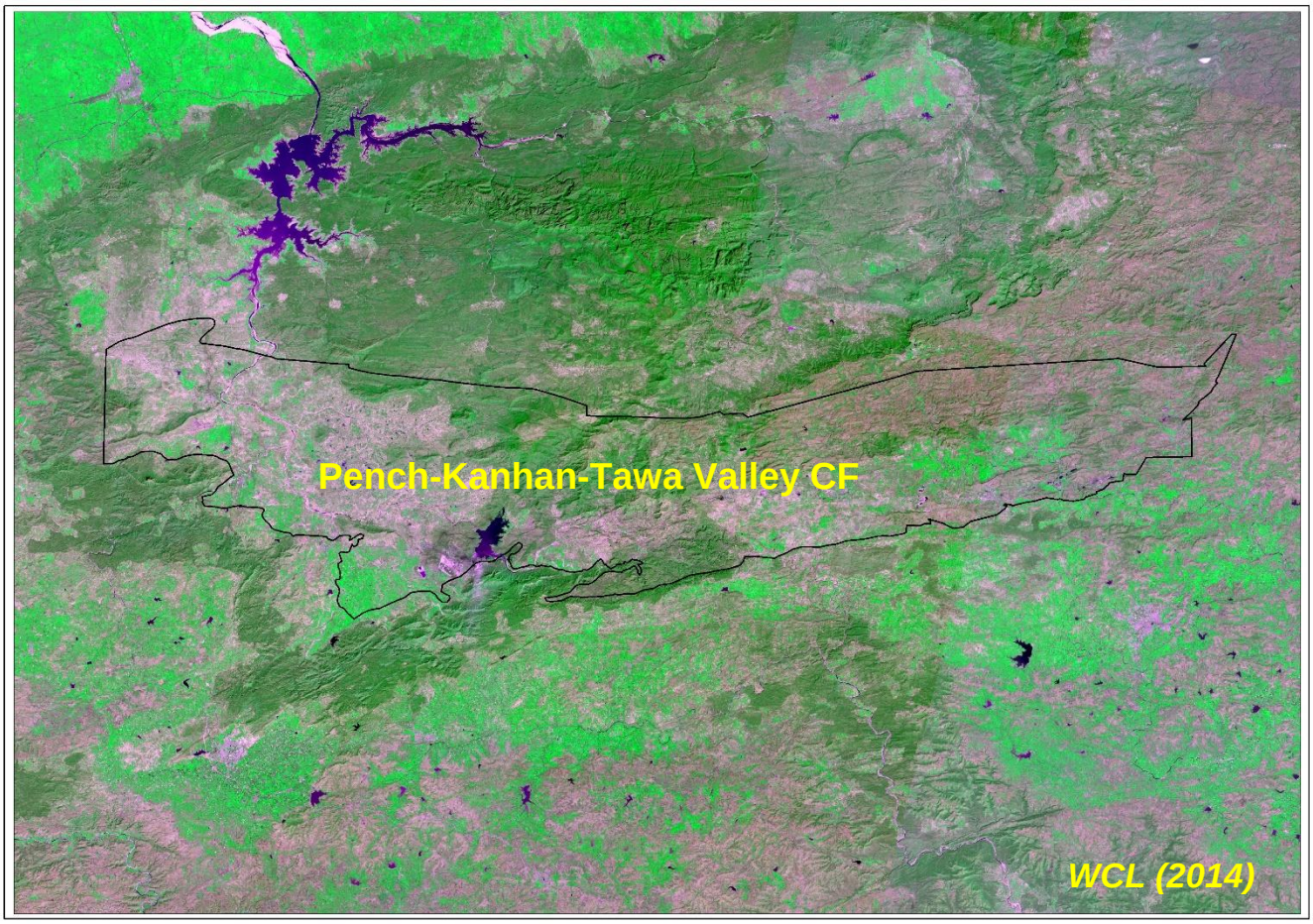
REPORT ON
Land use/Vegetation cover Mapping of Pench-Kanhan-Tawa Valley Coalfield based on Satellite data for the year- 2014



Submitted to

Western Coalfields Limited

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A Mini Ratna Company

Land use/Vegetation cover Mapping of Pench-Kanhan-Tawa Valley Coalfield based on Satellite data for the year- 2014

January-2015

Remote Sensing Cell
Geomatics Division
CMPDI, Ranchi

Document Control Sheet

(1) Job No.	**561410027**
(2) Publication Date	November 2014
(3) Number of Pages	38
(4) Number of Figures	8
(5) Number of Tables	12
(6) Number of Plates	2
(7) Title of Report	Land use / Vegetation cover mapping of Pench-Kanhan-Tawa Valley Coalfield based on satellite data for the year 2014.
(8) Aim of the Report	To prepare Land use / Vegetation cover map of Pench-Kanhan-Tawa Valley Coalfield on 1:50000 scale for assessing the regional impact of coal mining and associated industrialisation on land use pattern and vegetation cover in the coalfield by analysing the temporal satellite data.
(9) Executing Unit	Remote Sensing Cell, Geomatics Division Central Mine Planning & Design Institute Limited, Gondwana Place, Kanke Road, Ranchi 834008
(10) User Agency	Western Coalfields Ltd.
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(12) Security Restriction	Restricted Circulation
(13) No. of Copies	5
(14) Distribution Statement	Official

Restricted

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List of maps/plates prepared on a scale of 1:50,000 are given below:

1. Plate No. Landsat 8/ OLI FCC of Pench-Kanhan-Tawa Valley Coalfield
2. Plate No. 2 Landuse / Cover Map Pench-Kanhan-Tawa Valley C.F. based on Landsat 8/ OLI FCC data.

Chapter 1

Introduction

1.1 Project Reference

A road map was submitted by CMPDI to Coal India Ltd. for creating the geo-environmental data base of all the 28 major coalfields and to assess the impact of coal mining and associated industrialization on land use and vegetation cover at regular interval of three years. Work order no. CIL/WBP/Env/2009/2428 dated 29.12.009; was issued by CIL to CMPDI for the above study. In pursuant to the above work order, land use/vegetation cover mapping of Pench-Kanhan-Tawa Valley Coalfield based on satellite data was taken up in 2011 to create the geo-environmental data base of the coalfield using Remote Sensing techniques & GIS. The work order was renewed by CIL vide letter no. CIL/WBP/ENV/2011/4706 dt. 12.10.2012 for continuing the work till 2016-17. As follow up to the above work order, land use / vegetation cover mapping of Pench-Kanhan-Tawa valley coalfield was taken up based on satellite data of the year 2014 after three years.

1.2 Objectives

The objective of the present study is to prepare the land use and vegetation cover map of Pench-Kanhan-Tawa Valley coalfield based on satellite data of the year 2014, and compare the same with the data base prepared in 2011 in respect of land use, vegetation cover, drainage, mining area, infrastructure etc. to assess the impact of coal mining and other industrial activities on land use pattern and vegetation cover in the coalfield area.

1.3 Location & Accessibility

Pench-Kanhan-Tawa Valley Coalfield covering an area of about 2426.00 sq. Km. lies in the Chhindwara and Betul district of Madhya Pradesh. It forms the

southern fringes of Satpura basin. This coalfield has been divided into three parts: Pench, Kanhan and Tawa. It is bounded by Latitude 22^0 05' to 22^0 25' and Longitudes 78^0 00' to 79^0 05' and located in the central part of India i,e M.P. The coalfield area is covered under Survey of India topo-sheet no. 55 J/4, 55 J/8, 55 J/11, 55 J/12, 55 J/15, 55 J/16 & 55 N/3 on RF 1:50000.This coalfield holds a premier position in India for having a considerable share of reserve of thermal grades of non-coking coal.

Pench-Kanhan-Tawa Valley coalfield is well connected by rail and road ways. Parasia is the major mining town in the coalfield situated in Pench which is connected to the district town Chhindwara (27Km) in the south east via MP State Highway No.19 and South-Eastern Railway Barkuhi Branch (0.76 m gauge). Parasia is connected to Barkuhi and Chandmeta via SE railway (Barkuhi branch) in the west and Rawanwara (4.0 Km) towards east. Broad gauge line of Central Railways (Amla-Parasia Branch) is passing south of the coalfield connecting Parasia with Amla (87 Km) via Jamai (17 Km). The nearest air port is Nagpur at 160 Km. away from Chhindwara. MP State Highway No. 43 is running through the coalfield connecting Parasia, Chandmeta, Bhamodi, Eklehra in the east; Jamai, Damua in central part (Kanhan Area) and Sarni, Bagdona in the west (Tawa Valley). Satpura Reservoir is situated in the southern edge of Tawa valley connected to Sarni (5 Km.) TPS connected by a weather road built by Madhya Pradesh State Electricity Board. Sarni Thermal Power Station is one of the coal based power plants of MPPGCL situated at 18 Km. from Ghora Dongri railway station of western railway.

1.4 Physiography

The southern and eastern part of Tawa valley is hilly and rugged with thick forest cover whereas the western, north-western parts are comparatively flat. Tawa river flowing to the west and south is controlling the drainage of

Tawa reservoir. Few seasonal nallahs (Latiya Nala, Dagdaga Nala etc.) originating from Kilandev Pahad, Bagdev Pahad, Shri Phar and other elevated regions discharge in to Tawa river which flows in westerly direction. Satpura dam has been built across Tawa river to store water for Thermal Power Station at Sarni as well as to regulate the flow of water in the downstream of Tawa river. Pench-Kanhan area exhibits a rugged topography covered with Deccan Trap. The terrain comprises of many hills and valleys- structural hills, covered by Gondwanas, are seen in northern part; denudational hills in southern part and dissected Deccan plateau in eastern and northeastern parts. The area is drained by two major rivers - Pench and Kanhan river (flowing towards south east) and their tributaries namely Gonur, Magrahi, Ghatamai, Sukri river, Bor Nala, Rakhi Nala, Tambiya Nadi, Bardhar Nadi etc. The recent alluvium deposits are found at places along these rivers.

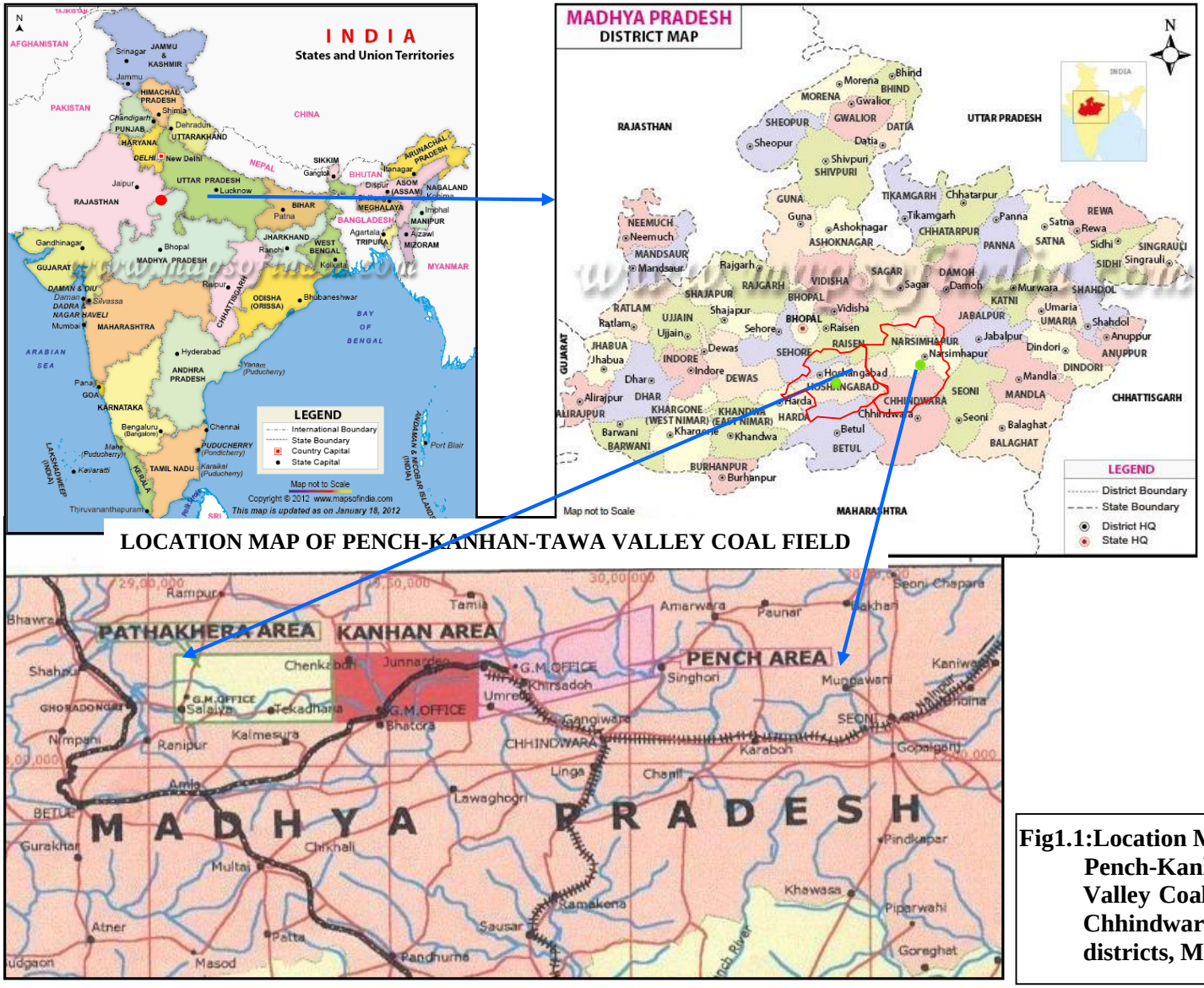

Fig1.1:Location Map of Pench-Kanhan-Tawa Valley Coalfield in Chhindwara & Betul districts, MP

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.

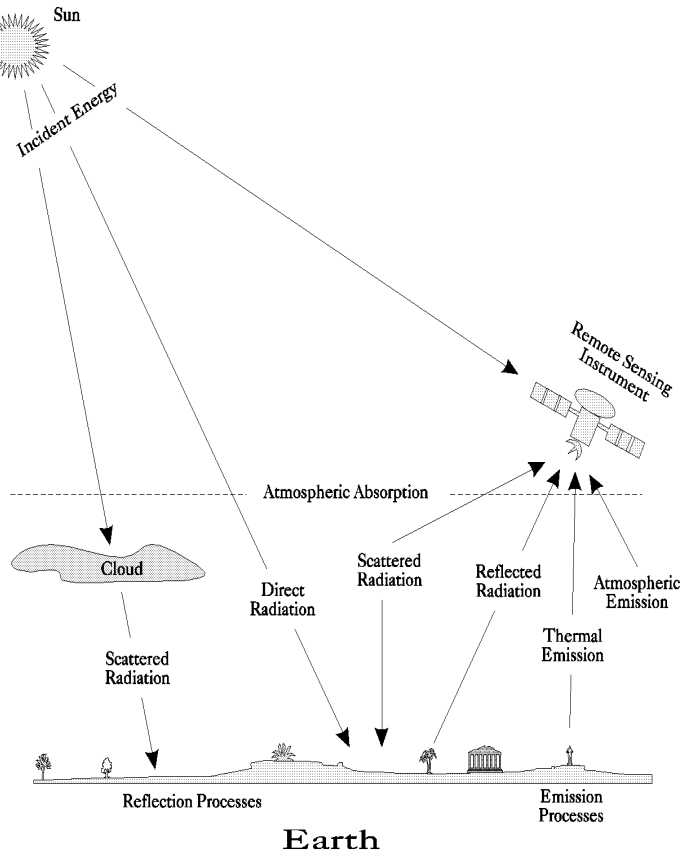

Figure 2.1 Remote sensing radiation system

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.

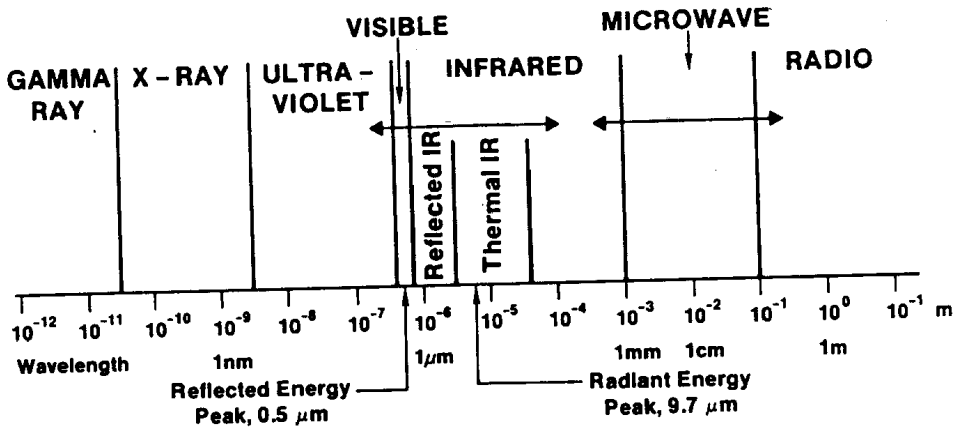

Figure 2.2 Electromagnetic spectrum. Expanded versions of the visible, infrared and microwave regions are shown in Figure 2.3.

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).

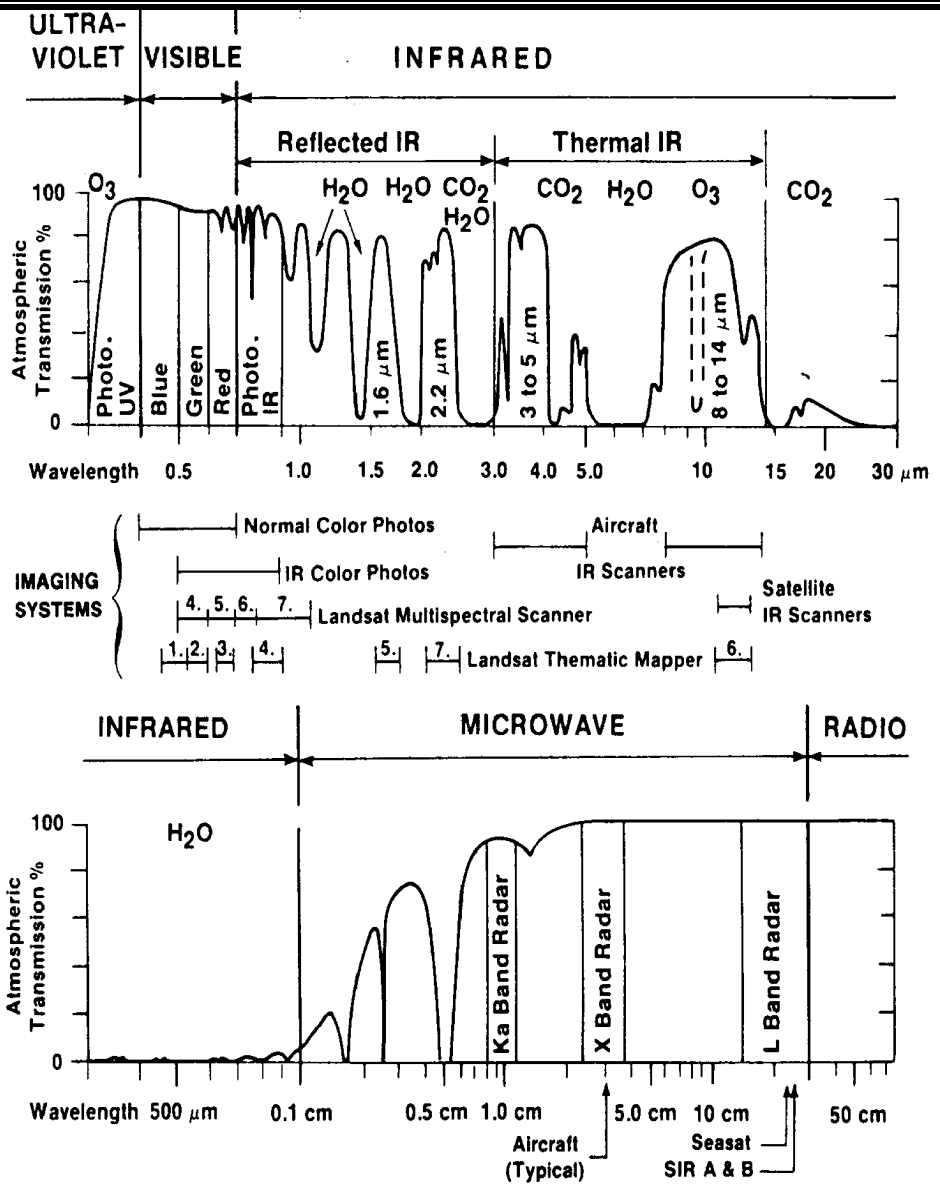

Figure 2.3 Expanded diagrams of the visible and infrared regions (upper) and the microwave regions (lower) showing atmospheric windows. Wavelength bands of commonly used remote sensing systems are indicated. Gases responsible for atmospheric absorption are shown.

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 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. OLI sensor of Landsat 8 of January 2014 having 30 m. spatial resolution was used in the present study.

- **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 **Pench-Kanhan-Tawa Valley Coalfield,** Survey of India topo-sheet no. 55 J/4, 55 J/8, 55 J/11, 55 J/12, 55 J/15, 55 J/16 & 55 N/3 on RF 1:50000 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 Landsat 8 satellite/ OLI 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
Landsat 8	OLI	B3 0.52 - 0.60 Green B4 0.63 - 0.68 Red B5 0.84 - 0.88 NIR	16-bit	30 m 30 m 30 m 30 m	16 days	USA

NIR: Near Infra-Red OLI: Operational Land Imager

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.

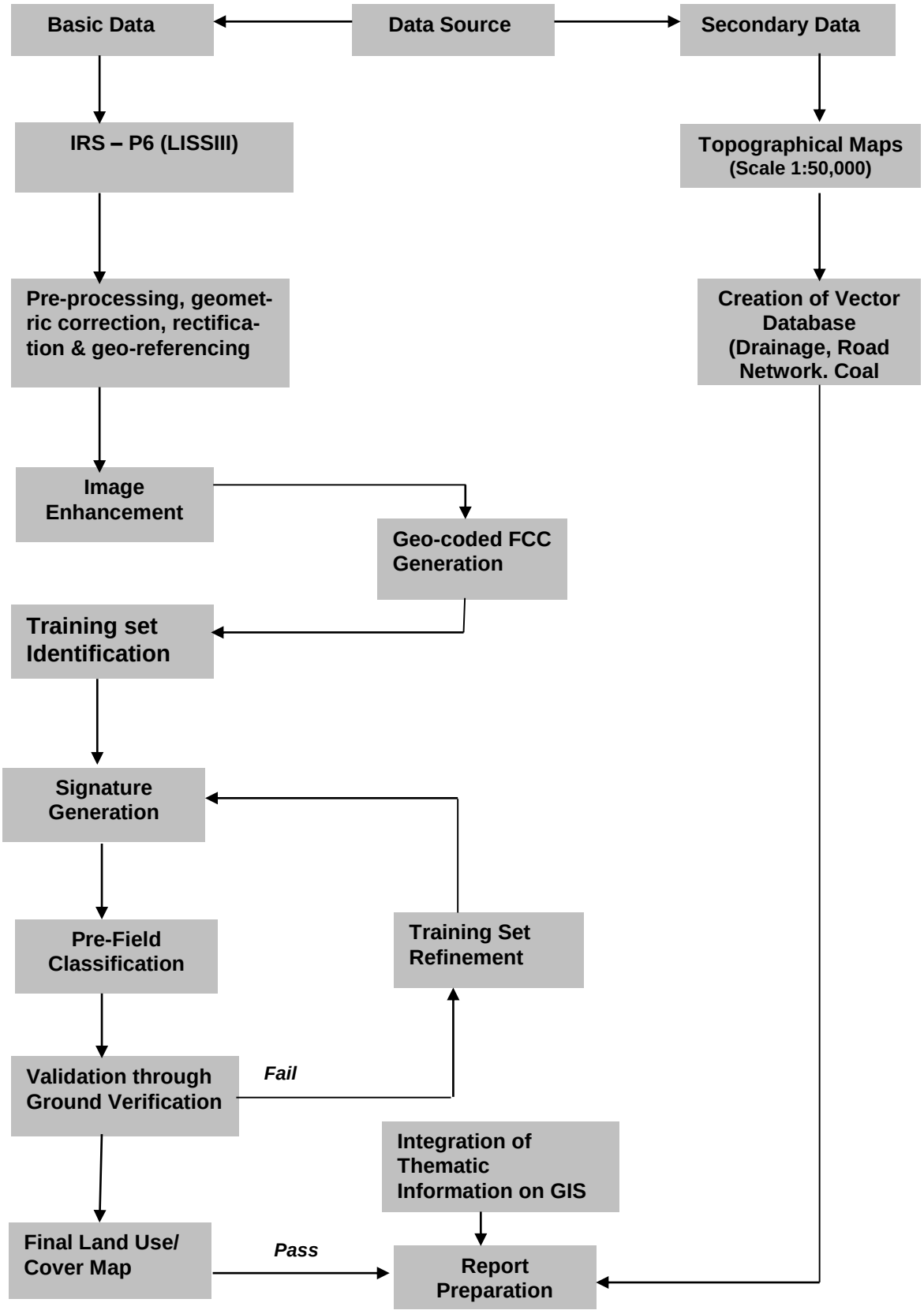

Fig-2.4 –Methodology of Land Use/Vegetation Cover Analysis

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 trans/formation 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*.

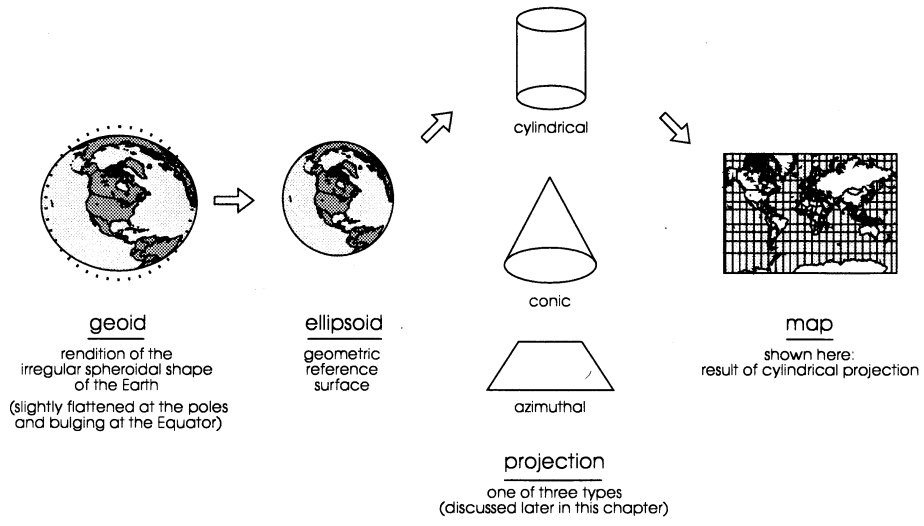

Fig 2.5: Geoid – Ellipsoid – Projection Relationship

In the present study, ***UTM projection*** along with ***WGS 84 datum model*** was used so as to prepare the map compatible with the satellite data**.** UTM projection is being used worldwide and is best suited for mapping larger areas as well as for areas with North-Up orientation. Maps prepared using these projections are globally acceptable, even though it is neither conformal

perspective nor equal area. Distances, areas and shapes are true along central meridian. Distortion may occur away from central meridian. Image transformation from generic co-ordinate system to a projected co-ordinate system was carried out using Arc GIS 9.0 software.

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 IMAGINE s/w. The enhanced and geocoded FCC image of Pench-Kanhan-Tawa Valley Coalfield is 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, 100 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. The classified image for the year 2014 for Pench-Kanhan-Tawa Valley Coalfield is shown in Plate No.2.

2.6.5 Creation/overlay of vector database

Plan showing coal block boundary is superimposed on the image as vector layer in the Arc GIS database. Road and drainage network are also digitised on Arc GIS database and superimposed on the classified image. Geo-environmental data base created on GIS platform to analyse the impact of mining on land use and vegetation cover at interval of three years.

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 Plantation on OB Dump, Sand Body and Barren OB Dump was 100%. Classification accuracy in case of Dense Forest and Water Bodies lie between 90% to 100%. In case of open forest, built-up land, the classification accuracy varies from 80.0% to 90.0%. Classification accuracy for scrubs was 73.3% due to poor ***signature separability index***. The overall classification accuracy is 90%.

2.6.7 Final land use/vegetation cover map preparation

Final land use/vegetation cover map (Plate - 2) was generated on 1:50,000 scale & printed in 1:90,000 scale for handling convenience using HP Design jet 4500 Colour plotter and the same is enclosed in the report. A soft copy in .pdf format is also attached. .

Table 2.3: Classification Accuracy Matrix for Pench-Kanhan-Tawa Valley 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
1	Urban Settlement	**C1**	**05**	5									
2	Dense Forest	**C2**	**10**		8	1	1						
3	Open Forest	**C3**	**10**		1	8	1						
4	Scrubs	**C4**	**10**		1	1	7	1					
5	Social Forestry	**C5**	**10**				1	8	1				
6	Agriculture Land	**C6**	**10**					1	9				
7	Waste Upland	**C7**	**10**							10			
8	Sand Body	**C8**	**10**								10		
9	Quarry Area	**C9**	**10**									10	
10	Water Bodies	**C10**	**10**										10
Total no. of observation points			**110**	05	10	10	10	10	10	10	10	10	10
% of commission				**00.0**	**20.0**	**20.0**	**30.0**	**20.0**	**10.0**	**0.0**	**0.0**	**0.0**	**0.0**
% of omission				**00.0**	**20.0**	**20.0**	**30.0**	**20.0**	**10.0**	**0.0**	**0.0**	**0.0**	**0.0**
% of Classification Accuracy				**100.0**	**80.0**	**80.0**	**70.0**	**80.0**	**90.0**	**100.0**	**100.0**	**100.0**	**100.0**
Overall Accuracy (%)			**90.000**										

Chapter 3

Land Use/ 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/ vegetation 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/Cover Classification

The array of information available on land use/cover requires be arranging or grouping 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 Agency, Hyderabad. Land use map was prepared on the basis of image interpretation carried out based on the satellite data for the year 2014 for Pench-Kanhan-Tawa Valley coalfield and following land use/cover classes are identified (Table 3.1).

Table 3.1:
Land use/cover classes identified in Pench-Kanha-Tawa Valley Coalfield

	Level -I	***Level -II***
1.	**Built-Up Land**	1.1 Urban 1.2 Rural 1.3 Industrial
2.	**Forest/Vegetation Cover**	2.1 Dense Forest 2.2 Open Forest 2.3 Scrub 2.4 Plantation under Social Forestry 2.5 Plantation on OB Dumps
3.	**Mining Area**	3.1 Coal Quarry 3.2 Barren OB Dump 3.3 Barren Backfill 3.4 Coal Dump 3.5 Advanced Quarry 3.6 Water filled Quarry
4.	**Agricultural land**	4.1 Crop Land 4.2 Fallow Land
5.	**Waste Land**	5.1 Waste upland with/without scrubs 5.2 Fly Ash Pond 5.3 Sand Body
6.	**Water bodies**	6.1 River/Streams /Reservoir/Ponds

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

3. Plate No. 1: Drawing No. HQ/REM/ 001: FCC (Landsat 8 OLI data of Pench-Kanhan-Tawa Valley coalfield of the year 2014) with Coalfield boundary and other infrastructural details.
4. Plate No. 2: Drawing No. HQ/REM/ 002 - Land use/Cover Map of Pench-Kanhan-Tawa Valley Coalfield based on Landsat 8 OLI data..

3.3 Land use/cover Analysis

Satellite data of the year 2014 was processed using ERDAS IMAGINE 13.0 image processing s/w in order to interpret the various land use/cover classes present in the study area of Pench-Kanhan-Tawa Valley coalfield. The analysis was carried out for entire coalfield covering 2426.03 sq. km. The area of each class was calculated and analysed using Arc-Info GIS & ERDAS IMAGINE s/w. Analysis of land use / vegetation cover pattern in Pench-Kanhan-Tawa Valley coalfield for the year 2014 was carried out and details of the analysis are shown in the table below. In the present study, the study area is covering the entire basinal area of Pench-Kanhan-Tawa Valley coalfield which comprises 2426.00 sq.km. The distribution of vegetation cover statistics classes covering the Pench-Kanhan-Tawa Valley coalfield is given detailed in the Table-3.2 below:

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TABLE -3.2

STATUS OF LAND USE / VEGETATION COVER IN PENCH-KANHAN-TAWA VALLEY COALFIELD IN THE YEAR 2014

LAND USE / VEGETATION COVER CLASSES	Year-2014	
	Area (Km^2)	% of total
SETTLEMENTS		
Rural Settlements	8.82	0.36
Urban Settlements	15.25	0.63
Industrial Settlements	7.28	0.30
Total Settlements	**31.35**	**1.29**
VEGETATION COVER		
FOREST		
Dense Forest	316.22	13.03
Open Forest	365.45	15.06
Total Forest (A)	681.67	28.10
SCRUBS		
Scrubs (B)	297.31	13.03
PLANTATION		
Social forestry	8.65	0.36
Plantation on OB	1.87	0.08
Total Plantation (C)	10.52	0.43
Total Vegetation (A+B+C)	**989.50**	**40.79**
MINING AREA		
Coal Quarry	0.17	0.01
Barren OB Dump	4.53	0.19
Barren Backfilled	0.41	0.02
Coal Dump	0.21	0.01
Advance Quarry	0.15	0.01
Water filled quarry	1.37	0.06
Total Mining Area	**6.84**	**0.28**
AGRICULTURE		
Crop Land	343.70	14.17
Fallow Land	767.15	31.62
Total Agriculture	**1110.85**	**45.79**
WASTELANDS		
Waste land	209.84	8.65
Sand Body	32.59	1.34
Fly Ash Pond	02.69	0.11
Total Wasteland	**245.12**	**10.10**
WATERBODIES		
River, nallah, pond etc.	42.37	1.75
TOTAL	**2426.03**	**100.00**

In the previous study carried out based on the satellite data of the year 2011, the study area was limited to only potential coal bearing area boundary covering an area of 907.90 sq. km. only. For comparison purpose, vegetation cover studies of Pench-Kanhan-Tawa Valley coalfield in 2014 for the area used in the 2011 report has also been calculated using Arc-Info GIS & ERDAS IMAGINE 9.0 s/w has been depicted in Table 3.3.

Blockwise area of each land use/cover class for Pench-Kanhan-Tawa Valley coalfield was calculated using Arc-Info GIS & ERDAS IMAGINE 9.0 s/w and tabulated in Table 3.8.

Distribution of various land use classes are shown in the Pie Charts (Fig. 3.2). Pench-Kanhan-Tawa Valley coalfield contains 91 coal blocks whose land use/cover classes are tabulated in Table 3.8.

TABLE -3.3

COMPARISON OF STATUS OF LAND USE & VEGETATION COVER PATTERN

IN PENCH-KANHAN-TAWA VALLEY COALFIELD DURING THE YEAR 2011 & 2014

LAND USE CLASSES	Year-2011		Year-2014		Change w.r.t. year 2011		Remarks
	Area (Km^2)	%	Area (Km^2)	%	Area (Km^2)	%	
SETTLEMENTS							
Rural Settlements	5.53	0.61	5.54	0.61	0.01	0.00	May be due to industrialisation in the area.
Urban Settlements	15.25	1.68	15.25	1.68	0.00	0.00	
Industrial Settlements	2.46	0.27	2.86	0.32	0.40	0.04	
Total Settlements	**23.24**	**2.56**	**23.65**	**2.60**	0.41	0.05	
VEGETATION COVER							
FOREST							
Dense Forest	159.87	17.61	156.24	17.21	-3.63	-0.40	Due to biotic interference.
Open Forest	85.24	9.39	84.52	9.31	-0.72	-0.08	
Total Forest (A)	**245.11**	**27.00**	**240.76**	26.52	**-4.35**	**-0.48**	
SCRUBS							
Scrubs (B)	**187.05**	**20.60**	**181.98**	**20.04**	**-5.07**	**-0.56**	Due to conversion of scrub land into fallow land.
PLANTATION							
Social forestry	8.32	0.91	8.35	0.92	0.03	0.01	Due to land reclamation carried out by WCL
Plantation on OB	1.89	0.21	2.01	0.22	0.12	0.01	
Total Plantation (C)	**10.21**	**1.12**	**10.36**	**1.14**	**0.15**	**0.02**	
Total Vegetation (A+B+C)	**442.37**	**48.72**	**433.10**	47.70	**-9.27**	**-1.01**	
MINING AREA							
Coal Quarry	0.16	0.02	0.17	0.02	0.01	0.00	Due to increase in mining activities.
Barren OB Dump	4.52	0.50	4.53	0.50	0.01	0.00	
Barren Backfilled	0.41	0.05	0.43	0.05	0.02	0.00	
Coal Dump	0.19	0.02	0.21	0.02	0.02	0.00	
Advance Quarry	0.18	0.02	0.19	0.02	0.01	0.00	
Water filled quarry	1.38	0.15	1.37	0.15	-0.01	0.00	
Total Mining Area	**6.84**	**0.76**	**6.90**	**0.76**	**0.06**	**0.01**	
AGRICULTURE							
Crop Land	151.07	16.64	160.46	17.67	9.39	1.03	Increase in agricultural land owing to conversion of waste land into crop land and fallow land.
Fallow Land	180.21	19.85	196.27	21.62	16.06	1.77	
Total Agriculture	**331.28**	36.49	**356.73**	**39.29**	**25.45**	**2.80**	
WASTELANDS							
Waste land	**82.52**	9.09	**65.36**	7.20	-17.16	-1.89	Decrease of waste land attributed to its conversion into agricultural land.
Sand Body	**4.65**	0.51	**3.84**	0.42	-0.81	-0.09	Due to submergence.
Fly Ash Pond	**2.68**	0.30	**2.69**	0.30	0.01	0.00	Due to Ash dump.
Total Wasteland	**89.85**	**9.90**	**71.89**	**7.92**	**-17.96**	**-1.98**	
WATERBODIES							
River, nallah, pond etc.	**14.32**	1.58	**15.63**	1.72	1.31	0.14	Due to more waterbodies.
TOTAL	**907.90**	**100.00**	**907.90**	**100.00**			

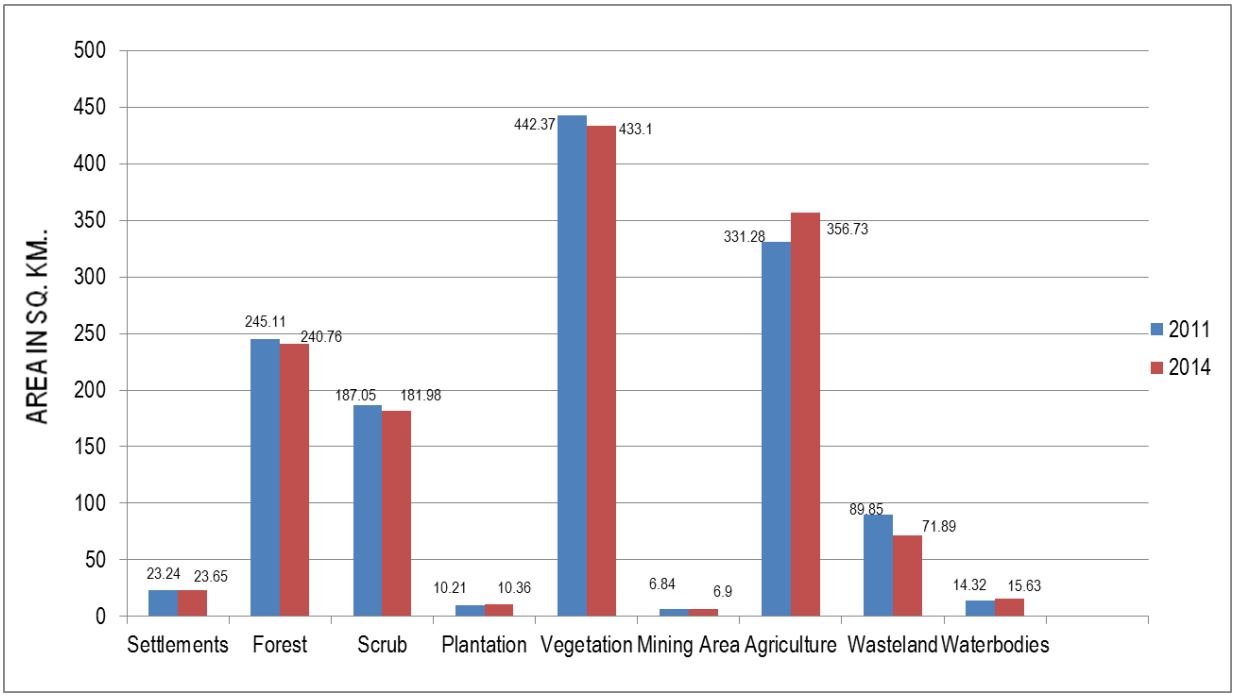

Fig.3.1: YEARWISE COMPARISON OF LAND USE/VEGETATION COVER IN PENCH-KANHAN-TAWA COALFIELD

3.3.1 Settlement/ Built-up land

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 based on availability of infrastructure facilities. In the present study, industrial settlement indicates only industrial complexes excluding residential facilities. In the year 2011 the total area covered by settlements were estimated to be 23.24 sq. km (2.56%). In year 2014 the estimated area under settlements has grown to 23.65 sq. km (2.60%). There is an increase in settlements by 0.41 sq. km which is about 0.05% of the total area. This increase is due to more urbanisation in mining and around small town.

The details of the land use under this category are shown in Table 3.4 as follows:

TABLE -3.4

STATUS OF CHANGE IN SETTLEMENTS IN PENCH-KANHAN-TAWA VALLEYCOALFIELD

DURING THE YEAR 2011 & 2014

LAND USE CLASSES	Year-2011		Year-2014		Change w.r.t. year 2011		Remarks
	Area (Km^2)	%	Area (Km^2)	%	Area (Km^2)	%	
SETTLEMENTS							
Rural Settlements	5.53	0.61	5.54	0.61	0.01	0.00	May be due to industrialisation in the area.
Urban Settlements	15.25	1.68	15.25	1.68	0.00	0.00	
Industrial Settlements	2.46	0.27	2.86	0.32	0.40	0.04	
Total Settlements	**23.24**	**2.56**	**23.65**	**2.60**	0.41	0.05	

3.3.2 Vegetation cover

Vegetation cover is an association of trees and other vegetation type capable of producing timber and other forest produce. It is also defined as the percentage of soil which is covered by green vegetation. Leaf area index (LAI) is an alternative expression of the term vegetation cover which gives the area of leaves in m^2 corresponding to an area of one m^2 of ground. Primarily vegetation cover is classified into the following three sub-classes based on crown density as per modified FAO-1963 (Food & Agricultural Organisation of United Nations) norms: (a) dense forest (crown density more than 40%), (b) open/degraded forest (crown density between 10% to 40%), and (c) scrubs (crown density less than 10%). The plantation that has been carried out on wasteland along the roadside and on the overburden dumps is also included under vegetation cover as social forestry and plantation on backfilled/over-burden dumps respectively. The percentage of vegetation cover shown in the analysis here are in terms of total land use cover only. Details of area statistics of the vegetation cover in Pench-Kanhan-Tawa Valley Coalfield area is given in Table 3.5.

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 3.5.

TABLE -3.5

STATUS OF CHANGE IN VEGETATION IN PENCH-KANHAN-TAWA COALFIELD DURING THE YEAR 2011 & 2014

LAND USE CLASSES	Year-2011		Year-2014		Change w.r.t. year 2011		Remarks
	Area (Km^2)	%	Area (Km^2)	%	Area (Km^2)	%	
VEGETATION COVER							
FOREST							
Dense Forest	159.87	17.61	156.24	17.21	-3.63	-0.40	Due to biotic interference.
Open Forest	85.24	9.39	84.52	9.31	-0.72	-0.08	
Total Forest (A)	**245.11**	**27.00**	**240.76**	26.52	**-4.35**	**-0.48**	
SCRUBS							
Scrubs (B)	**187.05**	**20.60**	**181.98**	**20.04**	**-5.07**	**-0.56**	Due to conversion of scrub land into fallow land.
PLANTATION							
Social forestry	8.32	0.91	8.35	0.92	0.03	0.01	Due to land reclamation carried out by WCL
Plantation on OB	1.89	0.21	2.01	0.22	0.12	0.01	
Total Plantation (C)	**10.21**	**1.12**	**10.36**	**1.14**	**0.15**	**0.02**	
Total Vegetation (A+B+C)	**442.37**	**48.72**	**433.10**	47.70	**-9.27**	**-1.01**	

Dense forest – Forest having crown density of above 40% comes in this class. In the year 2011 the total area covered by dense forest were estimated to be 159.87 sq. km (17.61%). In year 2014 the estimated area under dense forest has reduced to 156.24 sq. km (17.21%). There is a decrease in dense forest by 3.63 sq. km which is about 0.40% of the total area on account of conversion to open forest due to deforestation.

Open Forest – Forest having crown density between 10% to 40% comes under this class. Open forest cover over Pench-Kanhan-Tawa Valley coalfield which was estimated to be 85.24 sq. km (9.39%) in 2011 has been decreased to 84.52 sq. km, i.e.9.31 % of the coalfield area in 2014. Thus the decrease in open forest is 0.72 sq. km which is 0.08 % of the total coalfield area. This reduction is due to deforestation by local inhabitants.

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 181.98 sq. km. of scrubs, i.e. 20.04% of the coalfield area in 2014. In year 2011 the scrubs covered 187.05 sq. km which were 20.60% of the coalfield area. There is a decrease of 20.04 sq. km which is 0.56% of the coalfield area.

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 8.35 sq. km, which is 0.92% of the coalfield area in 2014. In 2011 the area covered under social forestry was 8.32 sq. km (0.91%). There is an increase of 0.03 sq. km. This increase is due to plantation around settlements.

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 10.36 sq. km, i.e. 1.14% of the coalfield area in 2014. In year 2011 the plantation on OB Dumps were estimated to cover an area of 10.21 sq. km which was 1.12% of the coalfield area. There is an increase of 0.15 sq. km (0.02%) in plantation over OB dumps. This is due to plantation done on OB dumps.

3.3.3 Mining

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
- Advance Quarry
- Water filled Quarry

In the year 2011 the coal quarry was estimated to be 0.16 sq. km which has increased to 0.17 sq. km in the year 2014. This minor increase is due to increase in production of coal from Open cast areas. In the year 2011 the barren OB dump was estimated to be 4.52 sq. km which has been decreased to 4.53 sq. km in the year 2014. This decrease is due to increase in plantation on OB dump. In the year 2011 the barren backfilled area was estimated to be 0.41 sq. km which has been increased to 0.43 sq. km in the year 2014. In the year 2011 the coal dump was estimated to be 0.19 sq. km which has been increased to 0.21 sq. km in the year 2014. In the year 2011 the advance quarry was estimated to be 0.18 sq. km which has been increased to 0.19 sq. km in the year 2014. In the year 2011 the water filled quarry was estimated to be 1.38 sq. km which has been decreased to 1.37 sq. km in the year 2014. The status of land Use in the mining area over the Pench-Kanhan-Tawa Valley Coalfield is shown in the table 3.6 below.

TABLE -3.6

STATUS OF CHANGE IN MINING AREA IN PENCH-KANHAN-TAWA VALLEY COALFIELD

DURING THE YEAR 2011 & 2014

LAND USE CLASSES	Year-2011		Year-2014		Change w.r.t. year 2011		Remarks
	Area (Km^2)	%	Area (Km^2)	%	Area (Km^2)	%	
MINING AREA							
Coal Quarry	0.16	0.02	0.17	0.02	0.01	0.00	
Barren OB Dump	4.52	0.50	4.53	0.50	0.01	0.00	
Barren Backfilled	0.41	0.05	0.43	0.05	0.02	0.00	
Coal Dump	0.19	0.02	0.21	0.02	0.02	0.00	Due to increase in mining activities.
Advance Quarry	0.18	0.02	0.19	0.02	0.01	0.00	
Water filled quarry	1.38	0.15	1.37	0.15	-0.01	0.00	
Total Mining Area	**6.84**	**0.76**	**6.90**	**0.76**	**0.06**	**0.01**	

3.3.4 Agriculture

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 356.73 sq. km in year 2014, which is 39.29 % of the coalfield area. In year 2011 the total agricultural area was estimated to be 331.28 sq. km which was 36.49% of the coalfield area. There is an increase of 25.45 sq. km which is 2.80% of the coalfield due to conversion of waste land in agricultural land. The details are shown below in Table 3.6.

TABLE -3.7

STATUS OF CHANGE IN AGRICULTURE IN PENCH-KANHAN-TAWA VALLEY COALFIELD

DURING THE YEAR 2011 & 2014

LAND USE CLASSES	Year-2011		Year-2014		Change w.r.t. Yr 2011		Remarks
	Area (Km^2)	%	Area (Km^2)	%	Area (Km^2)	%	
AGRICULTURE							
Crop Land	151.07	16.64	160.46	17.67	9.39	1.03	Increase in agricultural land owing to conversion of waste land into crop land and fallow land.
Fallow Land	180.21	19.85	196.27	21.62	16.06	1.77	
Total Agricul-ture	**331.28**	36.49	**356.73**	**39.29**	**25.45**	**2.80**	

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 – 3.8. The waste land was estimated to be 82.52 sq. km (9.09%) in the year 2011. In the year of 2014, waste land is estimated to be 65.36 sq. km (7.20%). So there is a decrease of 17.16 sq. km i.e. (1.89%) of the total coalfield area due to conversion of waste land into agricultural land on account of good monsoon over the last few years.

The sand body was estimated to be 4.65 sq. km (0.51%) in the year 2011. In the year of 2014, sand body is estimated to be 3.84 sq. km (0.42%). So there is a minor decrease of 0.81 sq. km i.e. (0.09%) of the total coalfield.

The fly ash pond was estimated to be 2.68 sq. km in the year 2011. In the year of 2014, sand body is estimated to be 2.69 sq. km. So there is a minor increase of 0.01 sq. km of the total coalfield.

The details are shown below in Table 3.8.

TABLE -3.8

STATUS OF CHANGE IN WASTELAND IN PENCH-KANHAN-TAWA VALLEY COALFIELD

DURING THE YEAR 2011 & 2014

LAND USE CLASSES	Year-2011		Year-2014		Change w.r.t. year 2011		Remarks
	Area (Km^2)	%	Area (Km^2)	%	Area (Km^2)	%	
WASTELANDS							
Waste land	**82.52**	9.09	**65.36**	7.20	-17.16	-1.89	Decrease of waste land attributed to its conversion into agricultural land.
Sand Body	**4.65**	0.51	**3.84**	0.42	-0.81	-0.09	Due to submergence.
Fly Ash Pond	**2.68**	0.30	**2.69**	0.30	0.01	0.00	Due to Ash dump.
Total Wasteland	**89.85**	**9.90**	**71.89**	**7.92**	**-17.96**	**-1.98**	

3.3.6 Surface 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 14.32 sq. km in year 2011, which is 1.58% of the coalfield area. In 2014 it have been estimated to be 15.63 sq. km which is 1.72% of the total area. So there is an increase of 1.31 sq. km. in water bodies which is 0.14% of the total coalfield area.

Table 3.9: Block wise Area Statistics of Pench-Kanhan-Tawa Valley coalfields (2014)

Area in Sq. Km.

Sl. No.	Block-Name	Vegetation						Agriculture			Settlement				Mining area						Waste Land				Water Body	Total Area
		Dense Forest	Open Forest	Scrub	Social Forest	Plantn. on OB	Sub Total	Crop Land	Fallow Land	Sub Total	Rural	Urban	Indus-trial	Sub Total	Coal Quarry	Barren OB	Barren backfill	Coal Dump	Water-fill Quarry	Sub Total	Ash Pond	Waste Land	Sand Body	Sub Total		
1	TANDSI NORTH	2.80	0.86	0.23			3.89	0.23	0.13	0.36												0.10	0.05	0.15	0.05	4.45
2	BANSI UG	0.94	0.27	0.03			1.24	0.52	0.12	0.65												0.02		0.02		1.91
3	KALICHAPPAR	0.00	0.01	0.16	0.08		0.25	0.09	0.19	0.28	0.00	0.07		0.08	0.00					0.00		0.13	0.02	0.15	0.10	0.86
4	TATARWARA			0.02	0.03		0.05	2.23	0.49	2.72	0.02			0.02												2.79
5	BARKHUHI WEST			0.28	0.23		0.52	0.56	0.44	1.00	0.02	0.57		0.59								0.20		0.20	0.01	2.32
6	EAST DONGAR		0.06	1.50	0.03		1.59	0.67	0.20	0.87	0.06	0.29		0.34		0.00		0.01		0.01		0.96		0.96		3.79
7	BHAMORI	0.01		0.39	0.39		0.79	3.34	0.48	3.82	0.03	0.12		0.15		0.01	0.00			0.01		0.16	0.25	0.41	0.29	5.46
8	DAMUA-SAJANIA (GSI)	5.28	1.55	3.69			10.52	1.35	0.37	1.72												1.28		1.28	0.25	13.77
9	CHOPNA SHAKTIGARH (GSI)	0.02	0.58	7.43	0.55		8.59	4.13	18.40	22.52	0.40			0.40								0.59		0.59	1.16	33.26
10	JHOLI SECTOR (GSI)	1.01	6.38	8.56	0.76		16.72	1.57	11.98	13.55	0.29			0.29								2.75	0.01	2.76	0.33	33.65
11	BHOKAL (GSI)	0.04	0.65	2.36			3.04	3.24	6.54	9.78	0.10	0.10	0.09	0.28								0.74		0.74	0.39	14.23
12	PAYALICHANA (GSI)		0.10	1.93			2.04	1.98	7.80	9.78	0.14			0.14								0.64		0.64	0.36	12.95
13	PATHAKHURI PIPARYA (GSI)	4.52	5.26	4.98			14.75	14.65	8.01	22.66	0.26			0.26								2.31		2.31	0.71	40.69
14	KHIRSADOH EXTENSION SUB		0.00	0.99	0.17		1.16	0.49	0.14	0.62		0.71		0.71								1.31		1.31	0.01	3.82
15	RAWANWARA KHAS	0.27	0.69	1.21	0.07	0.01	2.25	0.18	0.21	0.39		0.19	0.02	0.21	0.02	0.07	0.02		0.01	0.11		0.49	0.04	0.52	0.09	3.57
16	SIRGORA KHURD		0.14	0.42	0.03	0.01	0.61	0.29	0.16	0.45	0.01	0.22		0.22		0.09		0.01		0.10		0.47		0.47		1.85
17	RAKHIKOL	3.24	1.06	0.86			5.17		0.91	0.91	0.02			0.02								0.17		0.17		6.26
18	NANDAN-II	1.10	0.50	0.56			2.16	0.13	0.20	0.33												0.19		0.19	0.08	2.76
19	HARANBHATTA EXTN			0.12		0.01	0.13	0.20	0.18	0.38												0.05		0.05		0.55
20	HARANBHATTA			0.48		0.05	0.52	0.49	0.87	1.35					0.15	0.39			0.06	0.60		0.24		0.24	0.03	2.75
21	NEWTON CHIKLI B	0.00	0.00	0.58	0.20		0.78	5.52	0.86	6.39	0.09	0.13		0.22								0.12	0.23	0.35	0.57	8.30
22	NEWTON CHIKLI A			2.52	0.24		2.76	3.72	0.26	3.98	0.06	0.16		0.22								0.29	0.04	0.33	0.15	7.43
23	EKLEHARA			0.10	0.05		0.15	7.68	1.53	9.21	0.10	0.00		0.10								0.05	0.17	0.22	0.24	9.92
24	SIAL GHOGRI		0.02	1.45		0.01	1.48	0.25	0.86	1.10	0.04			0.04		0.20				0.20		4.04		4.04		6.87
25	SIAL GHOGRI EAST		0.09	2.14			2.23	0.17	0.56	0.73	0.02	0.01	0.01	0.04								1.04		1.04		4.03
26	CHANDAMETA			0.81	0.14		0.94	1.45	1.12	2.57	0.04	0.21		0.25								1.09		1.09		4.86
27	NORTH CHANDAMETA			0.14	0.32		0.47	0.83	0.16	0.99		0.24		0.24								0.13		0.13	0.00	1.83
28	BARKUHI			0.02	0.33		0.35	0.79	0.20	0.99	0.00	0.38		0.38		0.10	0.09		0.00	0.19		0.08		0.08	0.00	1.99
29	MAHADEOPURI		0.41	1.56	0.04		2.00	0.23	0.27	0.50		0.53	0.04	0.58								0.14		0.14	0.00	3.23
30	TAWA EXTN	3.93	0.52	2.12			6.57	0.24	0.93	1.17															0.39	8.13
31	DAMUA	0.08	0.33	0.79	0.37	0.05	1.61	0.12	0.96	1.08	0.10	0.56	0.05	0.71	0.12	0.23			0.05	0.39		0.35	0.04	0.39	0.08	4.26
32	DALTA WEST	0.04	0.25	1.58	0.01		1.88	1.38	1.53	2.90	0.01			0.01	0.01	0.15				0.16		0.17		0.17	0.00	5.13
33	DALTA EAST			1.72	0.33	0.03	2.07	1.39	3.62	5.01	0.04	0.94		0.99	0.14	0.57	0.03		0.08	0.82		0.07		0.07	0.14	9.09
34	SHARDA			0.24	0.01		0.25	2.04	1.47	3.52	0.05			0.05		0.01				0.01					0.01	3.84

Table 3.9: Block wise Area Statistics of Pench-Kanhan-Tawa Valley coalfields (2014)

Sl. No.	Block-Name	Vegetation						Agriculture			Settlement				Mining area						Waste Land				Water Body	Total Area
		Dense Forest	Open Forest	Scrub	Social Forest	Plantn. on OB	Sub Total	Crop Land	Fallow Land	Sub Total	Rural	Urban	Indus-trial	Sub Total	Coal Quarry	Barren OB	Barren backfill	Coal Dump	Water-fill Quarry	Sub Total	Ash Pond	Waste Land	Sand Body	Sub Total		
35	AMBARA SUKRI NORTH	5.94	2.85	1.57	0.07		10.44	10.46	6.96	17.42	0.16			0.16									0.01	0.01	0.30	28.32
36	SOUTH AMBARA			0.20	0.18	0.02	0.39	4.72	2.89	7.61	0.09	0.25		0.35	0.32	0.27			0.14	0.73		0.23		0.23	0.07	9.38
37	BANABEHRA (PROM)	0.20	2.36	2.75			5.32	4.59	22.77	27.35												1.80	0.44	2.23	0.71	35.62
38	GURGUNDA	0.02	0.00	0.24			0.25	2.45	6.33	8.78												0.16	0.38	0.54	0.14	9.71
39	CHIMRI	0.00	0.11	2.39			2.49	6.00	20.22	26.23			0.00	0.00								1.67	1.52	3.19	0.60	32.52
40	BISHNUPUR (PROM)	0.30	0.75	1.35	0.04		2.44	3.29	9.72	13.02	0.03			0.03								0.24	0.91	1.15	0.65	17.29
41	CHATTERPUR II		0.06	0.86	0.04		0.96	0.21	2.79	3.00		0.02	0.07	0.08											0.00	4.04
42	SATPURA II	0.67	0.62	0.95	0.01		2.25	0.07	0.71	0.79		0.62	0.01	0.63												3.66
43	SARNI		0.26	1.92			2.18	0.00	0.19	0.19		0.41	0.28	0.69							0.73	0.29		1.02		4.08
44	PATHERKHERA I & II	3.65	1.35	0.94	0.07		6.00	0.00	0.10	0.10		0.59		0.59											0.38	7.07
45	SARNI EXTN	0.01	0.02	1.18	0.07		1.29		0.13	0.13		0.97	0.60	1.57											0.06	3.04
46	SATPURA I	0.55	0.26	0.67	0.07		1.55		0.08	0.08		0.46	0.04	0.50								0.32		0.32		2.45
47	SHAKTIGARH			1.07	0.26		1.34	1.24	3.71	4.94	0.20			0.20								0.00	0.08	0.09	0.14	6.71
48	SHOBHAPUR EXTN	0.02	0.05	0.61	0.00		0.68	0.63	3.63	4.26	0.11			0.11									0.07	0.07	0.16	5.28
49	TAWA	2.23	1.87	1.22			5.32	0.00	0.06	0.06													0.18	0.18	0.40	5.97
50	GAJANDOH			0.22	0.02		0.24	0.75	0.56	1.31			0.05	0.05								0.51		0.51		2.10
51	MAORI	0.19	0.73	2.42		0.05	3.40	0.16	0.06	0.21						0.04				0.04		1.24		1.24		4.89
52	SUKRI			0.15			0.15	2.25	1.86	4.11		0.22		0.22											0.00	4.48
53	NEW CHIKALMAU			0.05	0.04		0.08	3.08	0.44	3.52	0.05	0.01		0.06								0.04		0.04		3.71
54	CHIKALMAU							0.37	0.12	0.50																0.50
55	JHARNA	0.36	0.38	0.77			1.51	0.03	0.03	0.06												0.57		0.57		2.14
56	GHORAWARI	0.27	1.32	3.07	0.28	0.05	4.99	0.51	1.57	2.08	0.04	0.11	0.04	0.19	0.18	0.48	0.07		0.07	0.79		0.44		0.44	0.07	8.57
57	NORTH NANDORA	0.19	0.32	0.92	0.08		1.51	0.05	0.34	0.38	0.02	0.16	0.02	0.20								0.18		0.18		2.27
58	JHARNA EXTN	0.51	0.48	0.69			1.68	0.57	0.16	0.72												0.32		0.32		2.73
59	DAMUA EAST	0.17	0.16	0.56			0.89	0.04	0.23	0.27												0.32		0.32		1.48
60	GORADEVI	0.05	0.71	6.07			6.83	3.57	8.94	12.51	0.13			0.13											0.18	19.65
61	BHAKRA		0.08	1.05			1.13	0.49	0.57	1.06												0.26		0.26	0.08	2.53
62	NANDAN-I	0.15	0.50	1.29	0.02		1.96	0.32	0.95	1.26	0.01	0.01		0.02								0.55		0.55	0.19	3.99
63	DHAU NORTH	1.33	0.53	0.75			2.60	0.11	0.21	0.31												0.09		0.09	0.18	3.18
64	RAKHINALA	7.73	0.94	0.22			8.88	0.86	0.43	1.30												0.17		0.17	0.06	10.41
65	DHAU EXTN	1.55	0.69	0.71			2.95	1.50	0.43	1.93			0.00	0.00								0.48		0.48	0.01	5.37
66	KOYALWARI	2.46	0.46	0.22			3.14	1.18	0.23	1.42												0.10		0.10		4.65
67	TAMBIA	13.87	3.52	0.13			17.51	0.14	0.17	0.31												0.13	0.03	0.16	0.23	18.22
68	TANDSI SOUTH	3.85	0.48	0.25			4.57	0.10	0.60	0.70												0.08	0.02	0.10	0.03	5.40
69	TANDSI-III	2.72	0.23	0.01			2.96	0.00		0.00												0.01		0.01		2.98

Table 3.9: Block wise Area Statistics of Pench-Kanhan-Tawa Valley coalfields (2014)

Sl. No.	Block-Name	Vegetation						Agriculture			Settlement				Mining area						Waste Land				Water Body	Total Area
		Dense Forest	Open Forest	Scrub	Social Forest	Plantn. on OB	Sub Total	Crop Land	Fallow Land	Sub Total	Rural	Urban	Indus-trial	Sub Total	Coal Quarry	Barren OB	Barren backfill	Coal Dump	Water-fill Quarry	Sub Total	Ash Pond	Waste Land	Sand Body	Sub Total		
70	DHANWA	13.55	3.00	0.49			17.04		0.24	0.24	0.01			0.01								0.07	0.04	0.10	0.60	17.99
71	GANDHIGRAM	4.06	1.31	1.81	0.08		7.27	0.03	3.08	3.11	0.09			0.09								0.27		0.27	0.08	10.82
72	SHABHAPUR	0.95	0.73	0.52			2.20	0.07	1.98	2.05													0.03	0.03	0.05	4.33
73	CHATARPUR I	0.03	0.02	0.67			0.72	0.13	1.82	1.95			0.06	0.06												2.73
74	CHATTERPUR I EXTN		0.00	0.42	0.06		0.48	0.82	2.87	3.69	0.14			0.14											0.00	4.31
75	UMRI	0.09	0.25	0.31			0.64	0.29	2.36	2.65													0.01	0.01	0.01	3.31
76	DULHARA	0.26	2.42	1.73			4.40	1.64	8.96	10.60			0.02	0.02									1.02	1.02	0.50	16.54
77	SHAHPUR			0.39			0.39	2.45	8.59	11.04			0.00	0.00											0.46	11.89
78	NEWTON CHIKLI (N)	0.72	1.14	2.64	0.10		4.59	14.81	4.65	19.46	0.22			0.22								1.39	0.02	1.41	0.58	26.25
79	KHIR SADOH SOUTH			0.31			0.31	0.29	0.17	0.46	0.01			0.01		0.07			0.00	0.07		0.33		0.33		1.18
80	RAWANWARA		0.01	0.64	0.09	0.22	0.95	0.86	0.50	1.37	0.08	0.43		0.50	0.02	0.23			0.05	0.30		0.50		0.50	0.00	3.62
81	RAWANWARA EAST			1.51	0.00	0.03	1.54	1.49	0.83	2.31		0.00		0.00	0.22	0.08	0.00		0.11	0.41		0.79		0.79	0.09	5.14
82	RAWANWARA N (CIL/CAPTIVE)	0.62	1.58	3.73			5.94	9.73	3.48	13.20	0.11			0.11								2.12	0.46	2.58	0.94	22.77
83	BRAMHPURI (CIL/CAPTIVE)	0.29	0.76	1.35		0.20	2.59	0.97	1.61	2.58	0.04	0.12		0.15	0.16	0.39			0.04	0.59		1.28	0.00	1.29	0.37	7.56
84	VISHNUPURI	0.00	0.18	1.21		0.00	1.39	1.22	2.00	3.22	0.05	0.02	0.06	0.13	0.09	0.12				0.20		0.31		0.31	0.10	5.35
85	SIRGORA		0.25	0.84	0.01	0.28	1.38	0.45	1.58	2.03	0.14	0.06	0.13	0.34	0.02	1.04		0.01	0.09	1.16		0.53		0.53		5.43
86	MANDLA SOUTH	0.67	1.28	1.11			3.06	0.77	1.88	2.65												0.27		0.27	0.02	6.01
87	MANDLA NORTH	2.10	4.62	1.00			7.72	0.31	1.64	1.95	0.02			0.02								0.26		0.26		9.94
88	THESGORA-A		0.34	1.05			1.40	0.51	1.69	2.20	0.01	0.05		0.06								0.17		0.17	0.01	3.84
89	THESGORA-C	0.01	0.34	2.02			2.37	1.23	3.91	5.14	0.05	0.02		0.06								0.19		0.19		7.76
90	THESGORA-B	0.09	0.50	1.42			2.02	0.86	1.37	2.23	0.02		0.02	0.04	0.09	0.28				0.37		0.34		0.34	0.03	5.04
91	MAGRAHI	0.24	0.35	1.09			1.68	0.31	0.79	1.10												0.21		0.21		2.98
92	URDHAN		0.13	0.76			0.89	0.28	0.87	1.16	0.00			0.00		0.19				0.19		0.08		0.08		2.32
93	JAMUNIA		0.10	0.96			1.06	0.76	1.72	2.48	0.03			0.03		0.03				0.03		0.45		0.45	0.07	4.11
94	JAMUNIA EXTN		0.14	0.51			0.65	0.02	0.26	0.27												0.06		0.06	0.05	1.03
95	NAHERIA	0.14	0.28	1.45			1.87	0.66	1.40	2.05	0.03		0.01	0.04								0.20		0.20	0.41	4.57
96	DHANKASA EXTN		0.20	0.54			0.74	0.21	0.85	1.05	0.01			0.01								0.19		0.19	0.05	2.04
97	SONPUR	0.32	1.46	0.57			2.36	0.28	3.10	3.38												1.08		1.08		6.82
98	DHANKASA	0.64	1.88	1.47			3.99	0.49	1.52	2.01	0.02			0.02								1.62		1.62	0.01	7.64
99	MOHAN INCLINE			0.34	0.01		0.35	0.09	0.30	0.39	0.02	0.16		0.18								1.03		1.03	0.01	1.96
100	GANPATI INCLINE		0.14	2.15			2.29	0.08	0.08	0.16	0.00			0.00								0.42		0.42		2.87
101	TANDSI NOKHARAK (GSI)	5.76	5.12	2.20			13.07	0.00	0.66	0.67												0.55	0.01	0.56	0.20	14.49
102	KHAPA RAJEGAON	6.07	1.43	0.24			7.75		0.26	0.26												0.22	0.02	0.23	0.13	8.37
103	PENCH PATCH	0.04	0.00	0.04			0.07		0.02	0.02																0.10
	TOTAL	108.92	71.77	126.96	5.97	1.02	314.63	153.97	237.34	391.31	3.84	10.07	1.63	15.54	1.51	5.02	0.21	0.03	0.71	7.48	0.73	45.53	6.08	52.35	14.82	796.13

Landuse/Vegetation cover in Pench-Kanhan-Tawa Valley CF based on satellite data of 2014.

(values in %)

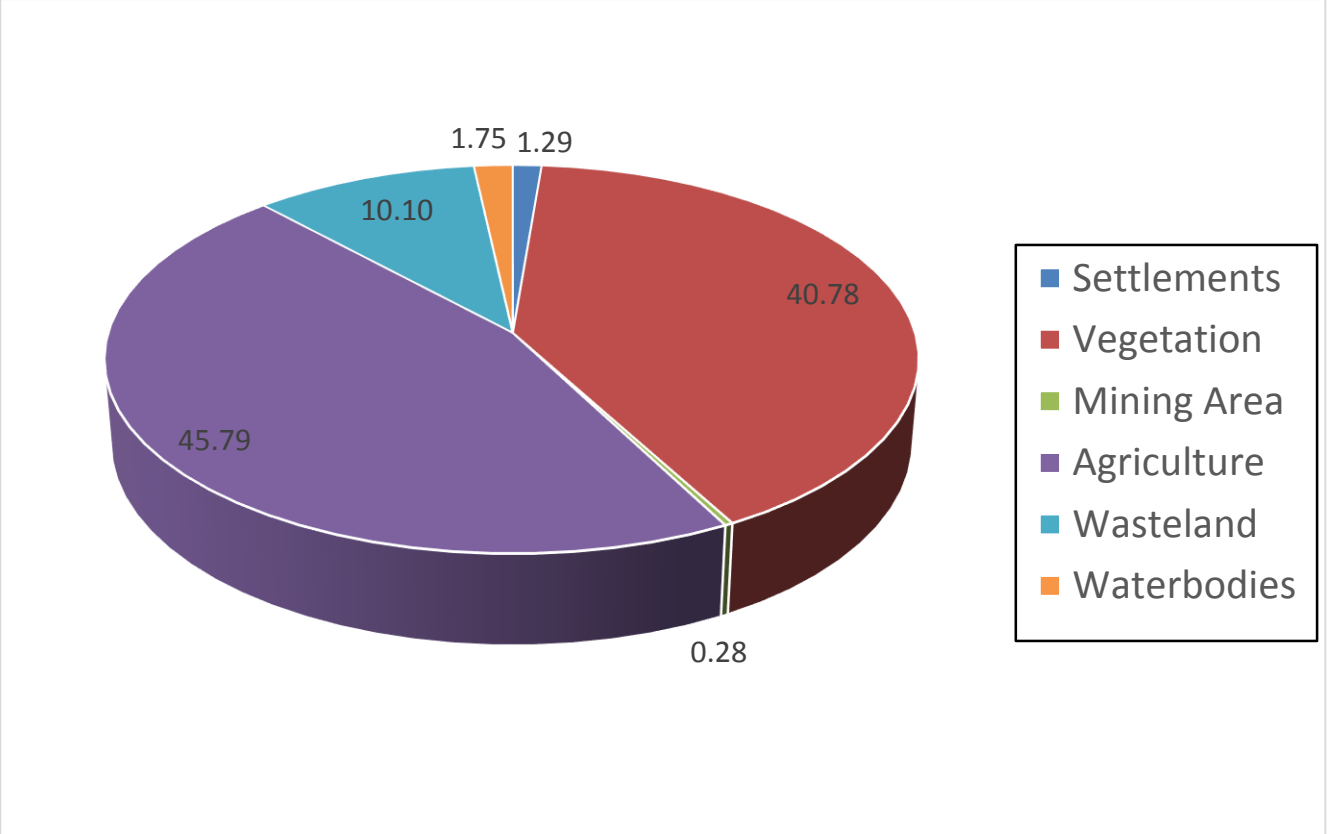

Fig. 3.2

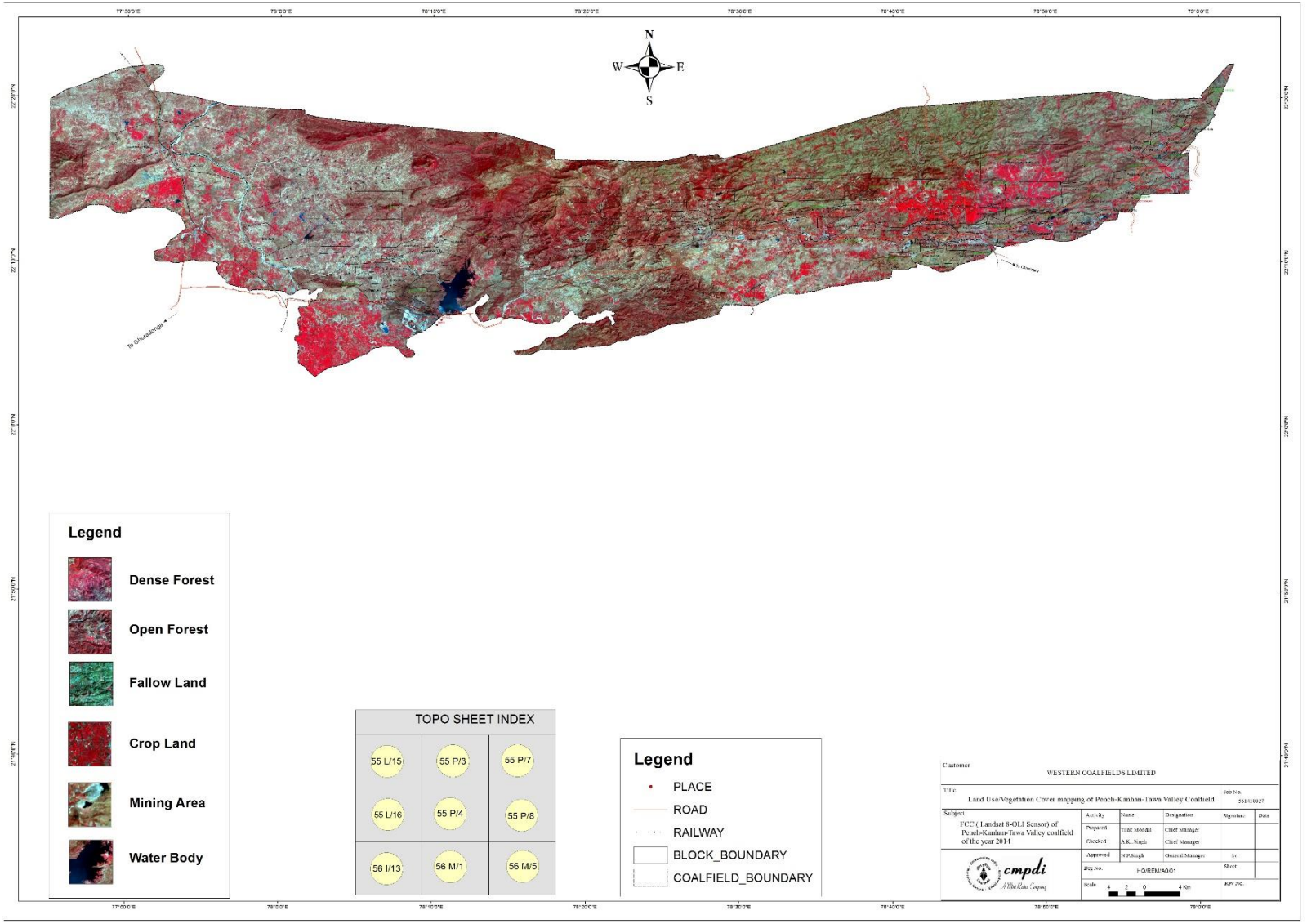
N
W
E
S
Legend
Dense Forest
Open Forest
Fallow Land
Crop Land
Mining Area
Water Body
TOPO SHEET INDEX
55 L/15
55 P/3
55 P/7
55 L/16
55 P/4
55 P/8
56 I/13
56 M/1
56 M/5
Legend
PLACE
ROAD
RAILWAY
BLOCK_BOUNDARY
COALFIELD_BOUNDARY
Customer
WESTERN COALFIELDS LIMITED
Title
Land Use/Vegetation Cover mapping of Pench-Kanhan-Tawa Valley Coalfield
Subject
FCC (Landsat 8-OLI Sensor) of Pench-Kanhan-Tawa Valley coalfield of the year 2014
cmpdi
Drg No.
HQ/REM/A0/01
Scale
4 2 0 4 Km

Plate 1: LU / FCC (Landsat 8-OLI Sensor) of Pench-Kanhan-Tawa Valley coalfield of the year 2014

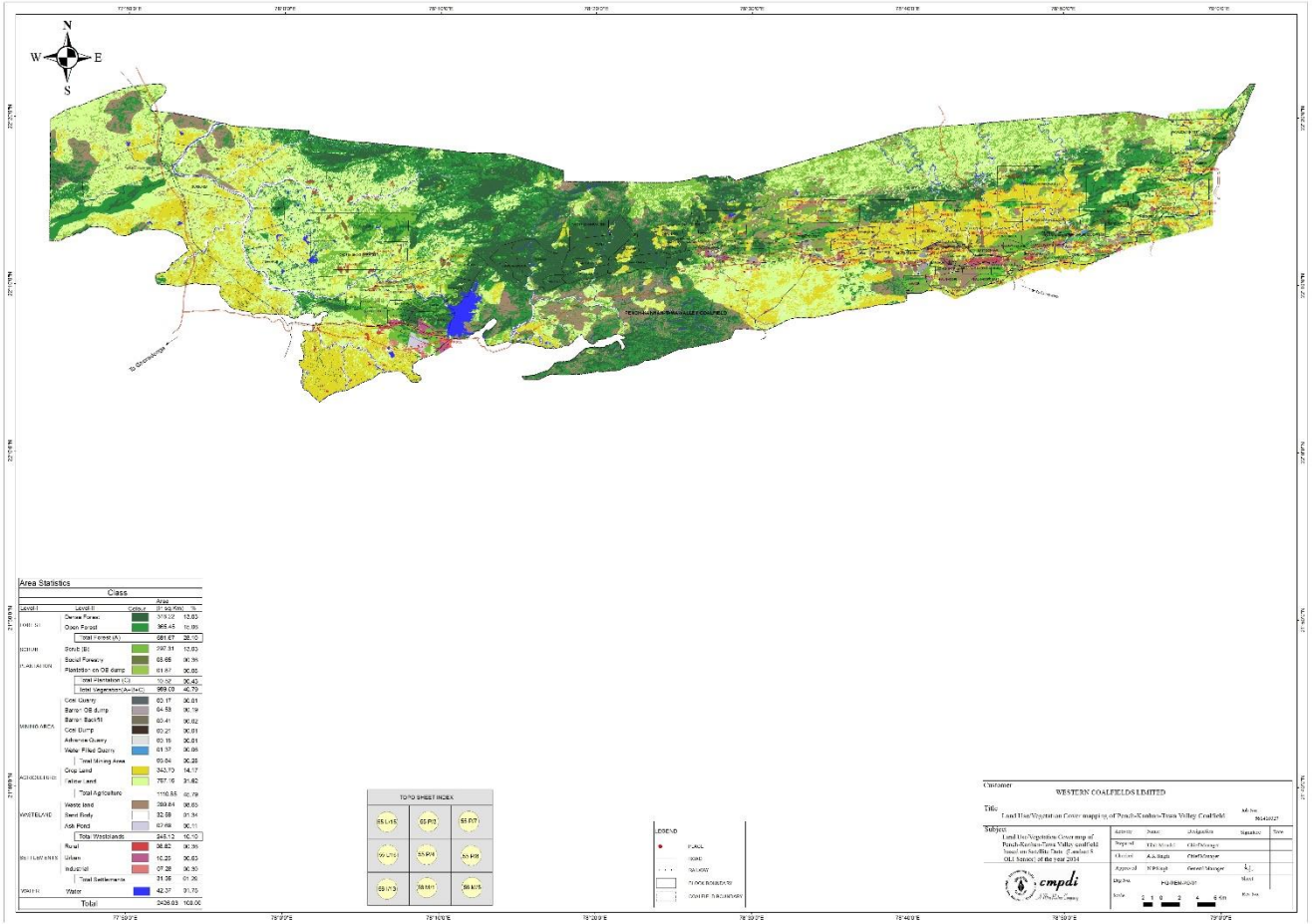

Plate 2: LU / Vegetation cover map of Pench-Kanhan_Tawa valley CF based on Satellite data (Landsat 8/OLI) of year 2014

Chapter 4

Conclusion & Recommendation

4.1 Conclusion

In the present study, land use/ vegetation cover map of Pench-Kanhan-Tawa Valley Coalfield has been prepared based on Landsat 8 / OLI satellite data of 2014 in order to assess the impact of coal mining and associated industrialisation on land use / vegetation cover in the coalfield based on satellite data of the year 2014. The land use / vegetation cover analysis will help to analyse and monitor the changes taken place in land use / vegetation cover in the last three years.

Study reveals that Pench-Kanhan-Tawa Valley Coalfields covers an area of 2426.03 Km^2. Settlements cover area of 31.35 Km^2 which is 1.29% of the coalfield area. Vegetation cover constitutes 989.44 Km^2 (40.78% of total coalfield area), Mining activities is 6.90 Km^2 (0.28% % of total coalfield area) where as agriculture and wasteland constitutes 1110.85 Km^2 (45.79% of total coalfield area) and 245.12 Km^2 (10.10% of total coalfield area) respectively. Surface water bodies, mainly rivers, reservoir and ponds cover an area of 42.37 Km^2 (1.75% of total coalfield area). Analysis of 2014 data reveals that settlements has been increased by 2.60 Km^2, forest has been decreased by 4.35 Km^2, scrub has been decreased by 5.07 Km^2, plantation has been increased by 0.15 Km^2, mining area has been increased by 0.06 Km^2, agricultural area has been increased by 25.45 Km^2, area of wasteland has been decreased by 17.96 Km^2 and waterbody has been increased by 1.31 Km^2 over 2011 satellite data.

4.2 Recommendation

Keeping in view the sustainable development together with coal mining in the area, it is recommended that similar study should be carried out regularly at interval of three years to monitor the change in land use /vegetation cover in the coalfield for

assessing the impact of coal mining and take the remedial measures required, if any. Efforts for afforestation should be given thrust in the coalfield on wasteland and mined out area to maintain the ecological balance in the region..

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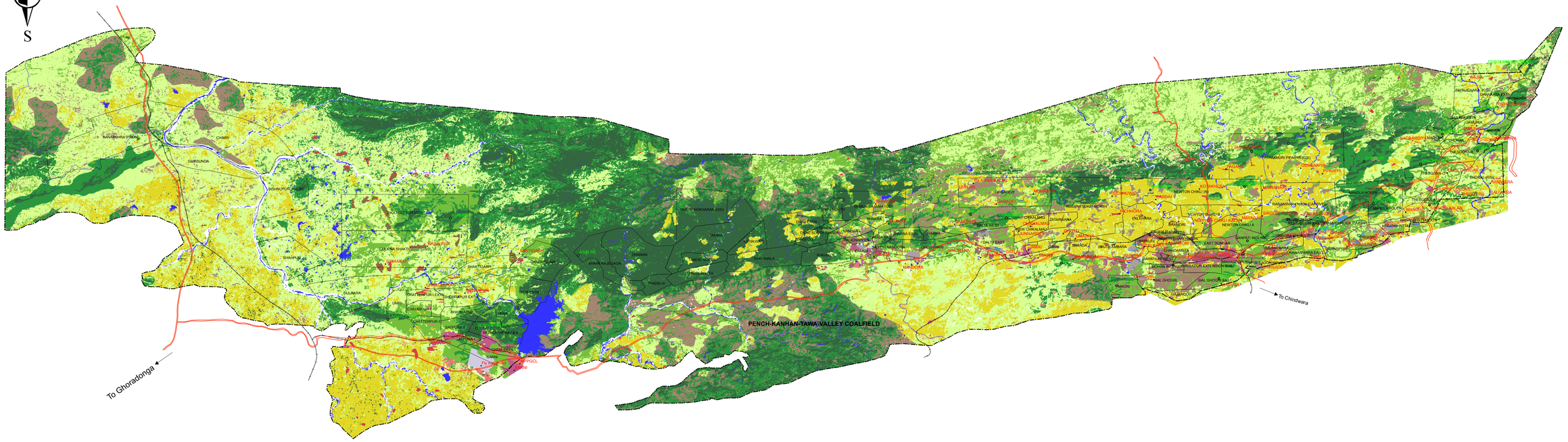
77°50'0"E 78°0'0"E 78°10'0"E 78°20'0"E 78°30'0"E 78°40'0"E 78°50'0"E 79°0'0"E

22°20'0"N 22°10'0"N 22°0'0"N 21°50'0"N 21°40'0"N

N W E S



Area Statistics

Class

Level-I	Level-II	Colour	Area (in sq.Km)	%
FOREST	Dense Forest		316.22	13.03
	Open Forest		365.45	15.06
	Total Forest (A)		681.67	28.10
SCRUB	Scrub (B)		297.31	13.03
PLANTATION	Social Forestry		08.65	00.36
	Plantation on OB dump		01.87	00.08
	Total Plantation (C)		10.52	00.43
	Total Vegetation(A+B+C)		989.50	40.79
MINING AREA	Coal Quarry		00.17	00.01
	Barren OB dump		04.53	00.19
	Barren Backfill		00.41	00.02
	Coal Dump		00.21	00.01
	Advance Quarry		00.15	00.01
	Water Filled Quarry		01.37	00.06
	Total Mining Area		06.84	00.28
AGRICULTURE	Crop Land		343.70	14.17
	Fallow Land		767.15	31.62
	Total Agriculture		1110.85	45.79
WASTELAND	Waste land		209.84	08.65
	Sand Body		32.59	01.34
	Ash Pond		02.69	00.11
	Total Wastelands		245.12	10.10
SETTLEMENTS	Rural		08.82	00.36
	Urban		15.25	00.63
	Industrial		07.28	00.30
	Total Settlements		31.35	01.29
WATER	Water		42.37	01.75
Total			2426.03	100.00

TOPO SHEET INDEX

55 L/15	55 P/3	55 P/7
55 L/16	55 P/4	55 P/8
56 I/13	56 M/1	56 M/5

LEGEND

- PLACE
- ROAD
- RAILWAY
- BLOCK BOUNDARY
- COALFIELD BOUNDARY

Customer: WESTERN COALFIELDS LIMITED

Title: Land Use/Vegetation Cover mapping of Pench-Kanhan-Tawa Valley Coalfield

Job No. 561410027

Subject: Land Use/Vegetation Cover map of Pench-Kanhan-Tawa Valley coalfield based on Satellite Data (Landsat 8 OLI Sensor) of the year 2014

Activity	Name	Designation	Signature	Date
Prepared	Tilak Mondal	Chief Manager		
Checked	A.K.Singh	Chief Manager		
Approved	N.P.Singh	General Manager		

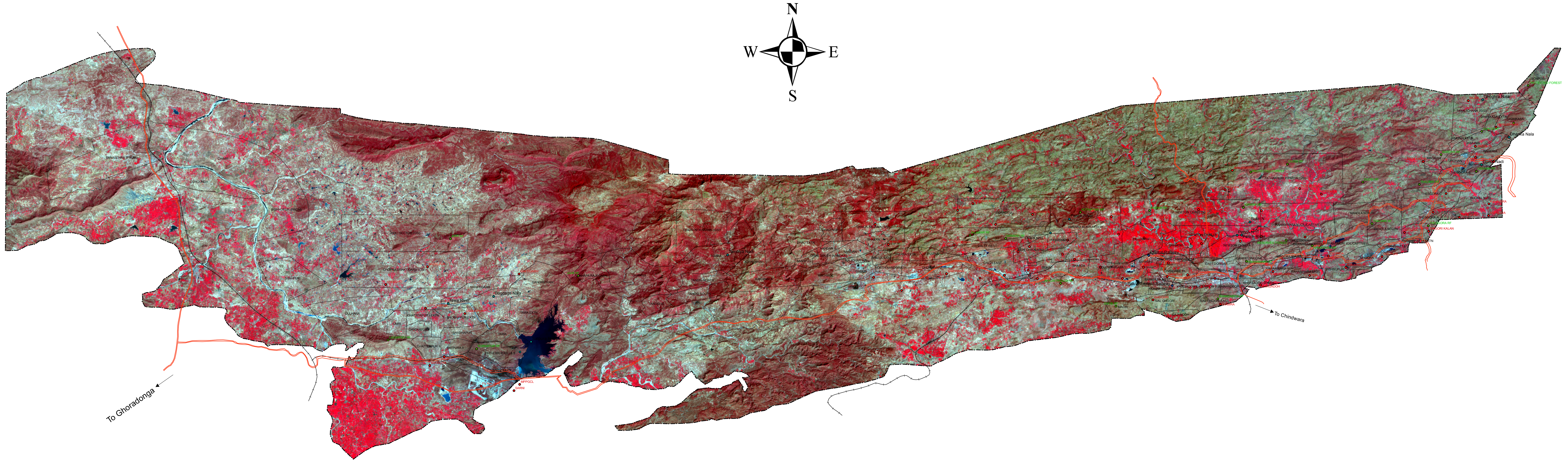
Drg No. HQ/REM/A0/01

Sheet

Scale 2 1 0 2 4 6 Km

Rev No.

cmpdi — A Mini Ratna Company



Legend

- Dense Forest
- Open Forest
- Fallow Land
- Crop Land
- Mining Area
- Water Body

TOPO SHEET INDEX

55 L/15	55 P/3	55 P/7
55 L/16	55 P/4	55 P/8
56 I/13	56 M/1	56 M/5

Legend

- PLACE
- ROAD
- RAILWAY
- BLOCK_BOUNDARY
- COALFIELD_BOUNDARY

Customer	WESTERN COALFIELDS LIMITED				
Title	Land Use/Vegetation Cover mapping of Pench-Kanhan-Tawa Valley Coalfield			Job No. 561410027	
Subject	Activity	Name	Designation	Signature	Date
FCC (Landsat 8-OLI Sensor) of Pench-Kanhan-Tawa Valley coalfield of the year 2014	Prepared	Tilak Mondal	Chief Manager		
	Checked	A.K..Singh	Chief Manager		
	Approved	N.P.Singh	General Manager		
cmpdi A Mini Ratna Company	Drg No.	HQ/REM/A0/01		Sheet	
	Scale 4 2 0 4 Km			Rev No.	