

**Vegetation Cover Mapping of Kamptee Coalfield based on
Satellite Data for the Year- 2013**

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**Remote Sensing Cell
Geomatics Division
CMPDI, Ranchi**

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2. Plate No. HQ/REM/A002: Classified Lan use/Cover map of Kamptee Coalfield

Chapter 1

Introduction

1.1 Project Reference

To monitor the regional impact of coal mining on land use pattern and vegetation cover in the 28 major coalfields at regular interval of three years based on remote sensing satellite data, Coal India Ltd. issued a work order to CMPDI vide letter no.CIL/WBP/ENV/2011/4706 dated 12.10.12. Geo-environmental data base for Kamptee Coalfield based on satellite data was prepared in the year 2010 under the above project. Impact of coal mining on land environment has to be assessed regularly at interval of three years with respect to the previous data. This report is based on satellite data of 2013 for monitoring the status of land use and vegetation cover in Kamptee coalfield.

1.2 Objectives

The objective of the present study is to prepare a regional land use and vegetation cover map Kamptee Coalfield on 1:50,000 scale based on satellite data of the year 2013, using digital image processing technique for updation of geo-environmental database and to assess the impact of coal mining and other industrial activities on land use and vegetation cover in the coalfield area.

1.3 Location & Accessibility

Kamptee Coalfield covering an area of about 1344.78 sq.km located in Nagpur district in the Vidarbha region of the Indian state of Maharashtra. It lies north of Kanhan railway station in Nagpur district. The coalfield extends in north-westerly direction from Kanhan railway station towards Saoner. The study area is bounded between North Latitudes 20° 55' 00" to 21° 25' 00" and East longitudes 78° 45' 00" to 79° 20' 00" and is covered by Survey of India (Sol) topo-sheet Nos. 55K/15, 55K/16, 55O/3, 55O/4, 55O/7, 55O/8, 55O/11, 55O/12. The total coalfield area is about 1344.78 sq. km.

This Coalfield holds a premier position in India for having the considerable share of reserve of thermal grades non-coking coal for catering the demand of coal in the western part of country.

Kamptee Coalfield approachable from Nagpur through Nagpur–Jabalpur road i.e. NH-7. The nearest town is Kanhan and Kamptee town which is 8 Km from Nagpur. Kanhan river is approachable throughout the year. Kanhan railway station lies on the Nagpur- Howrah railway line. Nagpur to Ramtek railway line is 10 km from the Kanhan town. The nearest railway station is Kanhan – junction (5km) of South Eastern Central railway on Bombay – Howrah main line. Location map of the Kamptee coalfield is given at fig 1.1

1.4 Topography & Drainage

The area exhibits gently undulating terrain and gently slopes towards south and southeast. The main drainage is controlled by southerly flowing Kanhan river which lies about 2 km. Kamptee Coalfield forms a part of the Kanhan river basin. The general flow direction of the Kanhan river is from south to north. Some of the coal block is mainly drained by Nand Nala and its tributaries. The Nand nala is a perennial one and ultimately discharges its water in Nand River.

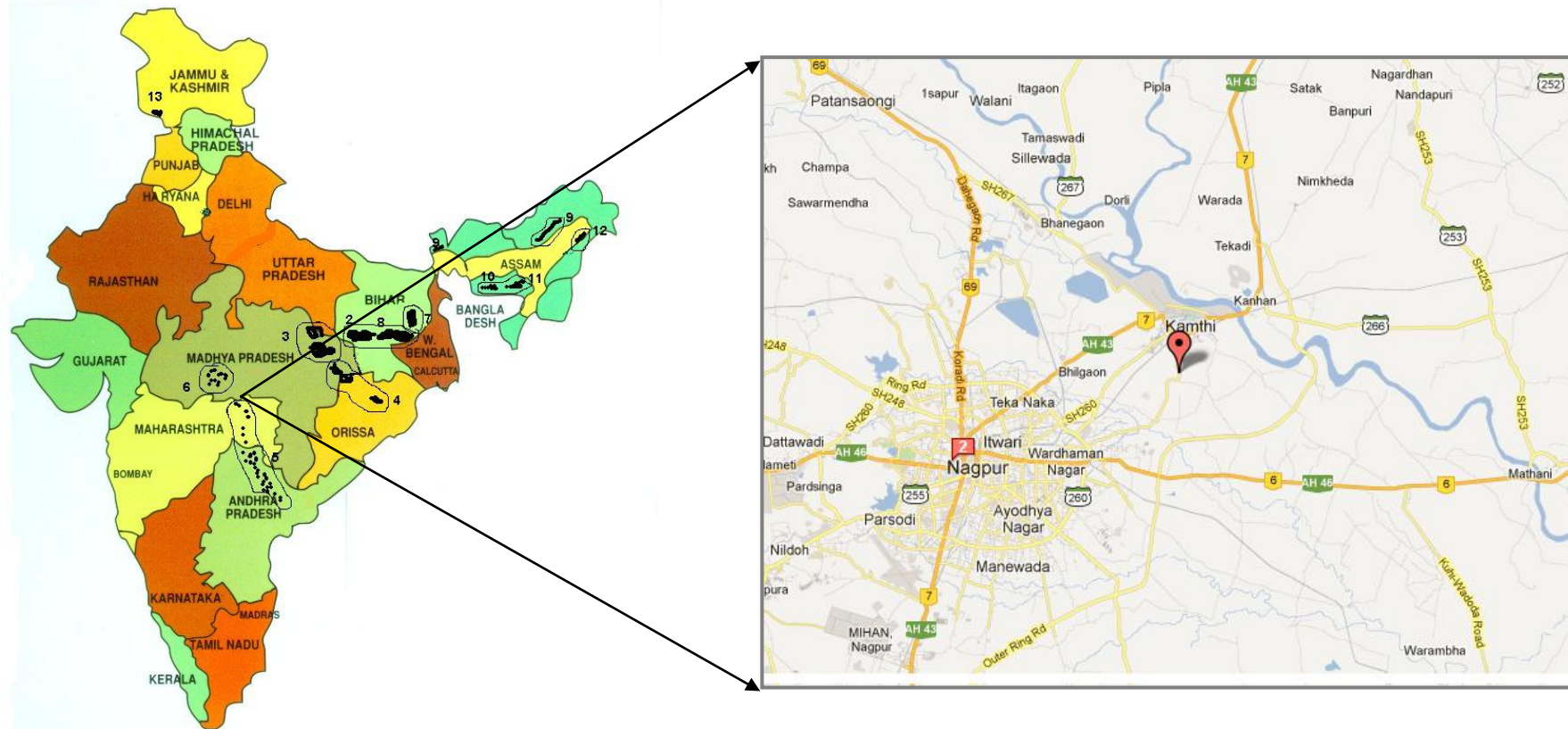


Fig. 1.1 : Location map of Kamptee Coalfield

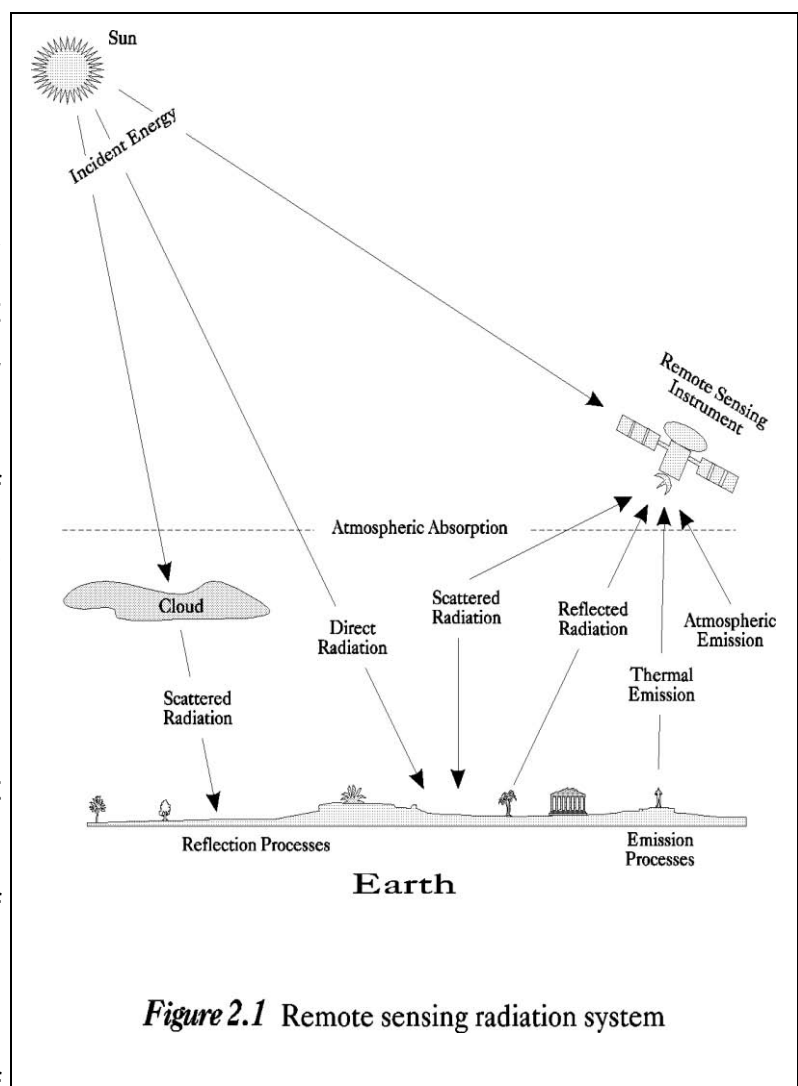
Chapter 2

Remote Sensing Concepts and Methodology

2.1 Remote Sensing

Remote sensing is the science and art of obtaining information about an object or area through the analysis of data acquired by a device that is not in physical contact with the object or area under investigation. The term *remote sensing* is commonly restricted to methods that employ electro-magnetic energy (such as light, heat and radio waves) as the means of detecting and measuring object characteristics.

All physical objects on the earth surface continuously emit electromagnetic radiation because of the oscillations of their atomic particles. Remote sensing is largely concerned with the measurement of



electro-magnetic energy from the *SUN*, which is reflected, scattered or emitted by the objects on the surface of the earth. Figure 2.1 schematically illustrate the generalised processes involved in electromagnetic remote sensing of the earth resources.

2.2 Electromagnetic Spectrum

The electromagnetic (EM) spectrum is the continuum of energy that ranges from meters to nanometres in wavelength and travels at the speed of light. Different objects on the earth surface reflect different amounts of energy in various wavelengths of the EM spectrum.

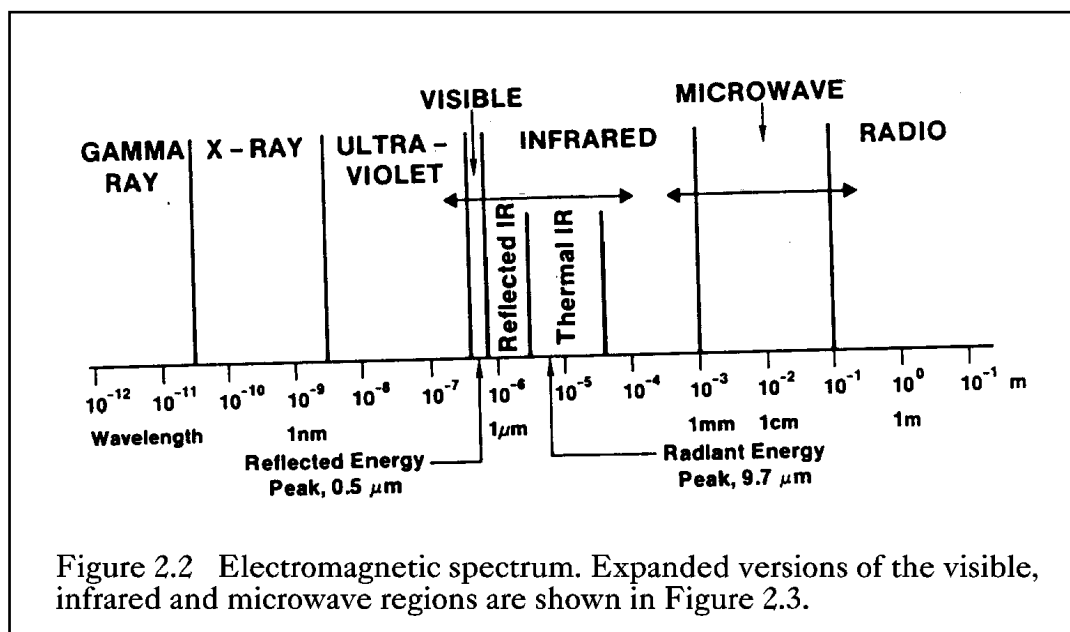


Figure 2.2 shows the electromagnetic spectrum, which is divided on the basis of wavelength into different regions that are described in Table 2.1. The EM spectrum ranges from the very short wavelengths of the gamma-ray region to the long wavelengths of the radio region. The visible region ($0.4\text{-}0.7\mu\text{m}$ wavelengths) occupies only a small portion of the entire EM spectrum.

Energy reflected from the objects on the surface of the earth is recorded as a function of wavelength. During daytime, the maximum amount of energy is reflected at $0.5\mu\text{m}$ wavelengths, which corresponds to the green band of the visible region, and is called the *reflected energy peak* (Figure 2.2). The earth also radiates energy both day and night, with the maximum energy $9.7\mu\text{m}$ wavelength. This *radiant energy peak* occurs in the thermal band of the IR region (Figure 2.2).

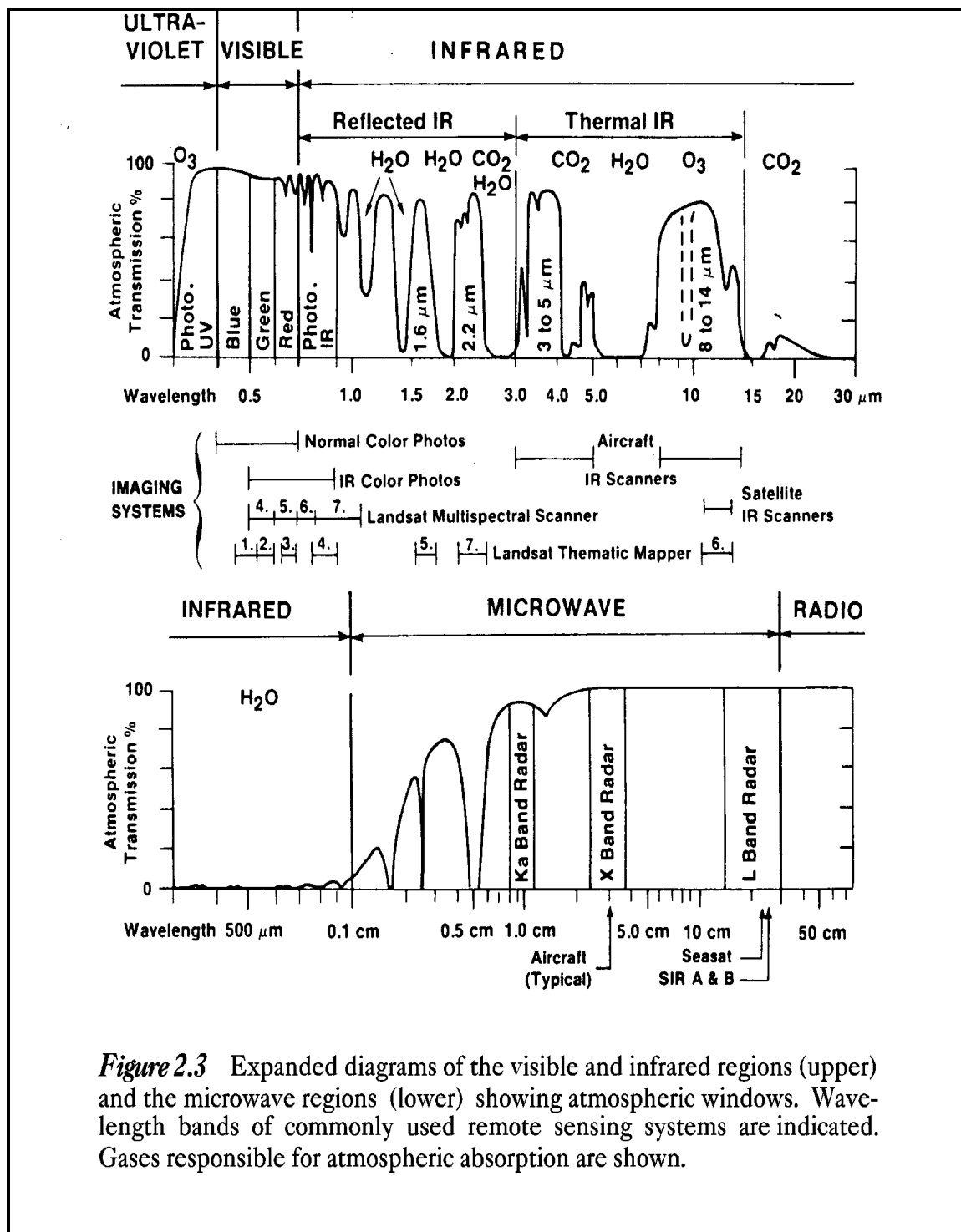


Figure 2.3 Expanded diagrams of the visible and infrared regions (upper) and the microwave regions (lower) showing atmospheric windows. Wavelength bands of commonly used remote sensing systems are indicated. Gases responsible for atmospheric absorption are shown.

Table 2.1 Electromagnetic spectral regions

Region	Wavelength		Remarks
<i>Gamma ray</i>	<	0.03 nm	Incoming radiation is completely absorbed by the upper atmosphere and is not available for remote sensing.
<i>X-ray</i>	0.03 to	3.00 nm	Completely absorbed by atmosphere. Not employed in remote sensing.
<i>Ultraviolet</i>	0.03 to	0.40 μm	Incoming wavelengths less than 0.3mm are completely absorbed by Ozone in the upper atmosphere.
<i>Photographic UV band</i>	0.30 to	0.40 μm	Transmitted through atmosphere. Detectable with film and photo detectors, but atmospheric scattering is severe.
<i>Visible</i>	0.40 to	0.70 μm	Imaged with film and photo detectors. Includes reflected energy peak of earth at 0.5mm.
<i>Infrared</i>	0.70 to	100.00 μm	Interaction with matter varies with wavelength. Absorption bands separate atmospheric transmission windows.
<i>Reflected IR band</i>	0.70 to	3.00 μm	Reflected solar radiation that contains no information about thermal properties of materials. The band from 0.7-0.9mm is detectable with film and is called the <i>photographic IR band</i> .
<i>Thermal IR band</i>	3.00 to 8.00 to	5.00 μm 14.00 μm	Principal atmospheric windows in the thermal region. Images at these wavelengths are acquired by optical-mechanical scanners and special videocon systems but not by film.
<i>Microwave</i>	0.10 to	30.00 cm	Longer wavelengths can penetrate clouds, fog and rain. Images may be acquired in the active or passive mode.
<i>Radar</i>	0.10 to	30.00 cm	Active form of microwave remote sensing. Radar images are acquired at various wavelength bands.
<i>Radio</i>	>	30.00 cm	Longest wavelength portion of electromagnetic spectrum. Some classified radars with very long wavelength operate in this region.

The earth's atmosphere absorbs energy in the gamma-ray, X-ray and most of the ultraviolet (UV) region; therefore, these regions are not used for remote sensing. Details of these regions are shown in Figure 2.3. The horizontal axes show wavelength on a logarithmic scale; the vertical axes show percent atmospheric transmission of EM energy. Wavelength regions with high transmission are called *atmospheric windows* and are used to acquire remote sensing data. Detection and measurement of the recorded energy enables identification of surface objects (by their characteristic wavelength patterns or spectral signatures), both from air-borne and space-borne platforms.

2.3 Scanning System

The sensing device in a remotely placed platform (aircraft/satellite) records EM radiation using a *scanning system*. In scanning system, a *sensor*, with a narrow field of view is employed; this sweeps across the terrain to produce an image. The sensor receives electromagnetic energy radiated or reflected from the terrain and converts them into signal that is recorded as numerical data. In a remote sensing satellite, multiple arrays of linear sensors are used, with each array recording simultaneously a separate band of EM energy. The array of sensors employs a spectrometer to disperse the incoming energy into a spectrum. Sensors (or *detectors*) are positioned to record specific wavelength bands of energy. The information received by the sensor is suitably manipulated and transported back to the ground receiving station. The data are reconstructed on ground into digital images. The digital image data on *magnetic/optical media* consist of picture elements arranged in regular rows and columns. The position of any picture element, *pixel*, is determined on a x-y co-ordinate system. Each pixel has a numeric value, called digital number (DN) that records the intensity of electromagnetic energy measured for the ground resolution cell represented by that pixel. The range of digital numbers in an image data is controlled by the radiometric resolution of the satellite's sensor system. The digital image data are further processed to produce master images of the study area. By analysing the digital data/imagery, digitally/visually, it is possible to detect, identify and classify various objects and phenomenon on the earth surface.

Remote sensing technique (airborne/satellite) in conjunction with traditional techniques harbours in an efficient, speedy and cost-effective method for natural resource management due to its inherited capabilities of being multispectral, repetitive and synoptic areal coverage. Generation of environmental 'Data Base' on land use, soil, forest, surface and subsurface water, topography and terrain characteristics, settlement and transport network, etc., and their monitoring in near real - time is very useful for environmental management planning; this is possible only with remote sensing data.

2.4 Data Source

The following data are used in the present study:

- **Primary Data**

Remote Sensing Satellite data viz. Resourcesat-IRS-P6/LISS-III of January 2013 having 23.5 m. spatial resolution was used in the present study. The raw digital satellite data was obtained from NRSC, Hyderabad, on CD-ROM media.

- **Secondary Data**

Secondary (ancillary) and ground data constitute important baseline information in remote sensing, as they improve the interpretation accuracy and reliability of remotely sensed data by enabling verification of the interpreted details and by supplementing it with the information that cannot be obtained directly from the remotely sensed data. For Kamptee Coalfield, Survey of India topo sheet no., 55K/15, 55K/16, 55O/3, 55O/4, 55O/7, 55O/8, 55O/11, 55O/12. as well as map showing details of location of area boundary, block boundary and road supplied by WCL were used in the study.

2.5 Characteristics of Satellite/Sensor

The basic properties of a satellite's sensor system can be summarised as:

(a) Spectral coverage/resolution, i.e., band locations/width; (b) spectral dimensionality: number of bands; (c) radiometric resolution: quantisation; (d) spatial resolution/instantaneous field of view or IFOV; and (e) temporal resolution. Table 2.2 illustrates the basic properties of Resourcesat satellite/sensor that was used in the present study.

Table 2.2 Characteristics of the satellite/sensor used in the present project work

Platform	Sensor	Spectral Bands in μm	Radiometric Resolution	Spatial Resolution	Temporal Resolution	Country
Rsource sat (P6)	LISS-III	B2 0.28 - 0.31 Green	7-bit (128-grey levels)	23.5 m	24 days	India
		B3 0.25 - 0.38 Red		23.5 m		
		B4 0.27 - 0.30 NIR		23.5 m		
		B5 6.90 MIR		70.5 m		

NIR: Near Infra-Red MIR: Middle Infra-Red

2.6 Data Processing

The details of data processing carried out in the present study are shown in Figure 2.4. The processing methodology involves the following major steps:

- (a) Geometric correction, rectification and geo-referencing;
- (b) Image enhancement;
- (c) Training set selection;
- (d) Signature generation and classification;
- (e) Creation/overlay of vector database;
- (f) Validation of classified image;
- (g) Final thematic map preparation.

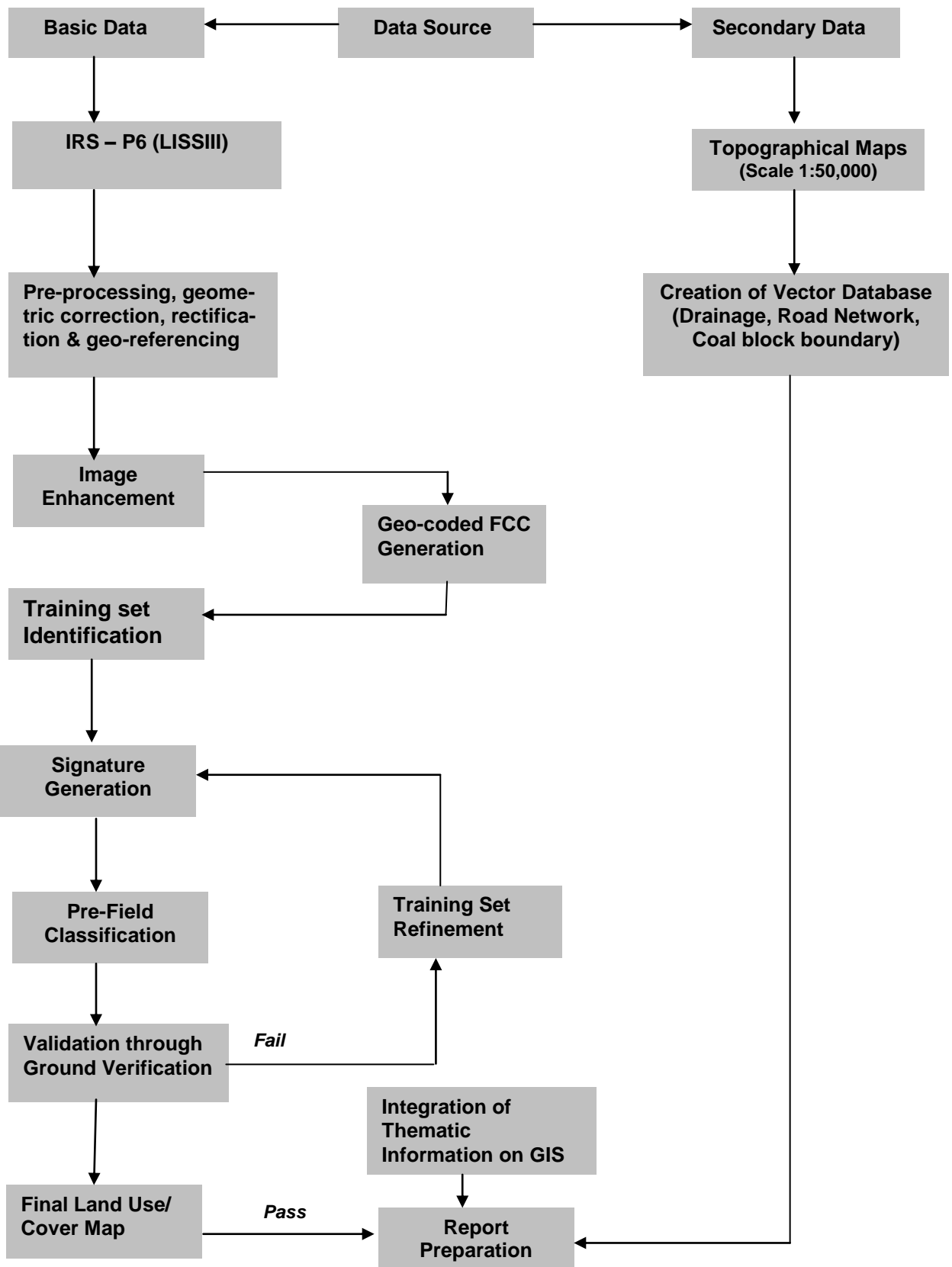


Fig-2.4 –Methodology of Land Use/Vegetation Cover Analysis

2.6.1 Geometric correction, rectification and geo-referencing

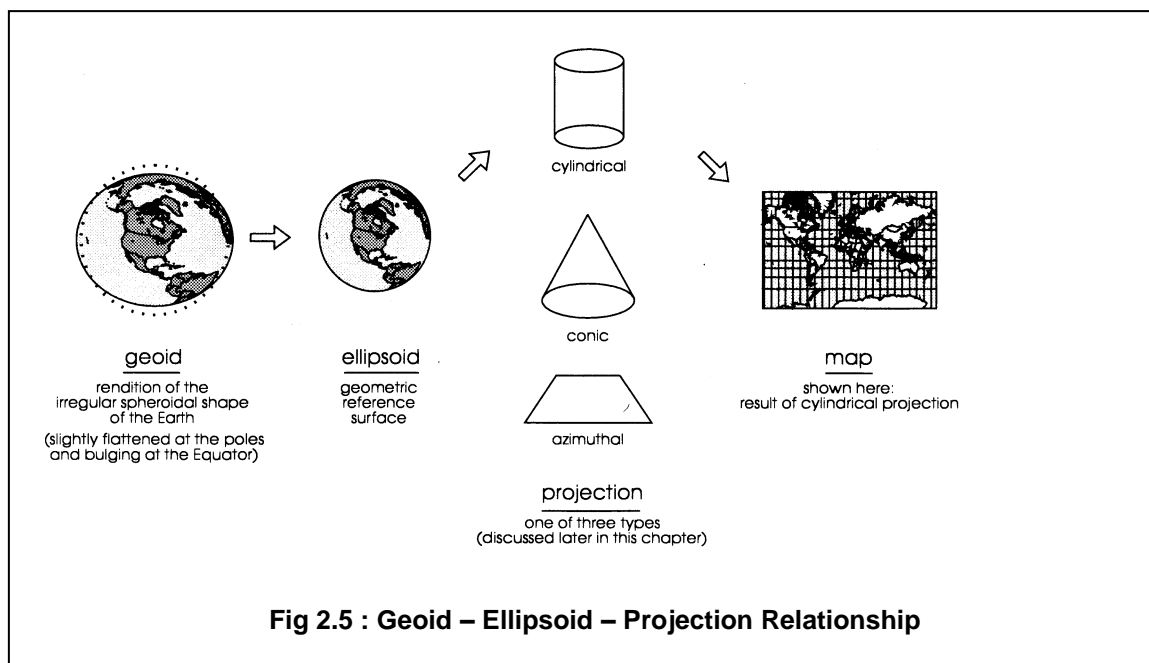
Inaccuracies in digital imagery may occur due to 'systematic errors' attributed to earth curvature and rotation as well as 'non-systematic errors' attributed to intermittent sensor malfunctions, etc. Systematic errors are corrected at the satellite receiving station itself while non-systematic errors/random errors are corrected in pre-processing stage.

In spite of 'System / Bulk correction' carried out at supplier end; some residual errors in respect of attitude attributes still remains even after correction. Therefore, fine tuning is required for correcting the image geometrically using ground control points (GCP).

Raw digital images contain geometric distortions, which make them unusable as maps. A map is defined as a flat representation of part of the earth's spheroidal surface that should conform to an internationally accepted type of cartographic projection, so that any measurements made on the map will be accurate with those made on the ground. Any map has two basic characteristics: (a) scale and (b) projection. While *scale* is the ratio between reduced depiction of geographical features on a map and the geographical features in the real world, *projection* is the method of transforming map information from a sphere (round Earth) to a flat (map) sheet. Therefore, it is essential to transform the digital image data from a generic co-ordinate system (i.e. from line and pixel co-ordinates) to a projected co-ordinate system. In the present study georeferencing was done with the help of Survey of India (Sol) topo-sheets so that information from various sources can be compared and integrated on a GIS platform, if required.

An understanding of the basics of projection system is required before selecting any transformation model. While maps are flat surfaces, Earth however is an irregular sphere, slightly flattened at the poles and bulging at the Equator. Map projections are systemic methods for "*flattening the orange peel*" in measurable ways. When transferring the Earth and its irregularities onto the plane surface of a map, the following three factors are involved: (a) geoid (b) ellipsoid and (c) projection. Figure 2.5 illustrates the relationship between these three factors. The *geoid* is the rendition of the irregular spheroidal shape of the Earth; here the variations in gravity are taken into account. The observation made on the geoid is then transferred to a regular geometric reference surface, the

ellipsoid. Finally, the geographical relationships of the ellipsoid (in 3-D form) are transformed into the 2-D plane of a map by a transformation process called map projection. As shown in Figure 2.5, the vast majority of projections are based upon *cones*, *cylinders* and *planes*.



In the present study, **UTM projection WGS 84 Datum** is used so as to prepare the map compatible with the Sol topo-sheets. Polyconic projection is used in Sol topo-sheets as it is best suited for small - scale mapping and larger area as well as for areas with North-South orientation (viz. India). Maps prepared using these projections are a compromise of many properties; it is neither conformal perspective nor equal area. Distances, areas and shapes are true only along central meridian. Distortion increases away from central meridian. Image transformation from generic co-ordinate system to a projected co-ordinate system was carried out using ERDAS IMAGINE v.1013 digital image processing system.

2.6.2 Image enhancement

To improve the interpretability of the raw data, image enhancement is necessary. Most of the digital image enhancement techniques are categorised as either point or local operations. Point operations modify the value of each pixel in the image data independently. However, local operations modify the value of each pixel based on brightness value of neighbouring pixels. Contrast manipulations/ stretching technique based on local operation was applied on the image

data using ERDAS IMAGINE 1013 version s/w. The enhanced and geocoded FCC image of Kamptee coalfield shown in Plate No. 1.

2.6.3 Training set selection

The image data were analysed based on the interpretation keys. These keys are evolved from certain fundamental image-elements such as tone/colour, size, shape, texture, pattern, location, association and shadow. Based on the image-elements and other geo-technical elements like land form, drainage pattern and physiography; training sets were selected/identified for each land use/cover class. Field survey was carried out by taking selective traverses in order to collect the ground information (or reference data) so that training sets are selected accurately in the image. This was intended to serve as an aid for classification. Based on the variability of land use/cover condition and terrain characteristics and accessibility, 150 points were selected to generate the training sets.

2.6.4 Signature generation and classification

Image classification was carried out using the maximum likelihood algorithm. The classification proceeds through the following steps: (a) calculation of statistics [i.e. signature generation] for the identified training areas, and (b) the decision boundary of maximum probability based on the mean vector, variance, covariance and correlation matrix of the pixels.

After evaluating the statistical parameters of the training sets, reliability test of training sets was conducted by measuring the statistical separation between the classes that resulted from computing divergence matrix. The overall accuracy of the classification was finally assessed with reference to ground truth data. The aerial extent of each land use class in the coalfield was determined using ERDAS IMAGINE s/w 2013 version. The classified image for the year 2013 for Kamptee Coalfield is shown in Plate No. 2.

2.6.5 Creation/overlay of vector database

Plan showing coal block boundary are superimposed on the image as vector layer in the Arc GIS database. Road network, rail network and drainage network are also digitised on Arc GIS 9.3 version database and superimposed on the classified image.

2.6.6 Validation of classified image

Ground truth survey was carried out for validation of the interpreted results from the study area. Based on the validation, classification accuracy matrix was prepared. The classification accuracy matrix is shown in Table 2.3.

Classification accuracy in case of Coal quarry, Barren OB Dump and water body was 100%. Classification accuracy in case of Dense forest, Open forest, agriculture land ,waste land, scrubs between 90% to 100%. In case of social forestry, the classification accuracy is 75.00%. Classification accuracy for urban settlement ,rural settlement and Industrial settlement varies from 60.00% to 85.71% due to poor *signature separability index*. Where as classification accuracy for Sand body and Fly ash pond are 80.00% and 66.66% respectively and overall classification accuracy in case of Kamptee Coalfield was estimated as 85.92%.

2.6.7 Final land use/vegetation cover map preparation

Final land use/vegetation cover map (Plate - 2) was printed using HP Design jet 4500 Colour Plotter. The maps are prepared on 1:50,000 scale and enclosed as drawing No. 2 along with the report. A soft copy in pdf format is also enclosed .

Table 2.3 : Classification Accuracy Matrix for Kamptee Coalfield

Sl. No.	Classes in the Satellite Data	Class	Total Obsrv. Points	Land use classes as observed in the field														
				C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15
1	Urban Settlement	C1	05	03	1	1												
2	Rural Settlement	C2	07	1	06	1												
3	Industrial Settlement	C3	05		1	04												
4	Dense Forest	C4	18				17	1										
5	Open Forest	C5	20				1	18	1									
6	Scrubs	C6	12					1	11									
7	Soc. Forestry	C7	08						1	06	1							
8	Agriculture Land	C8	23						1	1	21							
9	Waste Upland	C9	17	1								16						
10	Fly Ash Pond	C10	5									1	04					
11	Sand Body	C11	03									1		02				
12	Coal dump	C12	05									1			04			
13	Coal Quarry	C13	05													05		
14	Barren OB Dump	C14	06										1				05	
15	Water Bodies	C15	11															11
Total no. of observation points			150	05	07	05	18	20	12	08	23	17	05	03	05	05	06	11
% of commission				20.00	28.57	40.00	5.55	10.00	25.00	12.50	4.34	18.75	80.00	0.00	0.00	0.00	0.00	0.00
% of omission				40.00	28.57	20.00	5.55	10.00	8.33	8.33	8.70	5.88	40.00	33.33	20.00	0.00	20.00	0.00
% of Classification Accuracy				60.00	85.71	80.00	94.45	90.00	91.66	75.00	91.30	94.11	80.00	66.66	80.00	100.0	100.0	100.0
Overall Accuracy (%)				85.92														

Chapter 3

Land Use/ Vegetation Cover Mapping

3.1 Introduction

Land is one of the most important natural resource on which all human activities are based. Therefore, knowledge on different type of lands as well as its spatial distribution in the form of map and statistical data is vital for its geospatial planning and management for optimal use of the land resources. In mining industry, the need for information on land use/ vegetation cover pattern has gained importance due to the all-round concern on environmental impact of mining. The information on land use/ cover inventory that includes type, spatial distribution, aerial extent, location, rate and pattern of change of each category is of paramount importance for assessing the impact of coal mining on land use/ cover.

Remote sensing data with its various spectral and spatial resolution offers comprehensive and accurate information for mapping and monitoring of land use/cover pattern, dynamics of changing pattern and trends over a period of time.. By analysing the data of different cut-off dates, impact of coal mining on land use and vegetation cover can be determined.

3.2 Land Use/Vegetation Cover Classification

The array of information available on land use/cover requires to be arranged or grouped under a suitable framework in order to facilitate the creation of a land use/cover database. Further, to accommodate the changing land use/cover pattern, it becomes essential to develop a standardised classification system that is not only flexible in nomenclature and definition, but also capable of incorporating information obtained from the satellite data and other different sources.

The present framework of land use/cover classification has been primarily based on the '**Manual of Nationwide Land Use/ Land Cover Mapping Using Satellite Imagery**' developed by National Remote Sensing Centre, Hyderabad. Land use map was prepared on the basis of image interpretation carried out based on the satellite data for the year 2013 for Kamptee Coalfield and following land use/cover classes are identified (Table 3.1).

Table 3.1: Land use/cover classes identified in Kamptee Coalfield		
	Level -I	Level -II
1	Built-Up Land	1.1 Urban 1.2 Rural 1.3 Industrial
2	Agricultural Land	2.1 Crop Land 2.2 Fallow Land
3	Forest/Vegetation Cover	3.1 Dense Forest 3.2 Open Forest 3.3 Scrub 3.4 Plantation under Social Forestry 3.5 Plantation on OB Dumps 3.6 Plantation on Backfilled area
4	Wasteland	4.1 Waste upland with/without scrubs 4.2 Fly Ash pond 4.3 Sand Body
5	Mining	5.1 Coal Quarry 5.2 Backfilling area 5.3 Water filled Quarry 5.4 Barren OB Dump 5.5 Coal Dump
6	Water bodies	6.1 River/Streams /Reservoir

Following maps are prepared on 1:50,000 scale :

1. Plate No. 1 : Drawing No. HQ/REM/ 01: FCC (IRS-P6) LISS-III data of Kamptee Coalfield of the year 2013 with Coalfield boundary and other infrastructural details.
2. Plate No. 2 : Drawing No. HQ/REM/ 02 – Classified land use/cover Map of Kamptee Coalfield based on IRS-P6 LISS-III data of the Year 2013 .

3.3 Data Analysis & Change Detection

Satellite data of the year 2013 were processed using ERDAS IMAGINE 2013 version image processing s/w in order to interpret the various land use/cover classes present in the study area of Kamptee Coalfield covering 1344.78 sq.kms. The area of each land use/cover class for Kamptee Coalfield were calculated using ERDAS IMAGINE s/w and tabulated in Table 3.2. Comparison of various land use classes between years 2010 & 2013 are shown in the Bar Chart (Fig. 2.6). Kamptee Coalfield contains 46 coal block whose land use/cover classes are tabulated in Table 3.9(A) and 3.9(B)

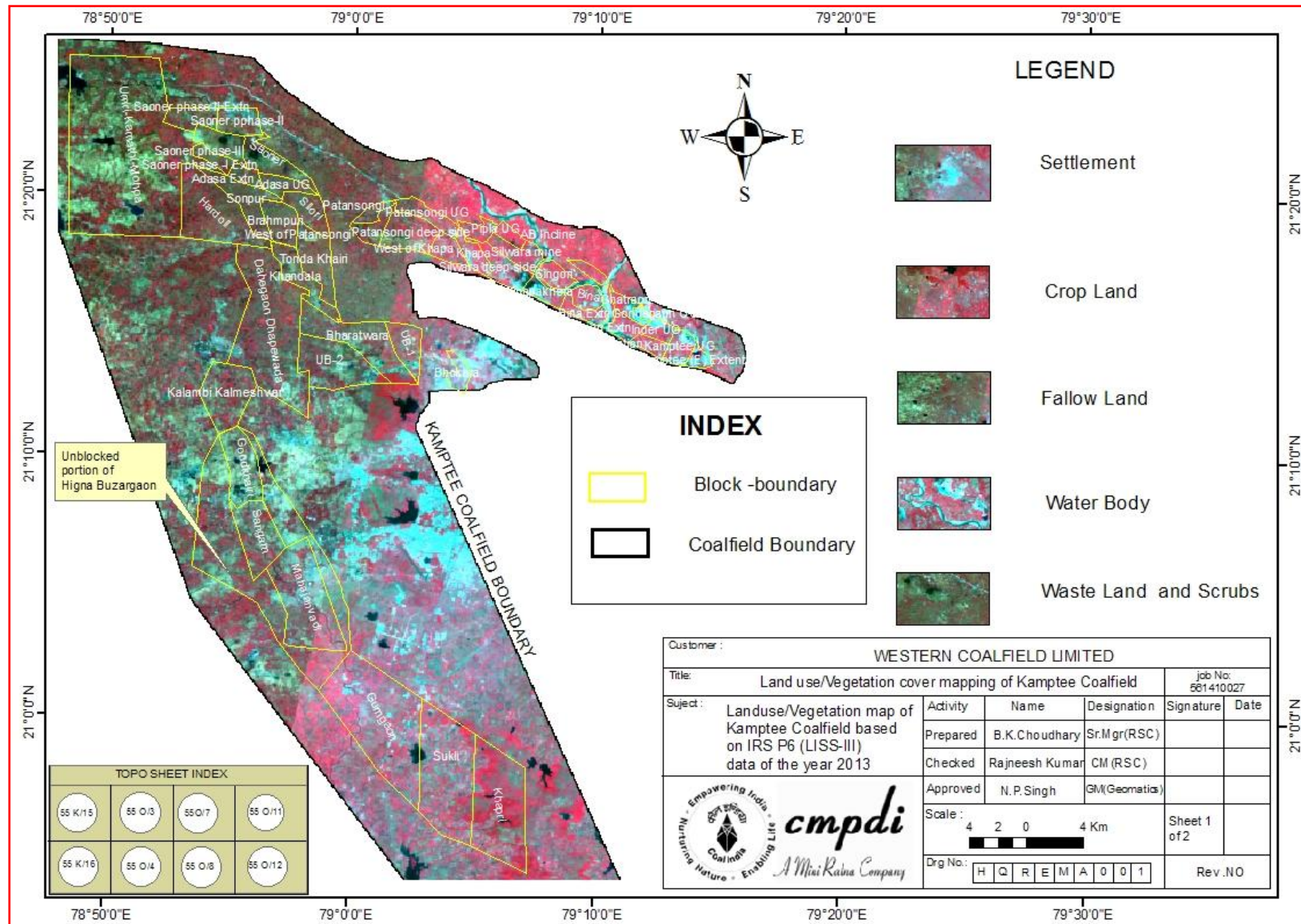


Plate 1 : FCC (Band 3, 2, 1) of Kamptee CF based on IRS-P6 (LISS – III) Data of Year – 2013

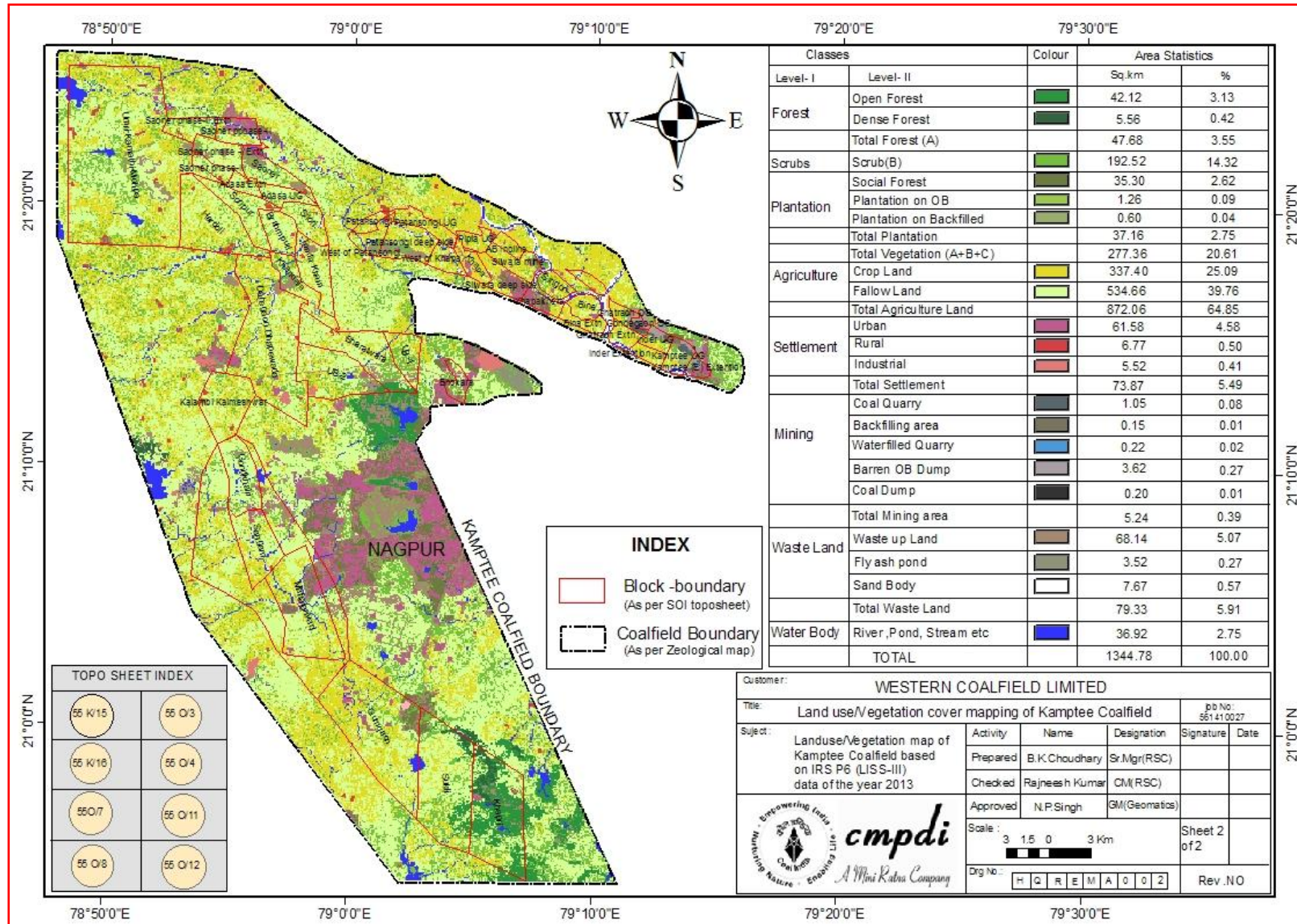


Plate 2 : LU / LC Map of Kamptee CF based on IRS-P6 (LISS-III) Data of Year 2013

TABLE-3.2 :STATUS OF LAND USE/COVER PATTERN IN KAMPTEE COALFIELD DURING THE YEAR 2010 &2013							
LAND USE CLASSES	Year 2010		Year 2013		Change w.r.t Yr 2010		Remarks
	Area(Km ²)	% age	Area(Km2)	% age	Area(Km2)	% age	
SETTLEMENT							
Urban	79.96	5.95	61.58	4.58	-18.38	-1.37	Due to Industrial development in the area.
Industrial	3.12	0.23	5.52	0.41	2.40	0.18	
Rural	8.77	0.65	6.77	0.50	-2.00	-0.15	
Total Settlement	91.85	6.83	73.87	5.49	-17.98	-1.34	
VEGETATION COVER							
Forest							
Dense Forest	6.84	0.50	5.56	0.41	-1.28	-0.09	Due to Biotic interference by local people and Coal Mining.
Open Forest	46.60	3.47	42.12	3.13	-4.48	-0.34	
Total Forest (A)	53.44	3.97	47.68	3.54	-5.76	-0.43	
SCRUBS							
Scrub (B)	162.51	12.08	192.52	14.32	30.01	2.24	On account of good monsoon ,Scrubs has been increased.
PLANTATION							
Social Forestry	36.67	2.73	35.30	2.62	-1.37	-0.11	Due to new construction near mining Area.
Plantation on Backfilling			0.60	0.04	0.60	0.04	
Plantation on OB Dump			1.26	0.09	1.26	0.09	
Total Plantation (C)	36.67	2.73	37.16	2.75	0.49	0.02	Due to massive plantation carried out by WCL.
Total Vegetation Cover(A+B+C)	252.62	18.78	277.36	20.61	24.74	1.83	
AGRICULTURE							
Crop Land	462.82	34.42	337.40	25.09	-125.42	-9.33	Due to industrialisation in the area.
Fallow Land	421.88	31.37	534.66	39.76	112.78	8.39	
Total Agriculture	884.70	65.79	872.06	64.85	-12.64	-0.94	
MINING AREA							
Coal Quarry	0.51	0.04	1.05	0.08	0.54	0.04	Due to increase in mining activity.Total mining area has increased.
Coal Dump	0.36	0.04	0.20	0.01	-0.16	-0.03	
Barren OB Dump	3.53	0.26	3.62	0.27	0.09	0.01	
Barren Back filling area			0.15	0.01	0.15	0.01	
Waterfilled Quarry			0.22	0.02	0.22	0.02	
Total Mining Area	4.40	0.34	5.24	0.39	0.84	0.05	
WASTELANDS							
Waste Land with/Without Scrubs	71.01	5.28	68.14	5.07	-2.87	-0.21	Due to conversion of Waste land in Scrubs ,there is mionr decrease in Waste land.
Fly ash Pond	1.99	0.15	3.52	0.27	1.53	0.12	Fly ash increased due to expansion of existing thermal Power.
Sand	5.80	0.43	7.67	0.57	1.87	0.14	
Total Waste Land	78.80	5.86	79.33	5.91	0.53	0.05	
WATER BODY							
Water Body	32.41	2.40	36.92	2.75	4.51	0.35	Water Body increased due to good monsoon.
Total Water Body	32.41	2.40	36.92	2.75	4.51	0.35	
Total	1344.78	100.00	1344.78	100.00	0.00	0.00	

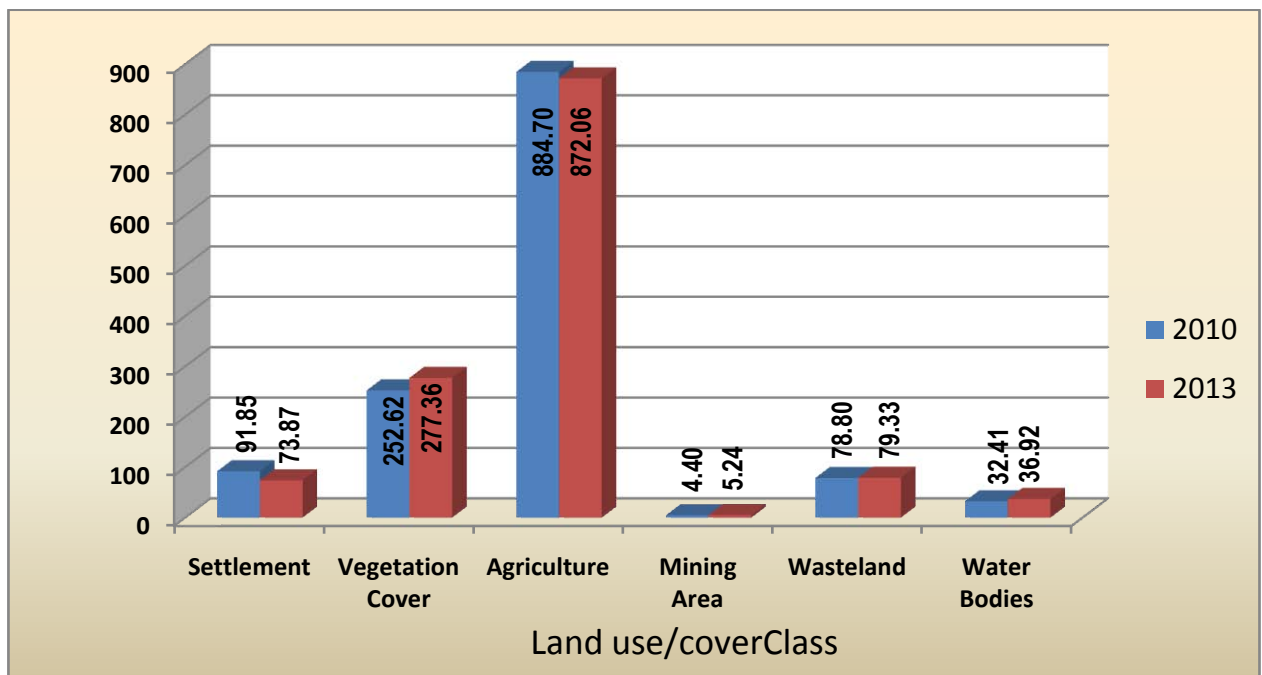


Fig. 2.6 : Yearwise Comparison of Land use / Vegetation Cover in Kamptee Coalfield

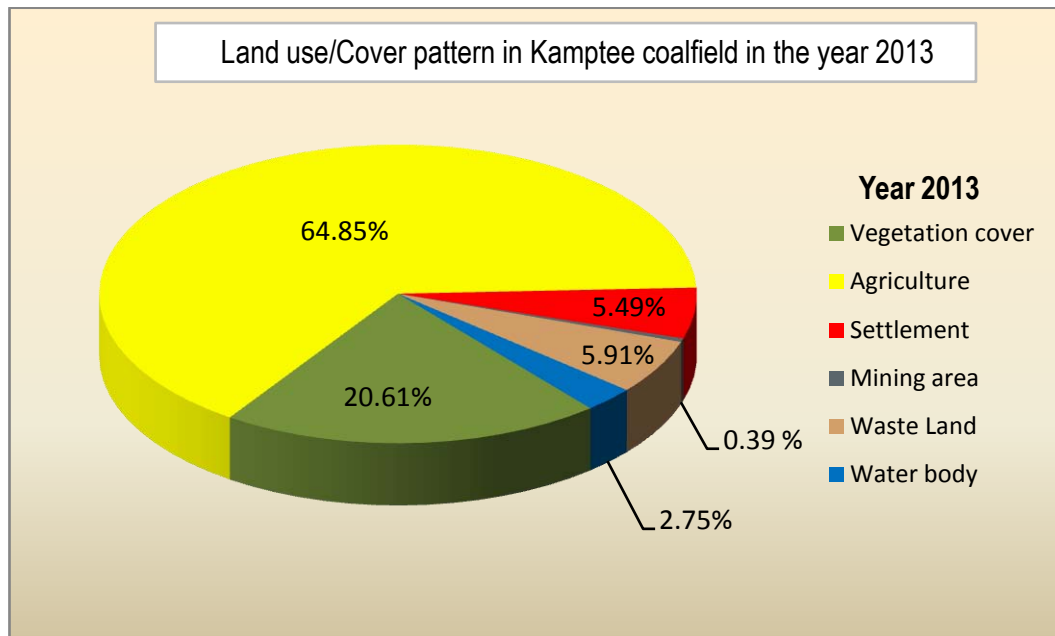


Figure-2.8

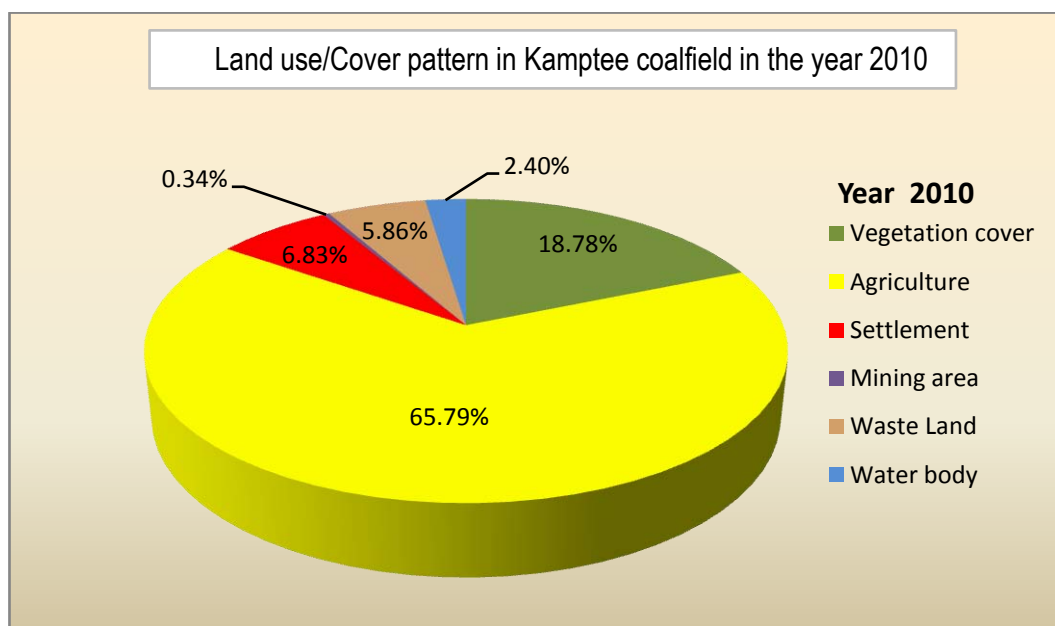


Figure-2.7

3.3.1 Settlements

All the man-made constructions covering the land surface are included under this category. Built-up land has been further divided into rural, urban and industrial classes. In the present study, industrial settlement indicates only industrial complexes excluding residential facilities. In the year 2010 the total area covered by settlements were estimated to be 91.85 sq km (6.83%). In year 2013 the estimated area under settlements has grown to 73.87sq km (5.49%). There is an decrease in total Settlements by 17.98 sq km which is about 1.34% of the total area. This decrease is due to Industrial development in the area . The details of the land use under this category are shown in Table 3.3 as follows:

TABLE – 3.3

STATUS OF CHANGE IN SETTLEMENTS IN KAMPTEE COALFIELD DURING YEAR 2010 & 2013

LAND USE CLASSES	Year 2010		Year 2013		Change w.r.t Yr 2010		Remarks
	Area(Km ²)	% age	Area(Km2)	% age	Area(Km2)	% age	
SETTLEMENTS							
<i>Urban</i>	79.96	5.95	61.58	4.58	-18.38	-1.37	Due to Industrial development in the area.
<i>Industrial</i>	3.12	0.23	5.52	0.41	2.40	0.18	
<i>Rural</i>	8.77	0.65	6.77	0.50	-2.00	-0.15	
Total Settlement	91.85	6.83	73.87	5.49	-17.98	-1.34	

3.3.2 Vegetation cover Analysis

Vegetation cover in the coalfield area comprises following five classes:

- Dense Forest
- Open Forest
- Scrubs
- Plantation on Over Burden(OB) Dumps / Backfilled area, and
- Social Forestry

There has been significant variation in the land use under the vegetation classes within the area as shown below in Table 3.4.

TABLE – 3.4

STATUS OF CHANGE IN VEGETATION COVER IN KAMPTEE COALFIELD DURING YEAR 2010 & 2013

LAND USE CLASSES	Year 2010		Year 2013		Change w.r.t Yr 2010		Remarks
	Area(Km ²)	% age	Area(Km2)	% age	Area(Km2)	% age	
VEGETATION COVER							
Forest							
Dense Forest	6.84	0.50	5.56	0.41	-1.28	-0.09	Due to Biotic interference by local people and Coal Mining.
Open Forest	46.60	3.47	42.12	3.13	-4.48	-0.34	
Total Forest (A)	53.44	3.97	47.68	3.54	-5.76	-0.43	
SCRUBS							
Scrub (B)	162.51	12.08	192.52	14.32	30.01	2.24	On account of good monsoon ,Scrubs has been increased.
PLANTATION							
Social Forestry	36.67	2.73	35.30	2.62	-1.37	-0.11	Due to new construction near mining Area.
Plantation on Backfilling area			0.60	0.04	0.60	0.04	
Plantation on OB Dump			1.26	0.09	1.26	0.09	
Total Plantation (C)	36.67	2.73	37.16	2.75	0.49	0.02	Due to massive plantation carried out by WCL.
Total Vegetation Cover(A+B+C)	252.62	18.78	277.36	20.61	24.74	1.83	

Dense forest – Forest having crown density of above 40% comes in this class. In the year 2010 the total area covered by dense forest were estimated to be 6.84sq km(0.50%). In year 2013 the estimated area under dense forest has reduced to 5.56sq km (0.41%). There is a decrease in dense forest by 1.28 sq km which is about 0.09% of the total coalfield area on account of conversion to open forest in to Scrubs due to deforestation .

Open Forest – Forest having crown density between 10% to 40% comes under this class. Open forest cover over Kamptee coalfield which was estimated to be 46.60 sq km (3.47%) in 2010 has been decreased to 42.12sq km, i.e.3.13 % of the total coalfield area in 2013. Thus the decrease in open forest is 4.48 sq km which is (0.34) % of the total coalfield area. This reduction is due to biotic interference by the local people and Coal mining.

Scrubs – Scrubs are vegetation with crown density less than 10%. Scrubs in the coalfield are seen to be scattered signature all over the area mixed with wastelands. There is 192.52 sq km. of scrubs, i.e. 14.32% of the coalfield area in 2013. In year 2010 the scrubs covered 162.51 sq km which were 12.08% of the coalfield area. There is a increase of 30.01 sq km which is 2.24% of the total coalfield area .The increase is on account of good monsoon.

Social Forestry – Plantation which has been carried out on wastelands, along the roadsides and colonies on green belt come under this category. Analysis of data reveals Social Forestry covers 35.30 sq km, which is 2.62% of the coalfield area in 2013. In 2010 the area covered under social forestry was 36.67 sq km (2.73%) . there is an decrease of 1.37 sq km (0.11%). This decrease is due to new construction near mining area.

Plantation over OB Dump and backfilled area – Analysis of the data reveals that WCL has carried out significant plantation on OB dumps as well as backfilled areas during the period for maintaining the ecological balance of the area. The plantation on the OB dumps and backfilled areas are estimated to be 1.86 sq km,(0.13%) of the coalfield area in the year 2013. There is total increase of 1.86 sq km (0.13%) in plantation over OB dumps /backfilled area with respect to Year 2010. This increase is due to massive plantation carried out by WCL.

3.3.3 Mining Area

The mining area was primarily been categorized as.

- Coal Quarry
- Barren OB Dump

To make the study more relevant and to give thrust on land reclamation, in the current study some more classes have been added as follows:

- Barren Backfilled Area
- Coal Dumps
- Water filled Quarry

In the year 2010 the coal quarry was estimated to be 0.51 sq km (0.04%) which has increased to 1.05 sq km (0.08%) in the year 2013. This minor increase is due to increase in production of coal from Open cast areas. In the year 2010 the barren OB dump was estimated to be 3.53sq km (0.26%) which has been increased to 3.62 sq km (0.27%) in the year 2013. This increase is due to increase in mining activity and total mining area in the year 2013 is 5.24 sq km(0.39%) with respect to 4.40 Sq.km (0.34%) total mining area in the Year 2010. The status of land Use in the mining area over the Kamptee Coalfield is shown in the table 3.5 below.

TABLE – 3.5

Status of change in Mining Area in Kamptee Coalfield during the year 2010 & 2013

LAND USE CLASSES	Year 2010		Year 2013		Change w.r.t Yr 2010		Remarks
	Area(Km ²)	% age	Area(Km2)	% age	Area(Km2)	% age	
MINING AREA							
Coal Quarry	0.51	0.04	1.05	0.08	0.54	0.04	Due to increase in mining activity.Total mining area has increased.
Coal Dump	0.36	0.04	0.20	0.01	-0.16	-0.03	
Barren OB Dump	3.53	0.26	3.62	0.27	0.09	0.01	
Barren Back filling area			0.15	0.01	0.15	0.01	
Waterfilled Quarry			0.22	0.02	0.22	0.02	
Total Mining Area	4.40	0.34	5.24	0.39	0.84	0.05	

3.3.4 Agricultural Land

Land primarily used for farming and production of food, fibre and other commercial and horticultural crops falls under this category. It includes crop land (irrigated and unirrigated) and fallow land (land used for cultivation, but temporarily allowed to rest)

Total agricultural land is 872.06sq km in year 2013, which is 64.85% of the coalfield area. In year 2010 the total agricultural area was estimated to be 884.70sq km which was 65.79% of the coalfield area. There is an decrease of 12.64 sq km which is 0.94% of the coalfield due to Industrialisation in the mining area. The details are shown below in Table 3.6.

TABLE – 3.6

Status of change in Agricultural land in Kamptee Coalfield during the year 2010 & 2013

LAND USE CLASSES	Year 2010		Year 2013		Change w.r.t Yr 2010		Remarks
	Area(Km ²)	% age	Area(Km2)	% age	Area(Km2)	% age	
AGRICULTURE							
Crop Land	462.82	34.42	337.40	25.09	-125.42	-9.33	Due to industrialisation in the area.
Fallow Land	421.88	31.37	534.66	39.76	112.78	8.39	
Total Agriculture	884.70	65.79	872.06	64.85	-12.64	-0.94	

3.3.5 Wasteland

Wasteland is degraded and unutilised class of land which is deteriorating on account of natural causes or due to lack of appropriate water and soil management. Wasteland can result from inherent/imposed constraints such as location, environment, chemical and physical properties of the soil or financial or management constraints.

The land use pattern within the area for waste lands is shown below in Table – 3.7. the waste land was estimated to 78.80sq km (5.86%) in the year 2010. In the year of 2013, waste land is estimated to be 79.33 sq km (5.91%). So there is a increase of 0.53sq km i.e. (0.05%) of the total coalfield area due to conversion of Agriculture land in waste land. The details are shown below in Table 3.7.

TABLE – 3.7

Status of Change in Wastelands in Kamptee Coalfield during the year 2010 & 2013

LAND USE CLASSES	Year 2010		Year 2013		Change w.r.t Yr 2010		Remarks
	Area(Km ²)	% age	Area(Km2)	% age	Area(Km2)	% age	
WASTELANDS							
<i>Waste Land with/Without Scrubs</i>	71.01	5.28	68.14	5.07	-2.87	-0.21	Due to conversion of Waste land in Scrubs ,there is mionr decrease in Waste land.
<i>Fly ash Pond</i>	1.99	0.15	3.52	0.27	1.53	0.12	Fly ash incresed due to expansion of existing thermal Power.
<i>Sand</i>	5.80	0.43	7.67	0.57	1.87	0.14	
Total Waste Land	78.80	5.86	79.33	5.91	0.53	0.05	

3.3.6 Water bodies

It is the area of impounded water includes natural lakes, rivers/streams and man made canal, reservoirs, tanks etc. The water bodies in the study area had been estimated to be 32.41sq km in year 2010, which is 2.40% of the coalfield area. In 2013 it has been estimated to be 36.92 sq km which is 2.75% of the coalfield area. So there is an increase of 4.51 sq. km. in water bodies which is 0.35% of the total coalfield area.

Table:3.8

Status of Change in Surface Water body in Kamptee Coalfield during the year 2010 & 2013

LAND USE CLASSES	Year 2010		Year 2013		Change w.r.t Yr 2010		Remarks
	Area(Km ²)	% age	Area(Km2)	% age	Area(Km2)	% age	
WATER BODY							
<i>Water Body</i>	32.41	2.40	36.92	2.75	4.51	0.35	Water Body increased due to good monsoon.
<i>Total Water Body</i>	32.41	2.40	36.92	2.75	4.51	0.35	

Table:3.9(A) Blockwise land use/ vegetation Cover Status in Kamptee Coalfield

Sl.no	Name of block	Area in Sq.Km																									
		Dense Forest	Open Forest	Total Forest	Scrubs	Social Forestry	Total plantation	Total vegetation	Crop Lands	Fallow Lands	Total Agriculture Land	Coal Quarry	Backfilling area	Barren OB dump	Water filled Quarry	Coal dump	Total Mining area	Waste up land	Fly ash pond	Sand body	Total waste land	Urban Settlement	Rural Settlement	Industrial Settlement	Total settlement	Water body	Total water body
1	Khapri	2.33	12.70	15.03	3.46	0.02	0.02	18.51	0.80	7.70	8.50						1.22			1.22	0.17	0.11		0.28	0.25	0.25	28.76
2	Sukll	0.78	2.87	3.65	6.02	0.70	0.70	10.37	4.90	15.84	20.74						0.29			0.29	0.06			0.06	0.52	0.52	31.98
3	Gumgaon				4.48	1.57	1.57	6.05	18.63	13.62	32.25						0.76		0.13	0.89	1.71			1.71	1.42	1.42	42.32
4	Mahajanvadi				1.95	1.20	1.20	3.15	7.18	12.20	19.38						0.93		0.06	0.99	1.44			1.44	1.07	1.07	26.03
6	Sangam				1.03			1.03	3.54	6.86	10.40						0.13		0.09	0.22	0.36	0.06		0.42	0.50	0.50	12.57
7	Gondkhairi				1.58	0.02	0.02	1.60	0.33	8.05	8.38						0.47			0.47	0.18			0.18	0.56	0.55	11.18
8	Kalambi Kalmeshwar				1.71			1.71	5.14	6.45	11.59						0.06		0.10	0.16		0.31		0.31			13.77
9	Dhaegaon Dhapewada				6.05	0.20	0.20	6.25	14.42	16.99	31.41						0.84		0.65	1.49	0.86	0.29	0.45	1.60	0.65	0.65	41.40
10	Bharatwada		1.12	1.12	1.86			2.98	2.72	9.89	12.61						1.44		0.04	1.48		0.05		0.05	0.13	0.13	17.25
11	Khandala				1.54			1.54	1.52	3.82	5.34						0.98			0.98		0.03		0.03	0.19	0.19	8.08
12	Tonda Khairi				0.71			0.71	2.25	5.67	7.92						0.58			0.58		0.10		0.10	0.14	0.14	9.45
13	Brahmpuri				0.53			0.53	1.13	4.58	5.71						0.04			0.04		0.03		0.03	0.11	0.11	6.42
14	Silori				0.76			0.76	1.67	3.25	4.92						0.01		0.07	0.08		0.06		0.06	0.12	0.12	5.94
15	Adasa UG				0.67			0.67	0.42	2.61	3.03						0.08			0.08		0.01		0.01			3.79
16	Sonpur				1.37	0.02	0.02	1.39	1.38	6.14	7.52						0.03			0.03		0.20		0.20			9.14
17	Hardoli		0.02	0.02	2.65			2.67	7.27	9.87	17.14						0.01		0.02	0.03		0.44		0.44	0.28	0.28	20.56
18	Adasa Extn				0.34			0.34	0.44	1.86	2.30									0.00		0.06		0.06			2.70
19	Saoner phase-iii				0.45			0.45	0.33	1.89	2.22						0.11			0.11		0.04		0.04			2.82
20	Saoner phase-1 extn				0.63			0.63	0.58	3.86	4.44						0.91			0.91							5.98

TABLE:3.9(B)

Sl.no	Name of block	Dense Forest	Open Forest	Total Forest	Scrubs	Social Forestry	Plantation on backfilling area	Plantation on OB	Total plantation	Total vegetation	Crop Lands	Fallow Lands	Total Agriculture Land	Coal Quarry	Backfilling area	Barren OB dump	water filled quarry	Coal dump	Total Mining area	Waste up land	Fly ash pond	Sand body	Total waste land	Urban Settlement	Rural Settlement	Industrial Settlement	Total settlement	Water body	Total water body	Total area (Sq.km)
21	Saoner PH-II				0.60					0.60	0.86	1.86	2.72							0.78			0.78	1.15			1.15	0.27	0.27	5.52
22	Saoner ph-ii extn				1.51					1.51	0.91	2.67	3.58							0.05			0.05	0.01	0.08		0.09	0.05	0.05	5.28
23	Patansaongi				0.27					0.27	1.11	0.45	1.56							0.03		0.08	0.11		0.13		0.13	0.11	0.11	2.18
24	West of patansaongi				1.08	0.03			0.03	1.11	2.42	1.46	3.88							0.65		0.17	0.82		0.19		0.19	0.46	0.46	6.46
25	Patansaongi UG				0.46					0.46	2.89	1.17	4.06							0.14			0.14	0.17	0.07		0.24	0	0	4.90
26	Patansaongi deep side				1.10					1.10	3.44	1.98	5.42							1.55		0.14	1.69	0.10			0.10	0.35	0.35	8.66
27	Pipla UG				0.35					0.35	1.86	0.6	2.46											0.13			0.13			2.94
28	Khapa				0.17					0.17	2.54	0.79	3.33							0.18		0.01	0.19	0.53			0.53			4.22
29	West of Khapa				0.29					0.29	1.99	0.81	2.80							0.04		0.11	0.15	0.13	0.01		0.14	0.20	0.20	3.58
30	Silwara dip side				0.23	0.98			0.98	1.21	2.25	0.75	3.00							0.43			0.43	1.31			1.31			5.95
31	AB incline				0.18					0.18	1.53	0.43	1.96										0.00	0.10			0.10			2.24
32	Silwara mine				0.62	0.15			0.15	0.77	2.73	1.11	3.84							0.17		0.07	0.24	0.19			0.19			5.04
33	Singori				0.82					0.82	1.55	0.75	2.30									0.08	0.08	0.13			0.13	0.13	0.13	3.46
34	Bina				0.23					0.23	1.82	0.96	2.78									0.17	0.17	0.14			0.14	0.12	0.12	3.44
35	Ghatraon extn				0.18					0.18	1.65	0.85	2.50							0.11		0.17	0.28				0.00	0.19	0.19	3.15
36	Inder UG				0.29	0.15		0.06	0.21	0.50	1.02	0.27	1.29	0.07	0.03	0.62		0.07	0.79	0.14			0.14	0.08			0.08			2.80
37	Inder extn				0.07					0.07	1.54	0.78	2.32									0.07	0.07					0.06	0.06	2.52
38	Kamptee UG				0.32	0.25		0.44	0.69	1.01	0.54	0.84	1.38	0.39	0.08	0.60			1.07	0.10		0.33	0.43	0.13			0.13	0.15	0.15	4.17
39	Kamptee (E) extn					0.23		0.24	0.47	0.47				0.06		0.26	0.15	0.01	0.48	0.18		0.06	0.24	0.81			0.81	0.04	0.04	2.04
40	Gondegaon OC							0.05	0.05	0.05				0.12	0.04	0.54	0.08		0.78	0.01			0.01							0.84
41	Ghatraon OC				0.26			0.12	0.12	0.38	0.98	0.36	1.34	0.44		0.29		0.04	0.77	0.16			0.16			0.05	0.05			2.70
42	Khapa Khera				0.25	0.63			0.63	0.88	0.50	0.28	0.78							0.22		0.13	0.35	0.6		0.29	0.89	0.24	0.24	3.14
43	Bokhara				0.66	0.26			0.26	0.92		0.80	0.80										0.70	0.79			0.79			3.21
44	Bina extn				0.12					0.12	1.85	1.01	2.86									0.11	0.11	0.01			0.01	0.10	0.10	3.20
45	Umri kamathi mohpa				16.62	0.34			0.34	16.96	27.64	45.24	72.88							2.92		0.05	2.97	0.33	1.16	0.18	1.67	3.12	3.12	97.60
46	Saoner				1.62	0.11			0.11	1.73	0.46	3.47	3.93							1.56			1.56	0.45	0.10		0.55	0.07	0.07	7.84
	Total	3.11	16.71	19.82	66.09	6.86		0.91	7.77	93.68	138.73	210.84	349.57	1.08	0.15	2.31	0.23	0.12	3.89	19.01		2.91	21.92	12.07	3.53	0.97	16.57	11.60	11.59	497.22

Chapter 4

Conclusion & Recommendation

4.1 Conclusion

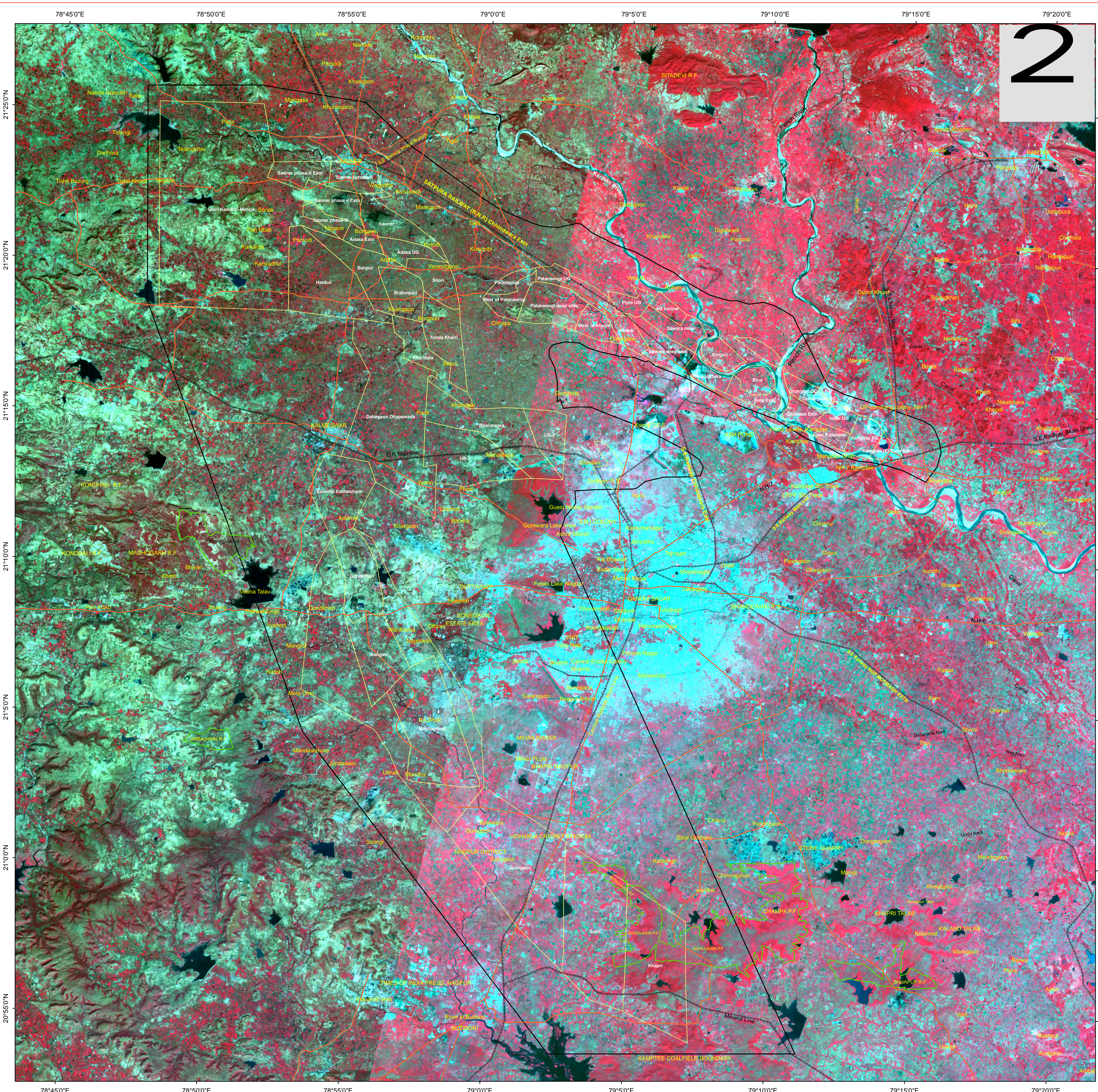
In the present study, land use/ vegetation cover mapping has been carried out based on IRS-P6/ LISS-III satellite data of January, 2013 in order to monitor the impact of coal mining on land environment which may helps in formulating the mitigation measures required, if any.

Study reveals that the total area of settlements which includes urban, rural and industrial settlements in the Kamptee coalfields covers 73.87Km² (5.49%) area. There is an decrease in settlements by 17.98 Sq Km over the year 2010 study .This decrease is due to Industrial development in the area. Vegetation cover which includes dense forests, open forests, scrubs, avenue plantation & plantation on over-burden dumps, covers an area of 277.36km² (20.61%). As compared to 2010 study there is a increase in overall vegetation cover by 24.74km² (1.84%) this is mainly because massive plantation carried out by WCL. Area of scrubs has increased by 30.01Sq.Km (2.24%). because of good monsoon. The analysis further indicates that total agricultural land which includes both crop and fallow land has decreased to 12.64km² (0.94 %).This is due to industrialisation in the area. The mining area which includes coal quarry, barren OB dump, barren backfilled area, covers 5.24km² (0.39%). As compared to 2010 there is a minor increase i.e 0.84Sq.Km (0.05%) in areas under mining operations because of increase in mining activity. Wasteland covers 79.33km² (5.91%) in 2013 and 78.80 km² (5.86%) in 2010. Waste lands have increased to 0.53 Sq.Km(0.05%) because some fallow land has been converted in waste land . Surface water bodies covered area of 36.92 km² (2.75%).in year 2013 as compared to 32.41 Sq.Km(2.40%) in year 2010 .Hence area covered by water body has increased to 4.51Sq.Km(0.35%) as compared to year 2010 due to good monsoon.

The detail statistical analysis is given under Table-3.2.

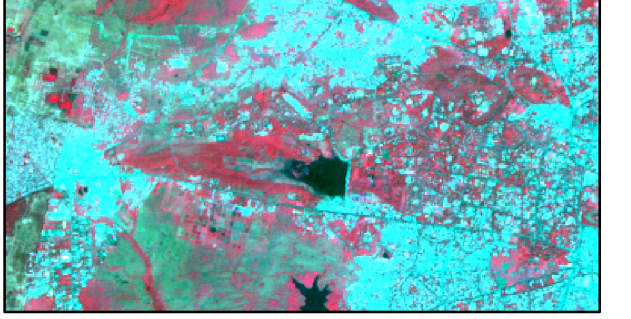

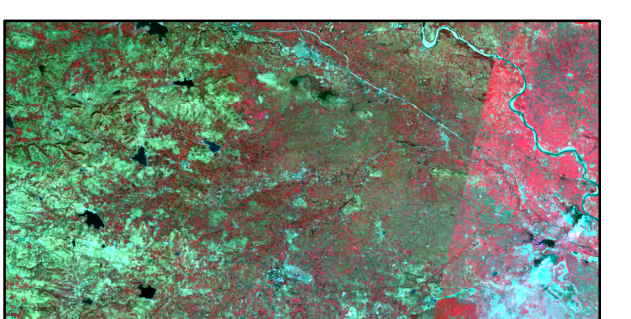
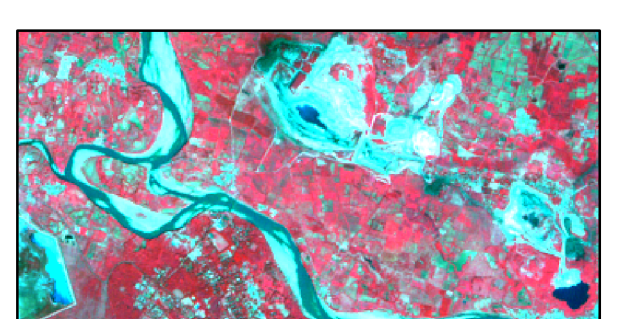
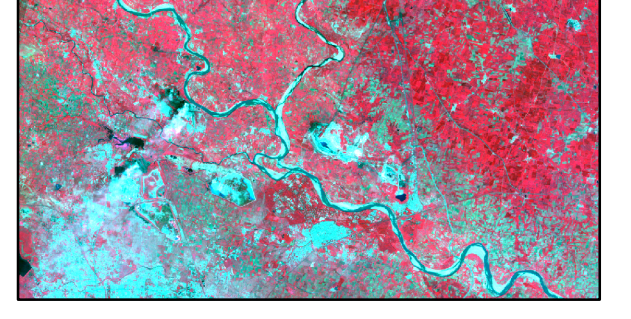
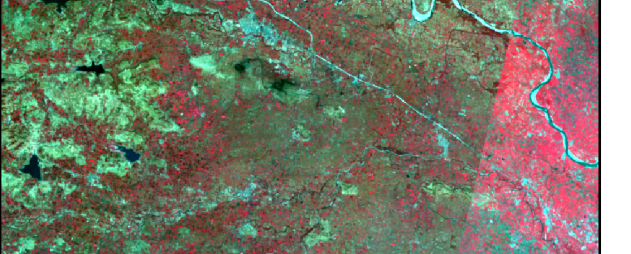
4.2 Recommendation

It is essential to maintain the ecological balance for sustainable development of the area together with coal mining in Kamptee coalfield. It is recommended that land reclamation of the mining area should be taken up on top Priority by WCL. Such study should be carried out regularly to assess the impact of coal mining on land use pattern and vegetation cover in the coalfield to formulate the remedial measures, if any, required for mitigating the adverse impact of coal mining on land environment. Such regional study will also be helpful in assessing the environmental degradation /upgradation carried out by different industries operating in the coalfield area.






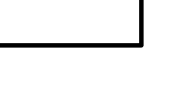


2

LEGEND

-  Settlement
-  Crop Land
-  Fallow Land
-  Water Body
-  Mining Area
-  Waste Land and Scrubs

INDEX

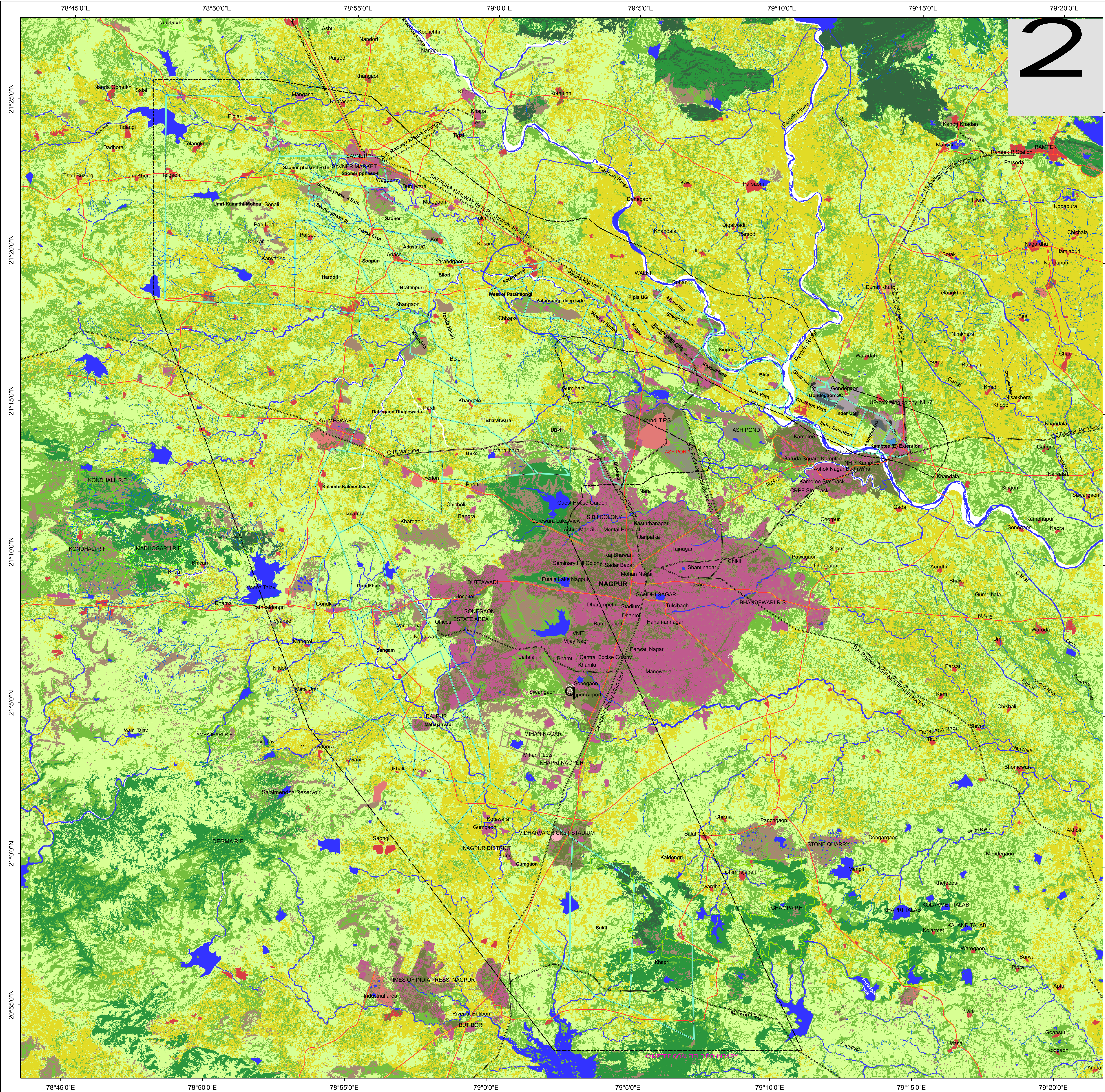
-  Place
-  Road
-  Railway
-  Forest Boundary
(As per SOI toposheet)
-  Block Boundary
-  Coalfield Boundary
(As per Geological map)

TOPO SHEET INDEX			
55 K15	55 D3	55 O7	55 D11
55 K16	55 D4	55 D8	55 D12

Projection: UTM DATUM WGS 84

Customer WESTERN COALFIELDS LIMITED					
Title Land Use/Vegetation cover mapping of Kamptee Coalfield					Job No: 561410027
Subject Land use/Vegetation cover map of Kamptee coalfield based on IRS P6(LISS-III) data of the year 2013.	Activity	Name	Designation	Signature	Date
	Prepared	B.K.Choudhary	Sr.Mgr(RSC)		
	Checked	Rajneesh Kumar	C.M(RSC)		
Approved	N. P. Singh	GM(Geomatics)			
Scale: 5 2.5 0 5 Km		Rev No: 0			
Drng No: H Q R E M A 0 0 1				Sheet 1 of 2	





2

AREA STATISTICS

Classes	Level - II	Colour	Area Statistics	
			Km ²	%
FOREST	Open forest		42.12	3.13
	Dense Forest		5.56	0.41
	Total Forest (A)		47.68	3.55
SCRUBS	Scrubs (B)		192.52	14.32
	Total Scrubs (B)		192.52	14.32
PLANTATION	Social Forest		35.30	2.62
	Plantation on OB		1.26	0.09
	Plantation on backfilled		0.60	0.04
Total Plantation (C)		37.16	2.75	
Total Vegetation (A+B+C)		277.36	20.61	
AGRICULTURE LAND	Crop Land		337.40	25.09
	Fallow Land		534.66	39.76
	Total Agriculture Land		872.06	64.85
SETTLEMENT	Urban Settlement		61.58	4.58
	Rural Settlement		6.77	0.50
	Industrial Settlement		5.52	0.41
	Total Settlement		73.87	5.49
MINING AREA	Coal Quarry		1.05	0.08
	Backfilling area		0.15	0.01
	Waterfilled quarry		0.22	0.02
	Barren OB Dump		3.62	0.27
	Coal dump		0.20	0.01
	Total area under mining		5.24	0.39
WASTE LAND	Waste up Land		68.14	5.07
	Fly ash pond		3.52	0.27
	Sand body		7.67	0.57
	Total Waste Land		79.33	5.91
WATER BODY	River,pond,stream etc		36.92	2.75
			1344.78	100.00

INDEX

- Place
- Road
- Streams
- Canal
- Railway
- Forest Boundary (As per SOI Topo sheet)
- Block Boundary
- Coalfield Boundary (As per Geological map)

TOPO SHEET INDEX			
55 K/15	55 O/3	55 O/7	55 O/11
55 K/16	55 O/4	55 O/8	55 O/12

Projection: UTM DATUM WGS 84

Customer: **WESTERN COALFIELD LIMITED**

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Prepared	B.K.Choudhary	Sr.Mgr(RSC)		
Checked	A.K.Singh	Chief. Mgr (RSC)		
Approved	N.P.Singh	GM(Geomatics)		

Scale: 1 0.5 0 1 2 3 4 Km

Dwg No.: H O R E M A O O I A

Rev. NO

Sheet 2 of 2

