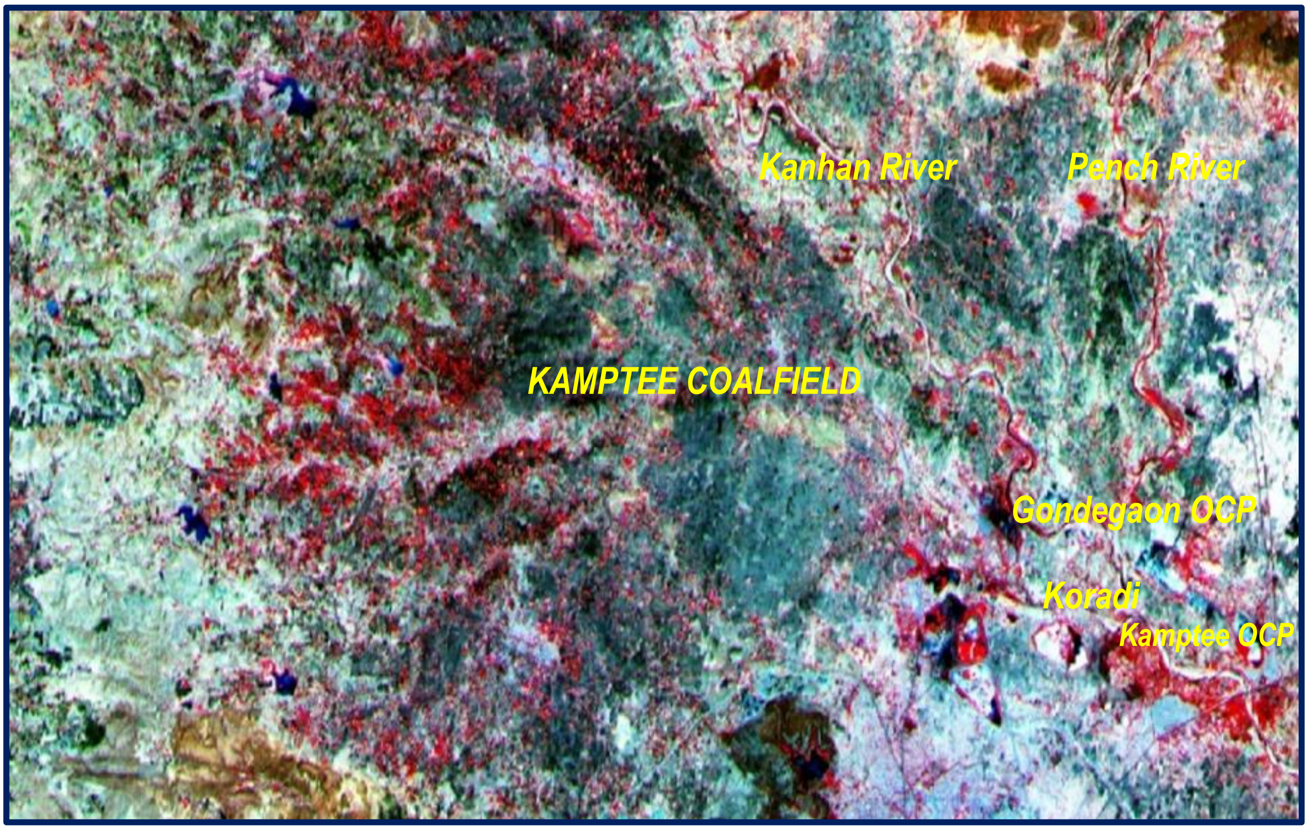
REPORT ON
LAND USE/VEGETATION COVER MAPPING OF KAMPTEE COALFIELD BASED ON SATELLITE DATA FOR THE YEAR 2019



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Land Use/Vegetation Cover Mapping of Kamptee Coalfield based on Satellite Data for the Year- 2019

February-2020

Remote Sensing Cell
Geomatics Division
CMPDI, Ranchi

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Chapter 1

Introduction

1.1 Project Reference

Coal India Ltd requested CMPDI to taken up the study based on remote sensing satellite data for creating the geo-environmental data base of coalfield for monitoring the impact of coal mining on land use pattern and vegetation cover .Accordingly, road map for implementation of project was submitted to Coal India Ltd for land use and vegetation cover mapping of 28 major coalfields for creating the geo-environmental data base and subsequent monitoring of impact of coal mining on land environment at regular interval of three years based on remote sensing satellite data . A work order no.CIL/WBP/Env/2009/2428 dated 29.12.2009 was issued by CIL Initially for three years. Sub-sequently, revised work order was issued vide letter no.CIL/WBP/ENV/2011/4706 dated 12.10.12 from coal India Ltd for the period 20-12-2013to 2016-17which was subsequently followed by another work order vide letter no: CIL/WBP/Env/2017/DP/8477 dated 21.09.2017 from Coal India Ltd for the period 2017-18 to 2021-2022 for land reclamation monitoring of all open cast mine as well as vegetation cover mapping of 19 major coalfields including Western Coalfield as per a defined plan for monitoring the impact of mining on vegetation cover.

Project Background

Western Coalfield Limited (WCL) is subsidiary of coal India Ltd ,dedicated for maintaining the ecological balance in the region has initiated a massive plantation programme on backfilled area ,OB Dump and Waste land. The advent of high resolution, multispectral satellite data has opened a new avenue in the field of mapping and monitoring of vegetation cover. The present study has taken up to access the impact of coal mining on land use and vegetation cover in Western Coalfield with respect to earlier study carried out of Western coalfield in the year 2016.

1.2 Objectives

The Objective of present study to prepare land Use/Cover map of Kamptee Coalfields covering an area 1344.78 Square Km on scale of 1:50000 based on satellite data of the year 2019, creating the geo-environmental data base in respect of land, vegetation cover, Drainage ,Mining area ,infrastructure etc and regular up-dation of data base at regular interval of three years to assess the impact of coal mining and other activities on land use and vegetation cover in 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^{0} 55’ 00” to 21^{0}25’ 00” and East longitudes 78^{0}45’00” to 79^{0} 20’00”and is covered by Survey of India (SoI) 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 Coalfields 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 ie 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 Kanahan 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.

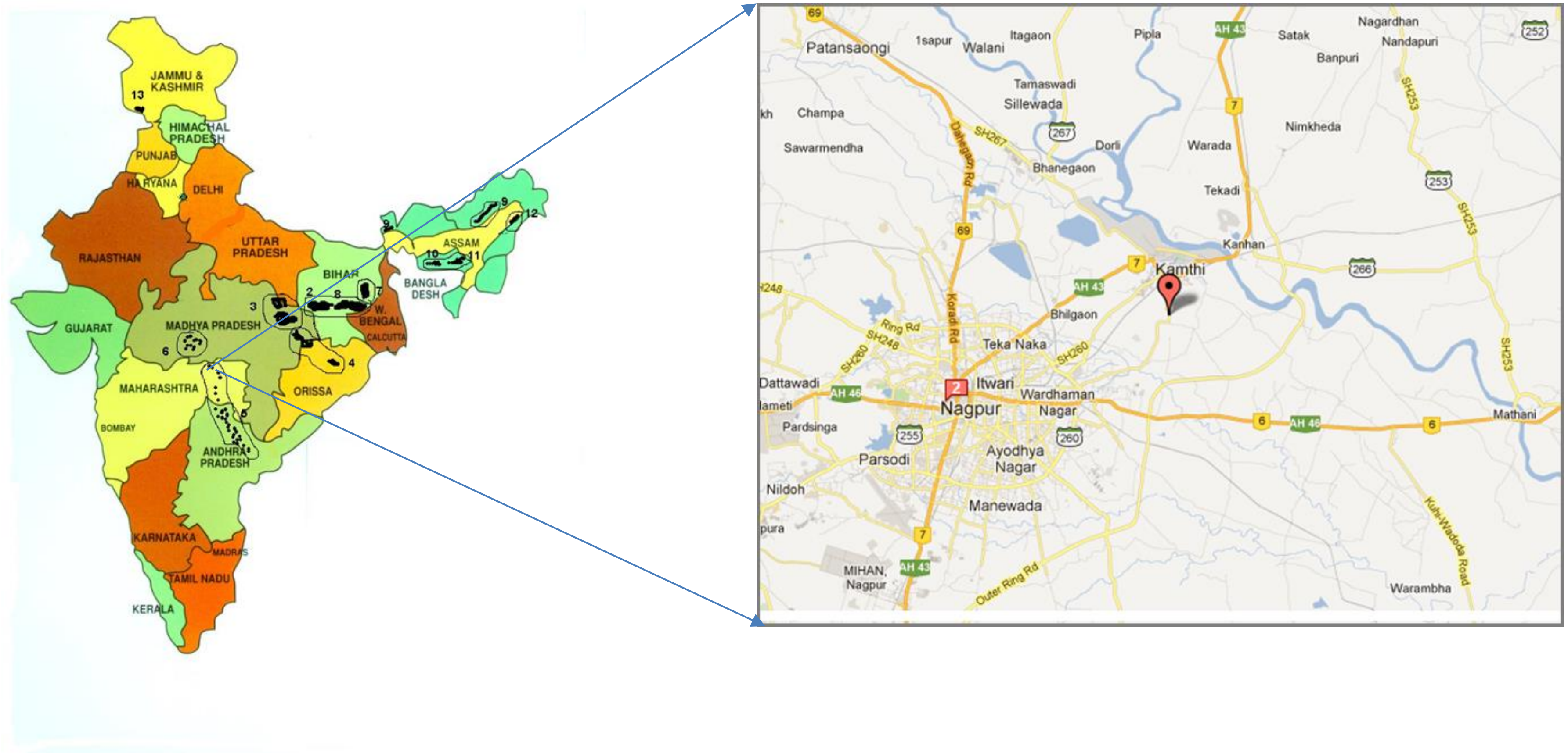


Fig. 1.1: Location map of Kamptee Coalfield

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.

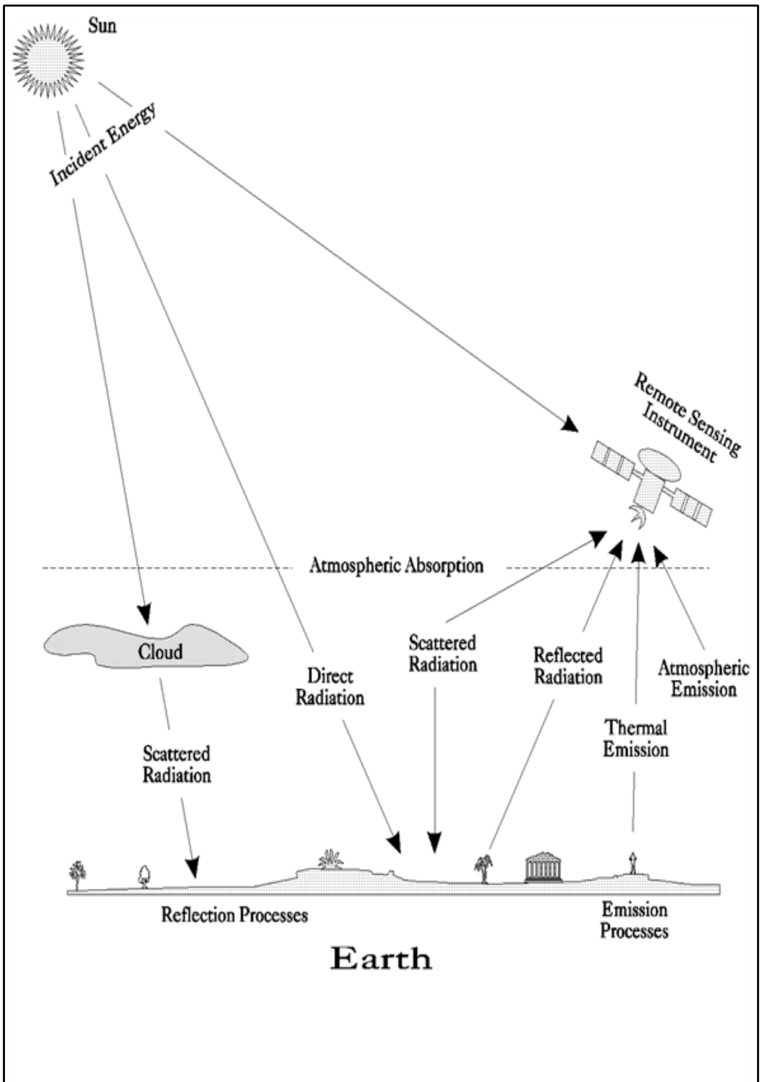


Figure 2.1 Remote sensing radiation system

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.

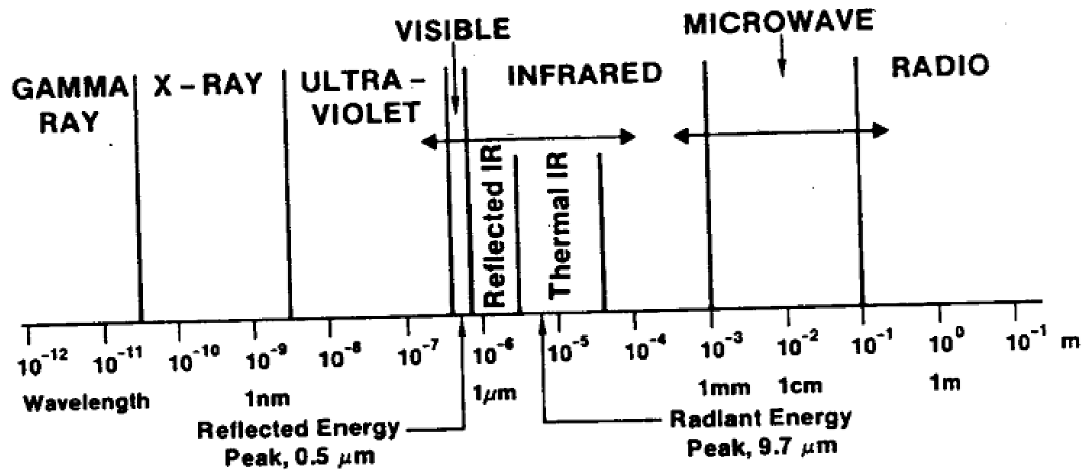


Figure 2.2 Electromagnetic spectrum. Expanded versions of the visible, infrared and microwave regions are shown in Figure 2.3.

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 (0.4-0.7µm 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 0.5µm 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 9.7µm wavelength. This *radiant energy peak* occurs in the thermal band of the IR region (Figure 2.2).

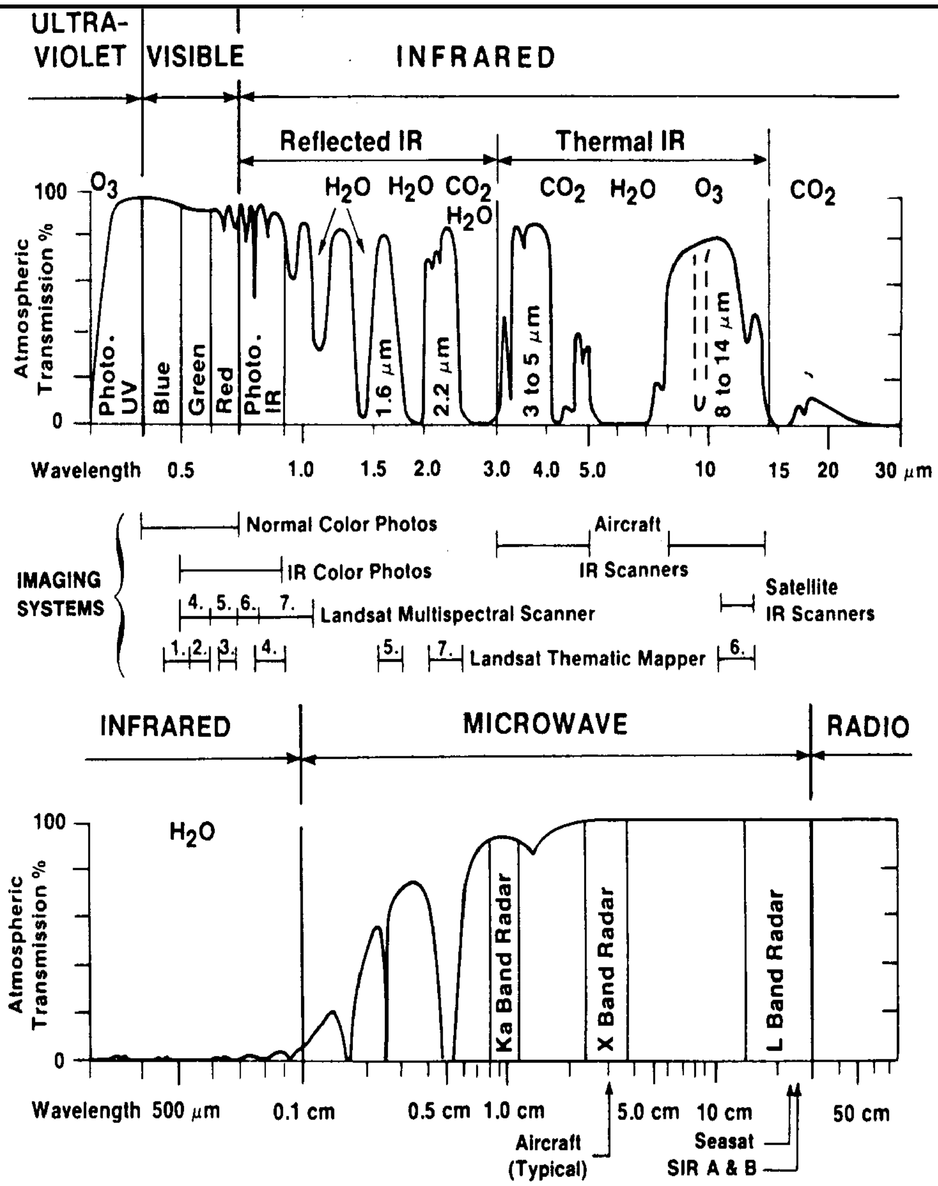


Figure 2.3 Expanded diagrams of the visible and infrared regions (upper) and the microwave regions (lower) showing atmospheric windows. Wavelength bands of commonly used remote sensing systems are indicated. Gases responsible for atmospheric absorption are shown.

Table 2.1 Electromagnetic spectral regions					
Region		**Wavelength**			**Remarks**
Gamma ray		<	0.03	**nm**	Incoming radiation is completely absorbed by the upper atmosphere and is not available for remote sensing.
X-ray	0.03	to	3.00	**nm**	Completely absorbed by atmosphere. Not employed in remote sensing.
Ultraviolet	0.03	to	0.40	**µm**	Incoming wavelengths less than 0.3mm are completely absorbed by Ozone in the upper atmosphere.
Photographic UV band	0.30	to	0.40	**µm**	Transmitted through atmosphere. Detectable with film and photo detectors, but atmospheric scattering is severe.
Visible	0.40	to	0.70	**µm**	Imaged with film and photo detectors. Includes reflected energy peak of earth at 0.5mm.
Infrared	0.70	to	100.00	**µm**	Interaction with matter varies with wavelength. Absorption bands separate atmospheric transmission windows.
Reflected IR band	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 *photographic IR band*.
Thermal IR band	3.00 8.00	to to	5.00 14.00	**µm** **µm**	Principal atmospheric windows in the thermal region. Images at these wavelengths are acquired by optical-mechanical scanners and special vediocon systems but not by film.
Microwave	0.10	to	30.00	**cm**	Longer wavelengths can penetrate clouds, fog and rain. Images may be acquired in the active or passive mode.
Radar	0.10	to	30.00	**cm**	Active form of microwave remote sensing. Radar images are acquired at various wavelength bands.
Radio		>	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 airborne 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-R2A/L4FX of the year 2019 having 5.8 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/10, 55K/14, 55K/15, 55K/16,55 L/13,55 L/14,55 O/3 ,55O/4, 55O/7, 55O/8 55 P/1and 55 P/2 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 -2 satellite/sensor that was used in the present study.

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

Platform	Sen-sor	Spectral Bands in µm	Radiometric Resolution	Spatial Resolution	Temporal Resolution	Country
Rsource-sat-R-2	L4FX	B2 0.28 - 0.31 Green B3 0.25 - 0.38 Red B4 0.27 - 0.30 NIR B5 6.90 MIR	7-bit (128-grey levels)	05.8 m 23.5 m 23.5 m 70.5 m	24 days	India

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.

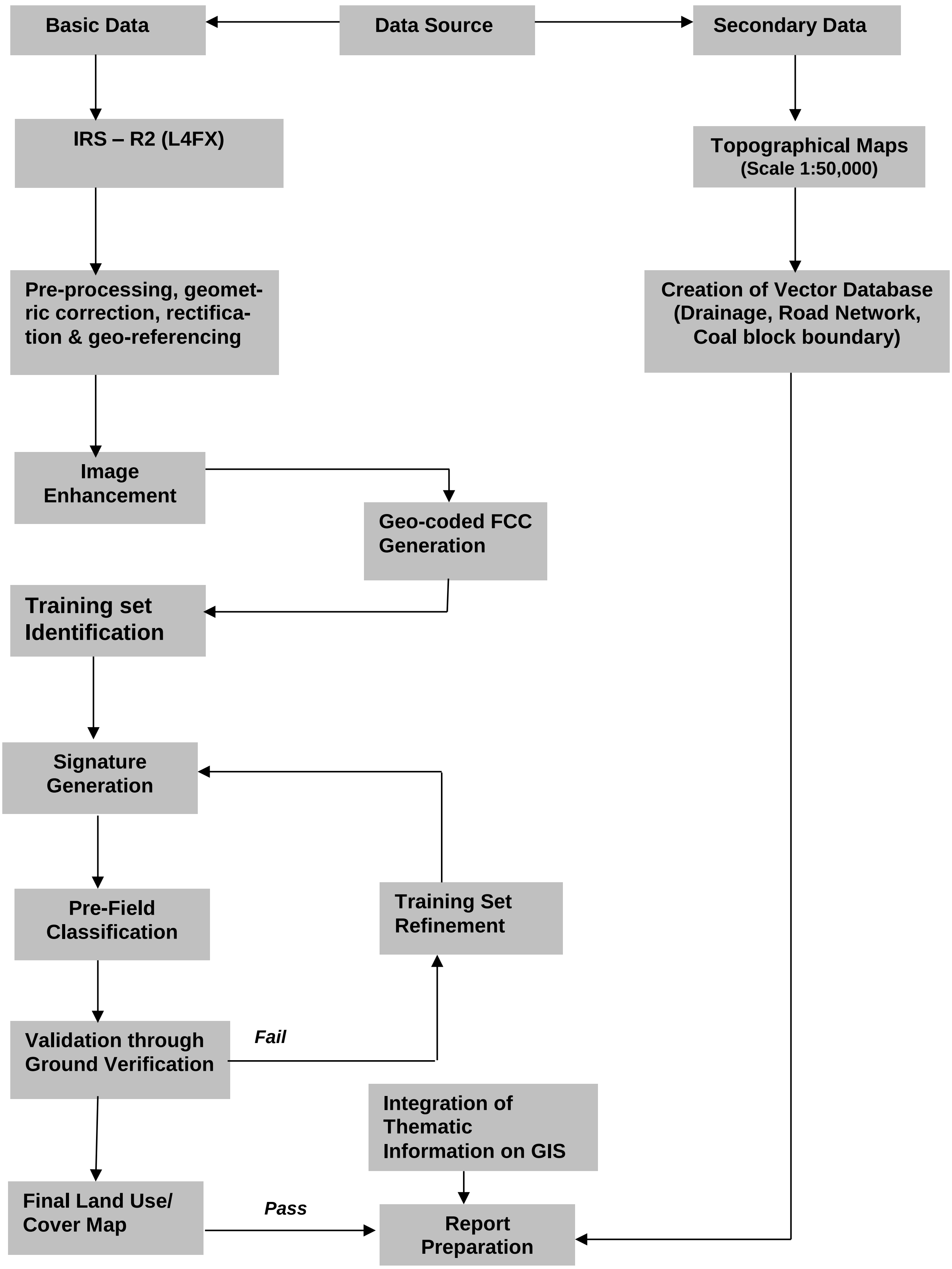


Fig-2.4 –Methodology of Land Use/Vegetation Cover Analysis

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 (SoI) 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*.

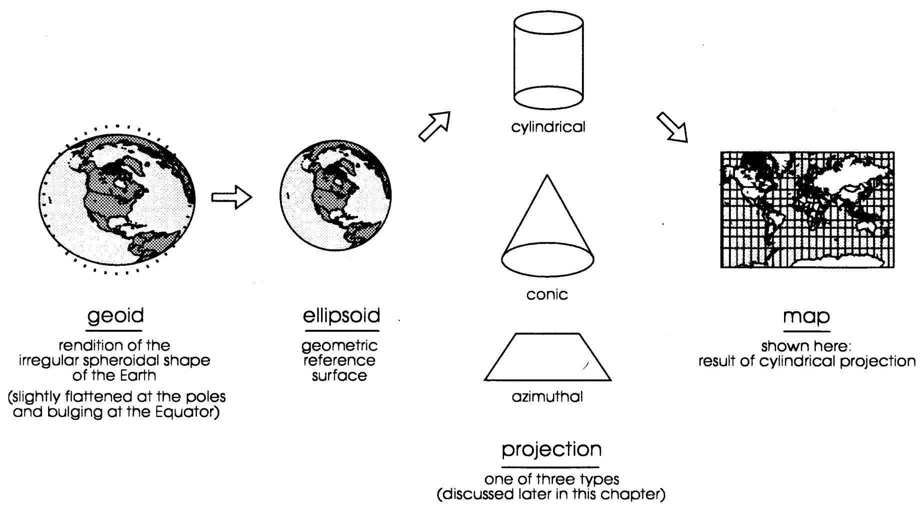


Fig 2.5 : Geoid – Ellipsoid – Projection Relationship

In the present study, ***UTM projection WGS 84 Datum is*** used so as to prepare the map compatible with the SoI topo-sheets**.** Polyconic projection is used in SoI 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.1014 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 2014 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 2014 version. The classified image for the year 2019 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 10.2 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 94.45%. In case of social forestry, the classification accuracy is 91.30%. Classification accuracy for urban settlement ,rural settlement and Industrial settlement varies from 80.00% to 85.71% due to poor *signature separability index*. Where as classification accuracy for Sand body and Fly ash pond are 66.66% and 80.00% 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				60.00	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				80.00	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 2019 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 Area under backfilling 5.3 Water filled Quarry 5.4 Barren OB Dump 5.5 Coal Dump
6	***Water bodies***	6.1 River/Streams /Reservoir / Nala etc.

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

1. Plate No:1 Drawing No. HQ/REM/ 01 – FCC of Kamptee Coalfield based on IRS-R2,L4FX data of the Year 2019, Date of pass :20.04.2019 .
2. Plate No.2 : Drawing No: HQ/REM/01- Classified image of Kamptee coalfield based on satellite data IRS-R2A, L4FX of the year 2019 ,Date of pass :20.04.2019 .

3.3 Data Analysis& Change Detection

Satellite data of the year 2019 has been processed using ERDAS IMAGINE 2014 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 2014 version s/w and tabulated in Table 3.3 to 3.8 and Comparison of various land use classes in the year 2016 & 2019 are shown in the pie Chart (Fig. 2.6&2.7).

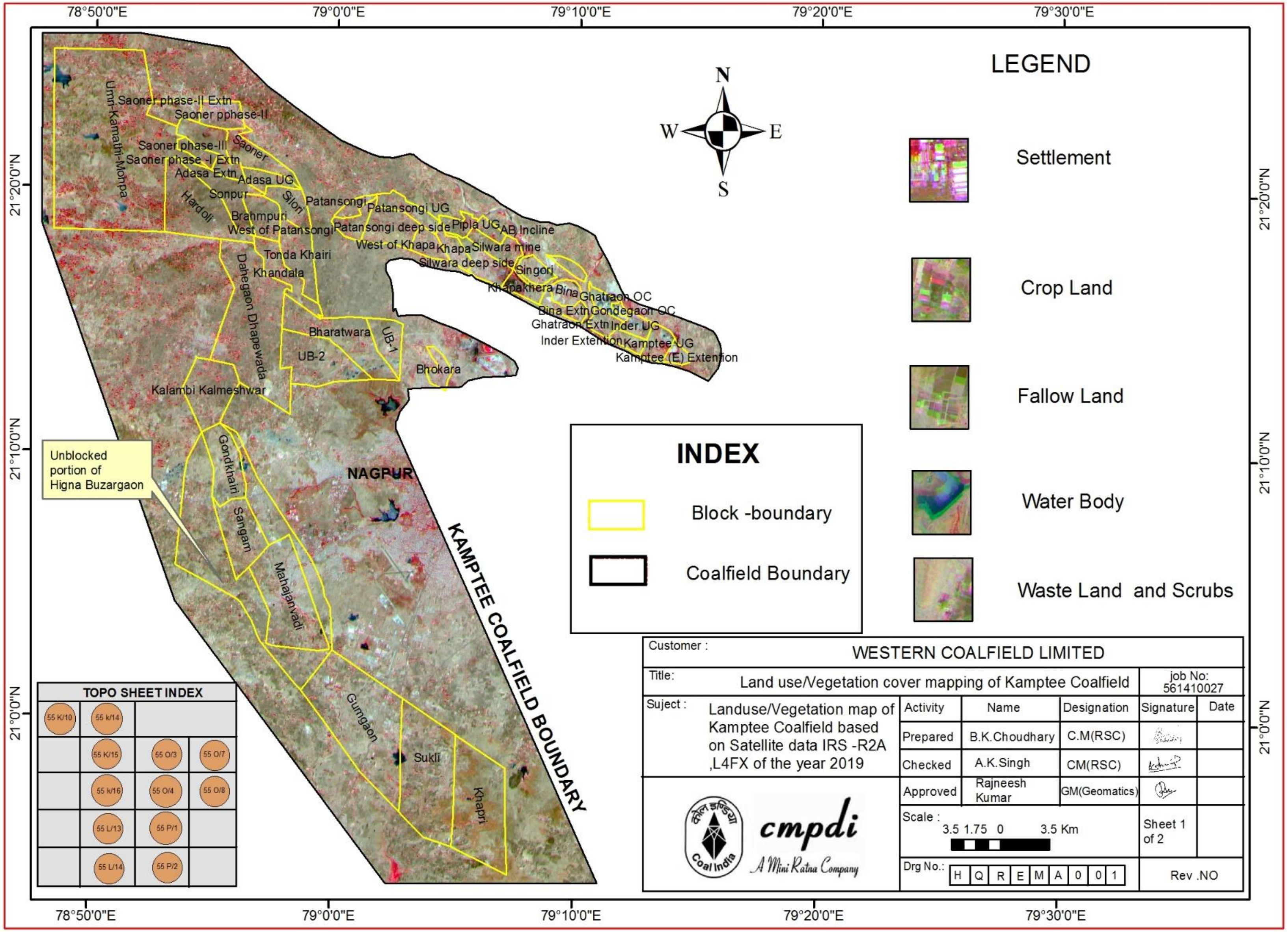
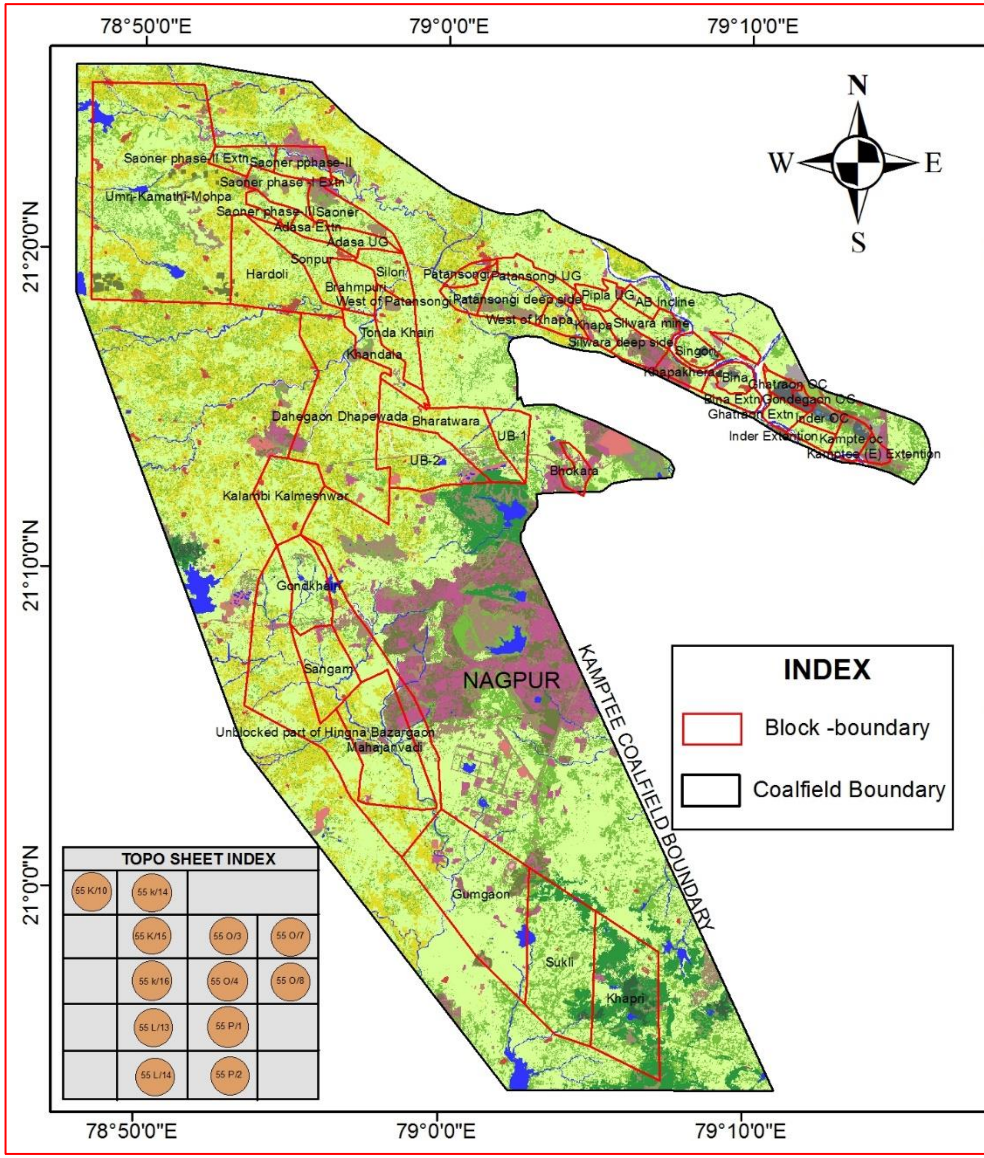


Plate 1 : FCC (Band 3, 2, 1) of Kamptee CF based on Satellite data IRS-R2A ,L4FX of the Year 2019



Classes		Colour	Area Statistics	
Level- I	Level- II		Sq.km	% age
Forest	Open Forest		44.56	03.31
	Dense Forest		04.36	00.32
	Total Forest (A)		**48.92**	**03.63**
Scrubs	Scrub(B)		196.91	14.65
Plantation	Social Forest		36.30	02.70
	Plantation on OB		02.07	00.15
	Plantation on Backfilled		00.61	00.05
	Total Plantation (C)		**38.98**	**02.90**
	Total Vegetation (A+B+C)		**284.81**	**21.18**
Agriculture	Crop Land		201.13	14.96
	Fallow Land		659.75	49.06
	Total Agriculture Land		**860.88**	**64.02**
Settlement	Urban		60.04	04.46
	Rural		07.48	00.56
	Industrial		07.69	00.57
	Total Settlement		**75.21**	**05.59**
Mining Area	Coal Quarry		03.18	00.24
	Area under backfilling		00.65	00.05
	Waterfilled Quarry		00.15	00.01
	Barren OB Dump		02.74	00.20
	Coal Dump		00.31	00.02
	Total Mining area		**07.03**	**00.52**
Waste Land	Waste up Land		68.15	05.07
	Fly ash pond		02.75	00.20
	Sand Body		07.94	00.59
	Total Waste Land		**78.84**	**05.86**
Water Body	River ,Pond, Stream etc		38.01	02.83
	TOTAL		**1344.78**	**100.00**

Customer : WESTERN COALFIELD LIMITED

Title: Land use/Vegetation cover mapping of Kamptee Coalfield — job No: 561410027

Subject: Landuse/Vegetation map of Kamptee Coalfield based on Satellite Data IRS -R2A,L4FX of the year 2019

Activity	Name	Designation	Signature	Date
Prepared	B.K.Choudhary	C.M(RSC)		
Checked	A.K.Singh	CM(RSC)		
Approved	Rajneesh Kumar	GM (Geomatics)		

cmpdi — A Mini Ratna Company

Scale : 3.5 1.75 0 3.5 Km — Sheet 2 of 2

Drg No.: HQREMA002 — Rev .NO

Plate 2 : LU / LC Map of Kamptee CF based on Satellite data IRS-R2A ,L4FX of the Year 2019

TABLE: 3.2

COMPARATIVE STATUS OF LAND USE/ VEGETATION COVER PATTERN IN KAMPTEE COALFIELD IN THE YEAR 2016 & 2019

LAND USE CLASSES	Year-2016		Year-2019		Change w.r.t. Yr 2016		Remarks
	Area (Km^2)	%	Area (Km^2)	%	Area (Km^2)	%	
SETTLEMENTS							
Rural Settlements	7.21	4.49	7.48	0.56	0.27	-3.93	*Increase in settlement area is due to increase in industrial activity as well as other socio -econonmic reasons.*
Urban Settlements	60.42	0.46	60.04	4.46	-0.38	4.00	
Industrial Settlements	6.24	0.54	7.69	0.57	1.45	0.03	
Total Settlements	**73.87**	**5.49**	**75.21**	**5.59**	**1.34**	**0.10**	
VEGETATION COVER							
FOREST							
Dense Forest	6.04	0.45	4.36	0.32	-1.68	-0.13	*There is minor change in Forest Cover due to increase in open forest.*
Open Forest	42.80	3.18	44.56	3.31	1.76	0.13	
Total Forest (A)	**48.84**	**3.63**	**48.92**	**3.63**	**0.08**	**0.00**	
SCRUBS							
Scrubs (B)	193.08	14.36	196.91	14.65	3.83	0.29	*Increase in scrub is due to good monsoon.*
PLANTATION							
Social forestry	35.04	2.61	36.30	2.70	1.26	0.09	*Increase in total plantation is a result of massive plantation carried out by WCL in mining areas.More plantation on backfill has been carried out in order to enhance the Biological reclamation. Increase in Social forestry and plantation on OB contribute in generating more green cover in respective mining area .*
Plantation onBackfill	0.36	0.03	0.61	0.05	0.25	0.02	
Plantation onOB	1.42	0.11	2.07	0.15	0.65	0.04	
Total Plantation (C)	**36.82**	**2.75**	**38.98**	**2.90**	**2.16**	**0.15**	
Total Vegetation (A+B+C)	**278.74**	**20.74**	**284.81**	**21.18**	**6.07**	**0.44**	
MINING AREA							
Coal Quarry	2.18	0.16	3.18	0.24	1.00	0.08	*Quarry increased due to expansion in mining projects .*
Coal Dump	0.30	0.02	0.31	0.02	0.01	0.00	
Barren OB Dump	2.57	0.19	2.74	0.20	0.17	0.01	*OB dump has increased due to increase in existing mining capacity .*
Barren Backfill	0.47	0.03	0.65	0.05	0.18	0.02	*Area under Backfilling is increased in order to enhance the Technical reclamation.*
Waterfilled Quarry	0.23	0.02	0.15	0.01	-0.08	-0.01	
Total Mining Area	**5.75**	**0.42**	**7.03**	**0.52**	**1.28**	**0.10**	
AGRICULTURE							
Crop Land	380.63	28.30	201.13	14.96	-179.50	-13.34	*Agriculture Land is decreased due to urbanisation and increased in mining activity .Major portion of Crop land has been converted into fallow Land .*
Fallow Land	486.35	36.17	659.75	49.06	173.40	12.89	
Total Agriculture	**866.98**	**64.47**	**860.88**	**64.02**	**-6.10**	**-0.45**	
WASTELANDS							
Waste land	70.16	5.22	68.15	5.07	-2.01	-0.15	*Decrease in waste land is due to increase in industrial area and mining activity.*
Fly ash pond	2.50	0.19	2.75	0.20	0.25	0.01	
Sand Body	8.00	0.59	7.94	0.59	-0.06	0.00	*There is minor decrease in sand Body.*
Total Wasteland	**80.66**	**6.00**	**78.84**	**5.86**	**-1.82**	**-0.14**	
WATERBODIES							
River, nallah, pond etc.	**38.78**	**2.88**	**38.01**	**2.83**	**-0.77**	**-0.05**	*Minor decrease in surface water body.*
TOTAL	**1344.78**	**100.00**	**1344.78**	**100.00**	**0.00**	**0.00**	

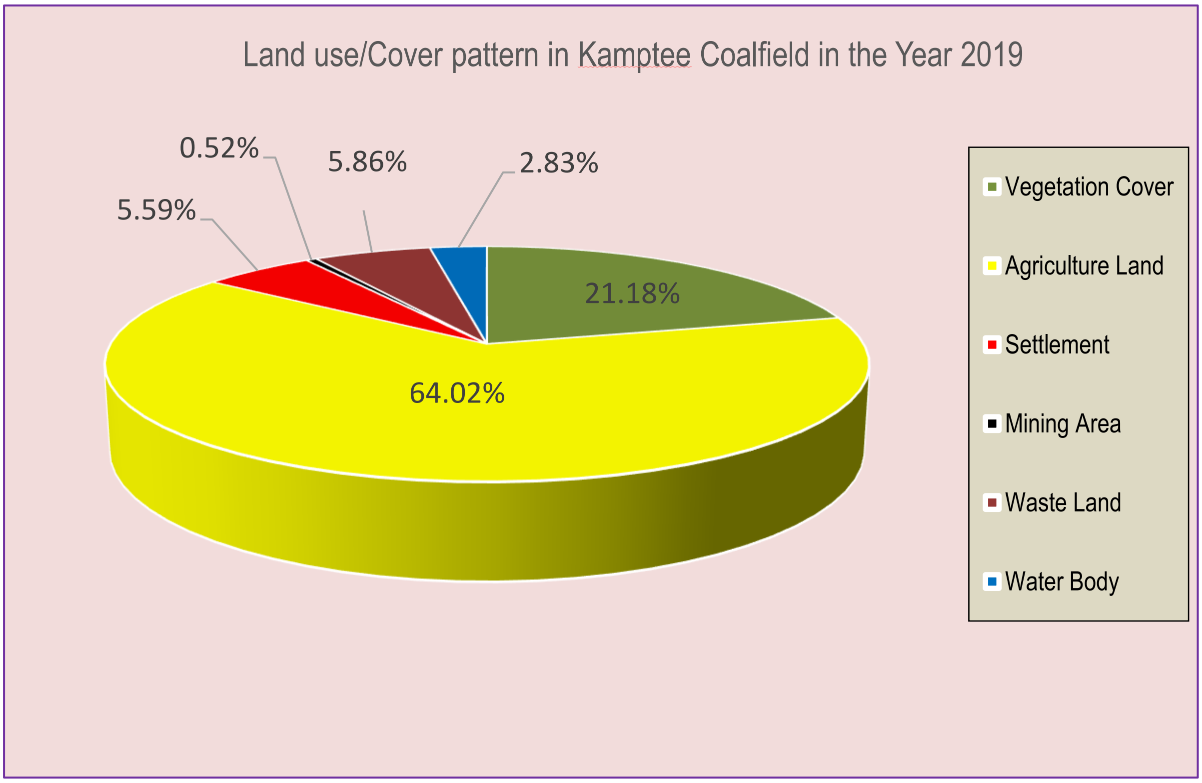


Figure-2.6

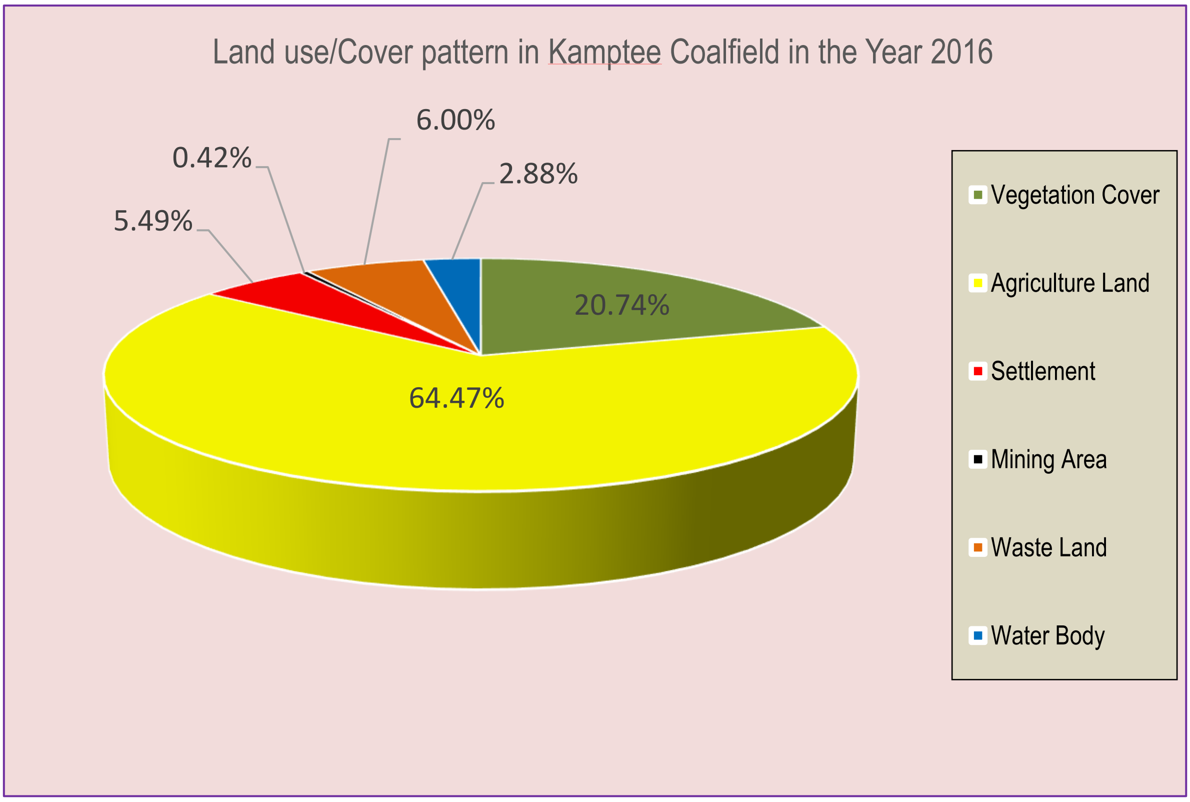


Figure-2.7

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 in to rural, urban and industrial classes. In the present study, industrial Settlement indicates only industrial complexes excluding residential facilities. Analysis of satellite data of the year 2019 indicated that area under Industrial Settlements has increased to 07.69sq km (0.57%) with respect to 6.24Sq. Km (0.54%) area in the year 2016. There is an increase in Industrial Settlements by 1.45 sq km which is about 0.03% of the total coalfield area. The increase in industrial settlement is due to urbanisation and coming up of new industry. Settlement coming under the coalfield boundary of kamptee Coalfield was distributed between Rural 7.48 sq.km (0.56%) ,Urban 60.04 sq.km(04.46%) and industrial 7.69 sq.km(0.57%) . Total area covered by settlement is 75.21 Sq.Km (5.59%) in the year 2019 with respect to 73.87 Sq.km (05.49%) in the year 2016. 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 2016 & 2019

LAND USE CLASSES	Year-2016		Year-2019		Change w.r.t. Yr 2016		Remarks
	Area (Km^2)	%	Area (Km^2)	%	Area (Km^2)	%	
SETTLEMENTS							
Rural Settlements	7.21	4.49	7.48	0.56	0.27	-3.93	*Increase in settlement area is due to increase in industrial activity as well as other socio -econonmic reasons.*
Urban Settlements	60.42	0.46	60.04	4.46	-0.38	4.00	
Industrial Settlements	6.24	0.54	7.69	0.57	1.45	0.03	
Total Settlements	**73.87**	**5.49**	**75.21**	**5.59**	**1.34**	**0.10**	

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 2016 & 2019

LAND USE CLASSES	Year-2016		Year-2019		Change w.r.t. Yr 2016		Remarks
	Area (Km^2)	%	Area (Km^2)	%	Area (Km^2)	%	
VEGETATION COVER							
FOREST							
Dense Forest	6.04	0.45	4.36	0.32	-1.68	-0.13	*There is minor change in Forest Cover due to increase in open forest.*
Open Forest	42.80	3.18	44.56	3.31	1.76	0.13	
Total Forest (A)	**48.84**	**3.63**	**48.92**	**3.63**	**0.08**	**0.00**	
SCRUBS							
Scrubs (B)	193.08	14.36	196.91	14.65	3.83	0.29	*Increase in scrub is due to good monsoon.*
PLANTATION							
Social forestry	35.04	2.61	36.30	2.70	1.26	0.09	*Increase in total plantation is a result of massive plantation carried out by WCL in mining areas.More plantation on backfill has been carried out in order to enhance the Biological reclamation. Increase in Social forestry and plantation on OB contribute in generating more green cover in respective mining area .*
Plantation onBackfill	0.36	0.03	0.61	0.05	0.25	0.02	
Plantation onOB	1.42	0.11	2.07	0.15	0.65	0.04	
Total Plantation (C)	**36.82**	**2.75**	**38.98**	**2.90**	**2.16**	**0.15**	
Total Vegetation (A+B+C)	**278.74**	**20.74**	**284.81**	**21.18**	**6.07**	**0.44**	

Dense forest – Forest having crown density of above 40% comes in this class. In the year 2016 the total area covered by dense forest were estimated to be 6.04 sq km area (0.45%) of the total coalfield area. Whereas in year 2019 the estimated area under dense forest has decreased to 4.36 Sq km area (0.32%) with respect to the year 2016. This decrease in area of dense forest to 1.68 sq km which is about 0.13% of the total coalfield area is due to conversion of dense forest into open forest.

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 42.80 sq km (3.18%) in 2016 has increased to 44.56 sq km (3.31%) of the total coalfield area in the year 2019. Thus the increase in open forest area is 1.76 sq km (0.13) % of the total coalfield area. This increase in open forest area is due to good monsoon, massive plantation carried out in the coalfield area.

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. It is observed that Scrubs covered over Kamptee Coalfield which was estimated to 193.08 sq km(14.36%) in the year 2016 has increased to 196.91Sq.km(14.65%) of the total Coalfield area in the year 2019.The increase of 3.83 Sq km area(0.29%) of the total Coalfield area is due to conversion of some of Fallow Land into Scrubs and 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 that Social Forestry covers 36.30 Sq km area (2.70%)of the Kamptee coalfield in 2019 with respect to area covered by social forestry of 35.04 Sq km area (2.61%) in the year 2016. Increase in area covered by social forestry in the year 2019 is estimated to 01.26 sq km (0.09%). It is due to plantation carried out by WCL in the colony and along road side in the mining area.

Plantation over OB Dump and backfilled area – Analysis of the satellite data of the year 2019 reveals that WCL has carried out significant plantation on OB dumps during 3 year span of time for maintaining the ecological balance of the area. The plantation on the OB dumps is estimated to be 02.07 Sq. km,(0.15%) of the coalfield area in the year 2019 as compared to area covered by plantation on OB 1.42 Sq.km(0.11%)in the year 2016. The increase in area covered by plantation on OB is estimated to be 0.65 Sq.km (0.04%) in the year 2019 with respect to Year 2016. This increase is due to massive plantation on OB carried out by WCL. The plantation on backfilled area in the year 2019 has also increased from 0.36 Sq.km (0.03%) in the year 2016 to 0.61 sq.km (0.05%) in the year 2019. This increase of 0.65% in area under plantation on backfill enhances the Biological reclamation in mining area and contributes in maintaining the ecological balances in the mining area also. However, it is important to note here that total area under plantation in mining area in the year 2019 is showing increasing trend with respect to the year 2016.

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

The area covered by Coal quarry is estimated to be 3.18 Sq km (0.24%) in the year 2019 as compared to 2.18 sq.km (0.16%) in the year 2016. The increase of 1.00 Sq.km in the area of coal quarry is due to expansion of existing opencast mine .Area covered under coal dump has also increased from 0.30sq km (0.02%) in the year 2016 to 0.31 sq.km (0.02%) in the year 2019.This increase is due to increase in production of coal. In the year 2016 the barren OB dump was estimated to be 2.57sq km (0.19%) which has increased to 2.74 sq km (0.20%) in the year 2019. This increase of 0.17 sq.km area (0.01%) is due to expansion of existing opencast mines .However, the overall mining area is estimated to increase from 5.75 sq.km (0.42%) in the year 2016 to 7.03 sq.km (0.52%) in the year 2019. The status of land use in the mining area of the Kamptee Coalfield is shown in the table 3.5 below.

Analysis indicates that there is an overall increasing trend in mining activity with increase to about 1.28 Sq.km (.10%) mining area as compared to year 2016.

TABLE – 3.5

STATUS OF CHANGE IN MINING AREA IN KAMPTEE COALFIELD DURING THE YEAR 2016 & 2019

LAND USE CLASSES	Year-2016		Year-2019		Change w.r.t. Yr 2016		Remarks
	Area (Km^2)	%	Area (Km^2)	%	Area (Km^2)	%	
MINING AREA							
Coal Quarry	2.18	0.16	3.18	0.24	1.00	0.08	*Quarry increased due to expansion in mining projects .*
Coal Dump	0.30	0.02	0.31	0.02	0.01	0.00	
Barren OB Dump	2.57	0.19	2.74	0.20	0.17	0.01	*OB dump has increased due to increase in existing mining capacity .*
Barren Backfill	0.47	0.03	0.65	0.05	0.18	0.02	*Area under Backfilling is increased in order to enhance the Technical reclamation.*
Waterfilled Quarry	0.23	0.02	0.15	0.01	-0.08	-0.01	
Total Mining Area	**5.75**	**0.42**	**7.03**	**0.52**	**1.28**	**0.10**	

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 estimated to 860.88sq km in year 2019, which is 64.02% of the Kamptee Coalfield area. While the total agricultural area was estimated to be 866.98.Sq km in the year 2016 which was 64.47% of the Coalfield area.

Analysis of satellite data of the year 2019 reveals that there is an decrease of 6.10 Sq km(0.45%) in agriculture land which is due to expansion of existing opencast mine ,urbanisation and associated industrial activities . The details are shown below in Table 3.6.

TABLE – 3.6

STATUS OF CHANGE IN AGRICULTURE LAND IN KAMPTEE COALFIELD DURING THE YEAR 2016 & 2019

LAND USE CLASSES	Year-2016		Year-2019		Change w.r.t. Yr 2016		Remarks
	Area (Km^2)	%	Area (Km^2)	%	Area (Km^2)	%	
AGRICULTURE							
Crop Land	380.63	28.30	201.13	14.96	-179.50	-13.34	*Agriculture Land is decreased due to urbanisation and increased in mining activity .Major portion of Crop land has been converted into fallow Land .*
Fallow Land	486.35	36.17	659.75	49.06	173.40	12.89	
Total Agriculture	**866.98**	**64.47**	**860.88**	**64.02**	**-6.10**	**-0.45**	

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. Analysis of data reveals that waste land in Kamptee Coalfields occupies 78.84sq km (5.86%) in the year 2019 out of which waste up land with scrubs or without scrubs occupies 68.15 Sq.km (5.07%) , Fly ash pond constitute 2.75 sq.km (0.20%) and sand bodies constitute 7.94 sq.km (0.59%) in the year 2019 .In *comparison to the year 2016 , waste land class in the year 2019 in Kamptee Coalfield has decreased marginally by 0.14% which might be due to increase in mining area as well as settlement area under Kamptee Coalfield . The details are shown below in Table 3.7*

TABLE – 3.7

STATUS OF CHANGE IN WASTELAND IN KAMPTEE COALFIELD DURING THE YEAR 2016 & 2019

LAND USE CLASSES	Year-2016		Year-2019		Change w.r.t. Yr 2016		Remarks
	Area (Km^2)	%	Area (Km^2)	%	Area (Km^2)	%	
WASTELANDS							
Waste land	70.16	5.22	68.15	5.07	-2.01	-0.15	*Decrease in waste land is due to increase in industrial area and mining activity.*
Fly ash pond	2.50	0.19	2.75	0.20	0.25	0.01	
Sand Body	8.00	0.59	7.94	0.59	-0.06	0.00	*There is minor decrease in sand Body.*
Total Wasteland	**80.66**	**6.00**	**78.84**	**5.86**	**-1.82**	**-0.14**	

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 38.78Sq km in the year 2016, which was 2.88% of the coalfield area. While in the year 2019, it has decreased to 38..01 Sq km which is 2.83% of the total Coalfield area. So there is an decrease of area 0.77sq. km.(0.05%) in water bodies.

Table: 3.8

STATUS OF CHANGE IN SURFACE WATER BODIES IN KAMPTEE COALFIELD DURING THE YEAR 2016 & 2019

LAND USE CLASSES	Year-2016		Year-2019		Change w.r.t. Yr 2016		Remarks
	Area (Km^2)	%	Area (Km^2)	%	Area (Km^2)	%	
WATERBODIES							
River, nallah, pond etc.	**38.78**	**2.88**	**38.01**	**2.83**	**-0.77**	**-0.05**	*Minor decrease in surface water body.*

Chapter 4

Conclusion & Recommendation

4.1 Conclusion

In the present study, land use/ vegetation cover mapping has been carried out based on IRS-R2A L4FX satellite data of the year 2019 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 Vegetation cover which includes dense forests, open forests, scrubs, avenue plantation & plantation on over-burden dumps, covers an area of 278.74km^2 (20.74%) in the year 2016. As compared to year 2016 there is an increase in overall vegetation cover by 6.07km^2 (0.44%) this is mainly because massive plantation carried out by WCL. Area of scrubs has also increased by 3.83Sq.Km (0.29%). It is due to good monsoon. The analysis further indicates that total agricultural land which includes both crop and fallow land has been decreased to 6.10km^2 (0.45 %) .This is due to some of fallow land occupied by mining area , social forestry ,scrubs and settlement. The mining area which includes coal quarry, barren OB dump, barren backfilled area, covers 5.75km^2 (0.42%) in the year 2016. As compared to year 2016 there is a decrease of 6.10Sq.Km (0.45%) in agriculture area in the year 2019 .This is due to expansion of existing opencast mine. Total Wasteland cover is estimated to 78.84km^2 (5.86%) in 2019 with respect to 80.66 sq.km (6.00%) area in the year 2016. Waste lands have decreased to 1.82 Sq.Km area (0.14%) because of increase in mining activity .Surface water bodies covered area of 38.01 km^2 (2.83%).in year 2019 as compared to 38.78 Sq.Km (2.88%) in year 2016 .Hence area covered by water body has decreased to 0.77Sq.Km(0.05%) as compared to year 2016 as indicated in 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.