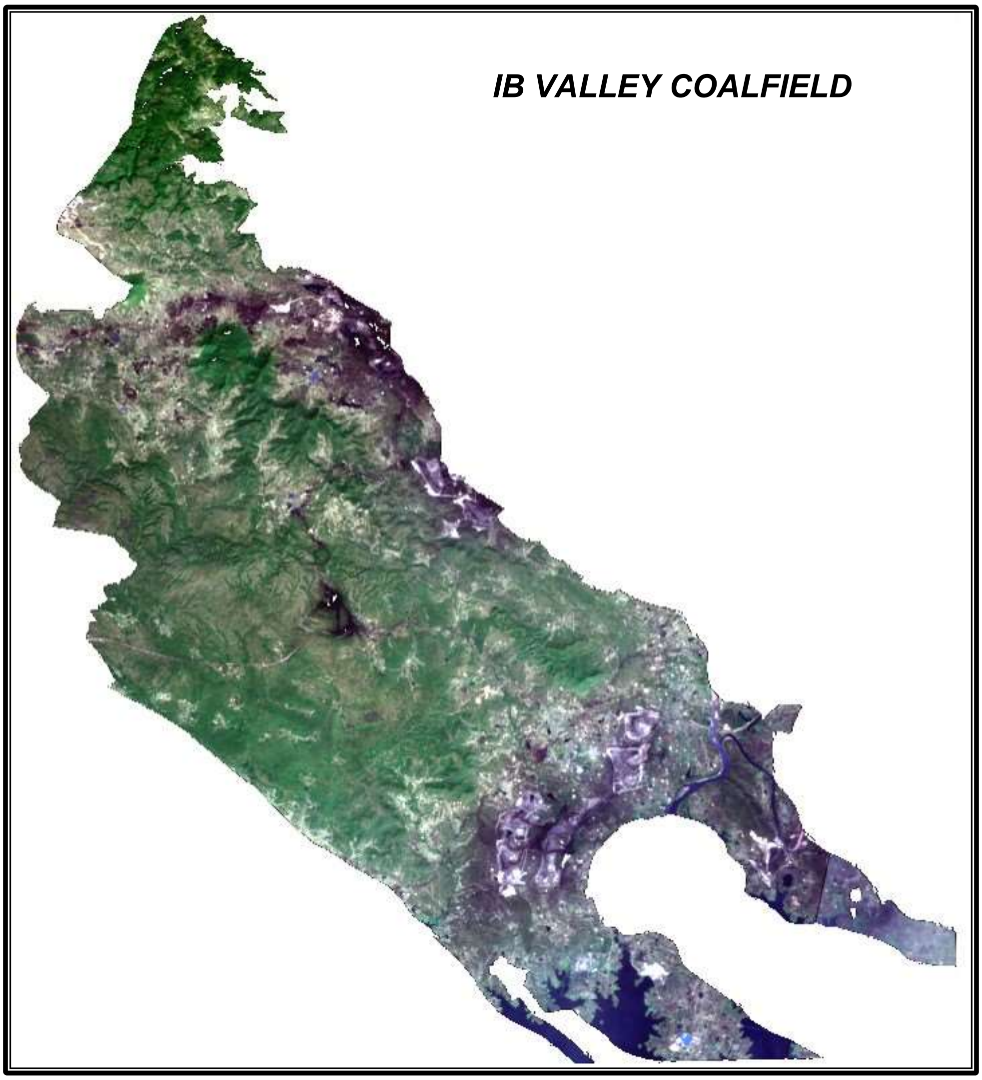
Report on Land Use / Vegetation Cover Mapping of Ib Valley Coalfield based on Satellite Data for the Year 2023



Submitted to

Mahanadi Coalfields Limited

Report on Land Use/ Vegetation Cover Mapping of Ib Valley Coalfield based on Satellite data for the year 2023

Submitted to

Mahanadi Coalfields Limited
Sambalpur

March - 2024

Remote Sensing Cell
Geomatics Division
CMPDI (HQ), Ranchi

Document Control Sheet

(1)	Job No.	RSC-564922120
(2)	Publication Date	March 2024
(3)	Number of Pages	39
(4)	Number of Figures	07
(5)	Number of Tables	12
(6)	Number of Plates	02
(7)	Number of Drawings	01
(8)	Title of the Report	Land use/ Vegetation Cover mapping of Ib Valley Coalfield using satellite data of the year 2023.
(9)	Aim of the Report	Preparation of land use/vegetation cover map of Ib Valley Coalfield on 1:50,000 scale based on Resourcesat-2/2A/LISS-IV satellite data for creating the geo-environmental database.
(10)	Executing Unit	Remote Sensing Cell Geomatics Division Central Mine Planning & Design Institute Ltd. Gondwana Place, Kanke Road, Ranchi
(11)	User Agency	Mahanadi Coalfields Limited, Sambalpur
(12)	Author	Ms. A. Biswas, Sr. Manager(Geology) Mr. M. Rastogi, GM (Geomatics)
(13)	Security Restriction	Restricted Circulation
(14)	No. of Copies	5
(15)	Distribution Statement	Official

List of Figures

List of Tables

List of Plates

List of Drawing

Contents

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 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 29.12.2009; was issued by CIL to CMPDI for the above study. In the year 2012, a revised work order CIL/WBP/ENV/2011/4706 dt. 12/10/2012 was issued for which was subsequently followed by another work order vide letter no. CIL/WBP/Env/2020/DP/8477 dated 21.09.2020 from Coal India Ltd. for the period 2020-18 to 2021-22 wherein land reclamation monitoring of opencast projects and vegetation cover monitoring of 19 major coalfields including Ib Valley Coalfield has to be done as per a defined plan for monitoring the impact of mining on vegetation cover. This work order was again renewed by CIL vide letter no CIL/ENVT/2022-23/W.O./10899 dated 06.07.2022 for continuing the work till 2023-24 as follow up to the above work order, landuse/vegetation cover mapping of Ib Valley Coalfield taken up based on satellite data of the year 2023 after three years.

1.2 Objective

The objective of the present study is to prepare a regional land use and vegetation cover map of Ib Valley coalfield on 1:50,000 scale based on satellite data of the year 2023, using digital image processing technique for creating the geo-environmental data base in respect of land use, vegetation cover, drainage, mining area, infrastructure etc. and up-dation of database at regular interval of three years to assess the impact of coal mining and other industrial activities on land use and vegetation cover in the coalfield area.

1.3 Location of the Area & Accessibility

Ib valley coalfield is located in the state of Orissa. It is broadly subdivided in two parts i.e. northern and southern. The northern half of the coalfield lies in Sundargarh district, whereas southern half lies in Jharsuguda district of Orissa. The area is well connected by rail and road to important business centres in Orissa like Rourkela, Jharsuguda, Sundargarh and Bhubaneswar. The Howrah-Mumbai railway line of the *South Eastern Railway* passes through the coalfield. Brajrajnagar, Belpahar and Himgir are the important Railway Stations through which the coalfield is approachable.

Ib Valley coalfield is confined to area bounded by latitude $21^0$41’26” & $22^0$09’02”N and longitudes $83^0$33’40”E & $84^0$00’21”E, covering an area of about 1316.00 Km^2. The location map of Ib Valley Coalfield is given at Figure 1.1.

1.4 Physiography

Ib Valley coalfield has undulating landscape with elevation ranging from 206 to 350 m above mean sea level. The coalfield is drained mainly by Ib River, Ghoghar Nadi, Sapai Nadi and Bhedan River among others.

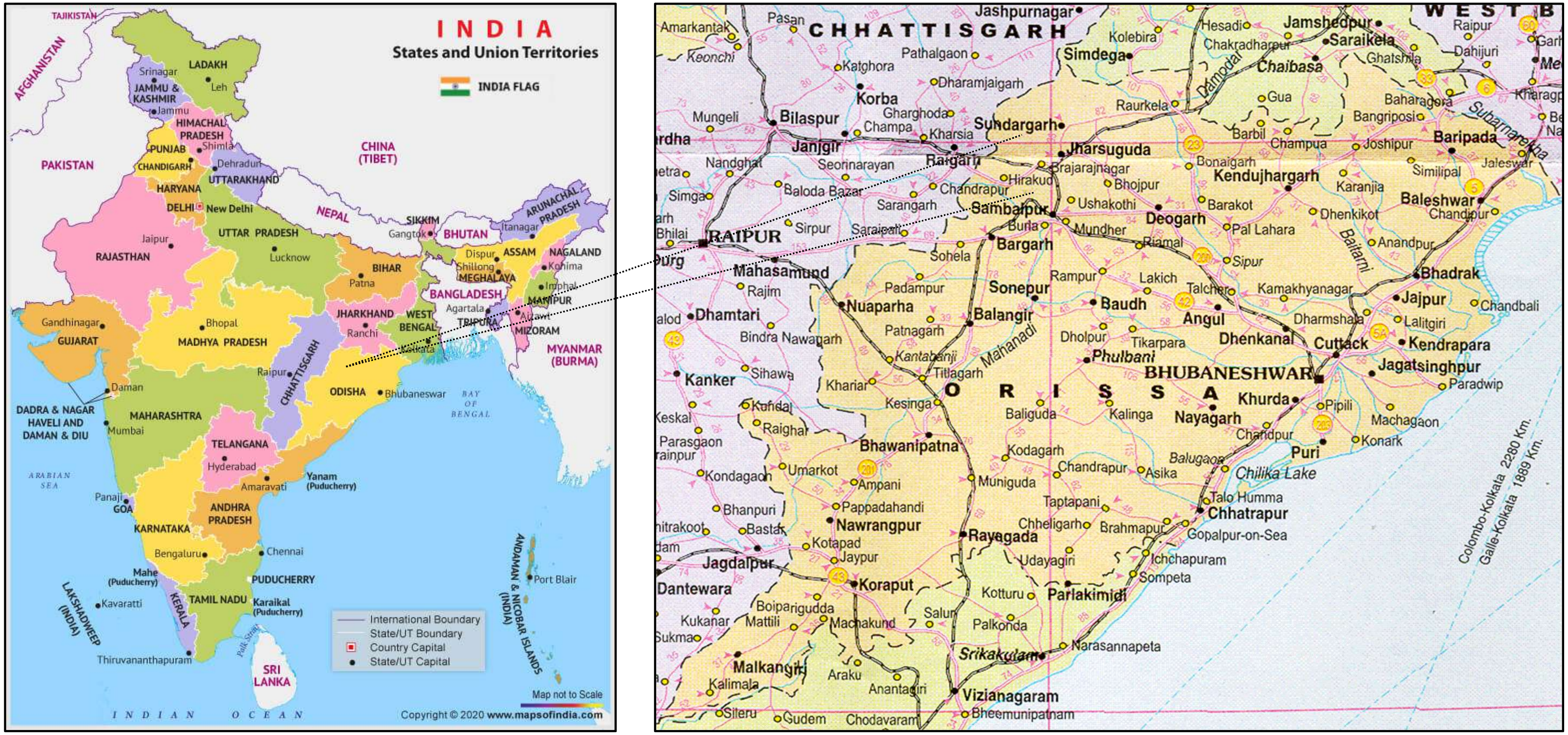


Fig 1.1 : Map of India Showing the Location of Ib Valley Coalfield

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.

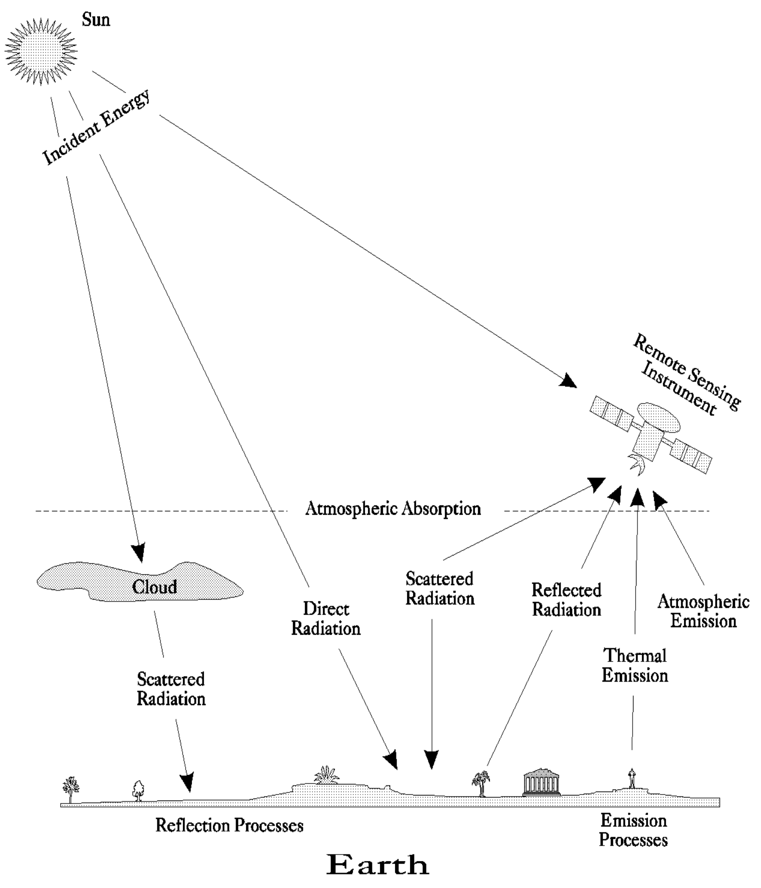


Figure 2.1 Remote sensing radiation system

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 nano meters 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.

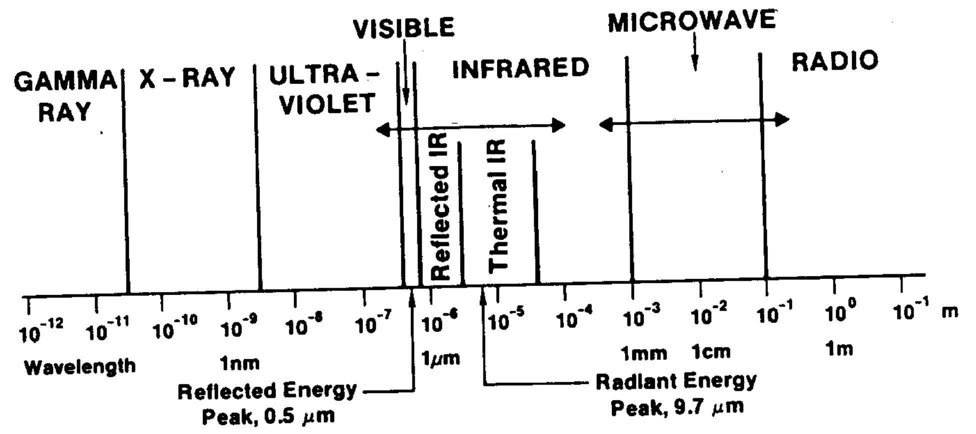


Figure 2.2 Electromagnetic spectrum. Expanded versions of the visible, infrared and microwave regions are shown in Figure 2.3.

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 2.3).

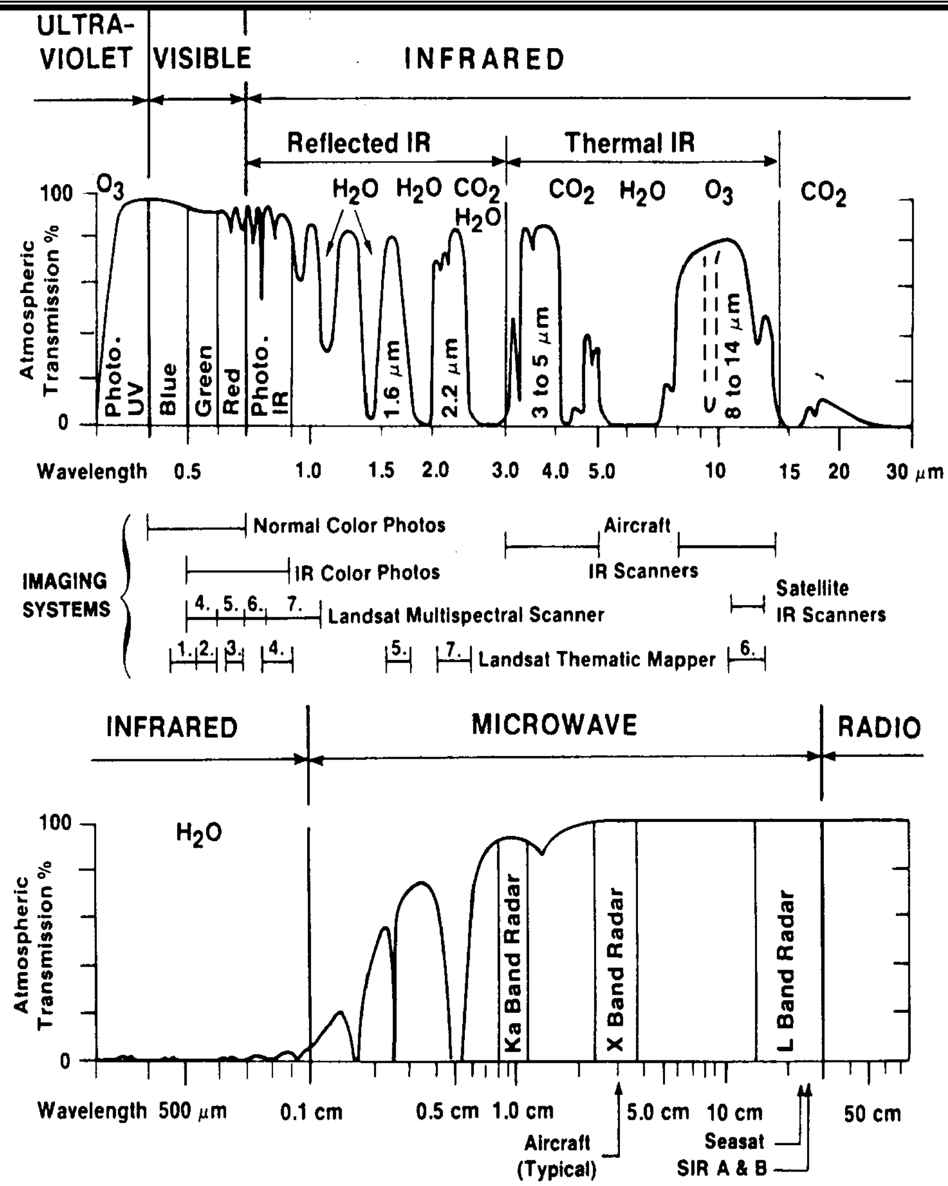


Figure 2.3 Expanded diagrams of the visible and infrared regions (upper) and the microwave regions (lower) showing atmospheric windows. Wavelength bands of commonly used remote sensing systems are indicated. Gases responsible for atmospheric absorption are shown.

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. The major remote sensing sensors record energy only in the visible, infrared and micro-wave regions. 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), which 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 provides an efficient, speedy and cost-effective method for assessing the changes in vegetation cover certain period of time due to its inherited capabilities of being multi-spectral, repetitive and synoptic aerial coverage.

2.4 Data Source

The following data are used in the present study:

- **Primary Data**
- Remote Sensing Satellite data viz. 1. IRS R2A/LISS-IV of 16th February, 2023, and 2. IRS R2/LISS-IV of 5th March, 2023 were used in the present study. The raw digital satellite data were obtained from NRSC, Hyderabad.

- **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 Ib Valley Coalfield, Survey of India open series topo sheets no. F44L-12, F44L-16, F44R-9, F44R-10, F44R-13, F44R-14, F45M-1 & F45M-2 as well as map showing details of location of area boundary, coal field boundary and road supplied by MCL were used in the study.

2.5 Characteristics of Satellite/Sensor

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

(a) Spectral coverage/resolution, i.e., band locations/width; (b) spectral dimensionality: number of bands; (c) radiometric resolution: quantisation; (d) spatial resolution/instantaneous field of view or IFOV; and (e) temporal resolution. Table 2.2 illustrates the basic properties of Resourcesat satellite/sensor that is 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
RESOURCESAT - 2A	LISS-IV	B2 0.52 - 0.59 Green B3 0.62 - 0.68 Red B4 0.76 - 0.86 NIR	16-bit	5.8 m 5.8 m 5.8 m	24 days	India

NIR: Near Infra-Red

2.6 Data Processing

The methodology for data processing carried out in the present study is shown in Figure 2.4. The processing 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) Layer wise theme extraction using GIS
(g) Final vegetation map preparation.

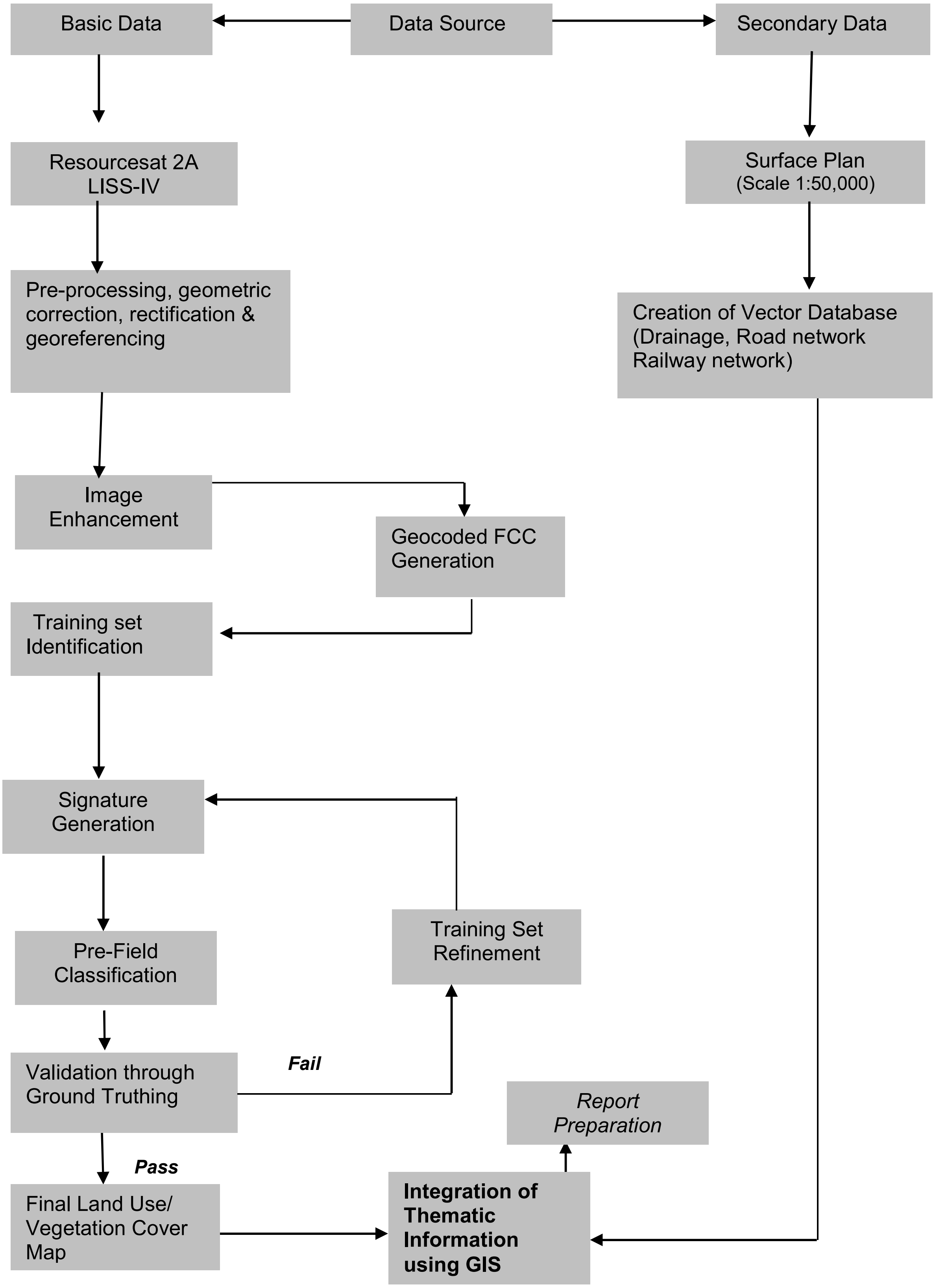


Fig 2.4 : Methodology for Land Use / Vegetation Cover Mapping

2.6.1 Geometric correction, rectification and georeferencing

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 geo-referencing 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*.

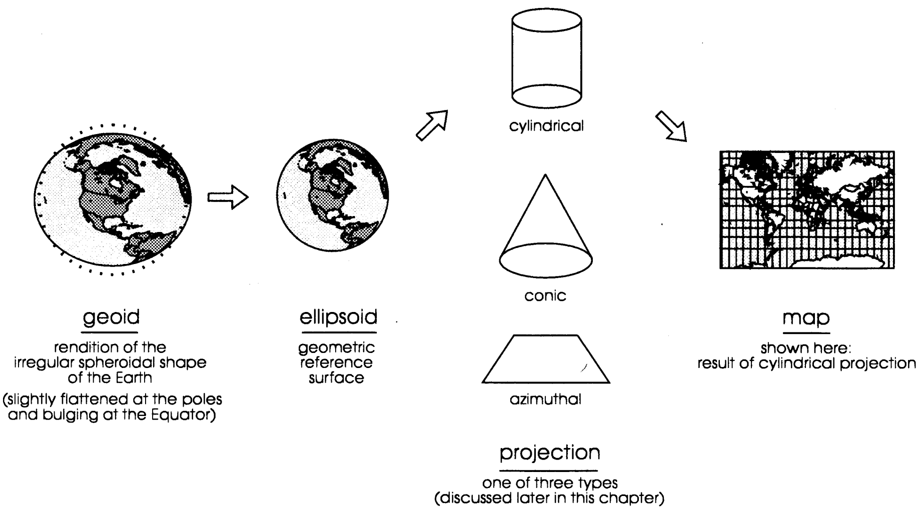


Fig 2.5 : Geoid – Ellipsoid – Projection Relationship

In the present study, ***UTM projection*** along with ***WGS 1984 Coordinate system*** was used so as to prepare the map compatible with the satellite image**.**

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 were applied on the image data using Erdas Imagine 2022 software. The enhanced and FCC image of Ib 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, 90 points were selected to generate the training sets.

2.6.4 Signature generation and classification

Image classification was carried out using the minimum distance 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 2022 s/w. The classified image for the year 2023 for Ib Valley Coalfield is shown in Drawing No. HQREM23A0702.

2.6.5 Creation/overlay of vector database in GIS

Plan showing leasehold areas of mining projects supplied by MCL are superimposed on the image as vector layer in the GIS database. Road network, rail network and drainage network are digitised on different vector layers in GIS database. Layer wise theme extraction was carried out using ArcGIS s/w and imported the same on GIS platform for further analysis.

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 overall classification accuracy for the year 2023 was found to be 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 using Arc GIS 10.8 s/w and the same is enclosed in the report.

A soft copy of this report is enclosed in .pdf format.

Table 2.3: Classification Accuracy Matrix for Ib Valley Coalfield in the year 2023

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	Plantation on OB	**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	Plantation on Backfill	**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/ Vegetation Cover Monitoring

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 resolutions, offers comprehensive and accurate information for mapping and monitoring of land use/cover 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/ vegetation cover requires be arranging or grouping under a suitable framework in order to facilitate the creation of database. Further, to accommodate the changing land use/vegetation 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, which has further been modified by CMPDI for coal mining areas. Land use/vegetation cover map was prepared on the basis of image interpretation carried out based on the satellite data for the year 2023. Following land use/cover classes are identified in the Ib Valley coalfield region (Table 3.1).

Table 3.1
Land use / Vegetation Cover classes identified in Ib Valley Coalfield

	LEVEL –I	LEVEL-II
1	**Vegetation Cover**	1.1 Dense Forest 1.2 Open Forest 1.3 Scrub 1.4 Social Forestry 1.5 Plantation on OB Dumps 1.6 Plantation on Backfilled area
2	**Mining Area**	2.1 Coal Quarry 2.2 Advanced Quarry 2.3 Barren OB Dump 2.4 Barren Backfilled Area 2.5 Water Filled Quarry 2.6 Coal Stock / Dump
3	**Agricultural Land**	3.1 Crop Land 3.2 Fallow Land
4	**Wasteland**	4.1 Waste upland with/without scrubs 4.2 Fly Ash Pond 4.3 Sand Body
5	**Settlements**	5.1 Urban/Township 5.2 Village / Rural 5.3 Industrial
6	**Water Bodies**	6.1 River/Streams /Reservoir

3.3 Data Analysis

Satellite data of the year 2023 was processed using Erdas Imagine 2022 image processing s/w in order to interpret the various land use and vegetation cover classes present in the Ib Valley coalfield. The analysis was carried out for entire coalfield covering about 1316.00 sq. km.

Due to paper size limitation in the plotter, the following maps are printed on 1:50,000 scale :

Plate No. 1: FCC (R2/2A / LISS-IV) data of Ib Valley coalfield of February, 2023 with Coalfield boundary and other infrastructural details.

Plate No. 2: Land use/Cover Map of Ib valley Coalfield based on LISS-IV data.

The area of each class was calculated and analysed using Erdas Imagine 2022 s/w and *ArcGIS* s/w. Analysis of land use / vegetation cover pattern in Ib Valley Coalfield for the year 2023 was carried out and details of the analysis are shown in Table 3.2. The comparative status of Land Use/ Vegetation Cover of Ib Valley Coalfield for the year 2020 and 2023 is based on coalfield boundary covering an area of 1186.60 which was used for the study in the year 2020. (Refer table 3.3)

TABLE – 3.2

STATUS OF LAND USE & VEGETATION COVER PATTERN IN IB VALLEY COALFIELD IN THE YEAR 2023

(Based on updated Coalfield Boundary)

(*Area in Km^2*)

LAND / VEGETATION COVER CLASSES	AREA STATISTICS	
VEGETATION COVER	**Area**	**% of total**
Dense forest	214.22	16.28
Open Forest	316.55	24.05
Total Forest (A)	**530.77**	**40.33**
Scrubs (B)	**331.81**	**25.21**
Plantation under Social Forestry	9.86	0.75
Plantation over Backfill	2.70	0.20
Plantation on OB Dump	2.34	0.18
Total Plantation (C)	**14.90**	**1.13**
Total Vegetation (A+B+C)	**877.48**	**66.68**
MINING AREA		
Coal Quarry	12.75	0.97
Advance Quarry Site	2.75	0.21
Coal Dump	1.97	0.15
Barren Backfilled Area	18.33	1.39
Barren OB Dump	4.86	0.37
Water Filled Quarry	2.04	0.15
Total Area under Mining Activity	**42.69**	**3.24**
AGRICULTURAL LAND		
Crop Land	38.90	2.96
Fallow Land	207.14	15.74
Total Agricultural Land	**246.04**	**18.70**
WASTE LAND		
Waste upland with/without Scrubs	62.51	4.75
Fly-Ash Pond / Alumina Sludge Pond	2.43	0.18
Sand Body	0.35	0.03
Total Wasteland	**65.28**	**4.96**
SETTLEMENTS		
Urban	8.24	0.63
Rural	16.65	1.27
Industrial	9.43	0.72
Sub Total	**34.32**	**2.61**
WATER BODIES	**50.17**	**3.81**
GRAND TOTAL (IB VALLEY COALFIELD)	**1316.00**	**100.00**

(**Note**: *Area Statistics Data are adjusted to two decimal places)*

TABLE – 3.3

STATUS OF LAND USE & VEGETATION COVER PATTERN IN IB VALLEY COALFIELD IN THE YEAR 2020 & 2023

Area in Sq. Km.

Table 3.2 Status of Land Use/ Cover Pattern in Ib Valley Coalfield During Year 2020 and 2023

Classes		Year 2020		Year 2023		Change w.r.t. Yr 2020		
		Area Km^2	%	Area Km^2	%	Area Km^2	%	Remarks
Level I	Level II							
Vegetation Cover	Dense forest	198.64	16.74	197.06	16.61	-1.58	-0.13	Overall forest area is increased marginally due to afforestation efforts taken by concerned agency.
	Open Forest	298.51	25.16	300.79	25.35	2.28	0.19	
	Total Forest(A)	**497.15**	**41.90**	**497.85**	**41.96**	**0.70**	**0.06**	
	Scrubs(B)	305.89	25.78	305.79	25.77	-0.10	-0.01	
	Plantation on OB Dump	2.40	0.20	2.34	0.20	-0.06	-0.01	Plantation Area reduced due to construction of roads, camp, silo and railway connectivity projects.
	Plantation on Backfill	2.89	0.24	2.70	0.23	-0.19	-0.02	
	Social Forestry	9.26	0.78	9.05	0.76	-0.21	-0.02	
	Total Plantation(C)	**14.55**	**1.23**	**14.09**	**1.19**	**-0.46**	**-0.04**	
	Total Vegetation (A+B+C)	**817.59**	**68.90**	**817.73**	**68.91**	**0.14**	**0.01**	
Agriculture	Crop land	44.35	3.74	43.19	3.64	-1.16	-0.10	Agriculture Land has marginally decreased due to increase in industrial activities in the region.
	Fallow Land	176.07	14.84	175.96	14.83	-0.11	-0.01	
	Total Agriculture	**220.42**	**18.58**	**219.15**	**18.47**	**-1.27**	**-0.11**	
Waste Land	Waste Land with/without scrub	65.15	5.49	51.44	4.34	-13.71	-1.16	Wasteland has decrease due to interchange of this class into othe classes viz. mining and waterbodies
	Sand Body	1.81	0.15	1.82	0.15	0.01	0.00	
	Fly Ash Pond	0.16	0.01	0.15	0.01	-0.01	0.00	
	Total Wasteland	**67.12**	**5.66**	**53.41**	**4.50**	**-13.71**	**-1.16**	
Mining Area	Coal Quarry	7.94	0.67	12.75	1.07	4.81	0.41	Mining area has increased in the span of three years due to mining and associated activities to meet the growing coal demand.
	Advance Quarry Site	0.93	0.08	2.75	0.23	1.82	0.15	
	Barren OB Dump	2.12	0.18	4.66	0.39	2.54	0.21	
	Barren Backfill	13.67	1.15	18.33	1.54	4.66	0.39	
	Coal Dump	1.36	0.11	1.88	0.16	0.52	0.04	
	Water Filled Quarry	1.88	0.16	2.04	0.17	0.16	0.01	
	Total	**27.90**	**2.35**	**42.40**	**3.57**	**14.50**	**1.22**	
Water Body	**River/ Ponds**	**20.14**	**1.70**	**21.20**	**1.79**	**1.06**	**0.09**	
Settlements	Urban Settlements	8.23	0.69	8.24	0.69	0.01	0.00	Settlement has marginally reduced due to increase in industrial activities.
	Rural Settlements	17.42	1.47	16.67	1.40	-0.75	-0.06	
	Industrial Settlements	7.78	0.66	7.80	0.66	0.02	0.00	
	Total	**33.43**	**2.82**	**32.71**	**2.76**	**-0.72**	**-0.06**	
Total		**1186.60**	**100.00**	**1186.60**	**100.00**			

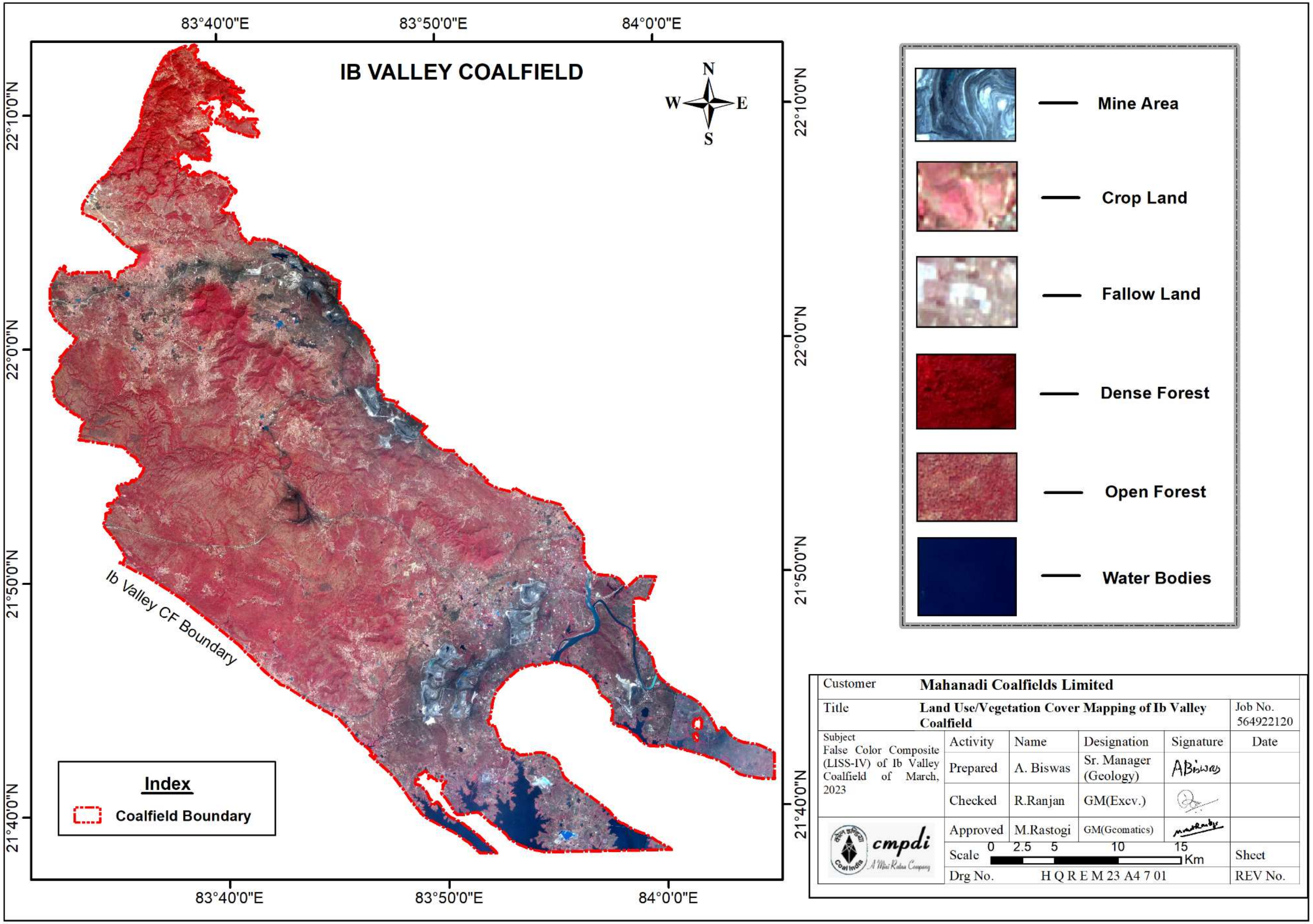
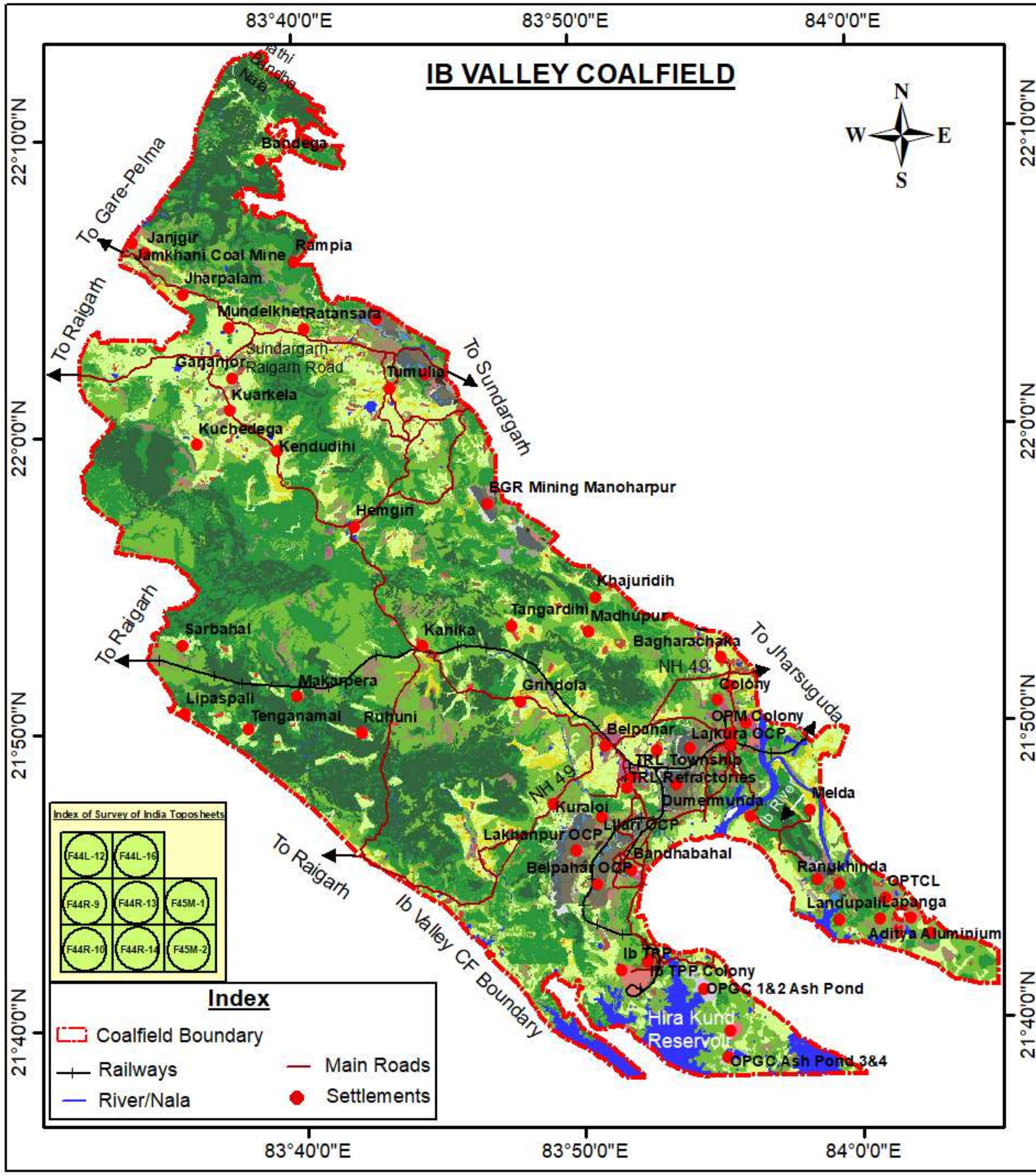


Plate 1: FCC (Band 2, 3, 4) of IB Valley CF based on R2/2A (LISS-IV) Data of Year – 2023



Area Statistics - Ib Valley CF (2023)				
Classes		Colour	Area	
Level-I	Level-II		Area (Km^2)	% of Total
Forest Area	Dense Forest		214.22	16.28
	Open Forest		316.55	24.05
	Sub Total		**530.77**	**40.33**
Scrubs	Scrubs		331.81	25.21
Plantation	Social Forestry		9.86	0.75
	Plantation on Backfill		2.70	0.20
	Plantation on OB Dump		2.34	0.18
	Total Plantation		14.90	1.13
	Total Vegetation Area		**877.48**	**66.68**
Agriculture	Crop Land		38.90	2.96
	Fallow Land		207.14	15.74
	Total Agriculture Area		**246.04**	**18.70**
Waste Land	Waste Land		62.51	4.75
	Sand Body		0.35	0.03
	Fly Ash Pond		2.43	0.18
	Total Waste Land		**65.28**	**4.96**
Mining Area	Coal Quarry		12.75	0.97
	Advance Quarry Site		2.75	0.21
	Barren OB Dump		4.86	0.37
	Area Under Backfilling		18.33	1.39
	Coal Dump		1.97	0.15
	Water Filled Quarry		2.04	0.15
	Total Mining Area		**42.69**	**3.24**
Settlements	Rural Settlement		16.65	1.27
	Urban Settlement		8.24	0.63
	Industrial Settlement		9.43	0.72
	Total Settlement Area		**34.32**	**2.61**
Water Body	River/Ponds		**50.17**	**3.81**
		Total	**1316.00**	**100.00**

Customer	**Mahanadi Coalfields Limited**				
Title	**Land Use/Vegetation Cover Mapping of Ib Valley Coalfield**				Job No. 564922120
Subject: Land Use/Vegetation Cover Mapping of Ib Valley Coalfield based on Satellite Data (LISS-IV) of the year 2023.	Activity	Name	Designation	Signature	Date
	Prepared	A. Biswas	Sr. Manager (Geology)		
	Checked	R.Ranjan	GM(Excv.)		
cmpdi A Mini Ratna Company	Approved	M.Rastogi	GM(Geomatics)		
	Scale	0 2.25 4.5 9 13.5 Km			Sheet
	Drg No.	H Q R E M 23 A4 7 02			REV No.

Plate 2: Land Use / Vegetation Cover Map of Ib Valley CF based on R2A (LISS-IV) Data of Year 2023

3.3.1 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.

Vegetation cover in the coalfield area comprises of following six classes:

- Dense Forest
- Open Forest
- Scrubs
- Plantation on OB Dumps
- Plantation on Backfilled Area and
- Social Forestry

Analysis of the satellite data of the year 2023 indicated that vegetation cover in Ib Valley Coalfield as per the updated coalfield boundary covers an area of 877.48 Km^2 (66.68%) out of the total coalfield area of 1316.00 Km^2. Vegetation Cover coming under the updated coalfield boundary of Ib Valley Coalfield is distributed between Dense Forest covering area of 214.22 Km^2 (16.28%), Open Forest covers 316.55 Km^2 (24.05%); Scrubs has covered an area of 331.81 km^2 (25.21%), Plantation under social forestry occupies area of 9.86 Km^2 (0.75%), Plantation on OB dumps occupies 2.34 km^2 (0.18%) and Plantation over backfilled areas has 2.70 km^2 (0.20%) area under its influence as per the analysis of Satellite Data of the Year 2023. (Refer Table 3.2).

As per the old coalfield boundary that has been used in Vegetation Cover Mapping report for the year 2020, the analysis of the satellite data of the year 2023 is shown in Table 3.4.

Area in Sq. Km.

Table 3.4 Status of Vegetation Cover Pattern in Ib Valley Coalfield During Year 2020 and 2023								
Classes		Year 2020		Year 2023		Change w.r.t. Yr 2020		
		Area Km²	%	Area Km²	%	Area Km²	%	Remarks
Level I	Level II							
Vegetation Cover	Dense forest	198.64	16.74	197.06	16.61	-1.58	-0.13	Overall forest area is increased marginally due to afforestation efforts taken by concerned agency.
	Open Forest	298.51	25.16	300.79	25.35	2.28	0.19	
	Total Forest(A)	**497.15**	**41.90**	**497.85**	**41.96**	**0.70**	**0.06**	
	Scrubs(B)	305.89	25.78	305.79	25.77	-0.10	-0.01	
	Plantation on OB Dump	2.40	0.20	2.34	0.20	-0.06	-0.01	Plantation Area reduced due to construction of roads, camp, silo and railway connectivity projects
	Plantation on Backfill	2.89	0.24	2.70	0.23	-0.19	-0.02	
	Social Forestry	9.26	0.78	9.05	0.76	-0.21	-0.02	
	Total Plantation(C)	**14.55**	**1.23**	**14.09**	**1.19**	**-0.46**	**-0.04**	
	Total Vegetation (A+B+C)	**817.59**	**68.90**	**817.73**	**68.91**	**0.14**	**0.01**	

- **Dense Forest** – Forest having crown density more than 40% comes under this class. In the year 2020 total area of dense forest in Ib Valley CF was 198.64 km^2 (16.74%). In year 2023 total area of dense forest is 197.06 km^2 (16.61%). There is a decrease in total dense forest by 1.58 km^2 which is 0.13% of the total area. This decrease is due to conversion of dense forest area to open forest.

- **Open Forest** – Forest having crown density between 10%-40% comes under this class. In the year 2020 total area of open forest in Ib Valley CF was 298.51 km^2 (25.16%). In year 2023 total area of open forest in Ib Valley CF is 300.79 km^2 (25.35%). There is an increase in total open forest by 2.28 km^2 which is due to afforestation efforts taken by concerned agency.

- **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 waste land and fallow land. There were 305.89 km^2 i.e. 25.78% of the coalfield area presents in 2020. In current year 305.79 km^2 i.e. 25.77% scrub is present. So there is a decrease of 0.10 km^2 which is 0.01% of the total coalfield.

- **Plantation Over OB Dump–** Analysis of the data reveals that plantation over ob dumps are estimated to be 2.34 km^2 i.e. 0.20% of total coalfield in current year. Whereas in 2020 plantation was 2.40 km^2 i.e. 0.20% of coalfield.

- **Plantation Over Backfilled Area-** Analysis of the data reveals that plantation over backfilled area is 2.70 km^2 i.e. 0.23% of total coalfield in 2023 which has decreased by 0.19 km^2 from previous year.

- **Social Forestry -** Plantations which have been carried out along the roadsides and colonies on the green belt come under this category. There is a decrease of 0.21 km^2 social forestry, i.e. 0.02% of total coalfield is present in current year.

The decrease in total plantation area of 0.46 km^2 i.e. 0.04% of total coalfield is due to construction of road, silo, camps, railway connectivity projects and some mining activities.

3.3.2 Mining Area

The mining area includes the area of

- Coal Quarry
- Advance Quarry Site
- Barren OB Dumps
- Barren Backfilled Area
- Coal Dumps and
- Water Filled Quarry Area.

Analysis of the satellite data of the year 2023 indicates that mining area coming under the updated Ib Valley Coalfield boundary is distributed between Coal quarry constituting 12.75 Km^2 (0.97%), Advanced quarry site constituting 2.75 Km^2 (0.21%), Coal dumps constituting 1.97 Km^2 (0.15%), Barren over burden dumps covering an area of 4.86 Km^2 (0.37%), Barren Backfilled areas constituting 18.33 Km^2 (1.39%) and

Water Filled Quarry constituting 2.04 km^2 (0.15%). Total area under mining activities is 42.69km^2 (3.24%) *(Refer Table 3.2).*

Area statistics based on the old Coalfield boundary is shown in Table 3.5

Area in Sq. Km.

Table 3.5 Status of Change in Mining Area in Ib Valley Coalfield During Year 2020 and 2023

Classes		Year 2020		Year 2023		Change w.r.t. Yr 2020		
		Area Km^2	%	Area Km^2	%	Area Km^2	%	Remarks
Level I	Level II							
Mining Area	Coal Quarry	7.94	0.67	12.75	1.07	4.81	0.41	Mining area has increased in the span of three years due to mining and associated activities to meet the growing coal demand.
	Advance Quarry Site	0.93	0.08	2.75	0.23	1.82	0.15	
	Barren OB Dump	2.12	0.18	4.66	0.39	2.54	0.21	
	Barren Backfill	13.67	1.15	18.33	1.54	4.66	0.39	
	Coal Dump	1.36	0.11	1.88	0.16	0.52	0.04	
	Water Filled Quarry	1.88	0.16	2.04	0.17	0.16	0.01	
	Total	**27.90**	**2.35**	**42.40**	**3.57**	**14.50**	**1.22**	

In the year 2020 coal quarry was 7.94 km^2 which has increased to 12.75 km^2 in year 2023. This increase is due to increase in production of coal from open cast mines. In 2020 barren ob dump was 2.12 km^2 (0.18%) which has been increased to 4.66 km^2 (0.39%). Barren backfilled area has increased to 18.33 km^2 (1.54%) from 13.67 km^2 (1.15%). This increase is due to increase in mining and associated activities over a span of three years. In current year total mining area covers 42.40 km^2 (3.57%) while in 2020 area under mining activities was 27.90 km^2 (2.35%). Due to increase in mining activities total mining area has been increased by 14.50 km^2 i.e. 1.22% of the total coalfield.

3.3.3 Agriculture Area

Land primarily used for farming and production of food, fibre and other commercial and horticultural crops falls under this category. It includes crop land and fallow land. Crop lands are those agricultural lands where standing crop occurs on the date of satellite imagery or land is used for agricultural purposes during any season of the year. Crops may be either kharif or rabi. Fallow lands are also agricultural land which is taken up for cultivation but temporarily allowed to rest, un-cropped for one or more season.

Analysis of the satellite data of the year 2023 indicated that agriculture coming under the updated Ib Valley Coalfield boundary is distributed between Crop Land (38.90 km^2; 2.96%), and Fallow Land (207.14 km^2; 15.74%). Agricultural land in Ib Valley Coalfield covers an area of 246.04 km^2 (18.70%). (Refer Table 3.2)

The variation of area statistics based on the old Coalfield boundary is shown in Table 3.6

Area in Sq. Km.

Table 3.6 Status of Change in Agriculture Area in Ib Valley Coalfield During Year 2020 and 2023

Classes		Year 2020		Year 2023		Change w.r.t. Yr 2020		
		Area Km^2	%	Area Km^2	%	Area Km^2	%	Remarks
Level I	Level II							
Agriculture	Crop land	44.35	3.74	43.19	3.64	-1.16	-0.10	Due to increase in industrial activities in the region.
	Fallow Land	176.07	14.84	175.96	14.83	-0.11	-0.01	
	Total Agriculture	**220.42**	**18.58**	**219.15**	**18.47**	**-1.27**	**-0.11**	

Analysis of data reveals that agriculture land in Ib Valley Coalfield area decreased marginally from 220.42 km^2 (18.58%) to 219.15 km^2 (18.47%) due to industrial activities in the region..

3.3.4 Wasteland

Wasteland is a degraded and under-utilised class of land that has deteriorated 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 other management constraints (NWDB, 1987). This also includes the sand body formed on the banks of the river owing to the non flow of water there.

Analysis of satellite data of 2023 reveals that waste land in the updated Ib Valley Coalfield boundary, occupies 65.28 km^2 (4.96%) out of which Waste upland with or without scrubs occupies 62.51 km^2 (4.75%), Fly Ash Ponds / Sludge Ponds constitute 2.43 km^2 (0.18%) and Sand bodies constitute 0.35 km^2 (0.03%). (Refer Table 3.2).

The variation of area statistics of Waste Land based on the old Coalfield boundary is shown in Table 3.7

Area in Sq. Km.

Table 3.7 Status of Waste Land in Ib Valley Coalfield During Year 2020 and 2023

Classes		Year 2020		Year 2023		Change w.r.t. Yr 2020		Remarks
		Area Km^2	%	Area Km^2	%	Area Km^2	%	
Level I	Level II							
Waste Land	Waste Land with/without scrub	65.15	5.49	51.44	4.34	-13.71	-1.16	Decrease in wasteland area is due to interchange of this class into the classes viz. mining and waterbodies
	Sand Body	1.81	0.15	1.82	0.15	0.01	0.00	
	Fly Ash Pond	0.16	0.01	0.15	0.01	-0.01	0.00	
	Total Wasteland	**67.12**	**5.66**	**53.41**	**4.50**	**-13.71**	**-1.16**	

Analysis of data reveals that in Ib Valley Coalfield, wasteland covers an area of 53.41 km^2 (4.50%). In 2020 it was 67.12 km^2 (5.66%). This decrease of 13.71 km^2 (1.16%) in waste land area is on account of increase in mining areas and water-bodies.

3.3.5 Settlement/ Built-up land

All the man-made constructions covering the land surface are included under this category. Built-up land has been 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. The percentage of settlement shown in the analysis here is in terms of total land use/ cover only.

Settlements in Ib Valley Coalfield as per the updated coalfield boundary covers an area of 34.32 Km^2 (2.61%) out of the total coalfield area. Analysis of the satellite data of the year 2023 indicated that settlement coming under the updated coalfield boundary of Ib Valley Coalfield is distributed between *Urban* (8.24 Km^2; 0.63%), *Rural* (16.65 Km^2; 1.27%) and *Industrial* (9.43 Km^2; 0.72%) *(Refer Table 3.2).*

The variation of area statistics of Settlement Area based on the old Coalfield boundary is shown in Table 3.8

Area in Sq. Km.

Table 3.8 Status of Settlement Area in Ib Valley Coalfield During Year 2020 and 2023

Classes		Year 2020		Year 2023		Change w.r.t. Yr 2020		Remarks
		Area Km^2	%	Area Km^2	%	Area Km^2	%	
Level I	Level II							
Settlements	Urban Settlements	8.23	0.69	8.24	0.69	0.01	0.00	Settlement has marginally reduced due to increase in industrial activities
	Rural Settlements	17.42	1.47	16.67	1.40	-0.75	-0.06	
	Industrial Settlements	7.78	0.66	7.80	0.66	0.02	0.00	
	Total	**33.43**	**2.82**	**32.71**	**2.76**	**-0.72**	**-0.06**	

Settlements in Ib Valley Coalfield cover an area of 32.71 km^2 (2.76%). Analysis of the satellite data of the year 2023 indicates that settlements coming under the coalfield boundary of Ib Valley were distributed between *Urban* (8.24 km^2; 0.69%), *Rural* (16.67 km^2; 1.40%) and *Industrial* (7.80 km^2; 0.66%).

3.3.6 Surface Water bodies

Surface Water Bodies in Ib Valley Coalfield as per the updated coalfield boundary covers an area of 50.17 Km2 (3.81%) out of the total coalfield area (refer table 3.2).

Comparison of data reveals that water bodies in Ib Valley Coalfield occupy an area of 21.20 km^2 (1.79%) and total water body area increased by an area of 1.06 km^2.

Area in Sq. Km.

Table 3.9 Status of Surface Water Bodies in Ib Valley Coalfield During Year 2020 and 2023								
Classes		Year 2020		Year 2023		Change w.r.t. Yr 2020		
		Area Km^2	%	Area Km^2	%	Area Km^2	%	Remarks
Level I	Level II							
Water Body	River/ Ponds	20.14	1.70	21.20	1.79	1.06	0.09	

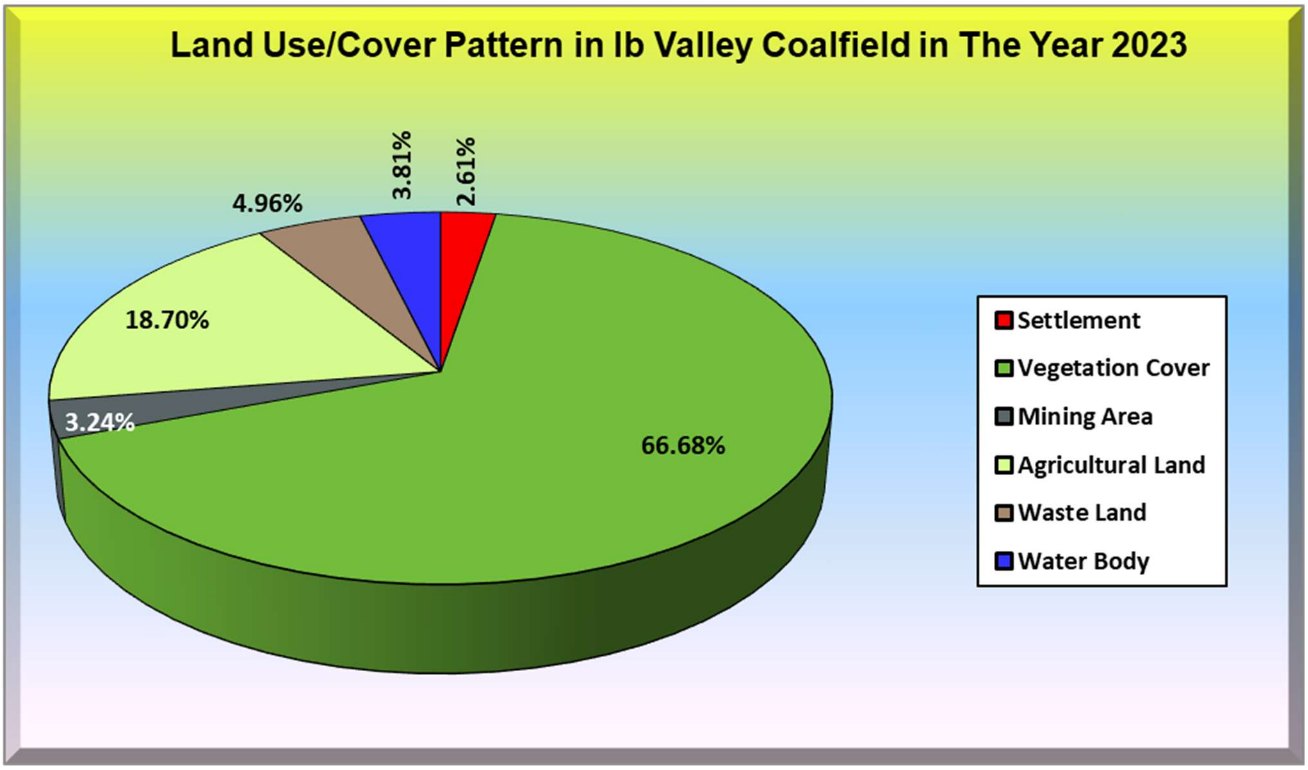


Figure.3.1- Land Use/cover pattern as per the updated coalfield boundary in IB Valley CF in the year 2023

Chapter 4

Conclusion & Recommendations

4.1 Conclusion

In the present study, land use/vegetation cover map of Ib Valley coalfield is prepared on the basis of Resourcesat-2A/2/LISS-IV data of the year 2023 in order to generate the geo-environmental database on vegetation cover and land use pattern for the year 2023 for effective natural resource management and its planning. The Land use/vegetation cover analysis at an interval of three years will help to analyse and monitor the impact of mining and other industrial activities in the area. The boundary of Ib Valley Coalfield has been updated to 1316.00 km^2 from 1186.60 km^2. From next year the comparison will be based on this updated boundary.

Study reveals that Ib Valley Coalfield covers an area of about 1316.00 Km^2. Settlements coming under the coalfield boundary cover an area of 34.32 Km^2 which is 2.61% of the total coalfield area. Vegetation cover constitutes 877.48 km^2 (66.68%), Mining activities is on 42.69 Km^2 area which is 3.24% of the total coalfield area whereas agriculture and wasteland are on 246.04 km^2 (18.70%) and 65.28 km^2 (4.96%) respectively. Water bodies cover an area of 50.17 Km^2 (3.81%). For detailed data analysis, refer Table-3.2 in this document.

4.2 Recommendations

The aim of this study is to incorporate the temporal changes based on satellite data to identify the pattern of vegetation cover and consequently enhance the interpretation capabilities. Keeping this in view, for the sustainable development of coal mining area, it is recommended that;

a) Similar study should be carried out regularly at interval of 3 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.

b) Afforestation helps in maintaining biodiversity and natural cycles by increasing greenery and preserving wildlife.

c) Efforts for afforestation should be given thrust in the coalfield on wasteland and mined out area to maintain the ecological balance in the region.

Central Mine Planning & Design Institute Ltd.
(A Subsidiary of Coal India Ltd.)
Gondwana Place, Kanke Road, Ranchi 834031, Jharkhand
Phone : (+91) 651 2230001, 2230002, 2230483, FAX (+91) 651 2231447, 2231851
Wesite : www.cmpdi.co.in, Email : cmpdihq@cmpdi.co.in