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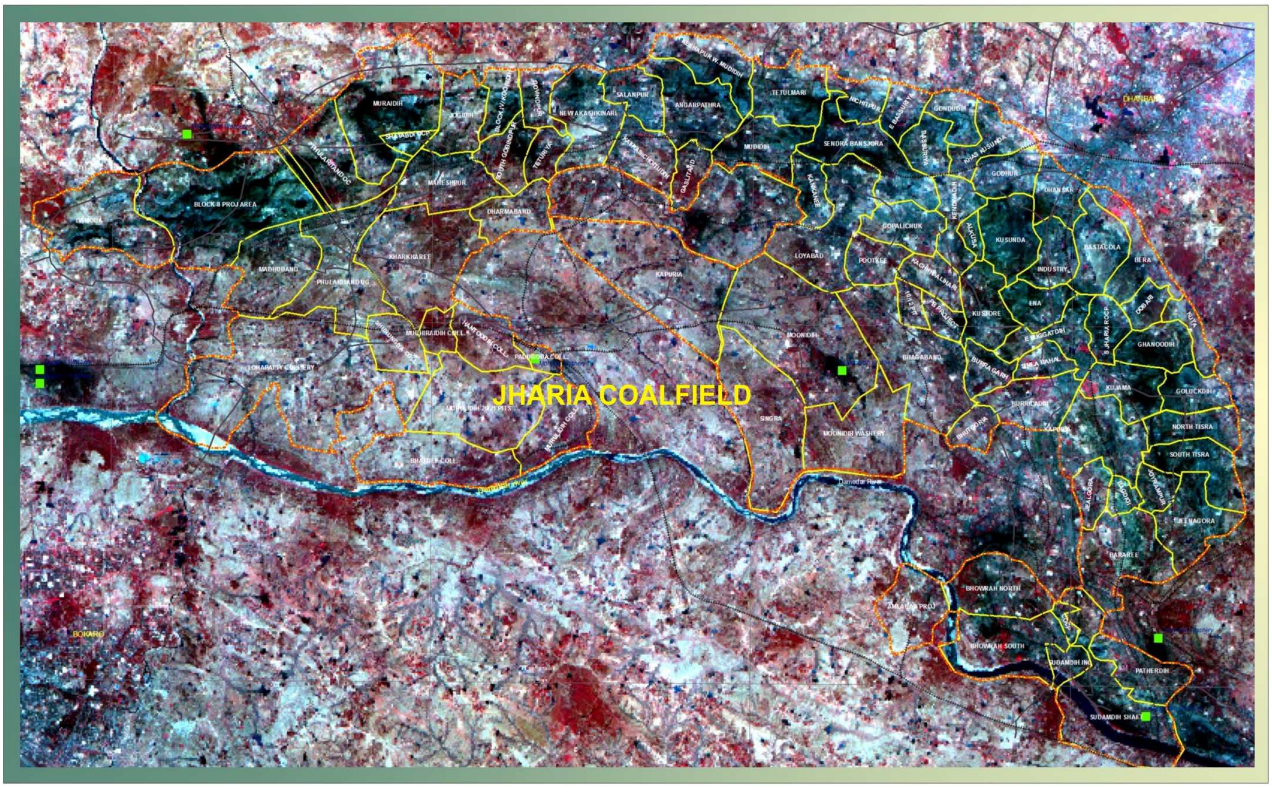
REPORT ON LAND USE/ VEGETATION COVER MAPPING OF JHARIA COALFIELD BASED ON SATELLITE DATA YEAR-2008



Submitted to

COAL INDIA LIMITED

March 2010

CMPDI
A MINI RATNA COMPANY

Land use/Land cover Mapping of Jharia Coalfield based on Satellite Data of the Year- 2008

March-2010

Remote Sensing Cell
Geomatics Division
CMPDI, Ranchi

Document Control Sheet

(1)	Job No.	RSC/561410027
(2)	Publication Date	March 2010
(3)	Number of Pages	28
(4)	Number of Figures	7
(5)	Number of Tables	6
(6)	Number of Plates	2
(7)	Title of Report	Land use / cover mapping of Jharia Coalfield on satellite data for the year 2008.
(8)	Aim of the Report	To prepare Land use / cover map of Jharia Coalfield on 1:50000 scale for creating the environmental data base for land, vegetation cover, drainage ,surface water and infrastructure.
(9)	Executing Unit	Remote Sensing Cell, Geomatics Division Central Mine Planning & Design Institute Limited, Gondwana Place, Kanke Road, Ranchi 834008
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(12)	Security Restriction	Restricted Circulation
(13)	No. of Copies	5
(14)	Distribution Statement	Official

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Chapter 1

Introduction

1.1 Project Reference

In view of creating the geo-environmental data base of coalfields for monitoring the impact of coal mining on land use and vegetation cover, Chairman, Coal India Ltd.(CIL) directed Central mine Planning & Design Institute (CMPDI) to take up the study based on satellite data using Remote Sensing technique. Accordingly, a road map for implementation of the project was submitted to Coal India Ltd. for land use and vegetation cover mapping of 28 major coalfields at regular interval of three years for creating the environmental data base. In pursuant to the work order no.CIL/WBP/Env/2009/2428 dated 29.12.009; land use/vegetation cover mapping of Jharia coalfield based on satellite data was taken up to create the geo-environmental data base for assessing the impact of coal mining on land and vegetation cover at regular interval of three years..

1.2 Objective

The objective of the present study is to prepare a regional land use and vegetation cover map of Jharia coalfield on 1:50,000 scale based on satellite data of the year 2008, 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 regular 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.

1.4 Location of the Area & Accessibility

The Jharia Coalfield (JCF) is located in the north east part of the State of

Jharkhand, approximately 260 km west of Kolkata. It is linked to Kolkata and Delhi through NH 2, which is the part of Golden Quadrilateral highway network of India. The coalfield contains proven coal reserves of approximately one billion tonnes in a crescent-shaped basin of approximately 400 km^2. BCCL operates within an area of approximately 258 Sq km. The Jharia coalfield covers an area of about 393 sq km. it is bounded by Lat $23^0$49'0.63"N and $23^0$38'36.50"N and Long $86^0$08'49.91"E and $86^0$25'54.92E. The major part of coalfield (about 400 sq km) lies in Dhanbad district of Jharkhand. Coalfield is connected by Major Highways road with Ranchi (117 km), Asansol (60 km), Jamshedpur (108 km) and Dhanbad (8 km). The nearest major railway station is Dhanbad, located on Delhi-Howrah Grand Chord line oh East Central Railway which passes parallel to northern boundary of the coalfield.

1.5 Physiography

Jharia coalfield is characterized by gently undulating to a rolling topography with an overall slope towards east-southeast. The coalfield is roughly sickle shaped on plan and occurs as a basin with its axis trending broadly east-west and plunging towards the west. The southern flank is truncated by a major Boundary Fault. The general dip of the formation is 10 to 15 degrees. Flatter dips have also been noted at places. The entire southern part of Jharia coalfield in the vicinity of the Boundary Fault, however shows generally steep dipping beds with amounts increasing even up to 70 degrees.

The strike of the formation is generally WSW to ENE in the western part and WNW to ESE in the southern part of the coalfield. This gradually swings to EW in the centre of the coalfield and then to NS further east. In the south-eastern part the strike is generally WNW-ESE. Besides the boundary part the coalfield is traversed by a number of other major and minor faults.

The Barakar formation contains 18 standard coal horizons (numbered I to XVIII). Of the Barakar formations, the coal seams XIII and above are generally thin and of relatively superior quality. Seams XII to IX/X are of medium to superior quality and attain sizable thickness at places. The V,VI,VII,IV, III & II are generally thick seams of inferior quality. The bottom most seam I is of superior medium coking quality in the eastern part of the coalfield.

The drainage pattern in the Jharia coalfield is dendritic in nature. This may be due to more or less homogeneous lithology and structural controls. Damodar river is the main control of drainage system along the Jharia coalfield. It is a fourth order stream to which a number of third to first order streams, viz. Jamunia, Khudia, Katri, Ekra, Tisra, Chatkari etc. join. Damodar river flows along the southern periphery of the coalfield and is guided by the Great Boundary Fault. The main flow direction is from west to east.

A map of India showing the location of Jharia Coalfield is given in Fig1.1.

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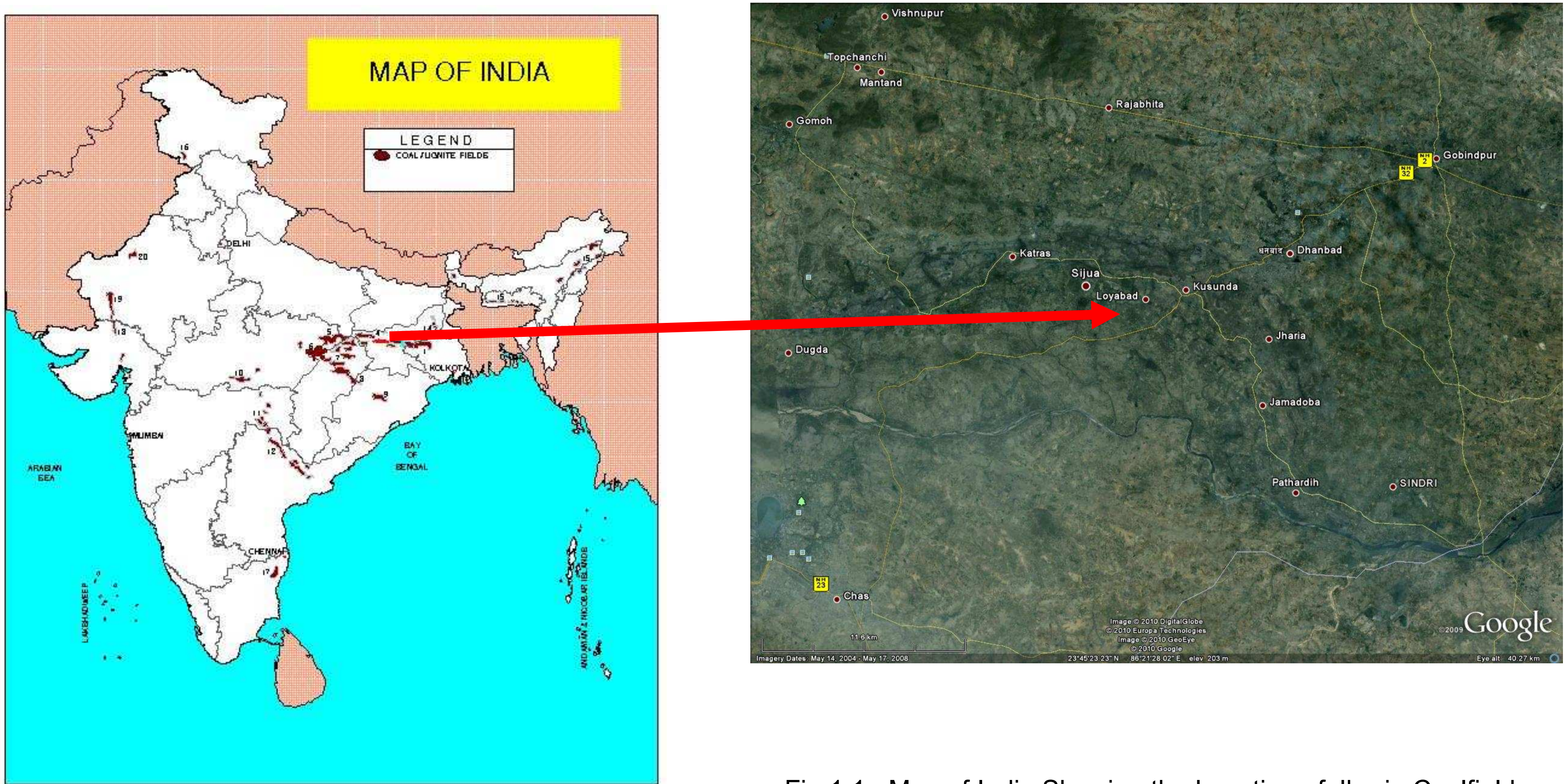

Fig 1.1 : Map of India Showing the Location of Jharia Coalfields

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.

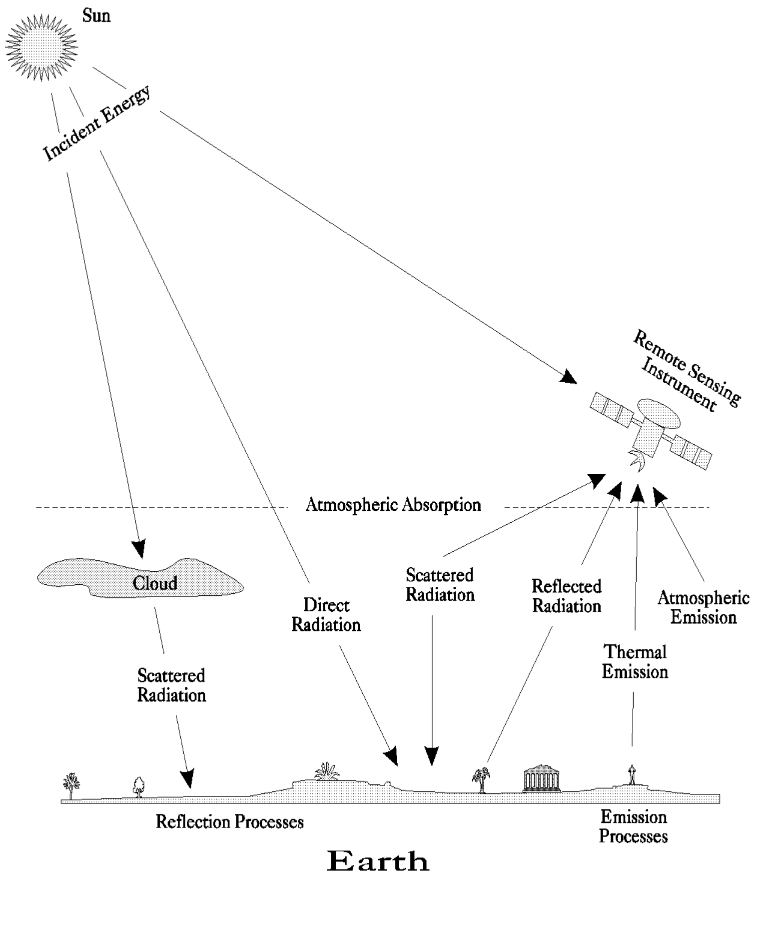

Figure 2.1 Remote sensing radiation system

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.

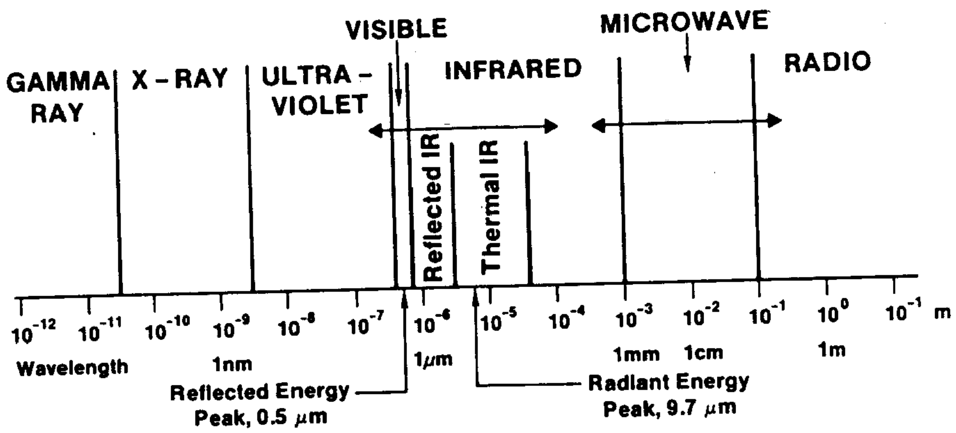

Figure 2.2 Electromagnetic spectrum. Expanded versions of the visible, infrared and microwave regions are shown in Figure 2.3.

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).

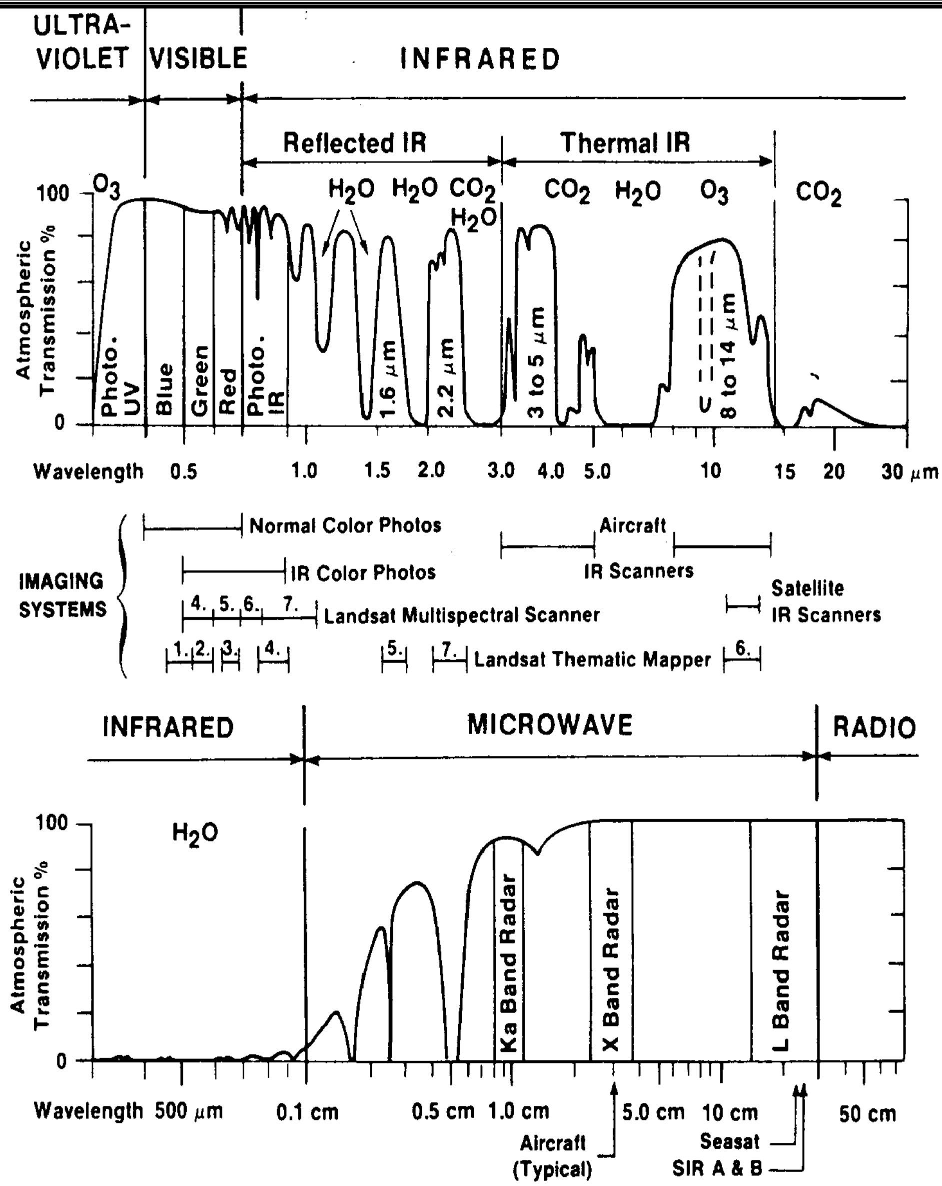

Figure 2.3 Expanded diagrams of the visible and infrared regions (upper) and the microwave regions (lower) showing atmospheric windows. Wavelength bands of commonly used remote sensing systems are indicated. Gases responsible for atmospheric absorption are shown.

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. IBCCLudes 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 Videocon 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 records 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** –Raw satellite data, obtained from National Remote Sensing Centre (NRSC), Hyderabad, as follows, was used as primary data source for the study.
  IRS P6/ LISS III; Band 2,3,4,5; Path # 106, Row # 055; Date of pass 11.01.2008*.
  The detail specification of the data is also given in Table 2.2.

- **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.

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 IRS-P6 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
IRS- P-6	LISS-III	B2 B3 B4 B5	0.52 0.62 0.77 1.55	- - - -	0.59 0.68 0.86 1.70	Green Red NIR MIR	7-bit (128-grey levels)	23.5 m 23.5 m 23.5 m 70.5 m	24 days	India
NIR: Near Infra-Red MIR: Middle Infra-Red										

2.6 Data Processing

The 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.

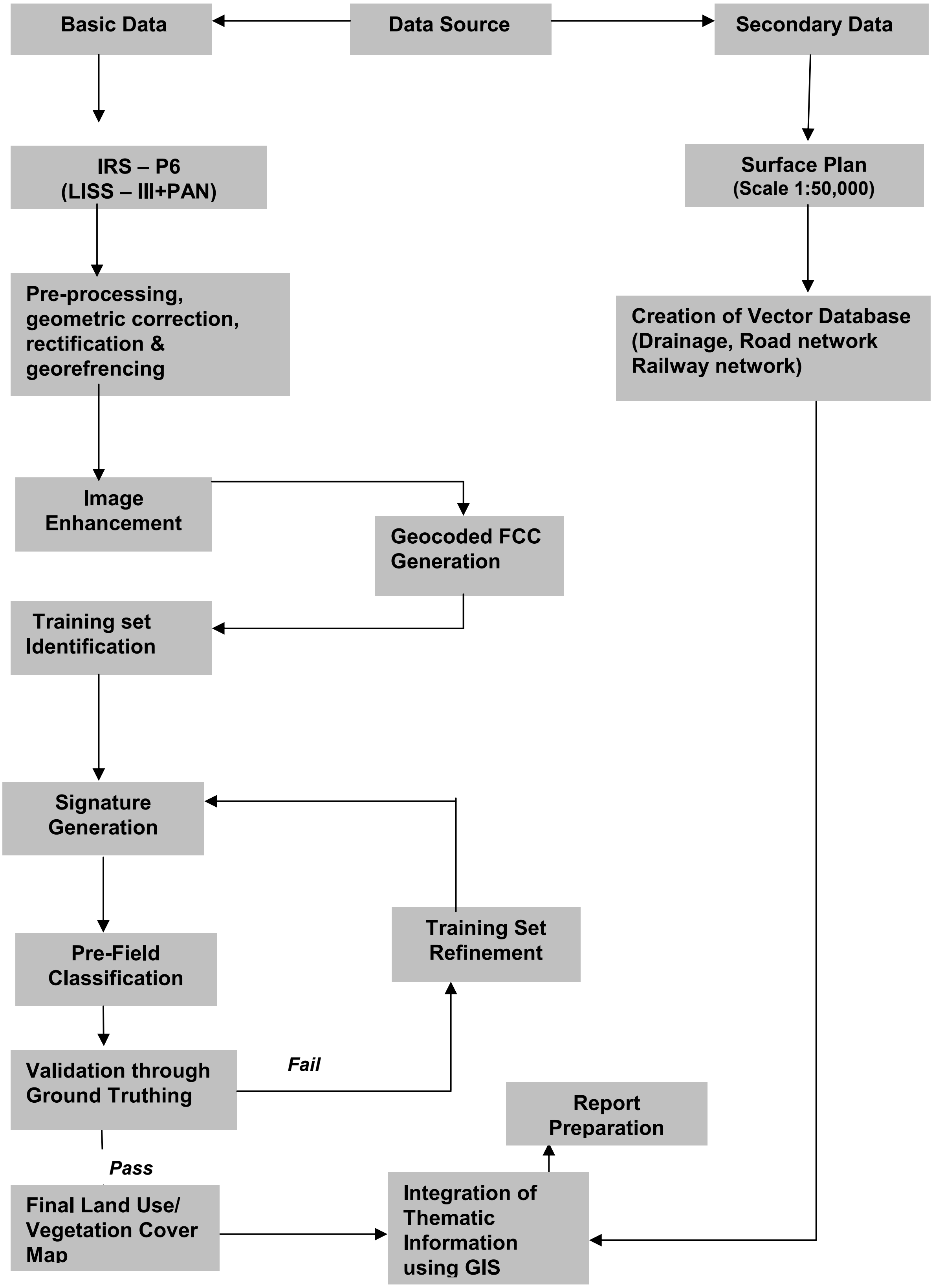

Fig 2.4 : Methodology for Land Use / Vegetation Cover Mapping

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*.

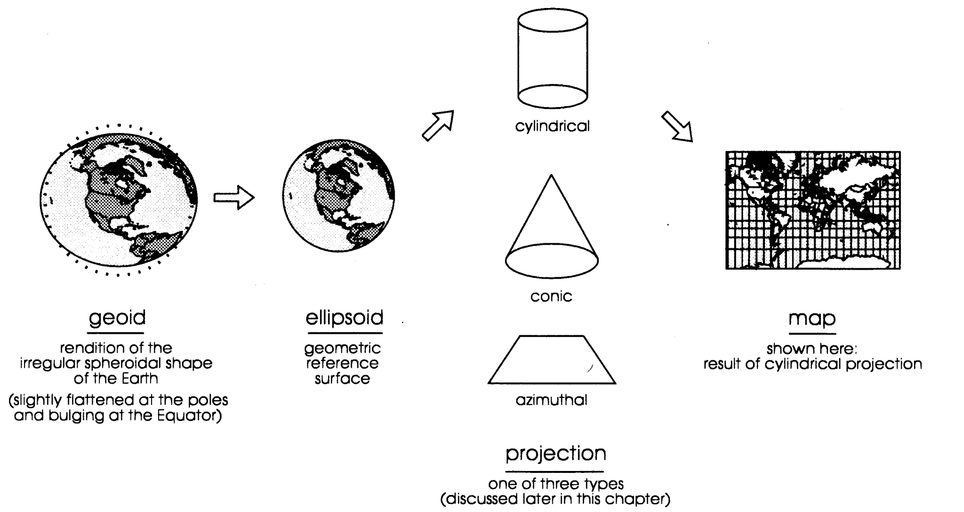

Fig 2.5 : Geoid – Ellipsoid – Projection Relationship

In the present study, ***Polyconic projection*** *along with* ***Modified Everest 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 this projection is 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 9.3 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 were applied on the image data using ERDAS Imagine 9.3 s/w. The enhanced and geocoded FCC (False colour composite) image of Jharia Coalfield is shown in Plate No. 1 for the year 2008.

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 9.3 s/w. The classified image for the year 2008 for Jharia Coalfield is shown in Drawing No. HQREMA10002.

2.6.5 Creation/overlay of vector database in GIS

Plan showing leasehold areas of mining projects supplied by BCCL 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 2008 was found to be 88.59%.

2.6.7 Interpretation of Data

Interpretation of data for Land Use/vegetation cover was carried out through GIS by analysing the Land Use/ vegetation Cover map of the year 2008. Final Land Use/vegetation cover maps (on 1:50,000 scale) were printed using HP Design jet 4500 Colour Plotter.

Table 2.3: Classification Accuracy Matrix for Jharia Coalfield in the year 2008

Sl.#	Vegetation\Land use classes as observed in the field	Built-up land	Vegetation Cover	Agriculture	Wasteland	Mining Area	Water Bodies	Total no. of observation points (Z)	% of observation points	% of classification accuracy	% of omission
		Land use/vegetation cover Classes based on Satellite Data									
(b)	Vegetation Cover		16	2				18	20.00	**88.89**	11.12
(g)	Mining Area				1	7		8	8.89	**87.5**	12.5
(c)	Agriculture		2	18				20	22.22	**90.00**	10.00
(d)	Wasteland	1			24		1	26	28.89	**92.31**	7.69
(a)	Built-up land	13			1			14	15.56	**92.86**	7.14
(h)	Water Bodies					1	4	5	5.56	**80.0**	20.0
Total no. of observation points (X)		14	18	20	26	8	5	90	–	**88.59**	–
% of Commission		7.14	11.11	10.00	7.69	12.5	20.0				

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 resolution offers comprehensive and accurate information for mapping and monitoring of land use/cover pattern, dynamics of changing pattern and trends over a period of time.. By analysing the data of different cut-off dates, impact of coal mining on land use and vegetation cover can be determined.

3.2 Land Use / Vegetation Cover Classification

The array of information available on land use/cover requires 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 Agency, 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 2008. Following land use/cover classes are identified in the Jharia coalfield region (Table 3.1).

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

	LEVEL –I	LEVEL-II
1	**Vegetation Cover**	3.1 Dense Forest 3.2 Open Forest 3.3 Scrub 3.4 Plantation under Social Forestry 3.5 Plantation on OB Dumps
2	**Mining Area**	5.1 Coal Quarry 5.2 Advance Quarry Site 5.3 Barren OB Dump 5.4 Barren Backfilled Area 5.5 Coal Dump 5.6 Water Filled Quarry
3	**Agricultural Land**	2.1 Crop Land 2.2 Fallow Land
4	**Wasteland**	4.1 Waste upland with/without scrubs 4.2 Fly Ash Pond 4.3 Sand Body
5	**Settlements**	1.1 Urban 1.2 Rural 1.3 Industrial
6	**Water Bodies**	6.1 River/Streams /Reservoir

3.3 Data Analysis

Satellite data of the year 2008 was processed using ERDAS Imagine v.9.3 image processing s/w in order to interpret the various land use and vegetation cover classes present in the Jharia coalfield. The analysis was carried out for entire coalfield covering about 393 sq. km.

The area of each class was calculated and analysed using *ERDAS Digital Image Processing* s/w and *ArcGIS* s/w. Analysis of land use / vegetation cover pattern in Jharia Coalfield in the year 2008 has been done and details are and shown in table 3.2.

TABLE – 3.2

STATUS OF LAND USE/COVER PATTERN IN JHARIA COALFIELD DURING YEAR 2008

LAND USE CLASSES	Area (Km^2)	%
SETTLEMENTS		
Urban Settlement	27.80	7.08
Rural Settlement	2.59	0.66
Industrial Settlement	3.44	0.80
Total Settlements	**33.82**	**8.61**
VEGETATION COVER		
FORESTS		
Dense Forest	0.29	0.07
Open Forest	8.53	2.17
Total Forest (A)	**8.82**	**2.24**
SCRUBS		
Scrubs (B)	**133.46**	**33.97**
PLANTATION		
Social forestry	17.71	4.51
Plantation on OB Dump	10.53	2.68
Total Plantation (C)	**28.24**	**7.19**
Total Vegetation (A+B+C)	**170.53**	**43.41**
MINING AREA		
Coal Quarry	7.19	1.83
Coal Dump	1.56	0.40
Quarry filled with water	0.43	0.11
Barren OB Dump	6.42	1.64
Barren Backfilled Area	9.35	2.38
Toal Mining Area	**24.96**	**6.35**
AGRICULTURE		
Crop Lands	4.69	1.19
Fallow Lands	34.90	8.88
Total Agriculture	**39.58**	**10.08**
WASTELANDS		
Wastelands	110.13	28.03
Ash pond/Slurry/ Tailing Ponds	0.26	0.07
Sand Body	1.55	0.39
Total Wastelands	**111.94**	**28.49**
WATERBODIES		
River, Lakes, Nallas, ponds, etc	12.02	3.06
TOTAL	**392.85**	**100.00**

3.3.1 Vegetation Cover

Vegetation cover in the coalfield area has been found to be predominantly of five classes.

- Dense Forest
- Open Forest
- Scrubs
- Plantation on Over Burden(OB) Dumps / Backfilled area, and
- Social Forestry

There has been significant variation in the land use under the vegetation classes within the area as shown below in Table 3.3.

TABLE – 3.3

Vegetation Cover in Jharia Coalfield during the year 2008

VEGETATION COVER	Area (Sq Km)	%
FORESTS		
Dense Forest	0.29	0.07
Open Forest	8.53	2.17
Total Forest (A)	**8.82**	**2.24**
SCRUBS		
Scrubs (B)	**133.46**	**33.97**
PLANTATION		
Social forestry	17.71	4.51
Plantation on OB Dump	10.53	2.68
Total Plantation (C)	**28.24**	**7.19**
Total Vegetation (A+B+C)	**170.53**	**43.41**

Dense forest – Forest having crown density of above 40% comes in this class. Dense forest over the area has decreased, basically due to deforestation by local inhabitants.. A total dense forest is estimated to be 0.29 sq km, i.e. 0.07% of the coalfield area.

Open Forest – Forest having crown density between 10% to 40% comes under this class. Open forest cover over Jharia coalfield is 8.53 sq km, i.e. 2.17 % of the coalfield area.

Scrubs – Scrubs are vegetation with crown density less than 10%. Scrubs in the coalfield is seen to be scattered signature al over the area mixed with wastelands. There is 133.46 sq km, of scrubs, ie 33.97% of the coalfield area.

Social Forestry – Plantation which has been carried out on wastelands, along the roadsides and colonies on green belt come under this category. Analysis of data reveals that there is 17.71 sq km, which is 4.51% of the coalfield area.

Plantation over OB Dump and backfilled area – Analysis of the data reveals that BCCL 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 plantaion on the OB dumps and backfilled areas are estimated to be 10.53 sq km, ie 2.68% of the coalfield area

3.3.2 Mining Area

The mining area was primarily been categorized as follows during the 2008 study.

- Coal Quarry
- Advance Quarry Site, and
- Barren OB Dump

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

- Barren Backfilled Area
- Coal Dumps
- Water filled Quarry

The status of land Use in the mining area over the Jharia Coalfield is shown in the table 3.4 below.

TABLE – 3.4

Distribution of Mining Area in Jharia Coalfield during the year 2008

MINING AREA	Area (Sq Km)	%
Coal Quarry	7.19	1.83
Coal Dump	1.56	0.40
Quarry filled with water	0.43	0.11
Barren OB Dump	6.42	1.64
Barren Backfilled Area	9.35	2.38
Toal Mining Area	**24.96**	**6.35**

3.3.3 Agricultural Land

Land primarily used for farming and production of food, fibre and other commercial and horticultural crops falls under this category. It includes crop land (irrigated and unirrigated) and fallow land (land used for cultivation, but temporarily allowed to rest)

Total agricultural land is 39.58 sq km in year 2008, which is 10.08 % of the coalfield area. The details are shown below in Table 3.5**.**

TABLE – 3.5

Agricultural land in Jharia Coalfield during the year 2008

AGRICULTURE	Area (Sq Km)	%
Crop Lands	4.69	1.19
Fallow Lands	34.90	8.88
Total Agriculture	**39.58**	**10.08**

3.3.4 Wasteland

Wasteland is degraded and unutilised class of land which is deteriorating on account of natural causes or due to lack of appropriate water and soil management. Wasteland can result from inherent/imposed constraints such as location, environment, chemical and physical properties of the soil or financial or management constraints. There are two types of wastelands predominant within the coalfield area, viz waste upland and fly ash pond.

The land use pattern within the area for waste lands is shown below in Table – 3.6.

TABLE – 3.6

Wastelands in Jharia Coalfield during the year 2008

WASTELANDS	Area (Sq Km)	%
Wastelands	110.13	28.03
Ash pond/Slurry/ Tailing Ponds	0.26	0.07
Sand Body	1.55	0.39
Total Wastelands	**111.94**	**28.49**

3.3.5 Settlements

All the man-made constructions covering the land surface are included under this category. Built-up land has been further divided in to rural, urban and industrial classes. In the present study, industrial settlement indicates only industrial complexes excluding residential facilities.

The details of the land use under this category are shown in Table 3.7 as follows:

TABLE 3.7

Distribution of Settlements in Jharia Coalfield during the year 2008

SETTLEMENTS	Area (Sq km)	%
Urban Settlement	27.80	7.08
Rural Settlement	2.59	0.66
Industrial Settlement	3.44	0.80
Total Settlements	**33.82**	**8.61**

3.3.6 Water bodies

It is the area of impounded water includes natural lakes, rivers/streams and man made canal, reservoirs, tanks etc**.** The water bodies in the study area have found to be 12.02 sq km in year 2008, which is 3.06%of the coalfield area.

Chapter 4

Conclusion & Recommendations

4.1 Conclusion

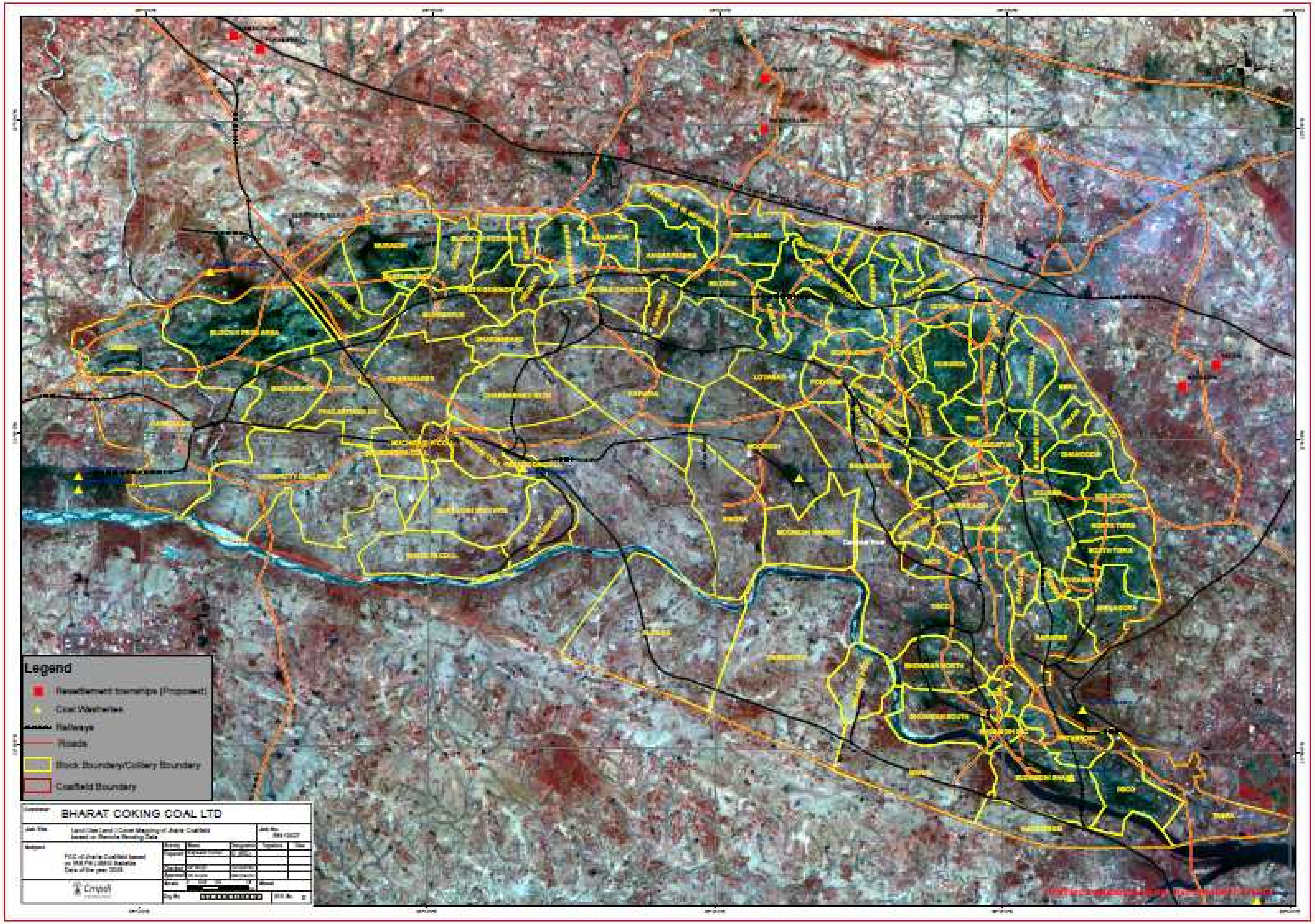
In the present study, land use/ vegetation cover mapping has been carried out based on IRS-P6/ LISS III satellite data of January, 2008 in order to generate the database on land use/vegetation cover in Jharia Coalfield for monitoring the impact of coal mining on land environment. The land use/cover data will help in assessing the impact of coal mining on land environment and helps in formulating the mitigation measures required, if any.

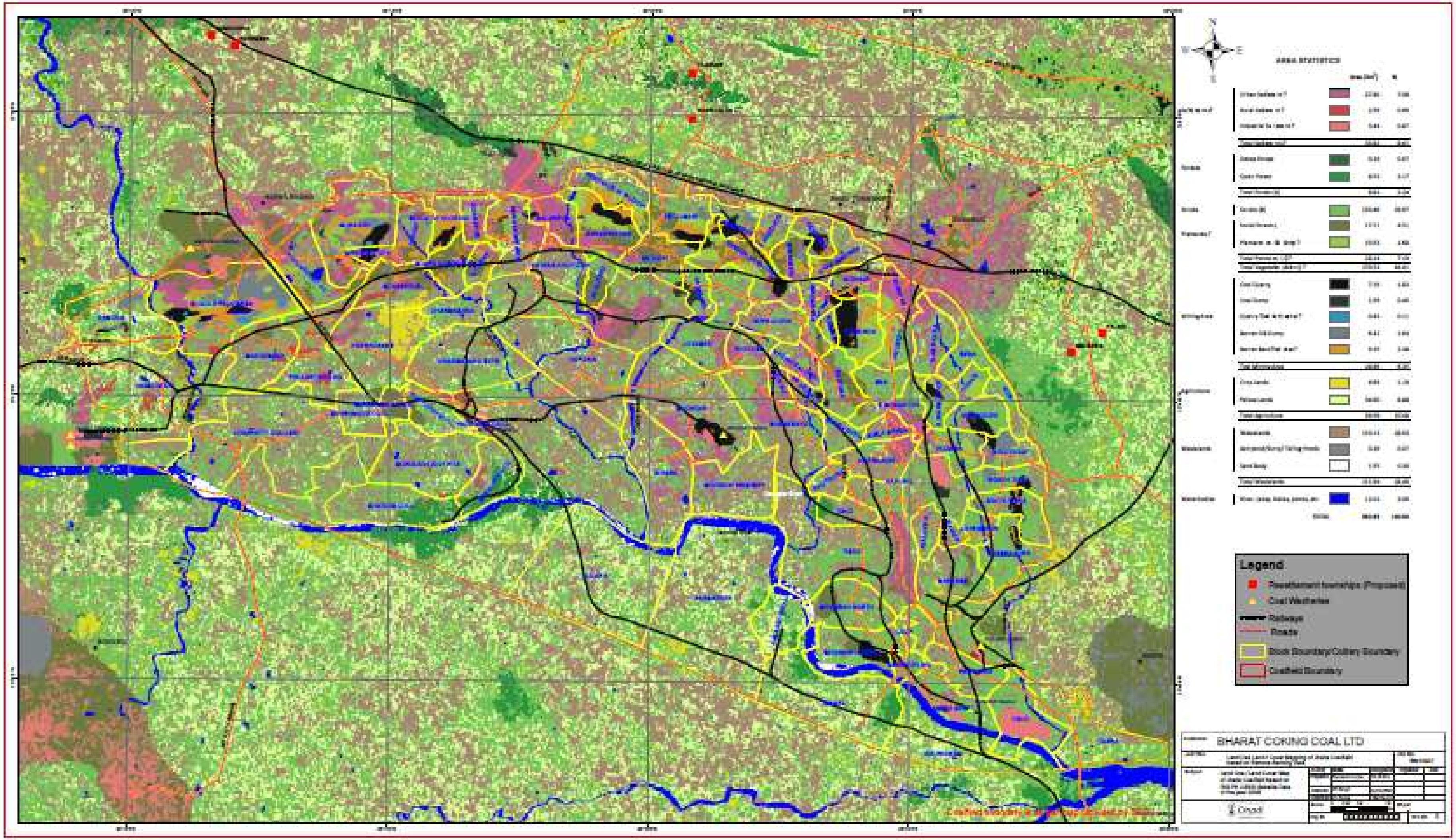
Study reveals that the total area of settlements which includes urban, rural and industrial settlements in the Jharia coalfields covers 33.82 km^2 (8.61%) area.. Vegetation cover which includes dense forests, open forests, scrubs, avenue plantation & plantation on over-burden dumps, covers an area of 170.53 km^2 (43.41%). The analysis further indicates that total agricultural land which includes both crop and fallow land covers an area of 39.58km^2 (6.35%). The mining area which includes coal quarry, advance quarry site, barren OB dump, barren backfilled area, covers 24.96 km^2 (6.35%) and wasteland covers 111.94 km^2 (28.49%). Surface water bodies covered area of 12.02 km^2 (3.06%) and Sand covered 1.55 km^2 (0.39 %) area.

The detail statistical analysis is given under Table-3.2.

4.2 Recommendations

Keeping in view the eco-fragile mixed terrain in the area, it is essential to maintain the ecological balance for sustainable development of the area together with coal mining. It is recommended that similar study should be carried out regularly at an interval of three years 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.


Legend
Resettlement townships (Proposed)
Coal Washeries
Railways
Roads
Block Boundary/Colliery Boundary
Coalfield Boundary
BHARAT COKING COAL LTD


AREA STATISTICS
Legend
Resettlement townships (Proposed)
Coal Washeries
Railways
Roads
Block Boundary/Colliery Boundary
Coalfield Boundary
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