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Habitat Suitability Map of Chital (*Axis axis*) in KNP with High Resolution Satellite Data

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Abstract: - Keoladeo National Park (KNP), a world heritage site is a unique ecosystem known for various resident and migratory birds. This important wetland was set aside as a bird's sanctuary in 1956 and it was elevated to the status of a national park in 1981. It has distinction of being the only Indian wetland to be included under both the Ramsar and the World Heritage convention. Chital is the third largest deer inhabiting the plains of India. Its coat is rufous brown and covered with white spots.

In the present study, habitat suitability analysis for Chital has been done in the various blocks of KNP. Each block was evaluated with respect to habitat parameters, viz., food, cover, water, space and disturbance. High resolution satellite data, IRS P6 (Resourcesat-1) LISS IV and IRS P5 (Cartosat -1) PAN data were used to generate the habitat suitability map. Data base design, creation and organization were carried out using ERDAS IMAGINE (8.7) image processing software and ARC/GIS (9.1) software. Total area of KNP was worked out as 28.96 Sq.Km. Out of total suitable area; it is observed that 60.36% area suitable for Chital. High Resolution satellite data thus can easily calculate the suitable area for ungulate.

Key words: -KNP, Lu/Lc, Satellite data, Habitat.

Introduction

In order to design meaningful conservation strategies, comprehensive information on the distribution of species as well as information on changes in distribution with time is required. It is nearly impossible to acquire such information purely on the basis of field assessment and monitoring (Heywood, 1995). Remote sensors provide a systematic, synoptic view of earth cover at regular time intervals, and have been indicated useful for this purpose (Lubchenko et.al. 1991; Innes and Koch, 1998). Utility of remotely sensed data in wildlife habitat assessment and forest mapping is now well established (Strahler, 1981; Kachhwaha, 1984 &1985). This technique could be used effectively without disturbance to wildlife and its habitat (Kachhwaha, 1984).

Wetland realms constitute one of the most productive ecosystems on the earth exhibiting a great biodiversity. These are unique situations having a great deal of ecological significance in terms of water purification, micro climatic regulation, blocking and storing nutrients, recharge of water table, as habitats and as refuge for wildlife. Moreover, virtue of their extensive geographical coverage, varied terrain, micro – and macro climatic variations, can be used profitably for meeting economic and human needs and also for environmental amelioration. Of course, much will depend on the biophysical parameters and catchments conditions of wetlands. The exploitation of such habitats necessarily will depend on the 'wise use' based on holistic, sustainable development and use- approach. Thus, looking to the importance of wetland's productive potential, these habitats can be marked as thrust areas of research for ecological investigation.

Chital is the third largest deer inhabiting the plains of India. It is belonging to the genus *Axis*. The average height of a male is 90 cm at shoulder level and that of a female is 75 cm. Its coat is rufous brown and covered with white spots. There is a dark dorsal stripe, running down from the nape to the tip of the tail. The under parts, inside of the legs, under tail, and inner side of the ear are white. The antlers are brownish with paler streaks and ivory-colored tips. In India, chital are found in the forests at the base of the Himalayas & practically throughout the Peninsula & Ceylon. The North Eastern part of Gujarat State forms the western limit to its distribution, from where it extends eastwards through most northern provinces of India except the Punjab. Assam forms its eastern limit. They also occupy forested areas of Peninsular India and Sri Lanka.

In recent years the use of high-resolution satellite data is quite common and can be obtained with the help of Remote sensing and Geographic Information System (GIS). The main purpose of GIS is to maintain and process geo-referenced data. The use of satellite remote sensing and GIS is a cost effective and quicker way to generate habitat suitability maps (Kushwaha and Madhavan Unni, 1986; Parihar et al, 1986; Singh, 1986). Prasad et al, (1994) studied the changes in the wild ass (*Equus hemionus khur*) habitat condition using remote sensing technology where changes in the land use, and vegetation cover etc. have been analyzed. In the present study, habitat analysis for Chital in Keoladeo National Park has been under taken using remote sensing and GIS techniques.

Study area

Keoladeo National Park (KNP), a world heritage site is a unique ecosystem known for various resident and migratory birds. It has distinction of being the only Indian wetland to be included under both the Ramsar and the World Heritage convention. Over 320 birds' species have been recorded in the park. Apart from birds, around 27 mammalian species are also available in the park. The most common are blue bull, spotted deer, sambar, Jackal etc. Keoladeo National Park is situated between 27° 7'06" to 27° 12'02" N latitude and 77° 29'05" to 77° 33'09" E longitude with an elevation of 572 m above msl in Bharatpur district of Rajasthan. The area of KNP is about 29 sq. km. It is a low-lying depression with a gentle slope towards the center forming a depression. The total wetland area is about 8.5 sq. km. This is the main submersible area of the park. The average elevation of the area is about 174 meter.

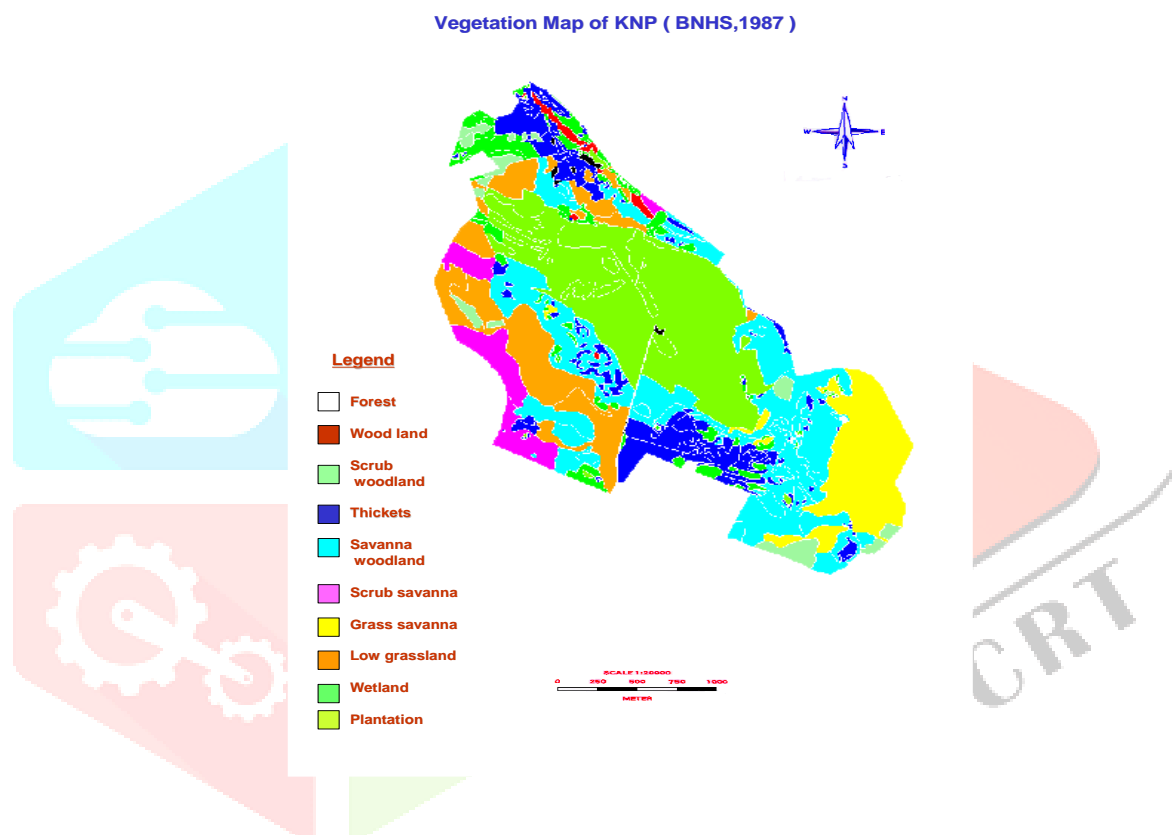


Figure-1 Vegetation map of KNP (BNHS, 1987)

Data used & methodology

Various satellite and collateral data were used for this study. The Satellite data used for the present study is presented in table-1.

Table-1 The Satellite data used for the present study

Sr. no.	Satellite	Sensor	Path-row	Date of pass
1.	IRS P6	LISS IV	202/59	19/1/07 & 14/4/08
2.	IRS P5 (Cartosat-1)	PAN	428/272	27/1/07 & 7/5/08

Methodology

Methodology can be divided in to following steps-

1. Cover type information is the primary need for food and shelter value. Vegetation map of KNP by BNHS are used as a base map. There is 10/12 categories of vegetation (figure-1). Cover type information was obtained from the maps generated by visual interpretation of satellite data & BNHS map.
2. Prepare a field data sheet, in which all information about animal habitat is included (such as block, habitat, types of vegetation, number of animals, activity, association and disturbance)
3. Seasonally (Monsoon, winter, summer) data of two years 2006-2008 were collected.

Animals were usually observed with the aid of a binocular 8×40 magnification from a distance of 30 to 240m depending upon the circumstance in different season such as Monsoon (July to Sept.), Winter (Oct. to Jan.), Summer (April to June). In each seasons 10 or 30 observation were made in early morning and evening hours of the day. The presences of species in block prefer the specific habitat, which are varies in different season. Each block have different habitat; we select the habitat type in terms of Ranks.

4. Distribution pattern & habitat preference of Chital in KNP were recorded from field data.
5. The interpreted details were transferred on to the base map on 1:50000 scale. The spatial data thus generated was entered in to GIS through digitization. In this study we use the On-Screen Digitization (Visual analysis) method. ARC / GIS 9.1 software is used for Land Use / Land Cover mapping of KNP. Visual analysis of multi-date satellite data was carried out for mapping and monitoring land use / cover changes for KNP.
6. Satellite data are procured from NRSA Hyderabad. Collateral data are collected from SOI, BNHS, and KNP park management. All digital maps (Satellite data and collateral data) are registered in ERDAS (8.7 version) software.
7. Various prominent features like road, canal, boundary and settlement etc., were taken as control points in the preparation of base map using Survey of India (SOI) topographical maps on 1:50 000 scale.
8. Land use /Land cover map of KNP was prepared using merged high resolution satellite data.
9. Identified the various habitats from high resolution satellite data.
10. Habitat suitability map was prepared for Chital.

Table-2 Area under various vegetation / land cover categories (Source:- BNHS 1987)

Habitat	Total area in sq. km.	Area covered in sq. km.	Percentage covered
Woodland (Wood)	0.18	0.03	17
Scrub-woodland (SCD)	1.35	0.27	20
Dense to discontinuous Thickets (DST)	2.43	0.51	21
Scattered Shrub (SSH)	0.63	0.11	18
Savannah woodland to Scattered tree savannah (SWS)	6.42	1.4	22
Shrub savannah (SHS)	0.91	0.15	17
Grass savannah (GRS)	2.97	0.45	15
Low grassland with scattered tree and shrub (LGR)	3.93	1.06	27
Wetland (WET)	8.5	4.2	49
Mosaic of several types (MOS)	1.08	0.19	18

Observation & Results

Basically, a habitat is a sum total of environmental conditions of a specific place occupied by wildlife species or a population of such species. The variability observed in the number of species and number of individuals within population results from differences in basic habitat elements like food, cover, water, space and other quality of habitat itself.

1 Distribution Pattern & Habitats Preference

In monsoon, Chital are distributed in all the blocks of the KNP, but preferred the blocks F, J, K, M, C, I, L. In winter they are present in most of the blocks but preferred the blocks F, J, B, I, M, G, L. In summer, their presence is limited in some blocks, such as B, E, K, F, J. While they are recorded in some more blocks also (C, H, and N), but they do not utilized the blocks for food, cover etc. Distribution pattern is presented in table no.-3

All the nine different habitat types have been ranked according to the intensity of utilization by Chital. According to this scheme LGR is highest in terms of preference followed by SCW. SHS and GRS habitat rank the lowest. During monsoon Chital were mostly seen in LGR, DST and SWS habitats, whereas in winter, they were seen in LGR, SCW and DST. During summer it mainly utilizes shrub-dominated areas like SCW, DST and WET habitat, when most of the grasses dry up in other habitats types (table-4).

Table-3 Distribution of Chital in various block of KNP

	Monsoon	Winter	Summer
Blocks	F,J, K,M,C,I, L.	F,J,B,I,M,G,L.	B,E,K,F,J.

Table- 4 Habitat Preference of Chital in KNP

	Monsoon	Winter	Summer
Habitat	LGR, DST, SWS.	LGR, SCW, DST.	SCW, DST, WET.

Table-5 Land use / Land cover area of KNP in Winter-07

Sr. No.	HABITATS	AREA (Km ²)
1	Scrub Woodland (SCW)	7.59
2	Thickets (DST)	2.46
3	Savanna Woodland (SWS)	2.37
4	Shrub Savanna (SHS)	4.23
5	Grass Savanna (GRS)	1.56
6	Low grass land (LGR)	0.87
7	Mosaic of several types (MOS)	1.10
8	Salt affected (SSH)	0.41
9	Wetland (WET)	8.15
	TOTAL	28.74

2 Identified the Habitats of KNP From Satellite Data And GIS.

The LU / LC map of KNP was prepared (Figure-3) using image-processing software ERDAS 8.7 version and ARC/GIS 9.1 version software. High-resolution satellite data (Merged IRS P6 LISS IV and CARTOSAT -1 PAN) are useful for delineating the various vegetation classes, which represent the various habitats of ungulates. In the interpretation of Land use / land cover of the KNP, it was found that the total geographical area is 28.96 sq km. In this classification, 7 and 15 classes were identified in level-1 and level-2 respectively (Table-5).

In the level-1 classification of LU / LC, out of the total Park area, 43.34 % under forest, 28.56 % under wetland, 23.15 % under grassland, 3.83 % area under mosaic of several types, 0.60 % under saline land, 0.08 % under settlement, and 0.45 % under water bodies. In the level-2 classification of LU / LC, out of the total Park area, 26.21 % scrub woodland, 8.50 % thickets, 8.19 % savanna woodland, 3.0 % low grassland, 14.60 % shrub savanna, 5.39 % grass savanna, 3.81 % mosaic of several type, 1.41 % scattered shrub, 0.08 % settlement, 0.09 % pond, 0.46 % canal, 18.86 % dried wetland, 9.24 % plantation in wetland, 0.03 % aquatic vegetation, and 0.14 % open water.

Table- 6 Habitats identified by satellite data & GIS

SR.NO.	CLASSES		AREA	
	LEVEL-1	LEVEL-2	Km ²	%
1	1.FOREST	1.Scrub Woodland	7.59	26.21
2		2.Thickets	2.46	8.50
3		3.Savanna Woodland	2.37	8.19
		SUB TOTAL	12.43	42.90
4	2.GRASSLAND	1.Low Grassland	0.87	3.00
5		2.Shrub Savanna	4.23	14.60
6		3.Grass Savanna	1.56	5.39
		SUB TOTAL	6.66	22.99
7	3.MOSAIC OF SEVERAL TYPES	1.Mosaic of Several Type	1.10	3.81
		SUB TOTAL	1.10	3.81
8	4.SALINE LAND	1.Scattered Shrub	0.41	1.41
		SUB TOTAL	0.41	1.41
9	5.SETTLEMENT	1.Settlement	0.02	0.08
		SUB TOTAL	0.02	0.08
10	6.WATERBODIES	1.Pond	0.03	0.09
11		2.Canal	0.13	0.46
		SUB TOTAL	0.16	0.56
12	7.WETLAND	1.Dried Wetland	5.46	18.86
13		2.Plantation in Wetland	2.68	9.24
14		3.Aquatic Vegetation	0.01	0.03
15		4.Open Water	0.04	0.14
		SUB TOTAL	8.19	28.26
		TOTAL	28.96	100.00

Chital of KNP preferred the following seven vegetation types / habitats. The habitat characteristics of these classes are given below.

1. Scrub-Woodland (SCW): The LULC map of KNP (Figure- 4) shows that this category is represented by the regular presence of thorny shrubs as undergrowth, which shows the reddish-brown tone in winter season. It has cover of 7.59 sq. km. (26.21%) area in KNP. This habitat distributed in blocks A, B, J, and O. Chital utilizes this habitat for food, shelter and cover

2. Dense to discontinuous Thickets (DST): This category is represented by thorny scrub along with *Mitragyna parvifolia*, *Acacia nilotica* and or *Zizipus mauritiana*, which shows of dark red, greenish and black color. It has cover of 2.46 sq. km. (8.50%) area in KNP. Chital were preferred this habitat, for food shelter and cover. This habitat distributed in blocks A, I, N, O.

3. Savanna Woodland (SWS): The LULC map shows that a continuous grass cover with trees characterizes this habitat. Trees show reddish brown tone with scattered pattern, grasses show greenish color with soil moisture. It has cover of 2.37 sq. km. (8.19%) area in KNP. This habitat distributed in blocks B, C, E, F, G, H, J, M and N. Chital herd, mostly use this habitat for feeding, mating resting and cover.

4. Low Grassland with scattered tree and shrub (LGR): This category is represented by presence of stray & scattered trees and shrubs. LGR shows the light greenish color in satellite data. It has cover of 1.56 sq. km. (3.00%) area in KNP. This habitat distributed in blocks B, K, J, M, and N. Chital utilizes this habitat for grazing, resting, mating and for shelter.

5. Mosaic of Several types (MOS): The LU / LC map of KNP shows that various types of vegetation represent this category. So, various types of tone and texture are present in satellite image. Generally, dark red and reddish brown colors are present. It has cover of 1.10 sq. km. (3.81%) area in KNP. This habitat distributed in blocks K and L.

6. Saline zone / Scattered Shrub (SSH): This is Salt-affected area. This area essentially delineated because of the high reflectance. These appear in white to light blue color depending upon moisture content present. Chital utilize the *P.juliflora* as food, so they preferred this habitat. It has cover of 0.41 sq. km. (1.41%) area in KNP. This habitat distributed in blocks B, C, H, J, M, O, and I. Chital use this habitat only for feeding.

7. Wetland (WET): It is a waterlogged area with aquatic vegetation. Wetland area divided in to dried wetland (Light greenish colour), open water (Black to blue colour), aquatic vegetation (Pink to light pink in colour) and plantation in wetland (Red to dark red tone). This habitat distributed in blocks B, D, E, F, K, L, and N. Total wetland area is 8.19 sq.km., which covered 28.26 % of total area of KNP. Presence of Chital in this habitat is for drinking, feeding and resting.

Discussions

The land use / Land cover of KNP were prepared using merged high resolution satellite data (IRS P6 LISS IV & CARTOSAT-1 PAN data), in ERDAS 8.7 and ARC/GIS 9.1 version software. The statistics is given in table 5.

When we compared the present statistics (LULC 2007) with BNHS (1987) vegetation classes, it is observed that-

1. Forest area of KNP slightly increased from 41.21% to 42.90% (Net gain 1.69%).
2. 3.27% grassland area decreased.
3. 2.31% area increased in Wetland.

Ungulates of KNP are distributed in all blocks of KNP in monsoon & winter, while in the summer; their distribution is restricted in some blocks. The availability of food and water resources remains restricted to only certain parts of the Parks in summer. These congregate in different parts of the Park. Chital gets distributed mainly in B, C, E, F, G, I, K, L, M blocks.

During winter Chital shared the habitat with Nilgai. This may be due to the preference of woodland habitat by the males of both the species (Haque 1988). During summer Chital were mainly seen in the scrub woodland (SCW) and dense to discontinuous thickets (DST), because of the abundance of browse species on which they mainly feed as the grasses are dried in the grasslands. The tree and shrub cover used by Chital during summer was comparatively higher than that in other seasons. This may be due to the structure of the vegetation of these habitats providing important thermal and hiding cover for the animal.

Ground methods have been in use for a long time to evaluate various habitats. These methods have specific limitations like whole area can not be traversed in one instance and the information collected may not be as accurate and adequate as through remote sensing. Remote sensing provides frequent coverage and unbiased data while the GIS facilitate data base generation & spatial analysis (Habib et. al. 2006).

Nine vegetation class/ habitats are recognized from high-resolution satellite data. A comparison between BNHS data recorded in 1987 and present area calculated in 2007. From the table-8 the following are observed:

- ❖ By 'convention method' 28.78 sq. Km area of KNP, while using remote sensing and GIS, 28.74 Sq. Km areas was recorded.
- ❖ Scrub woodland (SCW) area increased from 1.62 to 7.59 sq Km. Woodland / forest area have been shrinked due to replacement of tree species by the thorny shrubs and *Prosopis juliflora*.
- ❖ Shrub Savanna (SHS) increased by 1.16 sq. Km to 4.23 sq. Km. This habitat is least preferred by ungulates and the increase in area of shrub Savanna is a sign of loss of forest & grasslands habitat.
- ❖ A major change in low grassland (LGR) habitat showed decrease from 3.38 to 0.87 sq. Km. Chital preferred this habitat.
- ❖ Conventional method & previous study showed that salt affected (SSH) area increased in KNP, but satellite data study revealed that this category decreased in KNP.

Table-7 Source, GIS Layer and Habitat parameters used for analysis

S.No.	Source	GIS Layer	Habitat parameters
1.	Remote Sensing Data	Vegetation cover	Food, Shelter, breeding area
2.	SOI Toposheets Contour map	Drainage, Road, DEM, Buffer zone	Water Disturbance Elevation Disturbance
3.	BNHS maps	Vegetation classification	Food, Shelter, breeding area

Out of total suitable area, it is observed that 60.36% area suitable for Chital. High Resolution satellite data thus can easily calculate the suitable area for ungulate.

table 8 Comparison of various habitats of KNP from conventional and satellite data.

Sr. No.	HABITATS	AREA (Km ²)	
		BNHS (1987)	LULC (2007)
1	Scrub Woodland (SCW)	1.62	7.59
2	Thickets (DST)	2.68	2.46
3	Savanna Woodland (SWS)	7.42	2.37
4	Shrub Savanna (SHS)	1.16	4.23
5	Grass Savanna (GRS)	3.08	1.56
6	Low Grassland (LGR)	3.38	0.87
7	Mosaic of several types (MOS)	1.24	1.10
8	Salt affected (SSH)	0.67	0.41
9	Wetland (WET)	7.53	8.15
	TOTAL	28.78	28.74

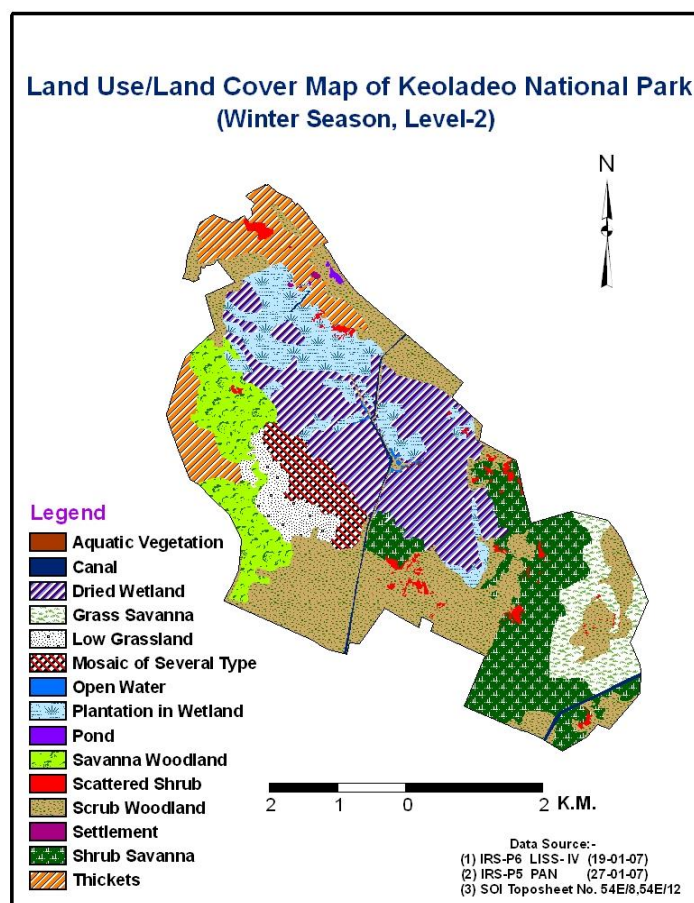


Figure- 3 Showing Land use / Land cover (Level-2) of Keoladeo National Park in winter season.

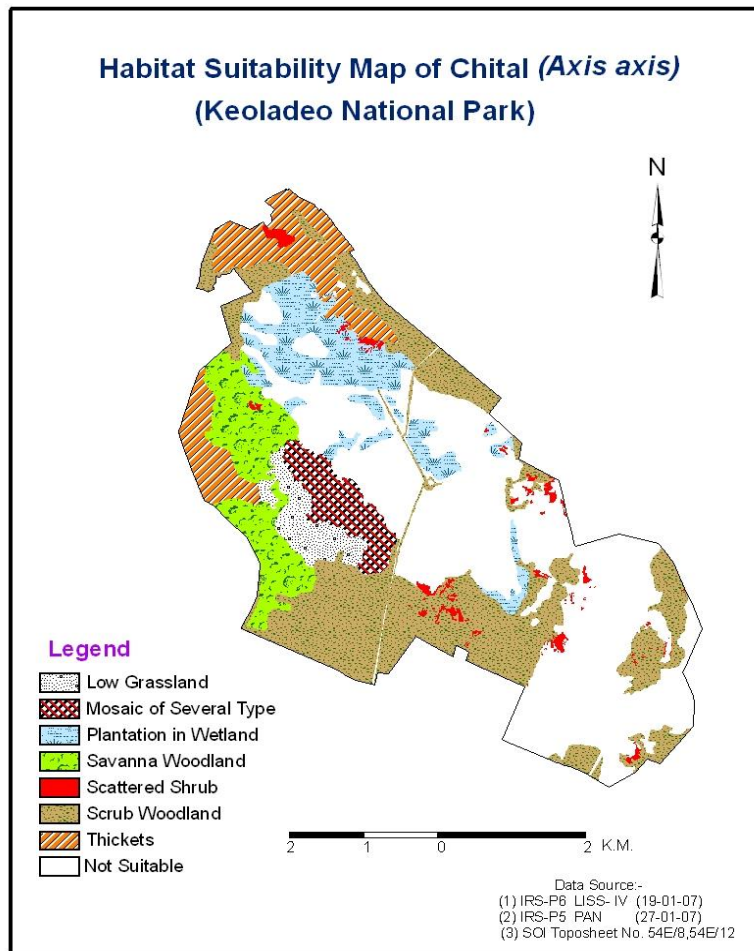


Figure-4 Showing habitat suitability map of Chital

Conclusion

In the interpretation of Land use / Land cover map of the KNP, it was found that the total geographical area is 28.96 sq km. In this classification, 7 and 15 classes were identified in level-1 and level-2 respectively.

It was concluded that some categories (forest and woodland in forest class) get transformed to other categories in the Park, while some categories decreased (Savanna woodland & Low grassland) and some categories increased (Scrub woodland & Shrub savanna). Over all, Forest and Wetland area increased to 1.69% and 2.31% respectively but grassland area is decreased to 3.27%.

Decrease in grassland area is a danger sign for grassland species of ungulates in KNP. Some year ago, sufficient number of Black Buck (Grassland species) is present in the KNP, but present time Black Buck totally disappeared from KNP.

A habitat suitability map of Chital was prepared with the help of software. Chital preferred 7 habitats. Total area of KNP was worked out as 28.96 Sq.Km. Out of this, 60.36 % area was suitable for Chital. The final habitat suitability map for Chital is given as fig.-4. The source and their corresponding GIS layers of various habitat parameters of Chital are given table-4.

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