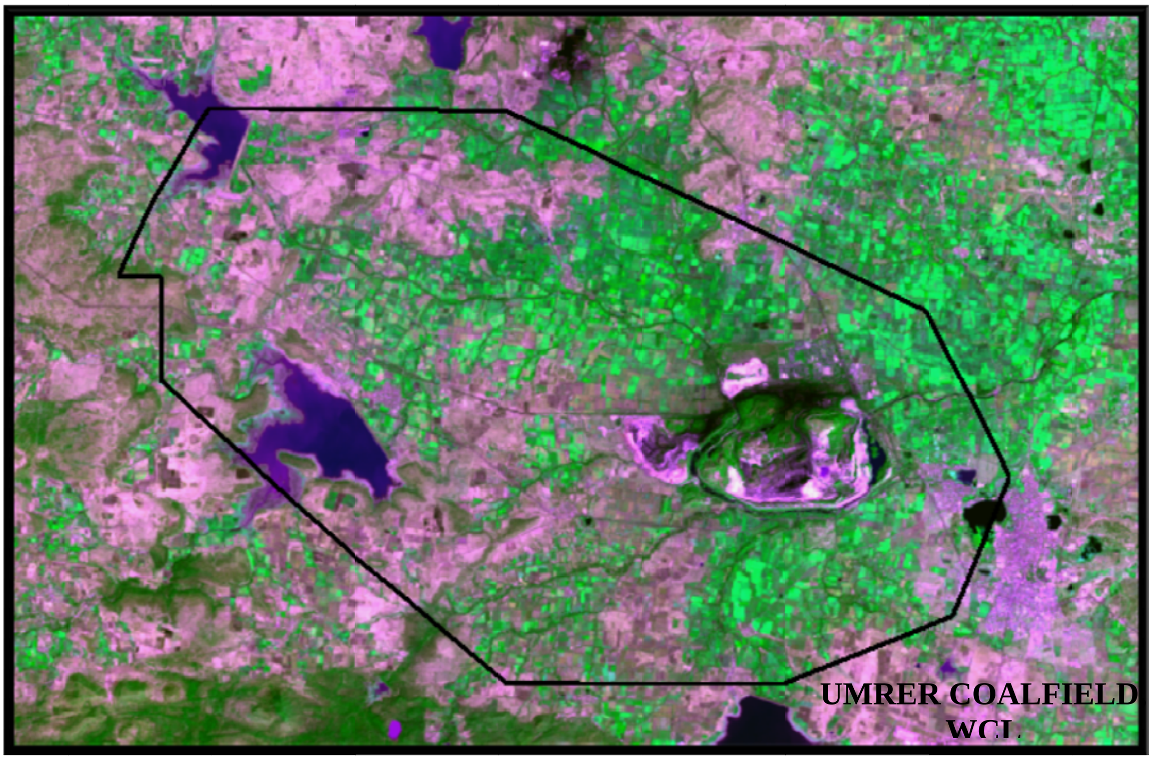
Report On
Land use/Vegetation cover Mapping of Umrer Coalfield based on Satellite data of the year- 2014



Submitted to

Western Coalfields Limited

Land use/Vegetation cover Mapping of Umrer Coalfield based on Satellite data of the year- 2014

October-2014

Remote Sensing Cell
Geomatics Division
CMPDI, 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 28 major coalfields and to assess the impact of coal mining and associated industrialization on land use and vegetation cover at regular interval of three years. Work order no. CIL/WBP/Env/2009/2428 dated 29.12.2009; was issued by CIL to CMPDI for the above study. In pursuant to the above work order, land use/vegetation cover mapping of Umrer Coalfield based on satellite data was taken up to create the geo-environmental data base of the coalfield using remote sensing data & GIS. The first report was submitted to CIL in March, 2012. The order was renewed by CIL vide letter no. CIL/WBP/ENV/2011/4706 dt. 12/10/2012 for continuing the work till 2016-17.

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 11th February, 2014, using digital image processing technique and compare the same with the data base prepared in 2011 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 49’ 36” to 20^0 55’ 07” and East Longitudes 79^0 10’ 18” to 79^0 19’ 32” 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 10 km in north-south direction and 16 km in east-west direction encompassing an area of about 110 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.

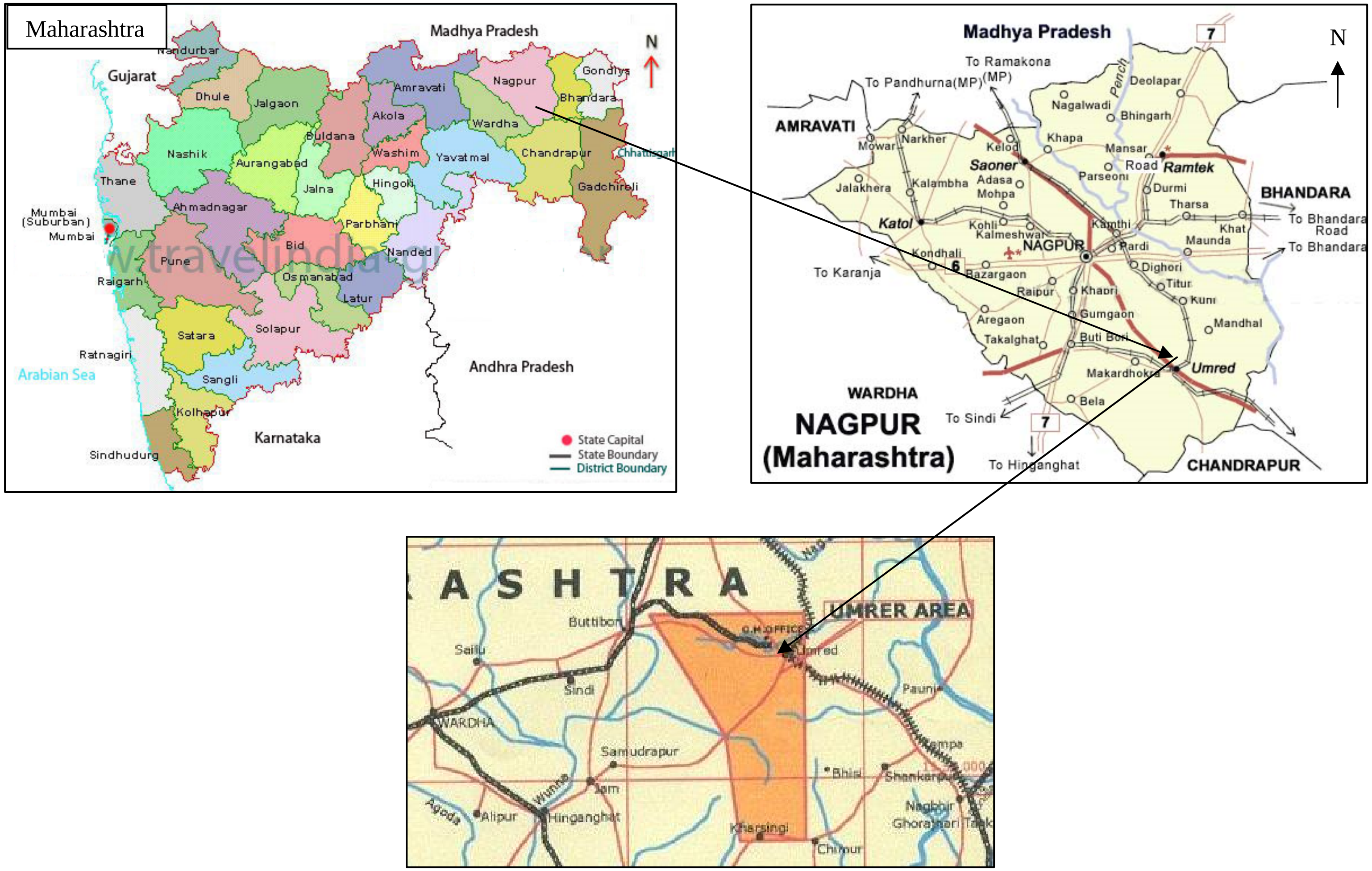


Fig. 1.1: **Location Map of Umrer Coalfield in Maharashtra's Nagpur district**

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.

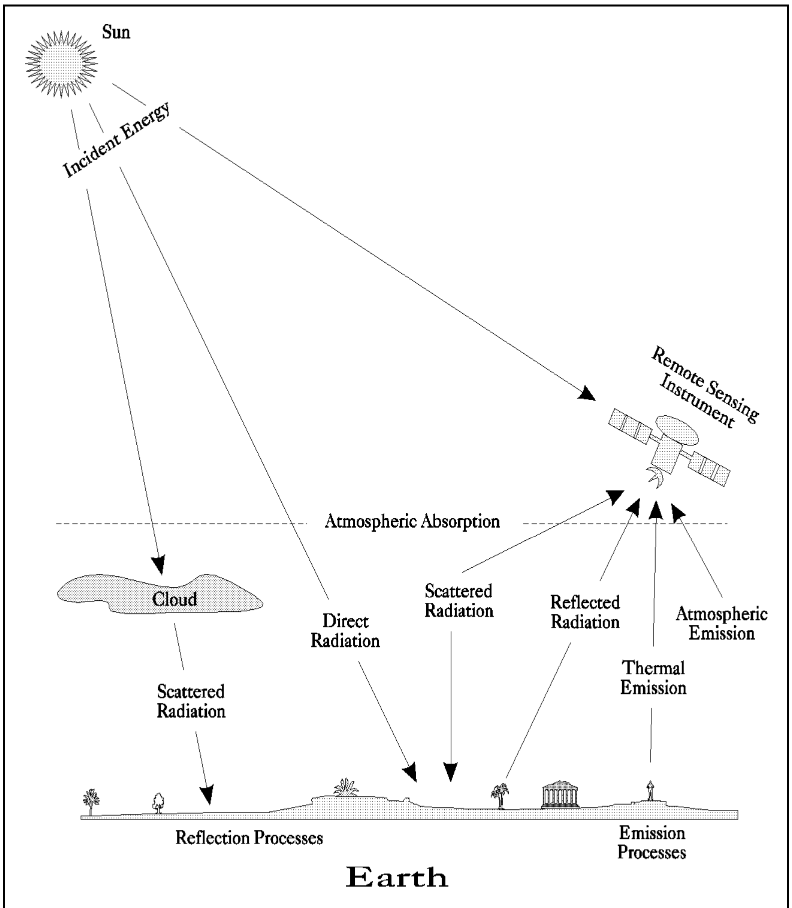


Figure 2.1 Remote sensing radiation system

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.

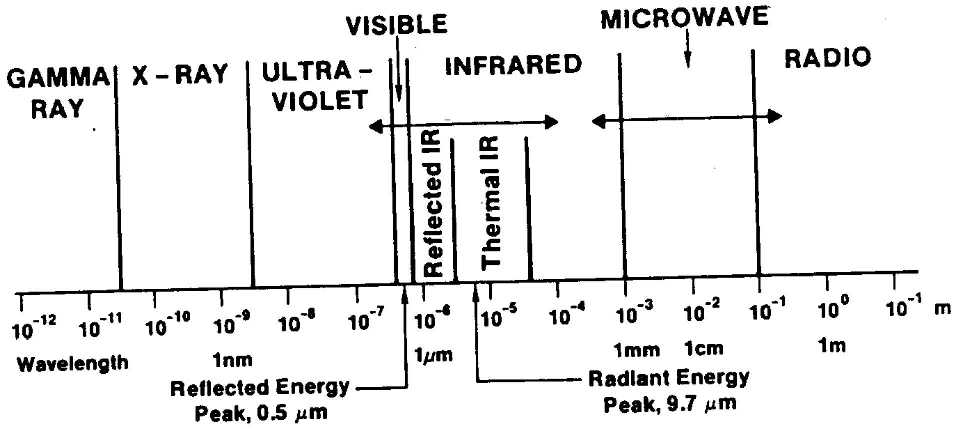


Figure 2.2 Electromagnetic spectrum. Expanded versions of the visible, infrared and microwave regions are shown in Figure 2.3.

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).

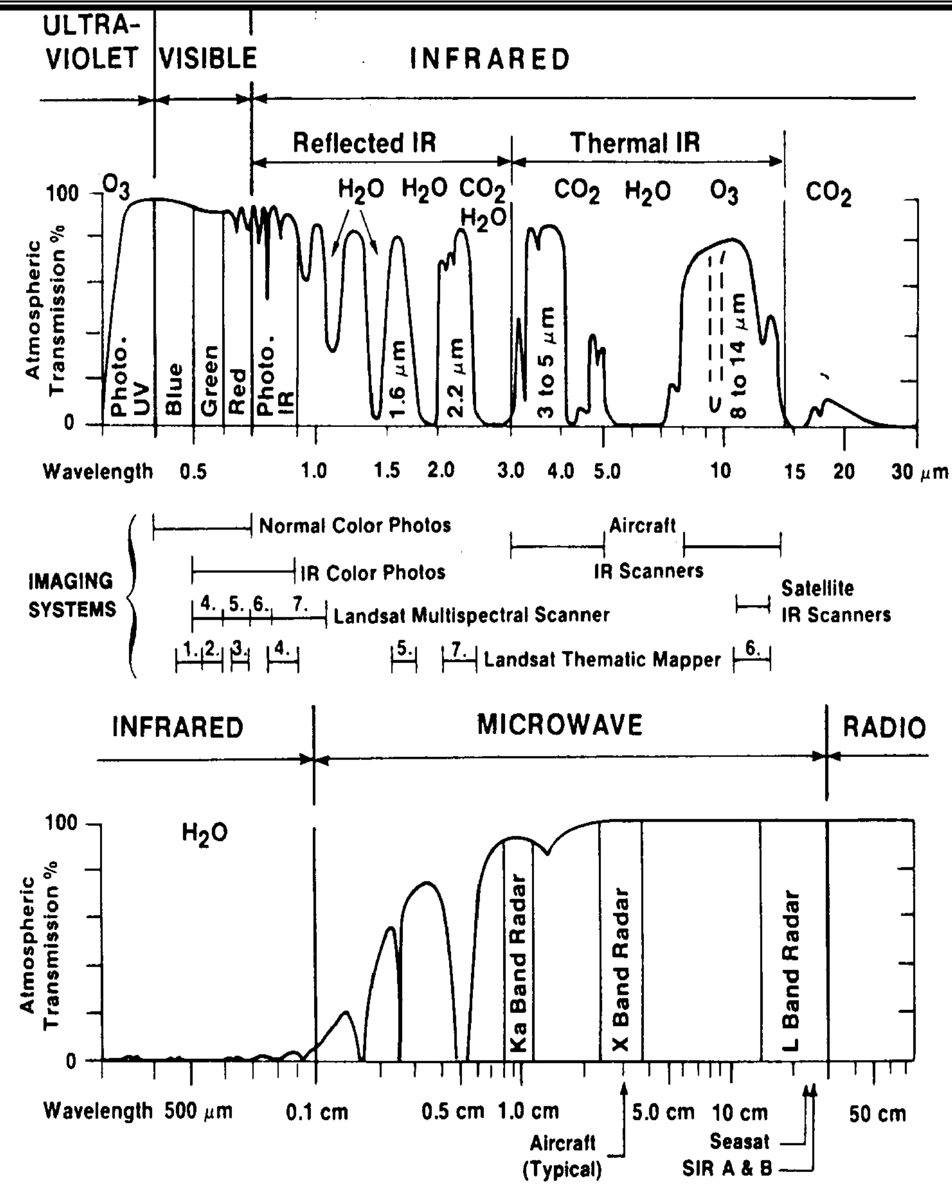


Figure 2.3 Expanded diagrams of the visible and infrared regions (upper) and the microwave regions (lower) showing atmospheric windows. Wavelength bands of commonly used remote sensing systems are indicated. Gases responsible for atmospheric absorption are shown.

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. Landsat 8/OLI of 11th February, 2014 having 30 m. spatial resolution was used in the present study. The raw digital satellite data was obtained from website of U.S. Geological Survey.

- **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 toposheet 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
Landsat 8	OLI	B3 0.53 - 0.59 Green B4 0.64 - 0.67 Red B5 0.85 - 0.88 NIR	16-bit (65536-grey levels)	30 m 30 m 30 m	24 days	U.S.

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.

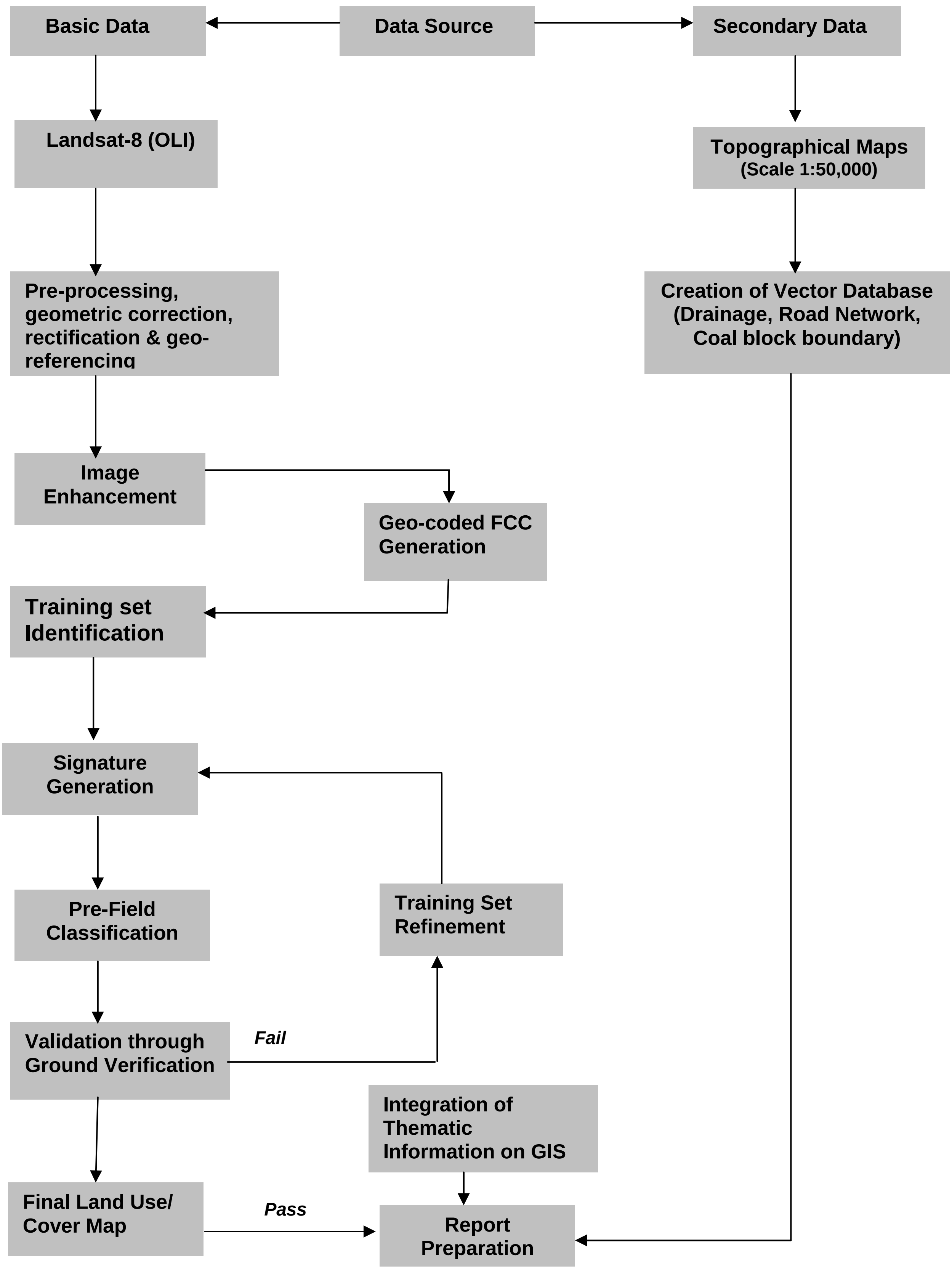


Fig-2.4 –Methodology of Land Use/Vegetation Cover Analysis

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*.

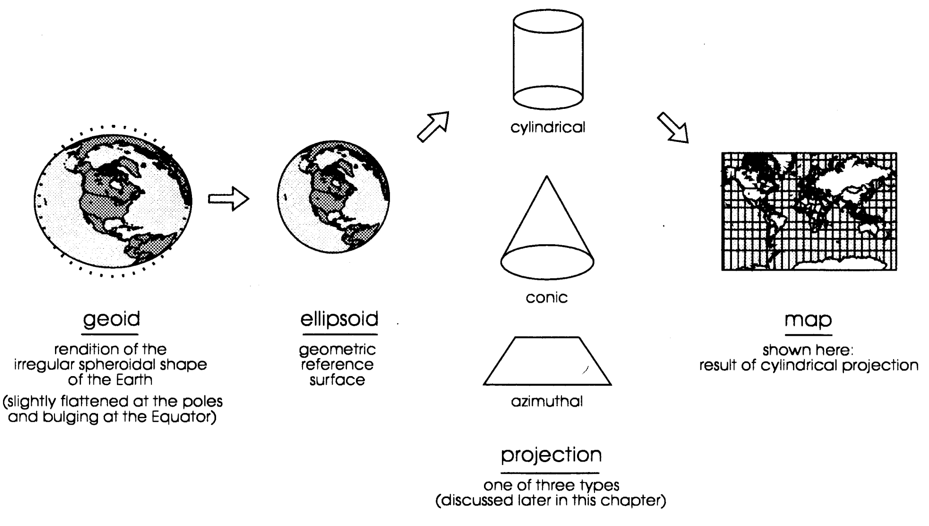


Fig 2.5 : Geoid – Ellipsoid – Projection Relationship

In the present study, ***Polyconic projection*** along with ***Everest 1956 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 2013 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 2013 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 2013 s/w. The classified image for the year 2014 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 lie 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 separability index***. The overall classification accuracy is 90%.

2.6.7 Final land use/vegetation cover map preparation

Final land use/vegetation cover map (Plate - 2) was generated on 1:50,000 scale using Arc GIS 9.0 s/w. Due to inconvenient size, map was printed on 1:90,000 scale using HP Design jet 4500 Colour plotter and the same is enclosed in the report. A soft copy in .pdf format is also attached. .

Table 2.3: Classification Accuracy Matrix for 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	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/ 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 2014 for Umrer coalfield and following land use/cover classes are identified (Table 3.1).

***Table 3.1*:**
Land use/cover classes identified in Umrer Coalfield

	Level -I	***Level -II***
1	Built-Up Land	1.1 Urban 1.2 Rural 1.3 Industrial
2	Agricultural Land	2.1 Crop Land 2.2 Fallow Land
3	Forest/Vegetation Cover	3.1 Open Forest 3.2 Scrub 3.3 Plantation under Social Forestry 3.4 Plantation on OB Dumps 3.5 Plantation on Backfills
4	Wasteland	4.1 Waste upland with/without scrubs
5	Mining	5.1 Quarry Area 5.2 Coal Dump 5.3 Barren OB Dump 5.4 Backfilled Area 5.5 Water Filled Quarry 5.6 Advanced Quarry Site
6	Water bodies	6.1 River/Streams /Reservoir/Ponds

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

Plate No. 1: FCC (Landsat 8 / OLI) data of Umrer coalfield of 11th February, 2014) with Coalfield boundary and other infrastructural details.

Plate No. 2: Land use/Cover Map of Umrer Coalfield based on Landsat 8 OLI data.

3.3 Land use/cover Analysis

Satellite data of 11th February, 2014 was processed using ERDAS IMAGINE 2013 image processing s/w in order to interpret the various land use/cover classes present in the study area of Umrer Coalfield covering 110.72 sq. kms. Area of each land use/cover class for Umrer coalfield was calculated using ERDAS IMAGINE 2013 s/w and comparison between land use/cover classes of year 2011 and 2014 tabulated in Table 3.2. Distribution of various land use classes are shown in the Pie Charts (Fig. 3.2 and 3.3).

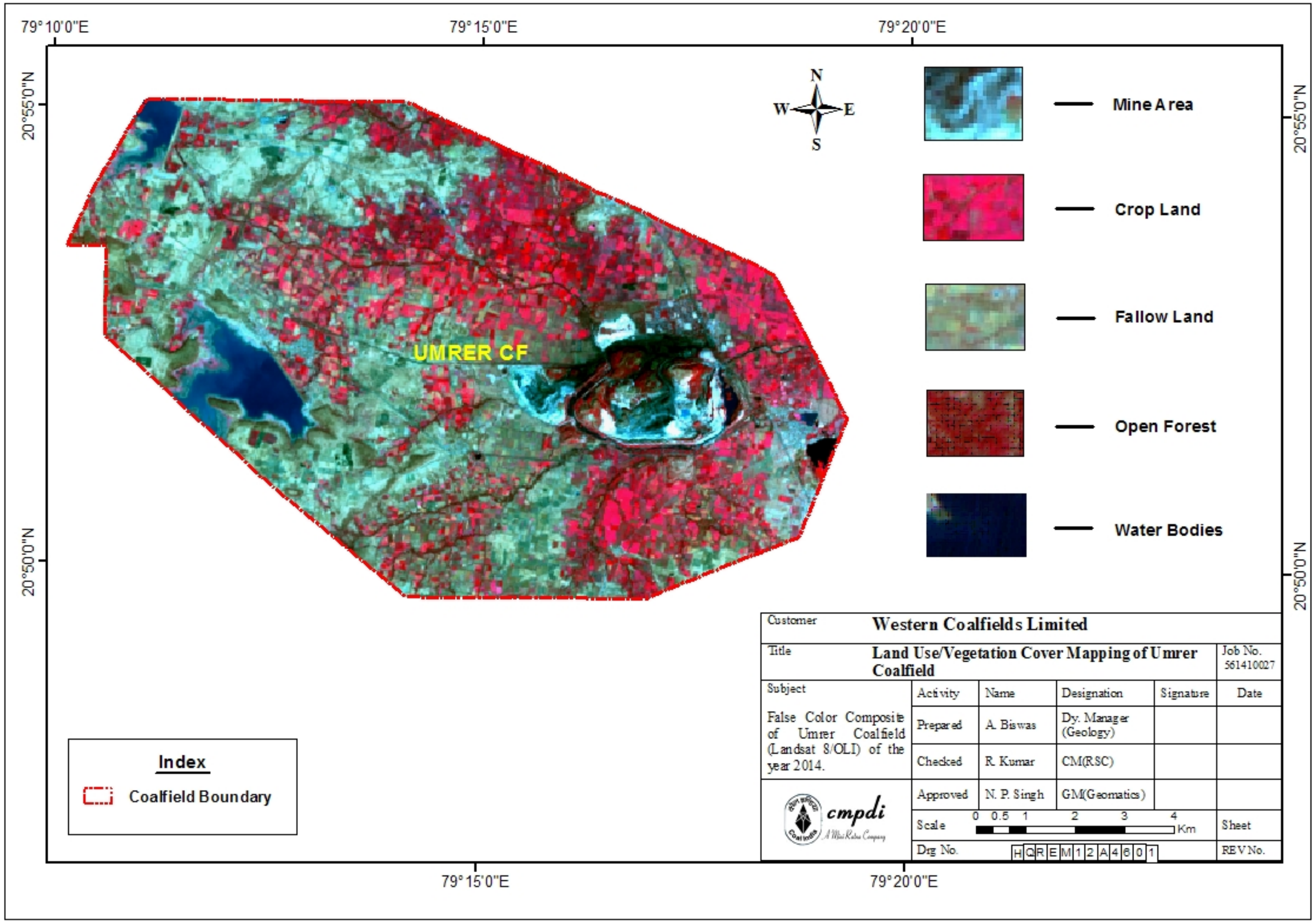
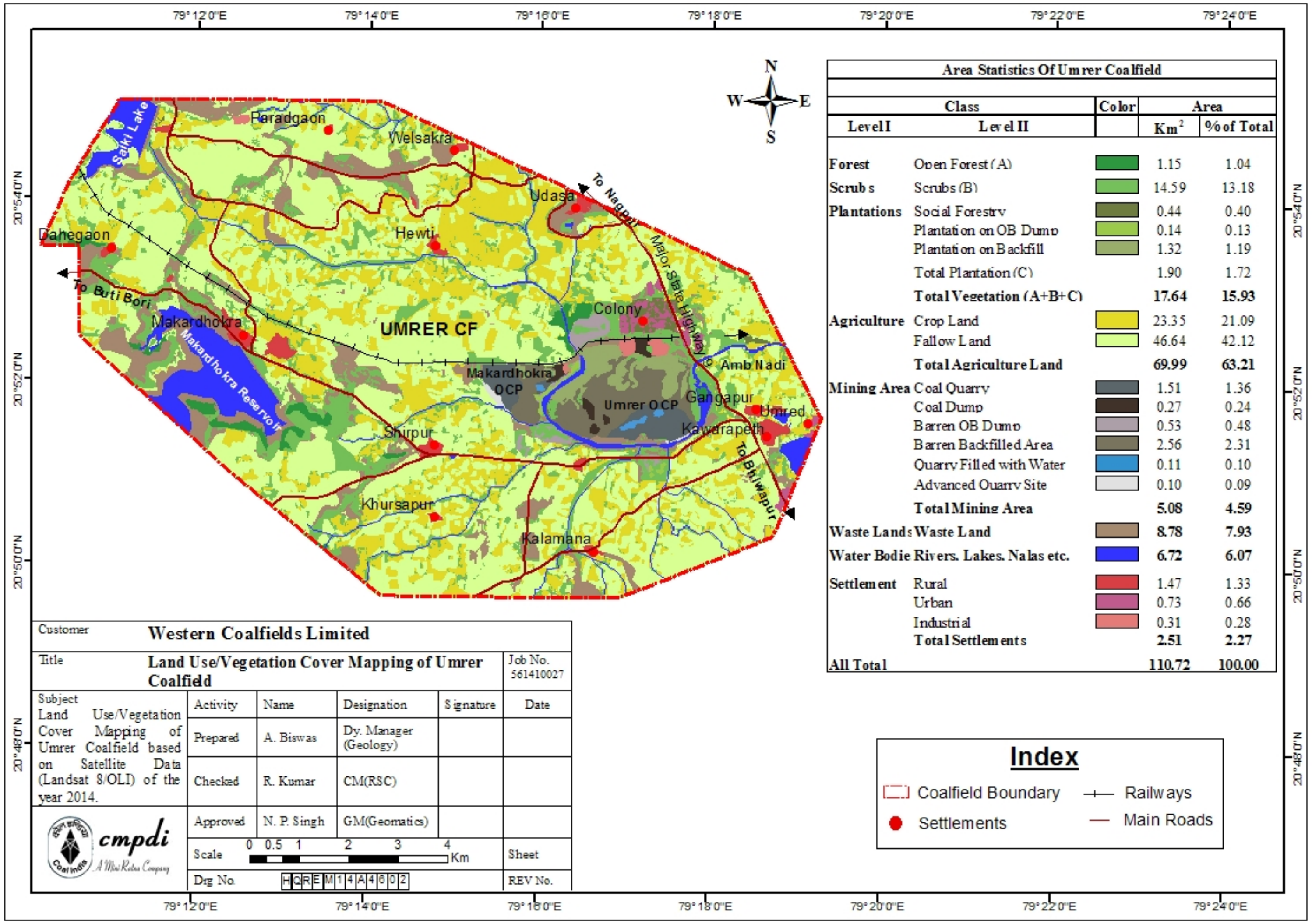


Plate 1: FCC (Band 3, 4, 5) of Umrer CF based on Landsat 8 (OLI) Data of Year – 2014



Area Statistics Of Umrer Coalfield

Class Level I	Class Level II	Color	Area Km²	Area % of Total
Forest	Open Forest (A)		1.15	1.04
Scrubs	Scrubs (B)		14.59	13.18
Plantations	Social Forestrv		0.44	0.40
	Plantation on OB Dump		0.14	0.13
	Plantation on Backfill		1.32	1.19
	Total Plantation (C)		1.90	1.72
	Total Vegetation (A+B+C)		**17.64**	**15.93**
Agriculture	Crop Land		23.35	21.09
	Fallow Land		46.64	42.12
	Total Agriculture Land		**69.99**	**63.21**
Mining Area	Coal Quarry		1.51	1.36
	Coal Dump		0.27	0.24
	Barren OB Dump		0.53	0.48
	Barren Backfilled Area		2.56	2.31
	Quarry Filled with Water		0.11	0.10
	Advanced Quarry Site		0.10	0.09
	Total Mining Area		**5.08**	**4.59**
Waste Lands	**Waste Land**		**8.78**	**7.93**
Water Bodie	**Rivers, Lakes, Nalas etc.**		**6.72**	**6.07**
Settlement	Rural		1.47	1.33
	Urban		0.73	0.66
	Industrial		0.31	0.28
	Total Settlements		**2.51**	**2.27**
All Total			**110.72**	**100.00**

Plate 2: LU / LC Map of Umrer CF based on Landsat 8 (OLI) Data of Year 2014

Table 3.2 Status of Land Use/ Cover Pattern in Umrer Coalfield During Year 2011 and 2014								
Classes		Year 2011		Year 2014		Change w.r.t. Yr 2011		
		Area Km^2	%	Area Km^2	%	Area Km^2	%	Remarks
Level I	Level II							
Vegetation Cover	Open Forest(A)	1.33	1.20	1.15	1.04	-0.18	-0.16	Due to biotic interference by local people and coal mining
	Scrubs(B)	13.57	12.26	14.59	13.18	1.02	0.92	
	Plantation on OB Dump	0.10	0.09	0.14	0.13	0.04	0.03	Due to plantation Carried out by WCL
	Plantation on Backfill	0.84	0.76	1.32	1.19	0.48	0.44	
	Social Forestry	0.45	0.41	0.44	0.40	-0.01	-0.01	
	Total Plantation(C)	1.39	1.25	1.90	1.72	0.51	0.46	
	Total (A+B+C)	16.29	14.71	17.64	15.93	1.35	1.22	
Agriculture	Crop land	24.96	22.54	23.35	21.09	-1.61	-1.45	Due to industrialization
	Fallow Land	46.83	42.30	46.64	42.12	-0.19	-0.18	
	Total	71.79	64.84	69.99	63.21	-1.80	-1.63	
Waste Land	Waste Land with/without scrub	8.30	7.50	8.78	7.93	0.48	0.43	Due to drying up of water bodies
Mining Area	Coal Quarry	1.50	1.36	1.51	1.36	0.01	0.01	Due to increase in mining activity total mining area has increased
	Advance Quarry Site	0.06	0.06	0.10	0.09	0.04	0.03	
	Barren OB Dump	0.38	0.34	0.53	0.48	0.15	0.14	
	Barren Backfill	2.77	2.50	2.56	2.31	-0.21	-0.19	
	Coal Dump	0.21	0.19	0.27	0.24	0.06	0.05	
	Water Filled Quarry	0.11	0.10	0.11	0.10	0.00	0.00	
	Total	5.04	4.55	5.08	4.59	0.04	0.03	
Water Body	River/ Ponds	6.97	6.29	6.72	6.07	-0.25	-0.22	Due to poor monsoon
Settlements	Urban Settlements	0.73	0.66	0.73	0.66	0.00	0.00	Due to rural and industrial development in the area
	Rural Settlements	1.34	1.21	1.47	1.33	0.13	0.12	
	Industrial Settlements	0.25	0.23	0.31	0.28	0.06	0.05	
	Total	2.33	2.10	2.51	2.27	0.18	0.17	
Total		110.72	100.00	110.72	100.00	0.00	0.00	

(Based on Landsat 8 / OLI Data)

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 divided in to rural, urban and industrial classes based on availability of infrastructure facilities. In the year 2011 total area of settlements in Umrer CF was 2.33 km^2 (2.10%). In year 2014 total area of settlements in Umrer CF is 2.51 km^2 (2.27%). There is an increase in total settlement by 0.18 km^2 which is 0.17% of the total area. This increase is due to rural and industrial development in the area.

Table 3.3 Status of Change in Settlement in Umrer Coalfield During Year 2011 and 2014

Classes		Year 2011		Year 2014		Change w.r.t. Yr 2011		Remarks
		Area Km^2	%	Area Km^2	%	Area Km^2	%	
Level I	Level II							
Settle-ments	Urban Settlements	0.73	0.66	0.73	0.66	0.00	0.00	Due to rural and industrial development in the area
	Rural Settlements	1.34	1.21	1.47	1.33	0.13	0.12	
	Industrial Settlements	0.25	0.23	0.31	0.28	0.06	0.05	
	Total	2.33	2.10	2.51	2.27	0.18	0.17	

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.

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

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

The variations in the vegetation cover classes are shown in Table 3.5.

Table 3.4 Status of Change in Vegetation Cover in Umrer Coalfield During Year 2011 and 2014

Classes		Year 2011		Year 2014		Change w.r.t. Yr 2011		
		Area Km^2	%	Area Km^2	%	Area Km^2	%	Remarks
Level I	Level II							
Vegeta-tion Cover	Open Forest(A)	1.33	1.20	1.15	1.04	-0.18	-0.16	Due to biotic interference by local people and coal mining
	Scrubs(B)	13.57	12.26	14.59	13.18	1.02	0.92	
	Plantation on OB Dump	0.10	0.09	0.14	0.13	0.04	0.03	Due to plantation Carried out by WCL
	Plantation on Backfill	0.84	0.76	1.32	1.19	0.48	0.44	
	Social Forestry	0.45	0.41	0.44	0.40	-0.01	-0.01	
	Total Plantation(C)	1.39	1.25	1.90	1.72	0.51	0.46	
	Total (A+B+C)	16.29	14.71	17.64	15.93	1.35	1.22	

▪**Open Forest** – Forest having crown density between 10%-40% comes under this class. In the year 2011 total area of open forest in Umrer CF was 1.33 km^2 (1.20%). In year 2014 total area of open forest in Umrer CF is 1.15 km^2 (1.04%). There is a decrease in total open forest by 0.18 km^2 which is 0.16% of the total area. This decrease is due to biotic interference by local people and coal mining.

▪**Scrubs** – Scrubs are vegetation with crown density less than 10%. Scrubs in the coalfield are seen to be scattered signature all over the area mixed with waste land and fallow land. There was 13.57 km^2 scrubs i.e. 12.26% of the coal field area present in 2011. In current year 14.59 km^2 i.e. 13.18% scrub is present. So there is a increase of 1.02 km^2 which is 0.92% of the total coal-field. This increase is on account of degradation of open forest area and growth of scrub in fallow and waste lands.

▪**Plantation Over OB Dump and Backfilled Area** – Analysis of the data reveals that plantation over ob dumps and backfilled area are estimated to be 1.46 km^2 i.e. 1.32% of total coalfield in current year. Whereas in 2011 plantation was 0.94 km^2 i.e. 0.85% of coalfield. The 0.52 km^2 i.e. 0.47% increase is due to massive plantation carried out by WCL.

▪**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 0.01 km^2 social forestry, i.e. 0.01% of total coalfield is present in current year. This negligible decrease is due to mining activities.

3.3.3 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.

The variations in the mining area classes are shown in Table 3.6

Table 3.5 Status of Change in Mining Area in Umrer Coalfield During Year 2011 and 2014

Classes		Year 2011		Year 2014		Change w.r.t. Yr 2011		Remarks
		Area Km^2	%	Area Km^2	%	Area Km^2	%	
Level I	Level II							
Mining Area	Coal Quarry	1.50	1.36	1.51	1.36	0.01	0.01	Due to increase in mining activity total mining area has increased
	Advance Quarry Site	0.06	0.06	0.10	0.09	0.04	0.03	
	Barren OB Dump	0.38	0.34	0.53	0.48	0.15	0.14	
	Barren Backfill	2.77	2.50	2.56	2.31	-0.21	-0.19	
	Coal Dump	0.21	0.19	0.27	0.24	0.06	0.05	
	Water Filled Quarry	0.11	0.10	0.11	0.10	0.00	0.00	
	Total	5.04	4.55	5.08	4.59	0.04	0.03	

In the year 2011 coal quarry was 1.50 km^2 which has increased to 1.51 km^2 in year 2014. This minor increase is due to increase in production of coal from open cast areas. In 2011 barren ob dump was 0.38 km^2 (0.34%) which has been increased to 0.53 km^2 (0.48%). This increase of 0.15 km^2 (0.14%) refers to increased mining activities. Barren backfilled area has been reduced to 2.56 km^2 (2.31%) from 2.77 km^2 (2.50%). As the area under plantation on backfilled area increased, the area under barren backfilled area decreased. In current year total mining area covers 5.08 km^2 (4.59%) while in 2011 area under mining activities was 5.04 km^2 (4.55%). Due to increase in mining activities total mining area has been increased by 0.04 km^2 i.e. 0.03% of the total coalfield.

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.

The variations in the agriculture area classes are shown in Table 3.7

Table 3.6 Status of Change in Agriculture Area in Umrer Coalfield During Year 2011 and 2014

Classes		Year 2011		Year 2014		Change w.r.t. Yr 2011		Remarks
		Area Km^2	%	Area Km^2	%	Area Km^2	%	
Level I	Level II							
Agriculture	Crop land	24.96	22.54	23.35	21.09	-1.61	-1.45	Due to industrialization
	Fallow Land	46.83	42.30	46.64	42.12	-0.19	-0.18	
	Total	71.79	64.84	69.99	63.21	-1.80	-1.63	

Analysis of data reveals that agriculture land in Umrer Coalfield area decreased from 71.79 km^2 (64.84%) to 69.99 km^2 (63.21%). This decrease of 1.80 km^2 (1.63%) is due to industrialization in coalfield area.

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 variations in the wasteland area classes are shown in Table 3.8

Table 3.7 Status of Change in Wasteland in Umrer Coalfield During Year 2011 and 2014

Classes		Year 2011		Year 2014		Change w.r.t. Yr 2011		
		Area Km^2	%	Area Km^2	%	Area Km^2	%	Remarks
Level I	Level II							
Waste Land	Waste Land with/without scrub	8.30	7.50	8.78	7.93	0.48	0.43	Due to drying up of water bodies

Analysis of data reveals that in Umrer Coalfield, wasteland covers an area of 8.78 km^2 (7.93%). In 2011 it was 8.30 km^2 (7.50%). This increase of 0.48 km^2 (0.43%) in waste land area is on account of drying up of water bodies due to poor monsoon and due to degradation of open forest area.

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 study area have been estimated to be 6.72 km^2 (6.07%). In 2011 it had been estimated to be 6.97 km^2 (6.29%). The decrease of water bodies by 0.25 km^2 (0.22%) is due to poor monsoon.

Table 3.8 Status of Change in Water Body in Umrer Coalfield During Year 2011 and 2014

Classes		Year 2011		Year 2014		Change w.r.t. Yr 2011		
		Area Km^2	%	Area Km^2	%	Area Km^2	%	Remarks
Level I	Level II							
Water Body	River/ Ponds	6.97	6.29	6.72	6.07	-0.25	-0.22	Due to poor monsoon

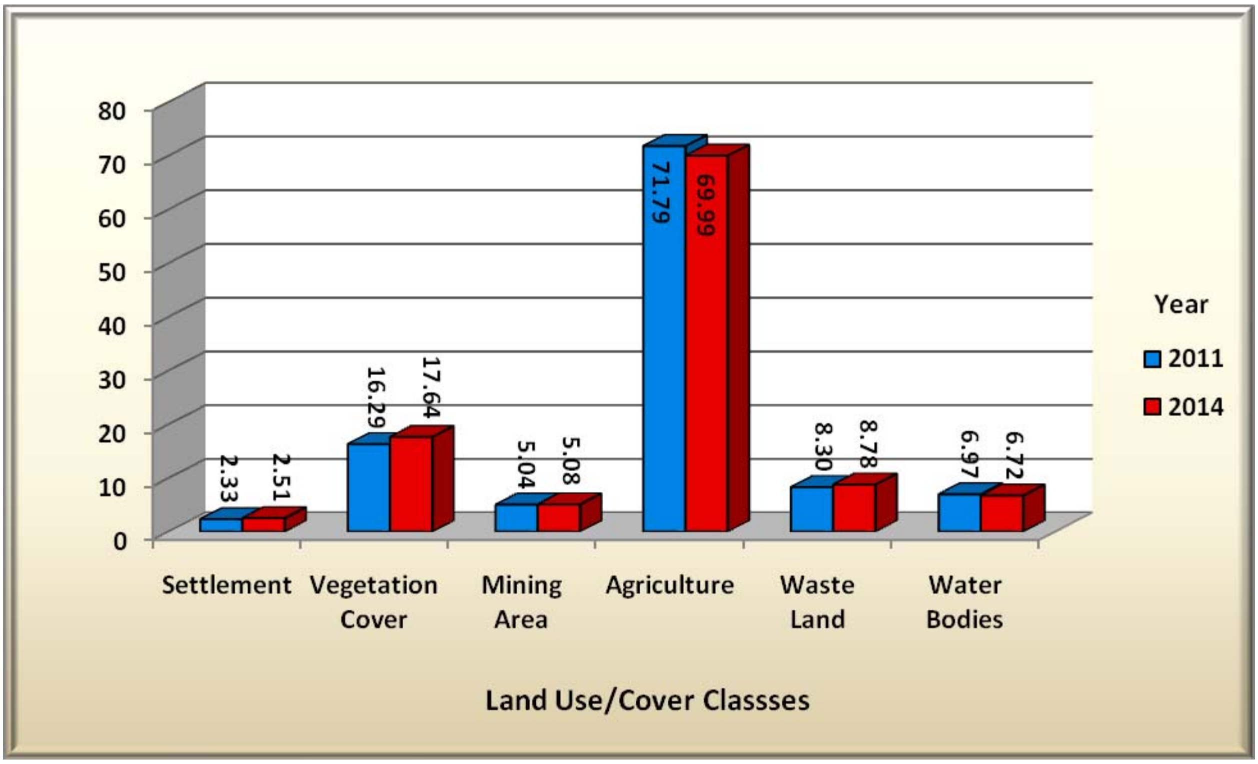


Figure 3.1: Year wise Comparison of Land Use/Cover in Umrer Coalfield

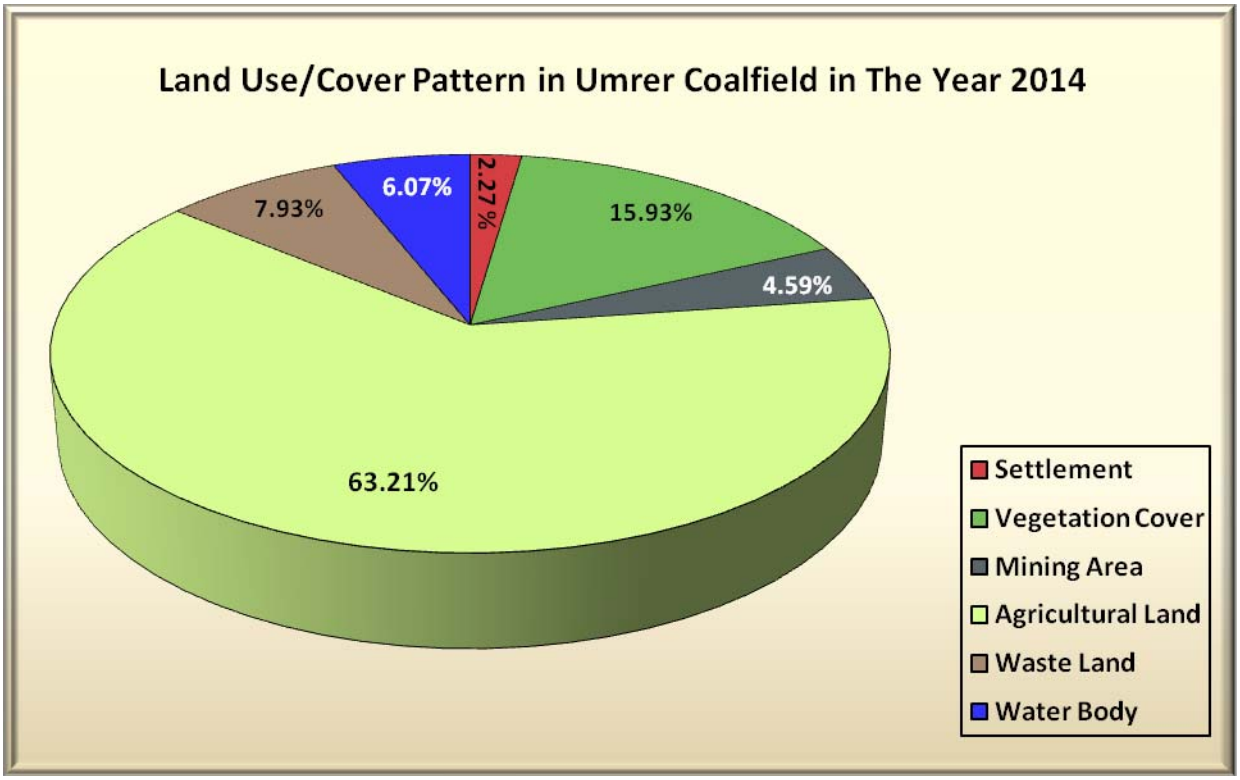


Figure: 3.2

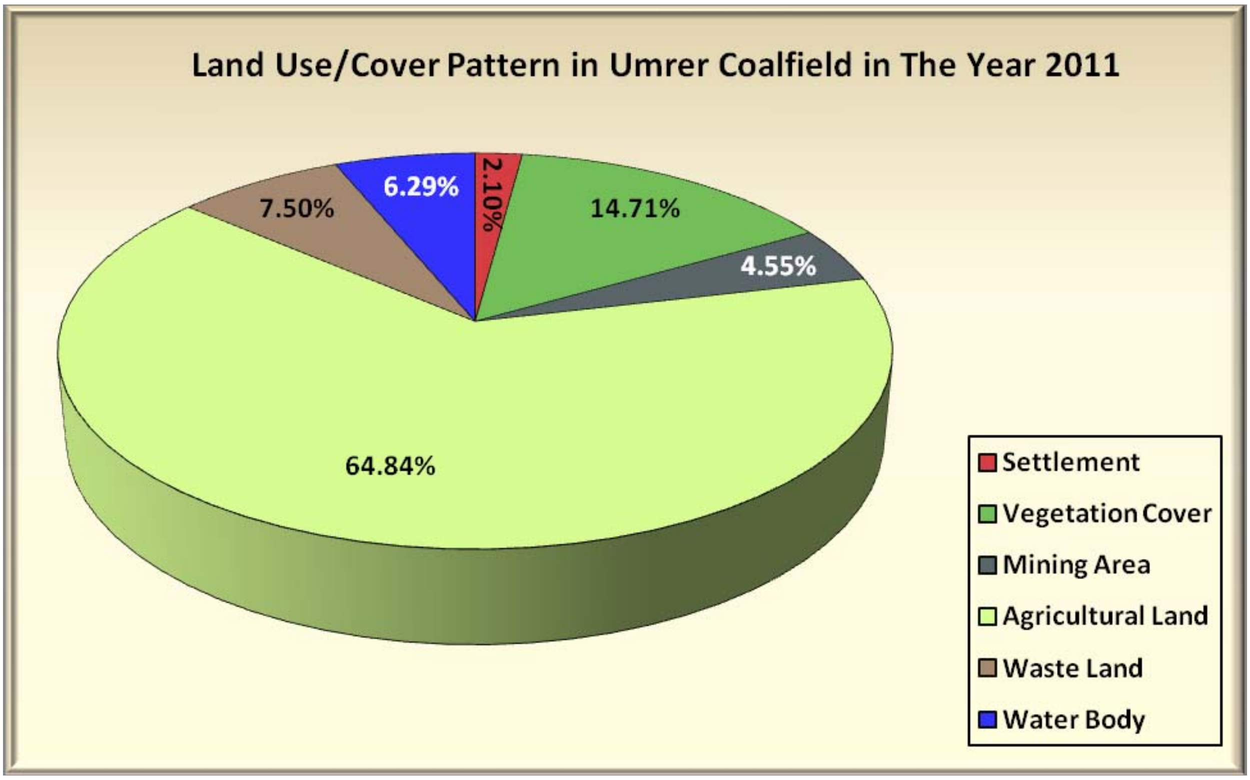


Figure: 3.3

Chapter 4

Conclusion & Recommendation

4.1 Conclusion

In the present study, land use/ vegetation cover mapping has been carried out, based on Landsat 8 OLI data in order to generate the geo-environmental data-base 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 helps in formulating the mitigation measures required, if any.

Study reveals that the settlements in the Umrer Coalfield are a mix of urban, rural and industrial which covers an area of 2.51 km^2 (2.27%). There is an increase in settlements by 0.18 $km^{2.}$ This increase is due to rural and industrial development in the area. Vegetation cover which includes open forests, scrubs, social forestry, plantation on ob dump and backfill, covers an area of 17.64 km^2 (15.93%). As compared to 2011 study there is an increase in overall vegetation cover by 1.35 km^2 (1.22%). This is mainly due to massive plantation carried out by WCL. The study further indicates that total agricultural land which includes crop and fallow land covers an area of 69.99 km^2 (63.21%). This has decreased by 1.80 km^2 (1.63%) due to industrialization in the study area. The mining area which includes coal quarry, barren ob dumps, barren backfilled area, coal dumps, advanced mining area and water filled quarry covers 5.08 km^2 (4.59%). This has been increased by 0.04 km^2 (0.03%) due to increase in mining activities. Waste lands have increased by 0.48 km^2 (0.43%) due to drying up of water bodies and degradation of open forest areas. Area covered by surface water bodies, decreased by 0.25 km^2 (0.22%) due to poor monsoon.

4.2 Recommendation

Keeping in view the sustainable development together with coal mining in the area, it is recommended that similar study should be carried out regularly to monitor the land use and vegetation cover status and impact of coal mining on land environment. This study identifies both the potential positive and negative impacts of the project. For those negative impacts upon the natural and the socio-economic environment, possible paths/ mitigation measures were identified in advance. These enable avoidance and/or minimization of impacts and make the project environmentally friendly and acceptable to the nearby community.

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