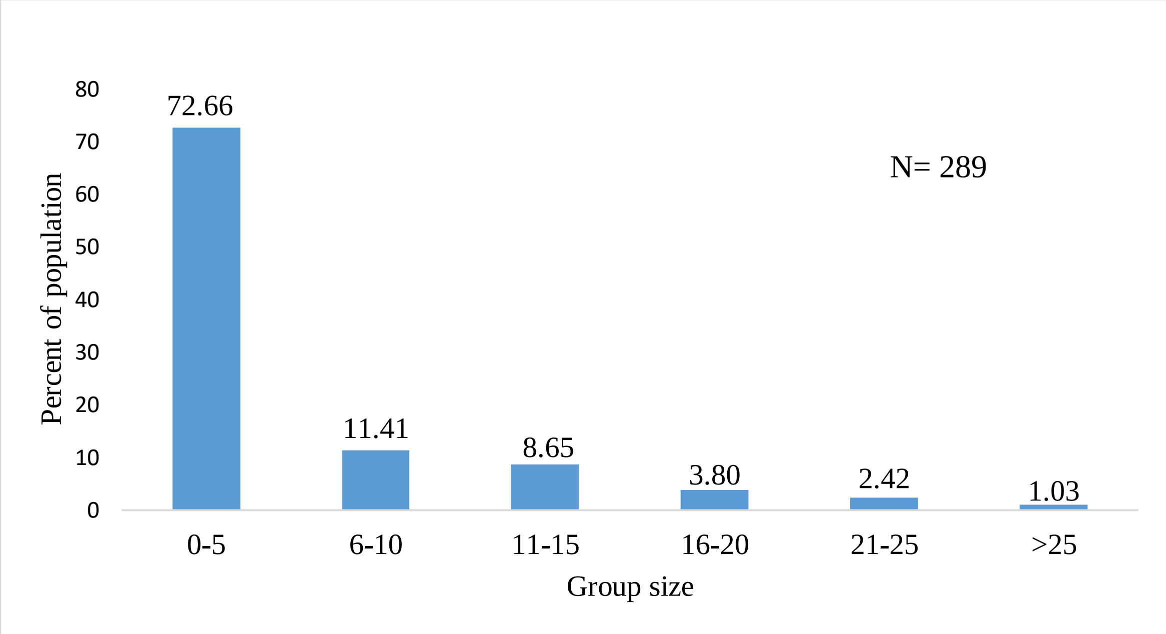


Figure 3.3. Distribution of various group size categories of Blackbuck during study period.

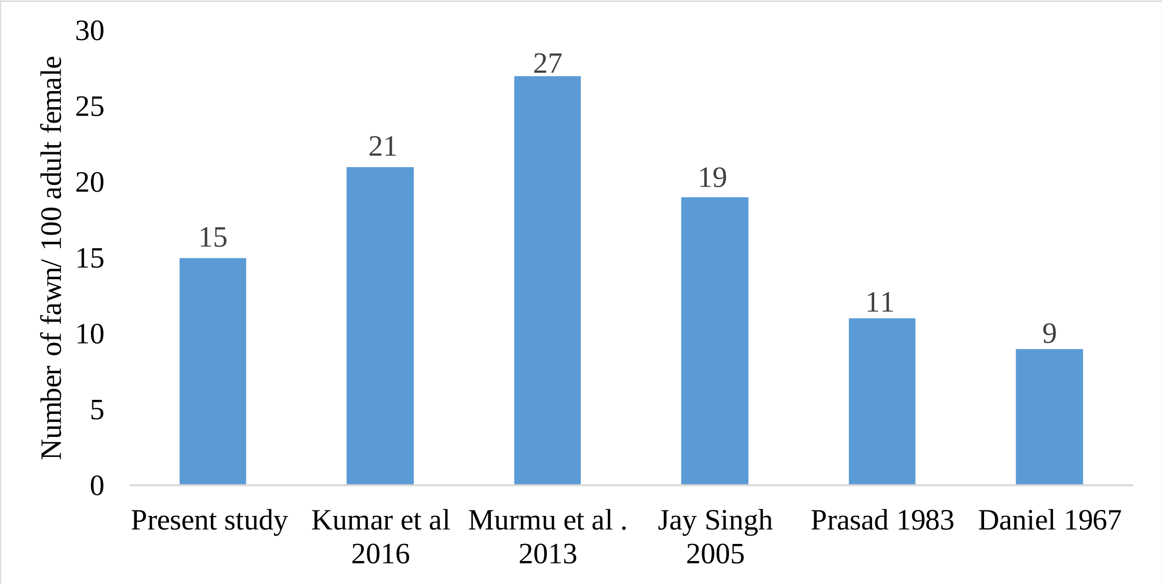
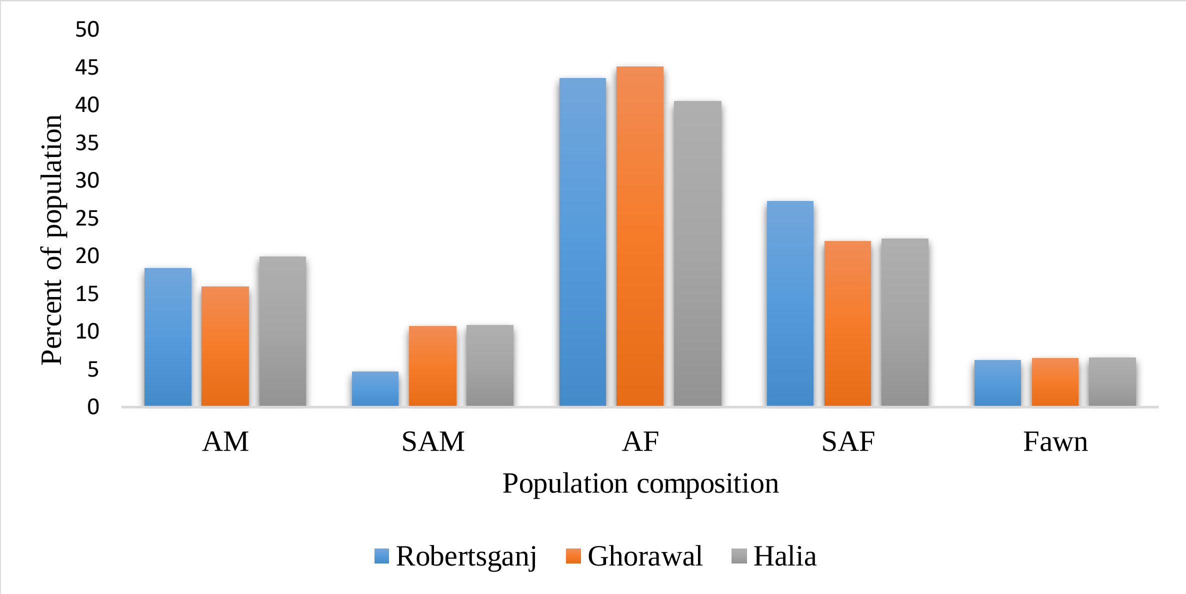


Figure 3.4. Fawn and adult female ratio in different study sites in India.



*AM= Adult male, SAM= Sub-adult male, AF= Adult female, SAF= Sub-adult female

Figure 3.5. Population composition of Blackbuck in different ranges of KWLS.

Table 3.1. Percentage of population found in various group size categories in different ranges of KWLS (N= 289).

Categories	0-5	6-10	11-15	16-20	21-25	>26
Robertsganj	67.6	19.1	10.2	1.5	1.5	0
Ghorawal	60.3	11.7	14.7	5.8	5.8	0
Halia	80.4	7.8	5.2	3.2	1.3	1.9

3.5. References:

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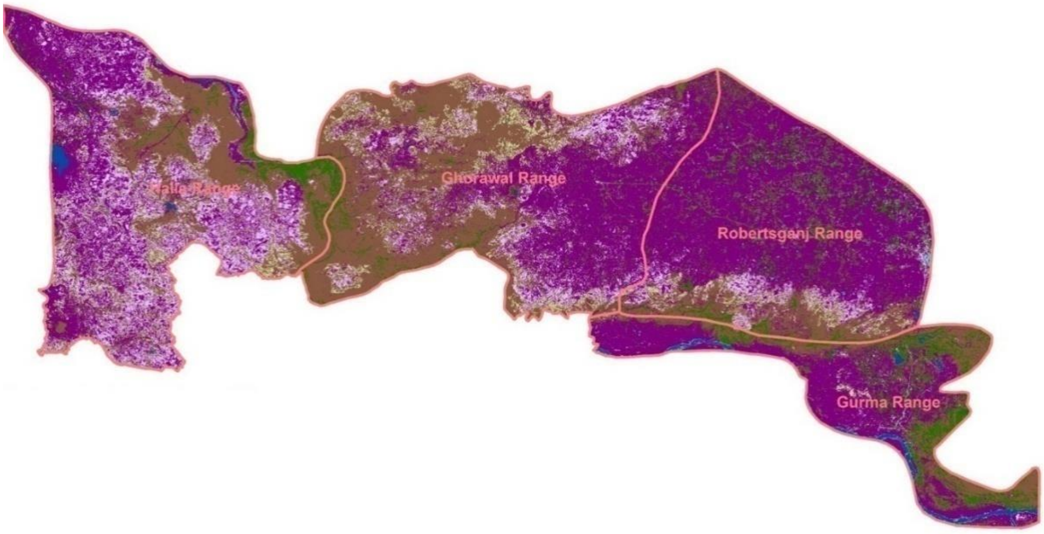
Chapter 4:



Land use and land Cover of Sonbhadra and Mirzapur districts of Uttar Pradesh

Summary

Both land use and land cover are essential tools for relating the terrestrial environment in relation to natural along with human-generated actions (Bender et al. 2005, Mendoza et al. 2010). In the land cover, the biological and physical cover is referred on the surface of land, as well as settlement, vegetation, water, bare soil and man-made structures (Ellis and Pontius Jr. 2006, Turner et al. 1995). For global change evaluation on various spatio-temporal scales, land use and land cover change is agreed an important technique (Lambin et al. 1997). The area of Kaimoor Wildlife Sanctuary and territorial range are of about 1767 km2 and of this 501 km2 respectively. Out of these 1767 km2, the major part is constituted under agriculture or cropland. The temporal examination of the Land use and Land cover (LULC) data indicates that fallow and barren land which are the key habitat for the Blackbuck Antilope cervicapra has declined over the period from 2000 to 2018. The maximum reduction was estimated in forest land (including open forest) from 47.0% to 6.5 followed by fallow land, 17.0% to 11.0 % respectively. However, the increase was recorded in agriculture land and shrubland from 29.0% to 44.5% and 3.0 % to 31.0 %. The increase recorded in scrubland is basically the increase of the Lantana (Lantana camara) and Parthenium (Parthenium hysterophorus) weeds. The habitat left of the fallow and barren land (16%) are mainly remaining area left for the grassland which is the crucial habitat for the Blackbuck. The crucial Blackbuck's habitat has been converted into the scrubland or agricultural land over a period of eighteen years and suitable habitat is very small of the total area. We also calculated the human population density in Mirzapur and Sonbhadra district, and in 10 km radius of the KWLS. It was found that the maximum number of villages (705) were in 0 - 200 population size category followed by 593 villages in population size category of 1801- 28393.

4.1. Introduction:

Both land use and land cover are essential tools for relating the terrestrial environment in relation to both natural as well as human-generated activities. "As per NRSA (1989) Land use refer to man's activities, and the varied uses which are carried on over land and land cover refer to natural vegetation, water bodies, rock/soil, artificial cover and other noticed on the land." The features present on the surface of the earth are considered as land cover. For purposes of agriculture, residential or recreational and industrial, change by human activity is considered as land use (Ramachandra and Bharath 2012). Modification and conversion of earth's surface features such as land productivity, changes in vegetation, biodiversity, quality of soil, erosion, run-off and sedimentation is referred as Land cover (Xiubin 1996). The association of geographic, ecological, economic and social aspects observes the changes in LULC for the landscape development process (Zang and Huang, 2006, Bürgi et al. 2004, Hersperger and Burgi 2009).

Natural landscapes are changing for human activities on human dominated lands, due to land use activities; a huge portion of the surface of the earth has changed. The landscape of the globe is changing an unavoidable way by human activities due to the deforestation of tropical regions, expanding urban centres, performing subsistence agriculture and growing farmland production (Foley et al. 2005).

Changes in land use eradicate species indigenously and deterioration of the functioning of the natural habitat and ecosystem, therefore, the provision of biodiversity and ecosystem is affecting. The changes are taking place in global biodiversity by an exceptional rate due to anthropogenic changes in LULC and global environment. The main causes of habitat loss, modifications in biodiversity and ecosystem changes in the landscapes of forest dominated are due to Land use land cover (LULC) changes. The most important factor causing the global biodiversity crisis is the loss of Habitat due to the change in LULC. (Setturu and Ramachandra 2012).

In monitoring of land use, land cover change and in the assessment of natural resources have proved to be an essential role of Satellite Remote Sensing data to provide timely and full coverage of any particular area (Satyanarayana et al. 2001). Vegetation conditions will be detected with help of spectral response of vegetation indices at pixel-level (Leckie et al. 2005, Wulder et al. 2005). This study was conducted to assess the change detection in land use and land cover of the two districts and study area.

4.2. Methodology:

4.2.1. Pre-processing

We adopted various methods and approaches to analysis the long-term changes in LULC and population trends of wildlife. In our approach, various remote sensing satellite data has been used; Intensive fieldwork survey, land use/land cover plan assessment have been related to habitat change, analysis of wildlife demographic data, livestock and human. Remote sensing satellite data Landsat TM (2000 & 2008) and SENTINEL-2A (2018) obtained from open sources at *(*http://earthexplorer.usgs.gov*)* and Google Earth data from *(http://earth.google.com).* All the descriptions of Satellite data are incorporated in table 1.

Table 4.1. Details of spatial data sources use in this study.

No.	Types of data used	Scale/Resolution	Year
1.	LANDSAT-5 TM	30 M	2000
2.	LANDSAT-5 TM	30 M	2008
3.	SENTINEL-2A	10 M	2018

Present study adopted RS, GIS and Geospatial technology based approach for the analysis of vegetation change, the data used for the analysis including Landsat (TM) (Thematic Mapper) satellite imagery 2000 & 2008 and SENTINEL-2A satellite data of 2018. The digital number (DN) values of the Landsat (TM) and SENTINEL-2A data were changed into radiance values using the corresponding satellite sensor parameters for analysis. Then the images undergo radiometric corrections, Geometric corrections, Image analysis and Accuracy assessment. A combined approach associated with manual and automated methods to generate LULC maps that is far better rather than single approach. We adopted a hybrid approach to initial classification using automated classification methods then the manual methods used to improve classification and refine the noticeable error. These are the important software (ArcGIS 10.5, QGIS 2.18 and ERDAS Imagine 2015) used for the analysis. Land use land cover change analysis has been done with help of classified satellite imageries. For analysis of land use/land cover change; raster data has been converted in polygon with the help of ArcGIS software. For this process, geographic analysis extension tool has required to use of ArcGIS software. The area of statistics has been calculated on the basis of LULC change detection analysis of the year 2000 to 2008, 2008 and 2018 in change table (Table. 4.3).

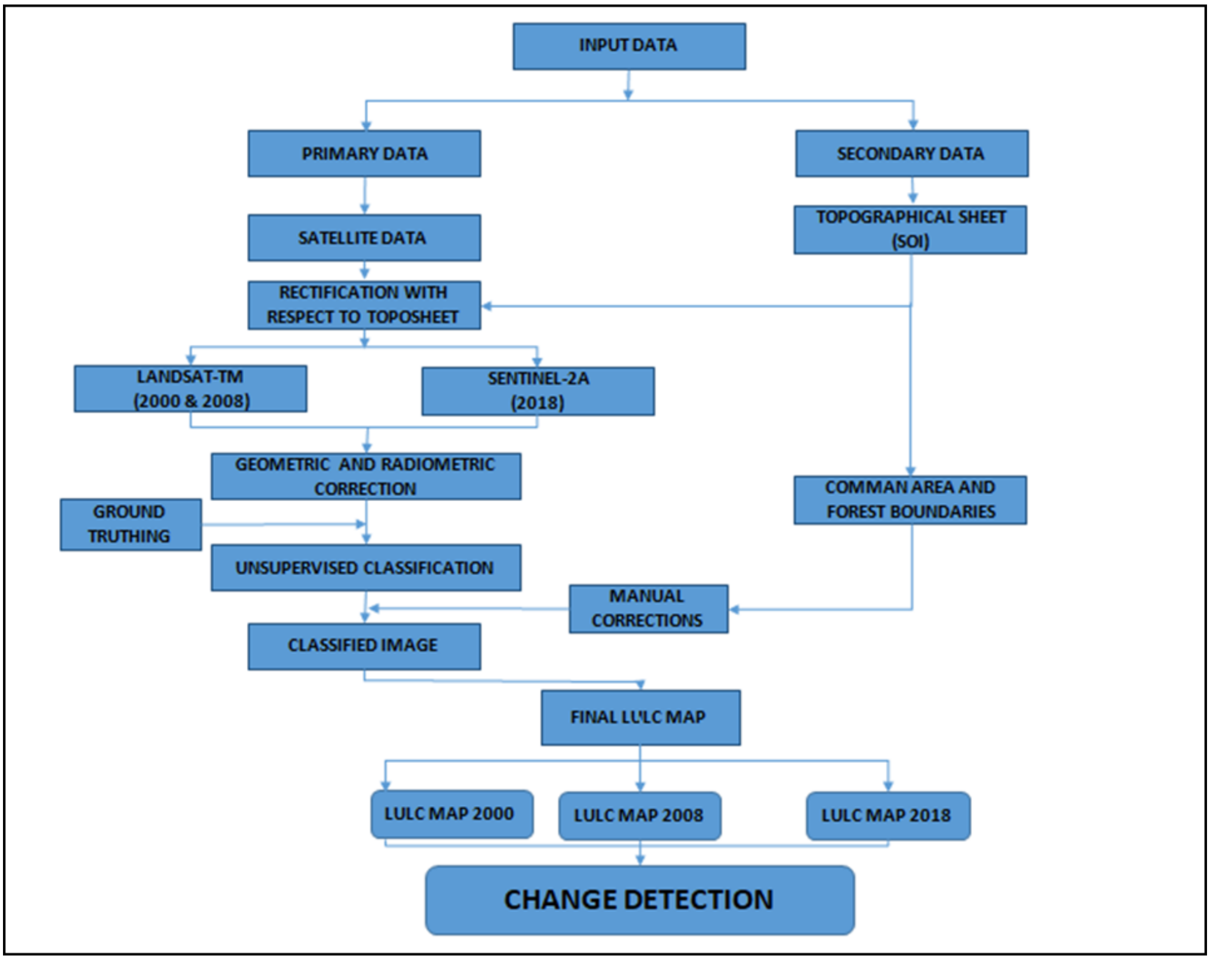


Figure 4.1. Flow chart of methodology used in data analysis.

4.2.2. Human Population in and around Kaimoor Wildlife Sanctuary:

To register the population of India, census has been conducted at every 10 years, beginning in 1872. The first complete census was conducted in 1881. We used collected data of interest from the last 'Census of India' conducted in 2011. The data was obtained in excel format from http://censusindia.gov.in/. Human population data has been downloaded from http://censusindia.gov.in/ of Mirzapur and Sonbhadra districts of Uttar Pradesh for human density mapping.

4.3. Results and Discussion:

4.3.1. Land use and land cover analysis of Mirzapur and Sonbhadra districts

We used the band-2, 3, 4 & 8 (Blue, Green, Red and NIR) of SENTINEL-2A to prepare the False Colour Composite (FCC). The FCC image was produce to detect the different covers in the landscape. For classification, we used various temporal remote sensing data.

"*The classification is based on the assumption that each land use class reflects different amount of light and in different spectral region, the properties of which are also prominent in the remotely sensed data.*"

Unsupervised classification technique has been used for the classification of image. These are the basic classes used in this study are; forest, scrub, fallow, Agriculture/cropped land, and barren land. LULC map of 2018 and area matrix of Mirzapur and Sonbhadra districts is shown in the figure and in the table (Fig. 4.2 & Table. 4.2).

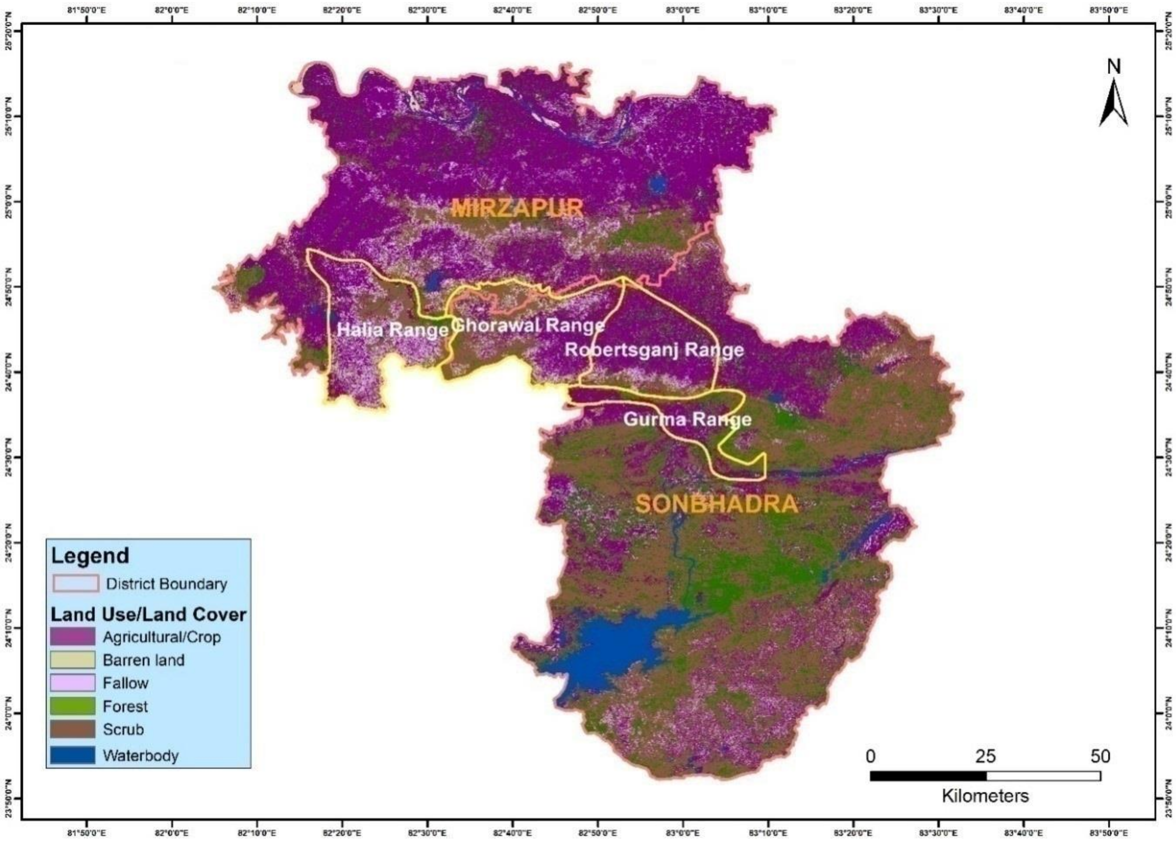


Figure 4.2. Land use land cover map of Mirzapur and Sonbhadra Districts.

Table 4.2. Details of land use land cover area of Mirzapur and Sonbhadra Districts.

Class	Mirzapur (Area in km^2)	(Area in %)	Sonbhadra (Area in km^2)	(Area in %)
Waterbody	60.94	1.38	376.31	5.45
Scrub	832.03	18.84	3047.25	44.12
Forest	297.22	6.73	1218.36	17.64
Agriculture /Crop land	2667.13	60.40	1873.96	27.13
Fallow land	413.65	9.37	307.44	4.45
Barren land	144.65	3.28	83.92	1.21
Total	**4415.63**	**100.00**	**6907.24**	**100.00**

The LULC data reveals that the dominating land cover was agricultural land (60.40%), followed by scrubland (18.84%), forest (9.73%), fallow land (9.37%) and water body (1.38%) in Mirzapur district, whereas in Sonbhadra district the dominating land cover is scrubland (44.12%), followed by agricultural (27.13%), forest (17.64%), fallow land (9.37%), and water body (5.45%).

4.3.2. Land use and land cover change analysis of Kaimoor Wildlife Sanctuary range:

The LULC map of the study area (KWLS & territorial ranges of Ghurma, Robertsganj, Ghorawal, and Halia) was prepared to find out the decadal changes during 2000, 2008 and 2018 (Fig. 4.3, 4.4 & Table. 4.3). The temporal examination of the land use and land cover data indicated that fallow and barren land which are the key habitat for the Blackbuck has declined over a period of time from 2000 to 2018. The maximum reduction was estimated in forest land (including open forest) followed by fallow land, i.e., 47 to 6% and 17 to 11% respectively. However, the increase was recorded in agricultural land and shrubs from 28.99 to 44.48% and 3 to 31% respectively. The gain recorded in scrubs was basically the increase of the Lantana (*Lantana camara*) and Parthenium (*Parthenium hysterophorus*) weeds. The fallow land and barren land encompass the grassland which are the crucial habitat for the Blackbuck, and has been converted into the scrub land or agricultural land throughout eighteen years. Scrub and agricultural land have increased exponentially, whereas scrub has increased more than 10 times *from 3%* to 31.64 % in the intensive study area.

In spite of being the highest revenue generated districts of Uttar Pradesh, the socio-economic status of the households are very poor. Most of the people residing inside or around the KWLS were dependent on the forest resources for their subsistence. Nearby people are mostly dependent on resources as they feed for livestock, for fuel to make food and non-wood forest products like like Tendu leaves (*Diospyros melanoxylon*), Mahua (*Madhuca longifolia*), Chiraunji (*Buchanania lunzan*), and other medicinal plants. This is one of the reasons that being a dry deciduous forest; it has been exploited as such level that the forest cover has been decreased from 834 km2 to 115 km2 in between 2000 to 2018. At the same time, the agriculture land has increased from 512 km2 to 784 km2. This degradation in the forested land provided a suitable environment for exotic weed *Lantana camara* to spread throughout the study area.

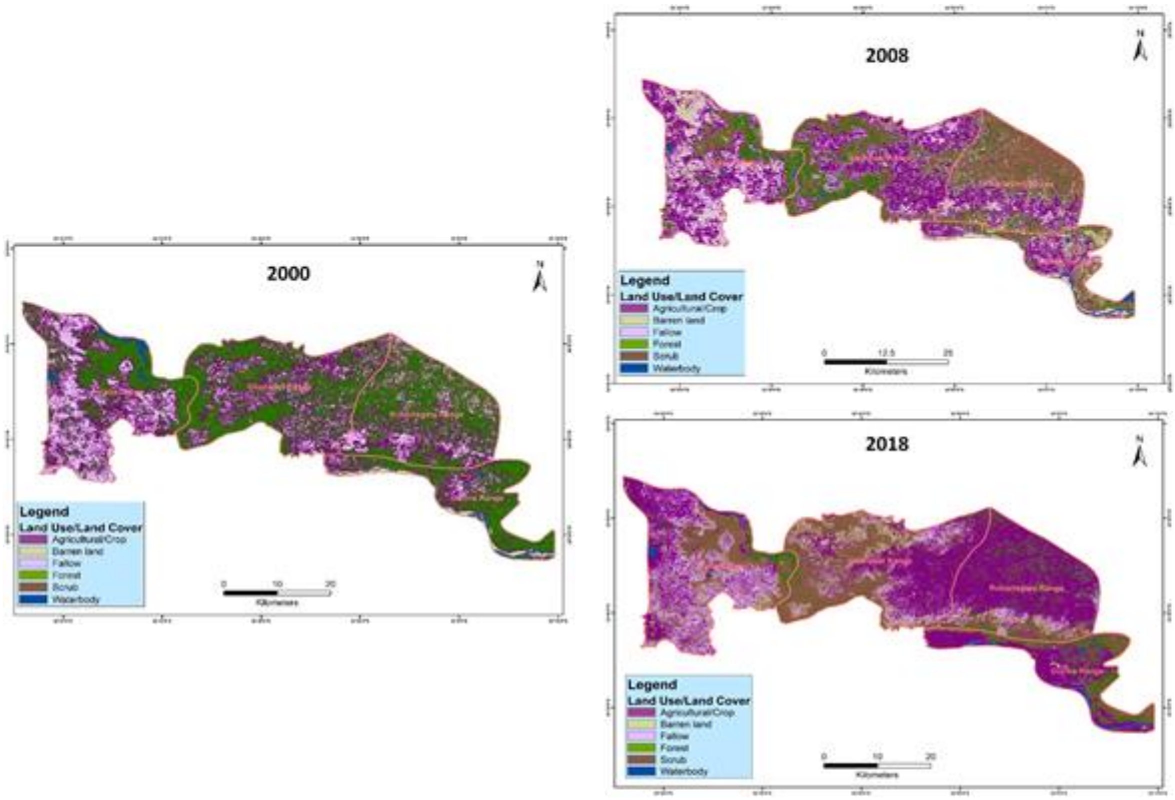


Figure 4.3. Change detection in LULC of study area from 2000, 2008 and 2018.

Table 4.3. Details of change detected in study area during 2000, 2008 and 2018.

Area in km^2				Area in percentage (%)		
Class/Year	**2000**	**2008**	**2018**	**2000**	**2008**	**2018**
Water	27.63	27.18	15.53	1.56	1.54	0.88
Forest	834.15	231.75	115.3	47.22	13.11	6.54
Scrub	60.16	455.22	557.7	3.41	25.76	31.64
Agri/Hab	512.02	552.00	784	28.99	31.23	44.48
Fallow	312.81	333.51	205.5	17.71	18.87	11.66
Barren	19.67	167.62	84.77	1.11	9.48	4.81
Total	1766.46	1767.31	1763	100.00	100.00	100.00

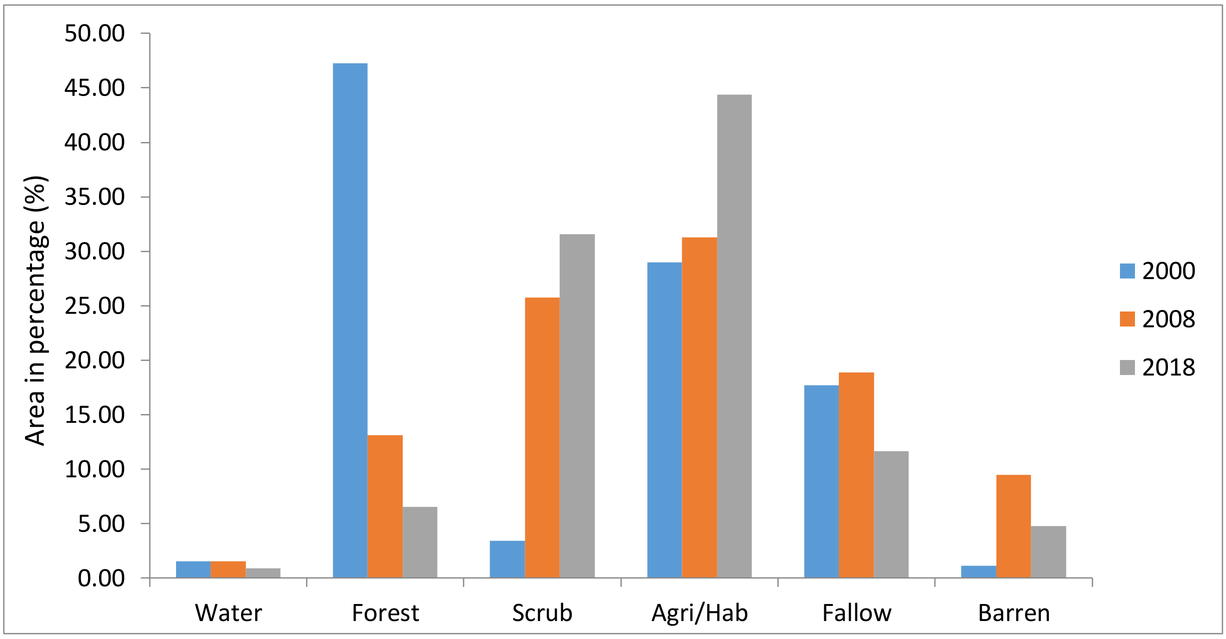


Figure. 4.4. Land use land cover changes during 2000 to 2018.

4.3.3. Human population in and around Kaimoor Wildlife Sanctuary:

It is widely believed that human population growth or density is an important aspect and is often the primary cause of deforestation (Wibowo and Byron, 1999). Prominently, there are non-integrated development policies of different government organizations who have conflict with conservation efforts.

The Census of India has been conducted a census in 2011. It conducts in every 10 years, it was first started in 1972, there was a complete census held in 1881. This dataset can be acquired from http://censusindia.gov.in in excel format. Human population data has been downloaded from http://censusindia.gov.in/ of Mirzapur and Sonbhadra district of Uttar Pradesh for Human density mapping. The result indicated that most of the villages (705) are in 0 - 200 population size category followed by 593 villages in population size category of 1801- 28393. It means that maximum villages have low density followed by high-density population in the Mirzapur and Sonbhadra districts (Fig. 4.5 & 4.6). The population density was also calculated in the 10 km radius of the study area (Fig. 4.7 & 4.8).

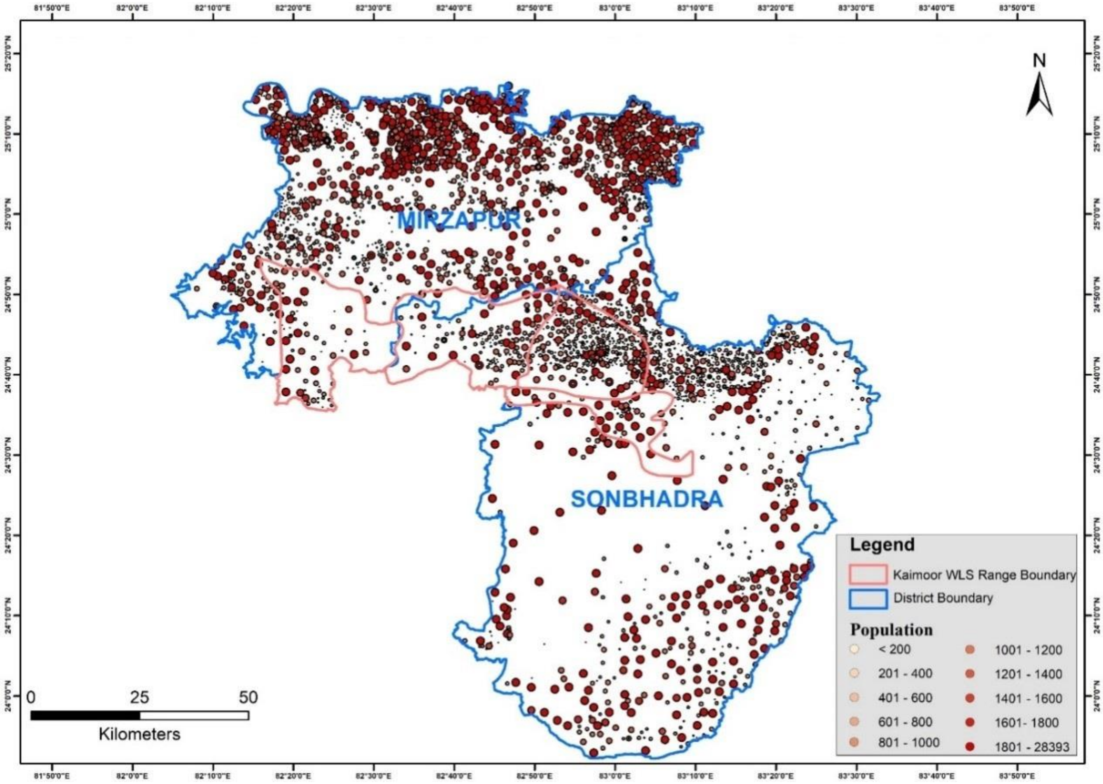


Figure 4.5. Variation in human population density of different class categories in Mirzapur and Sonbhadra Districts.

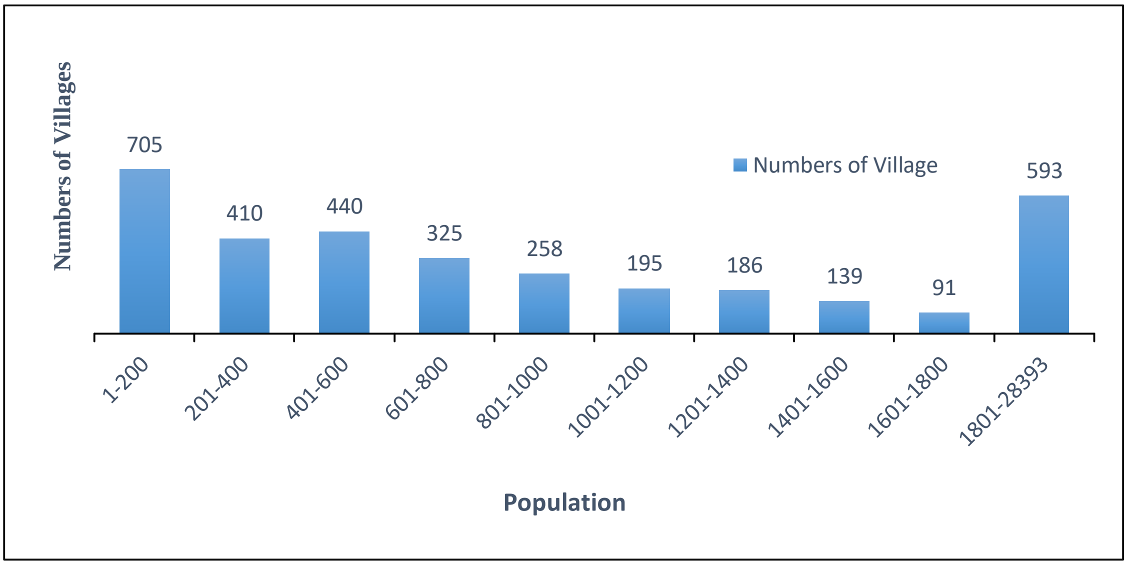


Figure 4.6. Number of villages in different human population categories in Sonbhadra and Mirzapur districts.

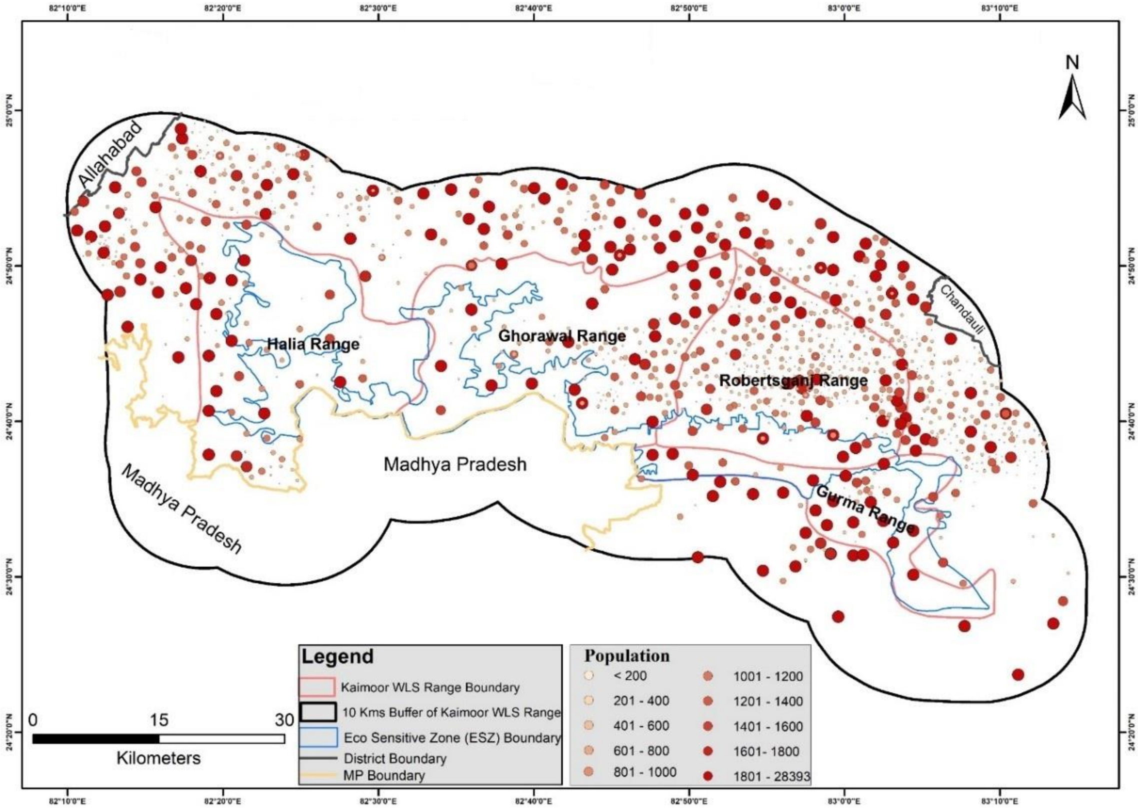


Figure 4.7. Number of villages in different population categories in 10 km radius of study area.

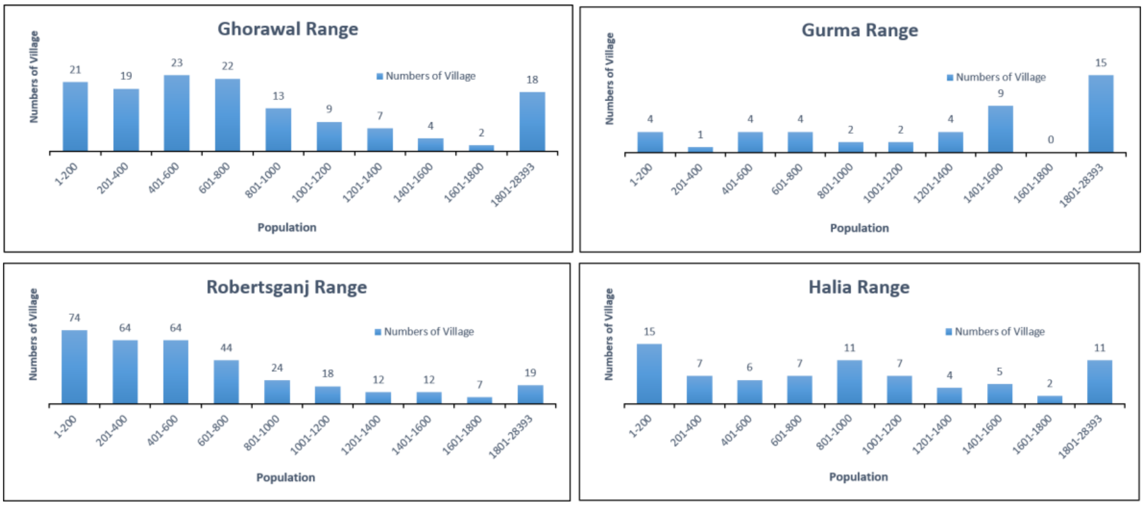


Figure 4.8. Number of villages in different population categories in four ranges of the study area.

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Chapter 5:

Vegetation characteristics of Kaimoor Wildlife Sanctuary

Summary

Habitats are crucial to predicting the wildlife presence, as it is essential for developing the strategies for the wildlife managers, and conservationists. Wildlife habitats are generally considered as the type of vegetation and landscape used by a species, which also includes the particular attributes of the vegetation characteristic. The plant grows in communities in a specific environment. Each community is characterized by its species diversity growth form, structure, dominance, and succession trends. The quantification of the vegetation was carried out on each transect at 200 m interval. The study of vegetation structure included the assessment of canopy cover, shrub cover and ground layer cover. Two circular areas were laid for sampling vegetation in each plot, 10 m and 5 m circular radius plot were taken for tree and shrubs respectively. Four 25 × 25 cm quadrats were laid for the ground cover. A total of 526 vegetation plots were laid in the four ranges of the study area. A total of 28 tree species, 33 shrub species, 17 herb species, and seven grass species were recorded in the study area. The maximum grass cover, grass height, and a total number of shrub species recorded in Halia range. Whereas, shrub density and tree density were highest in Ghorawal and Ghurma ranges respectively. Halia range has maximum shrub diversity, and Ghorawal has maximum tree diversity. The density of Lantana camara was very high throughout all the four ranges.

5.1. Introduction:

Globally, forests are known as significantly crucial habitats as it facilitates huge biological diversity including the myriads of ecological function they provide. The species count is taken to be a representation of diversity. Total described number of organisms is about 1.75 million, and it is also assumed that, it may be 13% of the true total (Hawksworth and Kalin-Arroyo 1995, Stork 1999). The uncertain fraction of these total exist in in the world's forest is unknown. Wilson (1992) suggests that, possibly half of described species exist in the tropical forest. WCMC (1992) predicts that the majority species are yet-to-be-discovered in tropical areas. Whatever the specific number of species, forests, including the tropical forests, are key areas for species diversity. The values of forest reflect the values of the biological diversity which they contain. The dry tropical forest, sub-tropical forest and woodlands were known to cover more than half of the world's tropics but, have decreased significantly during the last decade. 52% of the total forests on the global basis are tropical forest. 86% of the total forest land in India is of tropical forest. Though, this type of forest is severely impacted by anthropogenic pressure (Champion and Seth 1968). Due to high anthropogenic activities in the past several decades, the dry deciduous forest cover has been converted into dry deciduous scrub, dry savanna and dry grass land in many parts of central India. Considering the fact of wildlife existence, this alarming scenario calls for in-depth study of these forests with respect to species diversity, structure and regeneration.

To represent the population structure of the forest, density diameter (d-d) distribution of stem is used (FAO 1978). The population structure of different species represents their regeneration behaviour and succession patterns. The population structures of species are characterized by the occurrence of adequate number of seedlings, saplings, and adults. It also indicates regeneration pattern of species. The occurrence of saplings under the canopies of adult trees represents the future composition of a community. With respect to the information of the d–d distribution inferences can be drawn regarding the stand history. Also, the information can be used for developing strategies to achieve the desired size classes and composition of the species.

To generate information of spatio-temporal forest composition, structure, and dynamics, long-term permanent plot studies is potential methodology (Ayyappan and Parthasarathy 1999). There is a gap in the information pertaining to composition dry tropical forest of India by using large-scale permanent inventory plots. Though, this type of forests account for 46% of the forest land in India it is necessary to use large-scale permanent plot studies which are important for the conservation and management of tropical forests (Field and

Vazquezyanes 1993). The present study is conducted in and around Kaimoor Wildlife Sanctuary in the Sonbhadra and Mirzapur districts, to documents the vegetation characteristics and composition.

5.2. Methodology:

Vegetation sampling was done along line transects by establishing sampling stations at every 200m interval. The tree (>20 cm GBH) layer was quantified in 10m radius circular plots. All trees present in the plot were enumerated as to species level and their total individuals. GBH measurements of all tree individuals were taken at each plot. Also, canopy cover was documented at X and Y length.

The shrubs and sapling (<=20cm GBH) were quantified in 5m radius circular plots, and all the plants are falling within these plots was enumerated to species level. The canopy cover was also recorded at X and Y length axis along with the shrub height.

The ground cover was assessed in four quadrates each of 25 cm x 25 cm at every sampling station with respect to grass and seedlings. Three dominant grass species and percentage of ocular grass cover along with average grass height were recorded.

The disturbance factor like lopping, cutting of trees, presence or sign of livestock was recorded at each sampling station in 10 m radius circular plot. (Annexure VI)

5.3. Results and Discussion:

The vegetation of the study area is tropical dry deciduous forests, and is characterized by long dry and warm months and growth of vegetation resources is dependent on monsoonal rainfall. To assess the vegetation characteristic of the study area, the systematic sampling was done along the line transects at every 200 m. We recorded a total of 28 tree species, 33 shrub species, 17 herb species, and 7 grass species in the study area (Table 5.1). The overall tree density was 2.36/hectare and maximum value was recorded for *Butea monosperma* (0.58/ha) followed by *Diospyros melanoxylon* (0.41/ha), *Acacia catechu* (0.41/ha) and *Acacia nilotica* (0.18/ha) (Table 5.2). The overall shrub density was 381.32/hectare and the maximum shrub density was recorded for the *Lantana camara*163.8/ha followed by *Diospyros melanoxylon* (35.3/ha), *Butea monosperma* (34.8/ha), *Holarrhena antidysentrica (*23.4/ha) and *Acacia catechu* (15.2/ha) (Table 5.3). Dominant grasses were *Eragrostis tenella*, *Digitaria sp*, *Cynodon dectylon*, *Desmostichea sp*, etc. and average grass height was relatively more in Halia than other ranges. The range wise tree and shrub density were enumerated at species level (Table 5.4, 5.5, 5.6, 5.7, 5.8, 5.9, 5.10 & 5.11). The diversity

(Shannon-Wiener information index) for tree was found maximum in the Ghorawal range (2.48) and minimum in Ghurma range (2.05), while the evenness was estimated maximum in the Ghorawal and Ghurma ranges (0.83) and was estimated minimum in Halia range (0.78). The shrub diversity (Shannon-Wiener) was estimated maximum (2.66) in Halia range and minimum in Ghorawal range (1.36), while the evenness was found maximum (0.83) in Halia range and minimum (0.44) in Ghorawal range (Table 5.12 & 5.13). We prepared the heat map of tree cover, shrub cover and grass cover on the basis of the sampled vegetation plots which were shown in the Fig. 5.1, 5.2 & 5.3.

The data indicates that most of the preferred open grassland habitats are infested by high shrub cover in all the ranges. The tree cover has decreased in the study area over a period of time, due to lopping, cutting and other anthropogenic factors, but the forest department is dedicated to increase the forest cover in Mirzapur and Sonbhadra districts. For this purpose several exotic plant species like Prosopis juliflora, *Eucalyptus sp.*, *Senna siamea* which are not native to the dry deciduous habitat were planted in and around the KWLS. It resulted in severe damage to the Blackbuck habitat in the study area.

Table 5.1. Vegetation characteristics of KWLS.

Range	Grass Cover (%)	Average grass height (m)	Tree Density /hectare	Shrub Density /hectare	Total tree species recorded	Total shrub species recorded
Gurma	24.1	2.93	35.09	232.35	11	11
Robertsganj	21.5	2.84	26.06	226.26	16	16
Halia	38.05	6.18	31.04	411.60	17	25
Ghorawal	23.5	5.14	12.79	433.78	20	22

Table 5.2. The density of tree species in the study area.

S.No	*Species*	Density/hectare
1	*Acacia catechu*	0.14
2	*Acacia nilotica*	0.18
3	*Azadirachta indica*	0.14
4	*Buchanania lanzan*	0.02
5	*Butea monosperma*	0.58
6	*Cassia fistula*	0.01
7	*Dalbergia sissoo*	0.02
8	*Delonix regia*	0.01
9	*Diospyros melanoxylon*	0.41
10	*Emblica officinalis*	0.05
11	*Eucalyptus sp.*	0.02
12	*Ficus benghalensis*	0.01
13	*Ficus religiosa*	0.01
14	*Ficus sp.*	0.02
15	*Holarrhena antidysentrica*	0.09
16	*Lagerstroemia parviflora*	0.10
17	*Lannea coromandelica*	0.14
18	*Madhuca longifolia*	0.12
19	*Mangifera indica*	0.05
20	*Prosopis juliflora*	0.04
21	*Senna siamea*	0.02
22	*Syzygium cumini*	0.01
23	*Tectona grandis*	0.04
24	*Terminalia arjuna*	0.01
25	*Terminalia bellirica*	0.02
26	*Terminalia tomentosa*	0.03
27	*Ziziphus mauritiana*	0.02

Table 5.3. The density of shrub species in the study area.

S.No	Species	Density /hectare
1	*Pongamia pinnata*	0.5
3	*Acacia catechu*	15.2
4	*Acacia nilotica*	3.5
5	*Acacia pennata*	3.3
6	*Aegle marmelos*	0.3
7	*Ailanthus excels*	0.8
8	*Azadirachta indica*	1.6
9	*Butea monosperma*	34.8
10	*Calotropis procera*	0.5
11	*Capsicum annuum*	2.2
12	*Carissa spinarum*	6.5
13	*Cassia fistula*	0.8
14	*Dalbergia sissoo*	0.8
15	*Dendrocalamus strictus*	11.1
16	*Diospyros melanoxylon*	35.3
17	*Emblica officinalis*	0.5
18	*Eucalyptus sp.*	6.8
19	*Haplophragma adenophyllum*	4.3
20	*Helicteres isora*	4.9
21	*Holarrhena antidysentrica*	23.4
22	*Ipomea sp.*	1.4
23	*Lagerstroemia parviflora*	13.9
24	*Lannea coromandelica*	0.3
25	*Lantana camara*	163.8
26	*Madhuca longifolia*	1.9
27	*Phoenix dactylifera*	0.8
28	*Prosopis juliflora*	2.7
29	*Senna siamea*	1.1
30	*Solanum lycopersicum*	4.9
31	*Tectona grandis*	0.8
32	*Vitex negundo*	1.1
33	*Ziziphus mauritiana*	18.5
34	*Ziziphus oenoplia*	4.9

Table 5.4. The density of tree species in Ghurma range.

S.No.	Species	Density/hectare
1	*Acacia nilotica*	3.95
2	*Azadirachta indica*	4.61
3	*Butea monosperma*	4.61
4	*Cassia fistula*	1.32
5	*Dalbergia sissoo*	0.66
6	*Diospyros melanoxylon*	10.53
7	*Ficus religiosa*	0.66
8	*Madhuca longifolia*	1.32
9	*Prosopis juliflora*	3.95
10	*Tectona grandis*	2.63
11	*Ziziphus mauritiana*	0.66

Table 5.5. The density of shrub species in Ghurma range.

S.No	Species	Density/hectare
1	*Acacia catechu*	8.75
2	*Acacia nilotica*	14.58
3	*Azadirachta indica*	2.92
4	*Butea monosperma*	11.66
5	*Holarrhena antidysentrica*	5.83
6	*Ipomea sp.*	2.92
7	*Lantana camara*	122.45
8	*Phoenix dactylifera*	2.92
9	*Prosopis juliflora*	29.15
10	*Vitex negundo*	11.66
11	*Ziziphus mauritiana*	17.49

Table 5.6. The density of tree species in Robertsganj range.

S.No	Species	Density/hectare
1	*Acacia catechu*	3.25
2	*Acacia nilotica*	4.50
3	*Azadirachta indica*	1.50
4	*Butea monosperma*	6.75
5	*Dalbergia sissoo*	0.50
6	*Diospyros melanoxylon*	4.00
7	*Emblica officinalis*	1.00
8	*Eucalyptus sp.*	0.25
9	*Ficus species*	0.50
10	*Holarrhena antidysentrica*	0.50
11	*Madhuca longifolia*	0.75
12	*Mangifera indica*	0.50
13	*Prosopis juliflora*	0.25
14	*Terminali aarjuna*	0.25
15	*Unknown*	1.00
16	*Ziziphus mauritiana*	0.50

Table 5.7. The density of shrub species in Robertsganj range.

S.No	*Shrub*	Density/hectare
1	*Acacia nilotica*	2.21
2	*Azadirachta indica*	1.11
3	*Butea monosperma*	16.61
4	*Calotropis procera*	1.11
5	*Capsicum annuum*	8.86
6	*Dalbergia sissoo*	1.11
7	*Dendrocalamus strictus*	2.21
8	*Diospyros melanoxylon*	74.20
9	*Helicteres isora*	4.43
10	*Ipomea sp.*	4.43
11	*Lantana camara*	77.52
12	*Phoenix dactylifera*	1.11
13	*Solanumly copersicum*	19.93
14	*Tectona grandis*	2.21
15	*Unknown*	1.11
16	*Ziziphus mauritiana*	28.79

Table 5.8. The density of shrub species in Ghorawal range.

S.No	Species	Density/hectare
1	*Acacia catechu*	4.7
2	*Acacia pennata*	6.7
3	*Acacia nilotica*	2.0
4	*Aegle marmelos*	0.7
5	*Azadirachta indica*	1.3
6	*Butea monosperma*	25.6
7	*Calotropis procera*	0.7
8	*Carissa spinarum*	2.0
9	*Cassia fistula*	0.7
10	*Dalbergiasissoo*	1.3
11	*Dendrocalamus strictus*	14.8
12	*Diospyros melanoxylon*	14.8
13	*Haplophragma adenophyllum*	5.4
14	*Helicteres isora*	0.7
15	*Holarrhena antidysentrica*	49.8
16	*Lagerstroemia parviflora*	2.7
17	*Lantana camara*	287.5
18	*Phoenix dactylifera*	0.7
19	*Tectona grandis*	0.7
20	*Unknown*	2.0
21	*Ziziphus mauritiana*	1.3
22	*Ziziphus oenoplia*	6.1

Table 5.9. The density of tree species in Ghorawal range.

S.No	Species	Density/hectare
1	*Acacia catechu*	0.51
2	*Acacia nilotica*	0.67
3	*Azadirachta indica*	0.17
4	*Buchanania lanzan*	0.67
5	*Butea monosperma*	2.86
6	*Diospyros melanoxylon*	0.34
7	*Emblica officinalis*	0.34
8	*Eucalyptus sp.*	0.34
9	*Ficus benghalensis*	0.17
10	*Ficus religiosa*	0.17
11	*Ficus species*	0.17
12	*Holarrhena antidysentrica*	0.17
13	*Lannea coromandelica*	2.86
14	*Madhuca longifolia*	1.35
15	*Mangifera indica*	0.34
16	*Tectona grandis*	0.17
17	*Terminalia arjuna*	0.17
18	*Terminalia bellirica*	0.67
19	*Terminalia tomentosa*	0.34
20	*Unknown*	0.34

Table 5.10. The density of shrub species in Halia range.

S.No	Species	Density/hectare
1	*Pongamia pinnata*	1.79
2	*Acacia benzamin*	21.43
3	*Acacia catechu*	41.07
4	*Acacia pennata*	1.79
5	*Acaia nilotica*	2.68
6	*Ailanthus excels*	2.68
7	*Azadirachtai ndica*	1.79
8	*Butea monosperma*	63.39
9	*Carissa spinarum*	18.75
10	*Cassia fistula*	1.79
11	*Dendrocalamus strictus*	15.18
12	*Diospyros melanoxylon*	36.61
13	*Emblica officinalis*	1.79
14	*Eucalyptus sp.*	22.32
15	*Haplophragma adenophyllum*	7.14
16	*Helicteres isora*	11.61
17	*Holarrhena antidysentrica*	8.93
18	*Lagerstroemia parviflora*	41.96
19	*Lannea coromandelica*	0.89
20	*Lantana camara*	58.04
21	*Madhuca longifolia*	6.25
22	*Senna siamea*	3.57
23	*Unknown*	1.79
24	*Ziziphus mauritiana*	30.36
25	*Ziziphus oenoplia*	8.04

Table 5.11. The density of tree species in Halia range.

S.No.	Species	Density/hectare
1	*Acacia catechu*	1.41
2	*Acacia nilotica*	0.40
3	*Azadirachta indica*	1.81
4	*Butea monosperma*	8.87
5	*Delonix regia*	0.20
6	*Diospyros melanoxylon*	6.85
7	*Emblica officinalis*	0.40
8	*Holarrhena antidysentrica*	2.42
9	*Lagerstroemia parviflora*	3.23
10	*Lannea coromandelica*	1.21
11	*Madhuca longifolia*	1.21
12	*Mangifera indica*	0.81
13	*Senna siamea*	0.81
14	*Syzygium cumini*	0.20
15	*Tectona grandis*	0.20
16	*Terminalia tomentosa*	0.60
17	*Unknown*	0.40

Table 5.12. Shannon diversity (H´) and Evenness (S) of tree in four ranges of KWLS.

S.No	Range	Shanon (H´)	Evenness (S)
1	Ghorawal	2.48	0.83
2	Halia	2.21	0.78
3	Gurma	2.05	0.83
4	Robertsganj	2.23	0.80

Table 5.13. Shannon diversity (H´) and Evenness (S) of shrub in four ranges of KWLS.

S.No	Range	Shanon (H´)	Evenness (S)
1	Ghorawal	1.36	0.44
2	Halia	2.66	0.83
3	Gurma	1.65	0.69
4	Robertsganj	1.87	0.67

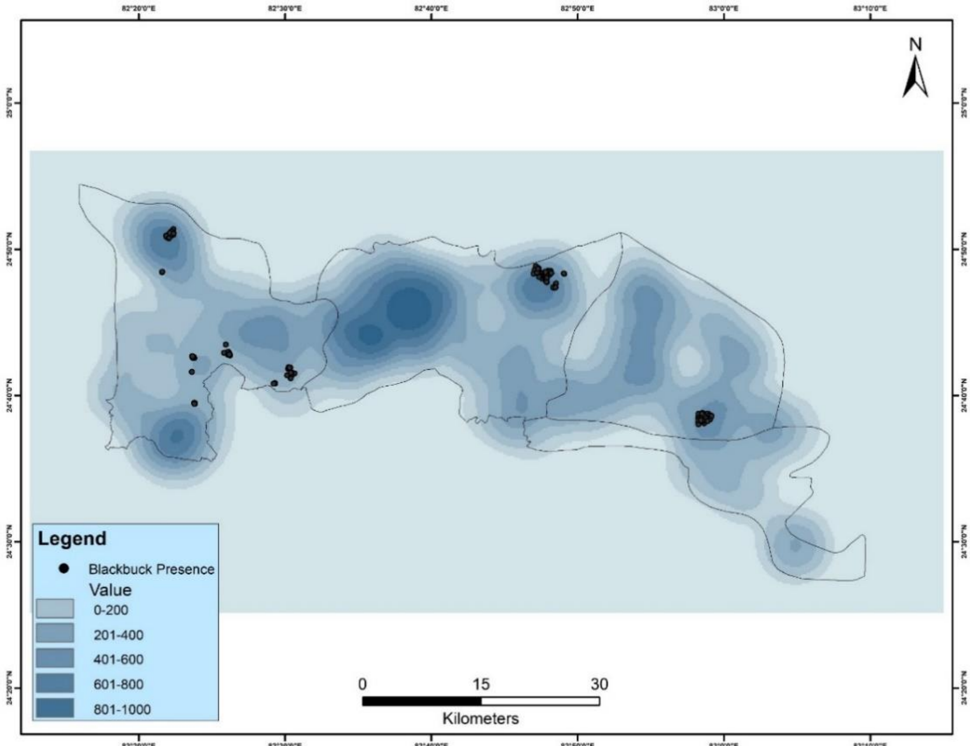

Figure 5.1. Heat map of tree cover in and around KWLS.

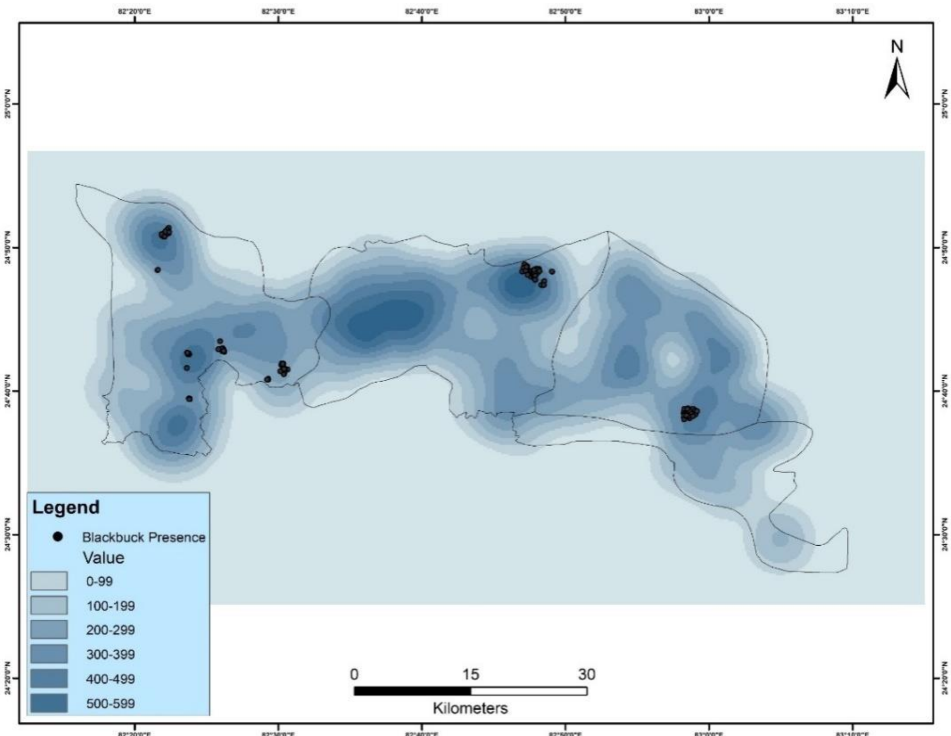

Figure 5.2. Heat map of shrub cover in and around KWLS.

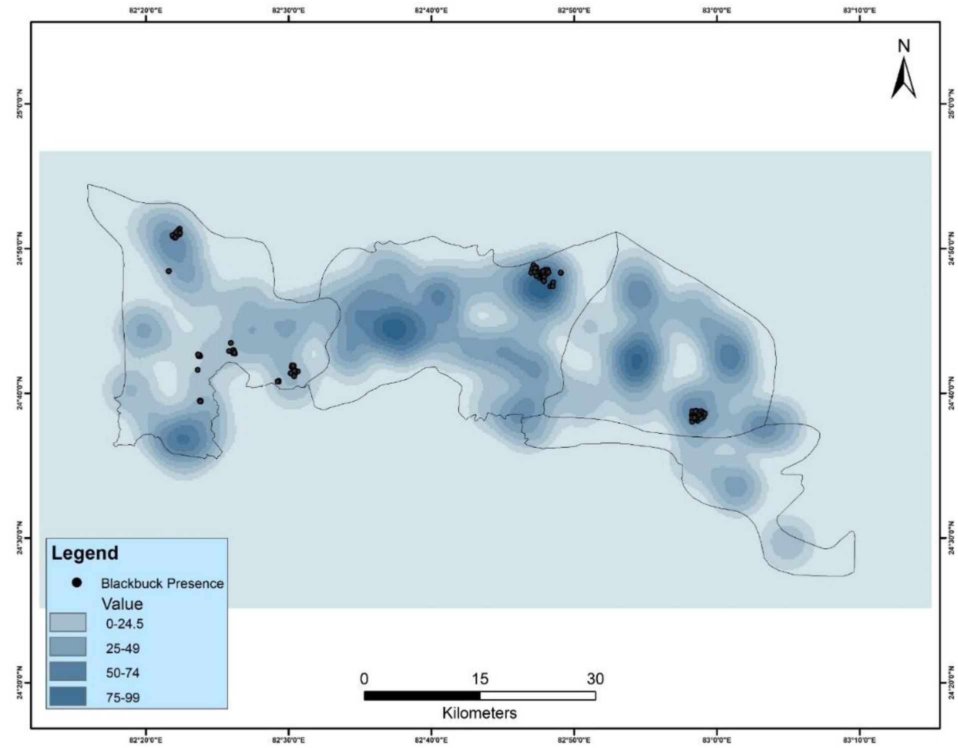

Figure 5.3. Heat map of grass cover in and around KWLS.

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Chapter 6:

Floral and Faunal characteristics of proposed Thermal Power Plant site and its relation to Blackbuck conservation in Kaimoor Wildlife Sanctuary

Summary

We assessed the extent of the suitability of Blackbuck habitat at the proposed Thermal Power Plant (TPP) site using eight radial transects radiating from the site. Maximum sighted animals were livestock with an encounter rate of 44.12±8.19 per km. Among livestock species, sheep comprises maximum 34.73±15.57 encounter rate followed by cattle and goat 7.67±1.67, 1.71±0.98 per km respectively. However, the encounter rate of wild animals were low 0.40±0.12 per km during the study period. Among the wild animal, Nilgai comprises maximum encounter rate of 02.8±0.10 per km. while the minimum encounter rate was estimated for the Indian hare 0.04 per km. Vegetation quantification at TPP site indicates that dominant trees species were of Acacia catechu (15.20/ha), Butea monosperma (9.55/ha), Lagerstroemia parviflora (4.24/ha) whereas another tree species with low-density were Aegle marmelos, Eucalyptus sp., Cassia fistula. We recorded 20 shrub species, and most of the areas were dominated by Ziziphus oenoplea (1.97/ha), Ziziphus mauritiana (0.50/ha), Acacia catechu (0.40/ha). The area was also heavily infested with the high density (116.18/ha) of the bamboo (Dendrocalamus strictus). The nearest population of Blackbucks from all the ranges of KWLS is around 24 to 49 km from the TPP site. We did not observe large areas of habitats preferred by the Blackbucks at TPP site such as short grassland, , and open scrub. Most of the areas in and around TPPsite are either surrounded by the moderate density of forests of Bamboo and other trees species which are not suitable Blackbuck habitats. We also examined the land use land cover in areas between TPP site and boundary of KWLS. Majority of the areas are dominated with a high density of human populations and under intense agriculture. Because of high anthropogenic factors including canal system, state highways, dense road, and high vehicular traffic between areas of TPP site and KWLS, we visualize the least possibility of recolonization of the Blackbucks in this landscape from the populations of Kaimoor Wildlife Sanctuary.

6.1. Introduction:

Welspun Group is a major multinational company with their business across the steel, energy and textiles industries. With an enterprises value of 15,000 crores in over 50 countries, Welspun is a rapidly growing conglomerate having clients operating in the oil, gas and retail sectors. Welspun Energy was established to setup over 5,000 MW commercial thermal power plants across various states of India. The group commits towards clean energy in the form of setting up solar, hydro, wind and biomass energy generation facilities.

Welspun Energy Limited planned to initiate two 660 MW thermal power plants in the district of Mirzapur to cater to the growing energy need of Uttar Pradesh helping the state to minimize the energy deficit. The company proposes using super critical technology minimizing adverse impact on the environment. The company plans to improve the lives of local people by generating employment in this region and would be investing in their health and education of the employee and their dependents. The proposed plant utilizes locally sourced as the primary fuel to be supplied by NCL/SECL/CCL or would import coal from Indonesia if the need arises. The plant has design life of 25 years is at the base load operation. Total land requirement for this project is 875 acres including the ancillaries – the power plant, ash pan and other auxiliaries required for day to day operations. An amount of Rs. 7500 crores are estimated as the total cost of the project

6.2. Study area:

The Welspun Energy UP Private Limited (WEUPPL) propose to setup a Greenfield Coal based Thermal Power Plant (TPP) of 1320 MW (2 x 660 MW) capacity. The project site is located at Dadri Khurd village and lies between $24^0$58’41.64” N to $82^0$39’50.42” E and $25^0$00’16.88” N to $82^0$41’03.728” E to Mirzapur Sadar Tehsil, Mirzapur district of Uttar Pradesh (Fig 6.1).

. The water requirement for the project is 36 MCM which will be sourced from river Ganga and pumped into upper Khajuri Dam located at a distance of 5.5 km from the project site. A reservoir will be built at the site to which water will be brought from upper Khajuri Dam through the pipeline. The reservoir will have a capacity of 4 days’ storage.

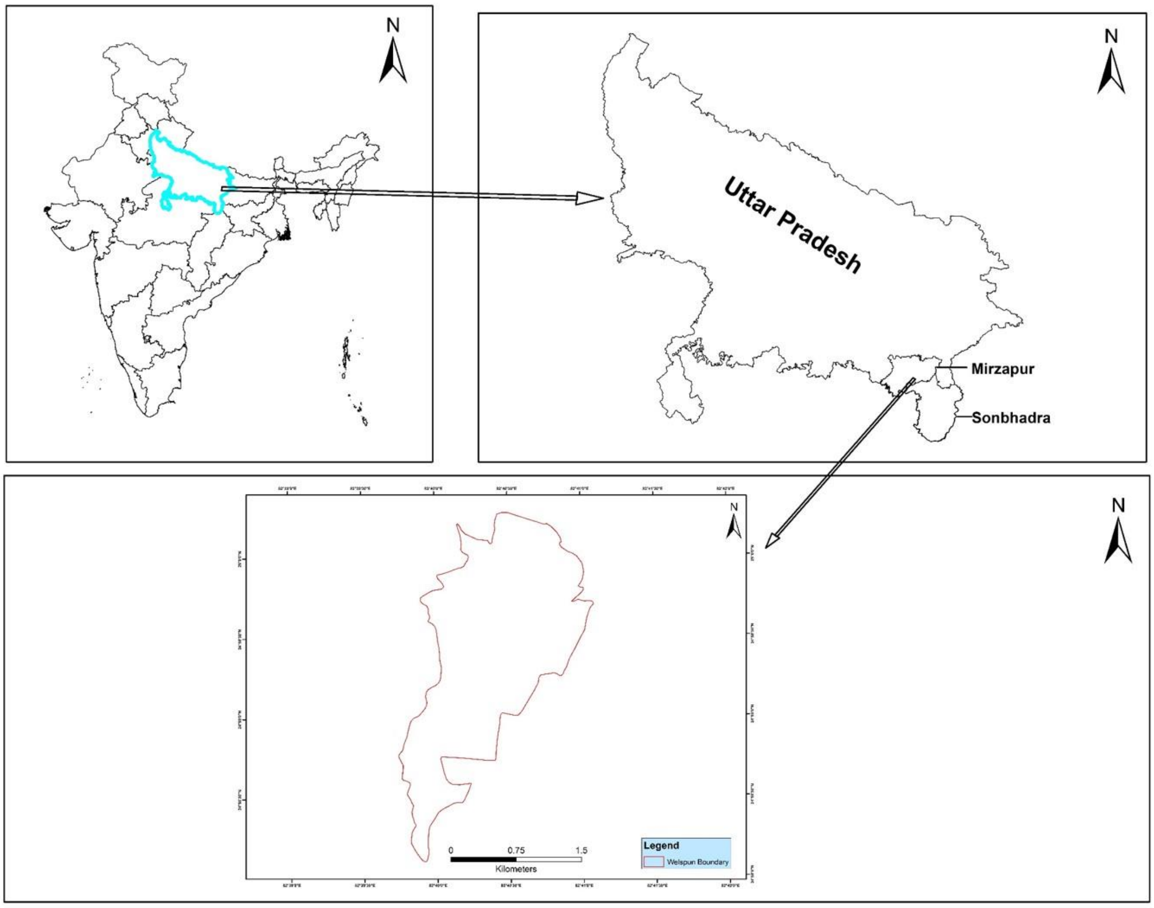

Figure 6.1. Location map of proposed Welspun TPP site.

The temperature of the area ranges between 12°C to 44°C and the average rainfall recorded is 900 mm. The minimum temperature was recorded in January while the Maximum was recorded in June. The site is about 185 meters from the mean sea level. The site is situated near the Marihan Range of Mirzapur forest Division. The topography of the area is slightly undulating, and the relative humidity was 30 % to 61% at early morning and 14 % to 45 % at evening. The nearest habitation is Dadri Khurd which has nine households. Dadri Gahira is the nearest village which has about 48 households. The Welspun Proposed Thermal Power Plant site (WPTPPs) is mostly barren and has been surrounded by plantation from all the three sides. The nearest railway stations areSakteshgarh and Sarsongram railway station (15.5 km), while the nearest Airport is Varanasi that is about 50 km far from the site. No National Park, Wildlife Sanctuary, Biosphere reserve, wildlife corridors, Protected Forest and Eco-Sensitive Zone falling with the 10 km radius of the project site except the Kaimoor WLS which is situated around 30 km far from the boundary of the TPPs.

6.3. Methodology:

The vegetation sampling was done along radial transects by establishing sampling stations at every 250 m interval (Fig. 6.2). The tree (>20 cm GBH) was quantified in 10 m radius circular plots (Mueller-Dombosis and Ellenberg 1967, Kershaw 1973). All trees present in the plot were enumerated as to species level and their total individuals. GBH measurements of all tree individuals were taken at each plot. The canopy cover was documented at X and Y length. The shrubs and sapling (<=20 cm GBH) were quantified in 5 m radius circular plots, and all the plants were falling within these plots were enumerated to species level. The canopy cover was recorded at X and Y length axis along with the shrub height. The ground cover was assessed in four quadrats each of 25 cm x 25 cm at every sampling station with respect to grass and seedlings. Three dominated grass species and percentage of ocular grass cover along with average grass height were recorded. The disturbance factor like lopping, cutting of trees was recorded in each sampling station at in 10m radius circular plot. Moreover, presence or sign of livestock was also recorded at 5m radius circular plot. (Annexure VI).

A total of 8 transects were laid radiating from the TPP site at different bearing (i.e., 0^0, 45^0, 90^0, 135^0, 180^0, 225^0, 270^0 and 315^0). Length of the transect ranges from 3 to 3.5 km (Fig. 6.2). The sign survey has also been conducted in the same radial transects from the start point. During the transect survey, fecal samples were also collected from different localities (Annexure V).

6.4. Results and Discussion:

A total of 24 species of tree were recorded in and around the TPP site. The maximum density of tree is recorded of Acacia *catechu* (15.20/ha) followed by *Butea monosperma* (9.55/ha), *Lagerstroemia parviflora* 4.24/ha), the minimum density was of *Aegle marmelos*, *Eucalyptus hybrid*, *Cassia fistula* and other species (Table 6.2). A total of 20 species of shrub were recorded in and around TPP site. The density of shrub was estimated in 5m radius plot and was maximum for the *Ziziphus oenoplea* (1.97/ha) followed by *Ziziphus mauritiana* (0.50/ha), *Acacia catechu* (0.40) and was minimum for *Ficus sp*. (0.01/ha) respectively (Table. 6.3).

The density of the bamboo (*Dendrocalamus strictus*) was estimated separately in 5m radius plot and was (116.18/ha). The bamboo was planted by the forest department through all the neighbouring area of TPP site.

A total of 24.5 km distance was covered during the transect survey and the maximum sighted animal were livestock and encounter rate was estimated to be 44.12±8.19 per km among livestock sheep comprises maximum encounter rate of 34.73±15.57 followed by goat and cattle 1.71±0.98, 7.67±1.67 per km respectively. However, the encounter rate of wild animals was 0.40±0.12 per km. Among the wild animal, Nilgai comprises maximum encounter rate of 02.8±0.10 while the minimum encounter rate was estimated for the Indian hare 0.04 per km. The direct and indirect evidence of the presence of wild animals in and around the TPPs were given in table 6.4 & 6.5.

The aerial distance of the Blackbuck presence site to the TPP site is around 48.93 km from Robertsganj (Blackbuck Valley), 33.32 km from Halia plantation (3) and 23.83 km from the Ghorawal (Visundhari). Most of the area of the TPP site is barren land. However, vegetation type around the TPP site was Bamboo and khair plantation with a high density of *Ziziphus*. The Blackbuck prefers short grassland, open salt pans and open scrub (Menon 2014). While the TPP site is totally barren land with sparse *Butea monosperma* tree. There is a heavy anthropogenic pressure in and around the TPP site especially by livestock grazing and tree felling (Fig. 6.4 to 6.7). The encounter rate of the livestock was 44.12±8.19 per km. The nearest population of Blackbuck is around 23 km far from this area. If Blackbuck started moving towards the TPP site for recolonizing, there are several hurdles they have to face.

There are several dense settlements in between the location of current Blackbuck population and TPP site. The road and rail network are passing through the way and road density in between these areas are very high, the frequency of traffic is also high especially on SH 5

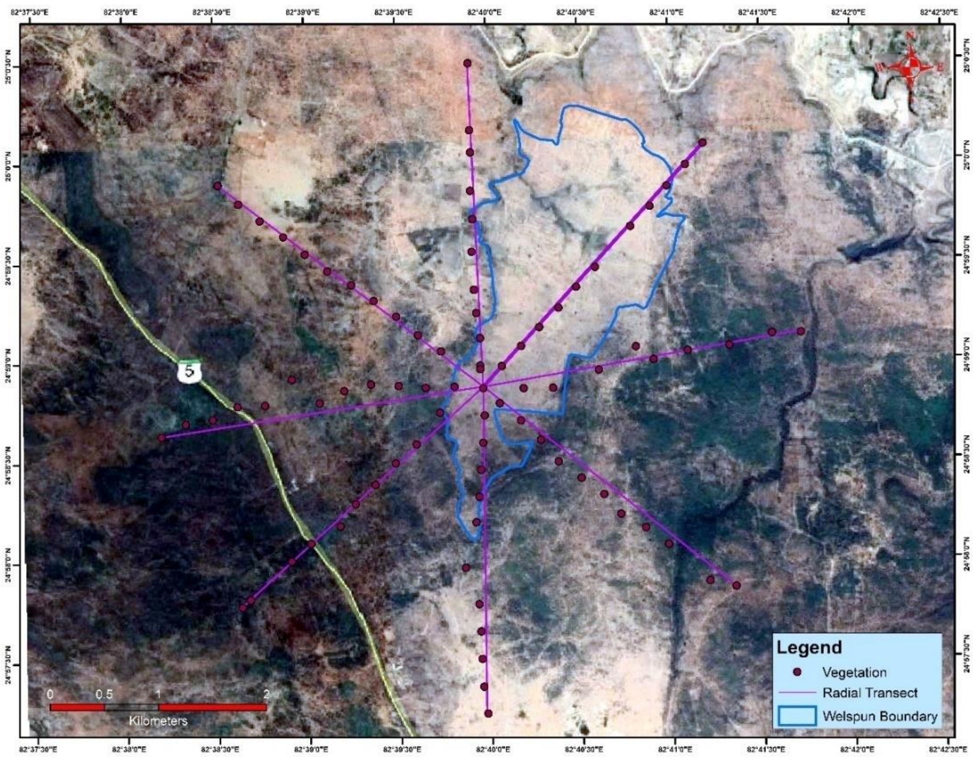

Figure 6.2. Radial transects and vegetation sampling stations within and around TPP site.

Mirzapur to Robertsganj which is passing very close proximity with the TPP site again its bifurcated from the Marihan and proceeded towards Ghorawal has high traffic pressure (Fig. 6.3). The maximum part of the total irrigated area of the country by canals is in Uttar Pradesh and Sonbhadra and Mirzapur placed high among other districts. The canal system also form hurdle to the movement of Blackbuck. Our data on LULC in areas between TPP site and boundary of KWLS and majority of the areas are dominated with a high density of human populations and under intense agriculture. Because of high anthropogenic factors including canal system, state highways, dense road density, and high vehicular traffic between areas of TPPs and KWLS, we visualize the least possibility of recolonization of the Blackbucks in this landscape from the populations of KWLS. So it is likely to be very hard for the Blackbuck to move from their present place and recolonize in and around the TPP site (Fig. 6.3).

Table 6.1. Details of the Proposed Thermal Power Plant site

(Source: EIA report – J.M. Enviro Net Pvt. Ltd.)

Sr. No	Particular	Details		
1	Location	Dadri Khurd Village, Mirzapur Sadar Tehsil, Mirzapur District, UttarPradesh		
2	Coordinate Range	Sr.No.	Latitude	Longitude
A	Plant Boundary	1	25°00’16.88”N	82°4029.20”E
		2	24°59’45.11”N	82°4103.72”E
		3	24°58’41.85”N	82°4023.80”E
		4	24°58’41.64”N	82°3950.42”E
		5	24°59’08.27”N	82°4000.40”E
		6	24°59’44.58”N	82°4000.55”E
B	Ash Dyke Area (with in plant boundary)	A	25°0'14.5"N	82°40'27.5"E
		B	24°59'57.1"N	82°40'57.8"E
		C	24°59'54.8"N	82°40'43.5"E
		D	24°59'46.8"N	82°40'8.2"E
		E	25°0'7.5"N	82°40'13.7"E
C	Chimney	C	24°59’35.08”N	82°40’26.15”E
3	Topo sheet No.	63K/12 &63L/9		
4	Site elevation	180 m above Mean Sea Level (MSL)		
5	Topography	Slightly undulating		
6	Climatic Conditions: IMD, Varanasi, Pre-Monsoon season	Mean Maximum Temperature: 37.6°C Predominant Wind Direction: W Relative Humidity: At 8:30 hrs: 31% to 61%and at 17:30 hrs: 14% to 45% Rainfall: 47.5mm Mean Minimum Temperature: 12.1°C		
7	Climatic conditions at site (monitored during Pre Monsoon season, 2011)	Mean Minimum Temperature: 11.6°C Mean Maximum Temperature: 42.0°C Predominant Wind Direction: W Relative Humidity: At 8:30 hrs: 32 % to 62%and at17:30 hrs:16% to 48 %		
8	Nearest habitations (Population as per Census-2001 Data)	Dadri Khurd (Population:09) Dadri Gahira (Population:48)		

9	Present land use at the site	Mostly barren
10	Nearest Major Roads/Highway	State Highway, SH-5(1.5 km, SW) National Highway, NH-7 (10.0 km, NNE)
11	Nearest Railway Line	Broad Gauge Railway line of Northern Railways (NR)
12	Nearest Railway Station	Sakteshgarh R.S. (15.5 km, ENE) Sarsongram R.S. (15.5 km, E)
13	Nearest Airport	Varanasi (50 km, NNE)
14	Nearest Seaport	Haldia
15	Nearest Town	Mirzapur–District Headquarters (18km, NW)
16	Nearest water bodies	Jamtlhwa Nadi (2.0 km, N) Jogiadar Nadi (2 kms, NE) Pahiti Nadi (3.75 kms, NE) Upper Khajuri Dam (5.5 km, W) Ganga River(17 km, NE)
17	Eco sensitive Zone (National Park, Wildlife Sanctuary, Biosphere reserve wildlife corridors etc.)Within10 km radius of the project site.	No Eco sensitive Zone viz. National Park, Wildlife Sanctuary, Biosphere reserve, Wildlife corridors and Protected Forest falling within 10 km radius of the project site.
18	Reserved/Protected forests	Danti RF (on northern side of project site) Mirzapur RF (on southern side of project site) Bahati RF (6.0 km in SW) Karaunda RF (5 km, SW) Patehra RF (5.0 km in SW) Malua RF (8.5 km in SW) Chandlewa Khurd RF (6.0 km in NNE) Nanauti RF (7 km in E) Golhanpur RF(6.5 km in E) Sarson RF (5.5km in SE)
19	Areas susceptible to natural hazards	No new with in10 km radius study area

20	Archaeologically important places as per Archaeological Survey of India	No new within 10 km radius study area
21	Existing Industries	No new with in10 km radius study area
22	Seismic Zone	Zone-III as per IS:1893-2000

Table 6.2. The density of tree species found in and around TPP site.

S.No.	Species	Density/hectare
1	*Acacia catechu*	15.20
2	*Acacia pinata*	1.06
3	*Aegle marmelos*	0.35
4	*Azadirachta indica*	2.12
5	*Bauhinia racemosa*	0.71
6	*Butea monosperma*	9.55
7	*Cassia fistula*	0.35
8	Unknown 1	0.35
10	*Eucalyptus sp.*	0.35
11	*Ficus* Species	1.06
12	*Holoptleta integrifolia*	0.71
13	*Gmelina arborea*	0.35
14	*Albizia amara*	0.35
15	*Garuga pinnata*	0.35
17	*Lagerstromia parviflora*	4.24
18	Unknown 2	0.35
19	Unknown 3	0.35
20	*Tamarindus indica*	0.35
21	*Tectona grandis*	1.06
22	*Ziziphus oenoplia*	0.35

Table 6.3. The density of shrub species found in and around TPP site.

S.No.	Species	Density/ hectare
1	*Acacia catechu*	0.42
2	*Acacia pinata*	0.10
3	*Aegle marmelos*	0.01
4	*Butea monosperma*	0.08
5	*Carissa spinarum*	0.18
6	*Ficus* sp.	0.01
7	*Helicteres isora*	0.10
8	*Heterophragma adenophyllum*	0.13
9	*Holarrhena antidysenterica*	0.11
10	Unknown 1	0.01
11	Unknown 2	0.01
12	*Lagerstromia parviflora*	0.18
13	Unknown 3	0.01
14	Unknown 4	0.01
15	Unknown 5	0.01
17	Unknown 6	0.03
18	*Tectona grandis*	0.03
19	*Zizhiphus mauritiana*	0.50
20	*Zizhiphus oenoplia*	1.97

Table 6.4. Detail of the direct and indirect evidences of the wild animal presence in and around TPP site.

Common Name	Scientific Name	Direct/Indirect Sign
Hanuman Langur	*Semnopithecus entellus*	D
Nilgai	*Boselaphus tragocamelus*	D
Indian Hare	*Lepus nigricollis*	D
Indian Fox	*Vulpes bengalensis*	D
Jackal	*Canis aureus*	D
Wild boar	*Sus scrofa*	Digging sign
Five striped palm squirrel	*Funambulus pennantii*	D
Striped Hyena	*Hyaena hyaena*	Footprint
Sloth bear	*Melursus ursinus*	Dropping
Chinkara	*Gazella bennettii*	Pellet

Table 6.5. The details of the indirect evidences along with coordinates of the wild animal presence signs in and around the TPP site.

Transect No.	Animal	Signs	Latitude	Longitude
RT0	Nilgai	Dung midden	24^0 58’59.63”	82^0 39’56.71”
RT0	Nilgai	Dung midden	24^0 59’14.81”	82^0 39’55.69”
RT0	Nilgai	Dung midden	24^0 59’19.73”	82^0 39’55.1”
RT0	Nilgai	Pellet	$25^0$0’10.07”	82^0 39’26.02”
RT90	Nilgai	Dung midden	24^0 58’49.4”	82^0 39’55.2”
RT90	Nilgai	Dung midden	24^0 58’19.59”	82^0 39’37.03”
RT135	Nilgai	Pellet	24^0 58’30.51”	82^0 39’20.46”
RT135	Peacock	(Poaching Sign)	24^0 58’3.12”	82^0 39’0.04”
RT135	Sloth bear	Dropping	24^0 57’52.6”	182^0 39’2.61”
RT180	Nilgai	Pellet	24^0 58’52.8”	82^0 39’28.8”
RT270	Nilgai	Dung midden	24^0 58’52.8”	82^0 39’20.6”
RT270	Nilgai	Dung midden	24^0 58’51.4”	82^0 39’13.2”
RT270	Hyena	Footprint	24^0 58’44”	82^0 39’14”

Table 6.6. Faecal sample collected from the TPP site.

		Location	
Species	**Sample**	**Latitude**	**Longitude**
Chinkara	Pellet	24^0 58’29.97	82^0 40’ 23.06
Chinkara	Pellet	24^0 58’29.3	82^0 39’ 28.8
Chinkara	Pellet	24^0 58’29.97	82^0 40’ 23.06
Chinkara	Pellet	24^0 58’58.77	82^0 41’ 6.05
Chinkara	Pellet	24^0 58’47.8	82^0 35’ 49.2
Jackal	Scat	24^0 58’52.8	82^0 39’ 13.2
Chinkara	Pellet	24^0 58’45.82	82^0 39’ 58.07
Chinkara	Pellet	24^0 58’14.3	82^0 39’ 55.26
Chinkara	Pellet	24^0 58’53.58	82^0 39’ 54
Chinkara	Pellet	24^0 58’50.34	82^0 39’ 59.41
Jackal	Scat	24^0 58’4.5	82^0 39’ 41
Sloth bear	Dropping	24^0 58’52.6	82^0 41’ 12.61
Chinkara	Pellet	24^0 58’30.51	82^0 40’ 20.46

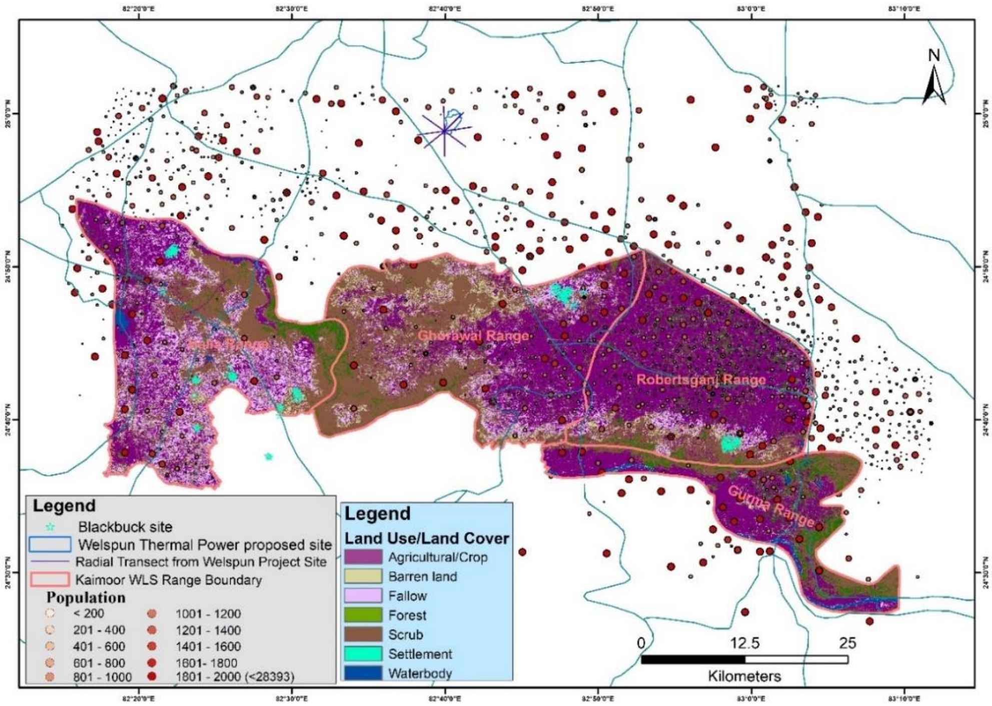

Figure 6.3. Human population density, TPP site, LULC and road network in and around Blackbuck presence location.

Figure 6.4. Plantation area used as a dumping ground near TPP site.

Figure 6.5. People collecting fuelwood from the plantation in and around TPP site.

Figure 6.6. Bamboo plantation present at the southern boundary of the TPP site.

Figure 6.7. Habitat type, open scrub, barren land and transmission line passing through the proposed Thermal Power Plant Site.

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Chapter 7:

Distribution pattern of domestic and wild carnivores

Summary

Distance sampling which can estimate the density of populations using measurements of distances of objects located near the transect (Buckland et al., 1993, Barraclough, 2000, Thomas et al. 2010). In order to understand the ecology and biology of a prey species, the predators are one of the most influencing factors of any wild population. Therefore, understanding the status of the domestic and wild carnivores inside the study area. Hence, we collected the data on these species during the line transect in and around KWLS. A total effort of 298.7 km was made to estimate the predators in and around KWLS, and we found that the overall density of wild and domestic predators was 1.96±0.69 per km^2. The average cluster size was of 1.56 with an effective strip width of 49 meters. The predator especially the dog are distributed throughout the study area as most of the areas are under village settlements or crop field. However, the wild carnivores were mostly distributed in barren land or inside the protected area.

7.1. Introduction:

For the conservation and effective management of the species, it is important to estimate wild animal species within and outside protected areas to know and monitor the wildlife in different biogeographic zones (Buckland et al. 2000). A regular census should be conducted for prediction, implementation and documentation of potential management and conservation actions for several species and their habitats (Blanco et al. 1996, Buckland et al. 2000). Accurate species status information, spatial and temporal distribution and extinction risk assessment are important for species conservation and management (Gaston and Fuller, 2009). Of the total threatened species assessed by the IUCN Red List categories, about 47 percent of the species in this group were categorized solely on the basis of range measures (Gaston and Fuller 2009). These measures include the extent of occurrence and occupancy area. The species occurrence is actually the geographic area bounded by the records of the outermost known or projected existing species and is often considered the range of the species (IUCN 2001, Hartley and Kunin 2003). The species range is used to assess the likelihood of simultaneous extinction in all areas occupied by the species, presuming that the risk of extinction is inversely related to the range size (Gaston and Fuller 2009). Area of occupancy is a finer-scale measure comprising specific locations within the extent of occurrence where the presence of species have been recorded, generalized to an appropriate spatial resolution (IUCN 2001, Hartley and Kunin 2003, Gaston and Fuller 2009). It reflects the rarity and fragmentation of the occupied locations and thus the likely resilience of the distribution to threats from stochastic and directional processes (Hartley and Kunin 2003, Gaston and Fuller 2009). Occupancy is another measure that expresses the proportion of an area or collection of sampling sites occupied and is frequently used as a surrogate for abundance in monitoring programs (MacKenzie et al. 2006).

Unfortunately, such data has often been missing for terrestrial carnivores as they are troublesome and work seriously to identify (Nowell and Jackson 1996, Sillero-Zubiri et al. 2004). Lack of this information has been mentioned in the South African Conservation Assessment and Management Plan (Friedmann and Daly 2004) to refresh the assessment directed about 20 years ago (Smithers 1986). About 35 percent of South Africa's terrestrial carnivores were categorized as threatened, Near Threatened or Data Deficient due to this procedure (Friedmann and Daly 2004). This includes the Brown hyaena, *Hyaena brunnea*, and serval *Leptailurus serval*, categorized as 'Near Threatened', and the cheetah *Acinonyx jubatus*, categorized as 'Vulnerable'. However, insufficient data on trends and current distributions hindered the accurate assessment of many species (Friedmann and Daly 2004).

The natural predator of the Blackbuck in India is Indian Wolf (*Canis lupus pallipes*) and Golden jackal (*Canis aureus*). The traditional predators of Blackbuck in KWLS were golden jackal, domestic dog, and fox. However, caracal has also been reported from the study area. The golden jackal and domestic dog are major predators reported from several other studies on the Blackbucks across the country. While jackal and fox are reported as potential predators, who use to hunt on the fawn (Jhala 1993, Gehlot and Jakher 2015, Meena et al. 2017).

7.2. Methodology:

The data of wild and domestic carnivores were collected during the line transect and random sampling survey from KWLS. A total of 53 transects were laid in all four ranges of KWLS. We walked, and temporal replications of the same were done in different habitat types like agricultural land, open scrub, dense scrub, barren land, and plantations) to document the status and distribution of wild and domestic carnivores. During the transect survey, we recorded a number of animals sighted and sighting distance whenever the wild or domestic carnivores were seen (Annexure IV). We also recorded the wild carnivore during random surveys carried out throughout the study area to assess the potential sites used by the Blackbucks in and around KWLS.

7.3. Results and discussion:

Distance sampling is a method which has been widely used to estimate the density of populations using measurements of distances of objects located near the transect (Buckland et al. 1993, Barraclough 2000 and Thomas et al. 2010). An effort of 298.7 km was made to estimate the predators in and around KWLS, and we found that the overall density of predators was 1.96±0.69 per km^2. The average cluster size was 1.56 with an effective strip width of 49 meters (Fig. 7.1). The predator, especially the domestic dogs are distributed throughout the study area as most of the area is under village settlements or crop field. However, the wild carnivores are distributed in barren land (protected areas) or near the settlement (Fig. 7.2).

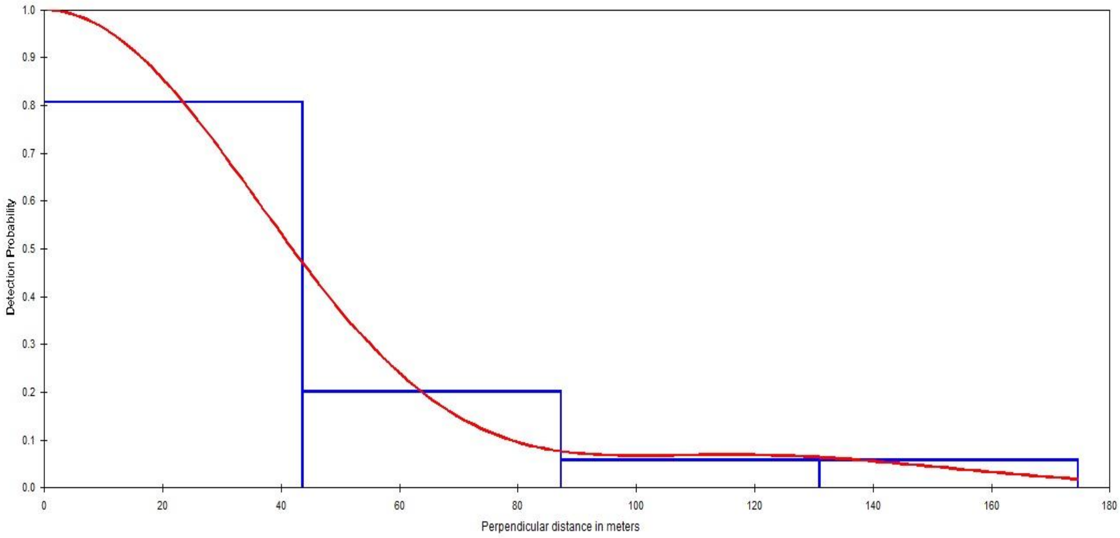

Figure 7.1. Detection probability curve of predators in and around KWLS.

Table 7.1. Mean group sighting of the different domestic and wild predator species encountered in KWLS.

S.No.	Species	Mean group sighting	SD	SE	CV
1.	Golden Jackal	1.76	0.72	0.49	0.40
2.	Domestic Dog	1.5	0.78	0.30	0.52
3.	Fox	1.0	0.0	1.0	0.0

A total of 138 predators (domestic and wild) were seen on transects out of which golden jackal has the mean group sighting of 1.76±0.49 SE followed by dog 1.5±0.30 (Table 7.1). The distribution of the wild and domestic carnivores on transects are shown in Fig 7.2. Another study conducted on the Pirotan Island, Gujarat recorded 413 Golden Jackal in an area of $3km^2$ with an average of 1.2 clusters/km (CV 5.32%) (Sagar and Anthoney 2017).

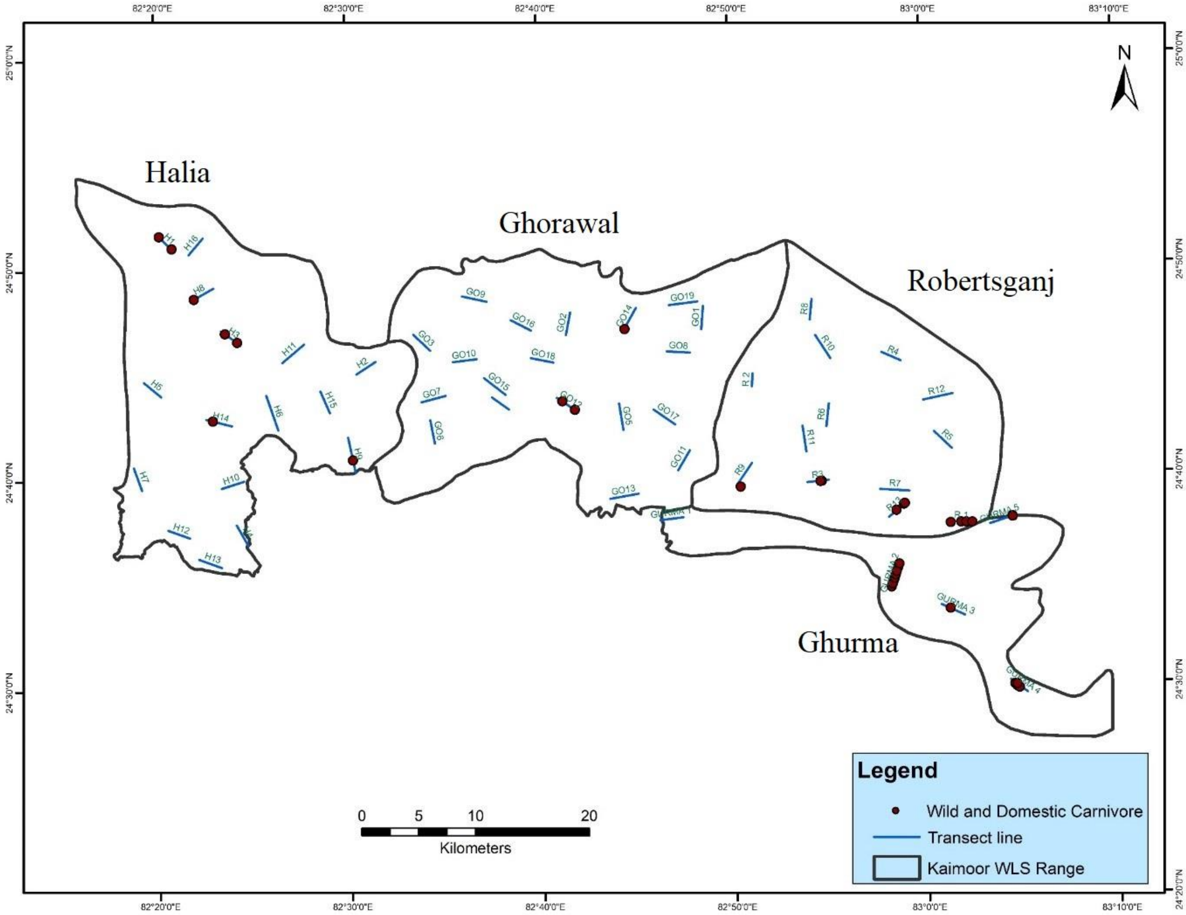

Figure 7.2. Distribution of wild and domestic carnivores on the transects.

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Chapter 8:

Food habits of wild carnivores and predation on the Blackbuck

Summary

For understanding the extent of predation by wild and domestic carnivores (Jackal, Fox, and Domestic Dog) on Blackbucks, a total of 138 scats were collected from the study area. Analysed scats (n=122) indicate that 5.73% of scats contain Blackbuck hair. However, we also noted the presence of Blackbuck hair in domestic dog scat (n=1). The Jackal is found to predate on the Blackbuck, and such incidences were maximum in Ghorawal followed by Robertsganj range. Hence, predation by domestic and wild carnivores may be a major threat to the small Blackbuck populations of KWLS. This may affect growth rate and requires long term monitoring the extent of such predation on Blackbuck population.

8.1. Introduction:

Optimal foraging theory is a theory of behavioural ecology which predicts, how prey selection is affected by prey abundance, the amount of energetic value of a prey item and the expenses of searching, handling and consuming the prey (MacArthur and Pianka 1966). The time and energy costs expected to seek and effectively chase a specific prey animal must be exceeded by the subsequent intake of energy (including specific nutrients such as protein). Therefore, predators should be selective in choosing their favourite prey, and their decision is expected to be influenced by changes in the abundance of specific prey species. This implies that the most energy-rich food should be taken at a constant rate, while the intake of less dietary food should vary with the abundance of food items. Several field studies on carnivorous species supported predictions of prey choice and hunting behaviour (Scheel 1993, Weber 1996, Hernández et al. 2002, Khan et al. 2017).

Determining each prey item contributing to the diet of a carnivore species by direct field observation is difficult. Thus scat analysis method is widely used to determine the food habits of carnivores due to their non-invasive nature, easy collection, and analysis (Korschgen 1980, Ackerman et al. 1984, Reynolds and Aebischer 1991). Therefore, scat analysis method was used to determine the food habits of golden jackal along with the domestic dog in KWLS. The scats of golden jackal are easy to identify as there is no ambiguity between the scats of other carnivores found in KWLS. The scats of golden jackal are larger in size and shape compared to the other carnivore like common palm civet, Indian fox, fishing cat, and jungle cat.

8.2. Methodology:

The scats were collected between October 2018 and December 2018 in KWLS. Scats were collected and stored in zipped polythene bags, and necessary information was recorded like habitat, GPS coordinates, time and date of collection. The collected scats were sun-dried, washed in running tap water within the sieve. The remains like hairs, feathers, seeds, bones, grasses were separated and sun-dried for further identification of species and observation through the microscope and macro lens. Hairs are the most important part to identify the prey species consumed by the predators. Different species have dissimilar kind of shape, size, the structure of medulla and cuticle in hairs. At least 10-20 hairs were picked randomly from each scat and are treated with xylene in order to see hair characteristics. These hairs are mounted on the permanent slide using gelatine. We observed cuticular characteristics of collected hair from scats under the microscope to identify the prey species. The hairs were compared with the already made reference slides and hair guard manual of Wildlife Institute of India (Bahuguna et al. 2010) (Fig. 8.1 to 8.3). The reference slides were made with the collected hair during the study period from KWLS, and the percentage of occurrence was estimated.

8.3. Result and Discussion:

A total of 138 scats were collected from the study area out of which 122 were analysed to see the percentage of predation on the Blackbuck by the domestic and wild carnivores (Table 8.1). Out of 122 scats, only 5.73% contains Blackbuck hair in the scats of Jackal followed by the domestic dog (Fig. 8.4). However, we did not find any evidence of predation by Bengal fox. The prepared slides (Fig. 8.5) were compared with the reference images. The jackal is found to scavenge and predate on the Blackbuck, and this event was found the maximum in Ghorawal followed by Robertsganj range. The more intensive study should be done to find out the predation of Blackbuck by the wild and domestic carnivore. So far no study has been conducted to estimate the predation of Blackbuck by a domestic or wild carnivore. However, Kumar and Rahmani (2008), recorded 99 kills in the territory of the collared wolf. The maximum was Blackbuck (46.5%), followed by the goat (37.4%) and sheep (16.2%) Therefore; livestock contributed about 54% of the total kills during 1991-1992. Whereas during 1993-1994, authors recorded 76 kills in total out of which, Blackbuck contributed 36.8%, goat 52.6%, and sheep 10.5%. We found only one scat of dog near the Blackbuck site in Ghorawal, and it contains the hair of cattle, goat, and Blackbuck.

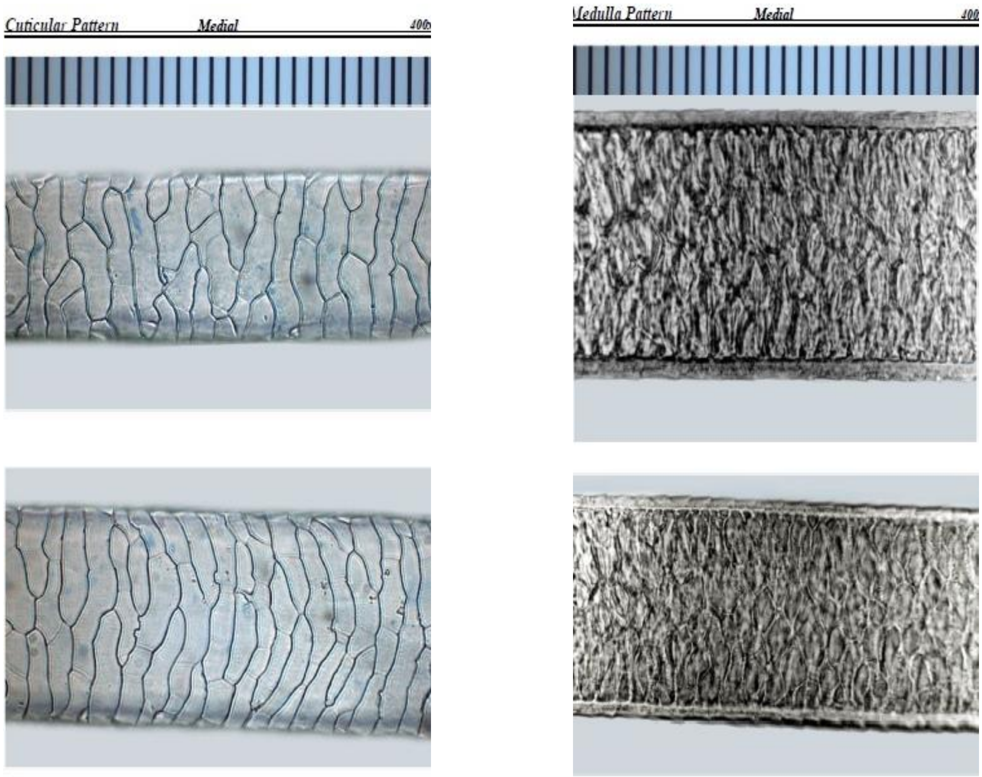

Figure 8.1. Cuticular and medullar pattern of Blackbuck hair (Source: Bahugana et al. 2010).

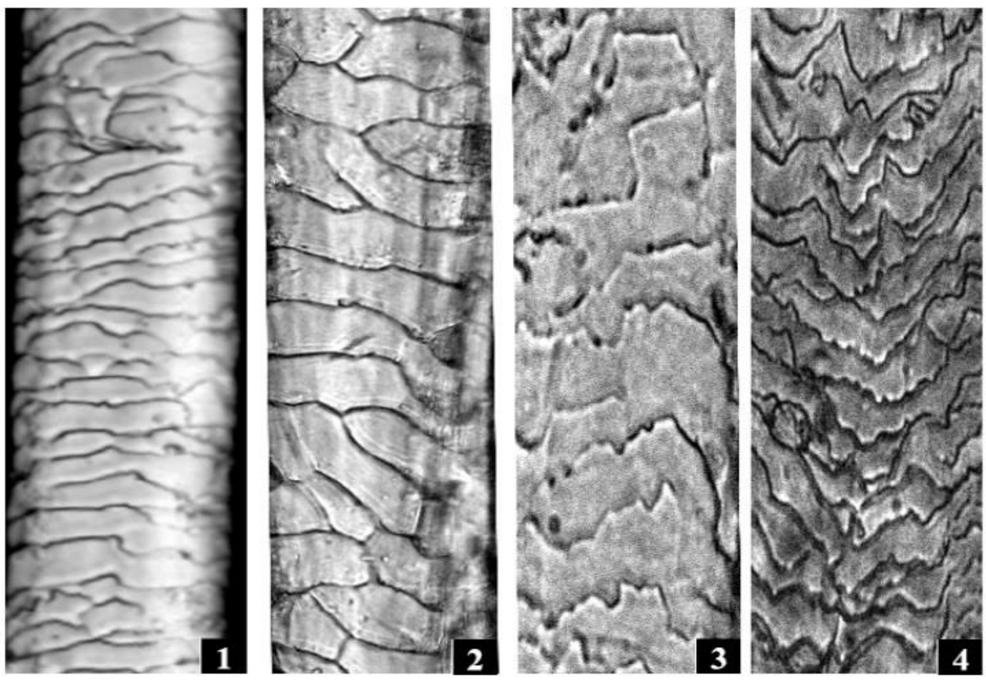

Figure 8.2. Observed cuticular pattern of 1. Goat 2. Sheep, 3. Cow and 4. Buffalo. (Source: Gharu and Trivedi, 2015).

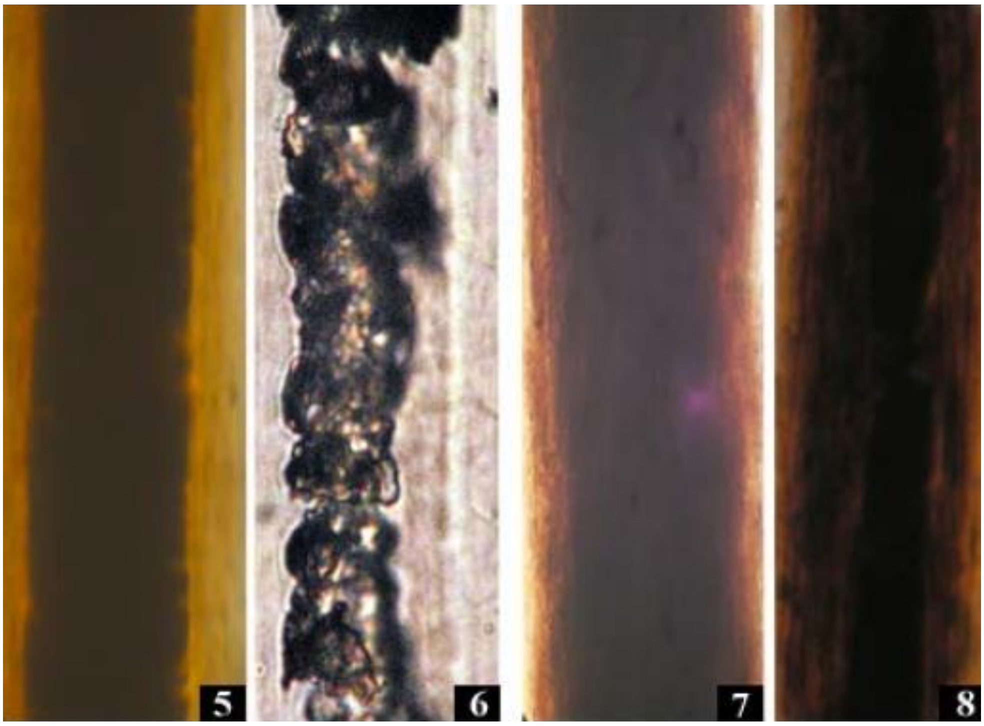

Figure 8.3. Medullar pattern of 5. Goat, 6. Sheep, 7. Cow and 8.Buffalo (Source: Gharu and Trivedi, 2015).

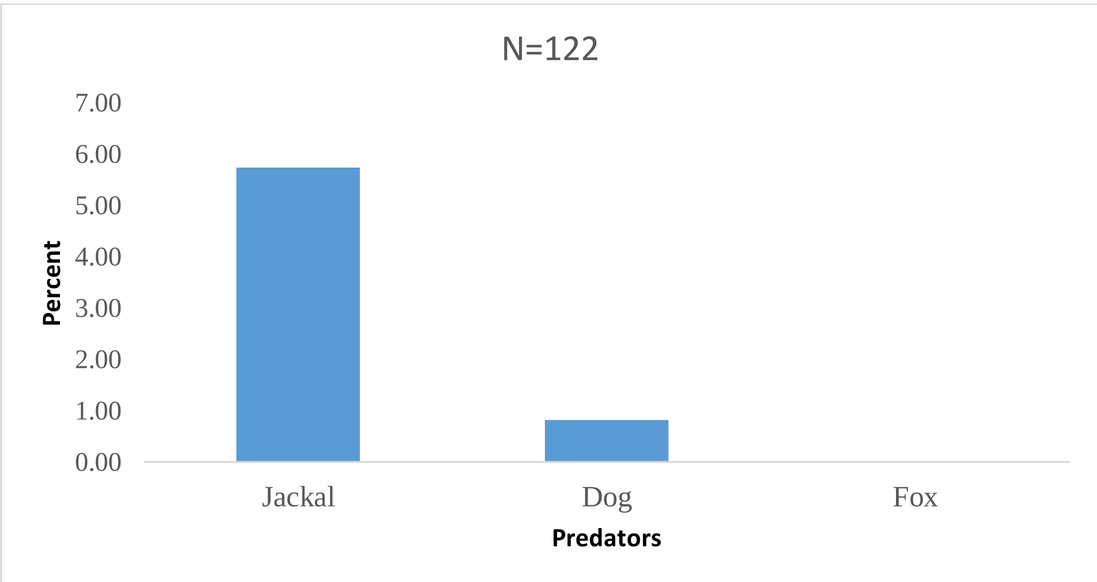

Figure 8.4. Percentage of scats containing Blackbuck hair in scats of carnivores in and around KWLS.

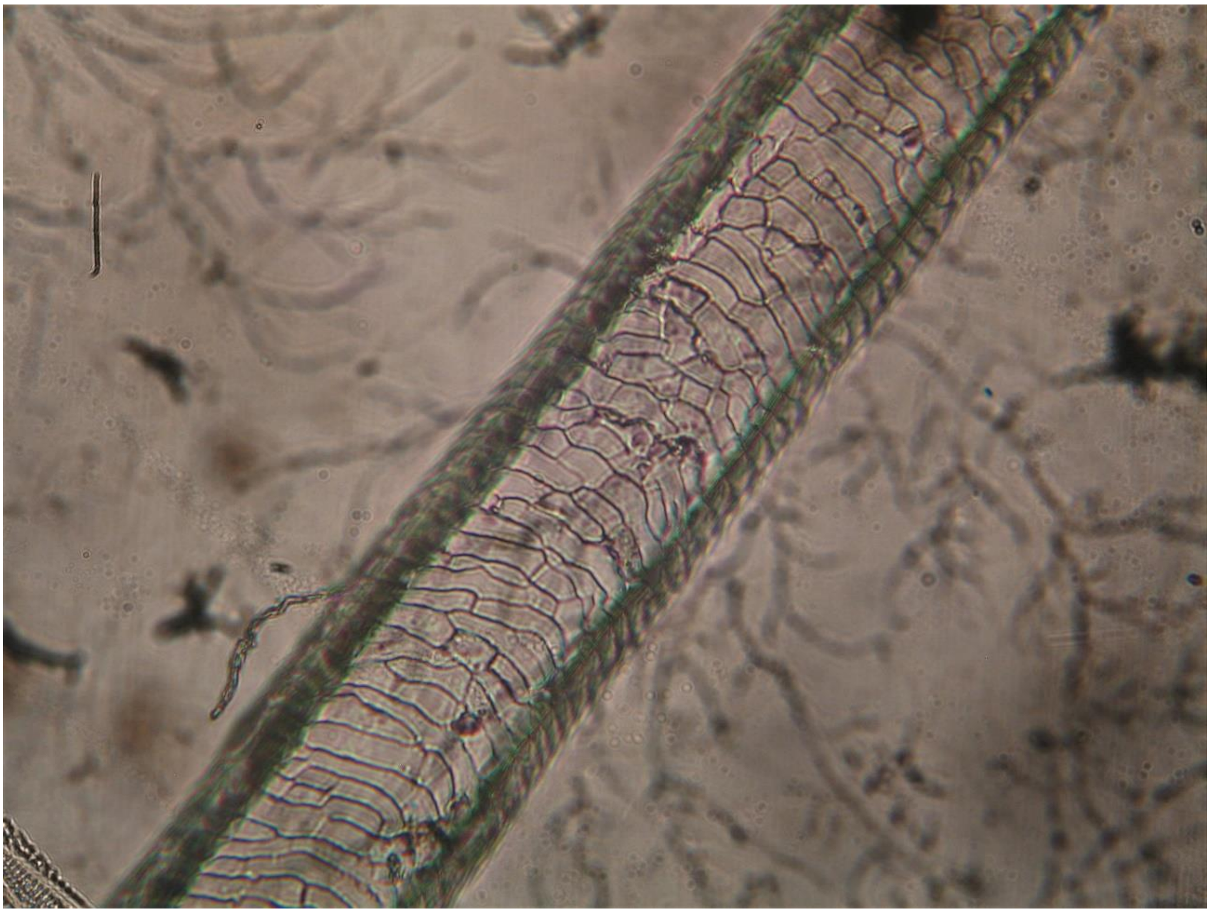

Figure 8.5. Cuticular pattern of Blackbuck hair seen in the scat of Jackal.

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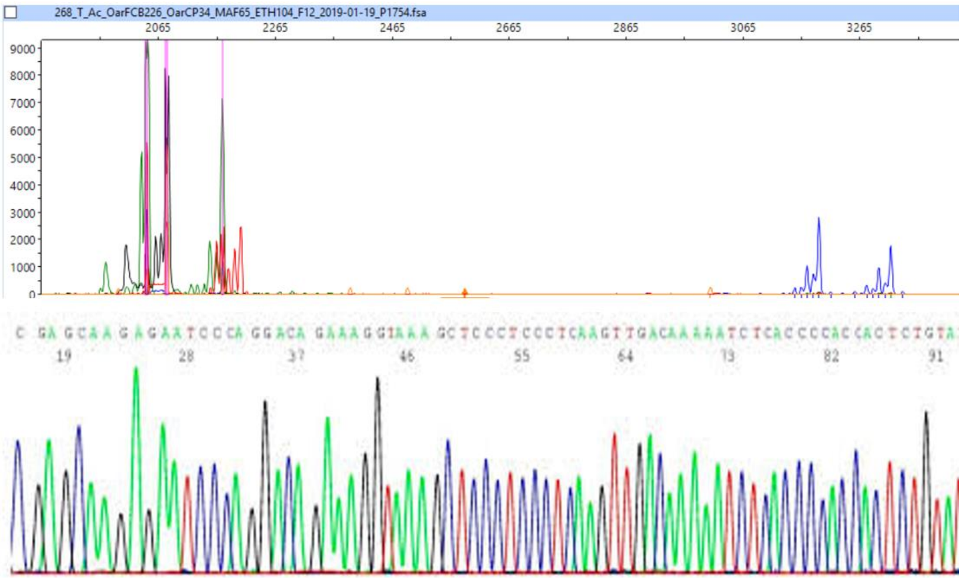
Chapter 9:



Genetic characteristics and connectivity of Blackbuck populations in and around KWLS

Summary

Understanding genetic characteristics have been a crucial component for a planning conservation plan, so as to ensure the genetic fitness of the population. Therefore, we characterize the genetic variabilities and population connectivity of the Blackbuck in the human-dominated landscape in and around Kaimoor Wildlife Sanctuary using mitochondrial DNA sequence analyses as well as multi-locus (n=11) microsatellite genotyping using faecal pellets as the source of DNA. Our analysis using mtDNA cytochrome b gene (370 bp) did not show any geographically related variations in comparison to data examined across Blackbuck range (Shukla et al. 2019). For understanding gene level population genetic structure we standardized 12 microsatellite markers and a sex linked marker to co-amplify in 4 multiplex reactions and generated data with 142 Blackbucks faecal pellet DNA. We analysed the good quality data of 11 microsatellites with 112 samples from the different parts of the study area and found that F_{ST} *values (ranged from 0.03 to 0.04) between the three ranges of KWLS had a high level of past gene flow and therefore, connectivity in historic time. However, Robertsganj was comparatively more differentiated from Halia and Ghorawal populations, whereas the highest differentiation between the Allahabad and the Bagdara populations.*

Similarly, the inbreeding coefficient (F_{IS}*) was higher in Robertsganj (0.49) followed by Ghorawal (0.46) and Halia (0.36) populations in order. Robertsganj and Ghorawal had lower observed heterozygosity (Ho) (0.35) than that of Halia (0.40). Individual based clustering (IBC) approaches found that the KWLS population was differentiated from the Allahabad, Bihar and Madhya Pradesh populations sampled. It also revealed that the allele sorting process due to non-random mating and gene flow among adjoining populations rendered the Robertsganj population separated from the Ghorawal and the Halia population. We also observed this population having a high proportion of genetically admixture individuals indicating that the allele sorting to be incomplete. Similar patterns were displayed and supported by the multivariate approach as well as a spatial principal component analysis. Factorial correspondence analysis also confirmed that the Robertsganj population diverged from the rest of the KWLS populations as well as the nearby areas.*

Therefore, we can conclude that though there were no differences between the ancestry of the Blackbuck population in the study area, stochastic environmental and evolutionary processes lead to incipient differentiation of the populations in the study area. With the very low population size and skewed sex ratio in the Robertsganj population, immediate conservation strategies are needed to be planned to avoid local extinction. The ideal way to achieve so is to establish and maintain connectivity with the Halia population as the Ghorawal population is already isolated by stretches of human habitation and crop-field. A second strategy would be to follow adaptive management by augmenting for ensuring long term conservation goals of this population. Realizing this pattern in and around KWLS, we suggest the need for genetic assessment of other Blackbuck populations of Uttar Pradesh.

9.1. Introduction:

The exponential increase in human population and consequent anthropogenic developmental activities have caused range shrinkage as well as local and global extinctions of a number of wild species in the Anthropocene (Dirzo et al. 2014). The immediate causative factors driving extinction events have been human predation, introduced invasive species and habitat degradation and adequate natural habitat. Protection to the focal species does not always guarantee species survival due to extrinsic factors such as the influence of predators, pathogens, natural catastrophe as well as intrinsic factors like species demography, inclusive fitness and genetic variability (Balkenhol et al. 2016). However, the abiotic extrinsic variables can modify the demographic and genetic traits by in the form of selection pressure thereby influencing the species persistence. Hence, understanding genetic variation is the most fundamental essence of biological diversity which affects the variability in a species in both population and ecosystem level (Primack 2010).

The first studies on genetic variability of wild mammals used protein electrophoresis as a simple, inexpensive but effective tool (O'Brien et al. 1987). However, mitochondrial DNA (mtDNA), though representing a small fraction of total genome, emerged as one of the most popular markers for genetic variation using both in population genetics as well as in molecular taxonomy. mtDNA has widely been adopted because of the high copy number of the mtDNA genome increasing the chance of successful amplification, lack of duplications and intron, higher mutation rate than coding nuclear DNA. The only known drawback of mtDNA studies might arise from improper amplification of nuclear inserts of mtDNA genes (numts). With the increase in literature, it has been possible to identify if there were numts in any particular genome. Therefore, mtDNA fragments have become markers of choice for exploring the genetic variability of wild species lacking baseline genetic information (Galtier et al. 2009) despite being propagated matrilineally thereby providing no information on male mediated gene-flow.

On the other hand, neutral nuclear markers such as microsatellite have become indispensable to answer ecological questions like gene-flow, migration rates, effective population size, recent and past bottlenecks and relatedness (Selkoe and Toonen 2006). Population genetics, with advancement in molecular tools and its integration with landscape features using GIS tools, has given rise to landscape genetics where the interaction of genetic structure with landscape features is being examined. Microsatellites are 1 to 6 base tandem repeats observed in high frequency across taxa, also known as SSR (simple sequence repeat), VNTR (variable number tandem repeat) or STR (short tandem repeat). Primers for microsatellite markers are designed at the flanking regions with invariant DNA. Due to variation in length of the microsatellite region of di, tri or tetra nucleotide repeat motifs, different alleles for a microsatellite loci vary in length which is recorded by means of capillary electrophoresis having 1 bp resolution. Due to shorter lengths of microsatellite amplicons by design (ca. 100-300bp), they are the ideal markers with biparental inheritance to use with degraded samples such as non-invasive faecal DNA.

With the recent advent in next generation sequencing (NGS) platforms, the numbers of markers available for the focal species increases by the orders of thousands, with high density across the complete genome resulting in much higher resolution (Supple and Shapiro 2018; Meek and Larson 2019) and found to be useful in a few (Hoffmann et al. 2015, McCartney-Melstad et al. 2018). However, the cost of NGS is still not within the budget of most conservation projects and lack of annotated genome in non-model species renders genome assembly difficult for the researchers. Obtaining high quality biological samples fit for NGS is another challenge in the field of conservation.

Populations with dispersed patchy distribution are affected by genetic drift as well as variable selection pressure at a local scale. This evolutionary processes are countered by population connectivity, i.e. gene flow which homogenizes local variations (Wright 1931), ultimately giving rise to population genetic structure which is governed by genetic drift, selection pressure, and gene flow based on multiple ecological and evolutionary factors. In such structured populations, the populations having higher quality resources grow till reaching the carrying capacity upon which individuals move out of the population to take refuge in lower quality 'sink' populations. Life histories and social hierarchies of individuals often decide the pattern of emigration. Identifying source populations for scantily distributed sinks is, therefore, necessary to device conservation actions such as management mediated population supplements to rescues the sink populations from the risk of extinction. Phylogenetic reconstruction using genetic distances between mtDNA haplotypes is useful to identify ancestral populations. Use of geographical information in such a framework can potentially identify matrilineal source population on a coarse scale. Use of microsatellites to identify local allele frequencies and Bayesian clustering approach along with calculating F statistics (Wright 1950) between populations can also identify source populations. Bayesian approach to detect the proportion of migrants and direction of gene-flow between populations (Piry et al. 2004) estimates recent genetic exchange.

The Indian antelope also known as Blackbuck used to be the most abundant wild animal across the Indian subcontinent (Rahmani 1991) and was once widespread across a vast range starting from river Indus in the west across the Indo-Gangetic plains as well as the Deccan plateau up to Point Calimere of the eastern coastal plains, Due to indiscriminate hunting during the 20th century (IUCN) a sharp decline of Blackbuck population caused local extinctions at the range extremities viz. Pakistan and Bangladesh causing to be restricted only to the scrublands and dry grasslands of India and Nepal. However, the introduction of the Wildlife (Protection) Act 1972 in India helped to curb Blackbuck poaching to some extent. As the Blackbuck frequents the habitat-agricultural land interfaces, conflict issues are on the rise with villagers considering Blackbuck as an agricultural pest in various high-density locations.

Groves (1980) reviewed the existing taxonomy of the Blackbuck and proposed two subspecies *A. c. cervicapra* and *A. c. rajputanae* based primarily on skull length *A. c. cervicapra* being the southern and eastern Blackbuck having less than 230 mm adult male skull length, no grey sheen on body, well-marked leg stripe and narrow eye rings whereas *A. c. rajputanae* the north-western Blackbuck having more than 230 mm adult male skull length, the grey sheen on breeding male body, indistinct leg stripes and broad eye rings.

However, the state of Uttar Pradesh (UP) was shown to harbour both the subspecies, the specimens from the western parts were classified as *A. c. rajputanae* whereas the eastern parts were of *A. c. cervicapra.* The nearest described populations to our study population are Banda in UP and Palamau in Jharkhand, both of the locations harbouring *A. c. cervicapra.* Our study provides a unique opportunity to verify the taxonomic status of the study population in Kaimur Wildlife Sanctuary, compare it with the surrounding populations to record genetic variabilities between the sampling locations. It would also be important to evaluate whether the genetic variability is up to the magnitude expected between subspecies, or the difference in the morphology are simply responses to variation in available resource resulting in local adaptations and consequent 'ecomorphs'.

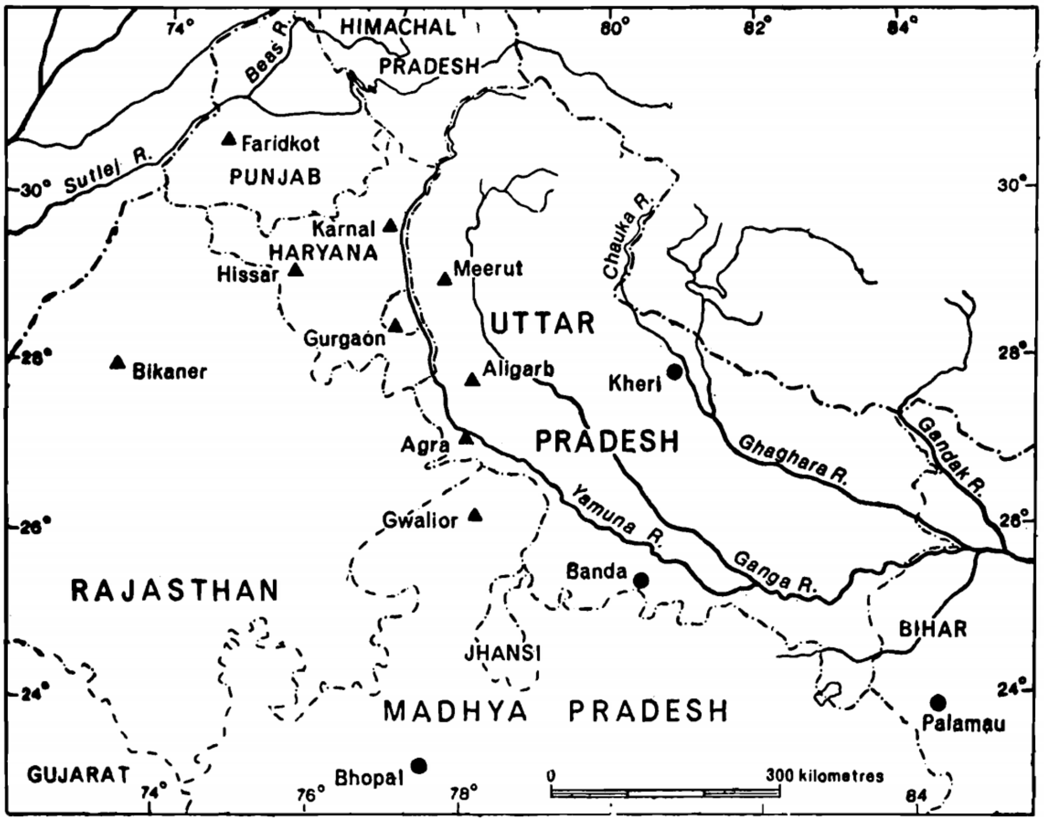


Figure 9.1. Distribution of *A. c. cervicapra* (circles) and *A. c. rajputanae* (triangles) in northern India reproduced from Groves (1980).

Rahmani (1991) estimated that UP held only ca. 350 Blackbuck individuals across a vast landscape of more than 3500 km^2 through the population in Meja in the district of Allahabad was not known during the study. The viability of small isolated populations is under constant threat from stochastic destabilising effects such as inbreeding, demographic changes as well as susceptibility to diseases (Lacy 2000). Moreover, the management of smaller populations with low effective population size (Ne) is necessary to avoid the extinction vortex for the species. The consensus, in this case, is maintaining 50 breeding individuals for short term conservation goals whereas 500 individuals are required for long term survival of a species. The other way to rescue a declining population is to establish connectivity with other populations by establishing a meta-population structure. Maintaining meta-population structures by ensuring genetic connectivity, however, aids the survival of patchily distributed small populations (Akçakaya et al. 2007). In drastic situations measures such as ‘genetic rescue’, the introduction of alleles in population through managed immigration to increase the fitness of the population, has been shown to have a positive impact (Whiteley et al. 2015). However, maintaining corridors in a human dominated landscape is a difficult task for the management authorities.

Therefore, we have undertaken mtDNA and microsatellite marker based genetic studies to explore the ancestral lineages and source population for the study area using non-invasive faecal DNA extracted from Blackbuck pellets our findings would help device management strategies for augmentation of the population if needed at any point of time in future. We also aim to understand population structuring on the basis of microsatellite data if present which would, in turn, identify barriers to gene-flow in this landscape helping in maintaining genetic connectivity.

9.2. Methodology:

9.2.1. Collection of Blackbuck faecal pellets:

During the study period (October to December 2018), we collected Blackbuck faecal pellets (n=355; Fig. 9.2) from spatially segregated pellet groups both on transects during distance sampling as well as random searches in Blackbuck habitat. We preserved the pellets in a dry condition in a container using silica gel until further processing for DNA extraction.

9.2.2. DNA extraction:

We scraped the outer surfaces of 5-6 pellets containing sloughed off intestinal epithelial cells into a 2ml centrifuge tube using sterile blades avoiding the inner stool particles to avoid PCR inhibitors. We isolated genomic DNA from pellets (n=142) having spatial representations of all populations sampled using Qiagen DNeasy Stool DNA Extraction Kit which employs a silica membrane column based purification of faecal DNA extracted using guanidine salts. We stored the DNA extracts in -20°C for further downstream use.

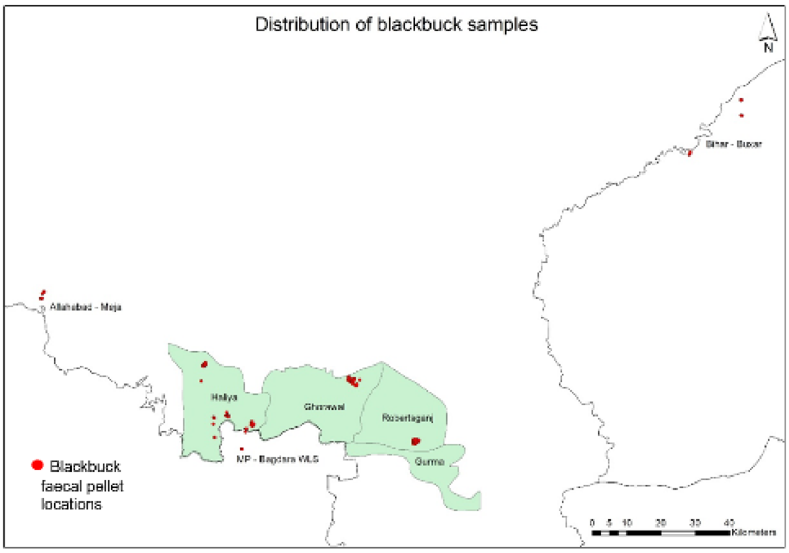


Figure 9.2. Locations of Blackbuck faecal pellet samples collected during the study.

9.2.3. Use of mtDNA marker:

A partial fragment of Cyt b (381 bp) (Meyer et al. 1995) of mtDNA genome was used for the amplification of DNA template. Amplification of each of the above gene was carried out individually in a 10 µl reaction volume containing 1 µl of 1x PCR buffer; 0.5 µl 10mM dNTPs; 0.5 µl 25mM $MgCl_2$; 0.4 µl of BSA; 0.5 U *Taq* DNA Polymerase and 2 µl of ~20 ng genomic DNA. A negative control, as well as positive control, was also set up along with reaction mixture to cross check any contamination. Thermal cycling conditions for the reaction mixture varied depending on the primer pairs we used. The conditions for the Cyt b gene were: initial denaturation at 94°C for 5 min; 35 cycles of denaturation at 40 seconds for 94°C; annealing temperature of 53°C for 45 seconds and extension at 72°C for 40 seconds with a final extension step at 72°C for 10 minutes. Amplification success was visualized under UV transilluminator after running the amplicons over 2% agarose gels immersed in 1x TAE buffer. We removed the residual primer, and dNTPs and PCR amplicons were then treated with Exonuclease-I and Shrimp Alkaline Phosphatase (Thermo Scientific Inc.) following the cycling condition of 37°C and 85°C each for 15 minutes. Purified products were then cycle sequenced with a master mix containing Big Dye Terminator v3.1 Cycle Sequencing Kit (Applied Biosystems, CA) and forward primers in standard proportions. The fragments were then directly electrophoresed on Applied Biosystems Genetic Analyzer 3130. The sequences generated were examined carefully manually. Based on pairwise genetic distances, we built a neighbour joining phylogenetic tree using sequences generated by us, along with Blackbuck mtDNA cytochrome *b* data provided by Shukla et al. (2019) as well as those available in the public domain (NCBI) using a Himalayan tahr (*Hemitragus jemlahicus*) sequence as an out group using the software BEAST 2 (Bouckaert et al. 2014).

9.2.4. Standardization of microsatellite amplification:

We tested microsatellite markers designed for bovids (n=35) and cervids (n=7) along a temperature gradient of 51°C to 61°C using Qiagen Multiplex PCR Kit (2X), 10µg BSA, 2µl of DNA extract having variable DNA quantity and sterile water to make the volume up to 10µl. Each marker was tested with 1/2 faecal DNA extracts at increasing annealing temperatures at a difference of 2°C to understand the optimal condition for amplification. We ran agarose gel electrophoresis to visualize the amplified products.

We amplified 142 Blackbuck faecal samples from with standardized conditions along with positive and negative controls using Qiagen Multiplex PCR kit. To obtain the measures of genetic diversity, we used the R package Pop Gen Report (Adamack and Gruber 2014), and MS Excel-based GenAlEx (Peakall and Smouse 2006, 2012) for calculation of allelic richness, observed and expected heterozygosity, fixation indices and allelic richness (AR). We also calculated pairwise F_{ST} between the six Blackbuck population's samples in the KWLS and the vicinity.

We estimated the population structure of the Blackbuck across Mirzapur and Sonbhadra districts of Uttar Pradesh along with the neighbouring populations in Bihar and Madhya Pradesh as well as the Allahabad population in Uttar Pradesh using STRUCTURE 2.4.1 (Pritchard et al. 2000)implementing a non-spatial individual based clustering (IBC) algorithm. We assumed population admixture as well as correlated allele frequencies. We simulated 500000 MCMC resampling after discarding the initial 50000 runs as burn-ins. A number of populations assumed (K) were allowed to vary between one to 10 whereas 15 independent runs were performed for each K. Most likely number of clusters were determined as the rate of change in the log probability of data fitting the assumed model between successive K. For the K we identified, we used the web based CLUMPAK pipeline (http://clumpak.tau.ac.il/) to summarize the individual assignment probabilities and average over all the runs.

An alternative to the IBC approaches, multivariate analyses summarizes genetic variabilities within and among populations without strong assumptions about Hardy-Weinberg equilibrium or linkage amongst the markers. Discriminant analysis of principal components (DAPC) (Jombart 2008, 2014) identifies genetic clusters using sequential grouping and model selection. It transforms the genotypes to principal components at the first step and then performs discriminant analysis by k means clustering to define groups of individuals. We used this approach with prior population information to understand the degree of genetic differentiation. A spatially explicit principal component analysis (sPCA) implemented by the R package ADEGENET (Jombart 2008) was used to identify cryptic spatial patterns of genetic structuring and clines across the landscape, if any, accounting for spatial autocorrelation which is often associated with clumped sampling effort.

We performed Factorial Correspondence Analysis to test for admixtures between the sampling blocks using the 'AFC sur populations' option of the GENETIX v4.04 (Belkhir et al. 2004) software.

To test for patterns of 'isolation by distance' (IBD) in the Blackbuck, the paired binary genetic distance was calculated between pairs of populations and the distance matrix was used for

Mantel test of matrix congruence with a matrix of log transformed geographic distance of these populations, with 100 permutations.

9.3. Results and discussion:

9.3.1. Phylogenetics and phylogeography:

The neighbour joining dendrogram from the mtDNA cytochrome *b* sequence data (Fig. 9.3) revealed no variation within our study population and the vicinity. They all grouped with samples originating from Pakistan, Madhya Pradesh, Rajasthan, Gujarat, and Maharashtra (Shukla et al. 2019) indicative of past bottleneck and population expansion from the small parent stock.

9.3.2. Population genetic structures:

We standardized 12 microsatellites and one sex marker to be amplified in four multiplex reactions in different annealing temperatures and carried out PCR for the panels in 142 faecal samples (Table 9.1, 9.2 & Fig. 9.4). However, the amplification success of locus 12 was 24% which was subsequently dropped from analyses. Out of 142 faecal DNA extracts, 49.2% were having more than 90% data at single amplification attempt (Fig. 9.5). Therefore, we chose to proceed with 11 loci data of 112 samples (87.9% data) as a subset for population and landscape genetic analyses as it would permit us to maximize spatial coverage through the largest number of individuals (Fig. 9.6). A number of samples from each sampling populations [Halia, Ghorawal, Robertsganj, Allahabad, Bagdara (MP) and to Buxar (Bihar)] were 27, 33, 26, 9, 7 and 10 respectively.

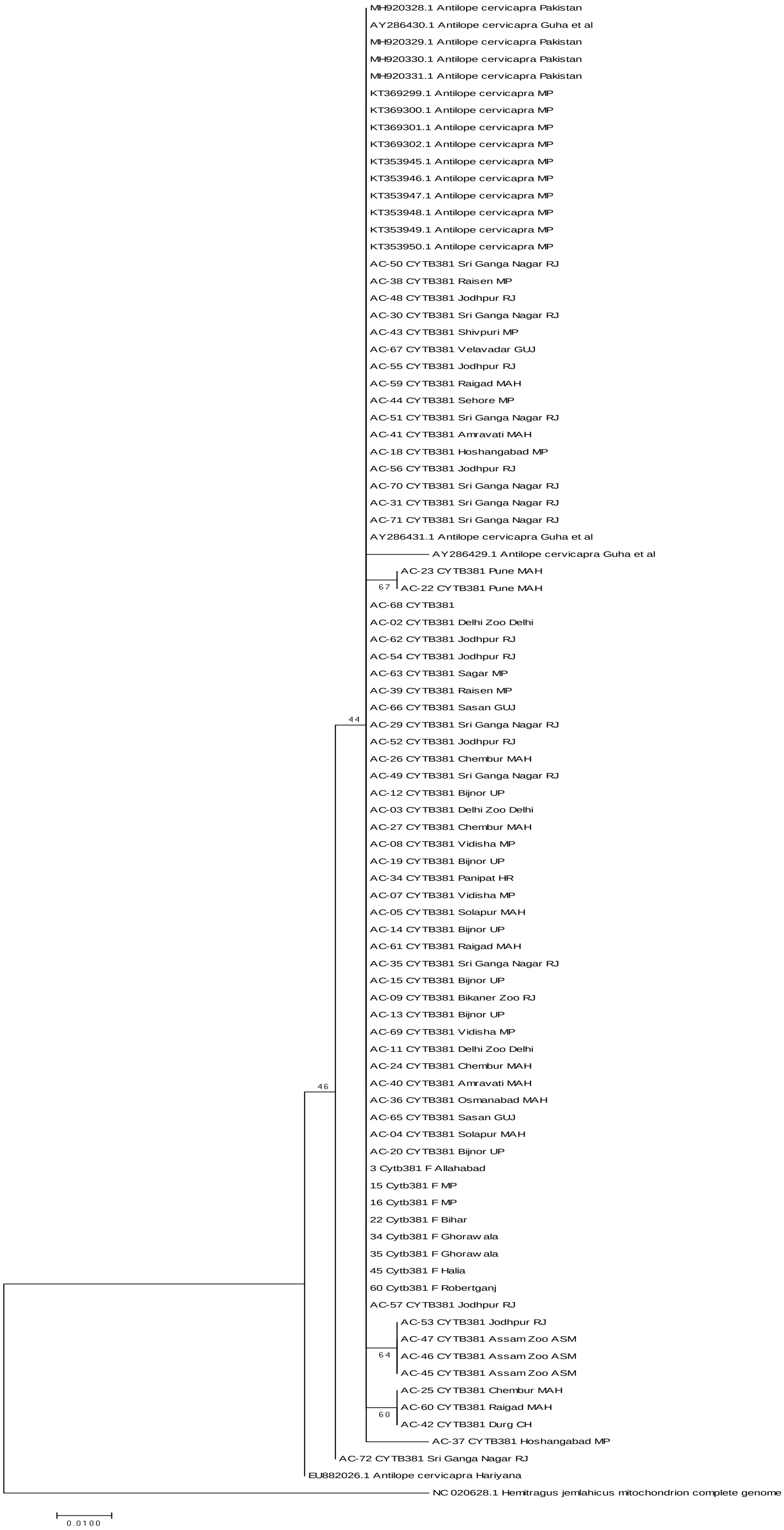


Figure 9.3. Neighbour joining mtDNA cytochrome *b* gene phylogenetic tree of Blackbuck sequences generated in this study and from an earlier study (Shukla et al. 2019).

A number of alleles in the selected 11 loci varied between 4 and 16 with mean allelic richness (AR) of 0.25 (Table 9.3). However, we found a low score for observed heterozygosity (ranges: 0.23 in Bagdara to 0.40 in Halia) due to which the inbreeding coefficient/fixation index of F_{IS} observed across the sampling blocks are having moderately high positive values (ranges: 0.36 in Halia to 0.49 in Robertsganj) indicating non-random mating or indicating high frequencies of null allele in the populations (Table 9.3). Mean a number of alleles were highest in Ghorawal (Na=5.91) whereas Bagdara population had the lowest value (Na=2.45). However, the values of the fringe populations outside the intensive study area should be scrutinized carefully as the statistics could be biased by the low sample size.

Pairwise F_{ST} values between the three ranges of KWLS were all below 0.05, marking the absence of historical (~10 generations) partitioning and the barrier between these populations. Highest F_{ST} (0.23) was observed between Allahabad and the Bagdara population which is expected due to the physical distance. Interestingly, F_{ST} was moderately high (0.20) between the Halia and the Bagdara population which is geographically close by.

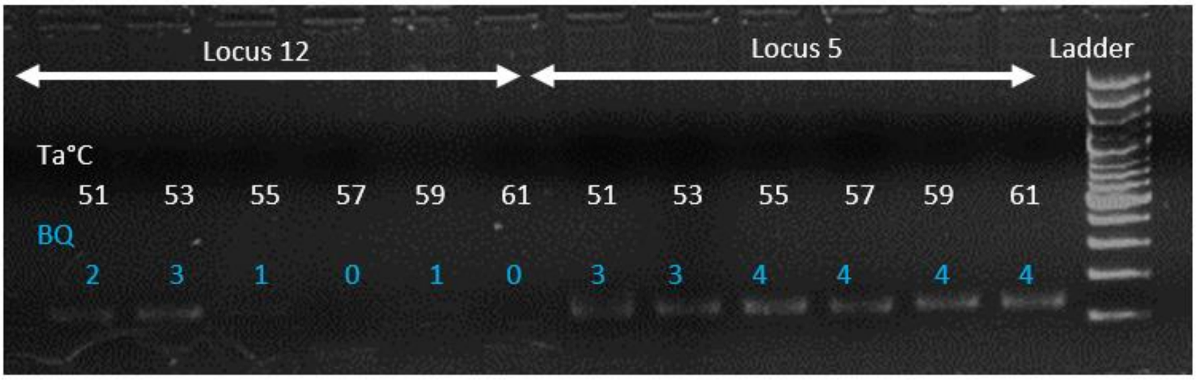


Figure 9.4. Agarose gel electrophoresis of gradient PCR products with faecal DNA. Key: Ta – Annealing temperature, BQ – Band quality; 0-no amplification to 5-strong band.

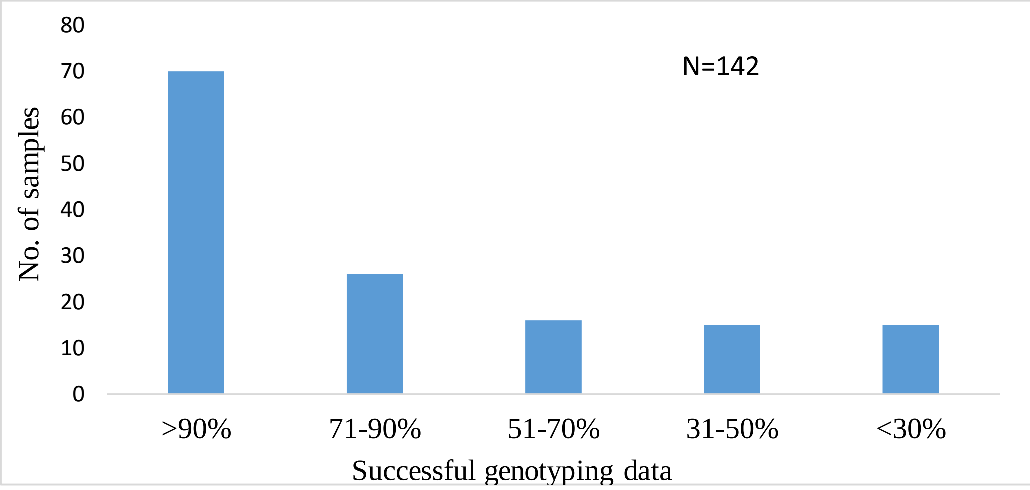


Figure 9.5. Sample-wise success of obtaining genotyping data across 12 loci in 142 Blackbuck faecal DNA extract.

Table 9.1. Screening of microsatellite markers with Blackbuck faecal pellet DNA.

Sl. No.	Marker	Observed amplicon size (approximate)	Band qualities* at different annealing temperatures (°C)					
			51	53	55	57	59	61
1	Locus 1	130	4	5	5	5	5	5
2	Locus 2	230	3	3	4	4	4	4
3	Locus 3	210	1	1	2	3	0	0
4	Locus 4	150	1	1	2	0	0	0
5	Locus 5	120	3	3	4	4	4	4
6	Locus 6	110	3	4	4	4	4	5
7	Locus 7	150	4	5	1	0	1	0
8	Locus 8	110	4	4	4	4	3	0
9	Locus 9	250	2	2	2	2	2	3
10	Locus 10	150	0	0	1	4	3	2
11	Locus 11	150	4	4	4	3	4	0
12	Locus 12	110	2	3	1	0	1	0
13	Locus 13	NA	0	0	0	0	0	0
14	Locus 14	NA	0	0	0	0	0	0
15	Locus 15	NA	0	0	0	0	0	0
16	Locus 16	NA	0	0	0	0	0	0
17	Locus 17	NA	0	0	0	0	0	0
18	Locus 18	NA	0	0	0	0	0	0
19	Locus 19	NA	0	0	0	0	0	0
20	Locus 20	NA	0	0	0	0	0	0
21	Locus 21	NA	0	0	0	0	0	0
22	Locus 22	NA	0	0	0	0	0	0
23	Locus 23	NA	0	0	0	0	0	0
24	Locus 24	NA	0	0	0	0	0	0
25	Locus 25	NA	0	0	0	0	0	0
26	Locus 26	NA	0	0	0	0	0	0
27	Locus 27	NA	0	0	0	0	0	0
28	Locus 28	NA	0	0	0	0	0	0
29	Locus 29	NA	0	0	0	0	0	0
30	Locus 30	NA	0	0	0	0	0	0
31	Locus 31	NA	0	0	0	0	0	0
32	Locus 32	NA	0	0	0	0	0	0
33	Locus 33	NA	0	0	0	0	0	0
34	Locus 34	NA	0	0	0	0	0	0
35	Locus 35	NA	0	0	0	0	0	0
36	Locus 36	NA	0	0	0	0	0	0
37	Locus 37	NA	0	0	0	0	0	0
38	Locus 38	NA	0	0	0	0	0	0
39	Locus 39	NA	0	0	0	0	0	0
40	Locus 40	NA	0	0	0	0	0	0
41	Locus 41	NA	0	0	0	0	0	0

*Increasing value of band quality (0 to 5; 0 denoting the absence of band) suggests brighter bands.

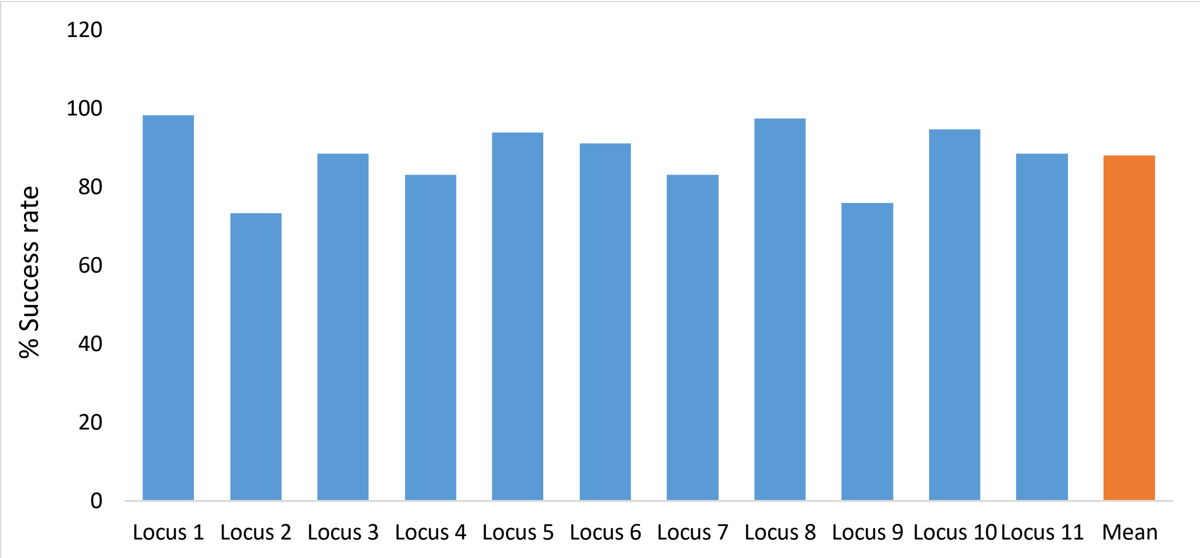


Figure 9.6. Percentage data in the 11 loci, 112 genotype subset amplified from Blackbuck faecal DNA

Table 9.2. Genetic diversity statistics of the Blackbuck in KWLS and adjoining areas.

	Na	Ne	Ho	He	uHe	F_{IS}	AR
Halia	4.82±0.42	2.80±0.39	0.40±0.08	0.55±0.07	0.56±0.07	0.36±0.11	0.26±0.12
Ghorawal	5.91±0.95	2.81±0.47	0.35±0.08	0.51±0.09	0.52±0.09	0.46±0.10	0.11±0.05
Robertsganj	4.91±0.61	2.96±0.39	0.35±0.08	0.56±0.08	0.57±0.09	0.49±0.11	0.61±0.13
Allahabad, UP	3.64±0.53	2.63±0.39	0.35±0.10	0.5±0.090	0.54±0.09	0.33±0.14	0.08±0.05
Bagdara, MP	2.45±0.39	1.94±0.31	0.23±0.08	0.34±0.09	0.39±0.11	0.36±0.13	0.02±0.01
Buxar, Bihar	4.09±0.67	2.64±0.46	0.34±0.08	0.46±0.10	0.49±0.10	0.31±0.10	0.39±0.12

Key:

Na - No. of alleles

Ne – Effective no. of alleles

Ho – Observed heterozygosity

He – Expected heterozygosity

uHe – Unbiased expected heterozygosity

F_{IS} – Fixation index and inbreeding coefficient

AR – Allelic richness

Table 9.3. Pairwise F_{ST} as a measure of genetic differentiation between the three Blackbuck populations of KWLS and of neighbouring areas.

	Halia	Ghorawal	Robertsganj	Allahabad, UP	Bagdara, MP	Buxar, Bihar
Halia	-					
Ghorawal	0.03	-				
Robertsganj	0.04	0.04	-			
Allahabad, UP	0.12	0.13	0.10	-		
Bagdara, MP	0.20	0.18	0.18	0.23	-	
Buxar, Bihar	0.10	0.09	0.08	0.07	0.22	-

Next, we tested whether the chosen set of 11 microsatellite markers were sufficient to distinguish between individuals. We calculated P_{ID} (probability of misidentifying two unrelated individuals as a single individual) and P_{ID}sib (probability of misidentifying two sibling individuals as a single individual) for increasing loci combination (Fig. 9.7). We observed that P_{ID}sib reaches less than 1%, the more conservative estimate with the addition of the sixth loci. Therefore, the panel used was sufficient to identify individuals on the basis of genotype data.

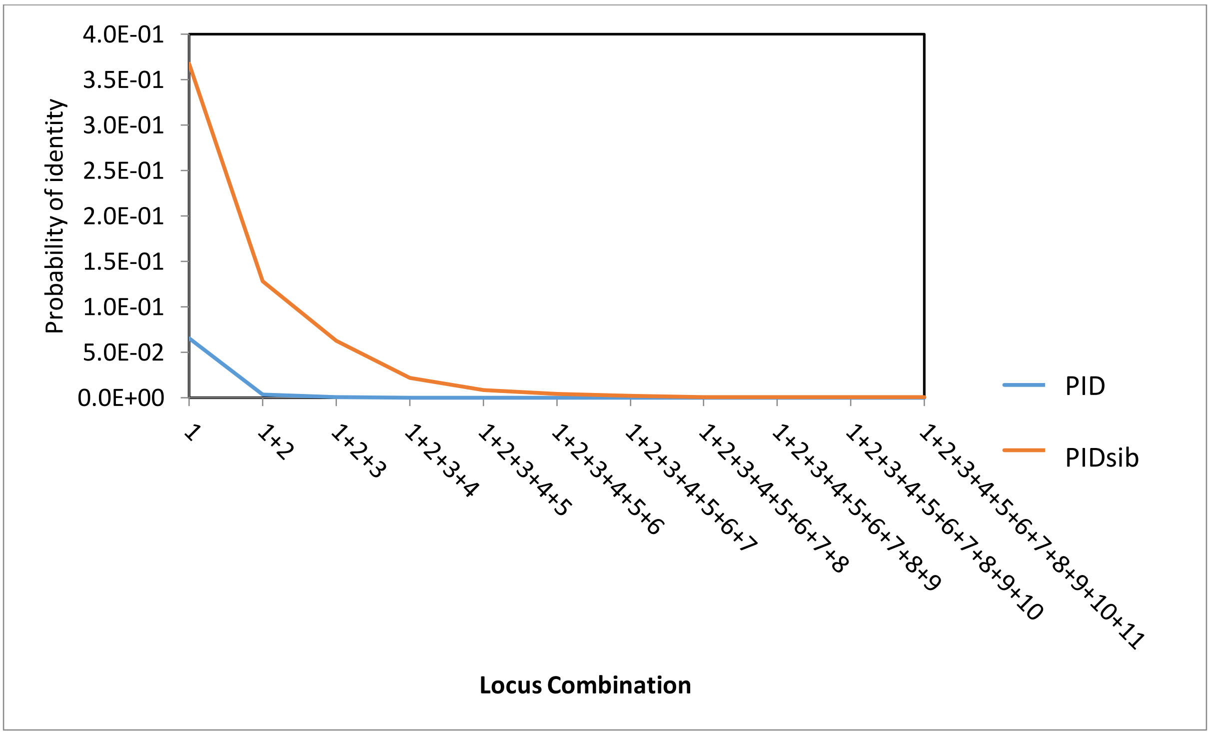


Figure 9.7. P_{ID} and P_{ID}sib with increasing loci combination in Blackbuck.

Non-spatial IBC algorithm implemented by STRUCTURE identified six populations (K=6, largest ΔK) by the Evanno method (Evanno et al. 2005) at the topmost level of population differentiation (Fig. 9.8). However, K=3 displayed a significant peak which could be the actual sub-structuring of the population and the peak at K=6 could be influenced by the additional samples from the surrounding areas for which, the low sample size could not complete the allele sorting. This is further evident from the pattern of admixture between individuals. Of all genotypes at K=3, 23.2% could not be grouped in any of the inferred clusters based on the threshold of Q=0.7, whereas the total proportion of admix individuals were 49.1% at K=6 (Fig. 9.9, Fig. 9.10). At K=3, the highest admix: non-admix ratio was from Robertsganj whereas, at K=6, Halia had the highest proportion of admix.

The IBC algorithm performed in structure clearly marked that the alleles in the Robertsganj population sorted with different frequencies from the Ghorawal and Halia population, while also retaining a high level of admixture. In spite of a relatively short distance between Robertsganj and Ghorawal, the agricultural field and the human habitat probably does not allow Blackbuck individuals to move between populations whereas the connectivity with Halia through a narrow scrubland lined by broken cliffs has succumbed to human habitation as per empirical information received from locals (Fig. 9.11, Fig. 9.12). There were marked similarities between the assignment patterns of the Halia and the Ghorawal population which was also supported by a low F_{ST} value of 0.03 (Table 9.4).

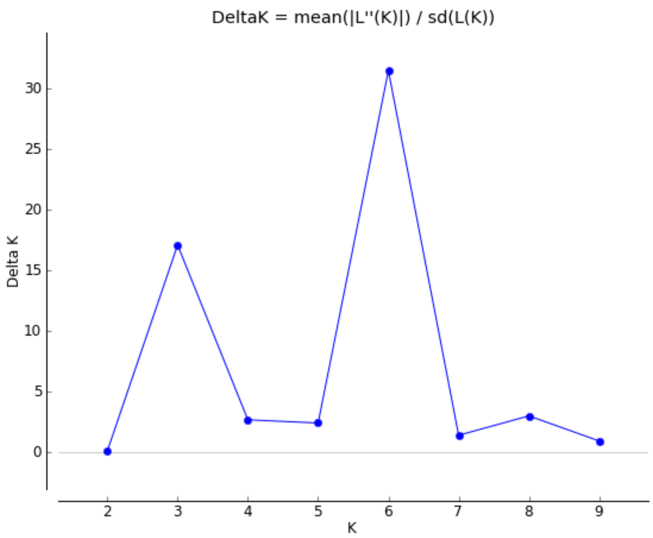


Figure 9.8. Detection of optimal number of population clusters from STRUCTURE output using Evanno method of finding largest ΔK.

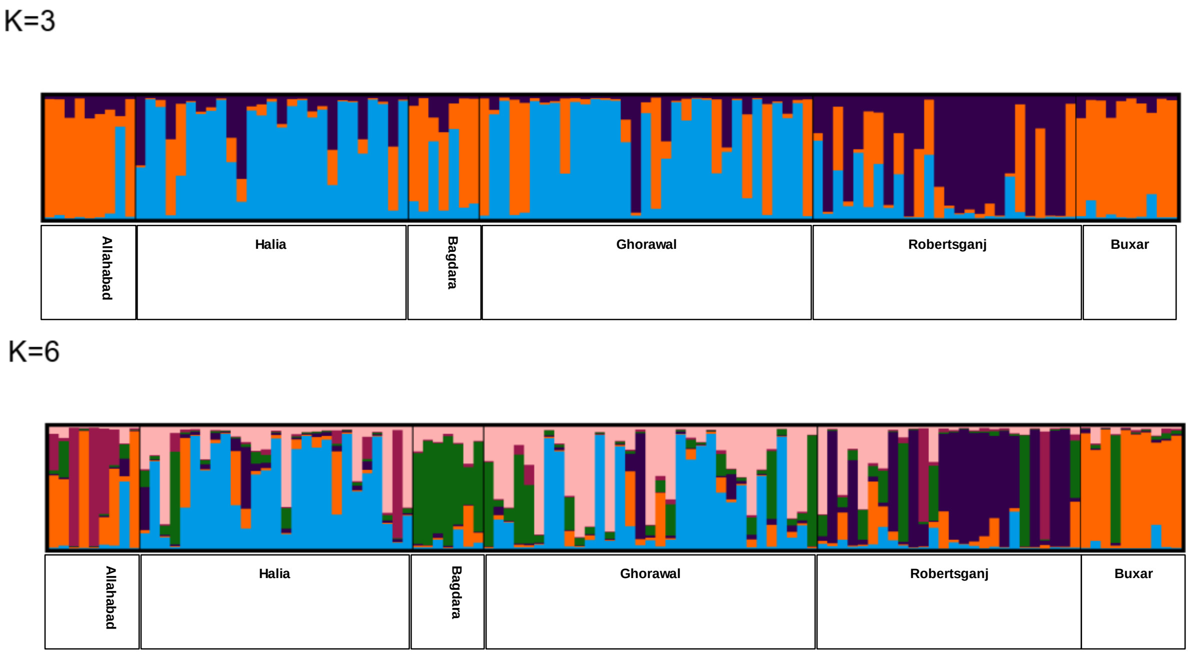


Figure 9.9. Assignment of genotypes into clusters by means of IBC algorithm as implemented by STRUCTURE.

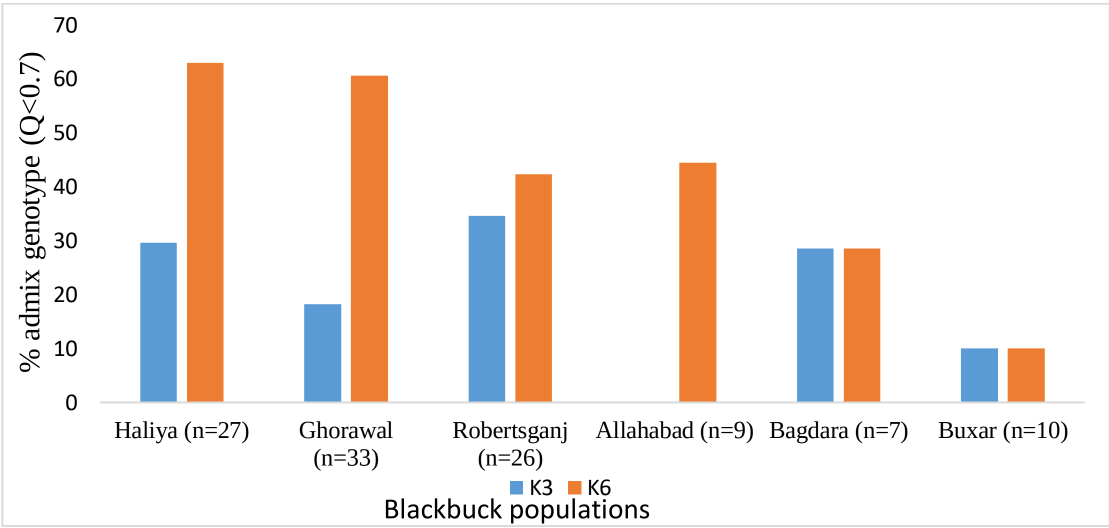


Figure 9.10. Percentage of admix individuals in each of the sampled Blackbuck population.

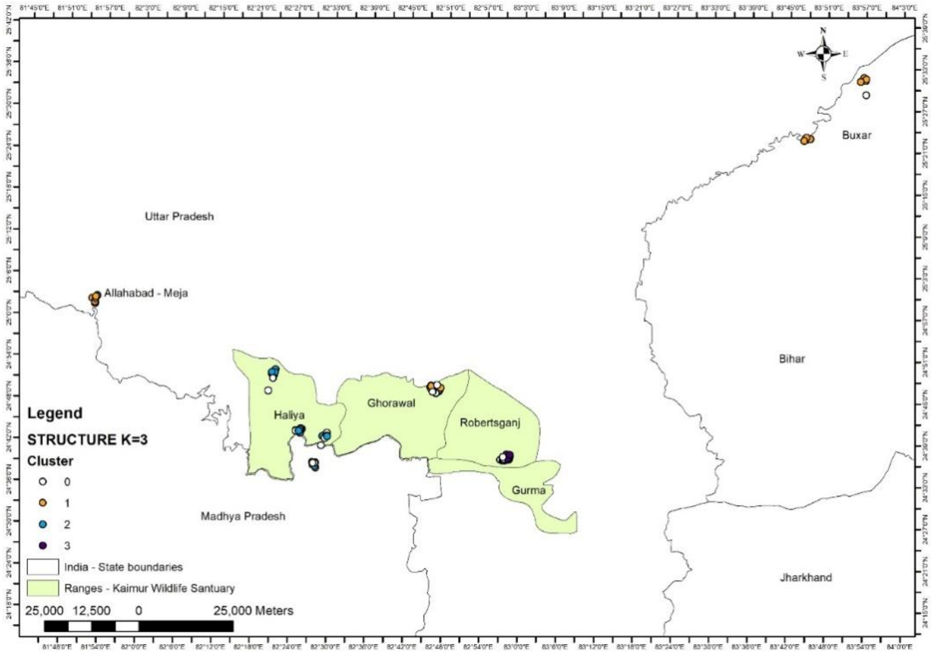


Figure 9.11. Spatial representation of the clustering approach implemented by STRUCTURE at K=3.

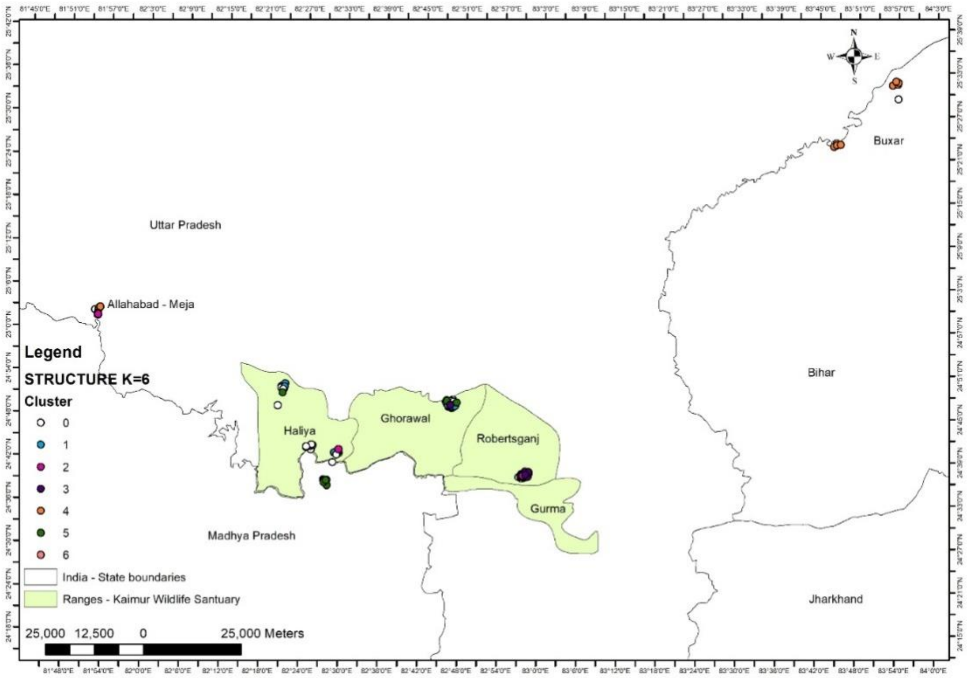


Figure 9.12. Spatial representation of the clustering approach implemented by STRUCTURE at K=6.

In addition to the IBC method, multivariate analyses were necessary to validate the results obtained from the genotyping data. We performed spatial PCA to understand patterns of population structuring (Fig. 9.13). A strong clinal pattern was found by sPCA suggested differentiation of KWLS population from the surrounding populations which corresponded to the similar pattern found by STRUCTURE. There were also evidences of weak differentiation of Robertsganj from Ghorawal as well as Ghorawal whereas similarities between allele frequencies of Ghorawal and Halia was observed.

We also carried out discriminant analysis of principal components (DAPC) to understand the interrelationship of the prior defined populations in terms of principal components of genotypes using α score optimization through spline interpolation technique (Fig. 9.14). We used 11 principal components and five discriminants to find three clusters in our genotypes – the first cluster consisting of individuals from Buxar and Allahabad, the second cluster being a complex of Ghorawal and Halia with slightly separated Bagdara whereas Robertsganj almost separated into a distinct group which suggests a differentiation suggesting similar patterns to the STRUCTURE and sPCA results.

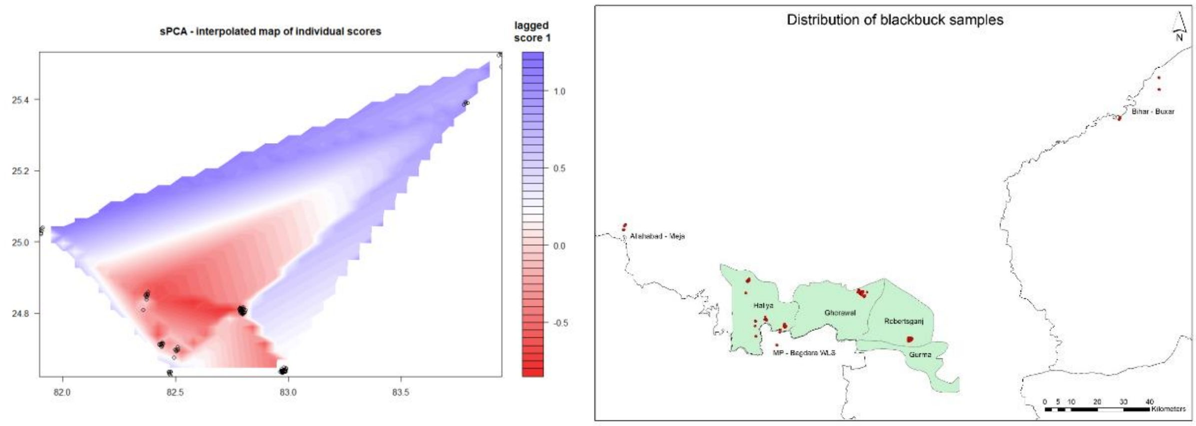


Figure 9.13. Interpolated map of individual scores obtained from sPCA of Blackbuck genotypes.

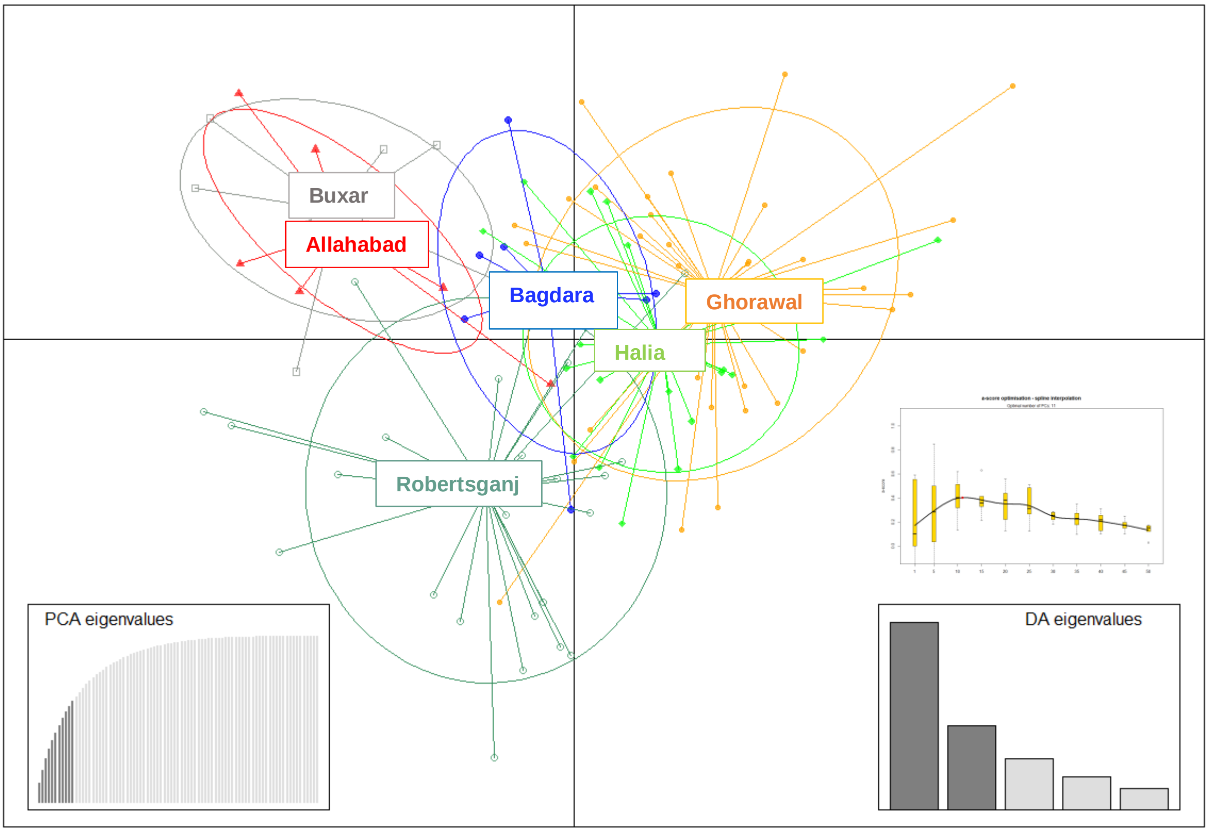


Figure 9.14. DAPC with prior population information on origins of genotypes with 11 PCs.

Factorial correspondence analysis (FCA) revealed the same pattern as DAPC without prior as it could not differentiate between Ghorawal, Halia and Bagdara in either axis 1 or axis 2 (Fig. 9.15). These three populations separated from the Allahabad and Buxar, remaining dispersed, on axis 1. Genotypes from Robertsganj were dispersed even after differentiating from all other populations on axis 2. Therefore, FCA obtained three similar clusters to the DAPC results strengthening our hypothesis.

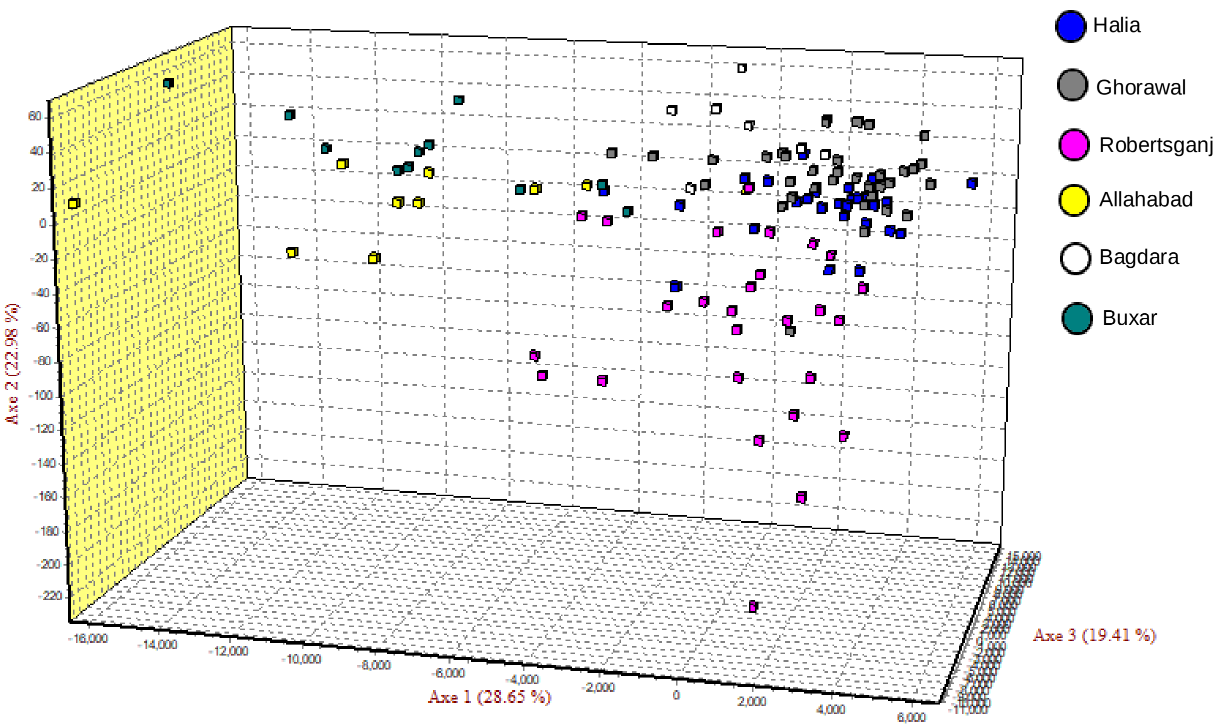


Figure 9.15. Factorial correspondence analysis in 3D space using Blackbuck genotypes across the KWLS and adjoining populations.

To test for isolation by distance, we plotted the binary genetic distances of the Blackbuck individuals against their respective log transformed geographic distances to perform a Mantel test of matrix congruence (Fig. 9.16). Though there was a positive slope to the curve, a very low R^2 value indicated the absence of isolation by distance mechanism in the Blackbuck populations under the current study.

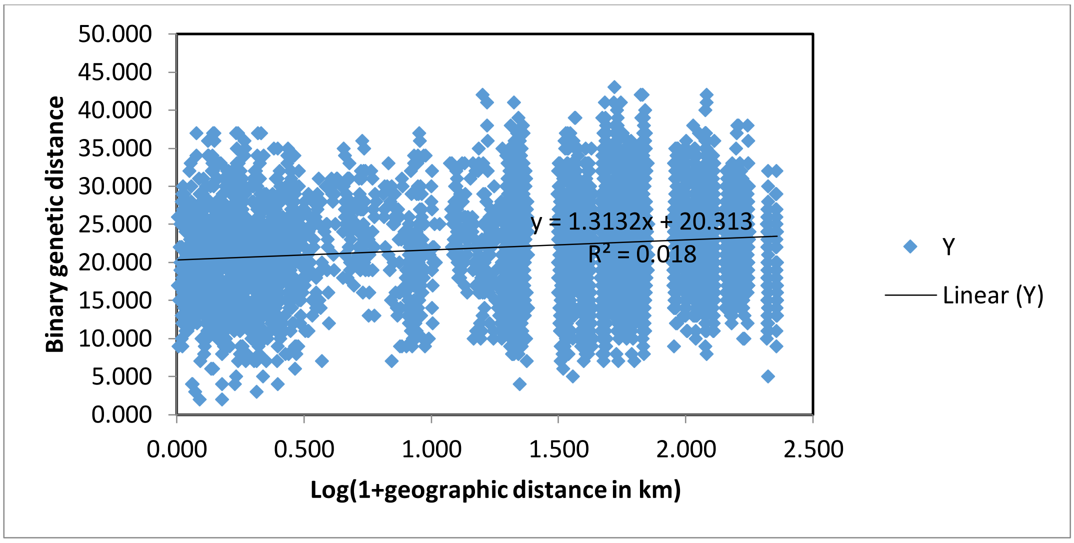


Figure 9.16. Testing for isolation by distance through Mantel test of matrix congruence between binary genetic distance and log of geographic distance.

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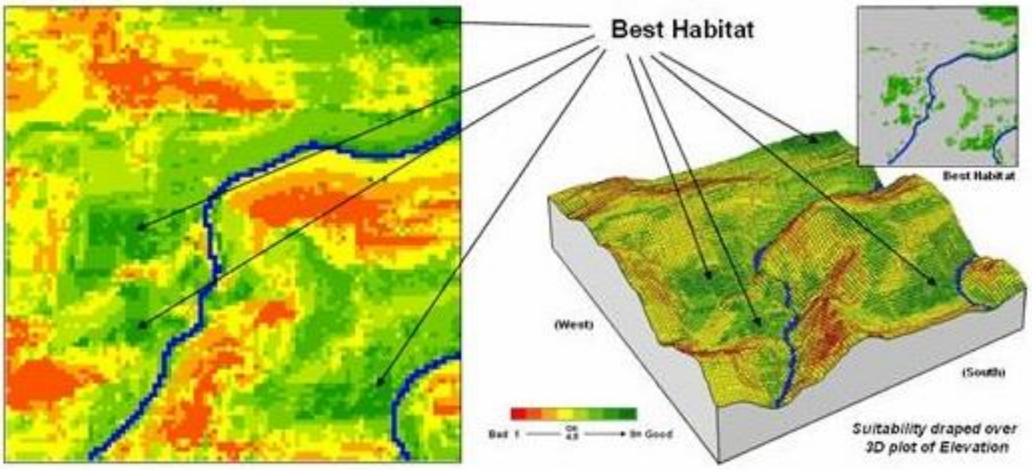
Chapter 10:



Habitat suitability and landscape connectivity of different populations of Blackbuck

Summary

Habitat is the area in which a species lives or area which provides basic needs that must be met for an animal to survive, i.e. sufficient space, food, water, and shelter. The suitable habitat proliferates the chance of the survival of species. To assess the habitat suitability and landscape connectivity based on the "Species Distribution Model" approach in relation to environmental variables for the Blackbucks, we used presence data in 'Maxent' and 'Circuitscape' software. The current land use patterns reveal the presence of small suitable habitats and connectivity among the different population is restricted and available only at few places in spite of the short distance between Robertsganj and Ghorawal. This has been due to anthropogenic factors. The connectivity between the Ghorawal and Halia is through a narrow scrubland which is dominated by Lantana camara, and river Belan may also form a barrier in the movement of Blackbuck between these two isolated populations.

10.1. Introduction:

Over explode of the human population on the Earth has resulted in rapid loss of natural ecosystems and wildlife habitat (Butchart et al. 2010). Consequently, functioning protected areas are the foundations for protection (Bruner et al. 2001, Macdonald et al. 2012, Watson et al. 2014), especially for large mammals that are commonly large in the home and appeal to poachers (Di Marco et al. 2014, Ripple et al. 2014 and 2015). Unfortunately, many protected areas are not sufficient to support large mammal populations on their own, and wide-ranging species rely specifically on the natural environment outside the protected areas (Di Minin et al. 2013, Ripple et al. 2015). It means that the landscapes between protected areas are essential to prevent extirpation within them and that detailed information on land cover and land use around protected areas is important for large mammal conservation and management planning (De Fries et al. 2007, Beier et al. 2008 and Jones et al. 2009).

There are certain ways to overcome some restraint of small protected areas, one of which is to provide connectivity between these areas through corridors (Walker and Craighead 1997, Haddad et al. 2003, Crooks and Sanjayan 2006). Corridors are habitat strips that allow species to move from one habitat patch to another (Hilty et al. 2006, Beier et al. 2008). The dispersal and increased movement of animal can support both genetic exchange and range shifts, thereby mitigating the effects of habitat fragmentation (Brudvig et al. 2009, Gilbert-Norton et al. 2010) Corridors are an important conservation management tool to increase connectivity between habitats (Crooks and Sanjayan 2006) and ensure long term conservation aim through meta-population framework. Defining and assessing corridors at regional or landscape level is challenging because it requires consistent, fine-scale and up-to- ate information on land cover for large areas (Sanderson et al. 2006, Wiens et al. 2009 and Zeller et al. 2012).

Our goal here was to utilize the environmental variables to assess landscape connectivity for Blackbuck and to identify the potential corridors between the different Blackbuck populations in and around KWLS.

10.1.1. Species distribution and modelling:

Species distribution connectivity modelling plays an important role in ecology and biogeography and is increasingly used in a range of applications, including biodiversity assessment, conservation biology, wildlife management and conservation planning (Smulders et al. 2010). Species distribution modelling refers to models that use the distribution and environmental characteristics of an observed species to predict its actual or potential distribution (Hengl et al. 2009).

10.2. Methodology:

We used MaxEnt to model the potential distribution of Blackbuck. Maximum entropy analysis has a recognized efficiency in the processing of presence-only data and small data sets. MaxEnt3.3.3k estimates the probability distribution with the study area of the maximum entropy of each environmental variable. Besides, we also used "Circuitscape" connectivity approach to determine the potential corridor exist in and around KWLS.

The distribution of Blackbuck in Kaimoor Wildlife Sanctuary is shown in Fig 2.4. In this study, we explored how the "Species Distribution Model" (SDM) could predict environmental conditions for Blackbuck in and around KWLS. The presence records of Blackbuck and only six environmental variables were used to predict the SDM are as follows:

1. Globe cover
2. NDVI
3. Distance to water
4. Soil wetness index
5. Human influence index
6. Elevation

10.3. Results and Discussion:

Potential distribution of Blackbuck is shown in a colour scale that represents the species probability of occurrence, where the increased probability of occurrence was valued close to 1, and decreased probability was valued close to 0 (Fig. 10.1). The AUC values of the model were 0.97±0.003 (Fig. 10. 2).

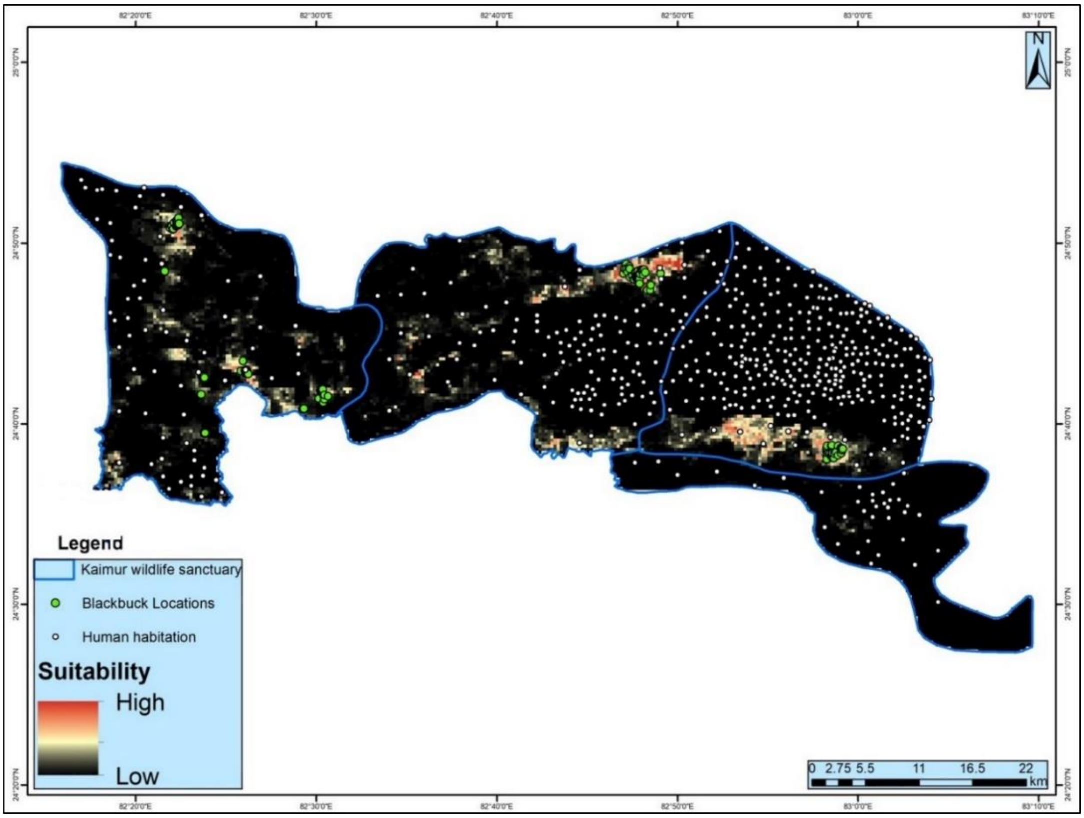


Figure 10.1. Predicted maximal entropy-based occurrences of Blackbuck.

The gradient of colours from blue to red illustrates the gradient of more appropriate environmental conditions (red= favourable; blue = adverse).

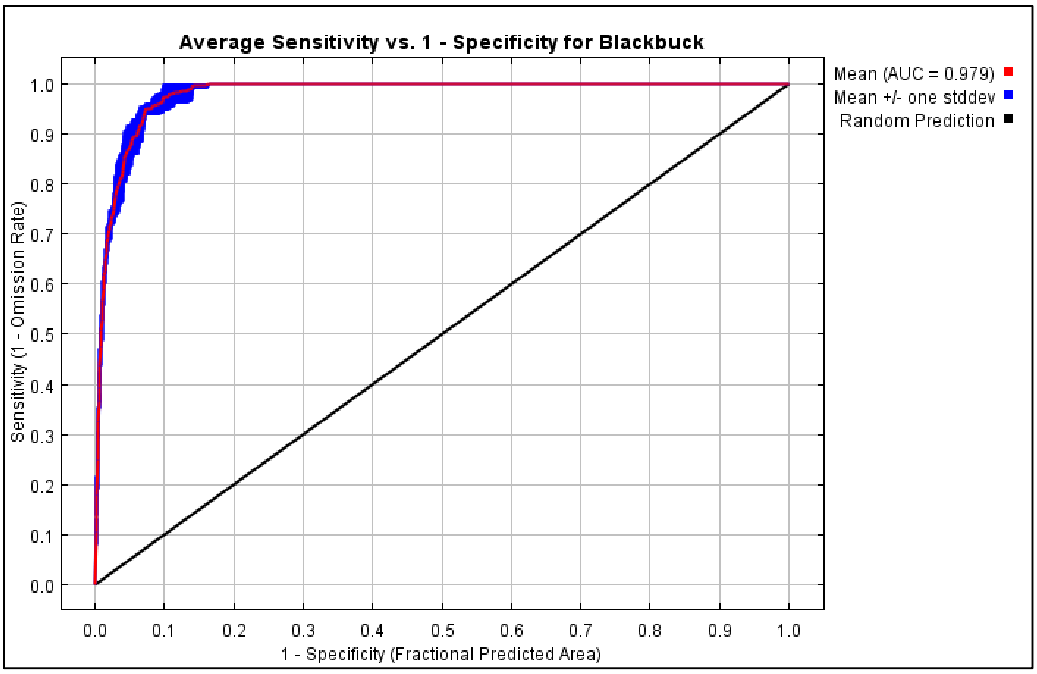


Figure 10.2. ROC curve showing omission and commission value.

10.3.1. Corridor mapping:

To measure landscape connectivity and to map corridors, land-cover map was converted into a resistance surface, which measured the difficulties in the movement of a certain species through the landscape (Zeller et al. 2012, Ziółkowska et al. 2014). An important step in evaluating connectivity using resistance surfaces is to set resistance values for each land-cover class. This is best done by using movement data for the species in question (Ziółkowska et al., 2016a), but such data are inadequate. We used the MaxEnt output model for developing the resistance layer of in and around KWLS. Then we used that resistance layer to identify the potential corridors for Blackbuck in the study area using software “Circuitscape”. The connectivity map for Blackbuck in the study area is shown in Fig. 10.3. We mapped pinch points, which are areas within linkages where movement is restricted, often by the lack of appropriate land use & land cover, or other features that are avoided by Blackbucks, such as human settlements, roads, industrial areas, stone mining areas or high human population density. Pinch points represent areas where movement would be funneled and thus may be predominantly important to keeping a linkage viable.

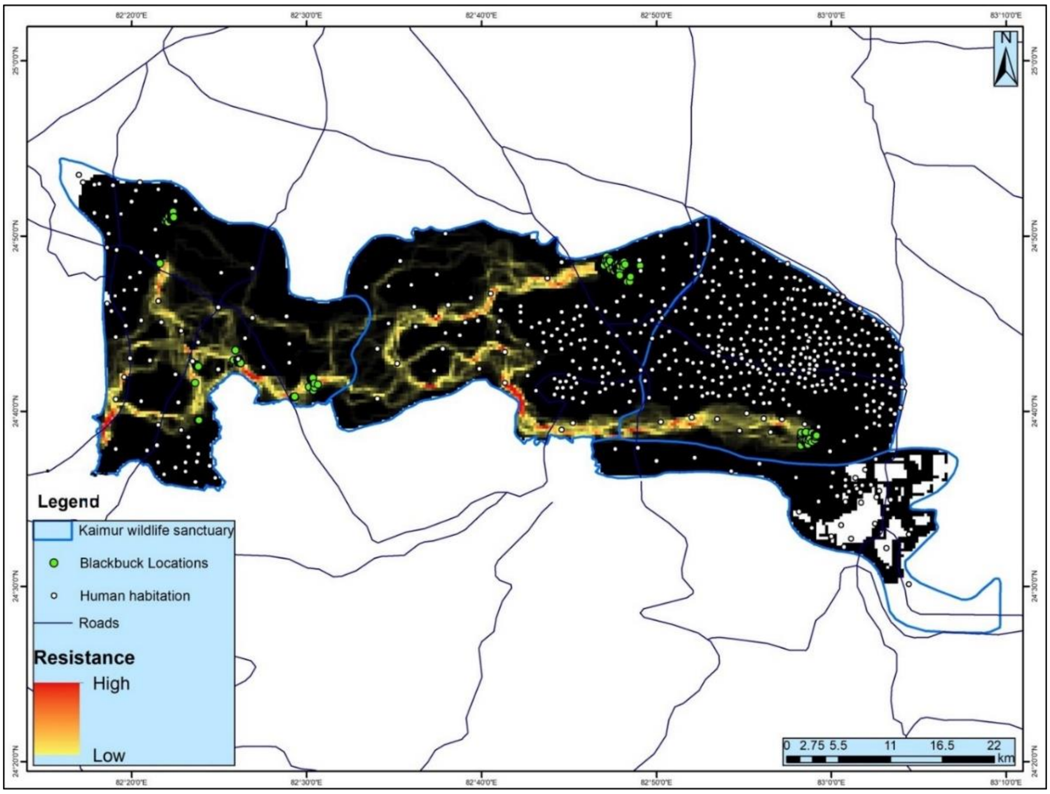


Figure 10.3. Pairwise pinch points, shown in shades of red, indicate areas where current flow is highly restricted between populations of Blackbuck.

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Chapter 11:

Extent of anthropogenic disturbance in and around Kaimoor Wildlife Sanctuary

Summary

Anthropogenic factors are one of the major threats to the conservation of wildlife. Especially for those animals which are grazers and found in and around the human-dominated landscape. Overexploitation of the resources by people to fulfill their needs cause major harm to wildlife. Habitat loss due to destruction, fragmentation, or degradation of habitat, overgrazing are the primary threats to the survival of wildlife. The grazing by livestock in the protected areas damaged the habitat and increased the resource competition with the wild animals. In order to know the status of livestock (cattle, sheep, goat, and buffalo) in the study area, we recorded the livestock during line transect survey. A total of 53 transects were walked during the survey with a sampling effort of 294.17 km. We encountered 51 herds encompass 604 individuals on transects throughout the study area. The density of livestock was of 132±16 individuals per km^2*, and the effective strip width was 77.95 meters with a mean cluster size of 13.28±0.92. We also estimated dung density across each range, and it was maximum in the Halia (177/ ha) followed by Robertsganj (149/ha), Ghorawal (143/ha) and minimum in Ghurma 105/ha. The intensity of the lopping was maximum in the Ghorawal and Halia ranges, whereas it was observed less in the Robertsganj and Ghurma ranges. We also visualize the likely threat due to the spread of Prosopis juliflora in the preferred grasslands of the Blackbuck in and around Kaimoor Wildlife Sanctuary.*

11.1. Introduction:

The forests maintain biological diversity as well as provide important ecosystem services for a human being. Moreover, providing such important benefits, the forests are still degrading due to poverty, exponential population growth, and lack of awareness about the ecosystem services. Forests in most of the developing countries are under enormous pressure from human activities and overexploitation by marginalized communities for their subsistence. Besides, the enormous demand for forest products for different industries worldwide, resulting in overexploitation of forests (FSI 2011, Davidar et al. 2010, MoEF 2009 and 2006, Khan et al. 2018). About 350 million people live in or on the peripheries of forests around the world, of which 60 million were mainly dependent for their subsistence (World Bank 2006). This has resulted in not only deforestation and degradation of forest quality across the world (Wright and Muller-Landau 2006), but also has accelerated the rate of extinction of fauna and flora in the last two centuries. The condition is considered more perilous in developing and poor countries, e.g. Asia and Africa, where forest losses in the later part of the 20th century were estimated at 163 million ha over a ten-year period, of which 154 million ha or 94.5% were in the tropics alone. (FAO 1995).

Grazing, along with fuelwood and fodder collection, is considered to be the cause of deforestation where human habitation is located within forested landscapes and dependent on large migratory livestock. India's no exception. India's forests sustenance about 270 million livestock against a carrying capacity of 30 million (ICFRE 2001), 78% of India's forests are considered to be affected by livestock grazing, out of which 18% are highly affected, while 31% are affected by medium grazing intensity and 29% by low grazing intensity (World Bank 2006, MoEF 2006). The huge livestock population also results in a massive collection of tree fodder, which adversely affects the quality of the forest.

Several field studies on forest product collection patterns and their impact on local forests in India have also found that forest dependence on local livelihood results in degradation (Maikhuri et al. 2001, Silori and Mishra 2001, Sagar and Singh 2004, Arjunan et al. 2005, Mishra et al. 2008, Davidar et al. 2010). More than 40 percent of India's marginal population lives on forest peripheries (MoEF 2006) and depends on forests for a variety of ecosystem services. Therefore, with such an enormous population and extensive dependence pattern, and over-exploitation and unsustainable harvesting practices, India's forests can potentially be degraded (Davidar et al. 2010, FSI 2011).

Therefore, we examine the extent of human dependency on resource use in and around KWLS. Such information is crucial while preparing the species' conservation plan. We quantified the extent of livestock grazing and lopping of plant species, which may be for fuel or fodder.

11.2. Methodology:

During the transect survey, we recorded the livestock species, a number of animals sighted, sighting distance and herd size. During the vegetation sampling, the dung of livestock was counted in every plot, and the lopping signs were recorded qualitatively on 0-4 scale.

11.3. Results and Discussion

A total of 53 transects were walked during the survey with a sampling effort of 294.17 km. We encountered 51 sightings of livestock encompass 604 individuals on transects throughout the study area. The data were analysed in the DISTANCE software to estimate the density, mean cluster size, detection probability and effective strip width for the livestock. The density of livestock was estimated to be 132 individuals per km^2. The effective strip width was estimated to be 77.95 with mean cluster size = 13.280±0.92 (Table 11.1 and Fig. 11.1).

The dung density was estimated range-wise, and the density was maximum in the Halia (177/ ha) followed by Robertsganj (149/ha), Ghorawal (143/ha) and minimum in Ghurma 105/ha. The other anthropogenic pressure measured was lopping in and around the KWLS. The heat map indicates that the intensity of the lopping was maximum in the Ghorawal and Halia ranges where it was observed relatively less in the Robertsganj and Ghurma ranges.

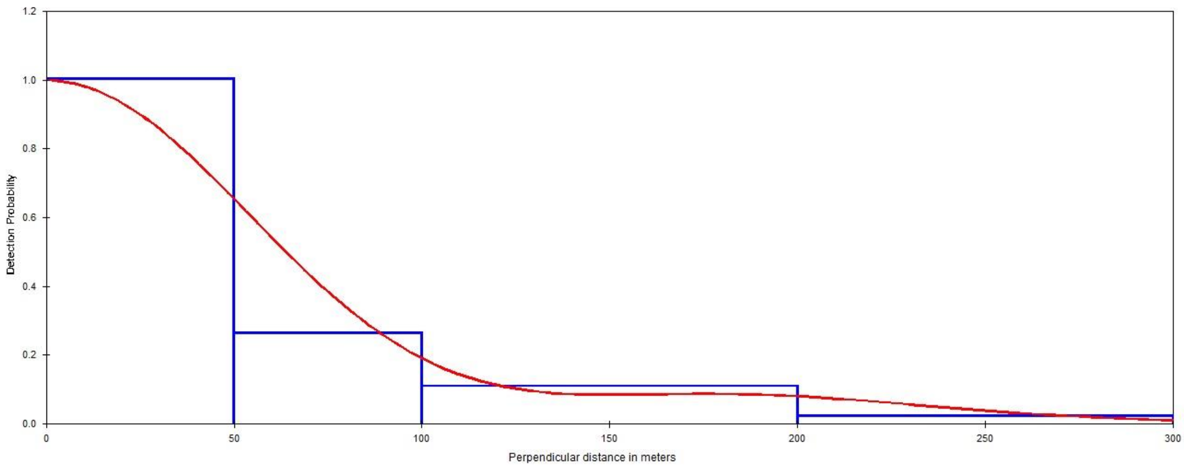

Figure 11.1. Detection probability curve of livestock.

Table 11.1. Density estimates of livestock in and around KWLS during the study period.

	Estimate	%CV	df	95% Confidence Interval	
Half-normal/Cosine					
DS	13.170	10.62	57.20	10.65	16.27
D	132.42	12.54	109.86	103.37	169.63
N	132.00	12.54	109.86	103.00	170.0
ESW	77.953	2.71	601.00	73.91	82.21

Parameter	Point Estimate	Standard Error	Percent Coef. of Variation	95% Percent Confidence Interval	
DS	13.170	1.3980	10.62	10.654	16.279
E(S)	10.055	0.67189	6.68	8.8196	11.463
D	132.42	16.610	12.54	103.37	169.63
N	132.00	16.558	12.54	103.00	170.00

Component Percentages of Variance (D)

Detection probability	4.7
Encounter rate	67.0
Cluster size	28.4

DS= Estimate of the density of clusters; E(S) = Estimate of expected value of cluster size; D= Estimate of the density of animals; N= Estimate of a number of animals in the specified area.

Table 11.2. Summary output of estimation of livestock in KWLS.

S.No.	Range	Number of Plots	No. of livestock dung	Dung/Hectare
1	Ghorawal	189	839	143.18
2	Ghurma	49	160	105.34
3	Halia	159	878	177.02
4	Robertsganj	129	598	149.88

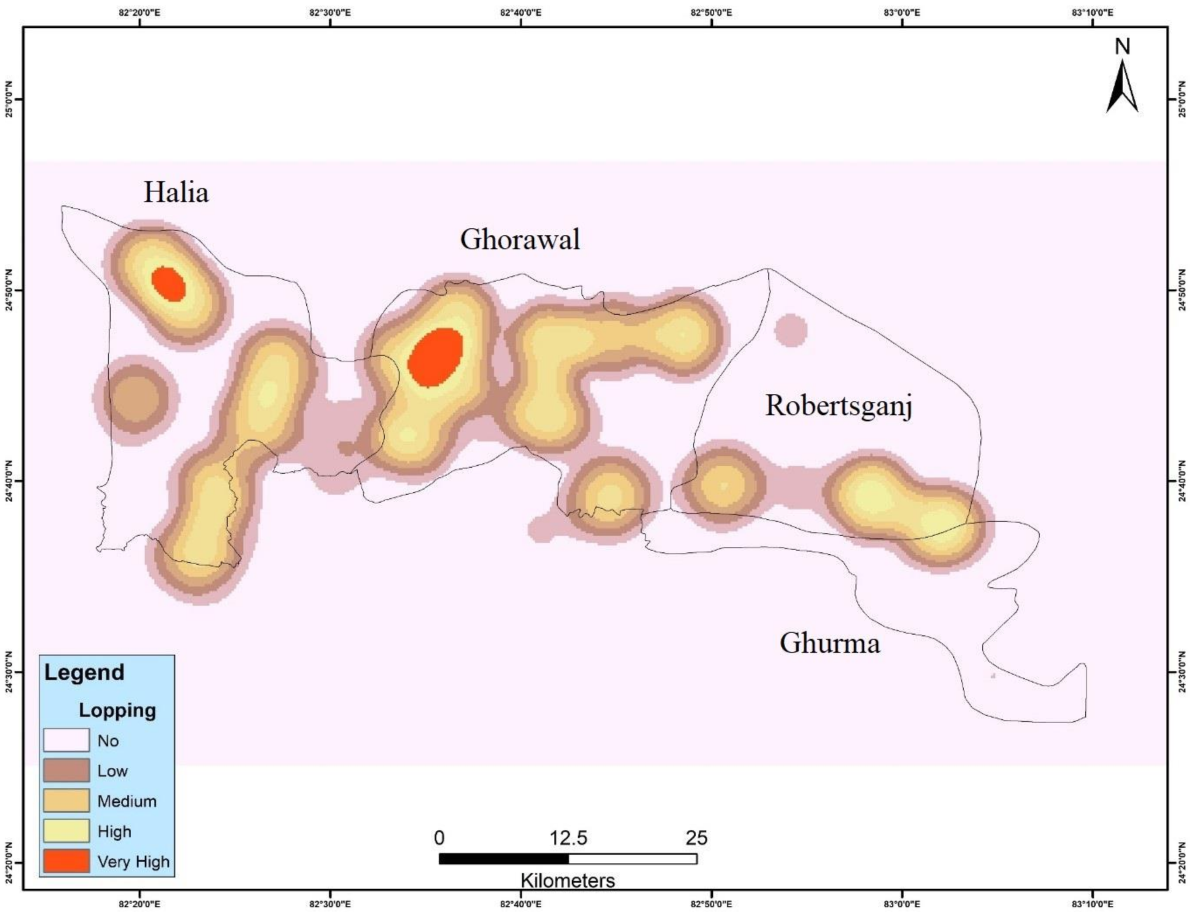

Figure 11.2. Heat map of lopping in KWLS.

11.4. An exotic mesquite (*Prosopis juliflora): A potential threat to the habitat of Blackbuck in and around KWLS:*

Prosopis juliflora is an alien invasive tree species has been planted throughout arid and semi-arid reason to check the desertification (Raizda and Chatterji 1954). Later on, it has been planted throughout north India to increase the forest cover and provide fuelwood/firewood to the rural people. Being their broad ecological amplitude, excellent growth rate, this invasive species has been adapted a wide range of different types of soil and sites and can survive even poorest lands that are unsuitable for many other tree species. The tree can be found on several soil types from pure sandy soils to heavy clay and stony soils (Harsh and Tewari 1998).

The aggressive and invasive character of the species has resulted in changes in the floristic composition of many areas (Sinha et al. 2009, Pandey et al. 2012). Also, species threaten to become the dominating plant in the grassland ecosystem. The species converts grassland habitat to a thorn forest which is unsuitable habitat for Blackbuck (Jhala1993). The seed has been dispersed by cattle and livestock (Pandey et al. 2012). The Blackbuck also influences the dispersal of this species in a grassland ecosystem through their dung (Jadeja et al. 2013). We had recorded *Prosopis juliflora* in two ranges of the study area viz. Ghurma and Robertganj with the density of 29.15/hectare and 0.25/hectare respectively (Fig. 11.3). This species has been introduced in the landscape by plantation drives by the forest department. The current coverage of the species seems to be low, but there is a high possibility that it might occupy a more extensive area through the dispersal of pods by domestic livestock and wild ungulates as the pods of species are palatable and readily eaten by wild and domestic ungulates (Jadeja et al. 2013). The ecological advantages of *Prosopis juliflora* compared to many native species and the resulting invasion of the tree reduce the biodiversity of the native flora. The plant of the *Prosopis juliflora* should be identified and removed from the study area before it could become a threat to the wild animals. It is suggested that the spread of this species should be monitored and managed by removal before the grasslands preferred habitat by the Blackbuck are encroached by this species.

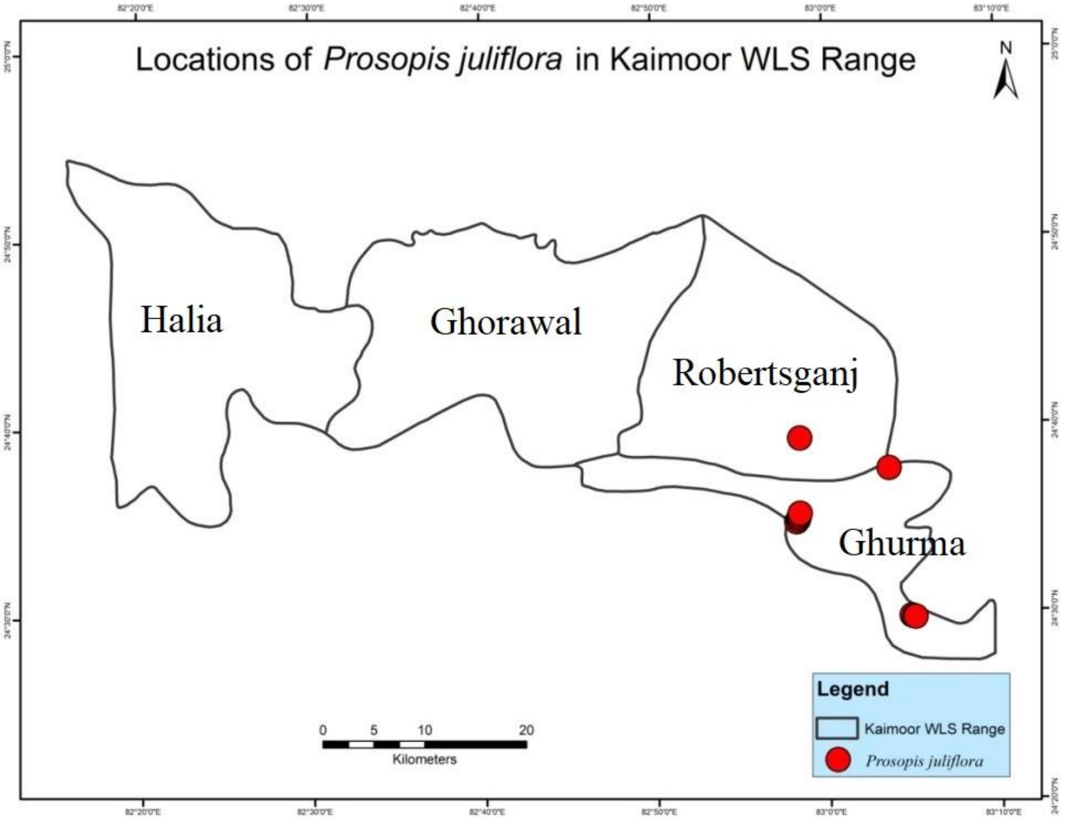

Figure 11.3. Locations of *Prosopis juliflora* recorded during vegetation sampling in the study area.

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Chapter 12:

Strategies and conservation action plan for Blackbuck in Kaimoor Wildlife Sanctuary, Uttar Pradesh

The Indian antelope (*Antilope cervicapra*) or Blackbuck is endemic to the Indian sub-continent. It is widely distributed in the wide range of habitats, from semi-arid grasslands and scrubs to open forest. However, it prefers open grasslands throughout its distributional ranges. Once distributed throughout the Indian sub-continent (India, Pakistan, Bangladesh and Nepal), and estimated to be four million has now been shrunk from its historical ranges (extinct from Pakistan and Bangladesh) and are now in several isolated pockets in thirteen states of India. However, in the last two decades, the population of Blackbuck along with its habitat has been degraded throughout its distributional ranges because of various factors like habitat loss, livestock grazing, historical hunting and rapid urbanization which leads to an overall decline of Blackbuck in Uttar Pradesh as well as within its distributional ranges across the country. The conservation measures are needed in Blackbuck distributed areas which are under intensive use by human either for the settlement or for the agricultural use. Most of the Blackbuck populations are in human-dominated landscape or outside the protected areas. Moreover, a few populations are found inside the protected areas. Majority of populations are fragmented and isolated from each other across its range and are struggling for their existence. One of such conservation importance area of Blackbuck in Uttar Pradesh is Kaimoor Wildlife Sanctuary which is situated in Sonbhadra and Mirzapur districts of Uttar Pradesh. The sanctuary is spread from east and west along the Kaimur hills. Kaimur hills along the river Son form the natural boundary of the sanctuary from the southern and eastern side. While the northern boundary is under croplands. The sanctuary has been notified and established in 1982 for providing a safeguard to the unique faunal and floral diversity of Vindhyan region. The area of wildlife sanctuary is only 501 km^2. There are other nearby areas which have good potential to provide habitat for the Blackbuck. Therefore, we have included wildlife sanctuary as well as territorial forest ranges viz. Robertsganj, Ghorawal, Halia, and Ghurma in this study with an area of 1767 km^2. The study area encompasses tree like Chiraungi (*Buchanania lanzan*), Tendu (*Diospyros melanoxylon*), Palas (*Butea monosperma*) and several medicinal plants. In animals, it comprises Blackbuck (*Antilope cervicapra*), Chinkara (*Gazella benetii*), Four-horned antelope (*Tetracerus quadricornis*), Nilgai (*Boselaphus tragocamelus*), Sambar (*Rusa unicolor*), Chital (*Axis axis*), Sloth Bear (*Melursus ursinus*) and Leopard (*Panthera pardus*). Apart from these, crocodiles and different species of snakes are common in the study area.

This study was conducted to prepare the conservation plan for the Blackbuck, so as to insure long term conservation of the species and effective conservation planning information on various aspects of species' ecology and biology are needed, and information was collected on different parameters (Fig. 12.1).

Figure 12.1. Information on different aspects of species' ecology and biology are needed for preparing conservation plan.

12.1. Monitoring the population status and demography: Counts of target species in an area is of high importance to know and monitor the wildlife value for effective management planning. In fact a regular census allows to predict, apply and verify potential management and conservation actions for several species and their habitats (Blanco et al. 1996, Buckland et al. 2000). Accurate information of spatial and temporal distribution patterns is fundamental to species management and conservation, and assessment of extinction risks (Gaston and Fuller 2009). A reconnaissance survey was conducted in the study area to know the status and distribution of the Blackbuck. We interacted with locals and forest officials to know about any possible Blackbuck population in and around KWLS. The status of Blackbuck was estimated through line transect and block count method. A total of 75 sightings encompasses 259 individuals were encountered on transects throughout the study area. The animals encountered has been identified and classified in different group size and age structure. We use the software DISTANCE to estimate the density, mean cluster size, detection probability, and effective strip width. The density calculated in the study area is 4.421 ± 2 SE with mean cluster density recorded 3.35 ± 0.40. The coefficient of variance was high, i.e. 57.77. Our random survey within the study area also resulted in the sighting of 226 individuals in the study area among which maximum individuals recorded were in Halia (127) followed by Ghorawal (58), and Robertsganj (41) ranges. During our transect surveys, we counted 226 different Blackbuck individuals within the sampled area of 811 km^2 determined based on minimum coverage polygon (MCP). Hence, the overall estimated population in the study area of 1767 km^2 could be between 450 and 500. Conservation measure without having an accurate demographic structure is impractical. Demography is one of the important key components of species management, which indicates population dynamics and sex ratio. During the study period, we found the population of Blackbuck was female biased. The adult female comprises 42.6% followed by the sub-adult female. Male to female sex ratio was estimated to be 1:2.37 while adult to sub-adult ratio was 1:0.53. The adult female to fawn ratio was 1:0.15. Low female to fawn ratio has been an indicator of the declining population as well as the degraded habitat quality. The result indicated that the population was on decreasing mode. Therefore, we

suggest a need to estimate Blackbuck population twice a year using our random transects laid in the KWLS (n= 8) having at least six replicates to reduce the variation in estimates as per the format (Annexure IV) between September to December and May to July.

12.2. Restoration of habitat:

The area of Kaimoor Wildlife Sanctuary and territorial range are about 1767 km^2 and of this 501km^2 are under the jurisdiction of wildlife sanctuary and the rest of the area are part of territorial ranges. Out of these 1767 km^2, the major part constituted under the agriculture or cropland. The temporal examination of the land use and land cover data indicates that fallow and barren land which are the key habitat for the Blackbuck has declined over the period from 2000 to 2018. The maximum reduction was estimated in forest land from 47% to 6.54% (including open forest) followed by fallow land 17% to 11%. However, the increase was recorded in agriculture land from 28.99% to 44.48% and scrubbland 3% to 31% respectively. The intensification recorded in scrubs is actually increased of the Lantana (*Lantana camara*) and Parthenium (*Parthenium hysterophorus*) weeds. The fallow and barren land encompasses the grassland which is the crucial habitat for the Blackbuck, and these areas have been converted into either scrub or agricultural land over a period of eighteen years. While the scrub and agriculture land have increased exponentially, and the only shrub has increased more than 10 times from 3% to 31.64 %.

The government policies to improve green cover throughout the country are going to be the major threat for the grassland and open scrub species. Grasslands and open scrubs are always considered as a wasteland and its make available good chance of enhancing the forest cover. So the whole Vindhyan range and especially the Kaimoor Wildlife Sanctuary and its surrounding was planted during the recent past under the different forest projects and especially Compensatory Afforestation Fund Management and Planning Authority

(CAMPA) and Japan International Cooperation Agency (JICA) which played a major role for plantation throughout the crucial Blackbuck habitat. The tree species like *Acacia catechu*, *Acacia benzamine, Ailanthus excelsa,* and *Acacia nilotica* were planted. All these activities have caused a change in the habitat and force the Blackbuck which is a species of grassland to remain in the fragmented small grasslands/ open scrubs.

The restoration of the habitat is crucial for the conservation of Blackbuck in and around Kaimoor Wildlife Sanctuary. No new plantation should be done in the Blackbuck valley (Robertsganj), Visundhary (Ghorawal), Halia 3, Parsia 3, Parsia 5, Chaura and Kusehra (Halia) ranges. The other potential areas near Gurval and Bargawan of Robertsganj range and connecting areas between Robertsganj and Ghorawal must be restored for the long term conservation of Blackbuck. Moreover, new plantation must be stopped in the nearby potential habitat of Blackbuck. The planted area in and around the Blackbuck population sites must be allowed to sustainably lopped and cut, and these key areas should be managed as grassland. This is because such existing plantation would need intensive management to avoid conversion of grassland and open scrub habitat to woodland. If the plantation is necessary, it must be done under the guidance of wildlife expert after undertaking adequate survey so as that any wildlife habitat of KWLS is not affected. Eradication programme must be initiated as soon as possible to eradicate Lantana (*Lantana camara*), Parthenium (*Parthenium hysterophorus*) and other weeds. The unique habitat of this landscape used by the Blackbuck should be restored for the long term survival of Blackbuck. Grass species must be planted around the waterholes and other places so that

it could provide forage for the Blackbuck in summer seasons. This practice is already in use in Ghorawal range, and they use to plant *Stylosanthus hamata* as a forage for the Blackbuck. We also suggest the villages located near the Blackbuck populations must be encouraged to keep their fallow land during the different season of the year, which provide habitat for the Blackbuck and compensation scheme may be initiated by the forest department to increase this practice.

12.3. Overgrazing:

The results indicated that the livestock density was 132±16/km^2 in the KWLS and especially found very high in and around the Blackbuck presence localities. The population of livestock and especially the cattle have increased rapidly during the recent past. It is a well-known fact that the competition increased between the Blackbuck and livestock specially cattle and sheep for the resources during the summer months because all are grazers. There is enormous dietary overlap was seen between Blackbuck and livestock during the study period. The Blackbuck are facing the problem of overgrazing by the livestock, and people use to graze the domestic animals in the sanctuary as rest of the area has been converted into the cropland. So it is more convenient for them to graze in the sanctuary without any restriction. Realizing existence of dietary overlap and competition for the resources between the Blackbuck and livestock, the illegal livestock grazing must be stopped in and around the Blackbuck presence locations and need to bring strict control especially during summer months when the resources are scarce. The livestock are not only utilizing the resource but likely to become a vector for the several diseases. During our study we found foot and mouth disease throughout all the ranges and Blackbuck were seen feeding and drinking at the same places with livestock.

We also suggest that there is an urgent need to place fencing in some areas situated near the Blackbuck population so that the illegal entry of livestock and human may be checked. Other anthropogenic pressure must be also restrained to provide a safeguard to Blackbuck in all the ranges. The trench should be constructed along the boundary of the sanctuary so that it could be a barrier for the livestock as well as the domestic dogs. Its urgent need to dig a trench/electric fence in the northern boundary of Blackbuck valley (Robertsganj), Northern and eastern boundary of Visundhary (Ghorawal) and Chaura and Parsia (Halia). The width of the trench must be more than 1.5 meters, and depth must be greater than 2 meters so that it could be impermeable for the livestock and dogs. The villages situated near the Blackbuck presence sites should be encouraged to raise fodder and have stall fed their cattle during the pinch period of time.

12.4. Construction of waterholes:

Blackbuck is known to be water dependent animal, while the climate of Vindhayan range is very harsh during the summer and most of the sources of natural water dry up. Due to the scarcity of water sources, Blackbucks are compelled to visit nearby artificial water sources for drinking and become easier prey for the human as well as domestic and wild carnivores. Therefore, artificial water holes are maintained in these habitats and made functional through the solar water pumps. There is an urgent need of the 5-10 waterholes in each range of Robertsganj, Ghorawal, and Halia so that Blackbuck will not stray due to the scarcity of water in harsh summer season. The water must be filled either by bore well or by tankers during the summer. At least one check post cum pumping station must be constructed in each Blackbuck population sites so that it could provide the safeguard as well as drinking water to the Blackbuck in the summer season. The bore wells have been already dug in the Halia range but were not functional. It’s necessary to make them functional as soon as possible to protect the Blackbuck from the scarcity of water.


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We also suggest constructing the ‘Guzzlers’ in all the Blackbuck presence sites. The guzzlers are permanent self-filing water systems, which has a low maintenance cost and high effectiveness in an arid and semi-arid area. These guzzlers minimized the evaporation of water and retained it for a longer time. We suggest that the forest staff should visit the Desert National Park, Rajasthan and learn the functioning and maintenance of Guzzlers.

12.5. Development of linear infrastructure:

The development is never ending process and essential part of the human civilization. But unregulated development is always harmful to the human as well as for nature. The development of linear infrastructure is rampant in the whole study area. There are three power grid lines passing through the Blackbuck valley in Robertsganj and construction of one

is under process. This construction creates a lot of disturbance to the Blackbuck. The maximum part of the total irrigated area by canals is in Uttar Pradesh, and Sonbhadra and Mirzapur districts are placed highest among other districts for the irrigation through the canal. There are several small canal passing through the KWLS, but most of them are seasonal, so it's likely to be impacted less on the movement of the Blackbuck and other animals.

However, recently constructed Bansagar canal will be impacted adversely on the movement of wildlife as it's passing throughout the Halia range of sanctuary and bifurcating the sanctuary in two parts and which may adversely impact the wildlife including Blackbuck.

The canal system also forms hurdle to the movement of Blackbucks. Besides, the road network has been spread in all the ranges. Therefore, the construction of new roads must be regulated, and permission should not be granted without proper "Environment Impact Assessment". During the study period, we noticed trespassing, which was very common in every range of KWLS. We suggest more overpasses on the Bansagar canal and study should be initiated to assess the impact of the road and canals (Bansagar) on wild animals.

12.6. Hunting, poaching, and encroachment:

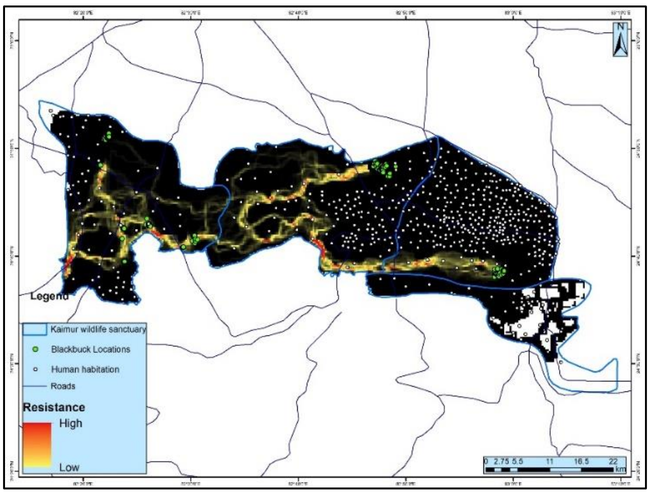
Hunting of wild animals is prohibited by law, but tribals hunt wild animals whenever they get the opportunity. They use the traditional means of hunting like a bow and arrow. It is their part of culture and tradition that they will hunt at least one wild animal during their festivals (Pers. comm. with villagers). We suggest the area should be monitored regularly and there is a need of coordination between the field forest staff of Bagdara range (M.P.) and Kusehra, Chaura and Parsia, blocks of the Halia range so that the patrolling will be more operative and poaching will be minimized in these bordering areas.

Encroachment is one of the major threat for the Blackbuck in all the ranges. Several hectares of land has been allotted to the poor and landless local people by Government before the declaration of the sanctuary. Later on, they started encroaching the crucial habitat of Blackbuck in and around there allotted land. The Blackbuck population in Chaura and Kusehra (Halia) are very small and fragile and may be vanished in the next one or two years if conservation measure were not taken urgently. The Blackbuck population in Kusehra is very small, and the poaching by the nearby tribal of Madhya Pradesh may induce them to be extinct in the near future. Rigorous monitoring of Blackbuck is essential in and around the neighbouring border areas. The forefront staff should be equipped with the necessary field equipment and with good communication network like wireless system which should be in place as early as possible. Moreover, a number of forest watcher may be deployed in Blackbuck population sites, and intensive monitoring is required in the breeding season to provide a safeguard to the Blackbuck and other wild animals.

12.7. Landscape and genetic connectivity:

Once the landscape was throughout connected from Ghurma to Halia and then Bagdara, Sanjay Tiger Reserve (M.P.) and the Blackbuck were distributed throughout Kaimur hills of Vindhyan range. Now they have been locally extinct from the Ghurma range and remaining populations are fragmented and isolated with each other. The present population in Robertsganj range has been surrounded by the villages, and the only connecting patch was so densely planted that the Blackbuck doesn’t prefer to move rather stay in the less preferred habitat. The same case is with the Visundhary (Ghorawal population) the Blackbuck is bounded by the canal in the northern side and by the villages in the eastern and southern side. The remaining connecting linkage is heavily invaded by the *Lantana camara* and *Holarrhena antidysenterica*. The connectivity among the Ghorawal and Halia is likely to be changed due to several linear infrastructure developments and anthropogenic pressure. Moreover, invasive species like Lantana (*Lantana camara*) and Parthenium (*Parthenium hysterophorus*) were invaded throughout the study area and changed the habitat from open scrub land to dense shrub. The Blackbuck prefers grassland and open scrub habitat rather than a dense shrub, and this kind of succession may lead to the habitat change which further impacted adversely to the Blackbuck population. Such changes in grassland habitat are known to lead local extinction of Blackbuck. Similar habitat change has caused the local extinction of Blackbuck from Kanha National Park. This succession will also resist the connectivity of the different Blackbuck populations. Once this connectivity will be lost these populations become isolated and may vanish from the sanctuary. The connectivity among the Roberstsganj and Ghorawal has also been lost due to densely populated villages throughout these areas. Earlier the Blackbuck was distributed along the lower reaches of the hilly terrain of Kaimur mountain range of the sanctuary. After eradication of Naxalism from the Vindhayan region, the exponential growth of human populations has taken place in both the districts (Mirzapur and Sonbhadra), which leads the habitat change from grassland and open scrubland to cropland or settlement. Due to habitat changes and anthropogenic pressure along with plantation, landscape connectivity analysis reveals that the Blackbuck populations are isolated from each other and later on locally extinct from Gurval and the nearby area which is the boundary of all the three ranges, i.e. Ghurma, Robertsganj, and Ghorawal. The Bagdara population of Madhya Pradesh is a sink population, and that must also be conserved for the long term survival of Blackbuck in this landscape.

The genetic heterozygosity is an important character of a healthy population. When the heterozygosity decreases due to inbreeding and non-random mating the population become homozygous and the chance of mutation and other genetic abnormality increases. Mostly in the mammals, male-biased dispersal occurred, where male use to move from one population to another and due to this they retain genetic heterozygosity among the population. The current population of Blackbuck in all the three ranges of KWLS has lower heterozygosity and have also lost their genetic as well as landscape connectivity. So the connectivity among the populations must be insured so that the population may remain to exist in the near future. The genetic study revealed that the Robertsganj population is became totally isolated from all other populations in KWLS and it will likely to become inbreed if connectivity is not enhanced. Establishing landscape connectivity among adjoining Blackbuck populations is not possible because of high human use areas. Therefore, to improve genetic heterozygosity of this population, male individuals from other nearby populations having similar co-ancestry should be introduced. We suggest for assessing the genetic diversity of other nearby populations such as Meja (Allahabad) or from Buxar (Bihar) so that population



having high genetic diversity may be selected for the translocation of the male to this population.

12.8. Monitoring the extent of predation on Blackbuck populations:

The natural predator of the Blackbuck was Cheetah (*Acynonyx jubatus*) which is now extinct in India. The other known predators were Wolf (*Canis lupus*) and Caracal (*Folis caracal*), which have been drastically decreased from the Blackbuck distributional ranges and has been locally extinct from most of the places. The other known predators affecting Blackbuck populations are Jackal and domestic dogs. They are found in good numbers in every Blackbuck population site. However, it is difficult for them to kill the adult Blackbuck, so they usually kill fawn and some extent to sub-adult rather than the adult one. It was not possible to assess the extent of predation by these two carnivores during the short study period, though we found the presence of Blackbuck hair in domestic dog and jackals scavenging Blackbuck carcasses. Therefore, we suggest that the populations of a domestic dog inside the Blackbuck area must be checked and controlled strictly and if needed must be eliminated from the sanctuary. Besides, the population of carnivore species like domestic dogs, golden jackal (*Canis aureus*) and fox (*Vulpes bengalensis*) must be regularly monitored and a long term study should be initiated to determine the food habits of the golden jackal, fox and domestic dogs in all the three ranges of KWLS and their percent of predation on Blackbuck. For assessing the extent of predation on Blackbuck by domestic and wild carnivores, scat of carnivores should be collected near the Blackbuck population presence sites and send it to Wildlife Institute of India to determine predation rate. This will enable to take appropriate, timely management action if the growth of Blackbuck population is affected by carnivores' predation.

We also suggest a need for detailed and long term study on assessment of habitat use and its quality and ranging patterns among populations of three ranges of KWLS.

12.9. Likely threats due to the presence of mesquite (*Prosopis juliflora*) in the future:

Prosopis juliflora is one of the known threat to the Blackbuck throughout India. It's adversely impacted on Blackbuck population in Aligarh (UP), Velavadar and other

Blackbuck distributed areas in Rajasthan, Gujarat, Uttar Pradesh, and Madhya Pradesh. The Blackbuck population has been reduced drastically wherever it has encroached the open grasslands. Most of these encroachments has been due to high dispersal of the seeds by the livestock as pods of this species are palatable. We assess the presence of the *Prosopis juliflora* in and around the KWLS, and it was recorded from Ghurma and Robertsganj ranges. The density of *Prosopis juliflora* was 29.15/hectare and 0.25/hectare in Ghurma and Robertsganj respectively. However, they are found less in number, but its broad ecological amplitude, excellent growth rate, and strategy of the seed dispersal by livestock and other wild animals, it might invade very fast in the study area and could be a possible threat for the Blackbuck in the near future. Therefore, we suggest that the distribution of this species should be monitored regularly at least once in five years in and around KWLS.

12.10. Awareness programme:

Awareness is one of the major tools to convey the message about the significance of species conservation and their importance in terms of ecosystem services. Once the people are understand the importance of the species and benefits to their livelihood, they will protect and help the forest department to conserve this Schedule I animal. The awareness programme for the conservation of Blackbuck and its role in ecosystem services must be initiated in the nearby villages as well as in the school to articulate them about the significance of the Blackbuck and the unique habitat of the Vindhyan region in reverence to the ecosystem. The awareness programme should be intensified in the villages situated near 1 km of the Blackbuck population and establish "Eco-development Committee" so as to strengthen overall conservation efforts and to provide a safeguard to the wildlife.

12.2. Conservation action plan for Blackbuck in KWLS, UP:

Based on the study undertaken on the status of population and habitat, we purpose strategies which are site specific for the conservation action plan for the Indian antelope or Blackbuck in KWLS, UP. Ensuring effective conservation of Blackbuck populations in the human-dominated landscape of KWLS, UP, we grouped action plans for the suggested key strategies under the following aspects:

a. Habitat restoration/improvement: Improve forage resources, ensure improved habitat connectivity among different populations, waterhole development,
b. Control of livestock grazing,
c. Anti-poaching strategies,
d. Public awareness program
e. Wildlife Health Monitoring
f. Research/ Monitoring/ Training

The estimated financial forecast for the action plan for the proposed key strategies during 2019-2024 are as follows:

S. No.	Proposed strategies for action plan years	Recurring cost (Lakhs)	Non-recurring cost, (Lakhs)	Total Cost (Lakhs)
1.	Habitat restoration/improvement			
1.1	Pasture development	299.0	27.2	326.2
1.2	Water hole development	36.0	13.5	49.5
2.	Control of livestock grazing	40.0	10.0	50.0
3.	Anti-poaching strategies	55.0	125.2	180.2
4.	Public awareness program	2.0	17.5	19.5
5.	Wildlife health monitoring	0.0	11.0	11.0
6.	Research/Monitoring/Training	10.0	32.0	42.0
	Grand Total	**442.0**	**236.4**	**678.4**

Details of the estimated financial forecast are given in Table 12.1.

This is to mention that it is not a substitute of ongoing Management Plan activities.

Table 12.1. Financial forecast (in Lakhs) for Blackbuck Conservation Plan, Kaimoor Wildlife Sanctuary, UP during 2019- 2024.

S.No.	Activities	Unit	Cost	Non-Recurring expenditure	Recurring expenditure	Total
1	**Habitat restoration/ Improvement**					
1.1	Development of pastureland, 44 plots each of 20/ha	880 ha	0.15/ha	132.0	-	132.0
1.2	Development of connectivity plots, 24 each of 20/ha	480 ha	0.15/ha	72.0	-	72.0
1.3	Maintenance of pastureland and connectivity plots, 68 each of 20/ha	1360 ha	0.004/ha/yr	-	27.2	27.2
1.4	Removal of existing plantation and weed eradication in 8 Habitat Blocks	950 ha	0.10/ha	95.0	-	95.0
1.5	Waterhole construction (6)	6	2.0	12.0		12.0
1.6	Maintenance of waterholes (WH)	6	0.50/WH (Every 2nd year)	-	6.0	6.0
1.7	Solar pump installation and fencing around the solar panel	6	4.0	24.0	-	24.0
1.8	Maintenance of solar pump	6	0.25/pump	-	7.5	7.5
			Sub-total	**335.0**	**40.7**	**375.7**
2	**Control of livestock grazing**					
2.1	Trench formation near the Blackbuck Population Sites			40.0	-	40.0
2.2	Maintenance of trenches			-	10.0	10.0
			Sub-total	**40.0**	**10.0**	**50.0**
3	**Anti-poaching**					
3.1	Six Anti-poaching camps (Blackbuck valley, Visundhari, Halia 3, Parsia 3, Kusehra, Chaura)	6	6.0	36.0	-	36.0
3.2	Maintenance of Anti-poaching camps	6	1.0/camp (every 2nd year)	-	12.0	12.0

3.3	Construction of watchtowers (WT)	5	2	10.0	-	10.0
3.4	Maintenance of watchtowers	5	0.5/WT (every 2nd year)	-	5.0	5.0
3.5	Purchase of vehicle for flying squad	1	9.0	9.0	-	9.0
3.6	Maintenance of vehicle	1	1.0/year	-	5.0	5.0
3.7	Petrol for vehicle 20 days/month (100 km/day)	1	16.80/year	-	84.0	84.0
3.8	Engaging CDL for Anti-poaching squad (@ Rs. 8000 per Month)	4	0.8	-	19.2	19.2
			Sub-total	**55.0**	**125.2**	**180.2**
4	**Public awareness program**					
4.1	Wildlife Week in (2 school and 2 colleges per year)	20	0.50/program		10.0	10.0
4.2	Awareness in nearby villages (3 villages per year)	15	0.50/program		7.5	7.5
4.3	Signage's (2 per km near blackbuck population sites and 1per km on roads passing through the sanctuary area	30		2.0	-	2.0
			Sub-total	**2.0**	**17.5**	**19.5**
5	**Wildlife Health Monitoring**					
5.1	Cattle inoculation in villages situated near the blackbuck presence sites			-	6.0	6.0
5.2	Wildlife Health Monitoring				5.0	5.0
			Sub-total	**0.0**	**11.0**	**11.0**

6	**Research/ Monitoring/ Training**					
6.1	Population estimation of Blackbuck and data analysis (Outsource Agency)	2	10.0/study		20.0	20.0
6.2	Equipment for population monitoring (Camera Trap (25), Rangefinder (10), Spotting scope (3), Compass (10), GPS 10 (Garmin etrex 30)	58		10.0		10.0
6.3	Maintenance and midterm purchase of equipment		2.0		2.0	2.0
6.4	Wildlife training (forest guards and Range Officers)	2	5.0		10.0	10.0
			Sub-total	**10**	**32**	**42**
			Grand Total	**442**	**236.4**	**678.4**

12.2.1. Habitat restoration/improvement:

Of the four ranges viz. Robertsganj, Ghorawal, Gurma, and Halia of 510 sq.km. of KWLS, UP, the majority of the Blackbuck populations were mainly found in three ranges (Robertsganj, Ghorawal, and Halia) whereas Halia range has six sub-populations (Fig. 12.2). Based on the distribution patterns, we have identified eight "Habitat Blocks" (HB) in all the three ranges ranging from 530 to 1660 ha. (Fig. 12.2). Details are as follows:

S. No.	Identified blackbuck habitat blocks (HB) in KWLS, UP				Details of each identified habitat blocks (HB)				
	Range	Area of range, ha	Total area of HB, ha	Area of HB as percentage of area of range	Habitat Block ID	Area of each HB, ha	Percentage area of respective range	Centroid Latitude	Centroid Longitude
1	Halia	55577	4210	7.57	H1	530	0.95	24°51'01.160"N	82°22'09.463"E
					H2	530	0.95	24°48'26.799"N	82°21'34.745"E
					H3	1030	1.85	24°42'08.050"N	82°23'32.922"E
					H4	530	0.95	24°39'29.699"N	82°23'52.135"E
					H5	530	0.95	24°42'54.648"N	82°26'09.124"E
					H6	1060	1.91	24°41'10.704"N	82°29'47.827"E
2	Ghorawal	58866	1660	2.82	GH1	1660	2.82	24°48'14.605"N	82°48'06.563"E
3	Robertsganj	45803	530	1.16	R1	530	1.16	24°38'26.221"N	82°58'33.177"E

For forage resource improvement/restoration, we have identified a series of smaller plots (n=44) each of 20 ha in all eight HB (Fig. 12.3) and 24 plots so as to establish connectivity among different populations in "Stepping Stone" model (Fig. 12.4) for pastureland improvement by planning endemic indigenous grasses as suggested under strategies. Details of identified plots are as follows:

Table. 12.2. Forage resource restoration plan:

a. Proposed Forage Resource Restoration plots in each HB

S. No.	Range	Habitat Block	Plot ID	Area, ha	Centroid Latitude	Centroid Longitude
1	Halia	H1	H1_1	19.8	24°51'20.537"N	82°22'11.455"E
2			H1_2	19.8	24°50'59.519"N	82°21'36.889"E
3			H1_3	19.8	24°50'30.009"N	82°22'08.255"E
4			H1_4	19.8	24°50'50.684"N	82°22'30.785"E
5			H1_5	19.8	24°50'58.620"N	82°22'06.068"E
6		H2	H2_1	19.8	24°48'37.090"N	82°22'03.704"E
7			H2_2	19.8	24°48'08.765"N	82°22'01.188"E
8			H2_3	19.8	24°48'33.289"N	82°21'33.502"E
9			H2_4	19.8	24°47'50.565"N	82°21'38.828"E
10		H3	H3_1	19.8	24°43'03.418"N	82°23'04.912"E
11			H3_2	19.8	24°42'34.596"N	82°22'56.915"E
12			H3_3	19.8	24°42'46.802"N	82°23'30.484"E
13			H3_4	19.8	24°42'28.341"N	82°23'39.008"E
14			H3_5	16.1	24°42'02.846"N	82°23'11.376"E
15			H3_6	19.8	24°41'41.023"N	82°23'36.680"E
16			H3_7	19.8	24°41'05.279"N	82°23'41.317"E
17			H3_8	19.8	24°41'24.110"N	82°24'07.286"E
18		H4	H4_1	19.8	24°39'49.690"N	82°23'31.777"E
19			H4_2	19.8	24°39'32.620"N	82°23'22.886"E
20			H4_3	19.8	24°39'19.368"N	82°23'53.137"E
21			H4_4	19.8	24°39'27.927"N	82°24'23.179"E
22		H5	H5_1	19.8	24°43'21.548"N	82°25'44.869"E
23			H5_2	19.8	24°43'14.979"N	82°26'15.970"E
24			H5_3	19.2	24°42'38.618"N	82°26'23.272"E
25			H5_4	19.8	24°42'52.684"N	82°25'59.763"E
26		H6	H6_1	19.8	24°41'03.928"N	82°28'52.068"E
27			H6_2	19.8	24°40'56.041"N	82°29'28.179"E
28			H6_3	19.8	24°41'04.381"N	82°30'07.118"E
29			H6_4	19.8	24°40'29.614"N	82°29'36.961"E
30			H6_5	19.8	24°41'30.429"N	82°30'34.612"E
31			H6_6	19.8	24°41'32.062"N	82°29'59.125"E
32	Ghorawal	GH1	GH1_1	19.8	24°48'11.360"N	82°46'45.390"E
33			GH1_2	19.8	24°48'39.910"N	82°48'07.305"E
34			GH1_3	19.8	24°48'56.827"N	82°49'13.811"E
35			GH1_4	19.8	24°48'11.705"N	82°49'06.101"E
36			GH1_5	19.8	24°47'31.798"N	82°48'33.719"E
37			GH1_6	19.8	24°47'55.538"N	82°47'55.236"E
38			GH1_7	19.8	24°48'37.189"N	82°47'30.653"E

39	Robertsganj	R1	R1_1	19.8	24°38'15.807"N	82°58'36.278"E
40			R1_2	19.8	24°38'00.346"N	82°58'19.365"E
41			R1_3	19.8	24°38'54.216"N	82°58'16.065"E
42			R1_4	19.8	24°38'33.186"N	82°58'55.202"E
43			R1_5	19.8	24°38'33.391"N	82°58'03.985"E
44			R1_6	19.8	24°38'45.455"N	82°58'37.019"E

b. Proposed Forage Resource Restoration plots in population connectivity habitats among populations each range.

S. No.	Range	Plot ID	Area, ha	Centroid Latitude	Centroid Longitude
1	Halia	HC1	19.89	24°45'26.019"N	82°22'09.401"E
2		HC2	19.89	24°49'50.623"N	82°24'56.974"E
3		HC3	18.40	24°48'17.637"N	82°26'41.936"E
4		HC4	19.89	24°46'09.104"N	82°26'41.897"E
5		HC5	19.89	24°44'52.246"N	82°28'25.939"E
6		HC6	19.89	24°44'14.660"N	82°31'29.448"E
7		HC7	19.89	24°44'55.805"N	82°33'27.468"E
8	Ghorawal	GHC1	19.89	24°39'20.798"N	82°47'31.840"E
9		GHC2	19.89	24°38'44.983"N	82°44'55.705"E
10		GHC3	16.90	24°39'56.972"N	82°42'18.695"E
11		GHC4	19.89	24°42'05.411"N	82°41'12.190"E
12		GHC5	19.89	24°43'11.409"N	82°41'20.840"E
13		GHC6	19.89	24°42'38.626"N	82°39'47.941"E
14		GHC7	19.31	24°41'24.744"N	82°37'06.100"E
15		GHC8	19.89	24°47'26.494"N	82°44'34.640"E
16		GHC9	19.89	24°47'09.588"N	82°42'03.189"E
17		GHC10	19.89	24°45'23.896"N	82°37'58.061"E
18		GHC11	19.89	24°42'33.040"N	82°35'01.141"E
19		GHC12	19.89	24°41'08.009"N	82°34'08.008"E
20		GHC13	19.89	24°46'14.200"N	82°39'59.878"E
21	Robertsganj	RC1	15.20	24°39'16.749"N	82°57'02.301"E
22		RC2	19.89	24°38'59.476"N	82°55'27.536"E
23		RC3	19.89	24°39'37.751"N	82°53'17.350"E
24		RC4	18.03	24°39'18.937"N	82°51'04.746"E

Removal of existing plantation within the Habitat Blocks:

During the last one decade, various plantation scheme of different tree species has been undertaken under different programs in the KWLS, UP. It is well know that grasslands vanish once areas are encroached by woody vegetation and lead to local extinction of grassland species and even Blackbucks. Therefore, we emphasize a need of eradication of plantation at least from the suggested eight habitat blocks for Blackbuck conservations (Fig. 12.4), so as the habitat may be managed a s grassland. It is also suggested that plantations should not be undertaken in the Blackbuck habitats. Accordingly, appropriate financial outlay has been proposed. Details of the plantation to be removed in each HB are as follows:

Sl. No.	Range	Habitat Block	Plantation ID	Area, ha	Centroid Latitude	Centroid Longitude
1	Halia	H1	H1_P1	237.11	24°51'07.078"N	82°21'58.254"E
2		H2	H2_P1	8.51	24°48'24.580"N	82°21'33.080"E
3			H2_P2	11.18	24°48'40.851"N	82°21'59.267"E
4		H3	H3_P1	31.95	24°43'09.274"N	82°23'52.326"E
5		H4	H4_P1	24.21	24°39'30.088"N	82°23'21.236"E
6			H4_P2	0.55	24°40'04.515"N	82°23'42.505"E
7			H4_P3	0.89	24°39'58.469"N	82°23'45.832"E
8			H4_P4	3.05	24°39'53.761"N	82°23'50.509"E
9			H4_P5	133.01	24°39'31.497"N	82°24'00.790"E
10		H5	H5_P1	73.82	24°42'52.039"N	82°26'07.983"E
11			H5_P2	25.52	24°43'11.660"N	82°26'33.575"E
12		H6	H6_P1	8.87	24°41'14.035"N	82°29'31.825"E
13			H6_P2	72.3	24°40'33.268"N	82°29'26.804"E
14			H6_P3	32.16	24°40'57.781"N	82°28'56.560"E
15			H6_P4	30.4	24°41'14.990"N	82°28'58.625"E
16	Ghorawal	GH1	GH1_P1	668.14	24°48'13.954"N	82°48'28.930"E
17	Robertsganj	R1	R1_P1	14.13	24°37'58.069"N	82°58'06.967"E

Waterhole development: Blackbucks are water-dependent species. Based on the distribution of major Blackbuck populations in KWLS, UP we have suggested for the creation of six waterholes (Fig. 12.4) so as that there would be at least one waterhole within the home range of 5 km^2. For regular management purposes, we have suggested solar pumps for each waterhole and accordingly financial allocation has been made.

The estimated financial forecast (Rs. Lakhs) for this component is as follows:

S.No.	Activities	Unit	Cost	Non-Recurring expenditure	Recurring expenditure	Total
1	**Habitat restoration/ Improvement**					
1.1	Development of pastureland, 44 plots each of 20/ha	880 ha	0.15/ha	132.0	-	132.0
1.2	Development of connectivity plots, 24 each of 20/ha	480 ha	0.15/ha	72.0	-	72.0
1.3	Maintenance of pastureland and connectivity plots, 68 each of 20/ha	1360 ha	0.004/ha/yr	-	27.2	27.2
1.4	Removal of existing plantation and weed eradication in 8 Habitat Blocks	950 ha	0.10/ha	95.0	-	95.0
1.5	Waterhole construction (6)	6	2.0	12.0		12.0
1.6	Maintenance of waterholes (WH)	6	0.50/WH (Every 2nd year)	-	6.0	6.0
1.7	Solar pump installation and fencing around the solar panel	6	4.0	24.0	-	24.0
1.8	Maintenance of solar pump	6	0.25/pump	-	7.5	7.5
			Sub-total	**335.0**	**40.7**	**375.7**

12.2.2. Control of grazing: Livestock

Livestock grazing is quite rampant in KWLS, UP and there is a need to control this. We suggest establishing trench around areas of eight HBs.

The estimated financial forecast (Rs. Lakhs) for this component is as follows:

S.No.	Activities	Unit	Cost	Non- Recurring expenditure	Recurring expenditure	Total
2	**Control of livestock grazing**					
2.1	Trench formation near the Blackbuck Population Sites			40.0	-	40.0
2.2	Maintenance of trenches			-	10.0	10.0
			Sub-total	**40.0**	**10.0**	**50.0**

12.2.3. Anti-poaching:

Blackbucks are known for poaching and therefore it is suggest strengthening anti-poaching activities by having a dedicated "Flying Squad" under the supervision of Range Officer along with vehicle support. We have proposed six anti poaching camp in areas of high Blackbuck population abundance (Fig. 12.4). A provision of the separate vehicle along with POL has been proposed exclusively for this purpose. Visualizing short of staff strength, the team would comprise four CDL engaged from the surrounding local villages.

The estimated financial forecast (Rs. Lakhs) for this component is as follows:

S.No.	Activities	Unit	Cost	Non-Recurring expenditure	Recurring expenditure	Total
3	**Anti-poaching**					
3.1	Six Anti-poaching camps (Blackbuck valley, Visundhari, Halia 3, Parsia 3, Kusehra, Chaura)	6	6.0	36.0	-	36.0
3.2	Maintenance of Anti-poaching camps	6	1.0/camp (every 2nd year)	-	12.0	12.0
3.3	Construction of watchtowers (WT)	5	2	10.0	-	10.0

3.4	Maintenance of watchtowers	5	0.5/WT (every 2nd year)	-	5.0	5.0
3.5	Purchase of vehicle for flying squad	1	9.0	9.0	-	9.0
3.6	Maintenance of vehicle	1	1.0/year	-	5.0	5.0
3.7	Petrol for vehicle 20 days/month (100 km/day)	1	16.80/year	-	84.0	84.0
3.8	Engaging CDL for Anti-poaching squad (@ Rs. 8000 per Month)	4	0.8	-	19.2	19.2
			Sub-total	**55.0**	**125.2**	**180.2**

12.2.4. Public awareness program:

Sensitization among stakeholder is a key issue for a successful conservation planning. Among stakeholders, target group should include school and college students of nearby colleges, villages in and around KWLS, UP. During these training program, emphasis should be made the need of Biodiversity conservation for human survival, conservation significance of Blackbuck in KWLS and climate change We propose this should be out sourced to actively involved NGO for the conservation of Blackbuck in KWLS, UP. We propose four training programs for school and college students during "Wildlife Week" and three villages every year. The estimated financial forecast (Rs. Lakhs) for this component is as follows:

S.No.	Activities	Unit	Cost	Non-Recurring expenditure	Recurring expenditure	Total
4	**Public awareness program**					
4.1	Wildlife Week in (2 school and 2 colleges per year)	20	0.50/program		10.0	10.0
4.2	Awareness in nearby villages (3 villages per year)	15	0.50/program		7.5	7.5
4.3	Signage's (2 per km near blackbuck population sites and 1per km on roads passing through the sanctuary area	30		2.0	-	2.0
			Sub-total	**2.0**	**17.5**	**19.5**

12.2.5. Wildlife Health Monitoring:

Monitoring of Blackbuck's animal condition and interaction of Blackbuck-domestic animals should be regularly monitored. Domestic animals in surrounding villages of the identified eight "Habitat Blocks" (Fig. 12.1.) should be undertaken for inoculation. Besides, it is also suggested a regular involvement of Veterinary Officer within three ranges having Blackbuck populations during Post-Mortem of wild and domestic animals. Appropriate honorarium should be paid for their services. Identified Veterinary Officers should also be trained in "Wildlife Health Monitoring" whenever such course is advertised at the Wildlife Institute of India, Dehradun.

The estimated financial forecast for this component is as follows:

S.No.	Activities	Unit	Cost	Non-Recurring expenditure	Recurring expenditure	Total
5	**Wildlife Health Monitoring**					
5.1	Cattle inoculation in villages situated near the blackbuck presence sites			-	6.0	6.0
5.2	Wildlife Health Monitoring				5.0	5.0
			Sub-total	**0.0**	**11.0**	**11.0**

12.2.6. Research/ Monitoring and Training:

For effective conservation planning, monitoring of population and habitat status has been a key issue for species management. Therefore, we suggest a need for undertaking one-year study twice (3rd and 5th year) during the five-year plan. This could be outsourced to any university or the Wildlife Institute of India. Proposed study should include distribution pattern, occupancy, population demography, estimation of the population on the identified 53 transects (Annexure III), extent of carnivore (wild and domestic) depredation on Blackbuck and habitat quality assessment. Appropriate mid-term implementation of management issue required to be addressed should be communicated to the DFO, KWLS, UP.

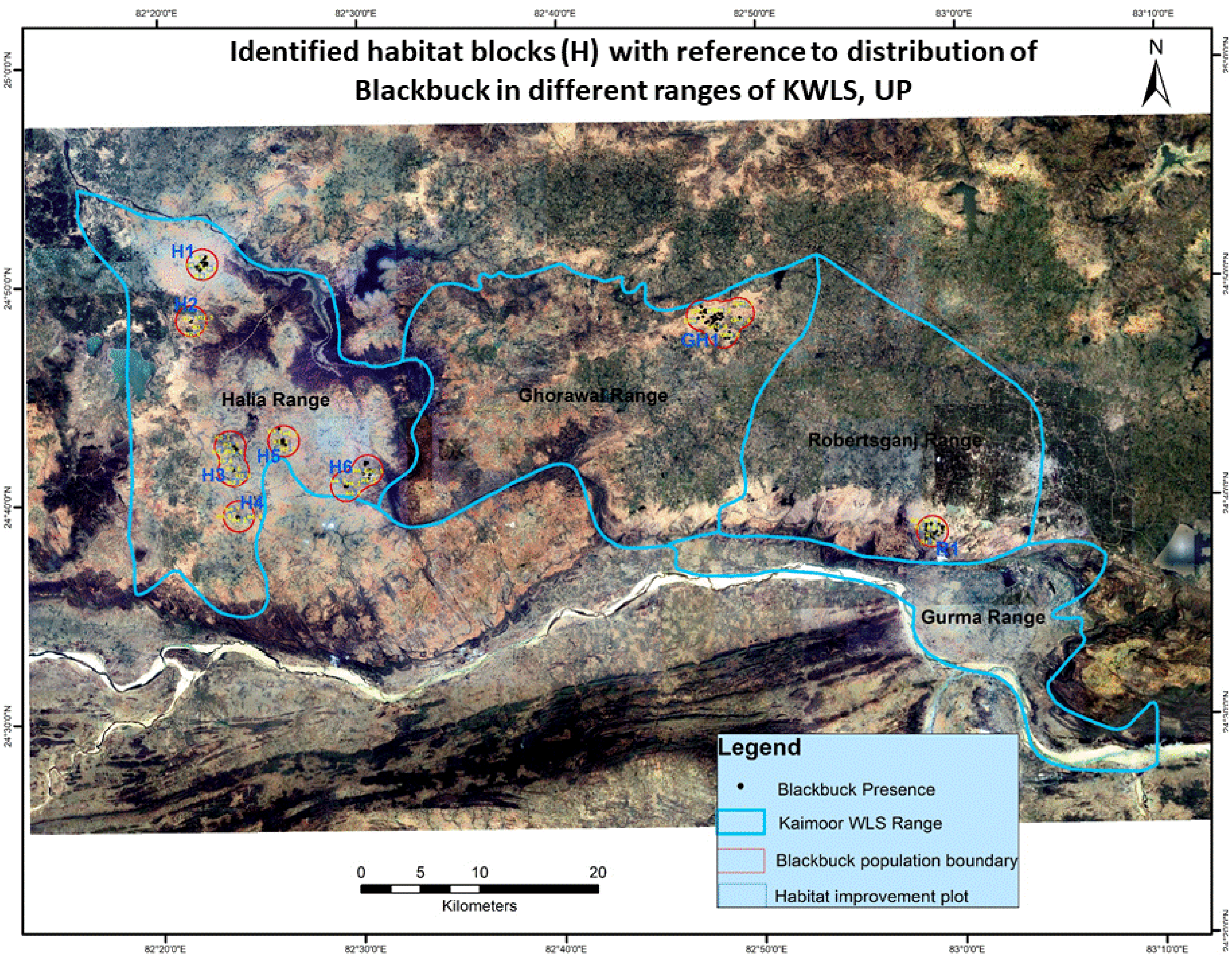
Besides, we also suggest regular involvement of the field staff in the monitoring of Blackbuck population, habitat, carnivore (wild and domestic), animal condition and livestock distribution in KWLS, UP. We suggest three days two training programs each of three days should be organized for the frontline field staff on "Monitoring wildlife and habitat" at KWLS, UP.

Appropriate resource persons from State or other institution may be invited. For this purpose, we also suggested procurement of equipment needed for monitoring of wildlife such as camera trap, rangefinder, spotting scope, compass, GPS etc.

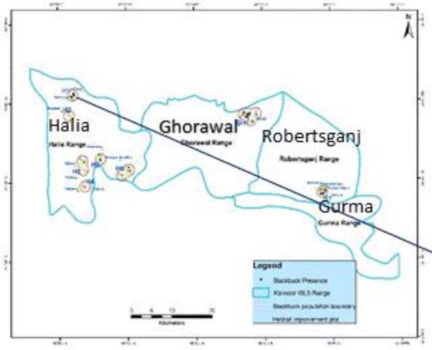
The estimated financial forecast for this component is as follows:

S.No.	**Activities**	**Unit**	**Cost**	**Non-Recurring expenditure**	**Recurring expenditure**	**Total**
6	**Research/ Monitoring/ Training**					
6.1	Population estimation of Blackbuck and data analysis (Outsource Agency)	2	10.0/ study		20.0	20.0
6.2	Equipment for population monitoring (Camera Trap (25), Rangefinder (10), Spottin scope (3), Compass (10), GPS 10 (Garmin etrex 30)	58		10.0		10.0
6.3	Maintenance and midterm purchase of equipment		2.0		2.0	2.0
6.4	Wildlife training (forest guards and Range Officers)	2	5.0		10.0	10.0

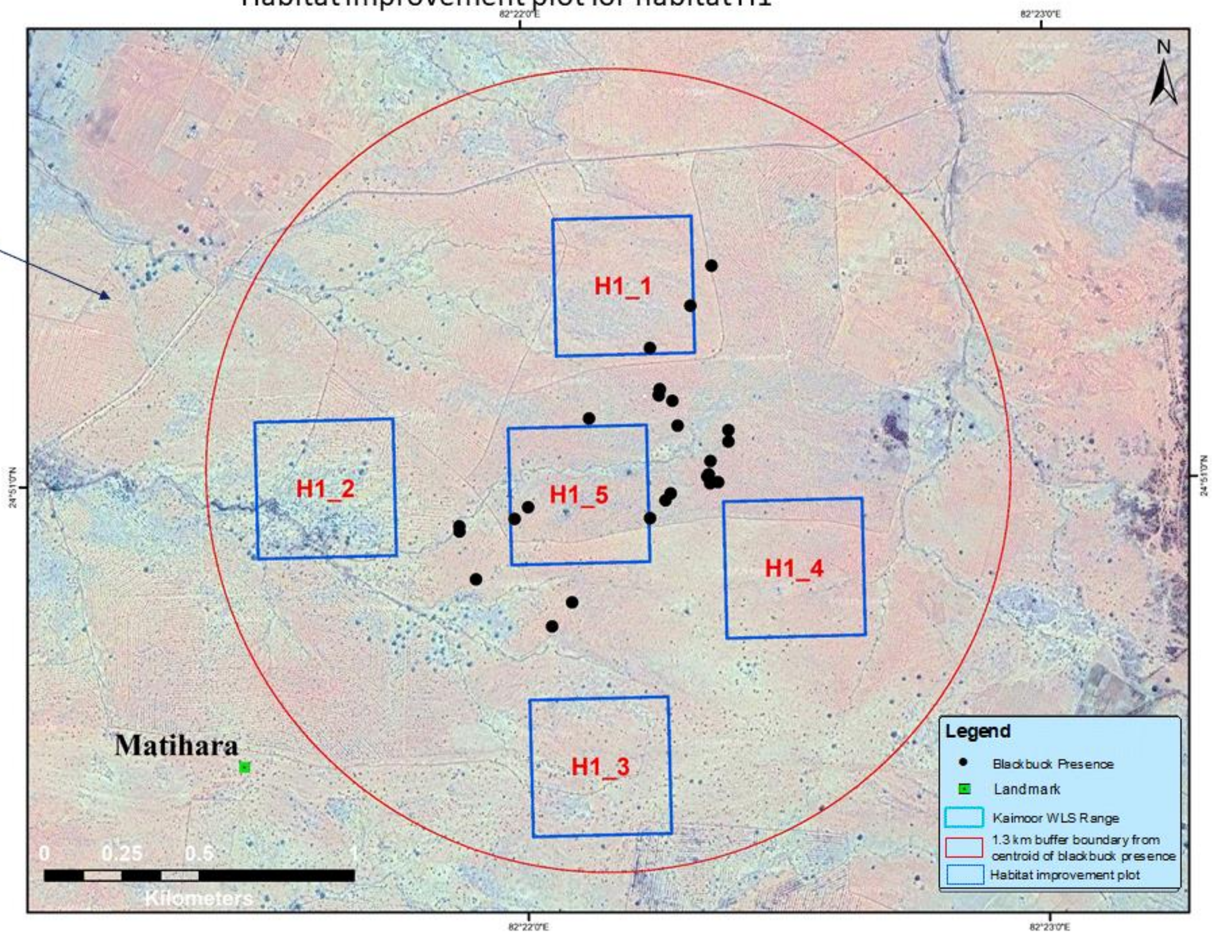
Figure 12. 2. Location of six habitat blocks (HB) identified close to the populations of Indian antelope or Blackbuck for habitat restoration in areas for conservation in Kaimmor Wildlife Sanctuary , UP



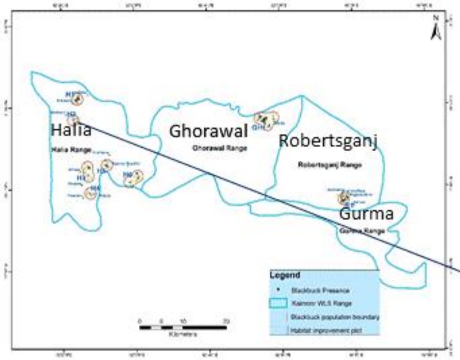
Identified habitat blocks (H) with reference to distribution of Blackbuck in different ranges of KWLS, UP
N
H1
H2
Halia Range
H3
H4
H5
H6
Ghorawal Range
GH1
Robertsganj Range
R1
Gurma Range
Legend
Blackbuck Presence
Kaimoor WLS Range
Blackbuck population boundary
Habitat improvement plot
0 5 10 20
Kilometers



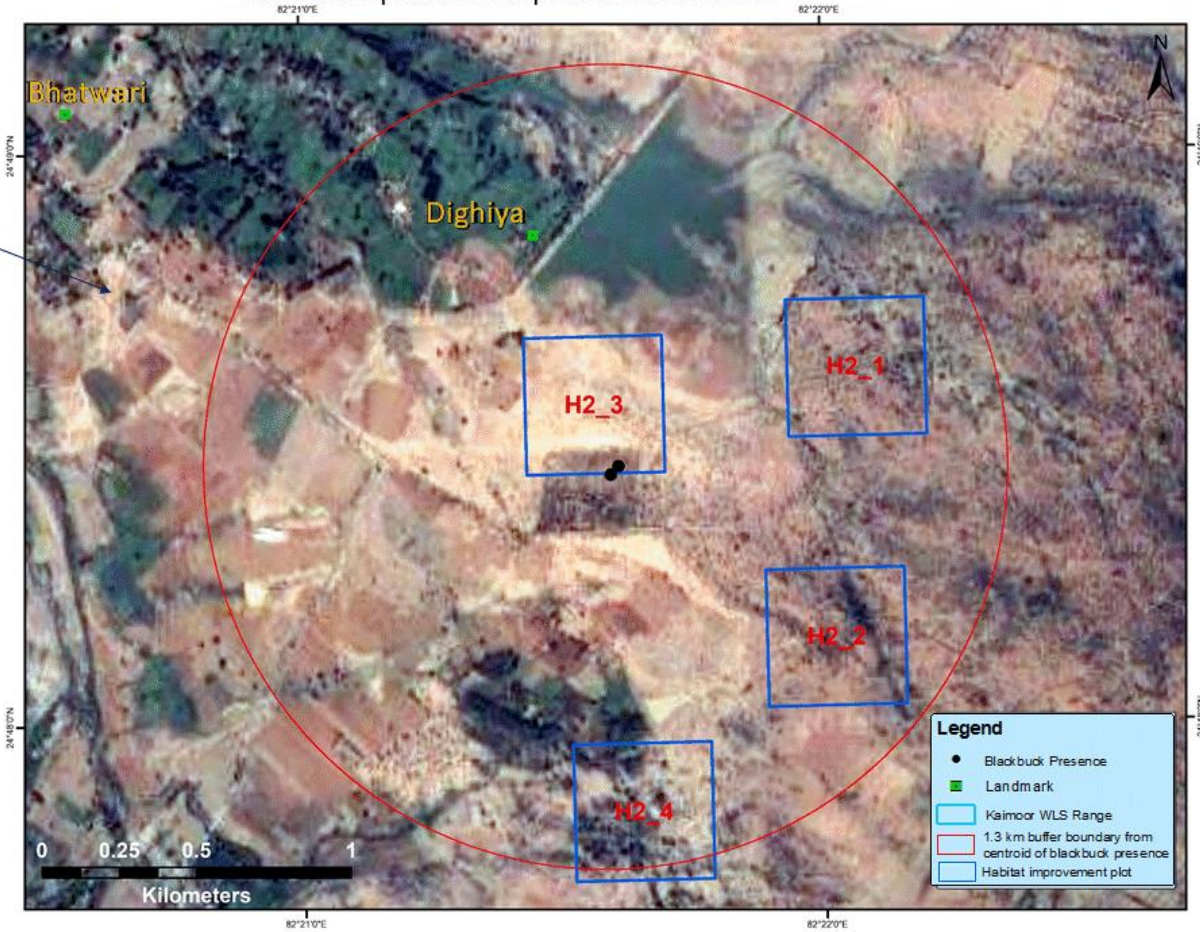
Habitat improvement plot for habitat H1



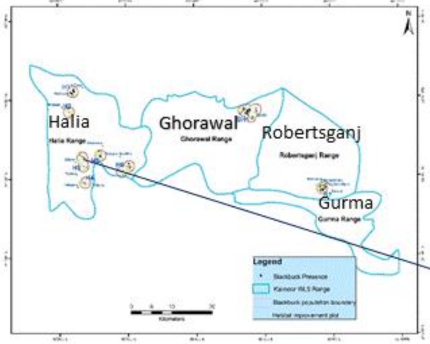
H1 buffer boundary of Halia range				
Plot Name	Area in Km	Area in Hactare	Centroid Lat	Centroid Long
H1_1	0.20	20	24°51'20.537"N	82°22'11.455"E
H1_2	0.20	20	24°50'59.519"N	82°21'36.889"E
H1_3	0.20	20	24°50'30.009"N	82°22'8.255"E
H1_4	0.20	20	24°50'50.684"N	82°22'30.785"E
H1_5	0.20	20	24°50'58.620"N	82°22'6.068"E



Habitat improvement plot for habitat H2

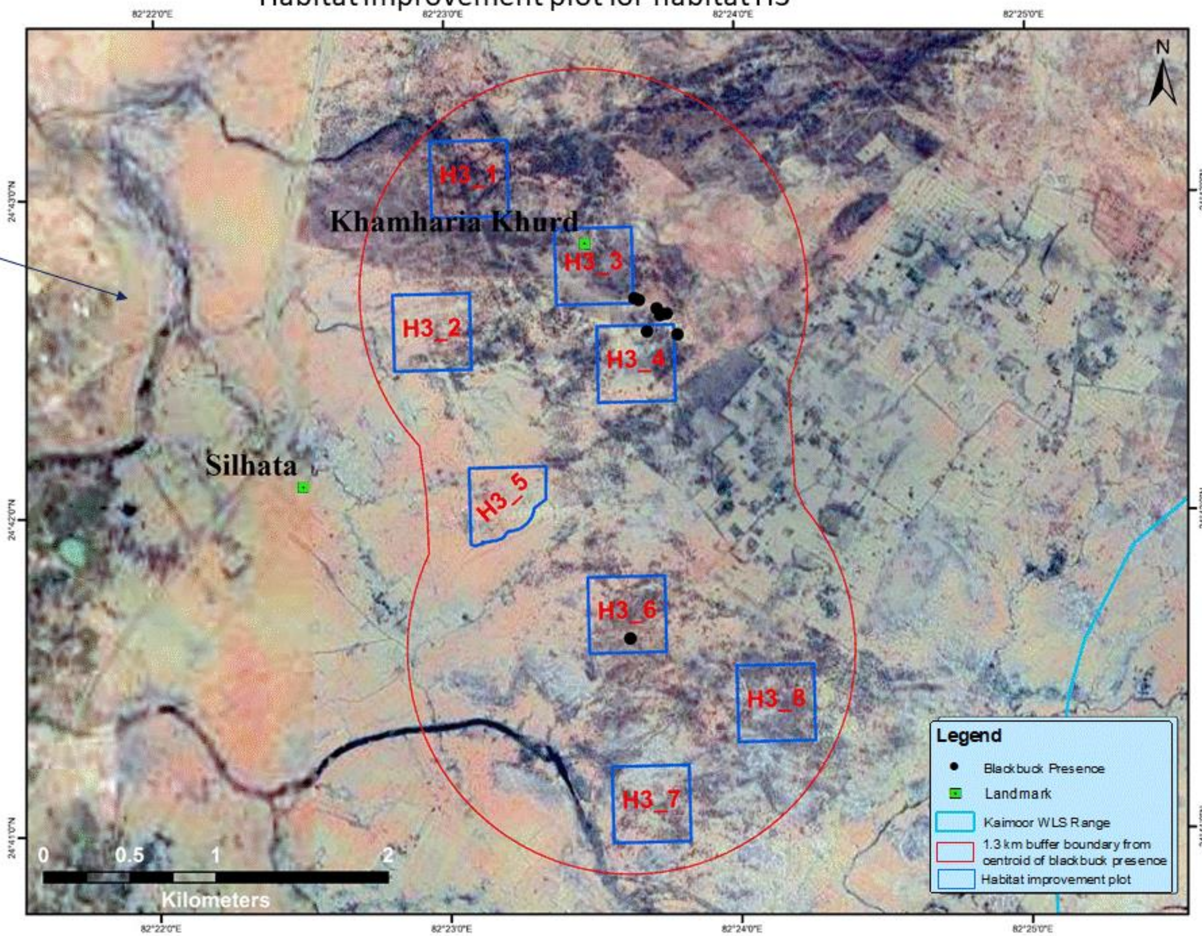


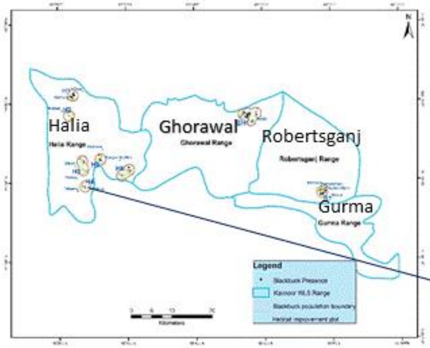
H2 buffer boundary of Halia range				
Plot Name	Area in Km	Area in Hactare	Centroid Lat	Centroid Long
H2_1	0.20	20	24°48'37.090"N	82°22'3.704"E
H2_2	0.20	20	24°48'8.765"N	82°22'1.188"E
H2_3	0.20	20	24°48'33.289"N	82°21'33.502"E
H2_4	0.20	20	24°47'50.565"N	82°21'38.828"E



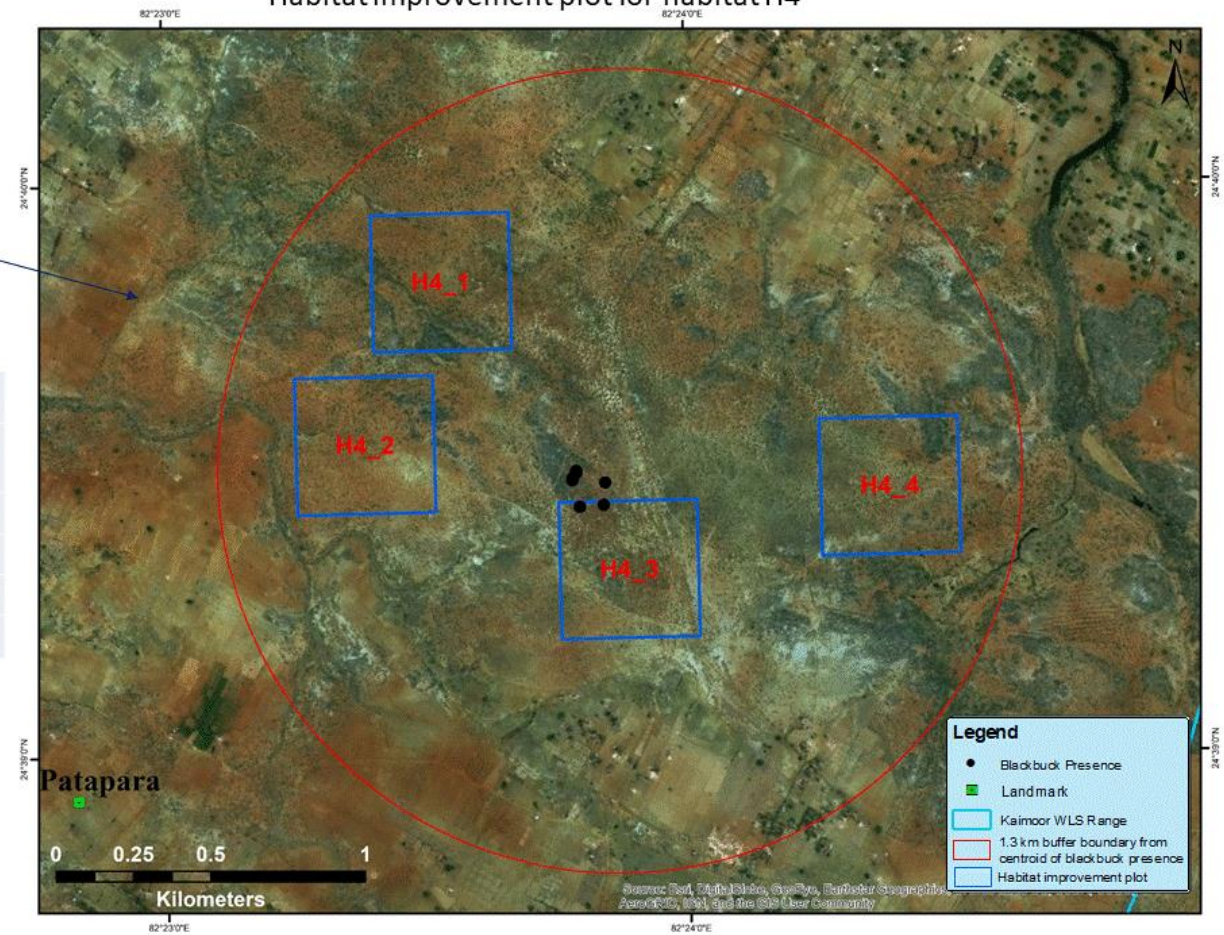
H3 buffer boundary of Halia range				
Plot Name	Area in Km	Area in Hactare	Centroid Lat	Centroid Long
H3_1	0.20	20	24°43'3.418"N	82°23'4.912"E
H3_2	0.20	20	24°42'34.596"N	82°22'56.915"E
H3_3	0.20	20	24°42'46.802"N	82°23'30.484"E
H3_4	0.20	20	24°42'28.341"N	82°23'39.008"E
H3_5	0.16	16	24°42'2.846"N	82°23'11.376"E
H3_6	0.20	20	24°41'41.023"N	82°23'36.680"E
H3_7	0.20	20	24°41'5.279"N	82°23'41.317"E
H3_8	0.20	20	24°41'24.110"N	82°24'7.286"E

Habitat improvement plot for habitat H3



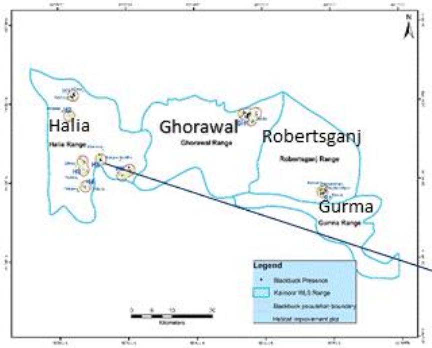


Habitat improvement plot for habitat H4

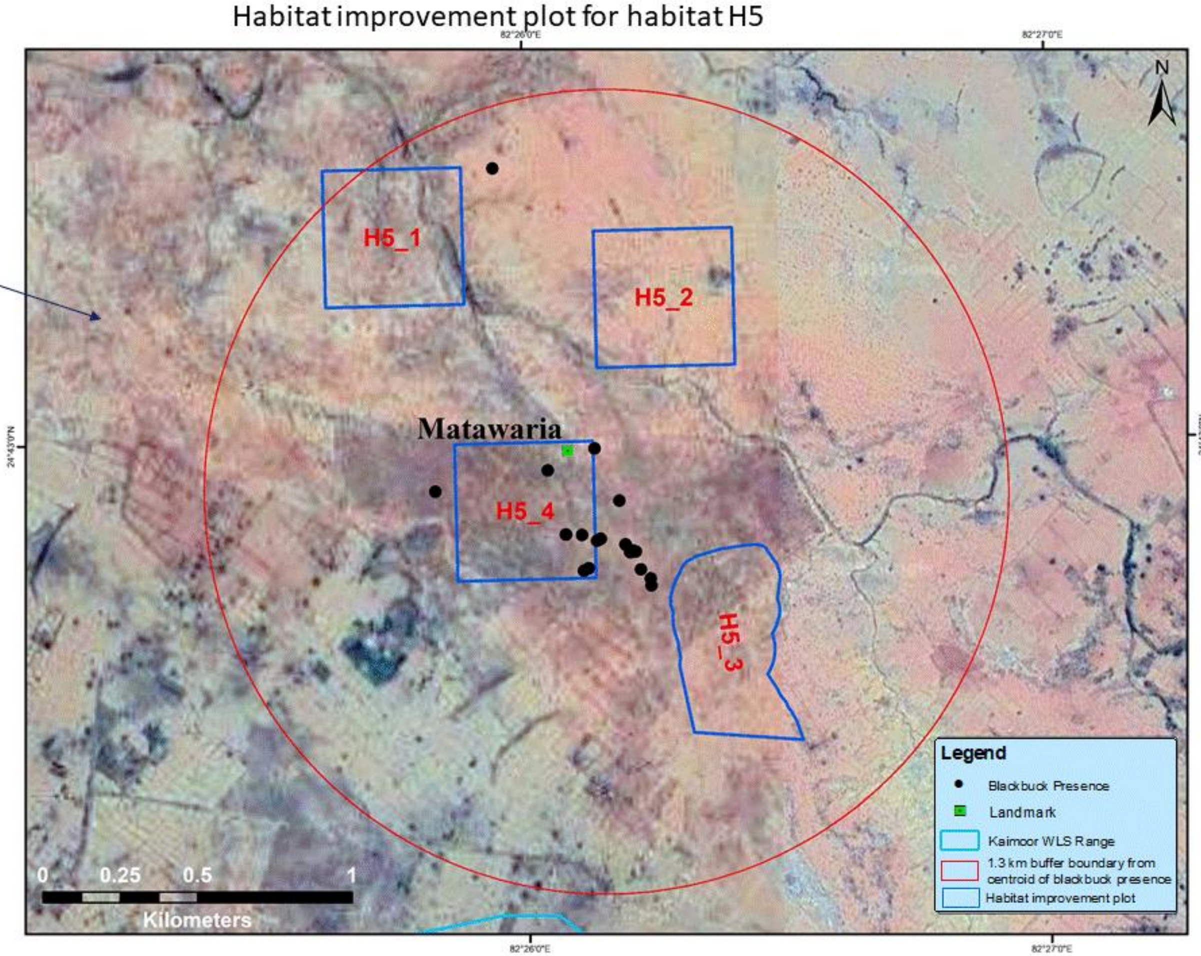


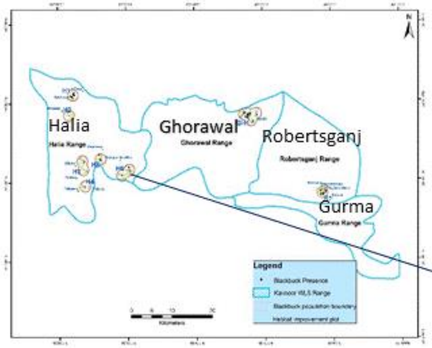
H4 buffer boundary of Halia range

Plot Name	Area in Km	Area in Hactare	Centroid Lat	Centroid Long
H4_1	0.20	20	24°39'49.690"N	82°23'31.777"E
H4_2	0.20	20	24°39'32.620"N	82°23'22.886"E
H4_3	0.20	20	24°39'19.368"N	82°23'53.137"E
H4_4	0.20	20	24°39'27.927"N	82°24'23.179"E



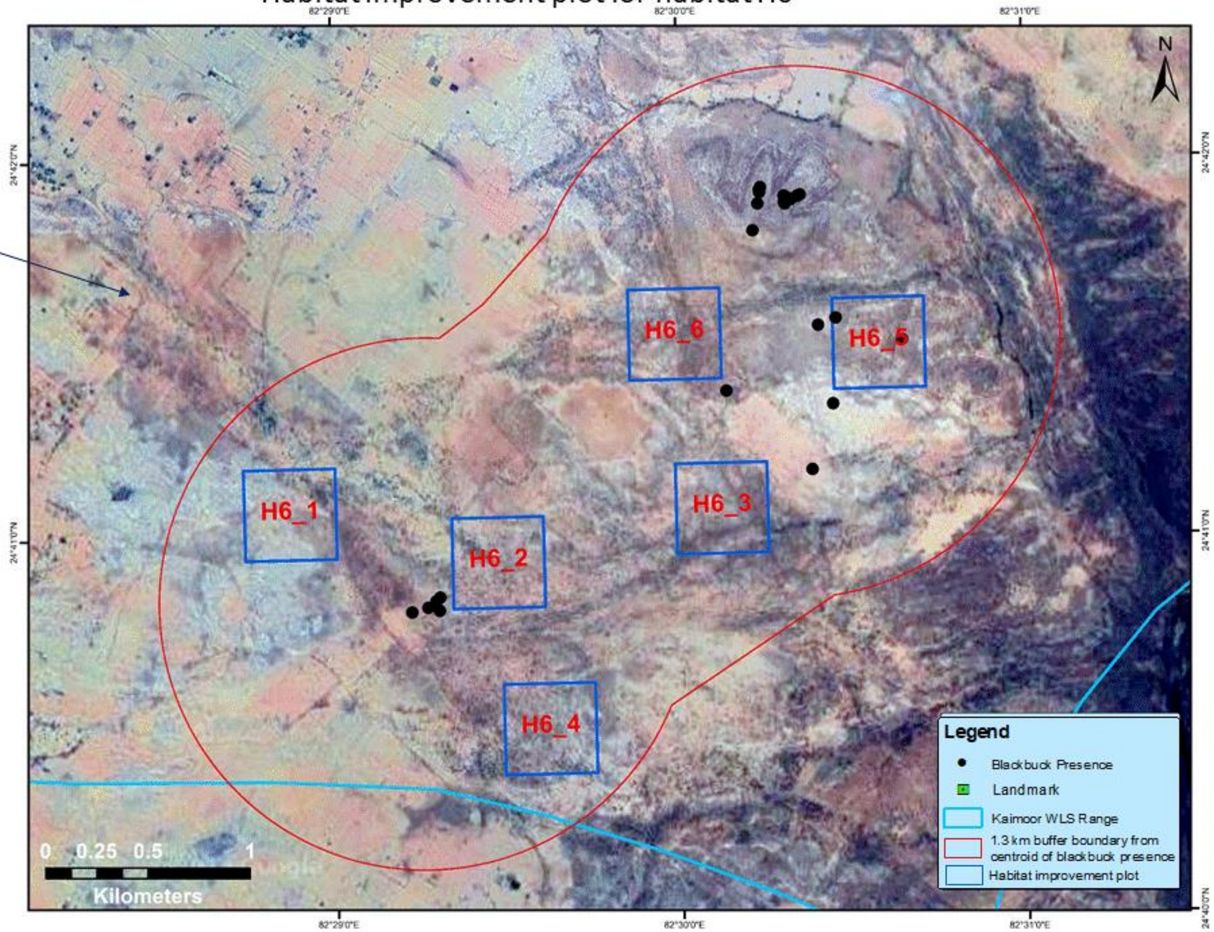
H5 buffer boundary of Halia range				
Plot Name	Area in Km	Area in Hactare	Centroid Lat	Centroid Long
H5_1	0.20	20	24°43'21.548"N	82°25'44.869"E
H5_2	0.20	20	24°43'14.979"N	82°26'15.970"E
H5_3	0.19	19	24°42'38.618"N	82°26'23.272"E
H5_4	0.20	20	24°42'52.684"N	82°25'59.763"E

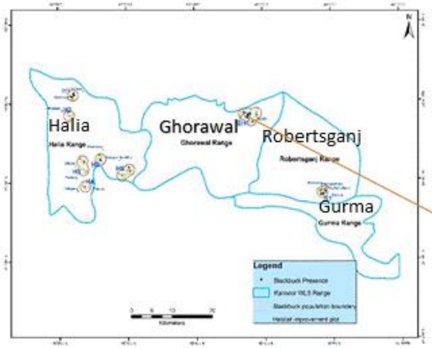




H6 buffer boundary of Halia range				
Plot Name	Area in Km	Area in Hactare	Centroid Lat	Centroid Long
H6_1	0.20	20	24°41'3.928"N	82°28'52.068"E
H6_2	0.20	20	24°40'56.041"N	82°29'28.179"E
H6_3	0.20	20	24°41'4.381"N	82°30'7.118"E
H6_4	0.20	20	24°40'29.614"N	82°29'36.961"E
H6_5	0.20	20	24°41'30.429"N	82°30'34.612"E
H6_6	0.20	20	24°41'32.062"N	82°29'59.125"E

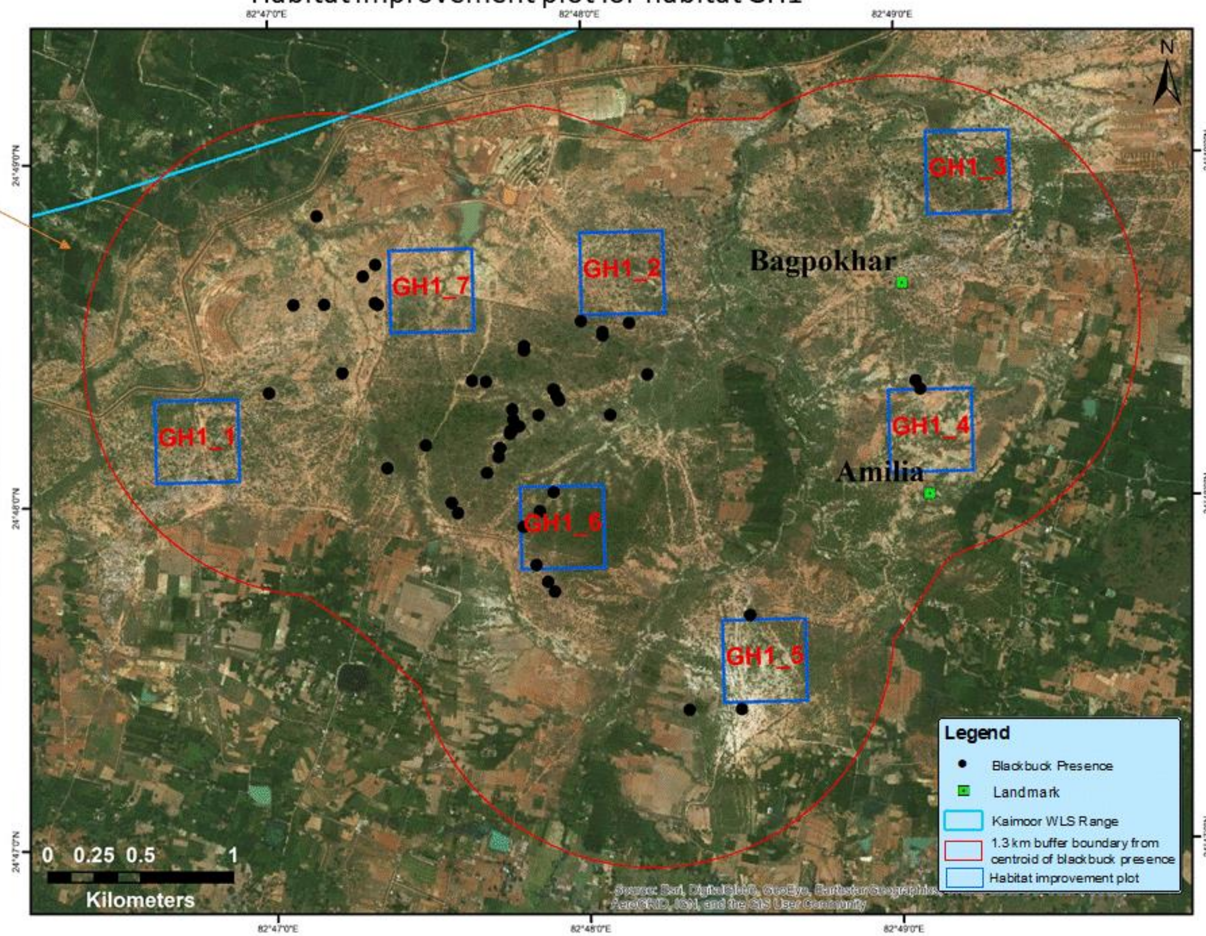
Habitat improvement plot for habitat H6

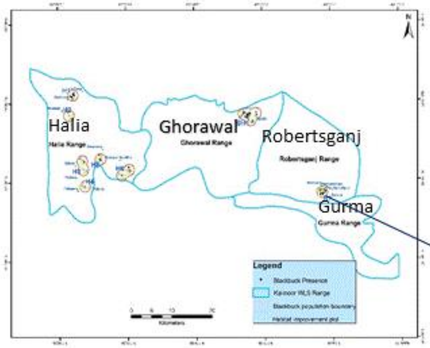




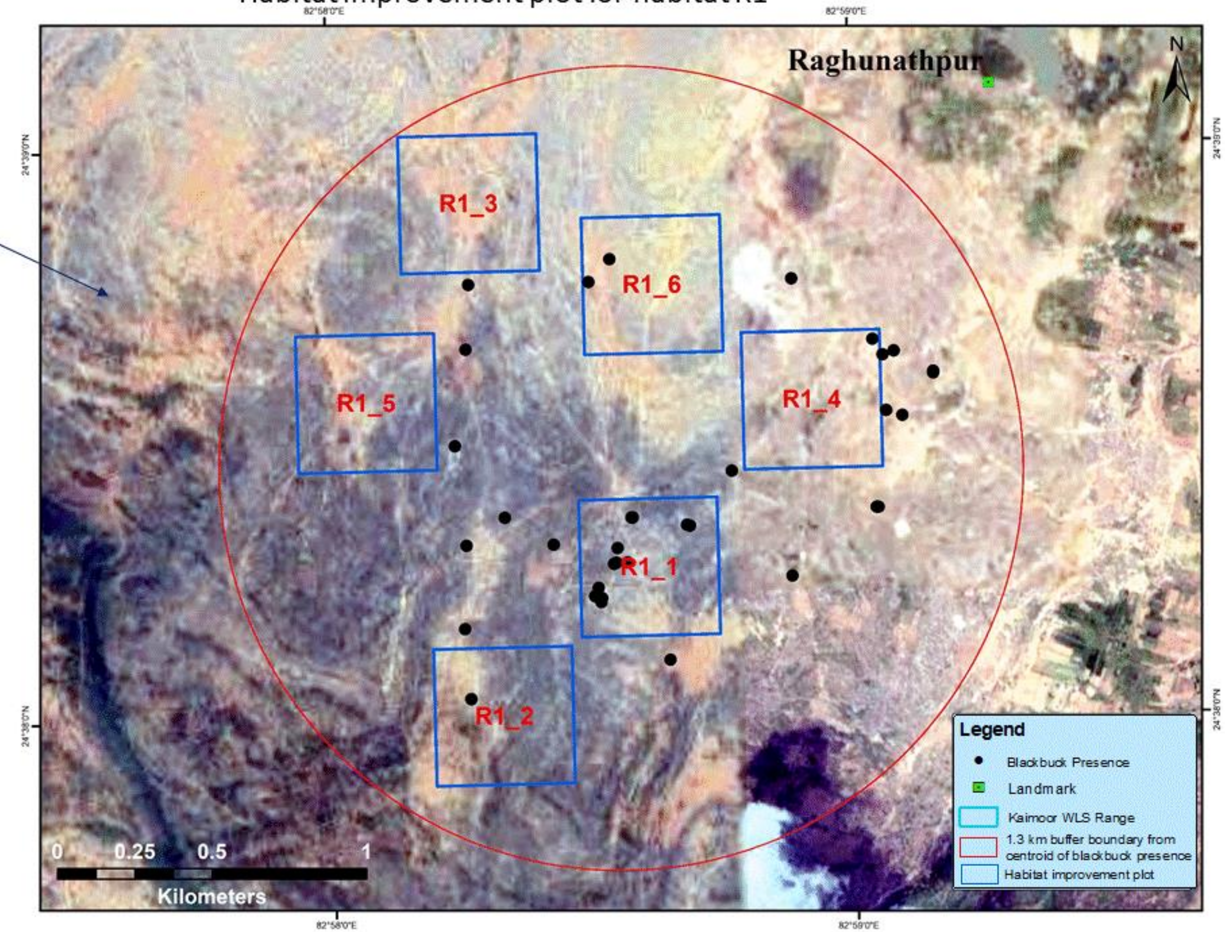
GH1 buffer boundary of Halia range				
Plot Name	Area in Km	Area in Hactare	Centroid Lat	Centroid Long
GH1_1	0.20	20	24°48'11.360"N	82°46'45.390"E
GH1_2	0.20	20	24°48'39.910"N	82°48'7.305"E
GH1_3	0.20	20	24°48'56.827"N	82°49'13.811"E
GH1_4	0.20	20	24°48'11.705"N	82°49'6.101"E
GH1_5	0.20	20	24°47'31.798"N	82°48'33.719"E
GH1_6	0.20	20	24°47'55.538"N	82°47'55.236"E
GH1_7	0.20	20	24°48'37.189"N	82°47'30.653"E

Habitat improvement plot for habitat GH1





Habitat improvement plot for habitat R1

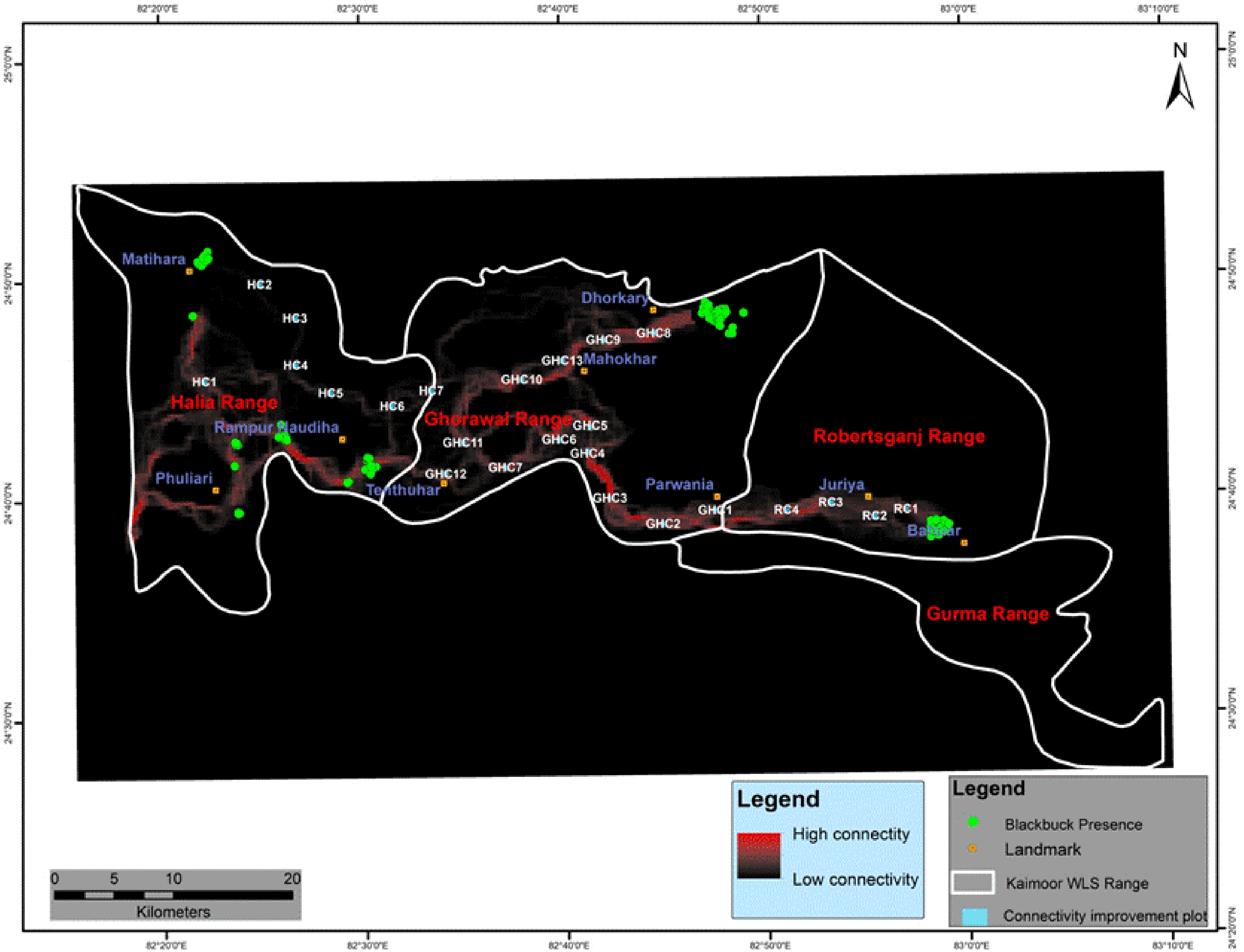


H1 buffer boundary of Halia range

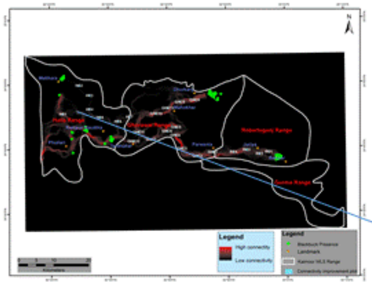
Plot Name	Area in Km	Area in Hactare	Centroid Lat	Centroid Long
R1_1	0.20	20	24°38'15.807"N	82°58'36.278"E
R1_2	0.20	20	24°38'0.346"N	82°58'19.365"E
R1_3	0.20	20	24°38'54.216"N	82°58'16.065"E
R1_4	0.20	20	24°38'33.186"N	82°58'55.202"E
R1_5	0.20	20	24°38'33.391"N	82°58'3.985"E
R1_6	0.20	20	24°38'45.455"N	82°58'37.019"E

Figure 12. 3. Location of plots for habitat restoration in areas needed for establishing connectivity among different populations for conservation of Indian antelope or Blackbuck in KWLS , UP

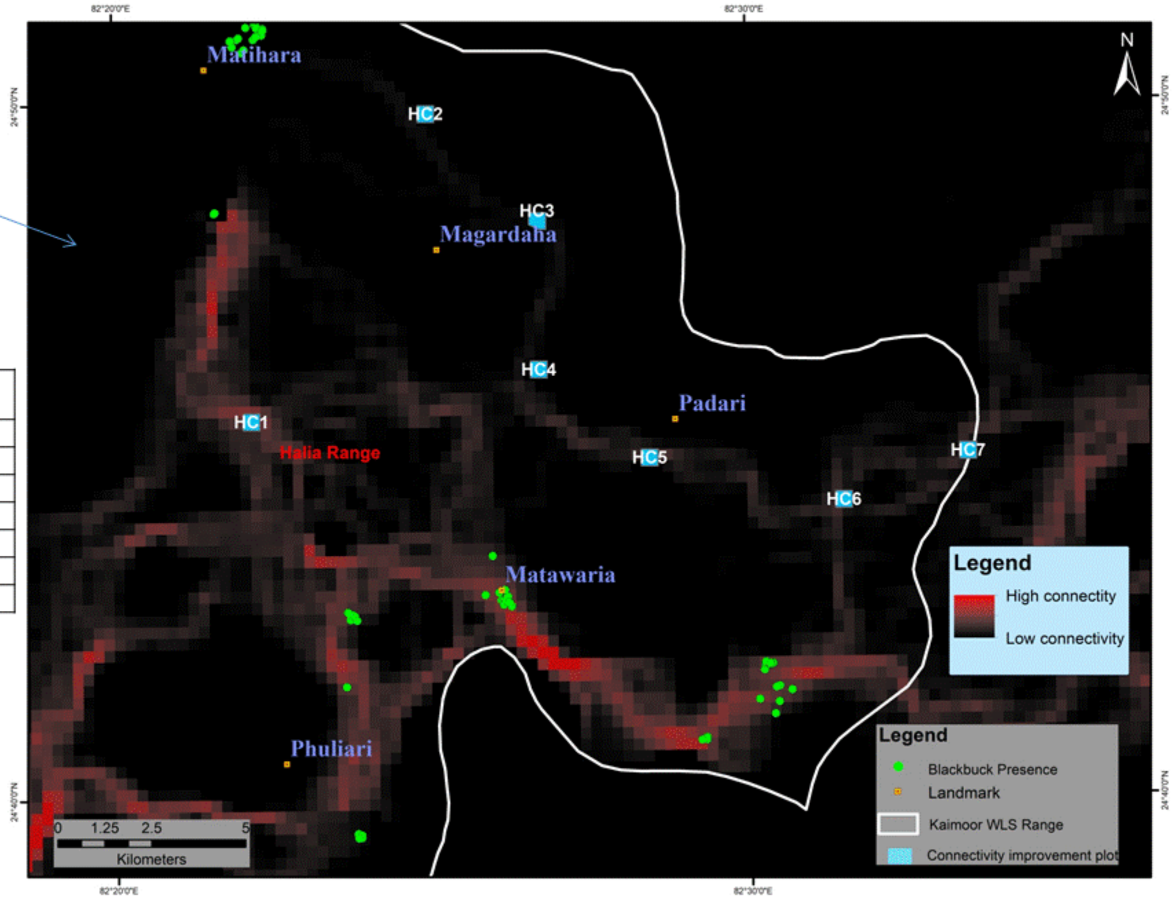
Connectivity improvement plot for Kaimoor WLS



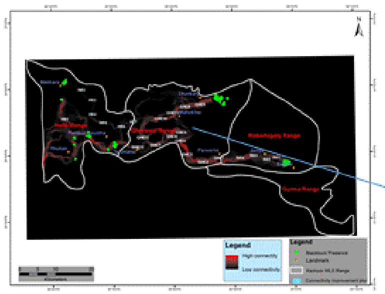
Connectivity improvement plot for Halia



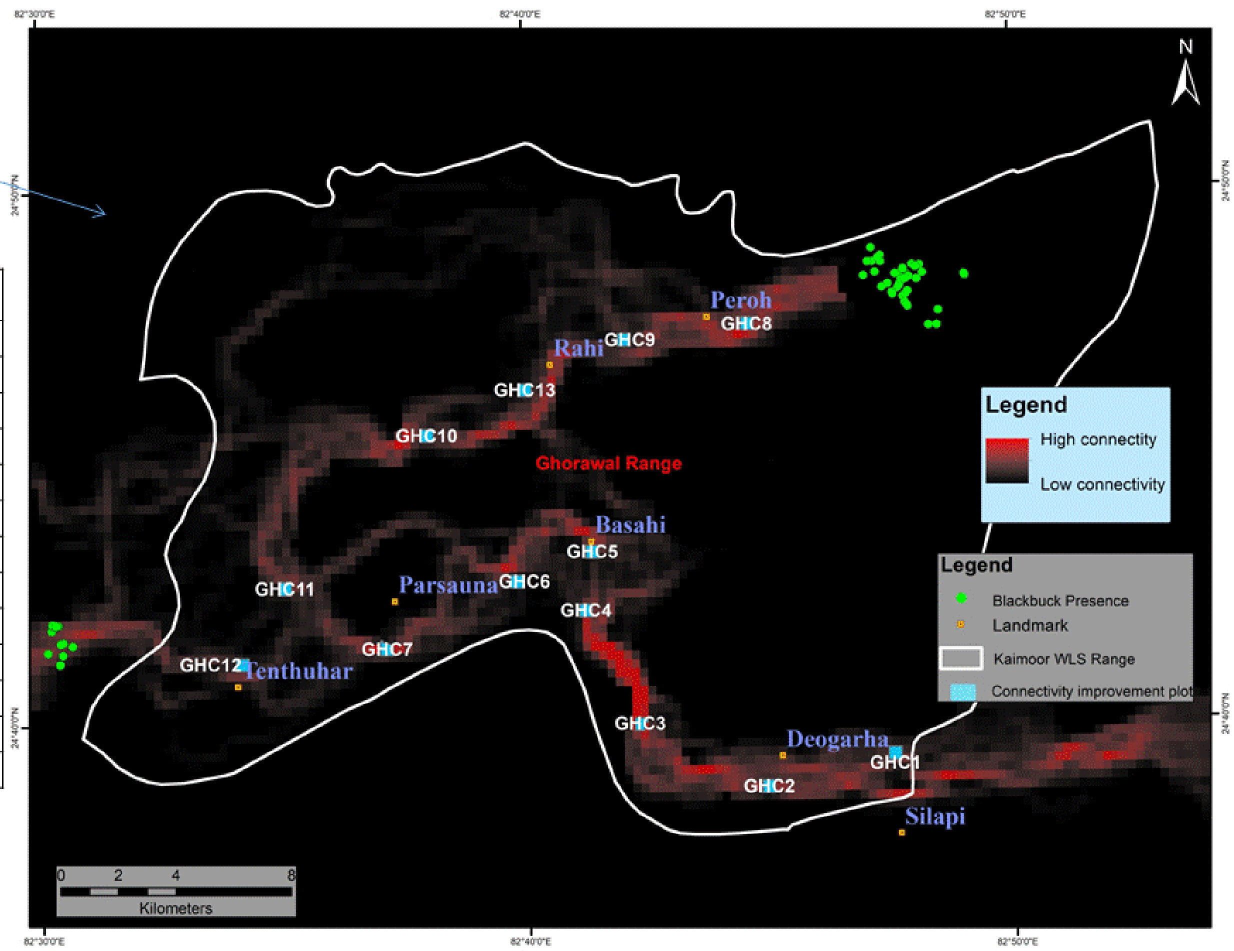
Range	Plot ID	Area (Ha)	Centroid Lat	Centroid Long
Haliya	HC1	19.89	24° 45' 26.019" N	82° 22' 09.401" E
Haliya	HC2	19.89	24° 49' 50.623" N	82° 24' 56.974" E
Haliya	HC3	18.40	24° 48' 17.637" N	82° 26' 41.936" E
Haliya	HC4	19.89	24° 46' 09.104" N	82° 26' 41.897" E
Haliya	HC5	19.89	24° 44' 52.246" N	82° 28' 25.939" E
Haliya	HC6	19.89	24° 44' 14.660" N	82° 31' 29.448" E
Haliya	HC7	19.89	24° 44' 55.805" N	82° 33' 27.468" E



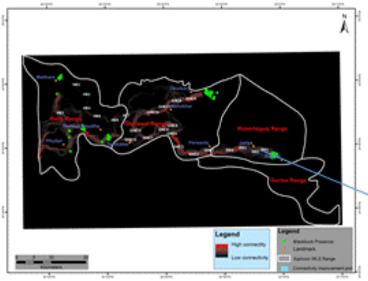
Connectivity improvement plot for Ghorawal



Range	Plot ID	Area (Ha)	Centroid Lat	Centroid Long
Ghorawal	GHC1	19.89	24° 39' 20.798" N	82° 47' 31.840" E
Ghorawal	GHC2	19.89	24° 38' 44.983" N	82° 44' 55.705" E
Ghorawal	GHC3	16.90	24° 39' 56.972" N	82° 42' 18.695" E
Ghorawal	GHC4	19.89	24° 42' 05.411" N	82° 41' 12.190" E
Ghorawal	GHC5	19.89	24° 43' 11.409" N	82° 41' 20.840" E
Ghorawal	GHC6	19.89	24° 42' 38.626" N	82° 39' 47.941" E
Ghorawal	GHC7	19.31	24° 41' 24.744" N	82° 37' 06.100" E
Ghorawal	GHC8	19.89	24° 47' 26.494" N	82° 44' 34.640" E
Ghorawal	GHC9	19.89	24° 47' 09.588" N	82° 42' 03.189" E
Ghorawal	GHC10	19.89	24° 45' 23.896" N	82° 37' 58.061" E
Ghorawal	GHC11	19.89	24° 42' 33.040" N	82° 35' 01.141" E
Ghorawal	GHC12	19.89	24° 41' 08.009" N	82° 34' 08.008" E
Ghorawal	GHC13	19.89	24° 46' 14.200" N	82° 39' 59.878" E



Connectivity improvement plot for Robertsganj



Range	Plot ID	Area (Ha)	Centroid Lat	Centroid Long
Robertsganj	RC1	15.20	24° 39' 16.749" N	82° 57' 02.301" E
Robertsganj	RC2	19.89	24° 38' 59.476" N	82° 55' 27.536" E
Robertsganj	RC3	19.89	24° 39' 37.751" N	82° 53' 17.350" E
Robertsganj	RC4	18.03	24° 39' 18.937" N	82° 51' 04.746" E

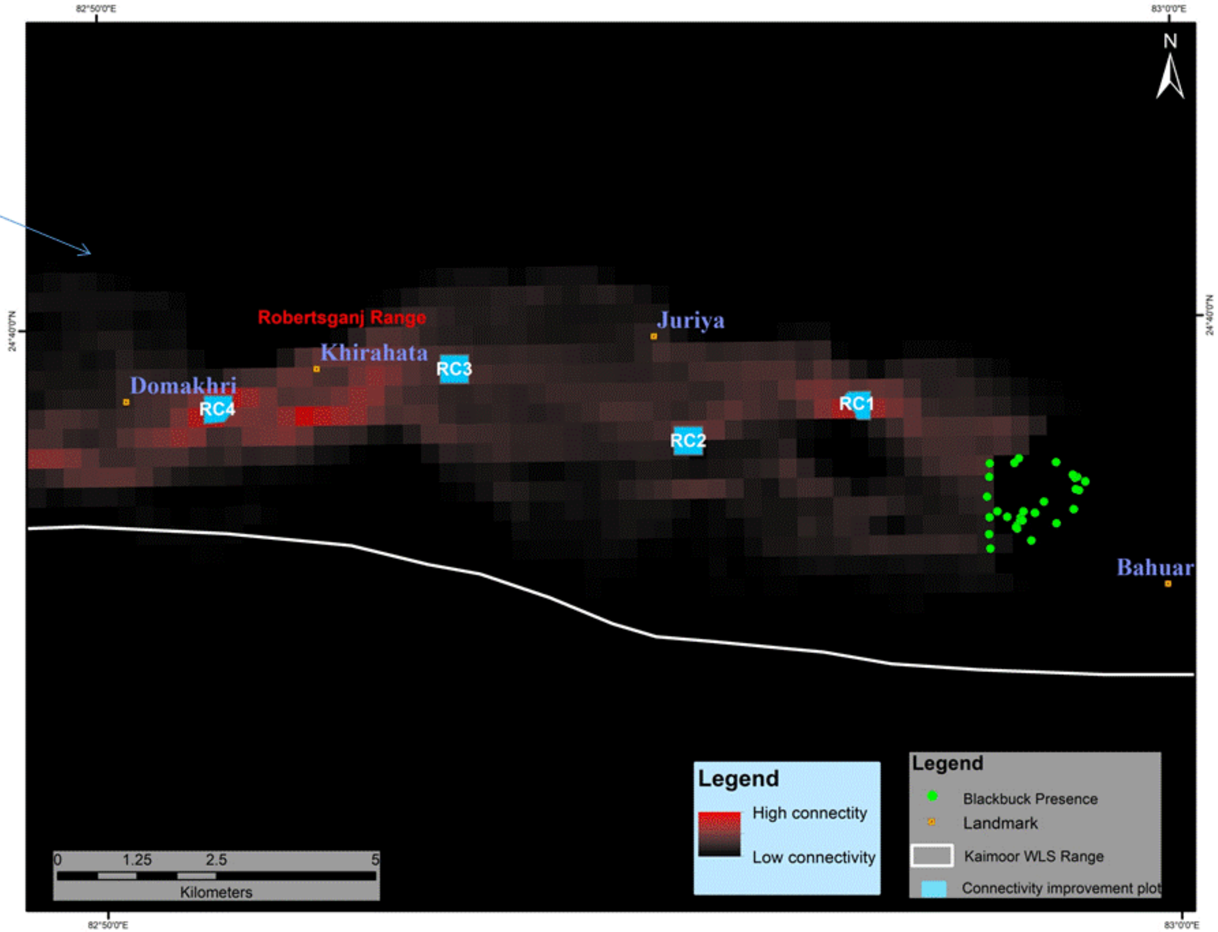


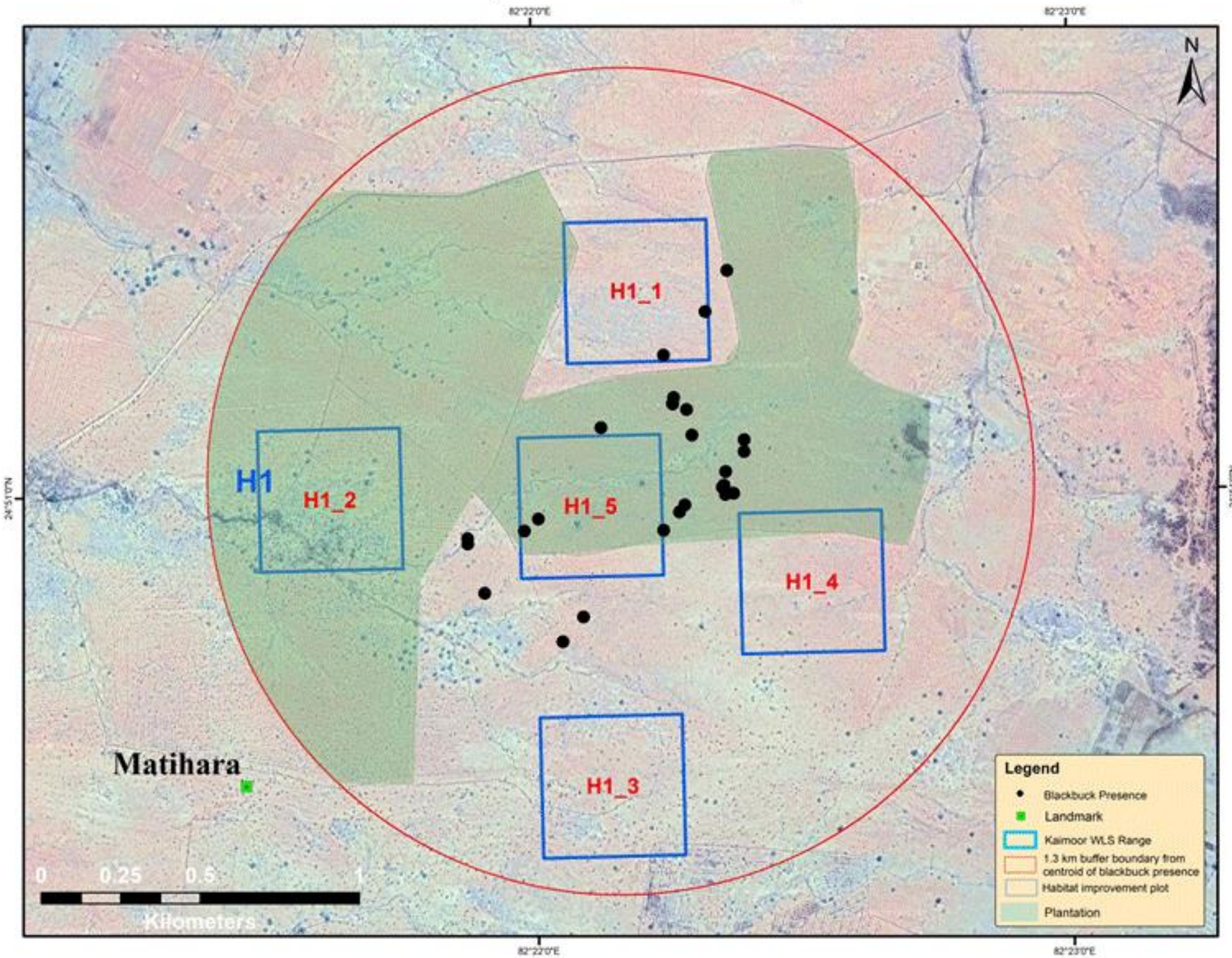
Figure 12. 4. Location and proposed area for the eradication of plantation within the identified habitat blocks (HB) for conservation of the Indian antelope or Blackbuck in KWLS, UP

Plantation Area of Kaimoor range

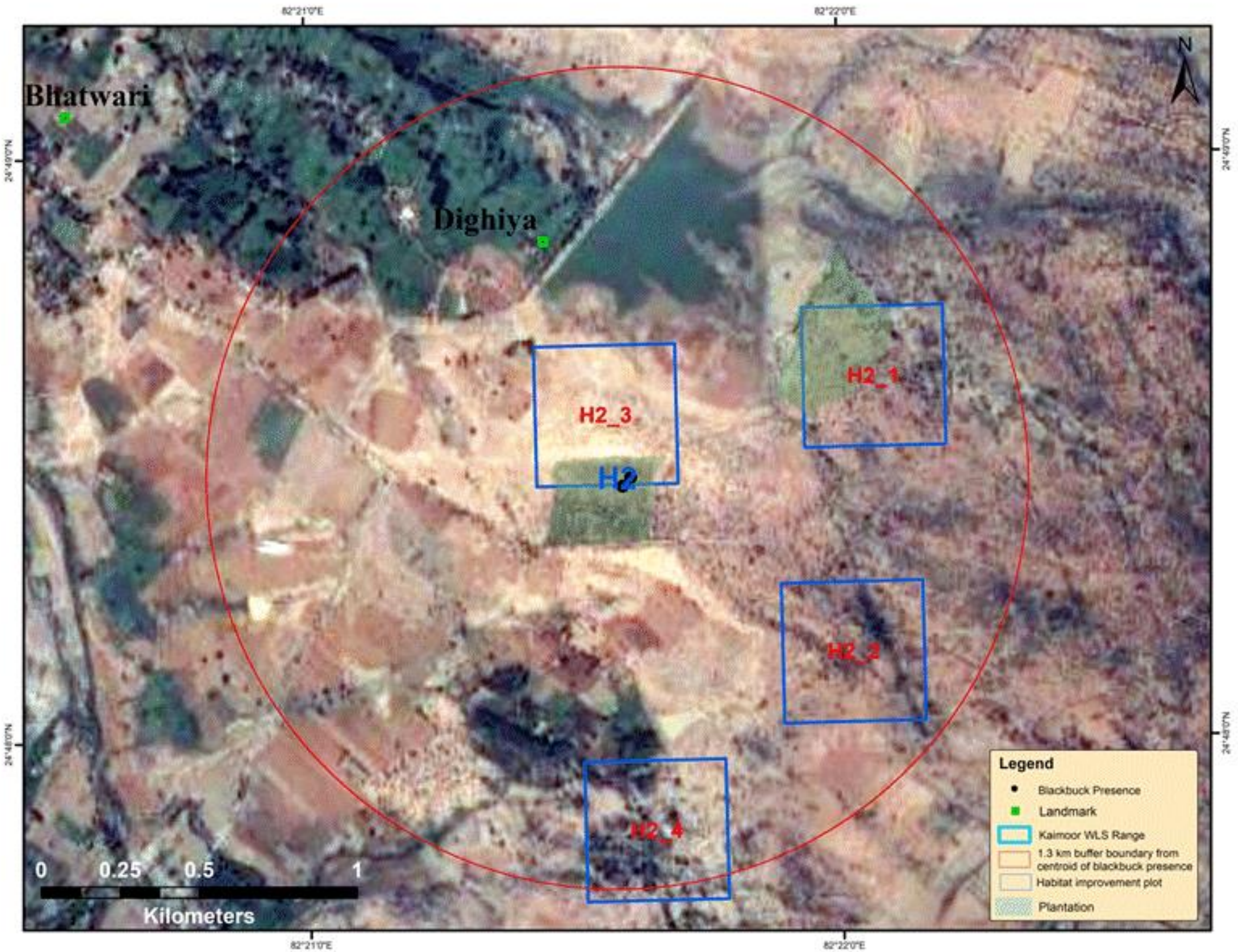
Sl No.	Range	Name	Area in ha	Centroid Lat	Centroid Long
1	Halia	H1_P	237.11	24°51' 7.078" N	82°21' 58.254" E
2	Halia	H2_P	8.51	24°48' 24.580" N	82°21' 33.080" E
3	Halia	H2_P	11.18	24°48' 40.851" N	82°21' 59.267" E
4	Halia	H3_P	31.95	24°43' 9.274" N	82°23' 52.326" E
5	Halia	H4_P	24.21	24°39' 30.088" N	82°23' 21.236" E
6	Halia	H4_P	0.55	24°40' 4.515" N	82°23' 42.505" E
7	Halia	H4_P	0.89	24°39' 58.469" N	82°23' 45.832" E
8	Halia	H4_P	3.05	24°39' 53.761" N	82°23' 50.509" E
9	Halia	H4_P	133.01	24°39' 31.497" N	82°24' 0.790" E
10	Halia	H5_P	73.82	24°42' 52.039" N	82°26' 7.983" E
11	Halia	H5_P	25.52	24°43' 11.660" N	82°26' 33.575" E
12	Halia	H6_P	8.87	24°41' 14.035" N	82°29' 31.825" E
13	Halia	H6_P	72.30	24°40' 33.268" N	82°29' 26.804" E
14	Halia	H6_P	32.16	24°40' 57.781" N	82°28' 56.560" E
15	Halia	H6_P	30.40	24°41' 14.990" N	82°28' 58.625" E
16	Ghorawal	GH1_P	668.14	24°48' 13.954" N	82°48' 28.930" E
17	Robertsganj	R1_P	14.13	24°37' 58.069" N	82°58' 6.967" E
Total area			**1375.79**		

Range: Halia (H)

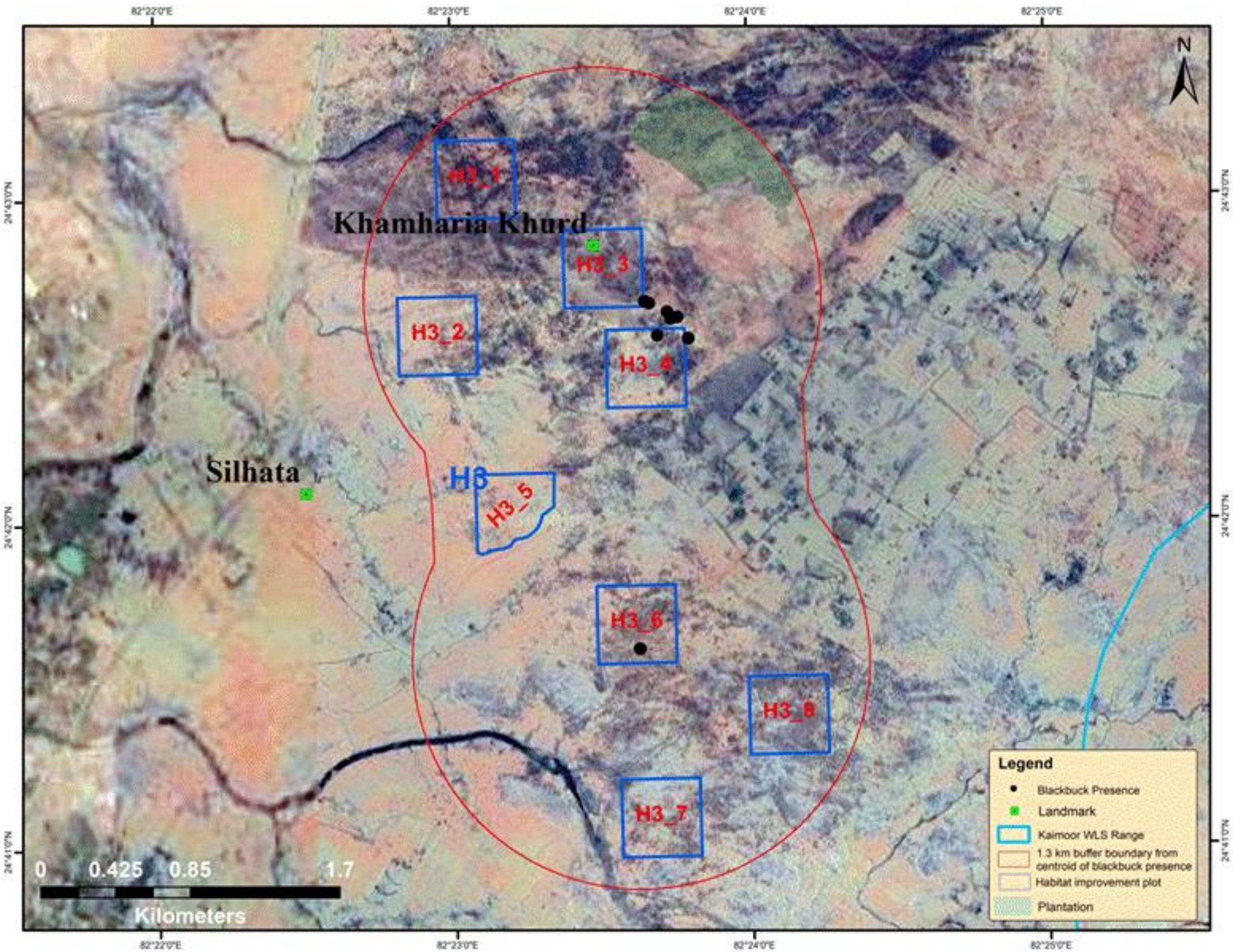
Plantation area of H1
(Total area: 12 km²)



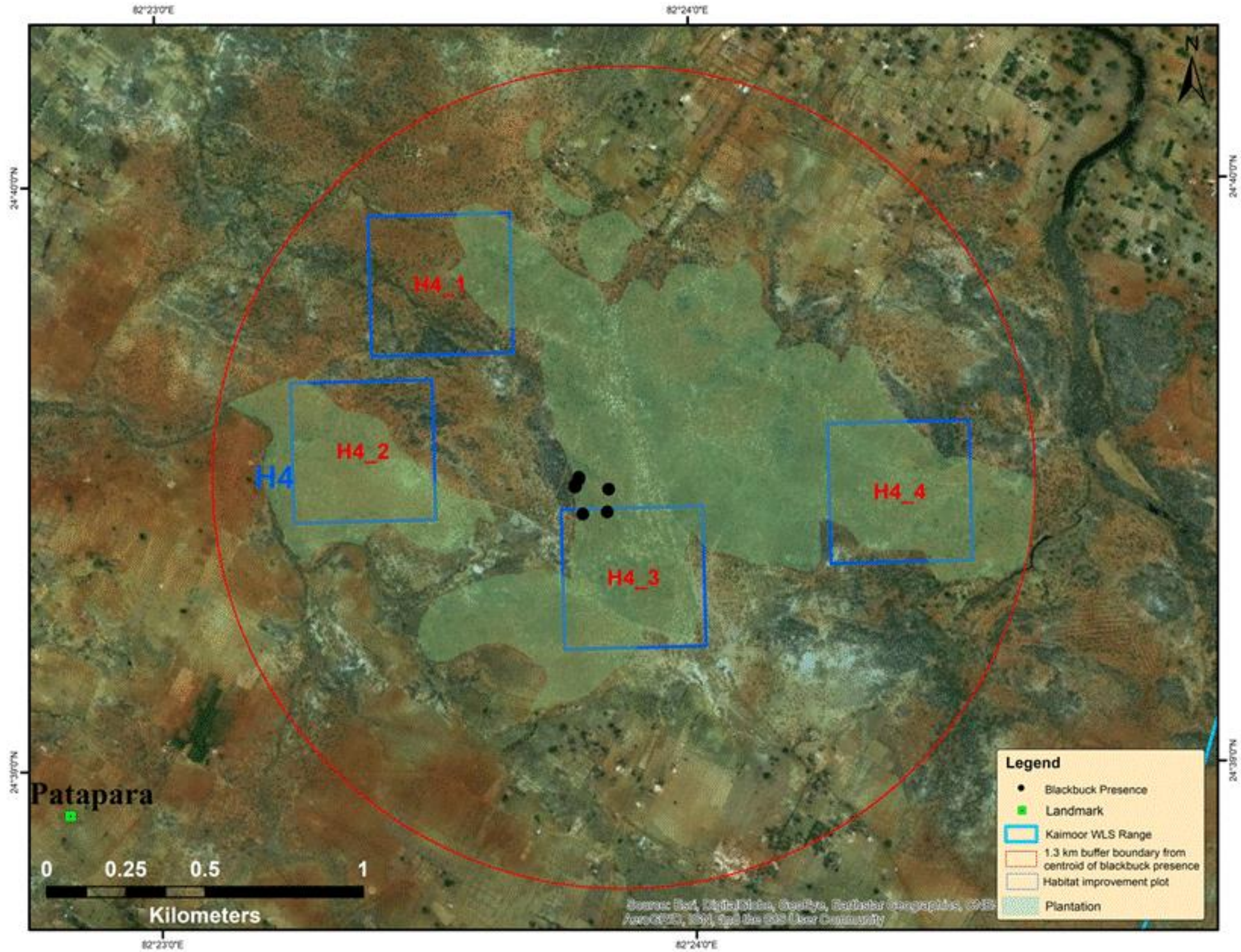
Plantation area of H2



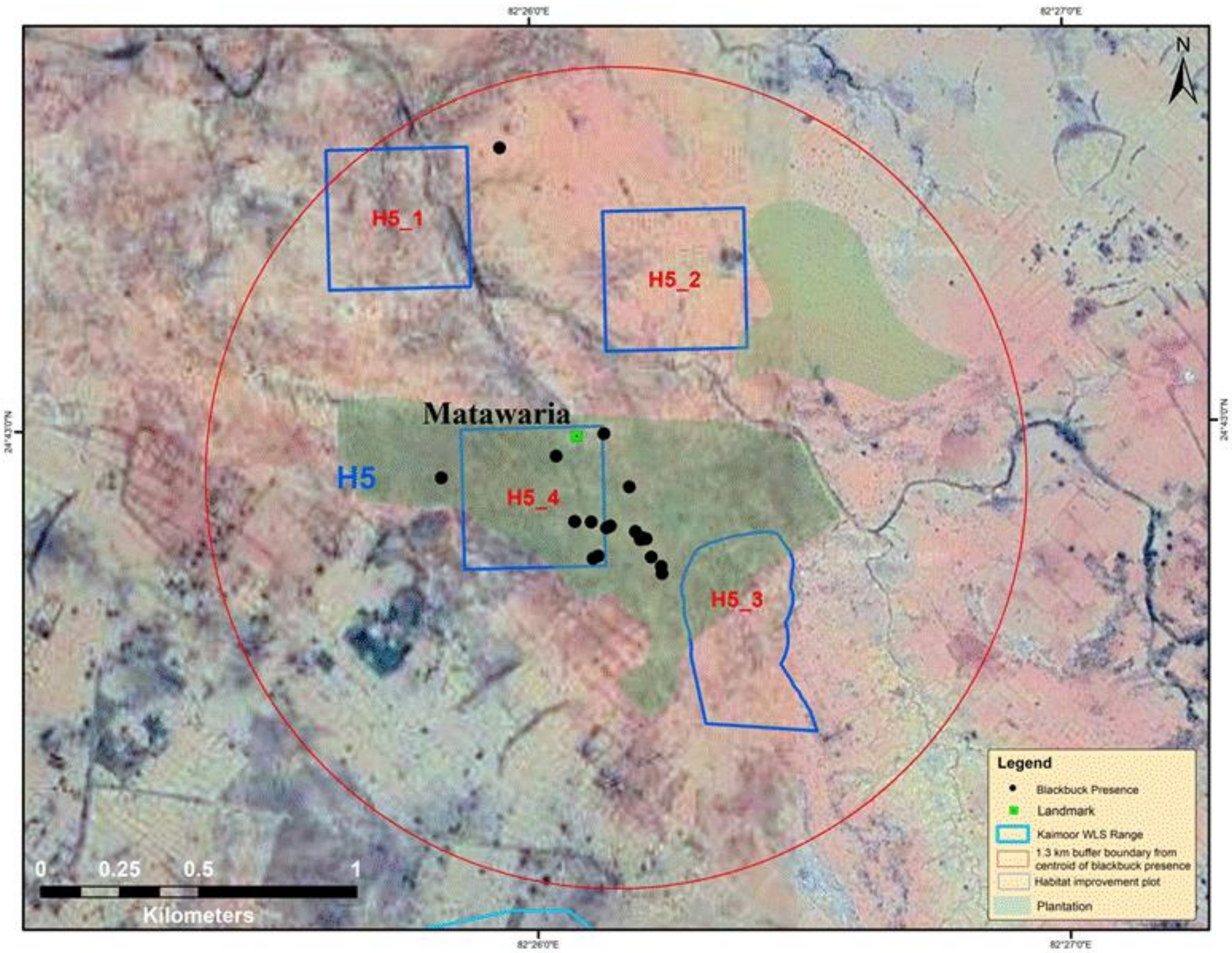
Plantation area of H3



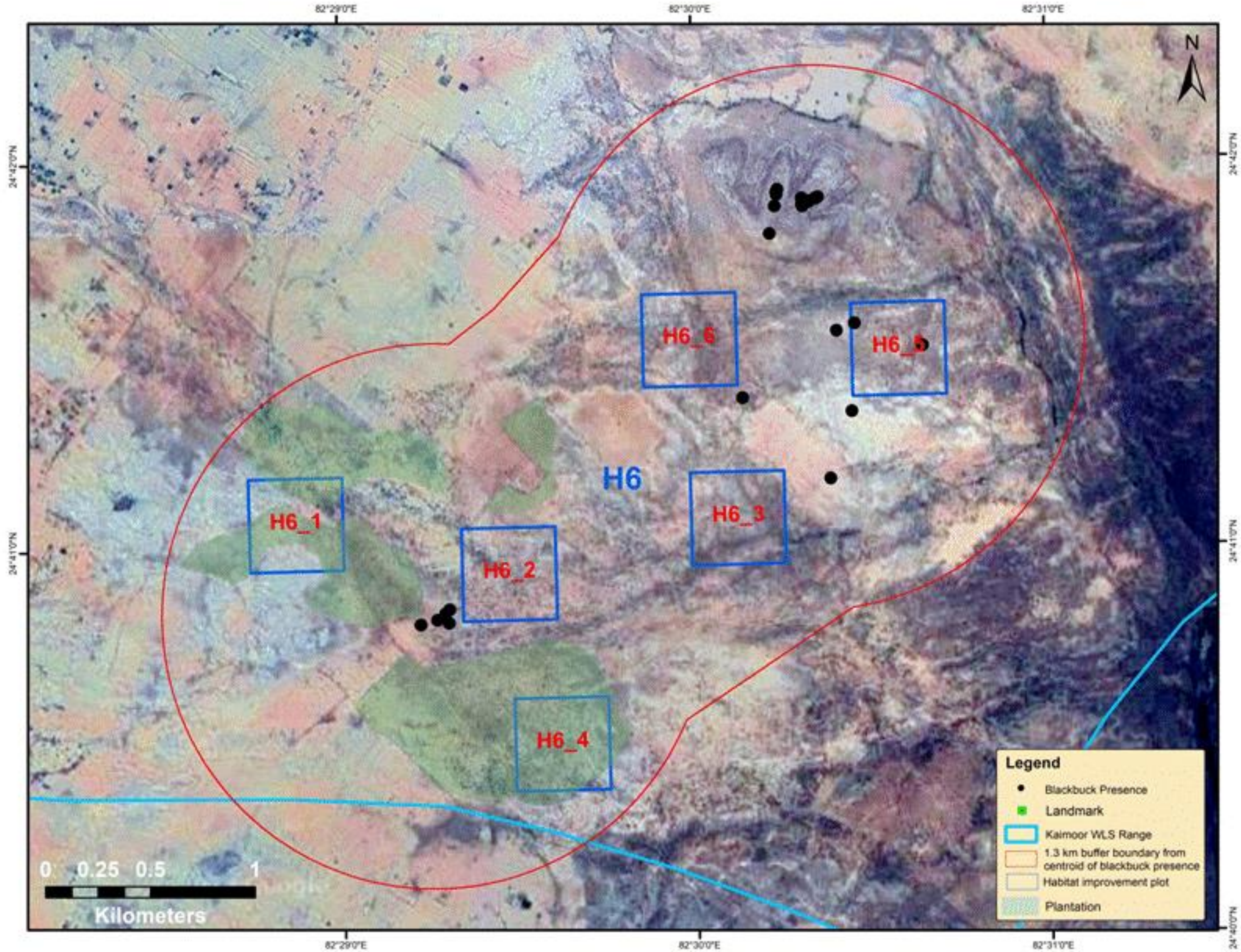
Plantation area of H4



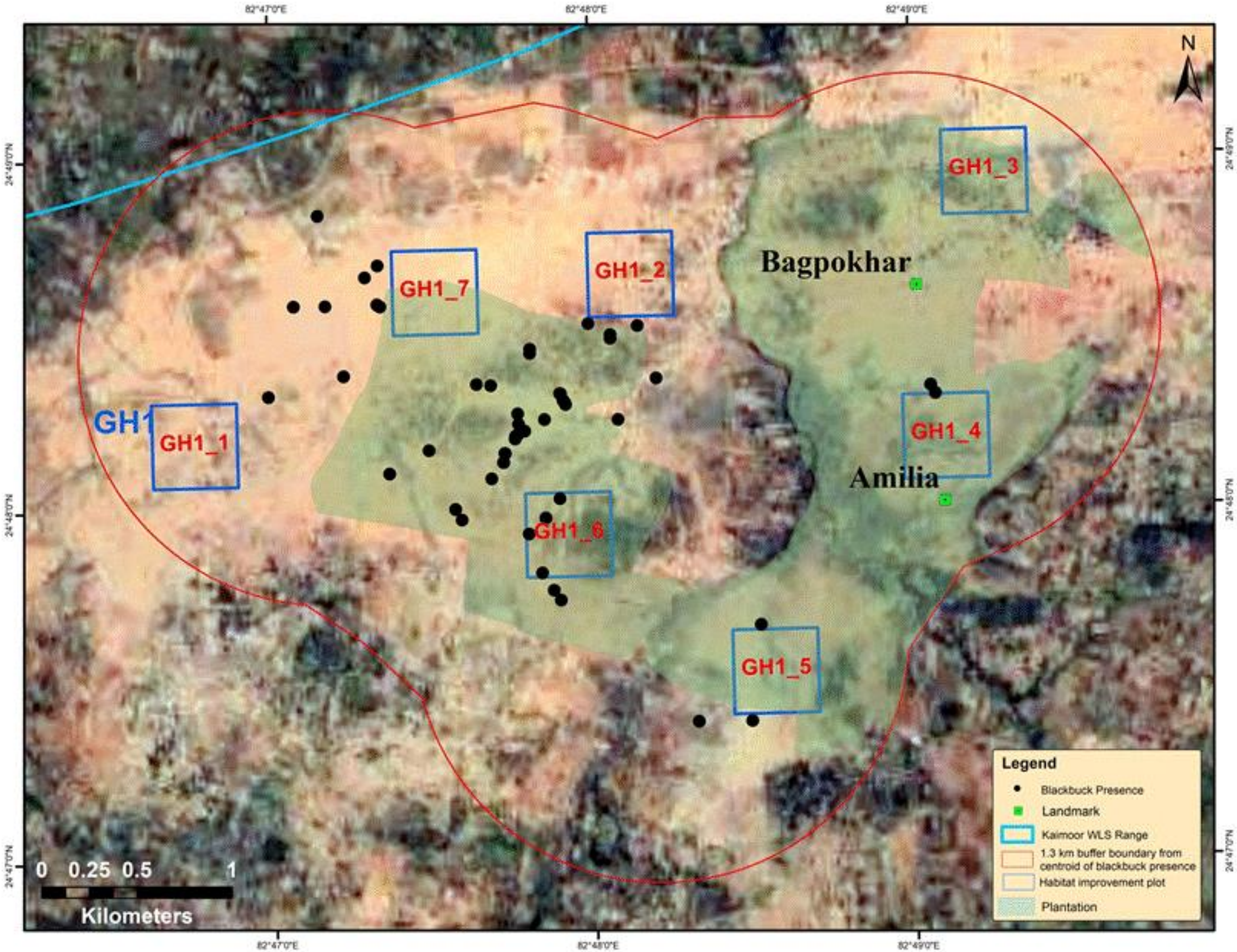
Plantation area of H5



Plantation area of H6



Plantation area of GH1



Plantation area of R1

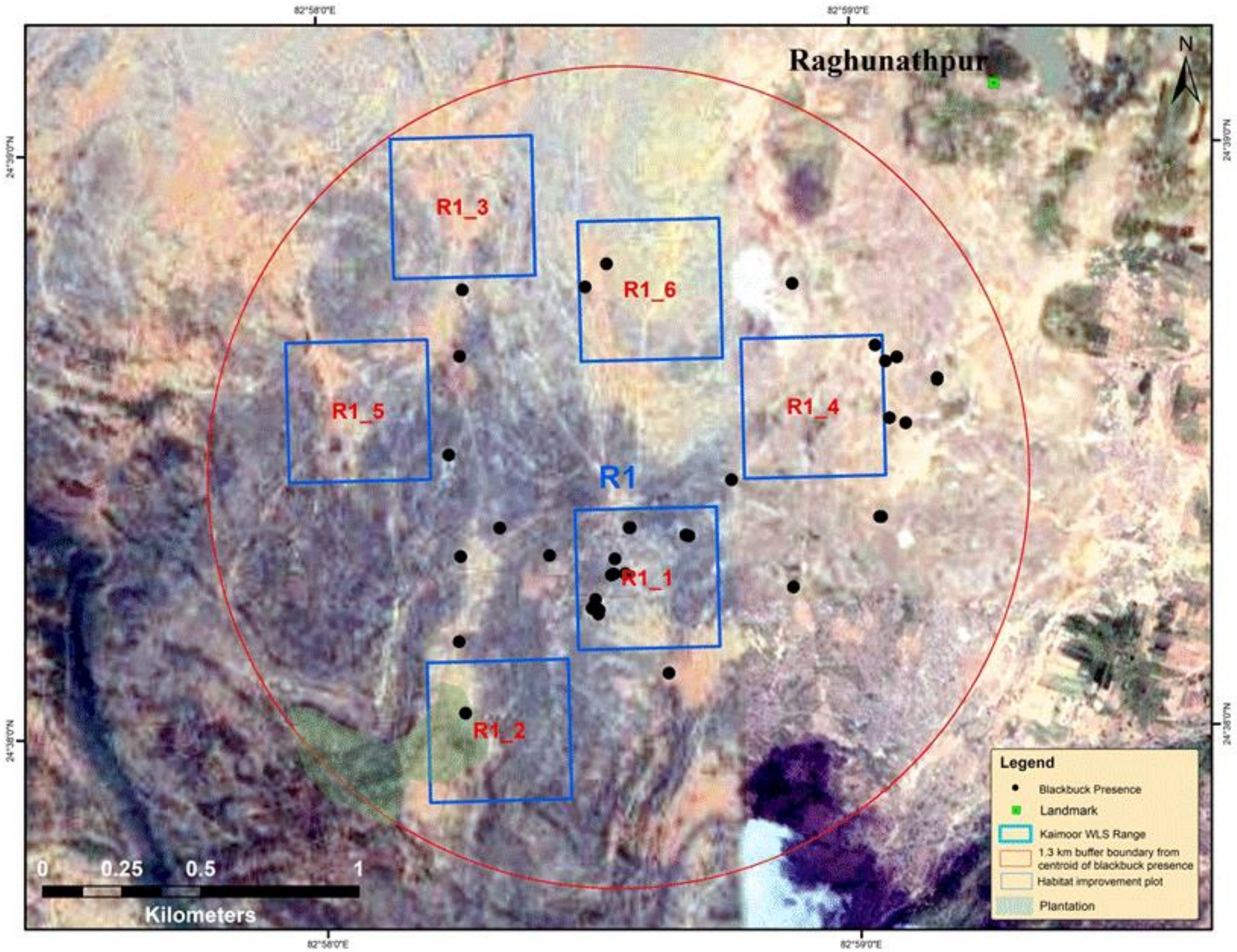
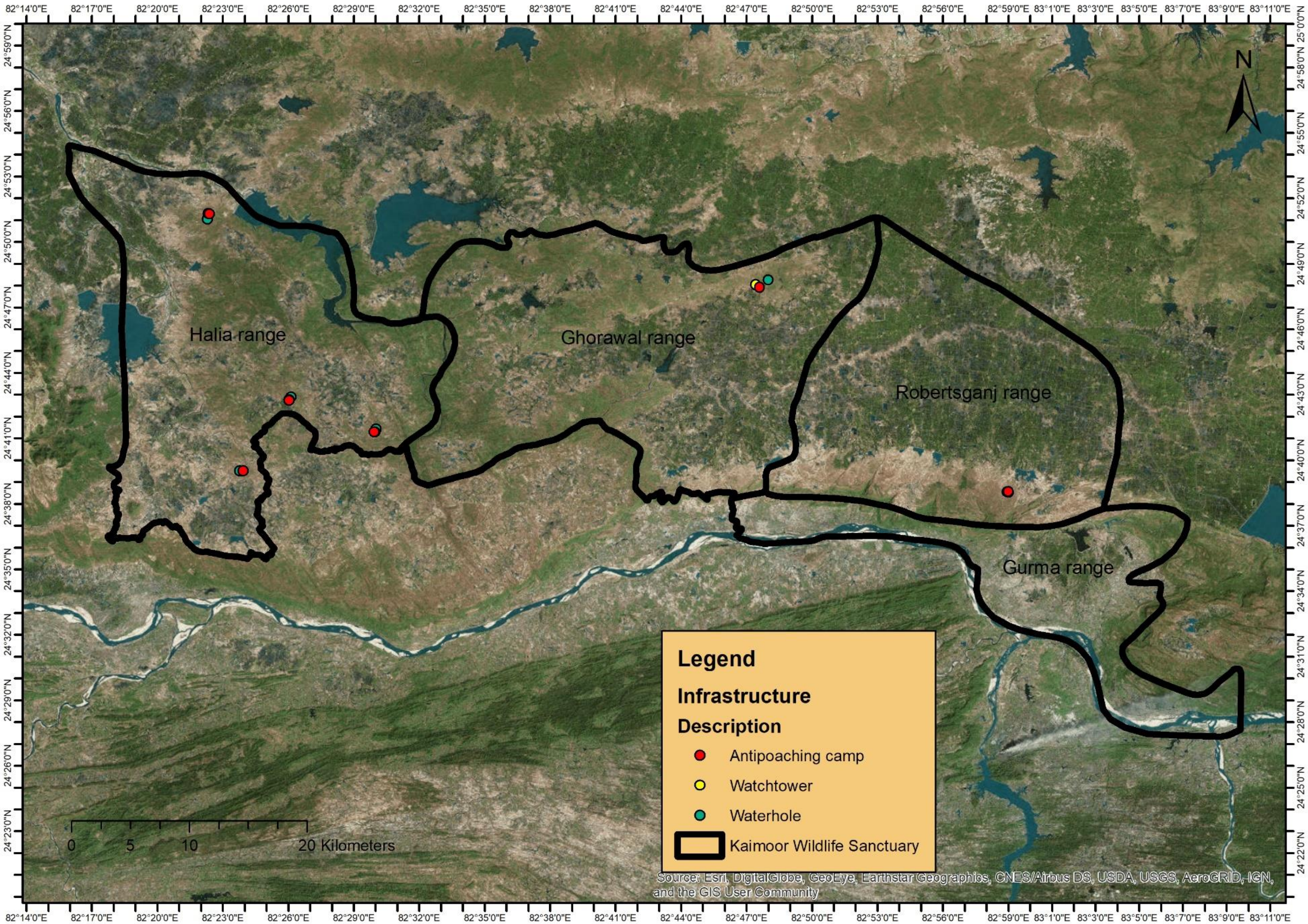


Figure 12. 5. Location of suggested antopoaching camps, waterholes and watchtowers for conservation of Indian antelope or Blackbuck in KWLS, UP


Halia range
Ghorawal range
Robertsganj range
Gurma range
N
Legend
Infrastructure
Description
Antipoaching camp
Watchtower
Waterhole
Kaimoor Wildlife Sanctuary
0 5 10 20 Kilometers
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Annexures

Annexure I

Annexure-A

कार्यालय प्रमुख वन संरक्षक, वन्य जीव, उत्तर प्रदेश, लखनऊ।

पत्रांक:- /26-11 (वेल्सपन एनर्जी) लखनऊ, दिनांक अक्टूबर, 15 2014

सेवा में,

मुख्य वन संरक्षक,
मीरजापुर क्षेत्र,उ0प्र0
मीरजापुर।

विषय:- ग्राम ददरी खुर्द, तहसील-सदर, जनपद मीर्जापुर में मेसर्स वेल्सपन एनर्जी यूपी प्राइवेट लि0 द्वारा 2x660 एम0डब्लू0 सुपर क्रिटिकल कोल आधारित थर्मल पावर प्लान्ट की स्थापना के सम्बन्ध में प्रस्तुत Biodiversity Assessment and Preparation of Conservation Management Plan(including wildlife) के अनुमोदन के सम्बन्ध में।

सन्दर्भ:- 1-आपका पत्रांक 1151/मी0 क्षे0/33 दिनांक 18-09-2014।
2-प्रभागीय वनाधिकारी, मीरर्जापुर वन प्रभाग, मीर्जापुर का पत्रांक 995/33-वेल्सपन दिनांक 09-09-2014।

महोदय,

कृपया उपरोक्त सन्दर्भित पत्रों से प्रेषित विषयक प्रस्ताव का अवलोकन करें। उल्लेखनीय है कि ग्राम ददरी खुर्द, तहसील-सदर, जनपद मीर्जापुर में, मेसर्स वेल्सपन एनर्जी यूपी. प्राइवेट लि0 द्वारा 2x660 एम0 डब्लू0 सुपर क्रिटिकल कोल आधारित थर्मल पावर प्लान्ट की स्थापना के सम्बन्ध इस कार्यालय के पत्रांक 272/26-11(वेल्सपन) दिनांक 24-06-2014 से वांछित आख्या के क्रम मे प्रभागीय वनाधिकारी, मीरजापुर वन प्रभाग, मीरजापुर द्वारा पत्रांक 995/33-वेल्सपन दिनांक 09-09-2014 से स्पष्ट किया गया है कि प्रश्नगत परियोजना कैमूर वन्य जीव विहार, मिर्जापुर की सीमा से लगभग 25 किमी0 दूर मीरर्जापुर वन प्रभाग क्षेत्रान्तर्गत प्रस्तावित है। परियोजना की स्थापना व कार्यान्वयन के सम्बन्ध में प्रस्तावक विभाग द्वारा 10 वर्षों हेतु प्रभाग के पादप व जन्तु जगत के संरक्षण उनसे प्रासंगिक विषयों के सन्दर्भ में प्रस्तुत Biodiversity Assessment and Preparation of Conservation Management Plan (including wildlife) में 184.15 लाख रूपये का प्राविधान किया गया है। उक्त के सम्बन्ध परीक्षण व वांछित आख्या के क्रम में आपके पत्रांक 1151/मी0 क्षे0/33 दिनांक 18-09-2014 से प्रश्नगत Biodiversity Assessment and Preparation of Conservation Management Plan (including wildlife) से सहमति के साथ प्रतिहस्ताक्षरित कर अनुमोदन हेतु प्रस्तुत किया गया है।

अतः आपके पत्रांक 1151/मी0 क्षे0/33 दिनांक 18-09-2014 द्वारा की गयी संस्तुति के क्रम में प्रस्तुत Biodiversity Assessment and Preparation of Conservation Management Plan (including wildlife) निम्न शर्तों के अधीन अनुमोदित कर संलग्न किया जाता है।

1- उक्त Biodiversity Assessment and Preparation of Conservation Management Plan (including wildlife) में वन्य जीवों के संरक्षण हेतु प्रस्तावित कार्यों का कार्यान्वयन सुनिश्चित

करने हेतु उक्त प्रबन्ध योजना में उल्लिखित Monitoring Committee का गठन कर जिसका अनुमोदन मुख्य वन संरक्षक, वन्य जीव पश्चिमी क्षेत्र, उ0प्र0, कानपुर से प्राप्त करना होगा।

2– जनपद मिर्जापुर व सोनभद्र में कैमूर वन्य जीव विहार क्षेत्र में व सन्निकट आरक्षित वन क्षेत्रों में विचरण करने वाले काले हिरन (Black Buck) के विस्तृत अध्ययन व संरक्षण हेतु एक कार्ययोजना वन्य जीव संस्थान देहरादून से तैयार करवा कर मुख्य वन्य जीव प्रतिपालक, उ0प्र0 को प्रस्तुत करना होगा।

भवदीय,

(डा0 रूपक डे)
प्रमुख वन संरक्षक, वन्य जीव,
उत्तर प्रदेश, लखनऊ।

पत्रांक 389 /उक्तादिनांकित।
प्रतिलिपिः–निम्नांकित को सूचनार्थ एवं आवश्यक कार्यवाही हेतु प्रेषित।

1. मुख्य वन संरक्षक, (मध्य क्षेत्र), भारत सरकार केन्द्रीय भवन पाँचवा तल, सेक्टर एच अलीगंज, लखनऊ।
2. मुख्य वन संरक्षक, (वन्य जीव) पश्चिमी क्षेत्र उ0प्र0, कानपुर।
3. प्रभागीय वनाधिकारी, मिर्जापुर वन प्रभाग, मिर्जापुर।
4. प्रभागीय वनाधिकारी, कैमूर वन्य जीव प्रभाग, मिर्जापुर।
5. मुख्य प्रबन्धक, मैसर्स वेल्सपन एनर्जी यूपी प्राइवेट लि0 मिर्जापुर।

(डा0 रूपक डे)
प्रमुख वन संरक्षक, वन्य जीव,
उत्तर प्रदेश, लखनऊ।

Annexure II

WELSPUN

WELSPUN ENERGY UP PVT. LTD.

Date: 23.04.2018

To,
Dr. V. B. Mathur,
Director, Wildlife Institute of India
Post Box # 18, Chandrabani
Dehradun 248 001, Uttranchal

Subject: To carry out detail study and preparation of conservation plan for Blackbuck movement in Kaimur Wildlife Sanctuary and in adjacent reserve forests in district Mirzapur and Sonbhadra.

References: A) Letter no. Even/26-11 (Welspun Energy), 15th October 2014 of Principal Chief Conservator of Forests (Wildlife), Lucknow, U.P for Approval of Wildlife Conservation and Management Plan. Copy of Letter is attached.

B) MOM of EAC, MoEF&CC dated 24 July 2017 (attached)

Dear Sir,

A 2x660 MW coal based thermal power plant was proposed by M/s Welspun Energy Uttar Pradesh Limited (WEUPL) at village Dadri Khurd, Distric Mirjapur, UP.
As per condition no (IX) of the TOR, "*Location of any National Park, Sanctuary, Elephant/ Tiger Reserve (Existing as well as proposed), migratory routes, if any, within 10 Km of the project site shall be specified and marked on map duly authenticated by the Chief Wildlife Warden*". M/s Green Future Foundation (GFF), New Delhi was engaged to carry out the study. Field work for study was conducted between April 2012 and June 2012.

DWII OFFICE
DIARY NO.: 3987
DATE: 27/04/18

Environmental Clearance from MoEFCC was obtained from MoEFCC wide letter no. J13012/12/2011-IA.II (T) dated 21st August, 2014 with specific condition (xxi) for "*wildlife conservation plan formulation in consultation with the Wildlife Department of the State and duly vetted by the concerned Chief Wildlife Warden shall be duly implemented. An in-built monitoring mechanism shall also be put in place*".

Site specific conservation and management plans were prepared and submitted for 10 years with proposed financial outlay of Rs. 184.15 Lacs.

The plan was approved on dated 15th October 2014 by Chief Wild Life Warden (CWLW), Forest Department, Lucknow with conditions stating that:

- For conservation of Black Buck found moving in Kaimur Wildlife Sanctuary and adjacent reserved forests situated in district Mirzapur and Sonbhadra, a detailed study and conservation plan shall have to be get prepared through Wildlife Institute of India (WII), Dehradun and it shall be submitted to Chief Conservator (Wildlife), Uttar Pradesh.

Project EC was challenged in NGT for various reasons. EC was set aside by NGT and project proponent was given liberty to rectify the defect and approach to MoEFCC.

Form-1 for reappraisal of the project was submitted by WEUPL to MoEFCC. EAC dated 24 July 2017 deferred the project for want of additional information from WEUPL. Additional information required by EAC includes "Recommendation from Standing Committee of the National Board for Wildlife (SC-NBWL)"

Details of the transects laid in study area. **Annexure III**

S. No.	Transect Name	Transect Length	Round off Length	Bearing	Start Point		End Point	
					Latitude	Longitude	Latitude	Longitude
1	GO1	2.03	2	3.84	24.78278	82.80793	24.80108	82.80954
2	GO2	2.02	2	10.67	24.77939	82.69009	24.79730	82.69403
3	GO3	2.03	2	313.33	24.76833	82.57189	24.78111	82.55739
4	GO4	2.01	2	305.38	24.72099	82.63973	24.73059	82.62529
5	GO5	2.34	2	350.64	24.70364	82.73908	24.72460	82.73559
6	GO6	2.06	2	168.85	24.71303	82.57136	24.69470	82.57508
7	GO7	2.17	2	74.87	24.72744	82.56400	24.73236	82.58486
8	GO8	2.02	2	92.74	24.76544	82.77772	24.76433	82.79767
9	GO9	2.21	2	101.95	24.81097	82.60021	24.80660	82.62159
10	GO10	2.09	2	83.18	24.75906	82.59160	24.76108	82.61217
11	GO11	2.02	2	30.20	24.67123	82.78632	24.68687	82.79659
12	GO12	2.17	2	123.46	24.72970	82.68172	24.71868	82.69951
13	GO13	2.51	3	259.91	24.65289	82.75150	24.64919	82.72700
14	GO14	2.24	2	29.34	24.78278	82.74025	24.80025	82.75133
15	GO15	2.38	2	307.56	24.73267	82.63702	24.74596	82.61856
16	GO16	2.00	2	117.13	24.78328	82.65975	24.79169	82.64228
17	GO17	2.29	2	304.65	24.70750	82.78414	24.71946	82.76571
18	GO18	2.01	2	101.31	24.76153	82.65950	24.75775	82.67894
19	GO19	2.52	3	82.74	24.80225	82.77997	24.80483	82.80478
20	GURMA 1	2.04	2	262.41	24.63386	82.79019	24.63167	82.77019
21	GURMA 2	2.14	2	18.56	24.57669	82.97039	24.59489	82.97739
22	GURMA 3	2.23	2	113.87	24.55378	83.03350	24.56219	83.01350
23	GURMA 4	2.04	2	126.49	24.50214	83.07279	24.49206	83.08722
24	GURMA 5	2.09	2	71.87	24.62594	83.05661	24.63154	83.07632
25	H1	2.02	2	314.20	24.84964	82.34881	24.86153	82.33567

26	H2	2.02	2	56.55	24.75000	82.50744	24.75986	82.52419
27	H3	2.01	2	305.17	24.77468	82.40638	24.78529	82.39023
28	H4	2.01	2	150.52	24.63125	82.40219	24.61533	82.41180
29	H5	2.00	2	308.98	24.73361	82.33767	24.74483	82.32278
30	H6	3.21	3	340.75	24.70631	82.43917	24.73377	82.42902
31	H7	2.10	2	159.53	24.67733	82.31319	24.65949	82.32027
32	H8	2.24	2	60.27	24.80938	82.36437	24.81923	82.38373
33	H9	3.15	3	167.63	24.69994	82.49975	24.67211	82.50608
34	H10	2.06	2	72.01	24.66042	82.38958	24.66597	82.40897
35	H11	2.49	2	49.40	24.75979	82.44336	24.77425	82.46224
36	H12	2.01	2	289.33	24.62142	82.36144	24.62758	82.34281
37	H13	2.13	2	109.62	24.60436	82.36933	24.59771	82.38910
38	H14	2.31	2	284.01	24.71000	82.39886	24.71525	82.37678
39	H15	2.06	2	336.20	24.71964	82.48414	24.73670	82.47614
40	H16	2.02	2	219.82	24.85919	82.37497	24.84600	82.36267
41	R 1	2.02	2	270.61	24.62723	83.04144	24.62769	83.02147
42	R 2	1.11	1	3.20	24.73699	82.85121	24.74699	82.85197
43	R3	2.01	2	263.42	24.66206	82.91691	24.66036	82.89861
44	R4	2.02	2	293.16	24.75597	82.98086	24.76278	82.96411
45	R5	2.14	2	133.74	24.69947	83.00908	24.68589	83.02417
46	R6	2.00	2	5.77	24.70464	82.91561	24.72247	82.91786
47	R7	2.57	3	273.01	24.65261	82.98685	24.65417	82.96148
48	R8	2.00	2	5.39	24.78920	82.90226	24.80536	82.90418
49	R9	2.15	2	214.06	24.67622	82.85044	24.66028	82.83831
50	R10	2.43	2	326.63	24.75849	82.91976	24.77695	82.90684
51	R11	2.28	2	171.23	24.70515	82.89480	24.68476	82.89793
52	R12	2.62	3	77.67	24.72460	83.00009	24.72931	83.02547
53	R13	2.11	2	229.82	24.64411	82.98497	24.63206	82.96889

*GO= Ghorawal, H= Halia, R= Robertsganj

Annexure IV

Datasheet for Distance Sampling

Transect ID: Bearing:
Date:
Team Members: Transect Length: km
Start Time: End Time:
Start Latitude and Longitude
End Latitude and Longitude

S.No.	Species	Group Size	Male			Female			Bearing	Angular sighting distance, m	Vegetation DF/F/OF/SL/G/AL/BL	Terrain F/GS/BC	Remarks
			A	SA	F	A	SA	Fawn					

A= Adult; SA=Sub-adult; F= Fawn DF=Dense forest; F= Forest; OF= Open forest; SL= Scrub Land; G= Grassland; AL= Agriculture Land; B= Barren Land

Datasheet for Faecal Sample Collection

Annexure V

Date:

Name of person(s):

S.No.	Date	Species Name	Collected on Transect (T)/ Randomly (R) (Write transect id	Location		Remark
				Latitude	Longitude	

Datasheet for Vegetation Sampling **Annexure VI**

Date: Transect Id: Team members:..

Sampling point: Random Point: Latitude: Longitude:

S. No.	Tree (10 m circular plot)				Shrub (5 m circular plot)					Grass Cover (25X25 cm quadrate)						(10 m circular plot)		Livestock/Wild animal use	
	Species	GBH (cm)	Canopy spread		Species	X length	Y length	Av Ht. (cm)	Browsing sign (0 to 4 scale)	Quadrate No.	% cover (ocular)	3 Dominate Species			Av Ht.	Lopping sign (0-4 scale)	Species	No. of dung pile	Remark
			X Length	Y Length															
										1.									
										2.									
										3.									
										4.									

Scale: 0= No; 1=Low; 2=Moderate; 3=High; 4= Very high