

A photograph of a herd of elephants in a lush green field with white flowers. The elephants are of various sizes, including several adults and a few calves. They are standing and grazing in the field. The background shows a dense forest with tall trees.

**FOREST COVER & HABITAT SUITABILITY
MAPPING OF
(KORBA – AMBIKAPUR – JASHPUR –
RAIGARH BELT) CHHATTISGARH
(REPORT)**

**SUBMITTED BY:
REMOTE SENSING / GIS DIVISION
IGCMC, WWF-INDIA
172-B, LODI ESTATE
NEW DELHI
110003**

Project Coordinator

Dr. G.Areendran (Director IGCMC)

Project Team

Krishna Raj
Sraboni Mazumdar
Himanshu Govil
Rajeev Kumar
Sandeep Kumar

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Executive Summary:

This desktop study is mainly conducted in the Surguja, Korba, Koriya, Jashpur and Raigarh districts of Chhattisgarh state under the aegis of GIS (Geographical Information system) and spatial science technology.

The aim of this study is to estimate the land cover information within the entire region and to track the elephant path and the human elephant conflict zone in the area.

The extents of these districts are very vast and manually it is impossible to estimate the landuse/land cover of the entire area. It is also impossible to find out the path of the elephant and the human elephant conflict zones with in the entire region in one go.

Desktop analysis has been conducted using the secondary source of data. The terrain of the area of concern has been obtained from the contours, digitized from the Survey of India 1:50,000 toposheets. Satellite imageries of the study area have been extensively used to obtain the information on land use. Imageries of the study area has also been used to drape on the DEM (Digital elevation Model) to get the real picture of the terrain.

The strategy adopted has been to create a live database of all the entities that are required to address the operational objectives. Therefore, GIS platform (ArcGIS in specific) has been used to capture a large number of themes. It has resulted in a very versatile information base on the stretch that is graphic and highly manageable.

All the required layers such as terrain, landuse, built-up, drainage, spot height, road, etc., have been created as separate layers with extensive attributes that explains the characteristics of the theme. With the themes being separate the user has the option of viewing only the required themes simultaneously.

Having created the base framework, analysis has been made to provide the detail of AOC, which facilitate the decision makers in decision making.

1 Introduction:

Chhattisgarh a state in central India formed when the sixteen Chhattisgarhi-speaking southeastern districts of Madhya Pradesh gained statehood on November 1, 2000. Raipur serves as its capital. It is the 10th largest state of India by area of 52,199 sq mi (135,194 km²). Chhattisgarh takes its name from 36 (Chattis is thirty-six in Hindi and Garh is Fort) princely states in this region from very old times, though the listing of these 36 states has always remained a point of dispute.

It borders Madhya Pradesh on the northwest, Maharashtra on the west, Andhra Pradesh on the south, Orissa on the east, Jharkhand on the northeast and Uttar Pradesh on the north.

The Chhattisgarhi language, part of the East-Central group of Indo-Aryan languages, is the predominant language in the region. It is often regarded by linguists to be a dialect of the western Hindi, which is the official language of the state. People in southern Chhattisgarh, Bastar, speak dialects of Dravidian languages. Other languages spoken in Chhattisgarh are Hindi, Oriya, Marathi and tribal languages. The officially recognized and patronized version of the dialect is spoken in the general area in the plains of Raipur and Bilaspur division that was under the direct British administration in the 19th and (the first four decades of) the 20th centuries. The dialect in the erstwhile princely-states-area has carried a flavor distinct from that that was spoken in the "Khalsa Chhattisgarh" as the British area was known as. The language in the northern Sarguja State area has the influence on it of dialects of Vindya Pradesh, UP and Bihar. As against Chhattisgarhi, the language over there is proudly called "Sargujia" by the people of that region. Likewise, in areas in the Eastern part that came under Raigarh, Sarangarh and Phuljhar (Saraipali) States, the language has a distinct influence of Oriya on the language.

1.1 Korba:

Korba is located at 22°21'N 82°41'E 22°35'N, 82°68'E'. It has an average elevation of 252 meters (826 feet).

Korba (population 1005, 965) is a center of Korba District in the newly formed state of Chhattisgarh, India (Nov.1, 2000). It is situated at the confluence of the Hasdeo and Ahiran rivers.

1.2 Koriya:

It is between $23^{\circ} 32'$ and $23^{\circ} 18'$ North latitude and $81^{\circ} 40'$ and $82^{\circ} 14'$ East longitudes. Koriya is the administrative center of Koriya District in the north-east of the state of Chhattisgarh in India.

The District came into existence on 25th May 1998 in Madhya Pradesh State. Its parent District was Surguja. After the formation of New State of Chhattisgarh on 1st November 2000, the District falls under the Chhattisgarh State. The District has derived its Name from the Korea State, the former princely State Korea. The town of Koriya is about 369 km away from Raipur, the capital of Chhattisgarh.

1.3 Jashpur:

The North-South length of this district is about 150 km, and its East-West breadth is about 85 km. Its total area is 6,205 km². It is between $22^{\circ} 17'$ and $23^{\circ} 15'$ North latitude and $83^{\circ} 30'$ and $84^{\circ} 24'$ East longitude.

It is divided geographically into two parts. The northern hilly belt is called the Upper Ghat. The remaining, southern part, is called Nichghat

1.4 Surguja:

Surguja District is a district in the northern part of the state of Chhattisgarh in India. The district capital is Ambikapur.

It lies between $23^{\circ} 37' 25''$ To $24^{\circ} 6' 17''$ north latitude and $81^{\circ} 34' 40''$ To $84^{\circ} 4' 40''$ east longitude. 244.62 km long east to west and 167.37 broad norths's to south, this land has as area of about 16359 Sq km.

1.5 Raigarh:

Raigarh is a district of the state of Chhattisgarh, located in the eastern part of the state bordering Orissa. Kelo river flows through the district and the average elevation of the district is about 215 mts. Raigarh is basically an old city with congested, narrow curving roads. However recently it has emerged as an industrial hub with number of iron and steel industries.

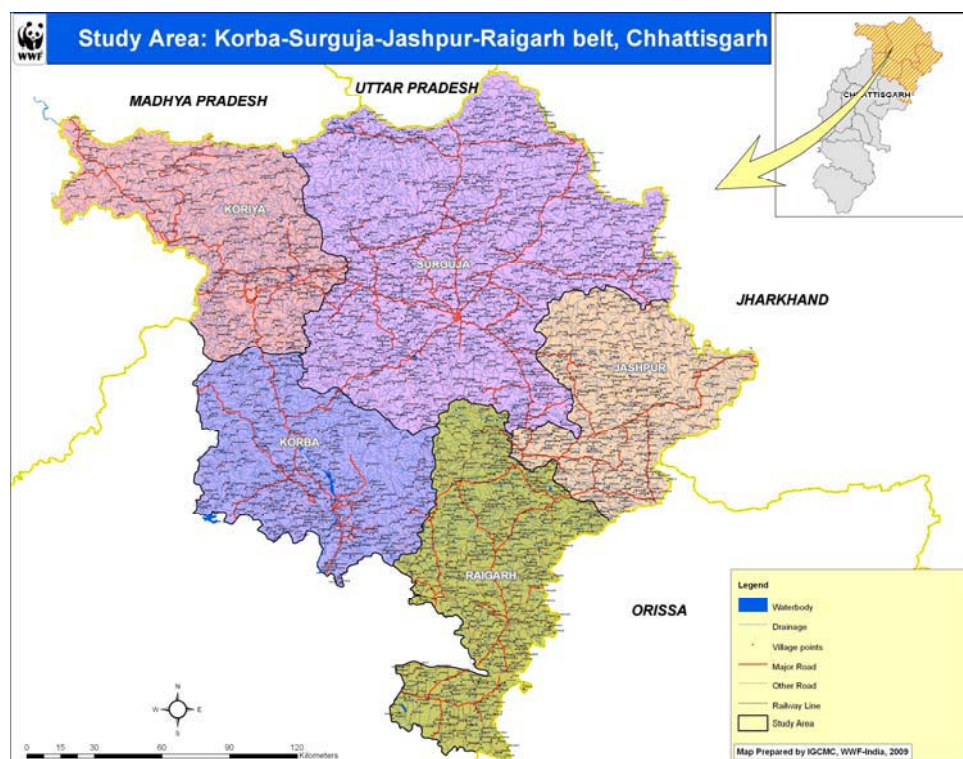


Figure 1 Study area map

2 Objectives:

The focus of the overall study is to:

Conduct a desktop study under the aegis of GIS (Geographical Information System) environment to facilitate the decision making and to know the path and the elephant conflict zone with in the AOC (area of concern) along with the detail information of land cover with the help of remote sensing technique

- ❖ GIS data creation of study area
- ❖ Forests cover assessment of AOC
- ❖ Digital database creation and thematic layer creation of physical features of AOC
- ❖ Layout preparation depicting the all the geographical features and land cover of AOC

2.1 Details of the work:

- ❖ Maps covering the administrative boundary of reserve forest and protected forest
- ❖ Forest cover and vegetation maps of study area
- ❖ District wise forest cover mapping
- ❖ Detailed analysis of area for each forest type
- ❖ Identification of natural water bodies, large streams etc. based on the satellite imagery
- ❖ Digital elevation model of AOC
- ❖ District wise map showing the human habitation and forests.
- ❖ GPS (Global Position System) data overlay to verify the analysis and features

3 Methodology:

To facilitate the work, methodology of this project had been divided into two broad spectrums

1. GIS Analysis
2. Remote Sensing Analysis

3.1 GIS Analysis:

3.1.1 Input for GIS Analysis:

All the GIS work had been performed on the SOI (Survey of India) 1:50,000 toposheets.

3.1.2 Pre-processing of the input data:

- ❖ Scanning of Topographical map in digital format
- ❖ Geo rectification of Digital map in GIS platform
- ❖ Clipping/Subset of AOC (Area of concern)

3.1.3 Digitization of the thematic layers:

- ❖ Digitization of the road layer
- ❖ Digitization of the drainage along with tributaries.
- ❖ Digitization of river and water bodies
- ❖ Digitization of village locations
- ❖ Digitization of spot heights
- ❖ Digitization of the contour
- ❖ DEM preparation

3.2 Remote Sensing Analysis:

3.2.1 Input for Remote sensing Analysis:

In this study LISS III images of IRS P6 satellites were used for the classification of landuse and land cover analysis. Details of the satellite and sensor are given below

Forest Cover Mapping

Satellite	Sensor	Orbit	Path/row	Date
IRS P6	L3 MX	21157	104-056	14 NOV 2007
IRS P6	L3 MX	21086	103-056	09 NOV 2007
IRS P6	L3MX	21086	103-055	09 NOV 2007
IRS P6	L3 MX	21356	102-056	28 NOV 2007
IRS P6	L3 MX	21356	102-055	28 NOV 2007

Table 1 LISS III images detail used for the study

Orbits/cycle	341
Semi major axis	7195.11 km
Altitude	817 km
Inclination	98.69 deg
Eccentricity	0.001
Number of orbits/day	14
Orbital period	101.35 minutes
Repetivity	24 days
Distance between adjacent paths	117.5 km
Distance between successive ground tracks	2820 km
Ground trace velocity	6.65 km/sec
Equatorial crossing time	10.30 A.M (at descending node)

Table 2 IRS P6 satellite details

3.2.2 Pre- processing of input data:

- ❖ Image extraction
- ❖ Image enhancement
- ❖ Image geo-rectification
- ❖ Image subset
- ❖ Image classification
- ❖ Overlay of DEM over the classified image

3.2.3 Post Processing of input data:

- ❖ Post processing of classified images
- ❖ Layout preparation depicting landuse of AOC (Area of concern)
- ❖ Area calculation of different landuse

3.3 Methodology Flow Chart:

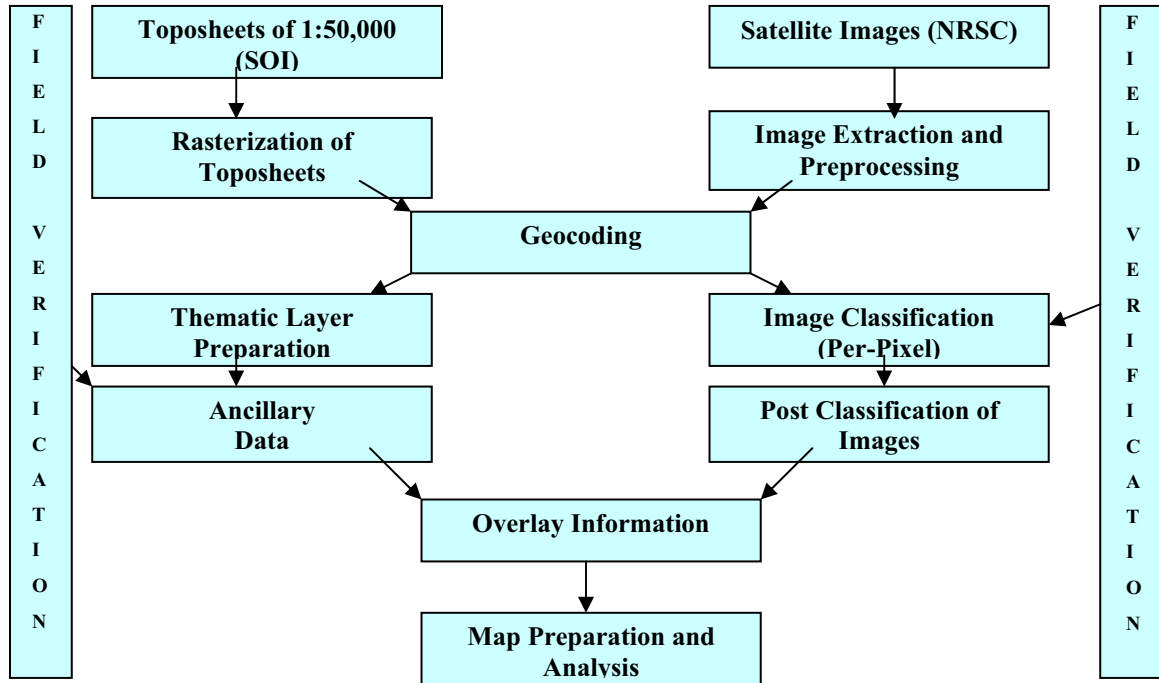


Figure 2 Methodology flow chart

4 Detailed maps of AOC:

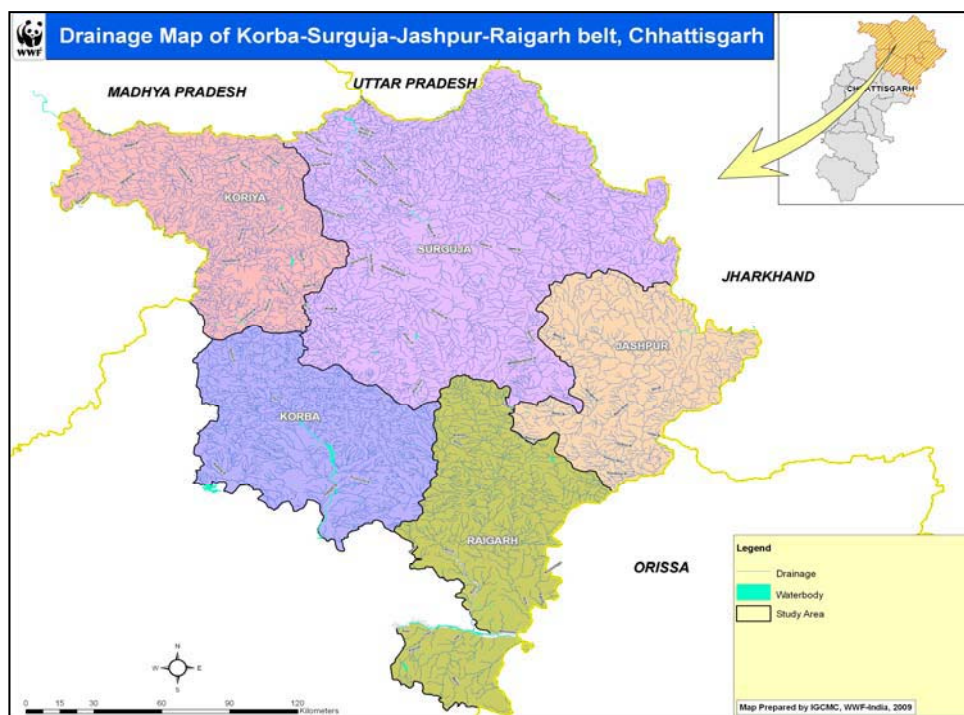


Figure 3 Drainage map of AOC

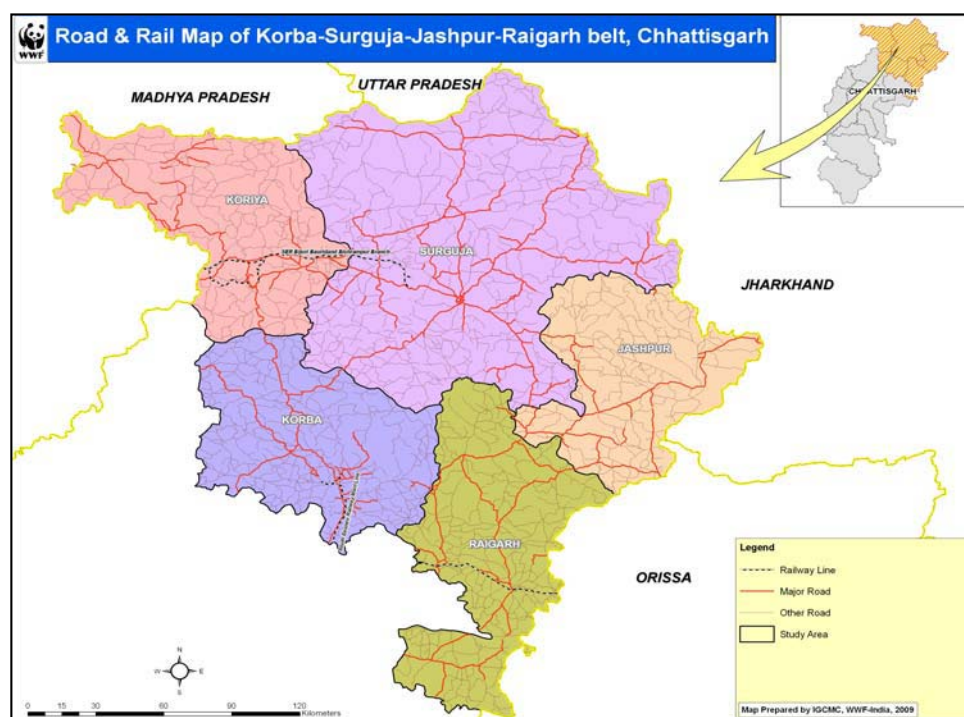


Figure 4 Road and railway map of AOC

Forest Cover Mapping

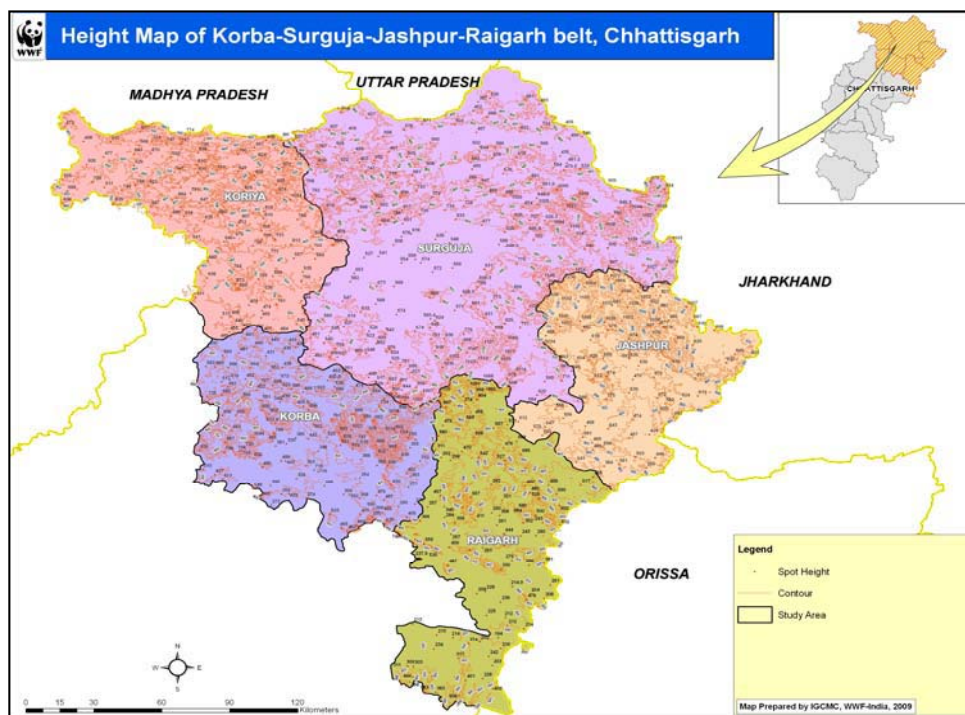


Figure 5 Height map of AOC

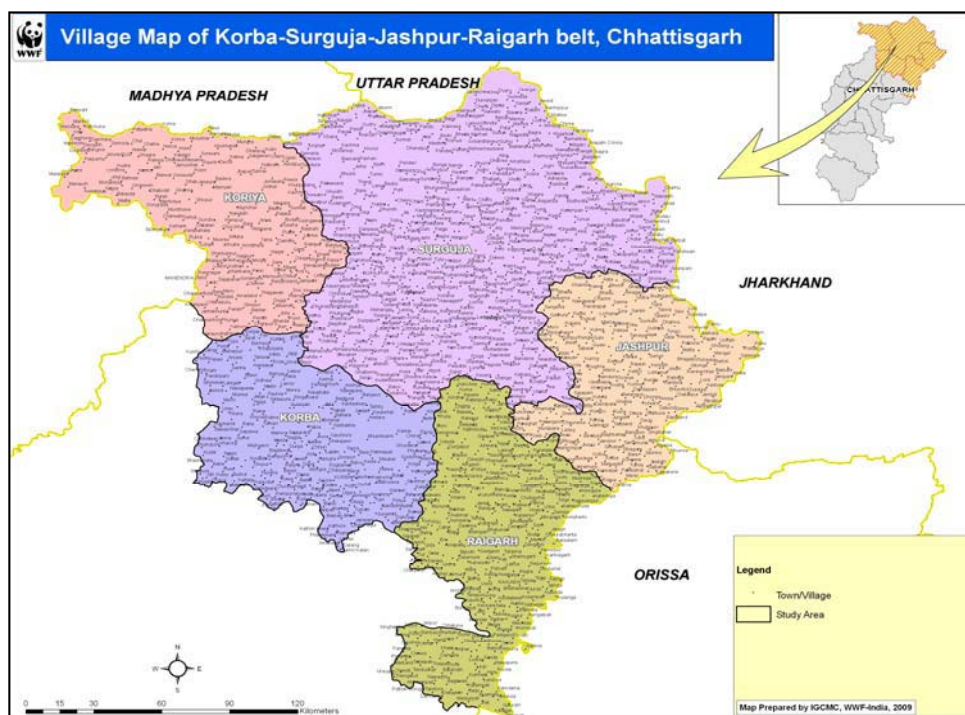


Figure 6 Village map of AOC

5 Landuse/ Landcover of AOC:

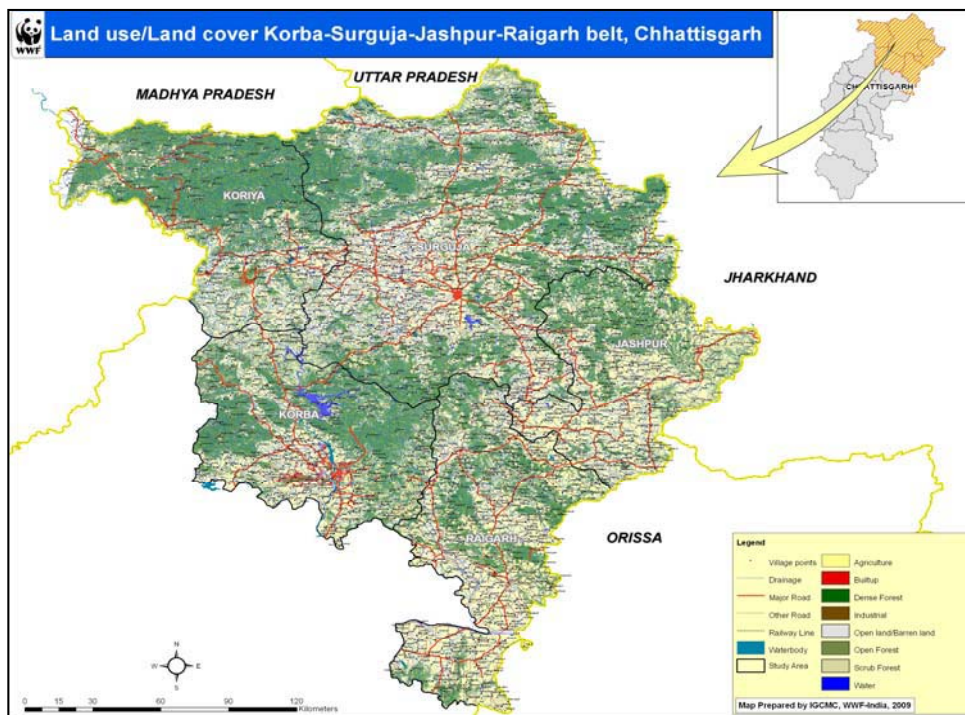


Figure 7 Landuse/Landcover map of AOC

5.1 Results:

SL NO.	LAND USE	AREA (Hectares)	AREA (Sq km)
1	Dense Forest	1177354.20	11773.54
2	Water	46738.42	467.38
3	Agriculture	1144094.80	11440.95
4	Open Forest	308617.07	3086.17
5	Industrial	8953.96	89.54
6	Open	492619.88	4926.20
7	Scrub Forest	230589.09	2305.89
8	Built-up	49061.84	490.62
	Total	3458029.25	34580.29

Table 3 Area under land use/land cover classes in the AOC

Forest Cover Mapping

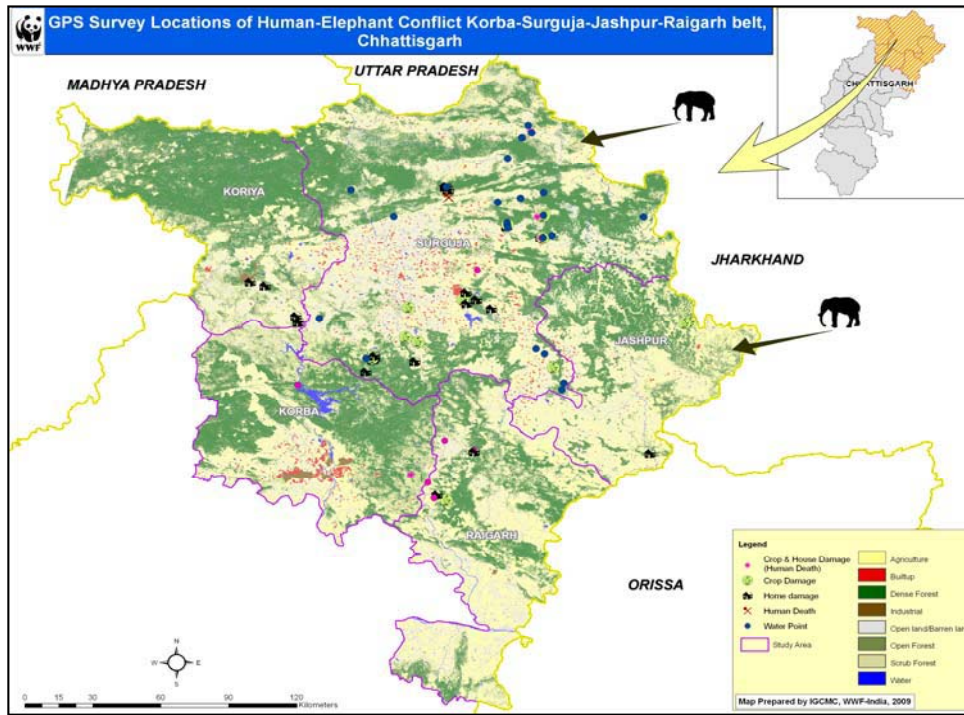


Figure 8 Human elephant conflict map of AOC

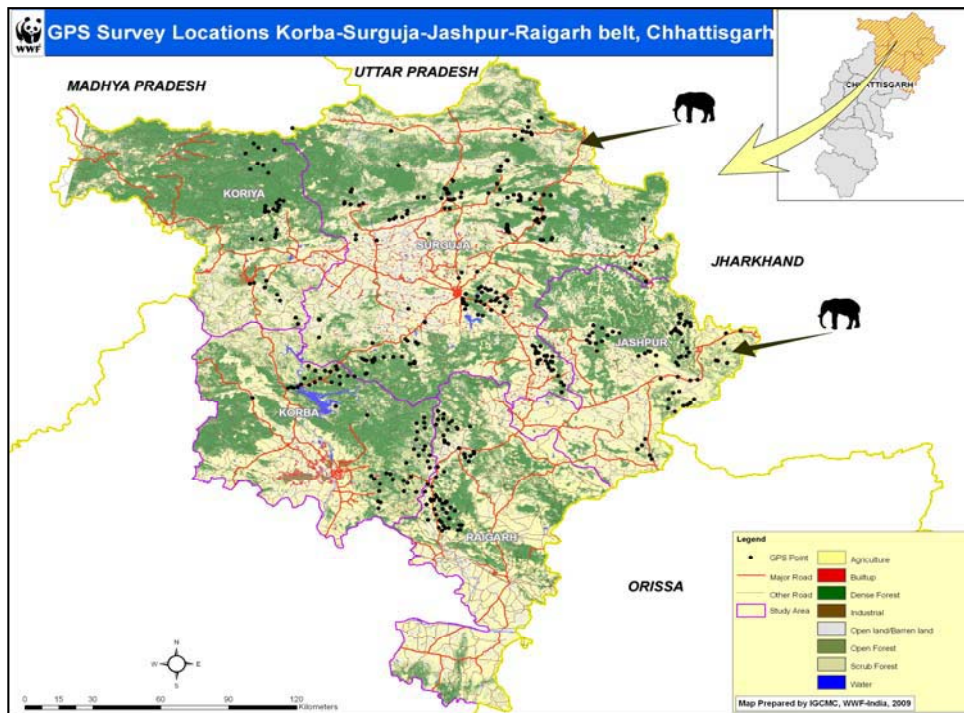


Figure 9 GPS location map of AOC

Forest Cover Mapping

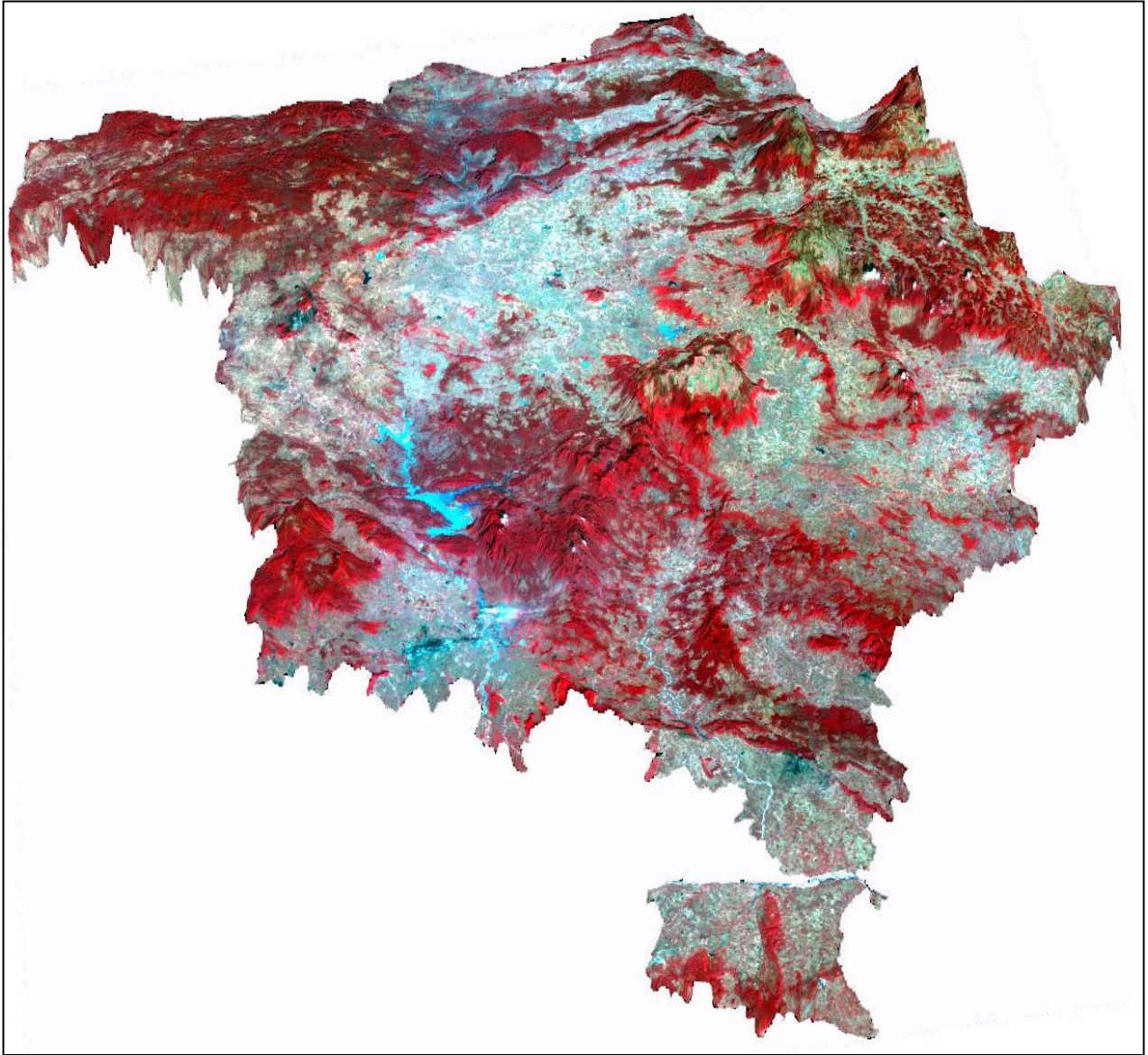


Figure 8 3D map of AOC

6 Landuse/ Landcover of Jashpur District:

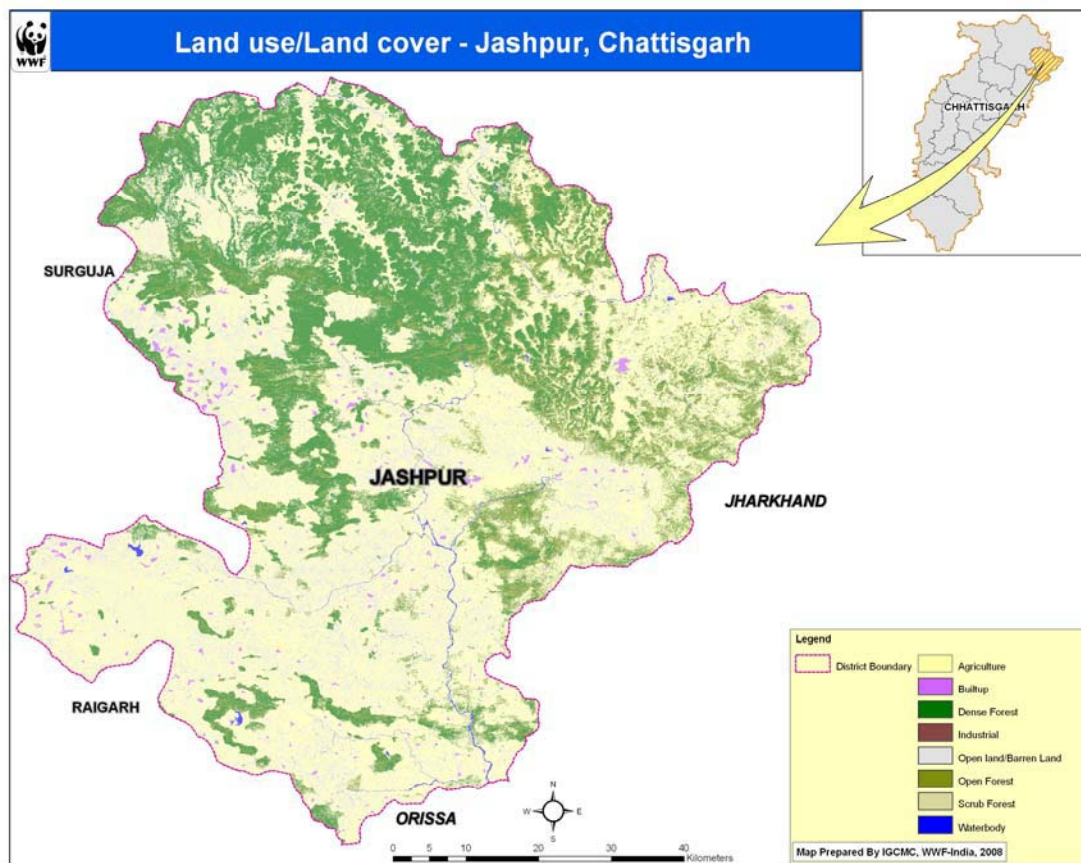


Figure 11 Landuse map of Jashpur District

6.1 Results:

SL NO.	LAND USE	AREA (Hectares)	AREA (Sq km)
1	Dense Forest	139040.67	1390.41
2	Water	4113.87	41.14
3	Agriculture	276136.04	2761.36
4	Open Forest	46513.96	465.14
5	Industrial	0.00	0.00
6	Open	95148.69	951.49
7	Scrub Forest	17169.81	171.70
8	Built-up	4080.02	40.80
	Total	582203.06	5822.03

Table 4 Area under land use/land cover classes within Jashpur

Forest Cover Mapping

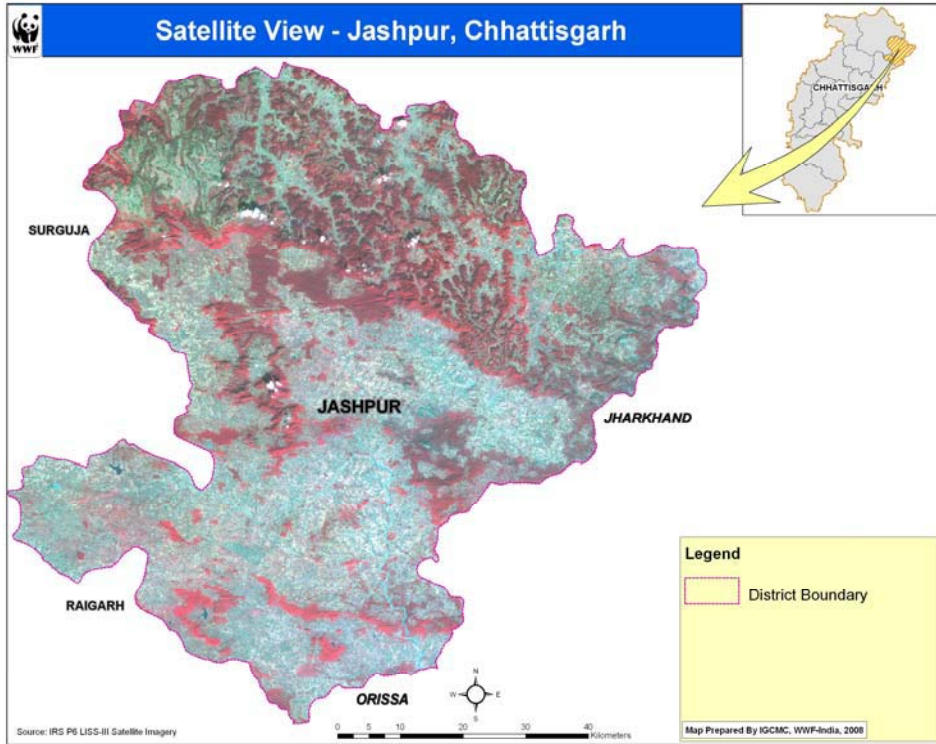


Figure 12 Satellite image of Jashpur District



Figure 13 Physical map of Jashpur District

Forest Cover Mapping

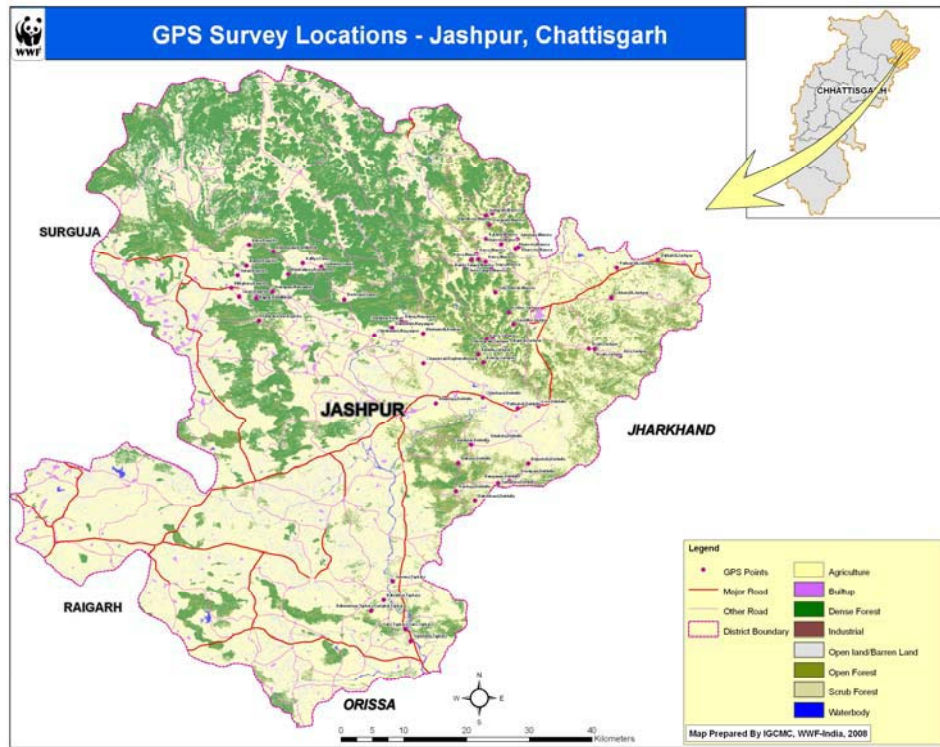


Figure 14 GPS location map of Jashpur District

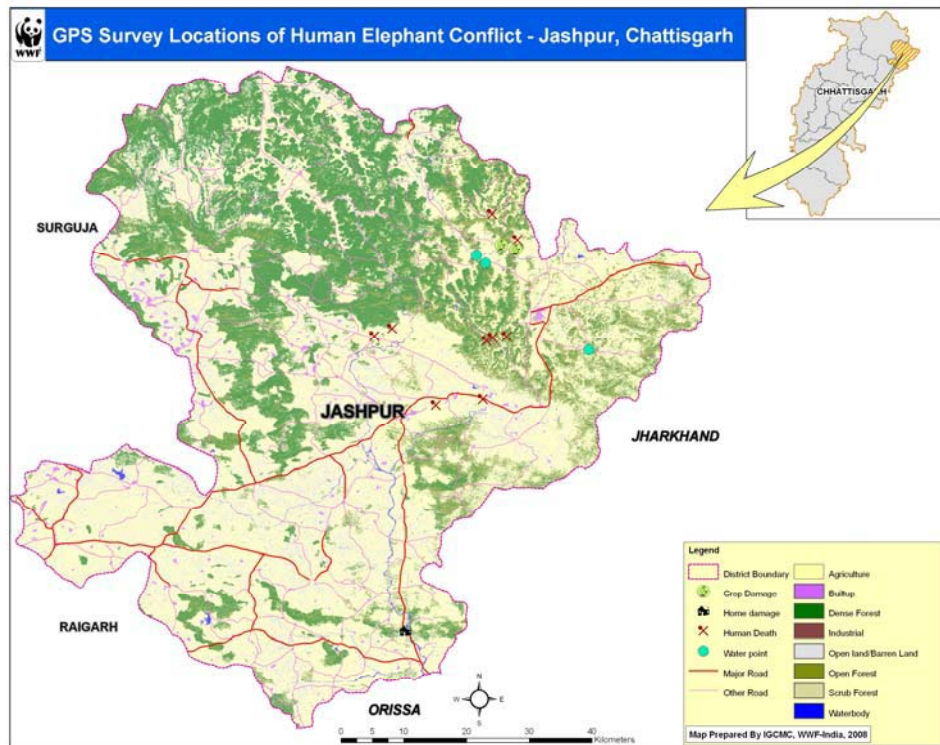


Figure 15 Human elephant conflict map of Jashpur District

7 Landuse/ Landcover of Korba District:

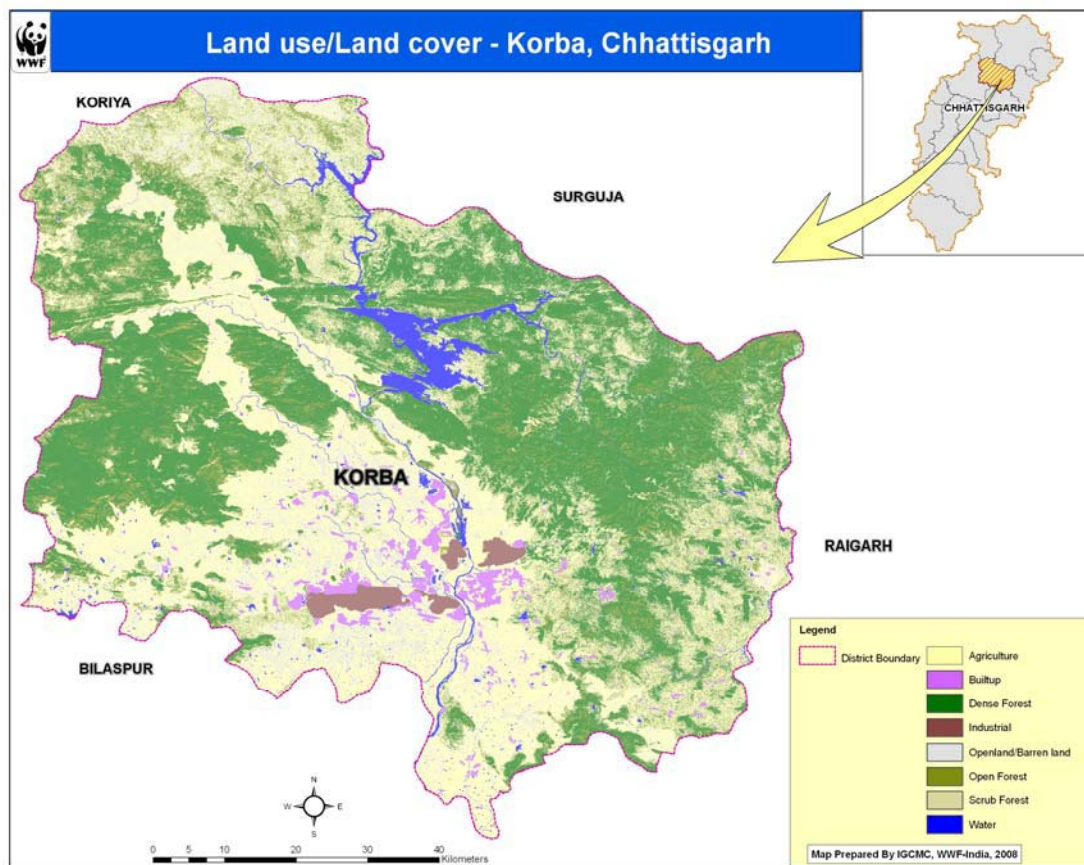


Figure 9 Landuse map of Korba

7.1 Results:

SL NO.	LAND USE	AREA (Hectares)	AREA (Sq km)
1	Dense Forest	239154.98	2391.55
2	Water	19695.89	196.96
3	Agriculture	224147.93	2241.48
4	Open Forest	61452.03	614.52
5	Industrial	6601.13	66.01
6	Open	52759.97	527.60
7	Scrub Forest	44224.08	442.24
8	Built-up	13119.83	131.20
	Total	661155.84	6611.56

Table 5 Area under land use/land cover classes within Korba

Forest Cover Mapping

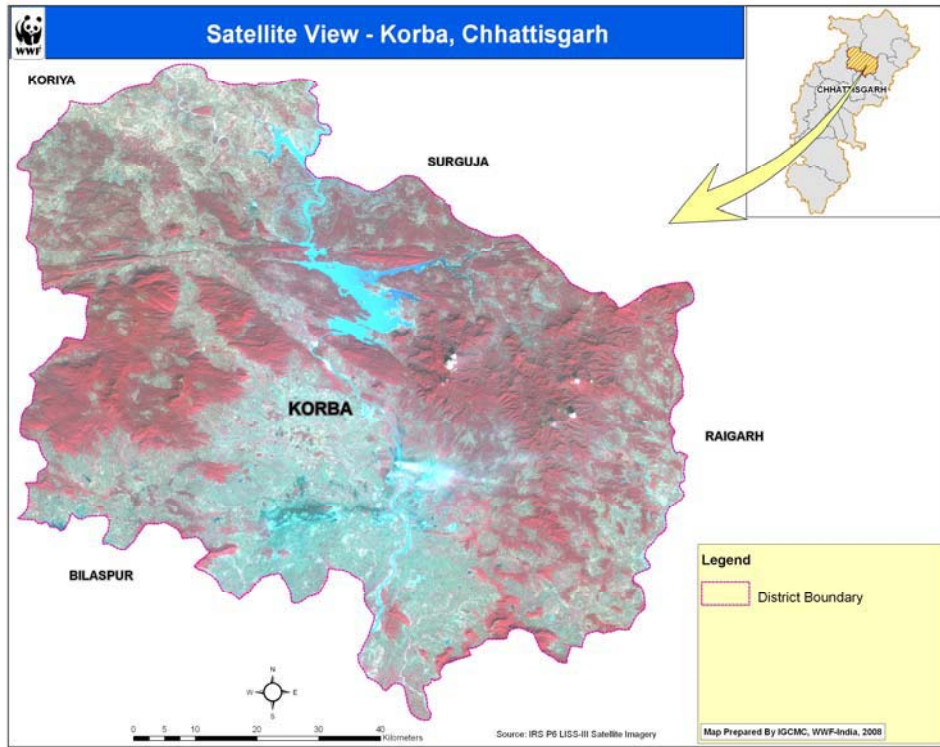


Figure 17 Satellite image of Korba

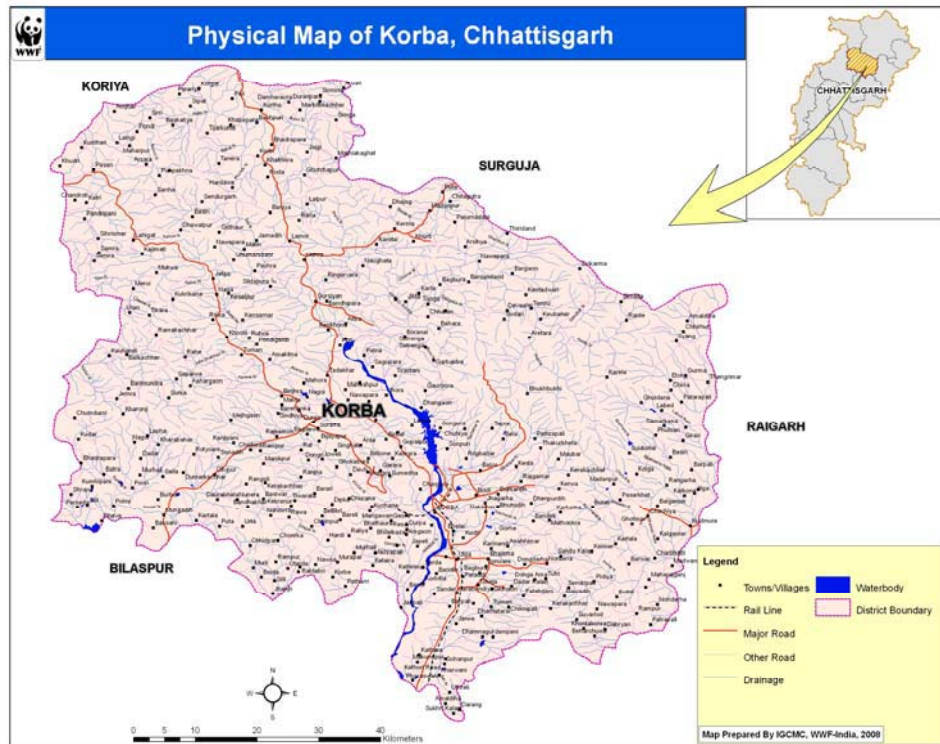


Figure 10 Physical map of Korba

Forest Cover Mapping

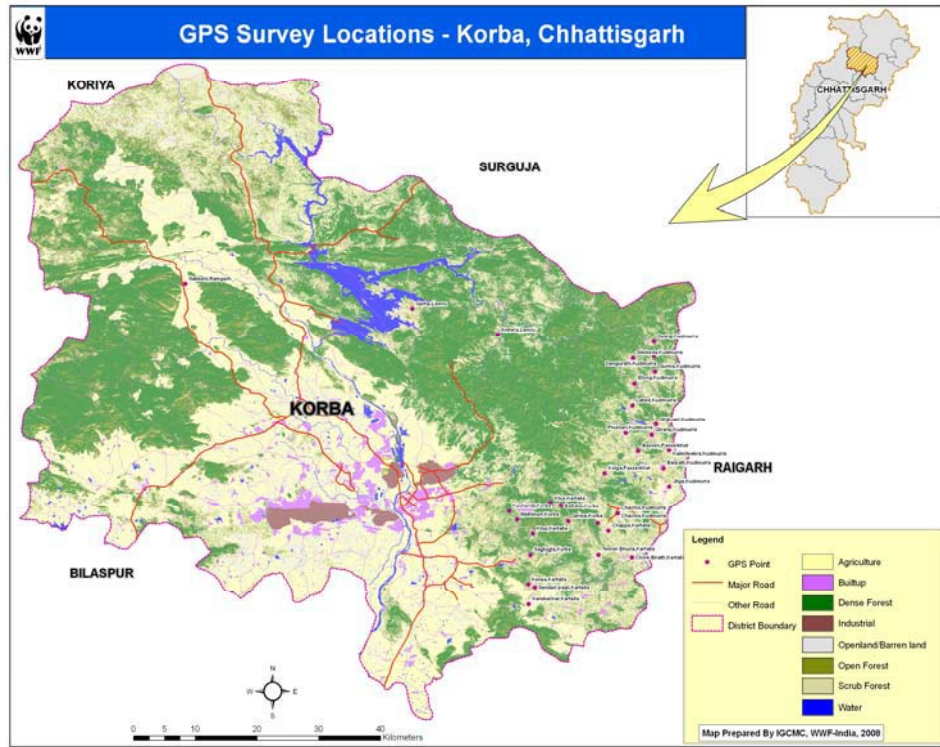


Figure 19 GPS location map of Korba

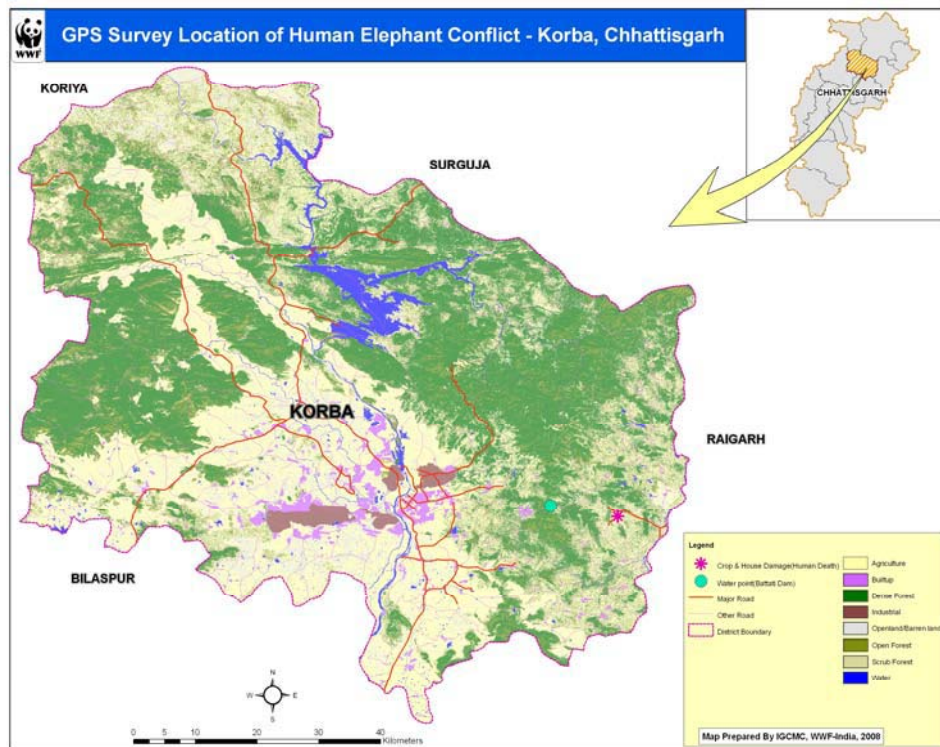


Figure 11 Human elephant conflict map of Korba

8 Landuse/ Landcover of Koriya District:

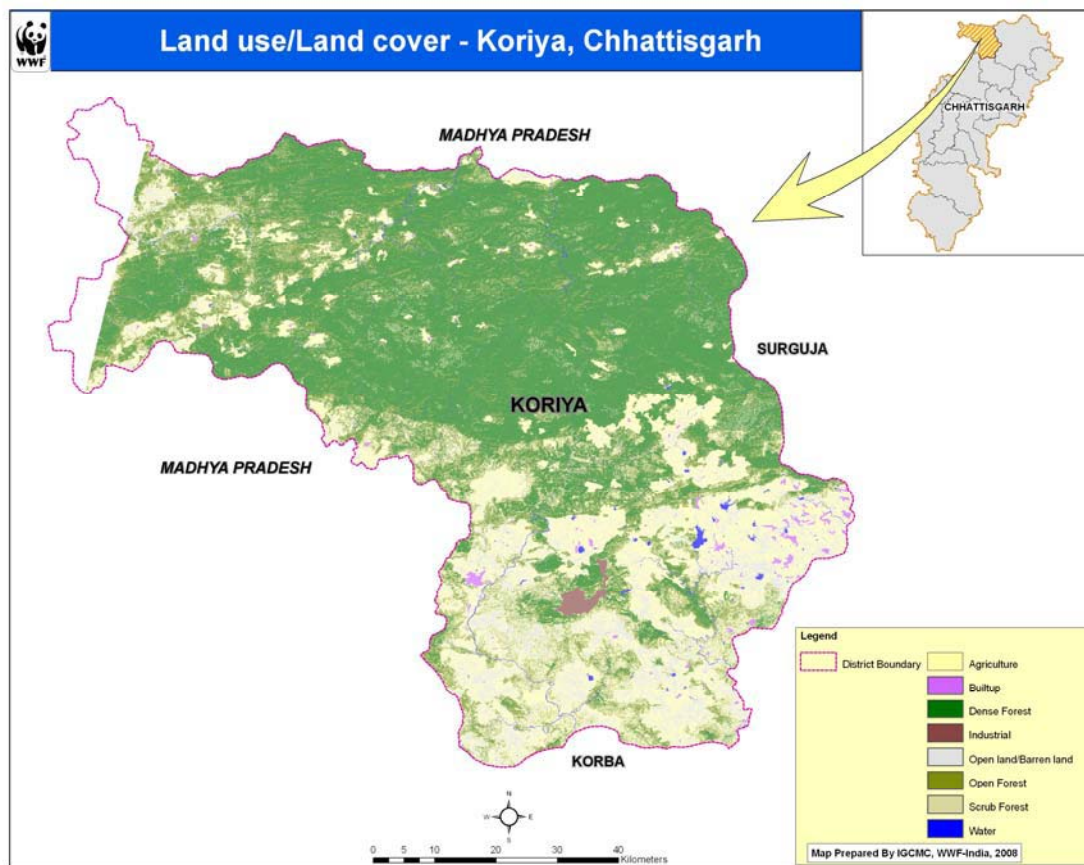


Figure 12 Landuse map of Koriya district

8.1 Results:

SL NO.	LAND USE	AREA (Hectares)	AREA (Sq km)
1	Dense Forest	303521.95	3035.22
2	Water	5632.69	56.33
3	Agriculture	138994.91	1389.95
4	Open Forest	89053.45	890.53
5	Industrial	2352.83	23.53
6	Open	61161.23	611.61
7	Scrub Forest	35980.41	359.80
8	Built-up	3533.77	35.34
	Total	640231.24	6402.31

Table 6 Area under land use/land cover classes within Koriya

Forest Cover Mapping

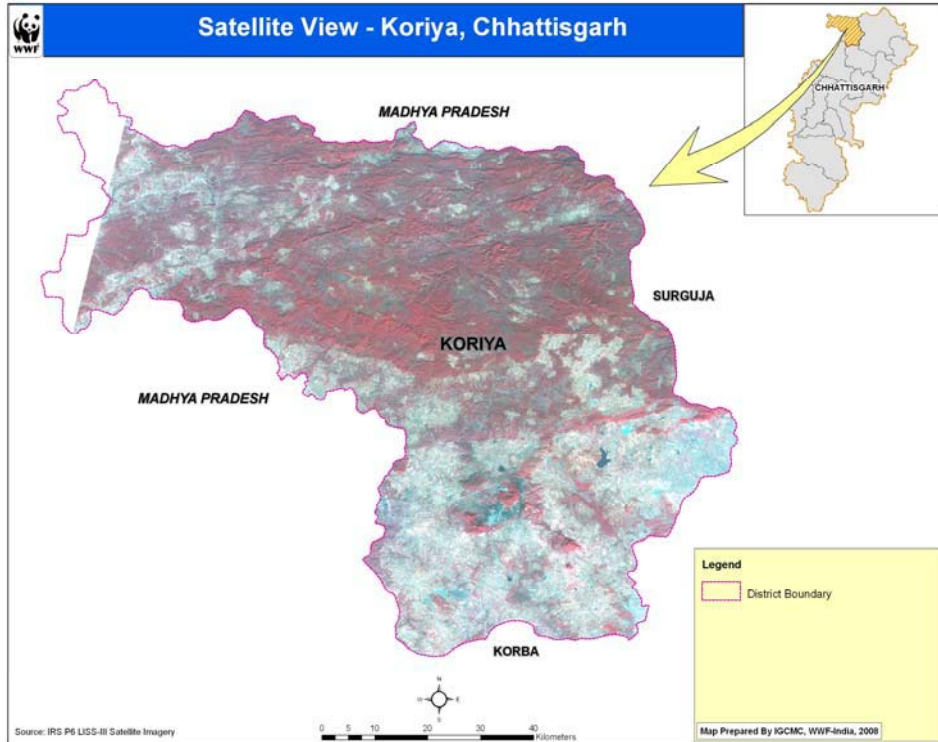


Figure 13 Satellite image of Koriya

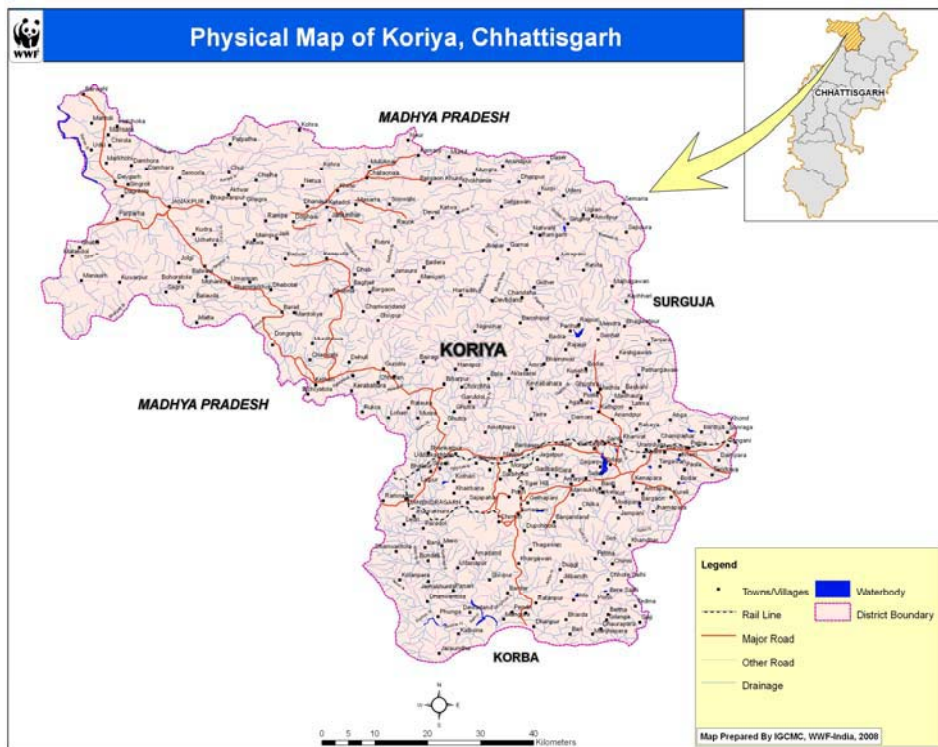


Figure 23 Physical map of Koriya

Forest Cover Mapping

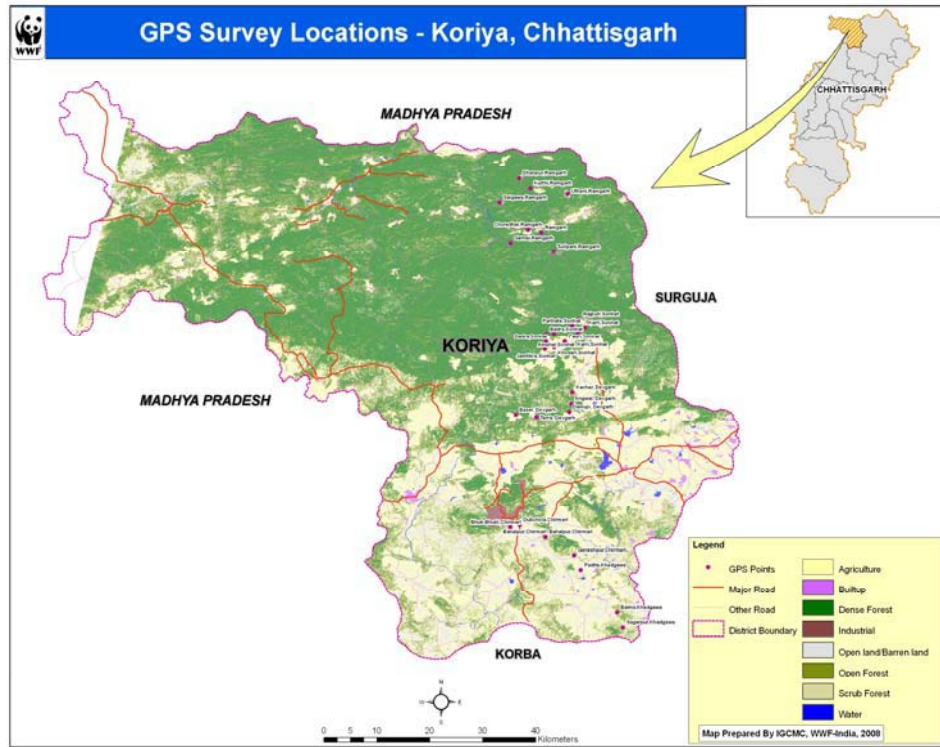


Figure 24 GPS location map of Koriya

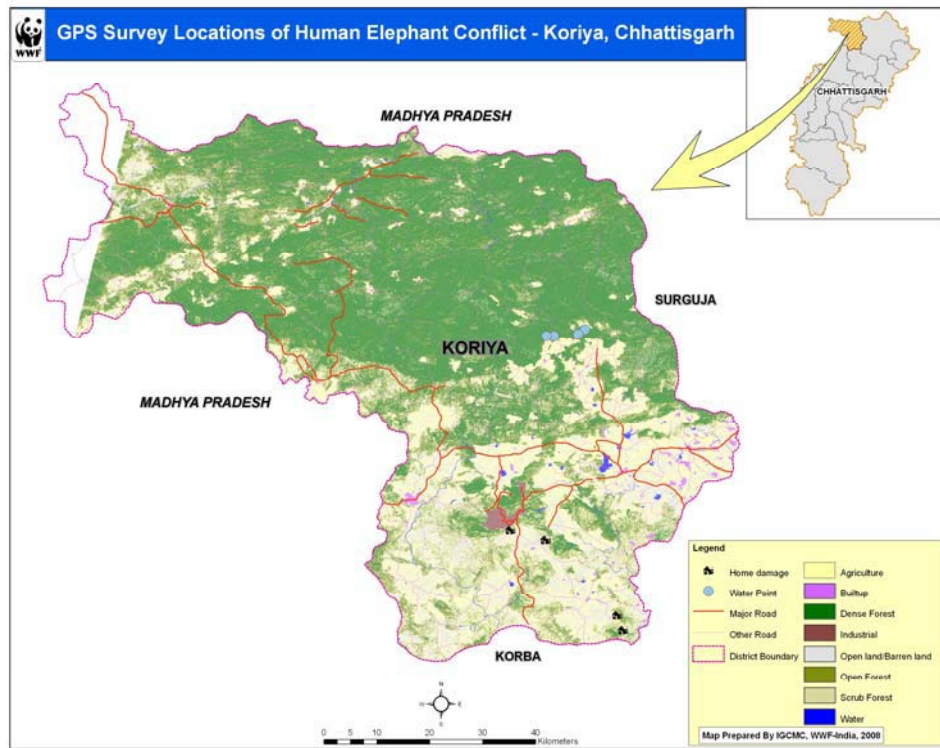


Figure 25 Human elephant conflict map of Koriya

9 Landuse/ Landcover of Surguja District:

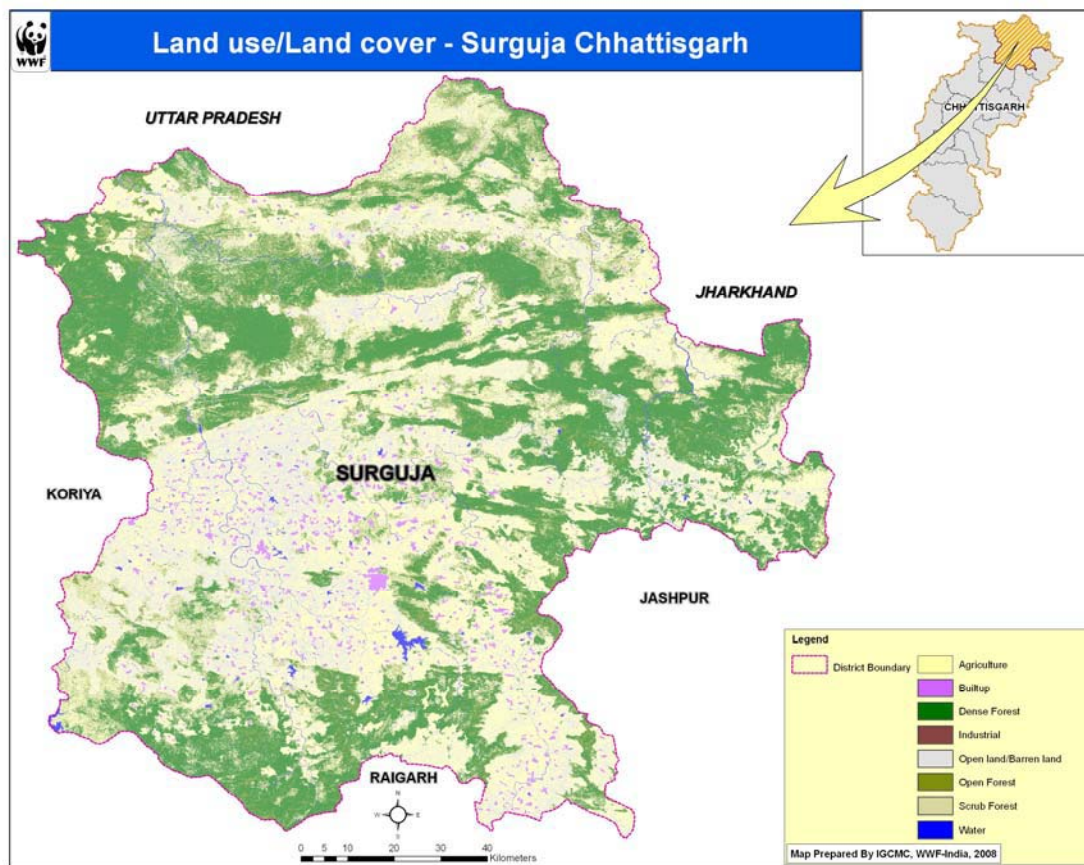


Figure 14 Landuse map of Jashpur District Surguja

9.1 Results:

SL NO.	LAND USE	AREA (Hectares)	AREA (Sq km)
1	Dense Forest	495849.21	4958.49
2	Water	17315.65	173.16
3	Agriculture	504867.92	5048.68
4	Open Forest	111613.82	1116.14
5	Industrial	0.00	0.00
6	Open	283642.98	2836.43
7	Scrub Forest	133233.20	1332.33
8	Built-up	28328.16	283.28
	Total	1574850.93	15748.51

Table 7 Area under land use/land cover classes within Surguja

Forest Cover Mapping

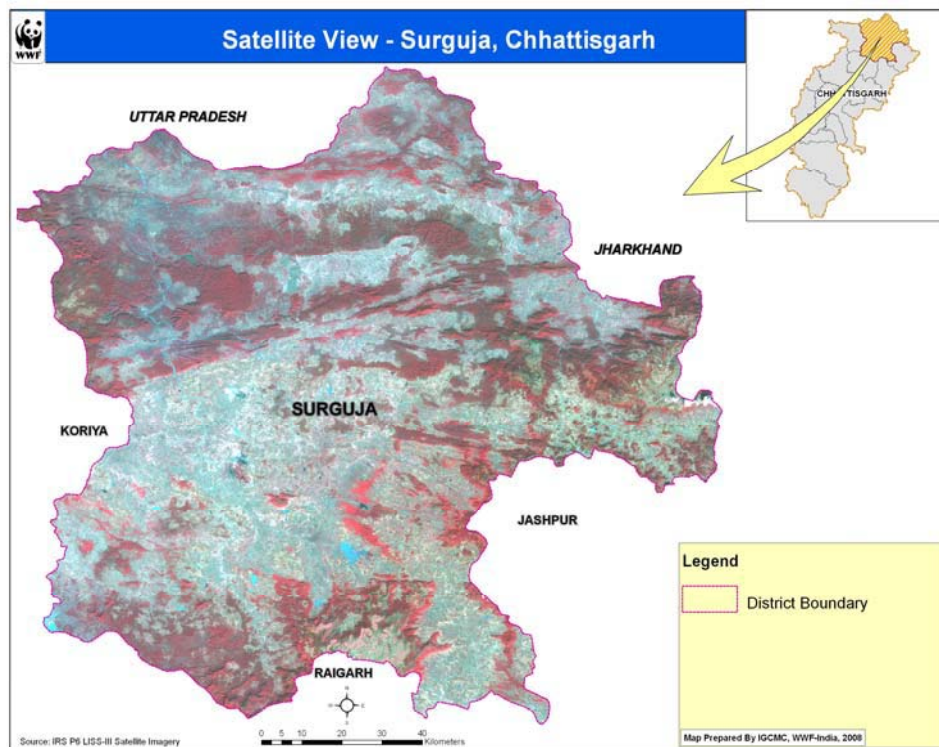


Figure 27 Satellite image of Surguja

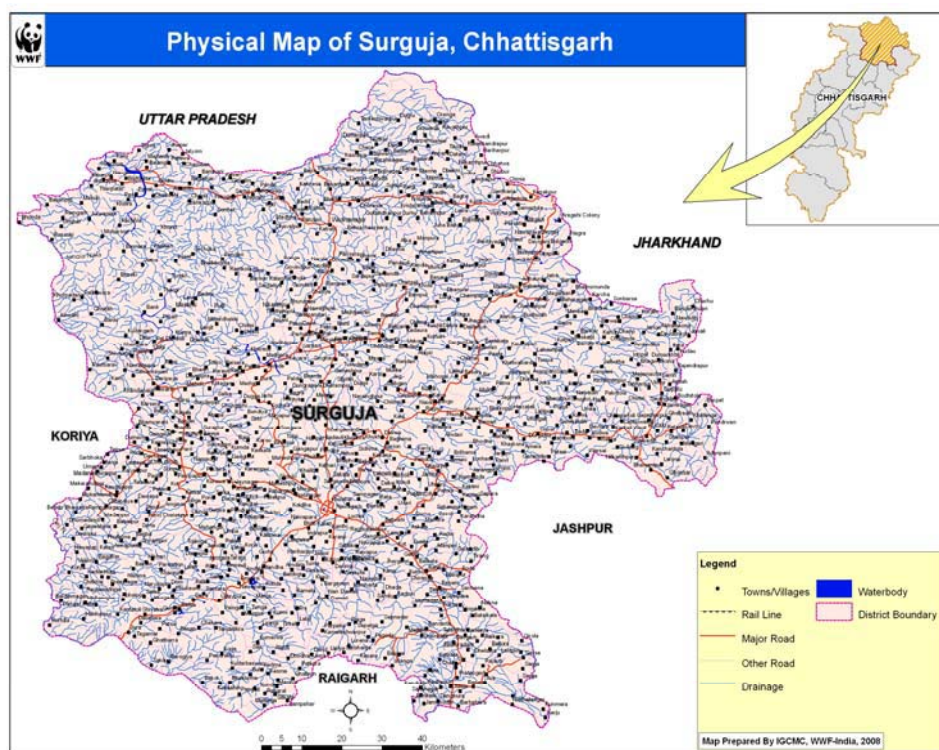


Figure 28 Physical map of Surguja

Forest Cover Mapping

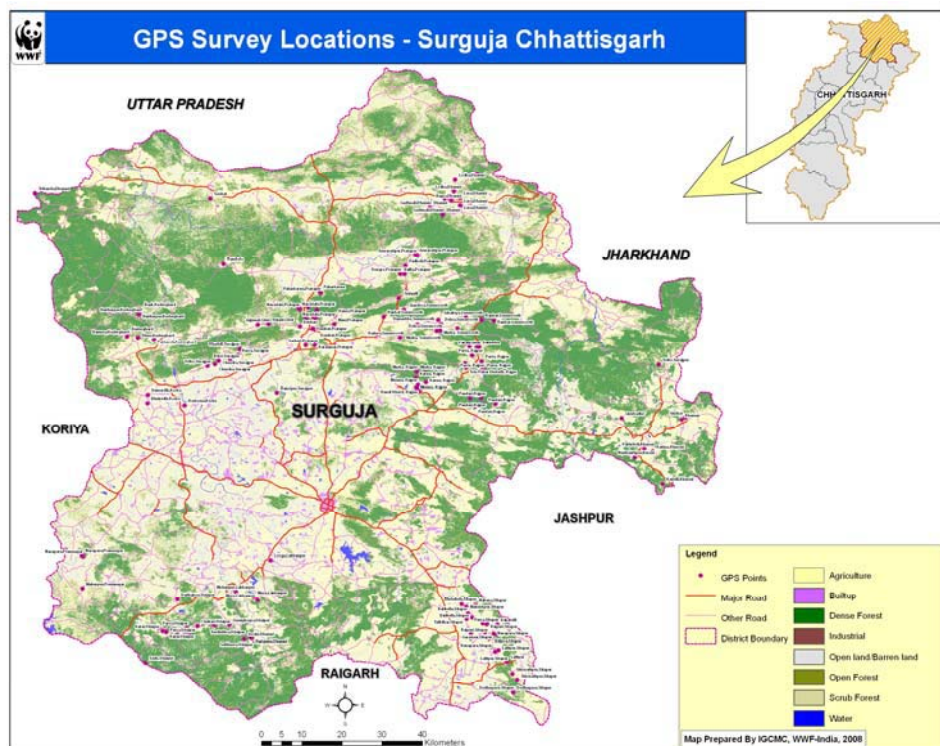


Figure 29 GPS location map of Surguja

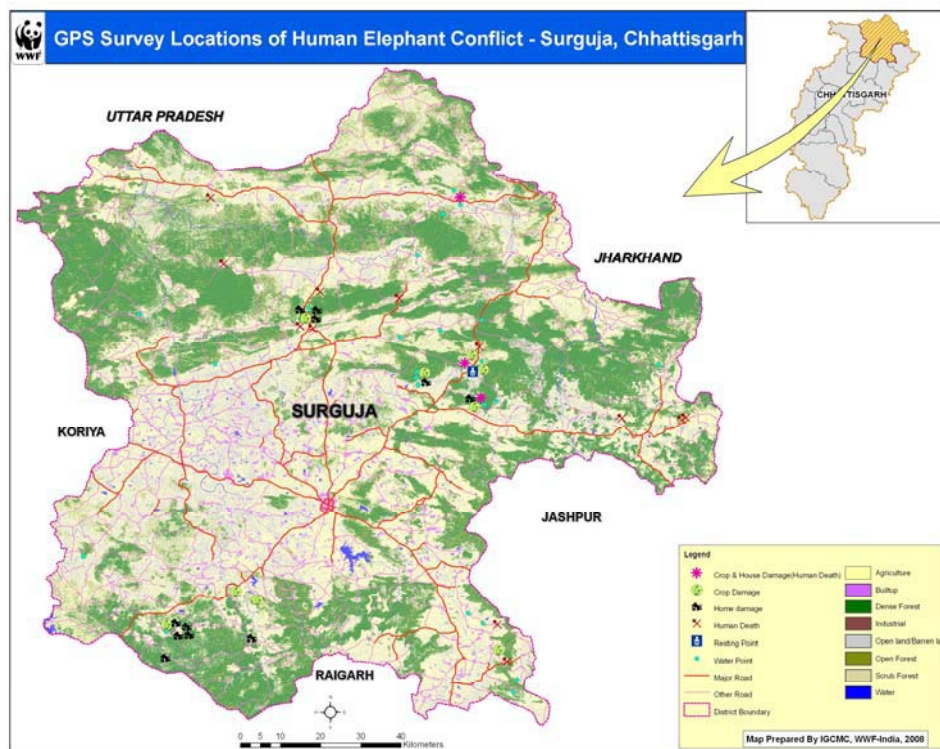


Figure 30 Human elephant conflict map of Surguja

10 Land use/Land cover of Raigarh District:

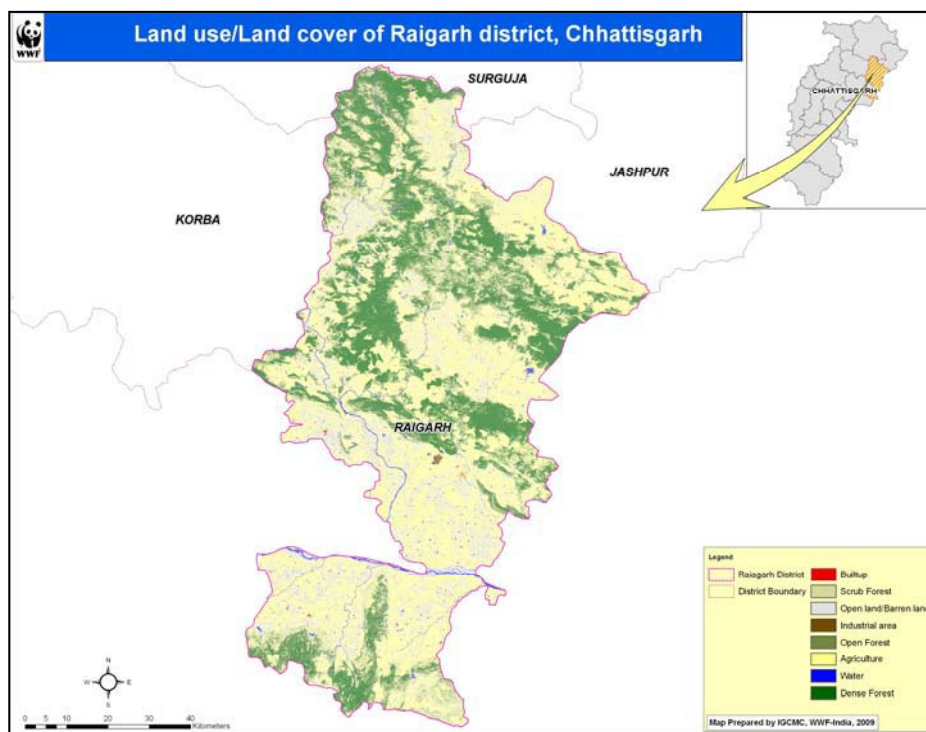


Figure 31 Landuse map of Raigarh District

10.1 Results

SL No.	LAND USE	AREA	
		(Hectares	AREA (Sq km)
1	Dense Forest	158557.56	1585.58
2	Water	10119.13	101.19
3	Agriculture	342623.19	3426.23
4	Open Forest	48543.63	485.44
5	Industrial	316.75	3.17
6	Open land	104980.50	1049.81
7	Scrub Forest	53872.69	538.73
8	Built up	1586.31	15.86

Table 8 Area under land use/land cover classes within Raigarh

Forest Cover Mapping

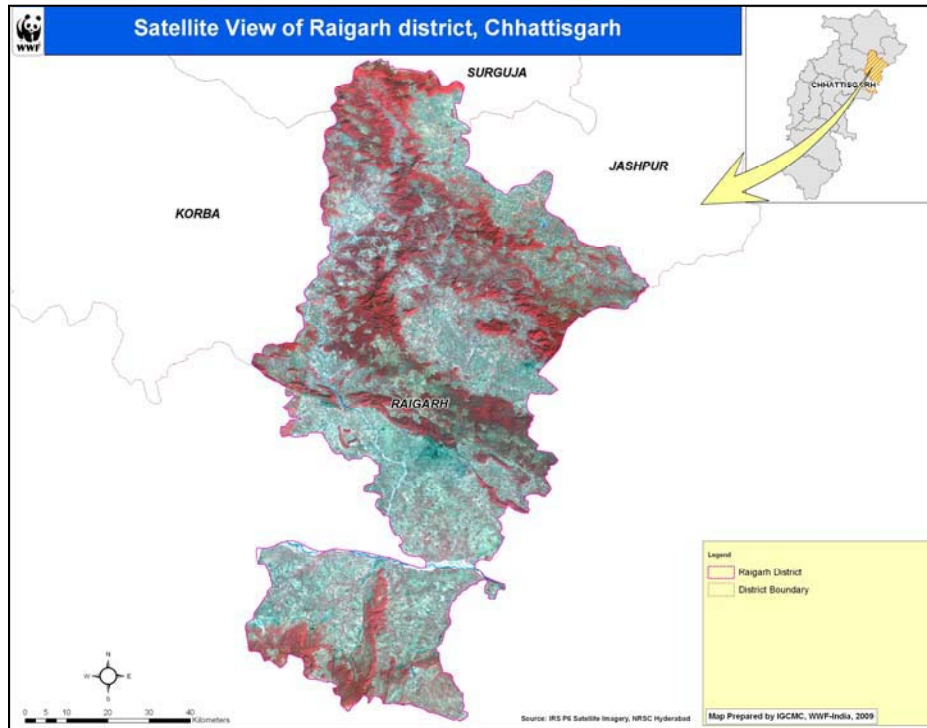


Figure 152 Satellite image of Raigarh

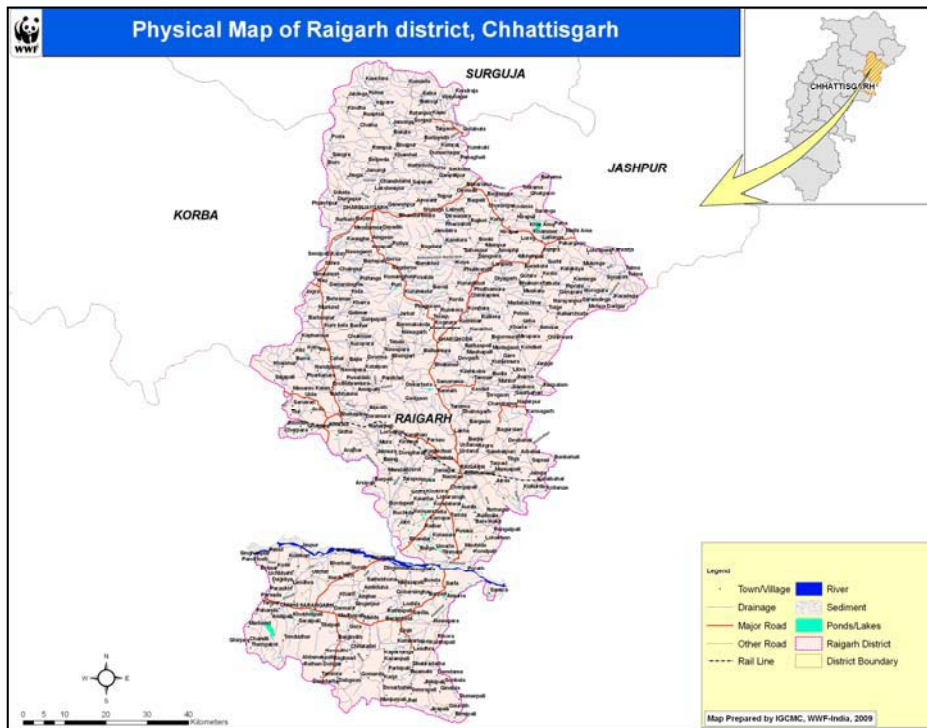


Figure 33 Physical map of Raigarh

Forest Cover Mapping

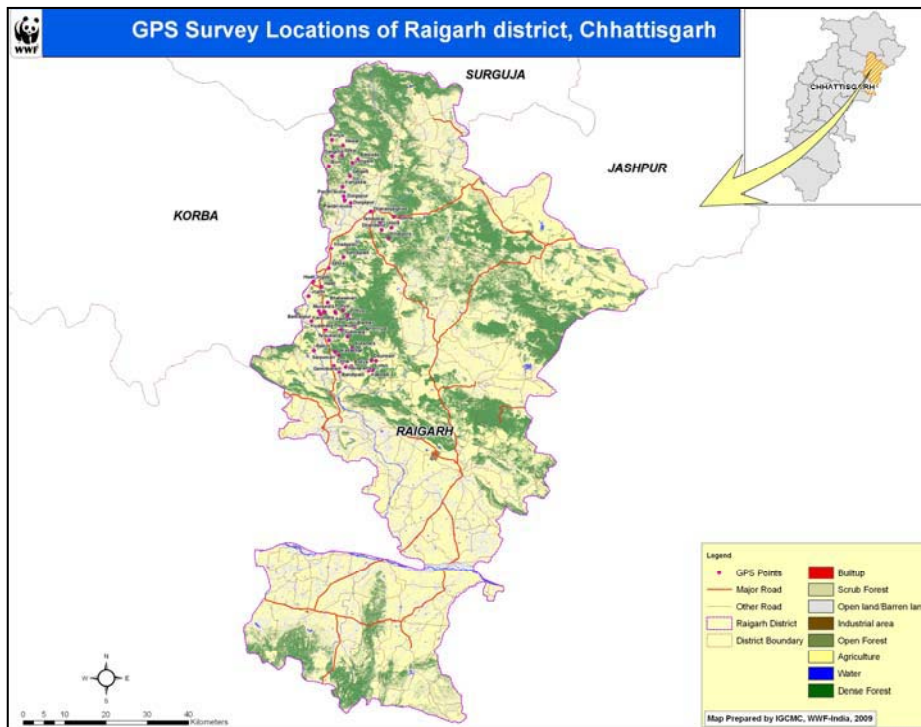


Figure 34 GPS Location map of Raigarh

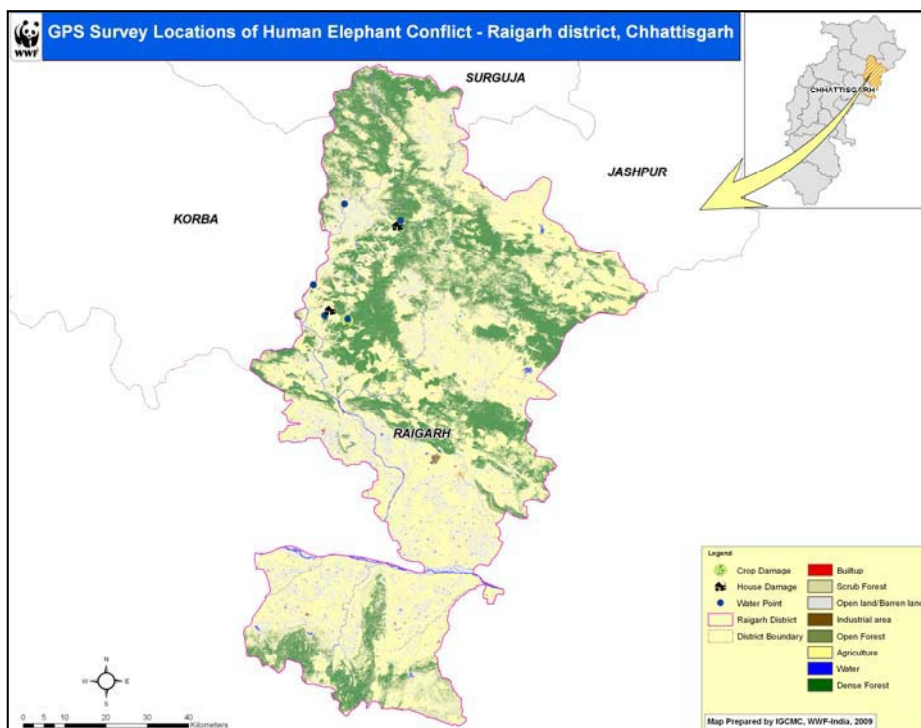


Figure 35 Human Elephant conflict map of Raigarh

11 Habitat Analysis:

Wildlife management is much more than the preservation of certain plant and animal species; it involves management of a complete ecosystem (De Wulf *et al.*, 1988). Quantification and analysis of current impacts on wildlife habitat such as logging, agriculture, road and railways development etc. are vital phases in the process of formulating sound wildlife management policies (Kushwaha, 2000). Relatively large number of ground based studies has been carried out on habitat and corridor use by wild animals (Johnsingh and Joshua, 1994). But such studies are essentially time consuming. This is where remote sensing and GIS can play an important role. It can be used as a tool for quick appraisal of habitat attributes and also to identify and manage wildlife corridors.

Remote sensing in conjunction with GIS (Geographical Information System) can be applied to wildlife habitat inventory, evaluation and wildlife census. Wildlife habitat mapping is very similar to any type of land cover mapping. But it involves the use of many more factors. Thus the geospatial technology of GIS and remote sensing can incorporate number of criteria and offers better scope for analysis and interpretation.

The study aims at identifying areas which suitable for elephant habitat in the Korba-Sarguja-Jashpur-Raigarh belt located in Chhattisgarh. Chhattisgarh is state in Central part of India. It borders Madhya Pradesh on the northwest, Maharashtra on the west, Andhra Pradesh on the south, Orissa on the east, Jharkhand on the northeast and Uttar Pradesh on the north. The northern part of the state, which comprises of the area under study, is hilly in nature, while the central part is a fertile plain.

The northern part of the state lies on the edge of the great Indo-Gangetic plain; the Rihand River, a tributary of the Ganges, drains this area. The eastern end of the Satpura Range and the western edge of the Chota Nagpur Plateau form an east-west belt of hills that divide the Mahanadi River basin from the Indo-Gangetic plain.

Forests cover roughly forty-four percent of the state and are largely concentrated in the northern and southern parts of the State. The forests of the state fall under two major forest types, i.e. Tropical Moist Deciduous forest and the Tropical Dry Deciduous forest. The state of Chhattisgarh is endowed with about 22 varied forest sub-types existing in the state. However from management point of view, there are four types of forests – Teak, Sal, Bamboo forests and miscellaneous.

Methodology for Habitat Suitability

The major steps followed in creating the habitat suitability map for Elephant in Korba-Sarguja-Jashpur-Raigarh belt, Chhattisgarh were as below:

The habitat requirements of the Elephants and the variables related to these requirements were established based on the existing information available on the species, especially with reference to the study area. Three factors were identified as being the most important in determining the suitability of an elephant. Each factor was then subdivided into three levels of suitability.

The table below represents the factors that were used to determine habitat suitability for elephants.

Table 9 Habitat Suitability factors and variables with levels of suitability

Vegetation type	Proximity to water body	Proximity to Human Habitation	Suitability
Dense Forest	Within 1km	More than 3km	3
Open Forest	1-1.5km	2-3km	2
Non Forest	More than 1.5km	Less than 2km	1

Table 10 Suitability code

Suitability value	Suitability code
1	Not Suitable
2	Moderately Suitable
3	Highly Suitable

Assigning Factor weights

The factors were each assigned weights based on a multi-criterion evaluation Analytical Hierarchy Procedure (Satty 1977). The AHP uses a nine point measurement scale.

- 1 – Equal importance
- 3 – Weak importance
- 5 – Strong importance
- 7 – Demonstrated importance
- 9 – Absolute importance

The other values of 2, 4, 6, and 8 constitute intermediate values between two adjacent judgments. This AHP is based on the assumption that some factors are more important than others are in a particular circumstance. The matrix below shows the allocation of weights.

Table 11 Factors weighting using the Analytical Hierarchy Procedure

	Vegetation	Proximity to water body	Proximity to Human Habitation	GP	Relative weights
Forest	1	1	6	1.82	0.48
Proximity to water body	1	1	4	1.59	0.42
Proximity to Human Habitation	0.17	0.25	1	0.35	0.09
TOTAL				3.75	

Each variable was given a value in comparison with another. After the matrix was filled by values of relative importance, the geometric progression values for each row were calculated. Then each factor was assigned a relative weight. Based on the same weights each factor was also assigned a priority ranking.

Forest Cover Mapping

Table 12 Adjusted weights and priority ranks for each factor

Factor	Factor weight	Priority Rank
Forest	0.48	1
Water body	0.42	2
Human Habitation	0.35	3

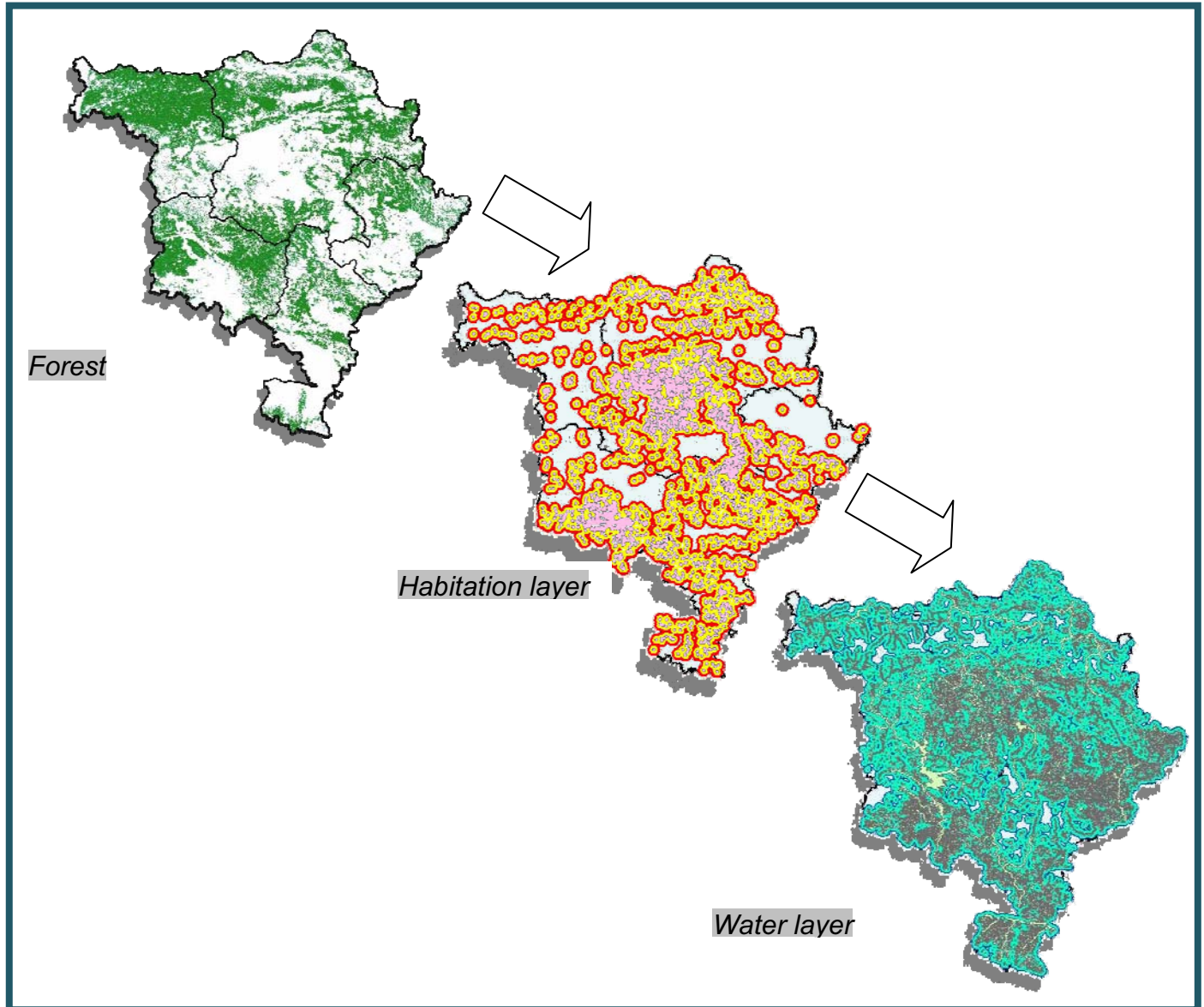


Figure 36 Overlay of factor layers for Habitat Suitability

Creation GIS Layers

GIS layers for each of the factors were prepared, as a part of the Elephant corridor mapping for Korba-Sarguja-Jashpur-Raigarh belt, Chhattisgarh. The factors representing proximity to different features were created using multiple ring buffers. Suitability values were entered as integer values in the attributes table of the respective layers.

GIS Analysis Module

The set of input layers were run on Arc Map 9.3 by two different methods. One, using the multiple files intersection using priority ranking while the other using weighted sum spatial analyst.

1.1 Priority Ranking

In the first method, input layers in shape format were used. Priority ranks were assigned to the factors based on the weights derived by the AHP. Priority ranks give greater control to feature layers that are known to have greater influence on the end result. Each variable was assigned an integer value of suitability as a score. The polygons with maximum suitability had a score of 3 and those polygons with minimum suitability had a score of 1. The output of the priority ranking intersection was tallied based on the cumulative sum of suitability of the factors and classified into suitability classes as defined previously in the suitability chart.

1.2 Weighted Overlay

In the second method, input set factors in the raster format were run using weighted sum approach. In this module each input raster is multiplied with a corresponding factor weight and then summed to arrive at a final suitability map in 3 classes. The weights used here were derived from the AHP procedure explained earlier.

The Output generated was then divided into three natural classes of suitability to obtain the final suitability maps.

Forest Cover Mapping

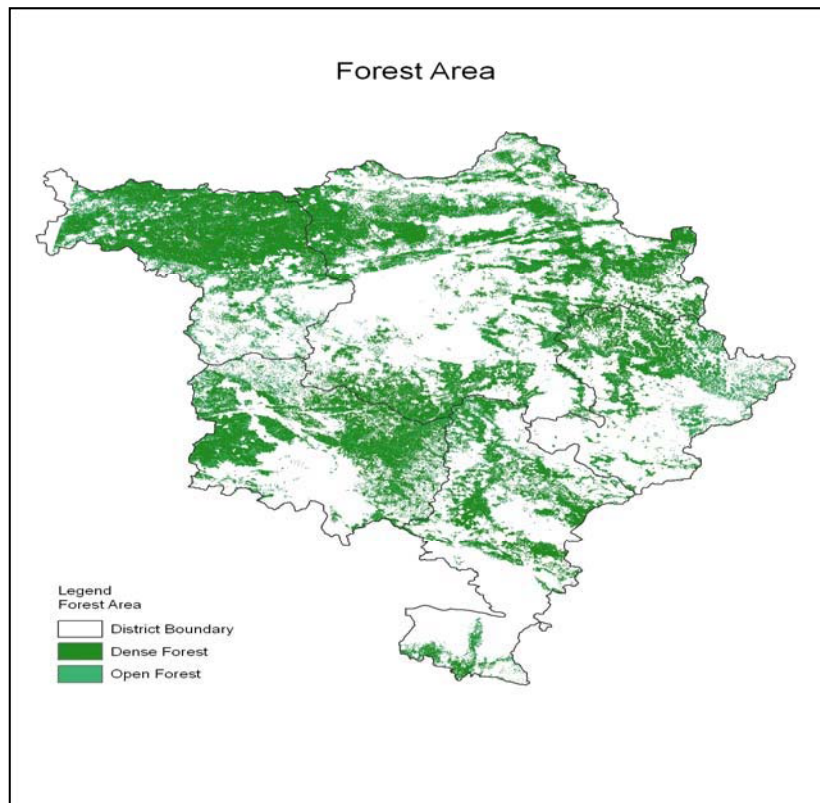


Figure 37 Vegetation map of study area

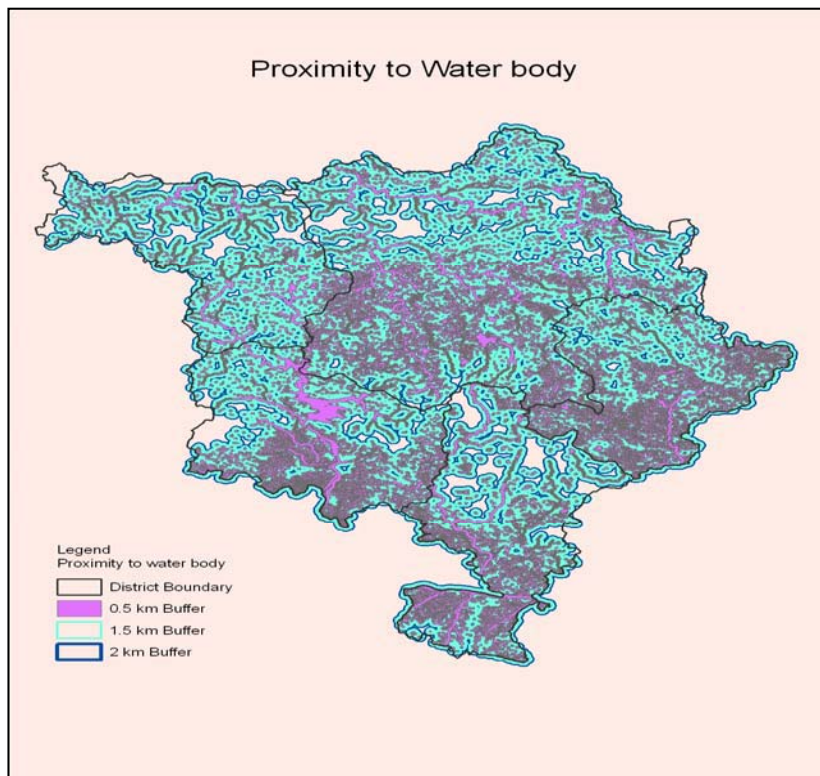


Figure 38 Proximity to Water body

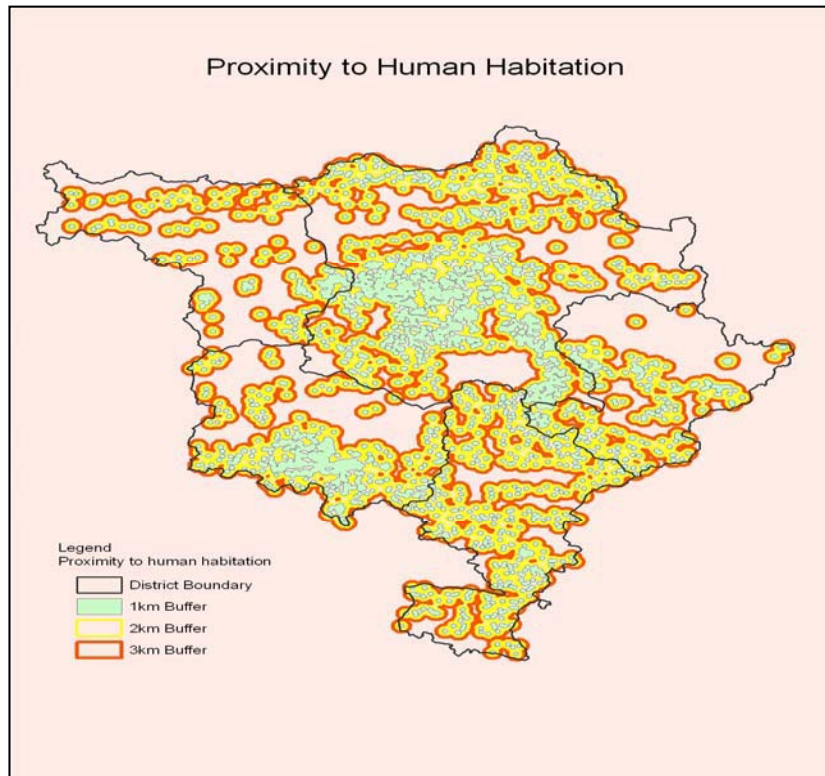


Figure 39 Proximity to Built up area

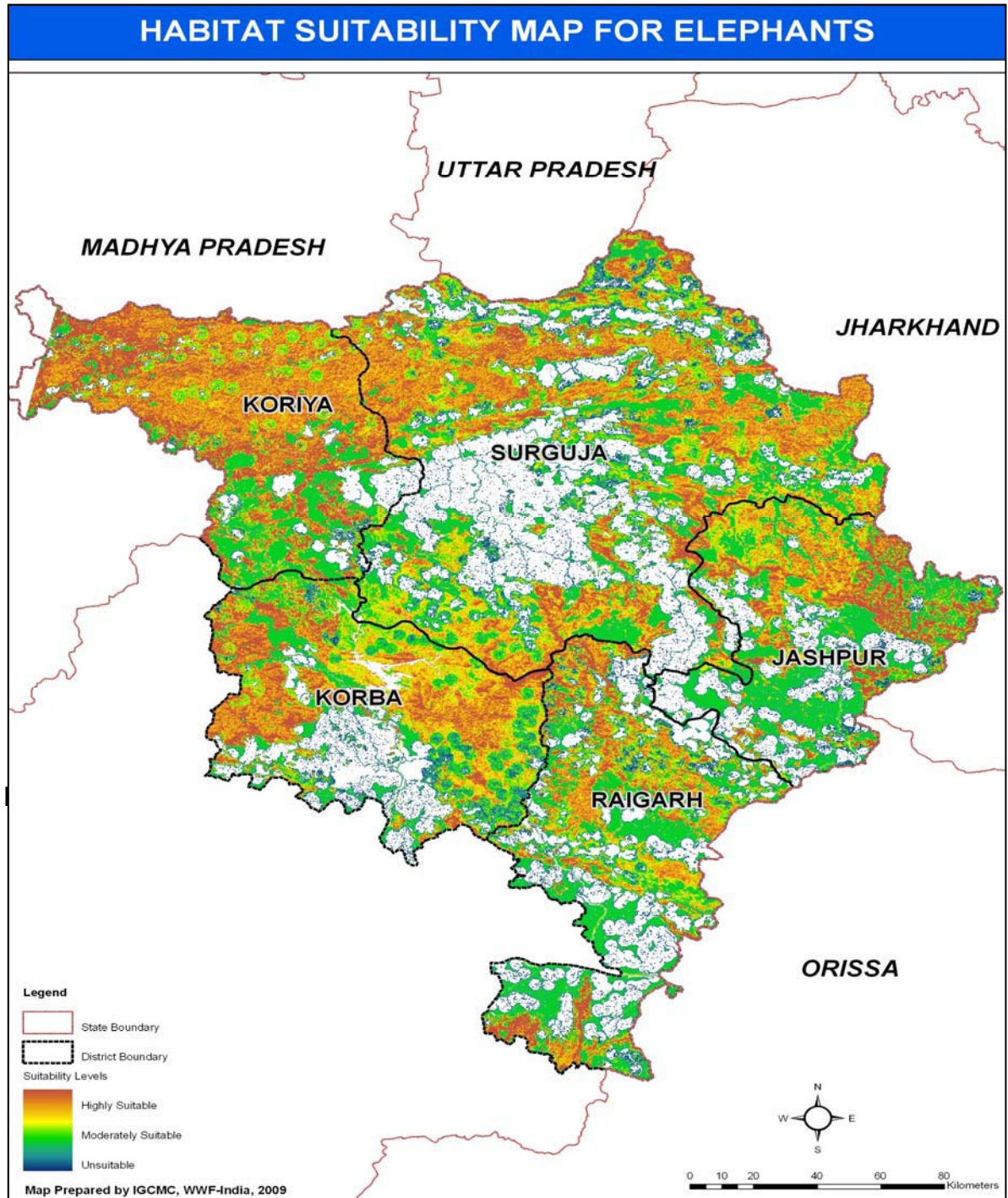


Figure 40 Habitat Suitability map for Elephants

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- Kushwaha, S., (2003) "Geoinformatics for wildlife habitat characterization", [Online] Available on <http://www.gisdevelopment.net>
- Kushwaha, S.P.S. & Roy, P.S., (2002) "Geospatial technology for wildlife habitat evaluation", *Tropical Ecology* 43 (1).
- Ritters, K.H., O'Neil, R.V. & Jones, K.B., (1997) "Assessing Habitat Suitability at Multiple Scales: A Landscape Level Approach", *Biological Conservation* 81 series. [Online] Available on www.ncrs.fs.fed.us