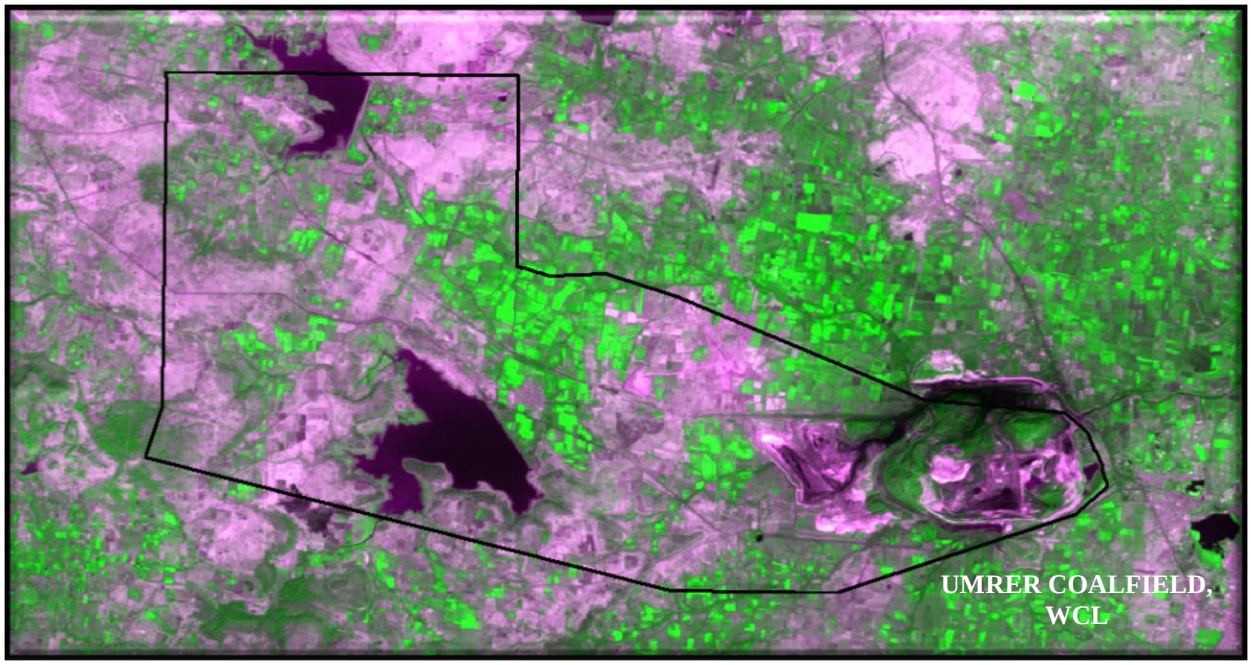
Report on Land use/Vegetation Cover Mapping of Umrer Coalfield based on Satellite Data of the Year- 2023



Submitted to

Western Coalfields Limited

Land use/Vegetation cover Mapping of Umrer Coalfield based on Satellite data of the year- 2023

March-2024

Remote Sensing Cell
Geomatics Division
CMPDI(HQ), Ranchi

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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 the period 2012-13 to 2016-17 which was subsequently followed by another work order vide letter no. CIL/WBP/Env/2017/DP/8477 dated 21.09.2017 from Coal India Ltd. for the period 2017-18 to 2021-22 wherein land reclamation monitoring of opencast projects and vegetation cover monitoring of 19 major coalfields including Umrer Coalfield has to be done as per a defined plan for monitoring the impact of mining on vegetation cover. Further, a revised work order was issued vide letter no. CIL/ENVT/2022-23/W.O/10899 dated 06.07.2022 from Coal India Limited for the period 2022-23 to 2023-24. According to this work order, vegetation cover mapping of 06 coalfields for 2022-23 and 07 coalfields including Umrer Coalfield for 2023-24 has to be done.

1.2 Objectives

The objective of the present study is to prepare a regional land use and vegetation cover map of Umrer coalfield on 1:50,000 scale based on satellite data of January, 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 updation 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 & Accessibility

Umrer Coalfield is situated about 44 km south-east of Nagpur city and it is in Nagpur district of Maharashtra state. The area is bounded between North Latitudes 20^0 50' 44" to 20^0 55' 05" and East Longitudes 79^0 09' 30" to 79^0 18' 07" and is covered by Survey of India (SOI) open series toposheet Nos. F44T/1 & F44T/5.The location map and the incidence of study area on toposheets are shown in Figure 1.1. The area extends for about 8 km in north-south direction and 15 km in east-west direction encompassing an area of about 66.75 sq. Km on RF 1:50000. This coalfield holds a premier position in India for having a considerable share of reserve of non-coking coal.

Umrer coalfield is well connected by rail and road ways. Umrer is a railway station on the Nagpur-Nagbhir-Chanda Fort route which is a narrow gauge section of the South-Eastern railway line. It is connected to Nagpur in the NW direction and to Nagbhir in SE direction by a good road named Maharashtra Major State Highway 9. Other major roads are also present.

1.4 Drainage

The area has almost flat to gently undulating topography with fertile land. The general slope of the area is towards east to south east. The whole area is rich in surface water bodies, mainly rivers, nalas, reservoirs and ponds. The river Amb is the major channel here which is flowing from NW to E direction. It has other tributaries which have made this area fertile. The western part of the area is having one big reservoir named Makardhokra Reservoir. Saiki Lake is also present in far NW part of the coalfield.

1.5 Forest Areas

The SW part of this area is having a few forest lands which are mainly open forests.

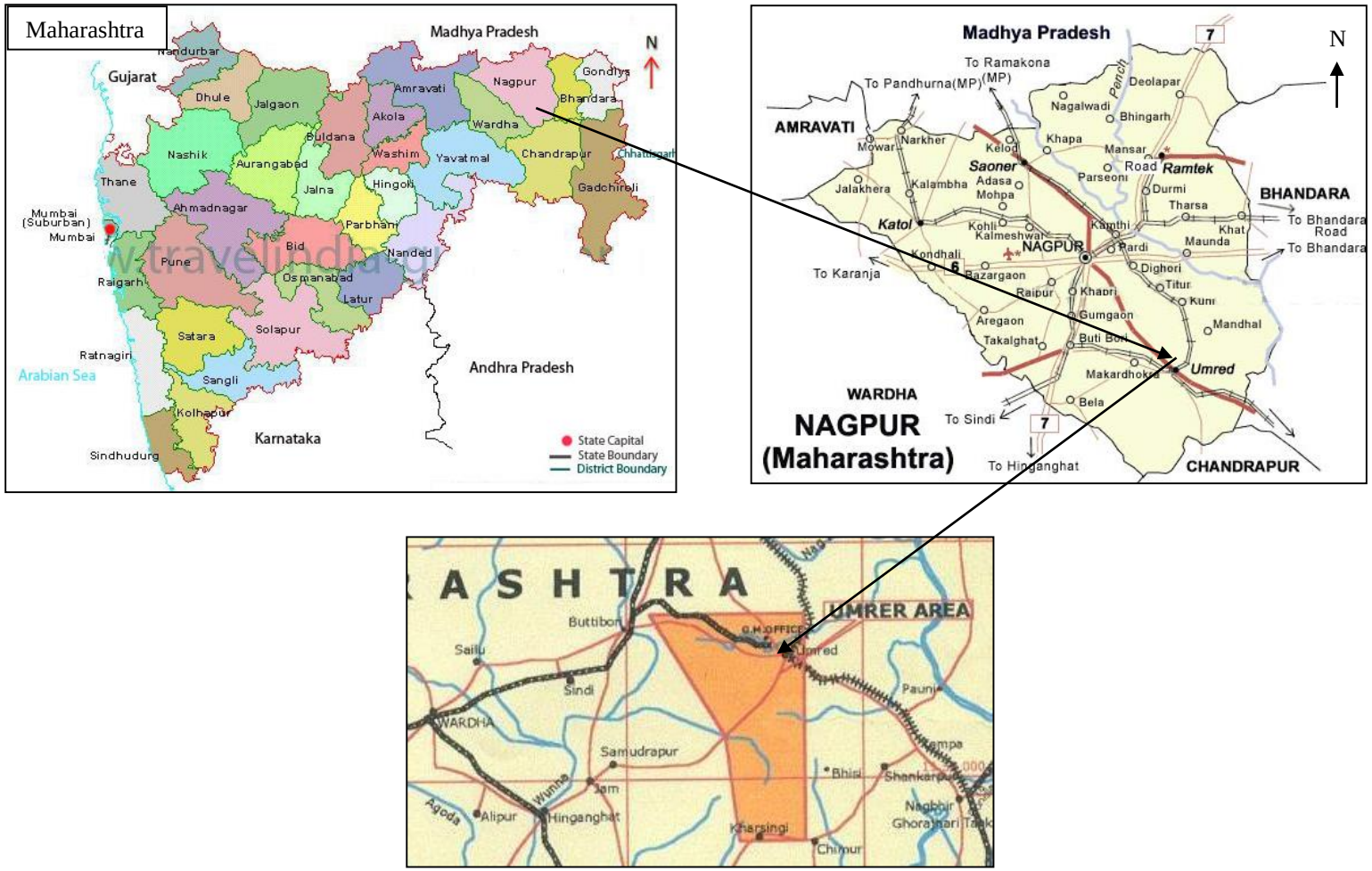


Fig. 1.1: **Location Map of Umrer Coalfield in Maharashtra's Nagpur district**

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.

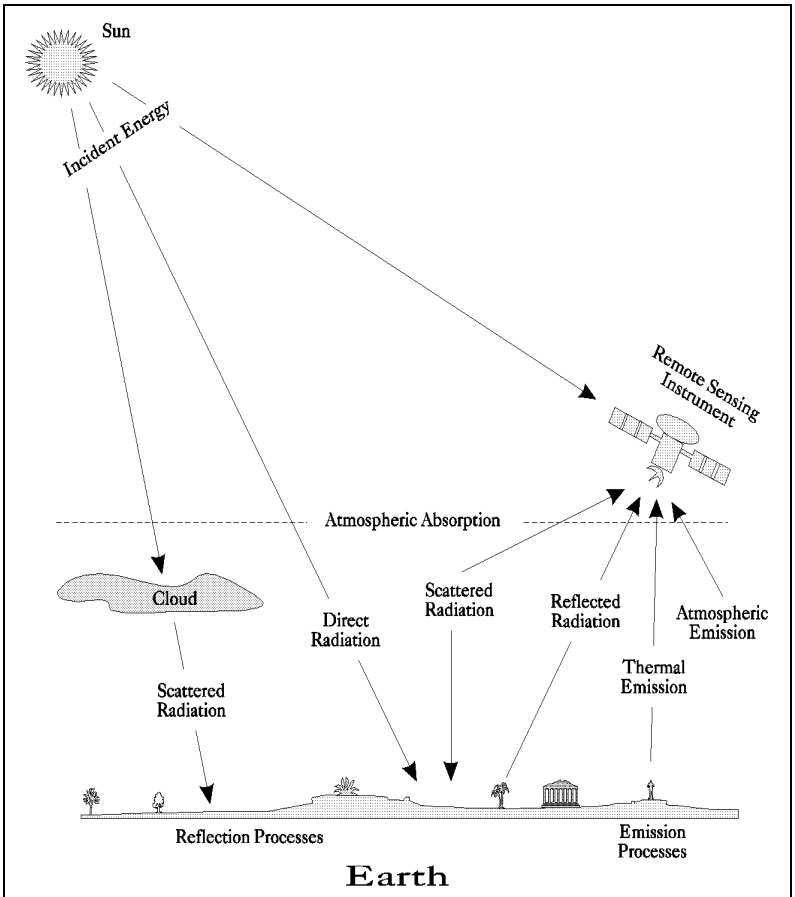


Figure 2.1 Remote sensing radiation system

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.

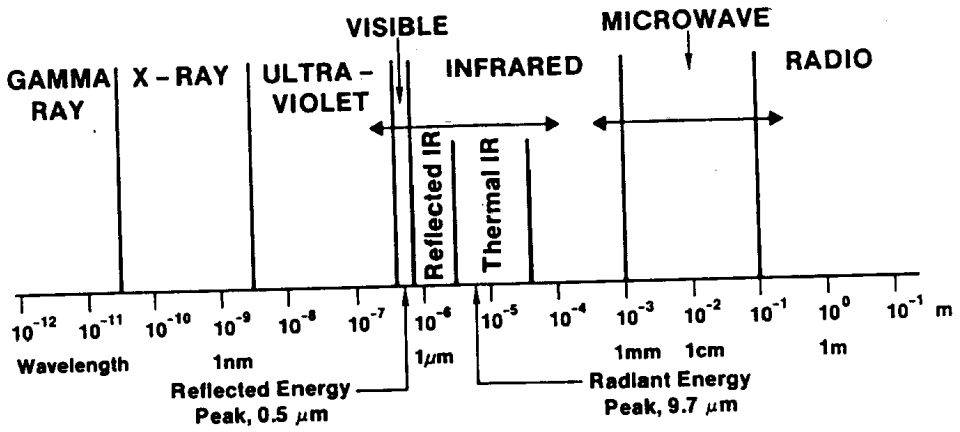


Figure 2.2 Electromagnetic spectrum. Expanded versions of the visible, infrared and microwave regions are shown in Figure 2.3.

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).

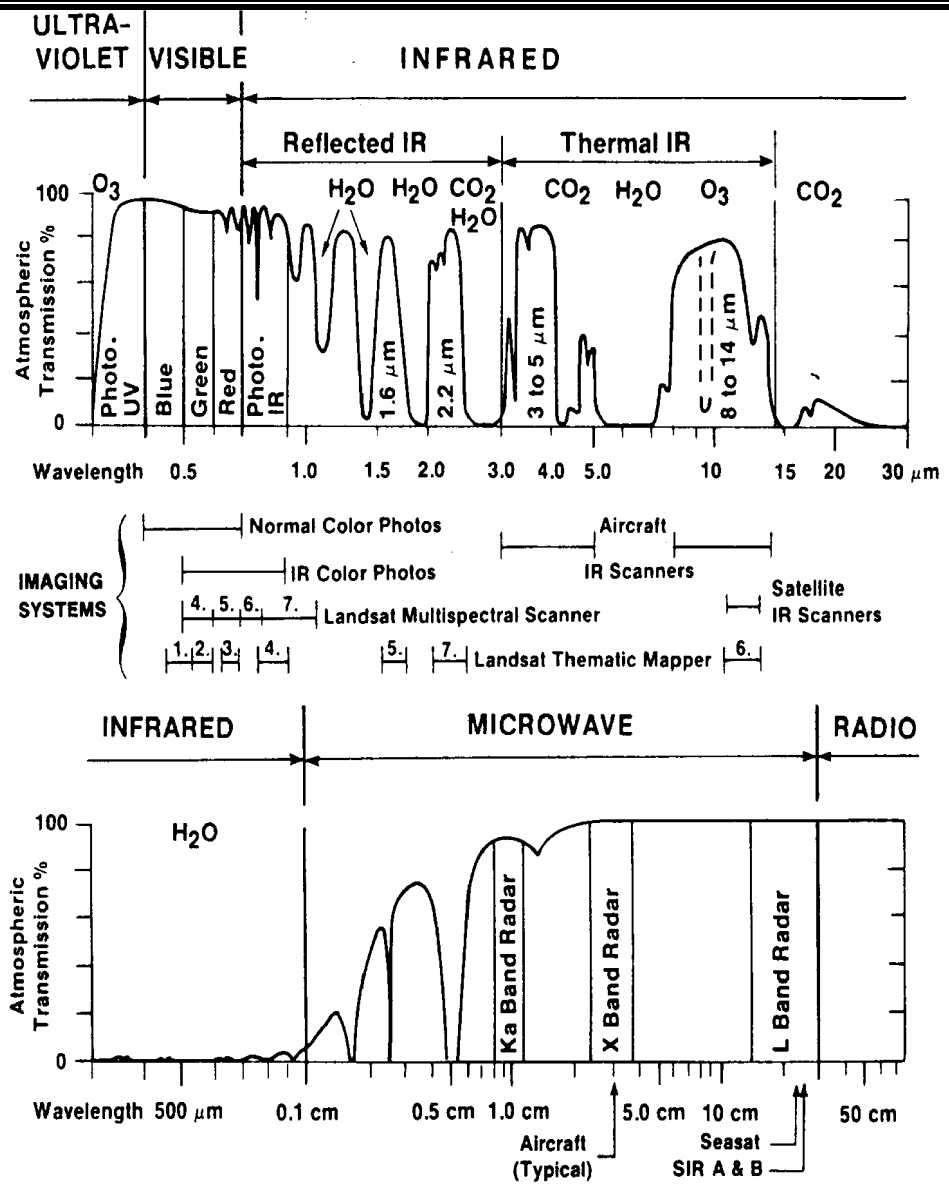


Figure 2.3 Expanded diagrams of the visible and infrared regions (upper) and the microwave regions (lower) showing atmospheric windows. Wavelength bands of commonly used remote sensing systems are indicated. Gases responsible for atmospheric absorption are shown.

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. IRS R2/LISS-IV of January, 2023 was used in the present study. The raw digital satellite data was 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 **Umrer Coalfield,** Survey of India open series topo-sheet no. F44T/1 & F44T/5 as well as map showing details of location of area boundary, coal field boundary and road supplied by WCL were used in the study.

2.5 Characteristics of Satellite/Sensor

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

(a) Spectral coverage/resolution, i.e., band locations/width;
(b) Spectral dimensionality: number of bands;
(c) Radiometric resolution: quantisation;
(d) Spatial resolution/instantaneous field of view or IFOV; and
(e) Temporal resolution.

Table 2.2 illustrates the basic properties of Resourcesat satellite/sensor that was used in the present study.

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

Platform	Sensor	Spectral Bands in µm	Radiometric Resolution	Spatial Resolution	Temporal Resolution	Country
RESOURCESAT - 2	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 details of data processing carried out in the present study are shown in Figure 2.4. The processing methodology involves the following major steps:

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

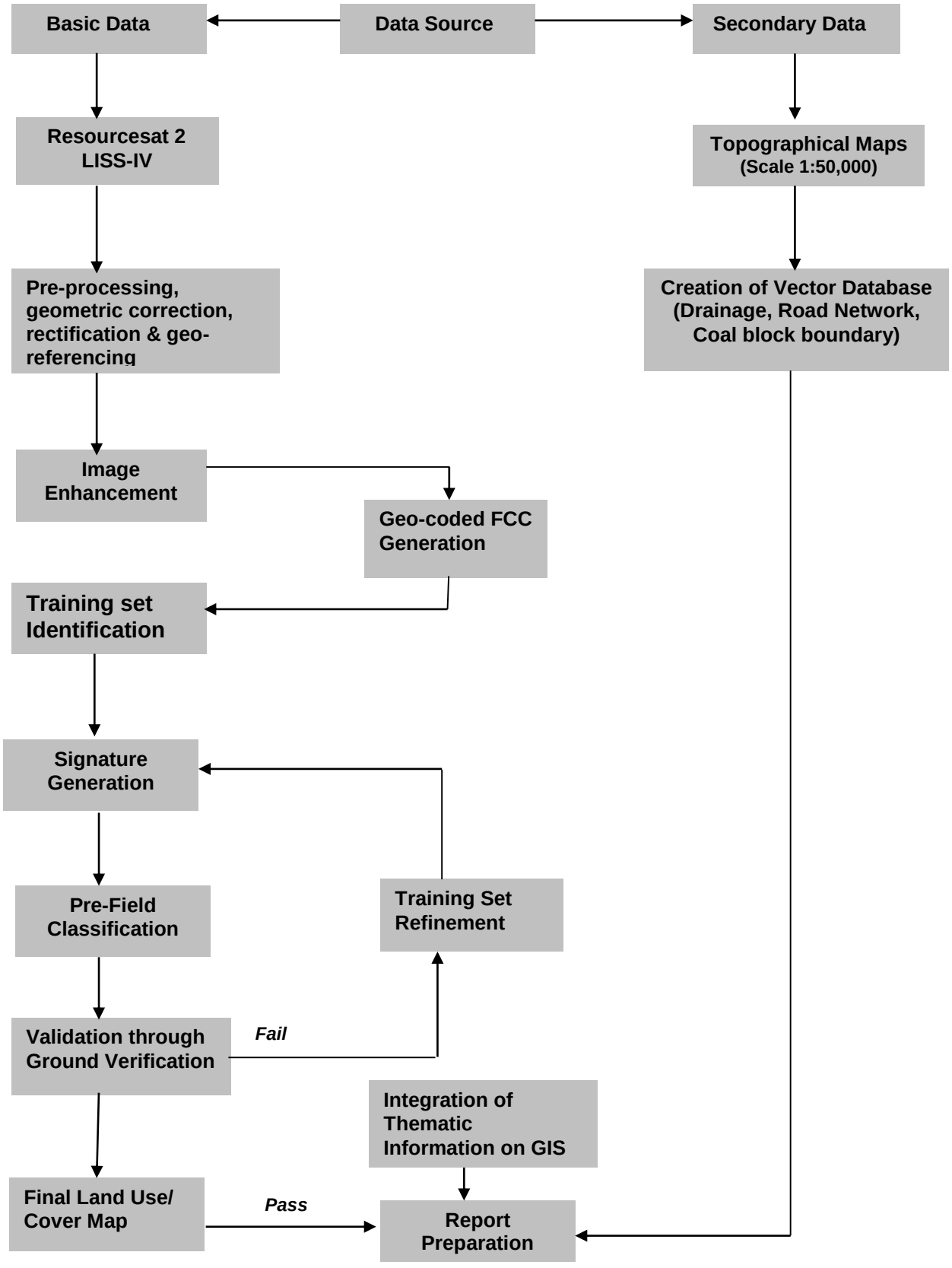


Fig-2.4 –Methodology of Land Use/Vegetation Cover Analysis

2.6.1 Geometric correction, rectification and geo-referencing

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

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

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

An understanding of the basics of projection system is required before selecting any transformation model. While maps are flat surfaces, Earth however is an irregular sphere, slightly flattened at the poles and bulging at the Equator. Map projections are systemic methods for "*flattening the orange peel*" in measurable

ways. When transferring the Earth and its irregularities onto the plane surface of a map, the following three factors are involved: (a) geoid (b) ellipsoid and (c) projection. Figure 2.5 illustrates the relationship between these three factors. The *geoid* is the rendition of the irregular spheroidal shape of the Earth; here the variations in gravity are taken into account. The observation made on the geoid is then transferred to a regular geometric reference surface, the *ellipsoid*. Finally, the geographical relationships of the ellipsoid (in 3-D form) are transformed into the 2-D plane of a map by a transformation process called map projection. As shown in Figure 2.5, the vast majority of projections are based upon *cones*, *cylinders* and *planes*.

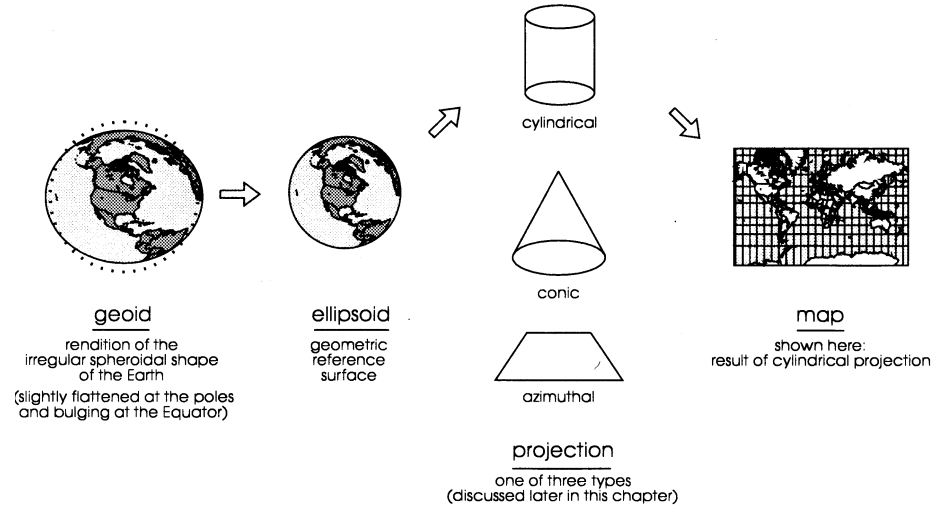


Fig 2.5 : Geoid – Ellipsoid – Projection Relationship

In the present study, ***UTM projection*** along with ***WGS 1984 Ellipsoidal model*** was used so as to prepare the map compatible with the SoI topo-sheets**.** Polyconic projection is used in SoI topo-sheets as it is best suited for small - scale mapping and larger area as well as for areas with North-South orientation (viz. India). Maps prepared using these projections are a compromise of many properties; it is neither conformal perspective nor equal area. Distances, areas and shapes are true only along central meridian. Distortion increases away from central meridian. Image

transformation from generic co-ordinate system to a projected co-ordinate system was carried out using ERDAS IMAGINE 2022 digital image processing system.

2.6.2 Image enhancement

To improve the interpretability of the raw data, image enhancement is necessary. Most of the digital image enhancement techniques are categorised as either point or local operations. Point operations modify the value of each pixel in the image data independently. However, local operations modify the value of each pixel based on brightness value of neighbouring pixels. Contrast manipulations/ stretching technique based on local operation was applied on the image data using ERDAS IMAGINE 2022 s/w. The enhanced and geocoded FCC image of Umrer 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, 250 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 2022 s/w. The classified image for the year 2023 for Umrer Coalfield is shown in Plate No. 2.

2.6.5 Creation/overlay of vector database

Plan showing coal field 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 urban settlements, plantation on backfill, quarry area, waste lands and surface water Bodies were 100%. Classification accuracy in case of agriculture land lies between 90% to 100%. In case of open forest, plantation on ob and social forestry the classification accuracy varies from 80.0% to 90.0%. Classification accuracy for scrubs was 73.3% due to poor ***signature separatibility 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 using Arc GIS 10.2 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 Umrer 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	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/ 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 resolutions offer 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 arrangement 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 2023 for Umrer coalfield and following land use/cover classes are identified (Table 3.1).

Table 3.1
Land use / Vegetation Cover classes identified in Umrer Coalfield

	LEVEL –I	LEVEL-II
1	**Vegetation Cover**	1.1 Open Forest 1.2 Scrub 1.3 Plantation under Social Forestry 1.4 Plantation on OB Dumps 1.5 Plantation over Backfill
2	**Mining Area**	2.1 Coal Quarry 2.2 Advance Quarry Site 2.3 Barren OB Dump 2.4 Barren Backfilled Area 2.5 Coal Dump 2.6 Water Filled Quarry
3	**Agricultural Land**	3.1 Crop Land 3.2 Fallow Land
4	**Wasteland**	4.1 Waste upland with/without scrubs
5	**Settlements**	5.1 Urban 5.2 Rural 5.3 Industrial
6	**Water Bodies**	6.1 River/Streams /Reservoir

3.3 Land use/cover Analysis

Satellite data of January, 2023 was processed using ERDAS IMAGINE 2022 image processing s/w in order to interpret the various land use/cover classes present in the study area of Umrer Coalfield covering 66.75 sq. kms. Areas of each land use/cover class for Umrer coalfield were calculated using ERDAS IMAGINE 2022 s/w and shown in Table 3.2. Distribution of various land use classes is shown in the Pie Chart (Fig. 3.2). Umrer coalfield contains 6 coal blocks (till date) whose land use/cover classes are tabulated in Table 3.3.

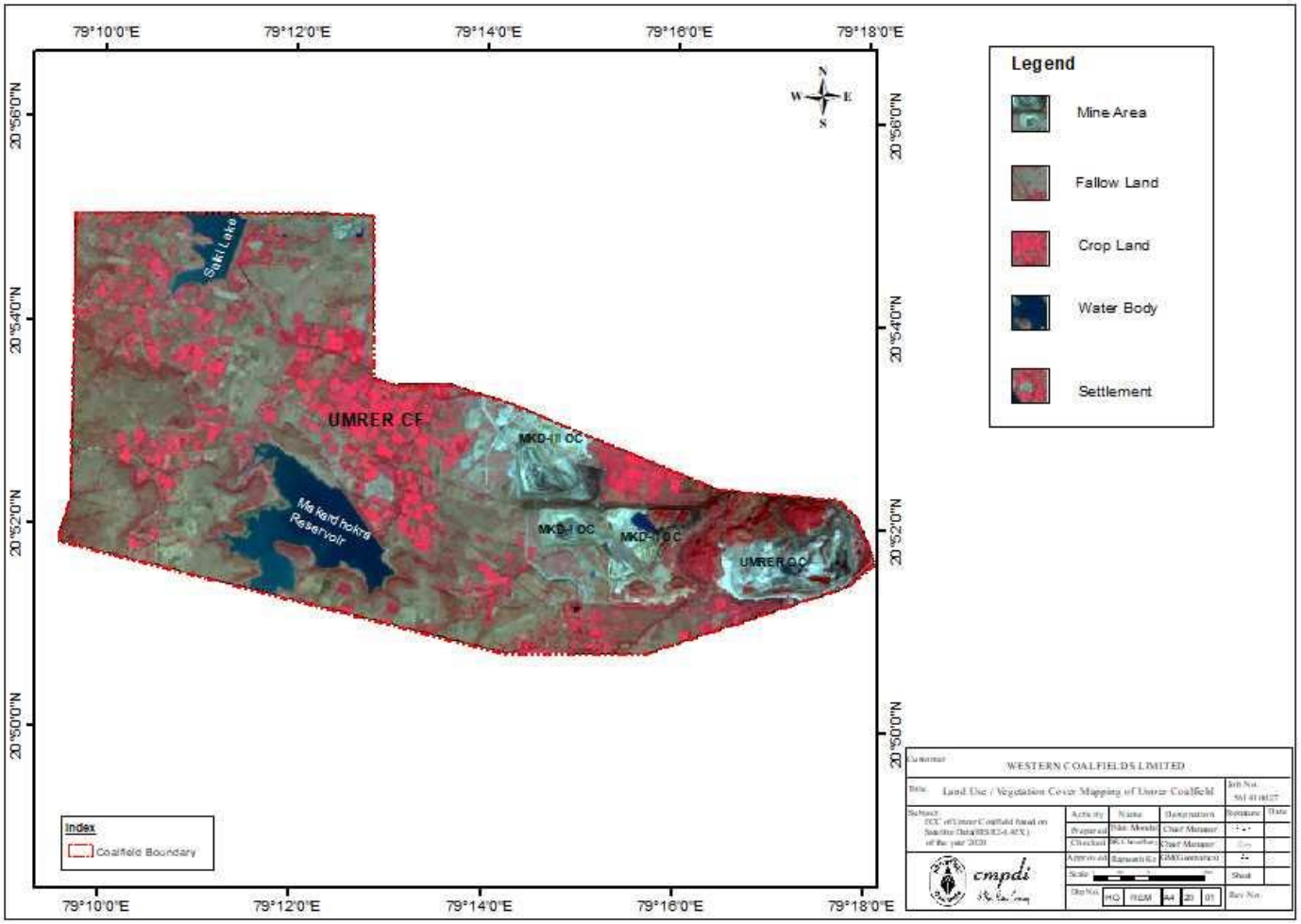
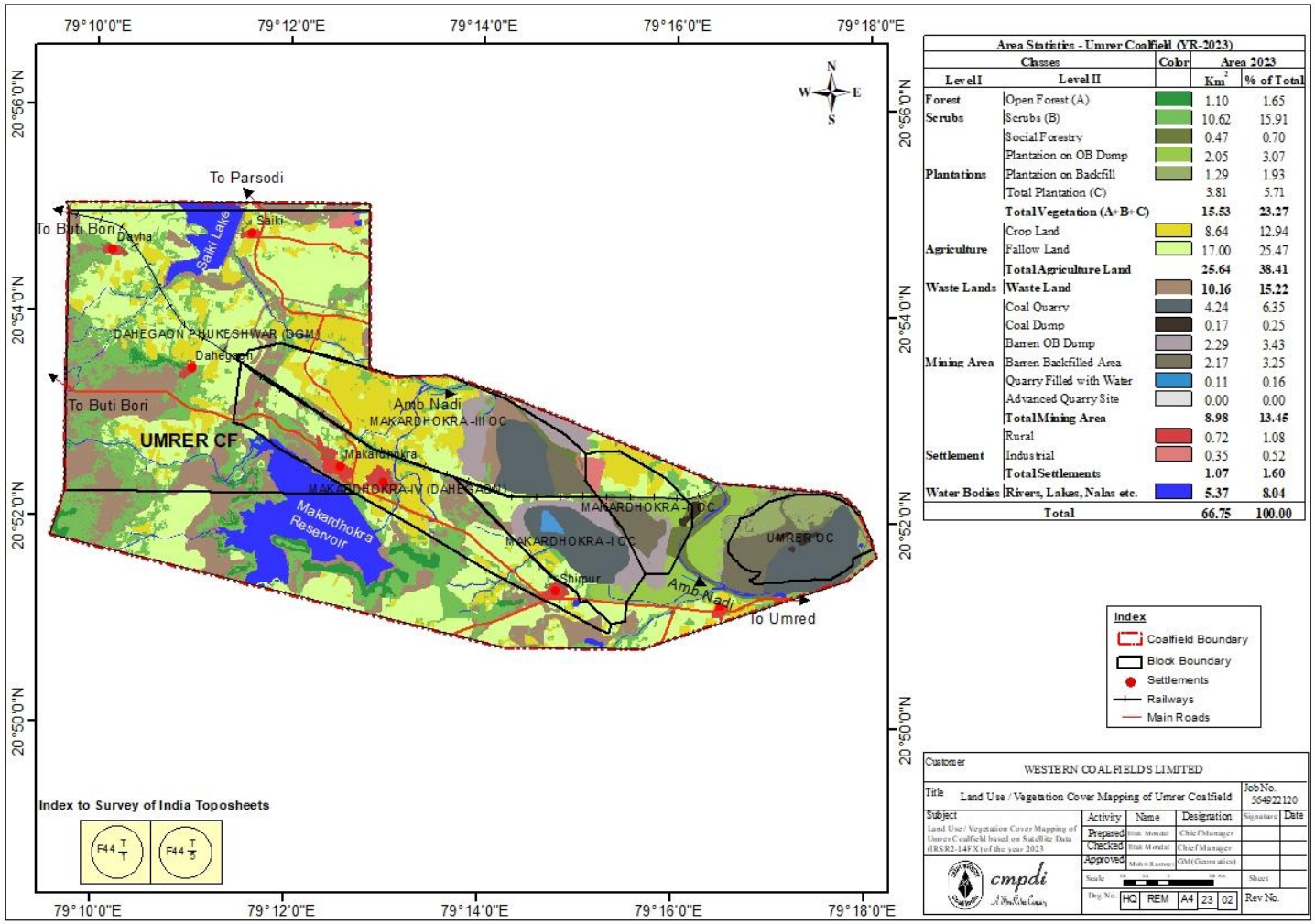


Plate 1: FCC (Band 2, 3, 4) of Umrer CF based on LISS Data of Year – 2023



Area Statistics - Umrer Coalfield (YR-2023)

Classes		Color	Area 2023	
Level I	Level II		Km²	% of Total
Forest	Open Forest (A)		1.10	1.65
Scrubs	Scrubs (B)		10.62	15.91
	Social Forestry		0.47	0.70
	Plantation on OB Dump		2.05	3.07
Plantations	Plantation on Backfill		1.29	1.93
	Total Plantation (C)		3.81	5.71
	Total Vegetation (A+B+C)		**15.53**	**23.27**
	Crop Land		8.64	12.94
Agriculture	Fallow Land		17.00	25.47
	Total Agriculture Land		**25.64**	**38.41**
Waste Lands	**Waste Land**		**10.16**	**15.22**
	Coal Quarry		4.24	6.35
	Coal Dump		0.17	0.25
	Barren OB Dump		2.29	3.43
Mining Area	Barren Backfilled Area		2.17	3.25
	Quarry Filled with Water		0.11	0.16
	Advanced Quarry Site		0.00	0.00
	Total Mining Area		**8.98**	**13.45**
	Rural		0.72	1.08
Settlement	Industrial		0.35	0.52
	Total Settlements		**1.07**	**1.60**
Water Bodies	Rivers, Lakes, Nalas etc.		5.37	8.04
	Total		**66.75**	**100.00**

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- Main Roads

Customer	WESTERN COALFIELDS LIMITED				Job No. 564922120
Title	Land Use / Vegetation Cover Mapping of Umrer Coalfield				
Subject	Land Use / Vegetation Cover Mapping of Umrer Coalfield based on Satellite Data (IRS R2-LISS IV) of the year 2023	Activity	Name	Designation	Signature / Date
		Prepared	Rituk Mondal	Chief Manager	
		Checked	Rituk Mondal	Chief Manager	
		Approved	Mohit Rastogi	GM (Geomatics)	
	cmpdi	Scale			Sheet
		Drg No.	HQ REM A4 23 02		Rev No.

Plate 2: LU / LC Map of Umrer CF based on LISS-IV Data of Year 2023

Table 3.2 : Status of Land use/ cover pattern in Umrer Coalfield during the year 2020 & 2023

LAND USE CLASSES	Year-2020		Year-2023		Change w.r.t. Yr 2020		Remarks
	Area (Km^2)	%	Area (Km^2)	%	Area (Km^2)	%	
SETTLEMENTS							
Rural Settlements	0.72	1.08	0.72	1.08	0.00	0.00	No change in settlement class is noticed.
Industrial Settlements	0.35	0.52	0.35	0.52	0.00	0.00	
Total Settlements	**1.07**	**1.60**	**1.07**	**1.60**	0.00	0.00	
VEGETATION COVER							
FOREST							
Open Forest	1.10	1.65	1.10	1.65	0.00	0.00	No change in Open forest class is noticed.
Total Forest (A)	**1.10**	**1.65**	**1.10**	**1.65**	**0.00**	**0.00**	
Scrubs (B)	11.07	16.58	10.62	15.91	-0.45	-0.67	
PLANTATION							
Social forestry	0.27	0.40	0.47	0.70	0.20	0.30	Social forest, Plantation on OB increased due to plantation by WCL but Plantation on Backfill decreased due to rehandling in Umrer OC
Plantation on OB	1.83	2.74	2.05	3.07	0.22	0.33	
Plantation on Backfill	1.36	2.04	1.29	1.93	-0.07	-0.10	
Total Plantation (C)	**3.46**	**5.18**	**3.81**	**5.71**	**0.35**	**0.52**	
Total Vegetation (A+B+C)	**15.63**	**23.42**	**15.53**	**23.27**	**-0.10**	**-0.15**	
MINING AREA							
Coal Quarry	3.54	5.30	4.24	6.35	0.70	1.05	Quarry increased due to mining
Coal Dump	0.18	0.27	0.17	0.25	-0.01	-0.01	Coal dump slightly decreased.
Barren OB Dump	1.87	2.80	2.29	3.43	0.42	0.63	OB dump increased due to mining
Barren Backfilled	1.43	2.14	2.17	3.25	0.74	1.11	Backfill increased.
Quarry filled with Water	0.03	0.04	0.11	0.16	0.08	0.12	Water-filled-Quarry increased.
Advanced Quarry Site	0.12	0.18	0.00	0.00	-0.12	-0.18	Advance quarry converted to coal quarry.
Total Mining Area	**7.17**	**10.74**	**8.98**	**13.45**	**1.81**	**2.71**	
AGRICULTURE							
Crop Land	9.60	14.38	8.64	12.94	-0.96	-1.44	Agricultural land within leasehold boundary of mine converted to coal quarry.
Fallow Land	18.76	28.10	17.00	25.47	-1.76	-2.64	
Total Agriculture	**28.36**	**42.49**	**25.64**	**38.41**	**-2.72**	**-4.07**	
WASTELANDS							
Waste land	8.97	13.44	10.16	15.22	1.19	1.78	Scrub area converted to waste land.
WATERBODIES							
River, nallah, pond etc.	5.55	8.31	5.37	8.04	-0.18	-0.27	Waterbodies slightly decreased.
TOTAL	**66.75**	**100.00**	**66.75**	**100.00**			

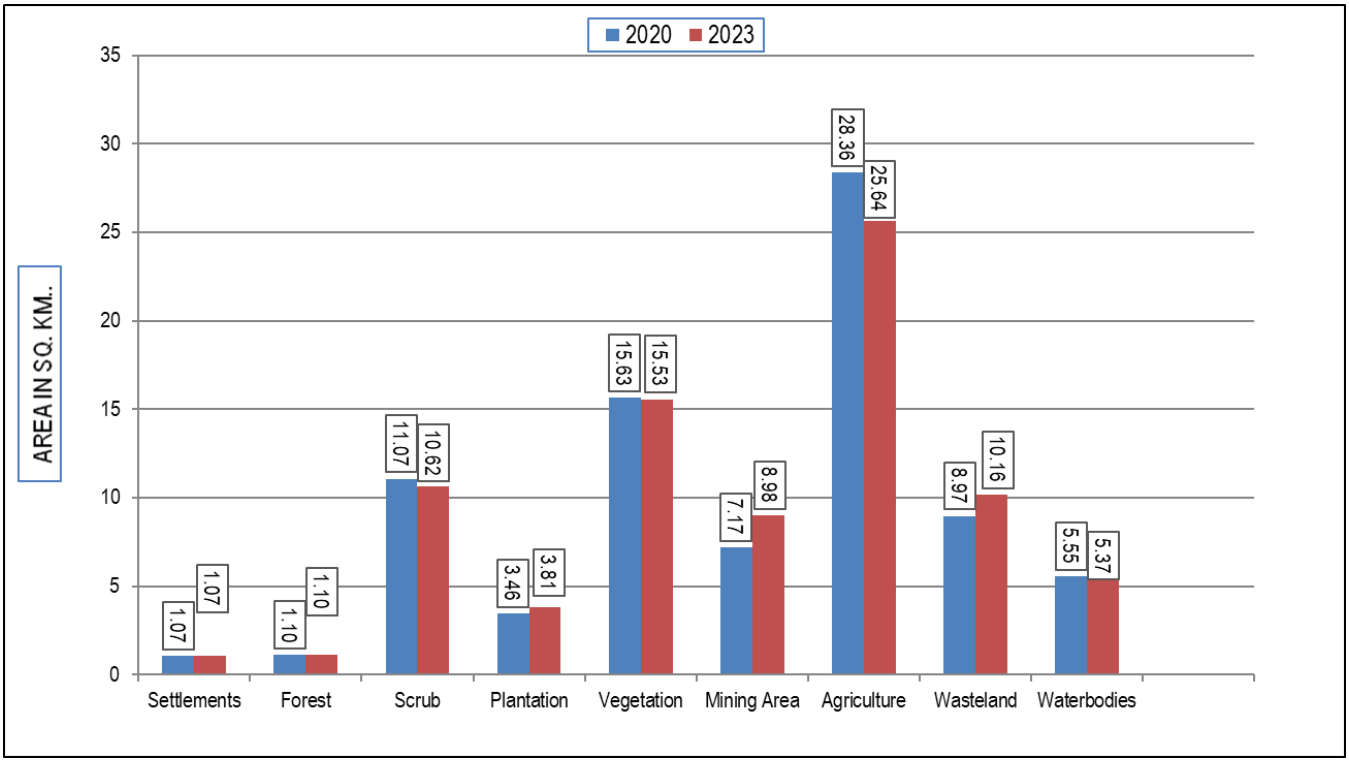

Fig. 3.1 : Year-wise Comparison of Land use / Vegetation Cover in Umrer Coalfield

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. In the present study, industrial settlement indicates only industrial complexes excluding residential facilities. In the year 2020 the total area covered by settlements were estimated to be 1.07 sq. km(1.60%). In year 2023 the estimated area under settlements is estimated to be 1.07 sq. km (1.60%). There is no change in settlement class.

The details of the land use under this category are shown in Table 3.3.

TABLE – 3.3

STATUS OF CHANGE IN SETTLEMENTS IN UMRER COALFIELD DURING YEAR 2020 & 2023

LAND USE CLASSES	Year-2020		Year-2023		Change w.r.t. Yr 2020		Remarks
	Area (Km^2)	%	Area (Km^2)	%	Area (Km^2)	%	
SETTLEMENTS							
Rural Settlements	0.72	1.08	0.72	1.08	0.00	0.00	No change in settlement class noticed.
Industrial Settlements	0.35	0.52	0.35	0.52	0.00	0.00	
Total Settlements	**1.07**	**1.60**	**1.07**	**1.60**	0.00	0.00	

3.3.2 Vegetation cover Analysis

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.

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

TABLE – 3.4

STATUS OF CHANGE IN VEGETATION IN UMRER COALFIELD DURING YEAR 2020 & 2023

LAND USE CLASSES	Year-2020		Year-2023		Change w.r.t. Yr 2020		Remarks
	Area (Km^2)	%	Area (Km^2)	%	Area (Km^2)	%	
VEGETATION COVER							
FOREST							
Open Forest	1.10	1.65	1.10	1.65	0.00	0.00	No change in Open forest class.
Total Forest (A)	**1.10**	**1.65**	**1.10**	**1.65**	**0.00**	**0.00**	
Scrubs (B)	11.07	16.58	10.62	15.91	-0.45	-0.67	
PLANTATION							
Social forestry	0.27	0.40	0.47	0.70	0.20	0.30	Social forest, Plantation on OB increased due to plantation by WCL but Plantation on Backfill decreased due to rehandling in Umrer OC
Plantation on OB	1.83	2.74	2.05	3.07	0.22	0.33	
Plantation on Backfill	1.36	2.04	1.29	1.93	-0.07	-0.10	
Total Plantation (C)	**3.46**	**5.18**	**3.81**	**5.71**	**0.35**	**0.52**	
Total Vegetation (A+B+C)	**15.63**	**23.42**	**15.53**	**23.27**	**-0.10**	**-0.15**	

Open Forest – Forest having crown density between 10% to 40% comes under this class. Open forest cover over Umrer coalfield which was estimated to be 1.10 sq. km (1.65%) in 2020 has been estimated to be 1.10 sq. km, i.e.1.65 % of the coalfield area in 2023. Thus there is no change in open forest class in the total coalfield area.

Scrubs – Scrubs are vegetation with crown density less than 10%. Scrubs in the coalfield are seen to be scattered signature all over the area mixed with wastelands. There is 10.62 sq km. of scrubs, i.e. 15.91% of the coalfield area in 2023. In year 2020 the scrubs covered 11.07 sq km which were 16.58% of the coalfield area. There is a decrease of 0.45 sq. km which is 0.67% of the coalfield area .This decrease is taken place because some area of scrubs has been converted into coal quarry.

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 0.27 sq. km, which is 0.40% of the coalfield area in 2020. In 2023 the area covered under social forestry was 0.47 sq. km (0.70%). There is an increase of 0.20 sq. km (0.30%). This increase is due to plantation by WCL.

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 were estimated to be 1.83 sq. km, (2.74% of the coalfield area) and 1.36 (2.04% of the coalfield area) respectively in 2020. In year 2023 the plantation on OB Dumps and backfilled area is estimated to cover an area of 2.05 sq. km (3.07% of the coalfield area) and 1.29 sq.km. (1.93% of the coalfield area) respectively. There is an increase of 0.22 sq. km (0.33%) in plantation over OB dump. There is a decrease of 0.07 sq.km. (0.10%) in backfilled area. Overall there is an increase of 0.35 sq.km (0.52%) in plantation class. This is due to initiative taken by WCL towards afforestation.

3.3.3 Mining Area

The mining area was primarily been categorized as.

- Coal Quarry
- Barren OB Dump

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

- Barren Backfilled Area
- Coal Dumps
- Water filled Quarry

In the year 2020 the coal quarry was estimated to be 3.54 sq. km (5.30%) which has increased to 4.24 sq. km (6.35%) in the year 2023. This increase is due to increase in production of coal from Open cast areas. In the year 2020 the barren OB dump was estimated to be 1.87 sq. km (2.80%) which has been increased to 2.29 sq. km (3.43%) in the year 2023. This increase is due to increase in mining activity. In the year 2020 the barren backfilled area was estimated to be 1.43 sq. km (2.14%) which has been increased to 2.17 sq. km (3.25%) in the year 2023. In the year 2020 the water filled quarry area was estimated to be 0.03 sq. km (0.04%) which has been

increased to 0.11 sq. km (0.16%) in the year 2023.The status of Land Use in mining area in Umrer Coalfield is shown in the table 3.5 below.

TABLE – 3.5

Status of change in Mining Area in Umrer Coalfield during the year 2020 & 2023

LAND USE CLASSES	Year-2020		Year-2023		Change w.r.t. Yr 2020		Remarks
	Area (Km^2)	%	Area (Km^2)	%	Area (Km^2)	%	
MINING AREA							
Coal Quarry	3.54	5.30	4.24	6.35	0.70	1.05	Quarry increased due to mining
Coal Dump	0.18	0.27	0.17	0.25	-0.01	-0.01	Coal dump slightly decreased.
Barren OB Dump	1.87	2.80	2.29	3.43	0.42	0.63	OB dump increased due to mining
Barren Backfilled	1.43	2.14	2.17	3.25	0.74	1.11	Backfill increased.
Quarry filled with Water	0.03	0.04	0.11	0.16	0.08	0.12	Water-filled-Quarry increased.
Advanced Quarry Site	0.12	0.18	0.00	0.00	-0.12	-0.18	Advance quarry converted to coal quarry.
Total Mining Area	**7.17**	**10.74**	**8.98**	**13.45**	**1.81**	**2.71**	

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 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.

Crop land along with fallow land was 28.36 sq. km in year 2020, which is 42.49 % of the coalfield area. In year 2023 the agriculture land was estimated to be 25.64 sq. km which is 38.41% of the coalfield area. There is a decrease of 2.72 sq. km which is 4.07% of the coalfield due to conversion of agricultural land within leasehold boundary of mine into coal quarry. The details are shown below in Table 3.6.

TABLE – 3.6

Status of change in Agricultural land in Umrer Coalfield during the year 2020 & 2023

LAND USE CLASSES	Year-2020		Year-2023		Change w.r.t. Yr 2020		Remarks
	Area (Km^2)	%	Area (Km^2)	%	Area (Km^2)	%	
AGRICULTURE							
Crop Land	9.60	14.38	8.64	12.94	-0.96	-1.44	Agricultural land within leasehold boundary of mine converted to coal quarry.
Fallow Land	18.76	28.10	17.00	25.47	-1.76	-2.64	
Total Agriculture	**28.36**	**42.49**	**25.64**	**38.41**	**-2.72**	**-4.07**	

3.3.5 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.

The waste land was estimated to be 8.97 sq. km (13.44%) in the year 2020. In the year of 2023, waste land is estimated to be 10.16 sq. km (15.22%). So there is an increase of 1.19 sq. km. i.e. (1.78%) of the total coalfield area. This is due to conversion of scrub area into waste land.

3.3.6 Surface Water bodies

It is the area of impounded water including natural lakes, rivers/streams and man-made canal, reservoir, tanks etc. The water bodies in the study area had been estimated to be 5.55 sq. km in year 2020, which is 8.31% of the coalfield area. In 2023 it have been estimated to be 5.37 sq. km which is 8.04% of the total area. So there is an decrease of 0.18 sq. km. in water bodies which is 0.27% of the total coalfield area.

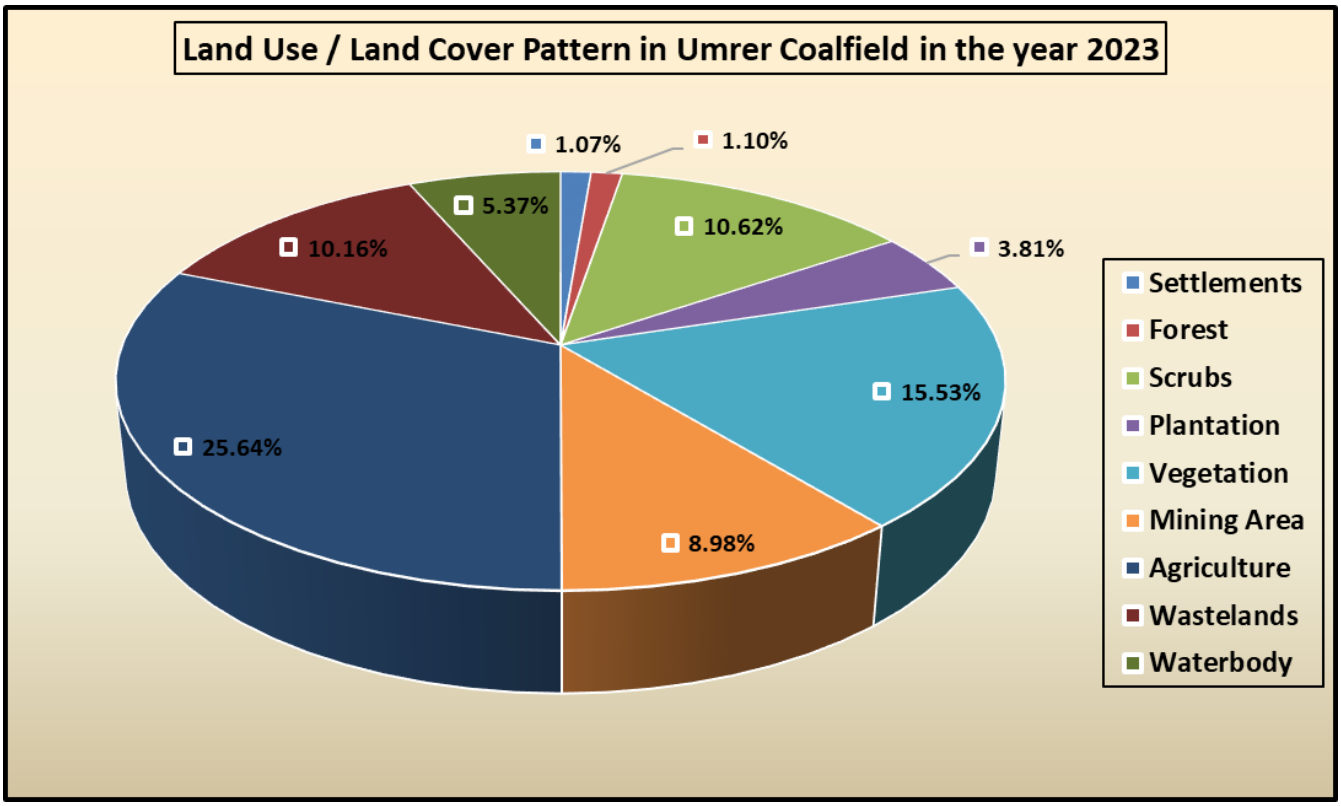
Land Use / Land Cover Pattern in Umrer Coalfield in the year 2023
1.07%
1.10%
10.62%
3.81%
15.53%
8.98%
25.64%
10.16%
5.37%
Settlements
Forest
Scrubs
Plantation
Vegetation
Mining Area
Agriculture
Wastelands
Waterbody

Figure: 3.2

Chapter 4

Conclusion & Recommendation

4.1 Conclusion

In the present study, land use/ vegetation cover mapping has been carried out, based on Resoursesat 2 / LISS-IV data in order to generate the geo-environmental database on land use/vegetation cover in Umrer Coalfield for monitoring the impact of coal mining on land environment. Change analysis in land use pattern may help in formulating the mitigation measures required, if any.

Study reveals that the total area of settlements which includes rural and industrial settlements in the Umrer coalfields covers 1.07 km^2 (1.60%) area. There is no change in settlements over the year 2020 study. Vegetation cover which includes open forests, scrubs, social forestry & plantation on over-burden dumps & backfilled area, covers an area of 15.53 km^2 (23.27%). As compared to 2020 study there is a decrease in overall vegetation cover by 0.10 km^2 (0.15%). This is mainly because scrub within the leasehold boundary of mine have been converted to coal quarry though there is considerable increase in total plantation over OB dump and backfilled area done by WCL. The analysis further indicates that total agricultural land which includes both crop and fallow land has decreased by 2.72 km^2 (4.07%) because of conversion of agricultural land within leasehold boundary of mine into coal quarry. The mining area which includes coal quarry, barren OB dump, barren backfilled area, covers 8.98 km^2 (13.45%). As compared to 2020 there is an increase in area under mining operations due to more production of coal. Wasteland covers 10.16 km^2 (15.22%) in 2023 and 8.97 km^2 (13.44%) in 2020. Waste lands have increased because some scrub area has been converted into waste land. The detail statistical analysis is given under Table-3.2.

4.2 Recommendation

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

ABBREVIATIONS

SoI	Survey of India
MoEF & CC	Ministry of Environment, Forest & Climate Change
CIL	Coal India Limited
ECL	Eastern Coalfields Limited
BCCL	Bharat Coking Coal Limited
CCL	Central Coalfields Limited
WCL	Western Coalfields Limited
SECL	South Eastern Coalfields Limited
NCL	Northern Coalfields Limited
MCL	Mahanadi Coalfields Limited
NEC	North Eastern Coalfields
CMPDIL	Central Mine Planning & Design Institute Ltd
NRSC	National Remote Sensing Centre
R2/ R2A	ResourceSat Satellites
LISS - 4	Linear Imaging and Self Scanning Sensor
FCC	False Colour Composite
OCP	Opencast Project
UGP	Underground Project
OB	Over Burden
GCP	Ground Control points
GIS	Geographic Information System
WGS-84	World Geodetic System
UTM	Universal Transverse Mercator

GLOSSARY

Sl.	Term	Definition
1.	Land Reclamation	To manage, reclaim and restore mined out/ degraded land as close as possible to its original stage.
2.	Over Burden	The material that lies above the coal seam/ deposit
3.	Monitoring	A process of evaluation to check or keep record for a period of time.
4.	Opencast Coal Mine	Open-pit mining, also known as opencast mining, is a surface mining technique that extracts minerals from an open pit in the ground.
5.	Social Forestry	Social forestry is the management and protection of forests and afforestation of barren and deforested lands with the purpose of helping environmental, social and rural development. Plantation (Social/ Avenue or other) carried out outside mining area.
6.	Biological Reclamation	Plantation on Backfilled areas (Stablised Internal Dumps)
7.	Technical Reclamation	Area under backfilling (Over burden dumped inside the mine voids) in mining area.
8.	Green Cover Generated	Total Plantation carried out in the lease area of Project. This includes Plantation on Backfill, Plantation on OB and Social Forestry.
9.	Leasehold Area	The area, for which lease is granted for the purpose of undertaking mining and allied operations.
10.	Excavated area	Mined out area which includes active mining, area under backfilling and plantation on backfilled areas
11.	Active Mining	Mining areas which include Coal Quarry, Advance Quarry, Quarry Filled with Water etc.

12.	Environmental Protection	It is the practice of protecting the natural environment by individuals, organizations and governments. Its objectives are to conserve natural resources and the existing natural environment and, where possible, to mitigate damage and reverse trends.
13.	Remedial Measure	Any measure or action required or undertaken to investigate, monitor, clean up, remove, treat, prevent, contain or otherwise remediate the presence or release of any hazardous substance or activity.
14.	Systematic Error	Every measurement differing from the true measurement in the same direction, and even by the same amount in some cases.
15.	Geometric Distortion	It refers to the improper positioning of any image with respect to their true geographic position when viewed in a properly scaled common image display plane.
16.	Land Use/ Cover Class	Land cover is what covers the surface of the earth and land use describes how the land is used.
17.	Accuracy	The closeness of agreement between a measured quantity value and a true quantity value.
18.	Environmental Clearance	Environmental Clearance (EC) for any developmental projects like coal mining projects etc. has been made mandatory by the Ministry of Environment, Forests and Climate Change (MoEF & CC) through its Notification issued on 27.01.1994 under the provisions of Environment (Protection) Act, 1986.
19.	Rectification and Geo-referencing	Geo-referencing is the assigning of absolute location of a data point or data points. Geo-rectification refers to the removal of geometric distortions between sets of data points, most often the removal of terrain, platform, and sensor induced distortions from remote sensing imagery.

20.	Image Enhancement	It is the process of modifying digital images so that the results are more suitable for processing or further image analysis.
21.	Training set selection	It is a portion of a data set used to fit or train a model for prediction or classification of values that are known in the training set, but unknown in other (future) data.
22.	Image Classification	It refers to the task of extracting information classes from a multiband raster image. The resulting raster from image classification can be used to create thematic maps.
23.	Temporal Changes	The 'temporal change' means the change in any entity with a period of time.
24.	Ground Truthing	Collection of primary/ basic information from ground realities for satellite image interpretation and thematic mapping.
25.	Cluster	Group of opencast and/ or underground mines clubbed together for administrative purposes.
26.	Arc GIS	GIS Software used for Map preparation
27.	ERDAS IMAGINE	Satellite Image Data Classification Software

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