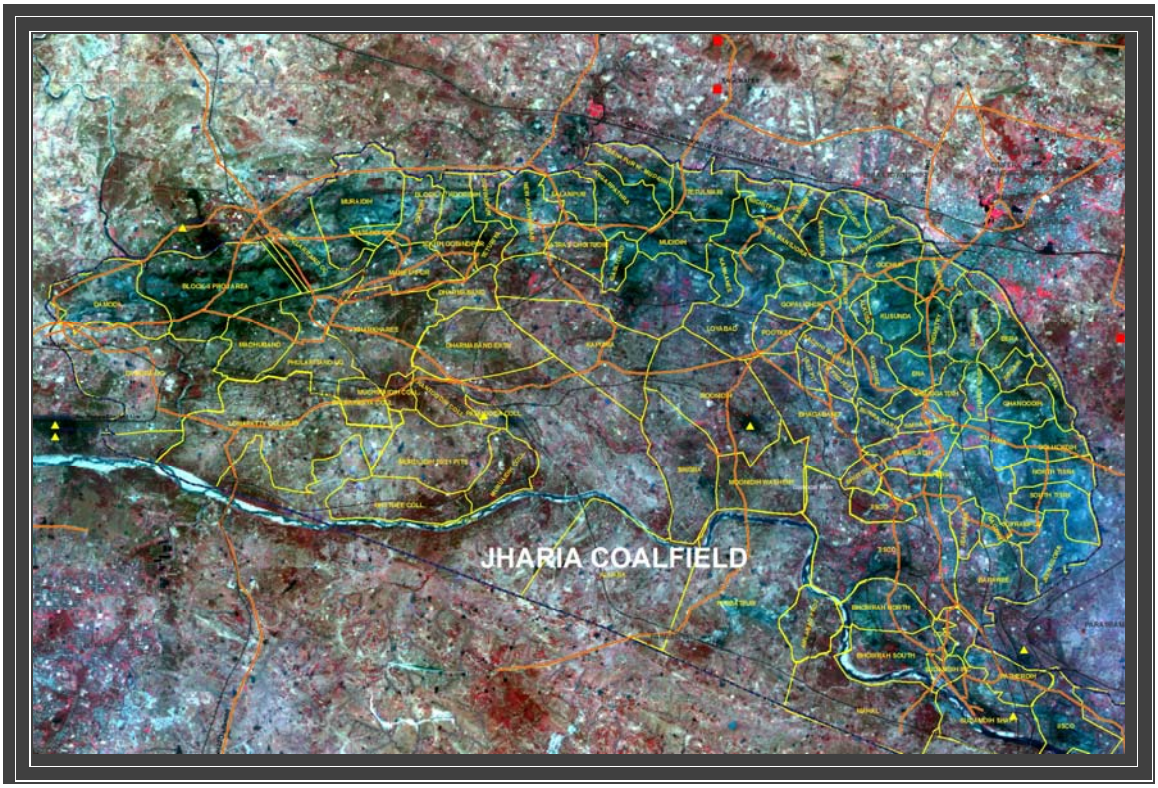
Vegetation Cover Mapping of Jharia Coalfield based on Satellite Data of the Year- 2016



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Remote Sensing Cell
Geomatics Division
CMPDI, Ranchi

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(11)	Authors	Ms Ayesha Parida, Assistant Manager (Remote Sensing)
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Chapter 1

Introduction

1.1 Project Reference

To monitor the regional impact of coal mining on land use pattern and vegetation cover in the 28 major coalfields at regular interval of three years based on remote sensing satellite data, Coal India Ltd. issued a work order to CMPDI vide letter no.CIL/WBP/ENV/2011/4706 dated 12.10.12. As the Impact of coal mining on land environment has to be assessed regularly at interval of three years, Geo-environmental data base for Jharia coalfield based on satellite data was prepared earlier in the year 2010, 2012 under the above project. The present study is based on the satellite data of the year 2016. BCCL vide their letter No BCCL/ DGM(Env)/File-/16/276 dated 25.05.2016 requested that the map of each cluster under Jharia Coalfield shall also be incorporated in the report for EC compliance. Therefore cluster-wise land use/cover maps are also included in this report.

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 2016, using digital image processing technique for monitoring the impact of coal mining and other industrial activities on land use and vegetation cover in the coalfield area in period of last three years.

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 and Geology

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 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 Main Boundary Fault. The main flow direction is from west to east.

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.

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

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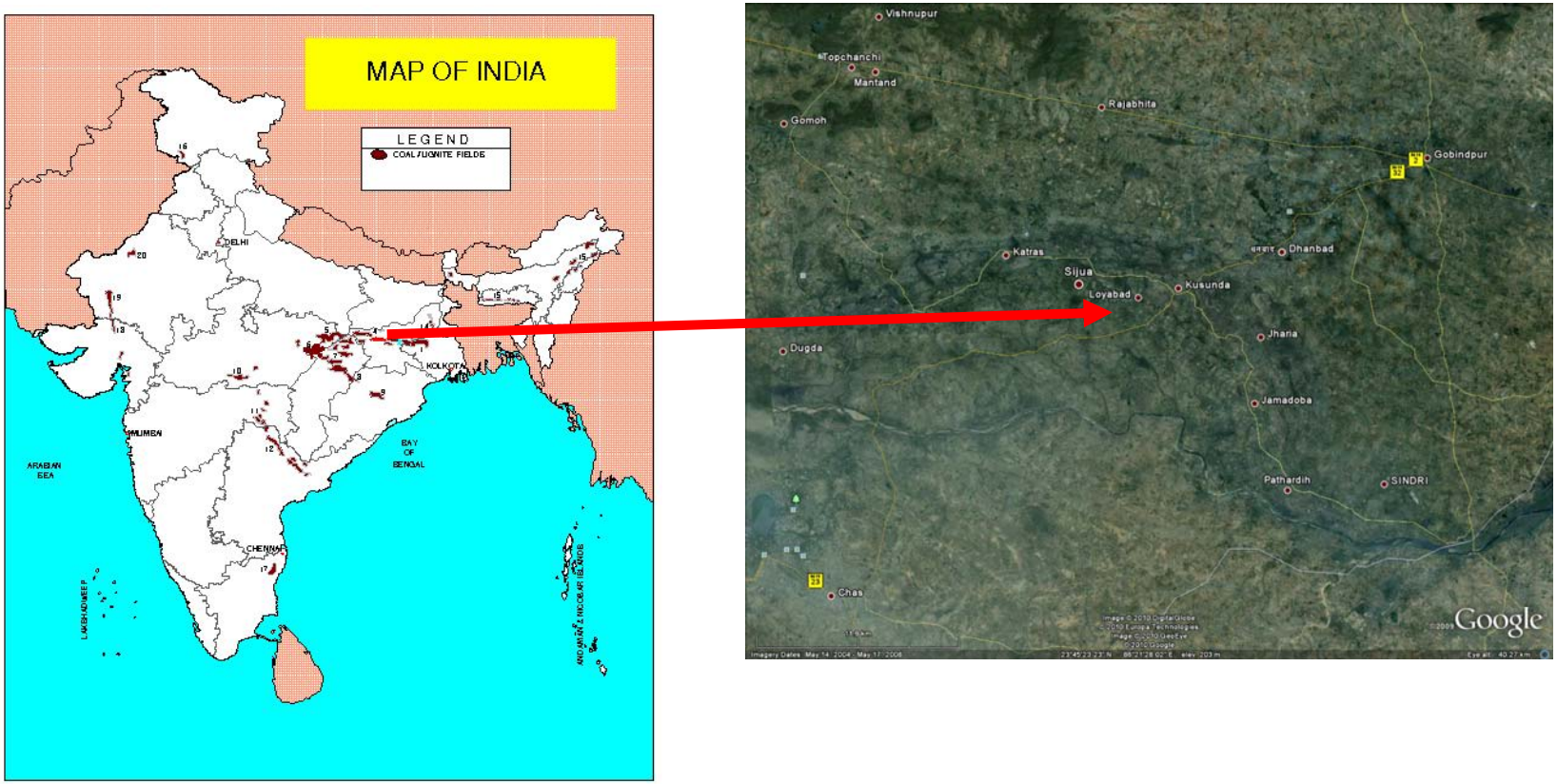


Fig 1.1: Map of India Showing the Location of Jharia Coalfields

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.

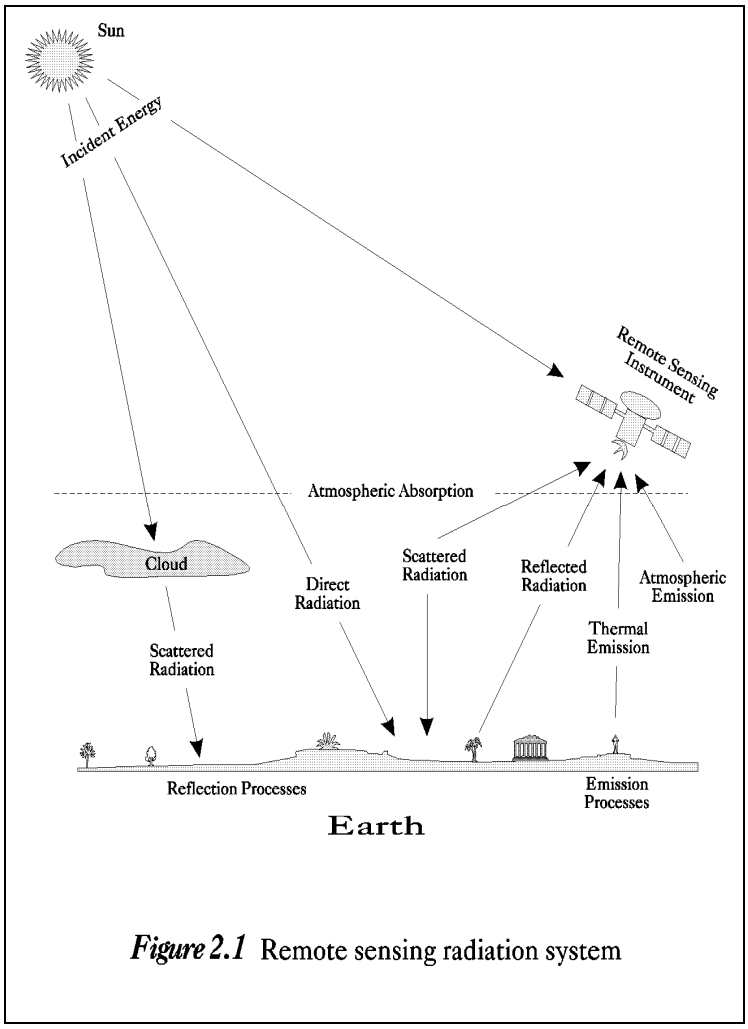


Figure 2.1 Remote sensing radiation system

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.

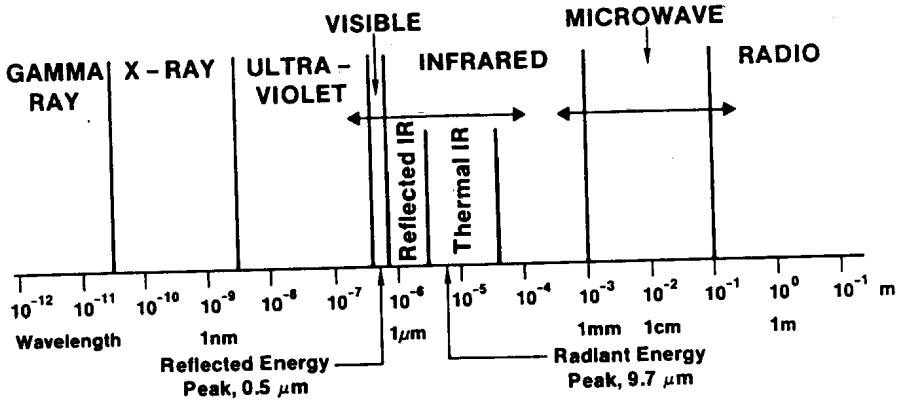


Figure 2.2 Electromagnetic spectrum. Expanded versions of the visible, infrared and microwave regions are shown in Figure 2.3.

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.

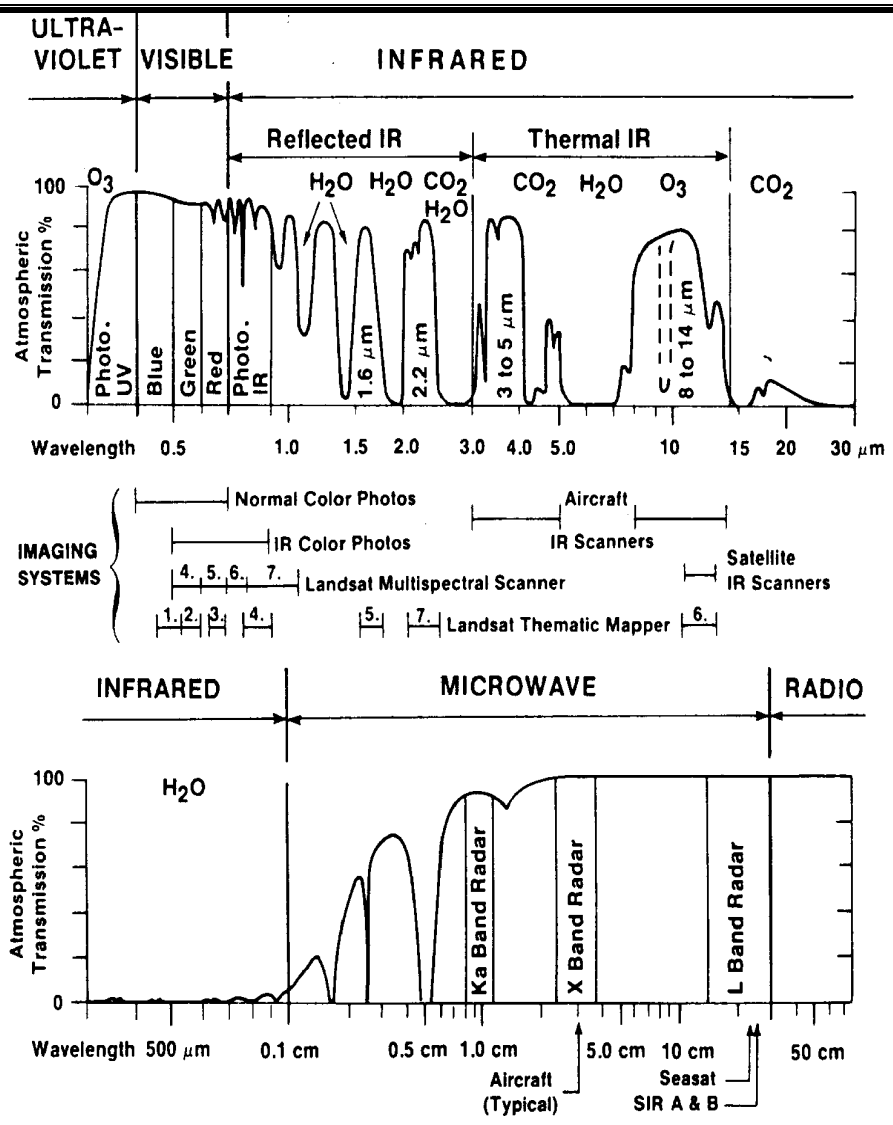


Figure 2.3 Expanded diagrams of the visible and infrared regions (upper) and the microwave regions (lower) showing atmospheric windows. Wavelength bands of commonly used remote sensing systems are indicated. Gases responsible for atmospheric absorption are shown.

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	to	5.00	**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.
	8.00	to	14.00	**µm**	
Microwave	0.10	to	30.00	**cm**	Longer wavelengths can penetrate clouds, fog and rain. Images may be acquired in the active or passive mode.
Radar	0.10	to	30.00	**cm**	Active form of microwave remote sensing. Radar images are acquired at various wavelength bands.
Radio		>	30.00	**cm**	Longest wavelength portion of electromagnetic spectrum. Some classified radars with very long wavelength operate in this region.

The earth's atmosphere absorbs energy in the gamma-ray, X-ray and most of the ultraviolet (UV) region; therefore, these regions are not used for remote sensing. Details of these regions are shown in Figure 2.3. The horizontal axes show wavelength on a logarithmic scale; the vertical axes show percent atmospheric transmission of EM energy. Wavelength regions with high transmission are called *atmospheric windows* and are used to acquire remote sensing data. The major remote sensing sensors record energy only in the visible, infrared and micro-wave regions. Detection and measurement of the recorded energy enables identification of surface objects (by their characteristic wavelength patterns or spectral signatures), both from air-borne and space-borne platforms.

2.3 Scanning System

The sensing device in a remotely placed platform (aircraft/satellite) records EM radiation using a *scanning system*. In scanning system, a *sensor*, with a narrow field of view is employed; this sweeps across the terrain to produce an image. The sensor receives electromagnetic energy radiated or reflected from the terrain and converts them into signal that is recorded as numerical data. In a remote sensing satellite, multiple arrays of linear sensors are used, with each array recording simultaneously a separate band of EM energy. The array of sensors employs a spectrometer to disperse the incoming energy into a spectrum. Sensors (or *detectors*) are positioned to record specific wavelength bands of energy. The information received by the sensor is suitably manipulated and transported back to the ground receiving station. The data are reconstructed on ground into digital images. The digital image data on *magnetic/optical media* consist of picture elements arranged in regular rows and columns. The position of any picture element, *pixel*, is determined on a x-y co-ordinate system. Each pixel has a numeric value, called digital number (DN), which records the intensity of electromagnetic energy measured for the ground resolution cell represented by that pixel. The range of digital numbers in an image data is controlled by the radiometric resolution of the satellite's sensor system. The digital image data are further processed to produce master images of the study area. By analysing the digital data/imagery, digitally/visually, it is possible to detect, identify and classify various objects and phenomenon on the earth surface.

Remote sensing technique provides an efficient, speedy and cost-effective method for assessing the changes in vegetation cover certain period of time due to its inherited capabilities of being multi-spectral, repetitive and synoptic aerial coverage.

2.4 Data Source

The following data are used in the present study:

- **Primary Data** –Raw satellite data, obtained from National Remote Sensing Centre (NRSC), Hyderabad, as follows, was used as primary data source for the study.

  IRS R2/ L4FMX; Band 2,3,4,5; Path # 106, Row # 055; Date of pass 5.01.2016*.

  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-R2 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-IV	B2 B3 B4 B5	0.52 0.62 0.77 1.55	- - - -	0.59 0.68 0.86 1.70	Green Red NIR MIR	10 bits (7 bits transmitted with DPCM)	5.8m	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.

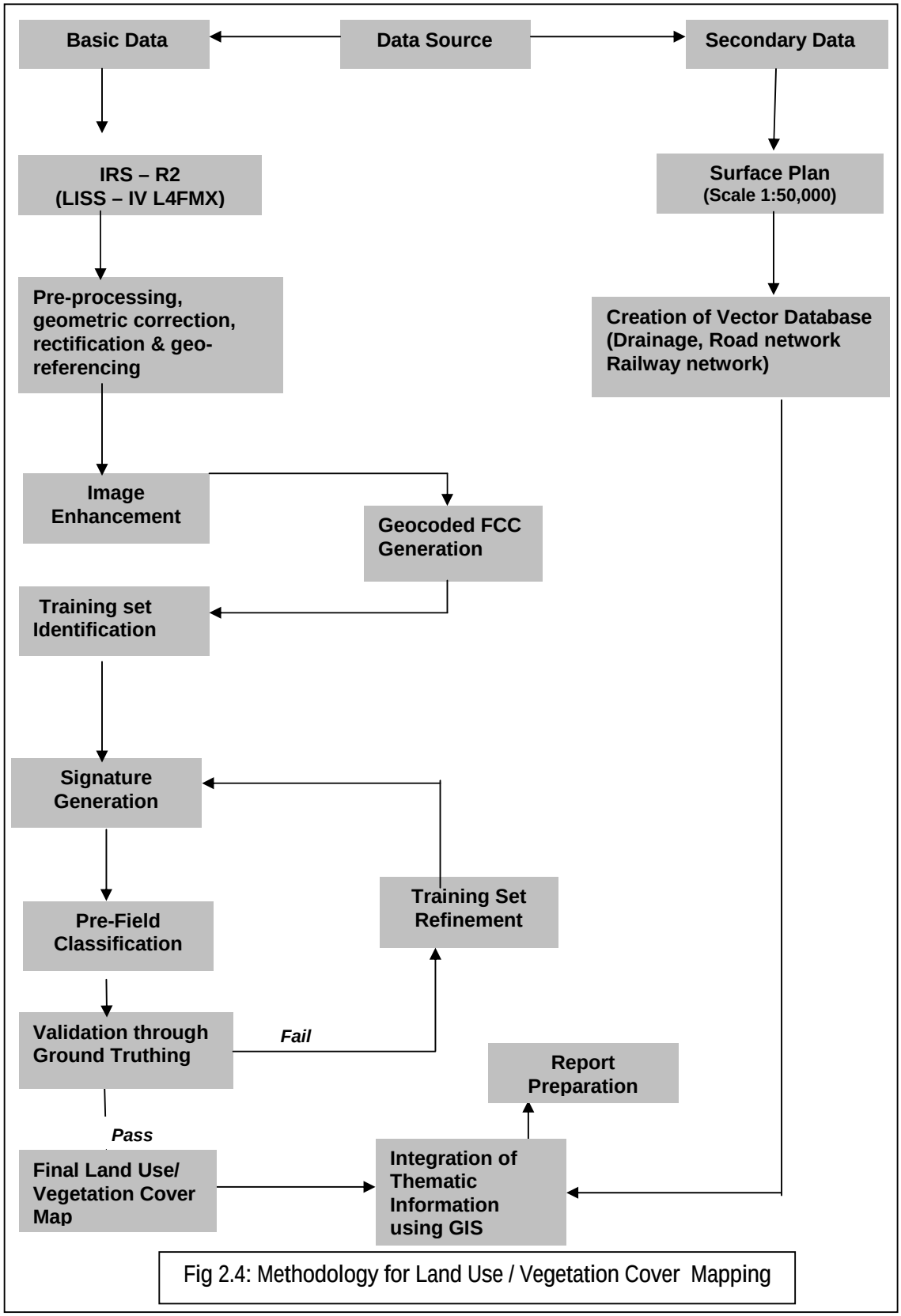


Fig 2.4: Methodology for Land Use / Vegetation Cover Mapping

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*.

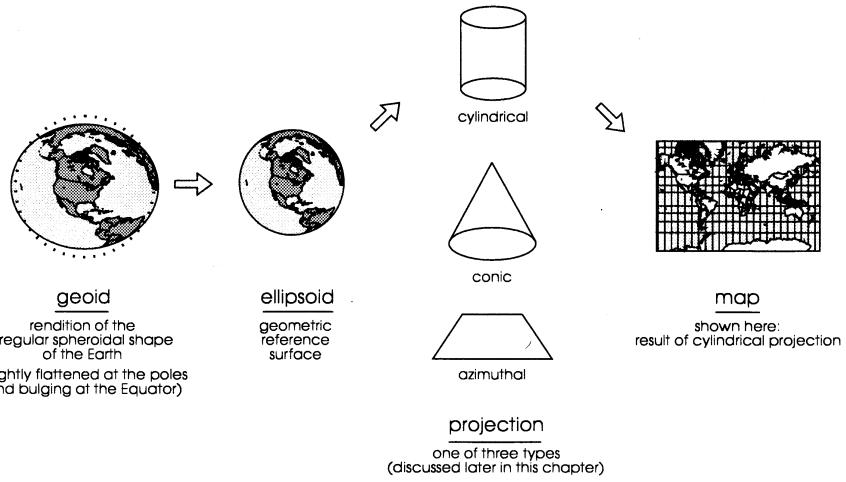


Fig 2.5 : Geoid – Ellipsoid – Projection Relationship

In the present study, ***UTM projection*** *along with* ***WGS 84 model*** was used so as to prepare the map compatible with the SoI topo-sheets**.** UTM 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 2014 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 2014 s/w. The enhanced and geocoded FCC (False colour composite) image of Jharia Coalfield is shown in Plate No. 1 for the year 2013.

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 2014 s/w. The classified image for the year 2016 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 Arc GIS 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 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 2016. Final Land Use/vegetation cover maps (on 1:50,000 scale) were printed using HP Design jet 4500 Colour Plotter.

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/vegetation 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 2016. Following land use/cover classes are identified in the Jharia coalfield region (Table 3.1).

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 Barren OB Dump 5.3 Area Under Backfilling 5.4 Coal Dump 5.5 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 Slurry 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 of Jharia Coalfiled

Satellite data of the year 2016 was processed using ERDAS Imagine v.2014 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 2016 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 2013 & 2016

LAND USE CLASSES	Year 2013		Year 2016		Change		Reasons for change
SETTLEMENTS	**Area (Km^2)**	**%**	**Area (Km^2)**	**%**	**Area (Km^2)**	**%**	
Urban Settlement	35.05	8.92	35.05	8.92	0.00	0.00	No change
Rural Settlement	3.17	0.81	3.74	0.95	0.57	0.15	Migration of population to mining areas
Industrial Settlement	3.35	0.85	2.29	0.58	-1.06	-0.27	Dismantling of some industrial structures, eg Lodna Washery
Total Settlements	**41.57**	**10.58**	**41.08**	**10.46**	**-0.49**	**-0.12**	
VEGETATION COVER							
FORESTS							
Dense Forest	0.29	0.07	0.29	0.07	0.00	0.00	No Change
Open Forest	8.51	2.16	6.27	1.60	-2.24	-0.56	Minor decrease due to deforestation
Total Forest (A)	**8.8**	**2.23**	**6.56**	**1.67**	**-2.24**	**-0.56**	
SCRUBS							
Scrubs (B)	**122.5**	**31.2**	**105.87**	**26.95**	**-16.63**	**-4.25**	Coversion of UG mines into OC mines, Land with scrubs were used
PLANTATION							
Social forestry	19.41	4.94	19.52	4.97	0.11	0.03	Increase in plantation along roads, creation of ecological resoration parks
Plantation on OB Dump	11.94	3.04	8.59	2.19	-3.35	-0.85	Decrese due to increase in mining activity & conversion of UG mines into OC mines
Total Plantation (C)	**31.35**	**7.98**	**28.11**	7.16	-3.24	-0.82	
Total Vegetation (A+B+C)	**162.65**	**41.4**	**140.54**	**35.77**	**-22.11**	**-5.63**	
MINING AREA							
Coal Quarry	6.98	1.78	11.36	2.89	4.38	1.11	Increase in mining activity
Coal Dump	1.3	0.33	0.23	0.06	-1.07	-0.27	Places where coal dumps were obeserved have been shifted
Quarry filled with water	0.25	0.06	0.77	0.20	0.52	0.13	Minor change in places with water filled quarries
Barren OB Dump	19.06	4.85	12.55	3.19	-6.51	-1.66	Some area under small OB dumps coming under new amalgamated projects
Area Under Backfilling	7.36	1.87	15.62	3.98	8.26	2.10	Due to increase in excavation due to opencast mining activities
Toal Mining Area	**35.22**	**8.97**	**40.53**	**10.32**	**5.31**	**1.35**	
AGRICULTURE							
Crop Lands	3.94	1	3.71	0.94	-0.23	-0.06	Derease due to crop land being converted into fallow land
Fallow Lands	35.85	9.13	40.68	10.36	4.83	1.23	Conversion of scrub land into fallow land
Total Agriculture	**39.79**	**10.13**	**44.39**	**11.30**	**4.60**	**1.17**	
WASTELANDS							
Wastelands	100.05	25.47	113.97	29.01	13.92	3.54	Scrubland converted to wasteland
Ash pond/Slurry/ Tailing Ponds	0.26	0.07	0	0.00	-0.26	-0.07	
Sand Body	1.53	0.39	4.85	1.23	3.32	0.85	Temporal change over period
Total Wastelands	**101.84**	**25.92**	**118.82**	**30.25**	**16.98**	**4.32**	
WATERBODIES							
River, Lakes, Nallas, ponds, etc	11.78	3	7.48	1.90	-4.30	-1.09	Temporal change over period
TOTAL	**392.85**	**100**	**392.85**	**100.00**	**0.00**	**0.00**	

3.3.1 Vegetation Cover

Vegetation cover in the coalfield area comprises following five classes:

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

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

TABLE – 3.3

Status of change in Vegetation Cover in Jharia Coalfield during the year 2013 & 2016

VEGETATION COVER	Year 2013		Year 2016		Change	
FORESTS	Area (sq Km)	%	Area (sq Km)	%	Area (sq Km)	%
Dense Forest	0.29	0.07	0.29	0.07	0.00	0.00
Open Forest	8.51	2.16	6.27	1.60	-2.24	-0.56
Total Forest (A)	**8.80**	**2.23**	**6.56**	**1.67**	**-2.24**	**-0.56**
SCRUBS						
Scrubs (B)	**122.50**	**31.20**	**105.87**	**26.95**	**-16.63**	**-4.25**
PLANTATION						
Social forestry	19.41	4.94	19.52	4.97	0.11	0.03
Plantation on OB Dump	11.94	3.04	8.59	2.19	-3.35	-0.85
Total Plantation (C)	**31.35**	**7.98**	**28.11**	7.16	-3.24	-0.82
Total Vegetation (A+B+C)	**162.65**	**41.40**	**140.54**	**35.78**	**-22.11**	**-5.63**

Dense forest – Forest having crown density of above 40% comes in this class. Dense forest over the area is same as in year 2013.. A total dense forest is estimated to be 0.29

sq km, i.e. 0.07% of the coalfield area. The area of the dense forest within the coalfield has remained same since 2013.

Open Forest – Forest having crown density between 10% to 40% comes under this class. Open forest cover over Jharia coalfield which was estimated to be 8.51 sq km (2,16%) in 2013 has marginally decreased to 6.27 sq km, i.e. 1.60 % of the coalfield area. Thus the area reduced is 2.24 sq km which is 0.56 % of the total coalfield area. This reduction is due to deforestation by local inhabitants.

Scrubs – Scrubs are vegetation with crown density less than 10%. Scrubs in the coalfield are seen to be scattered signature all over the area mixed with wastelands. There is 105.87 sq km, of scrubs, ie 26.95% of the coalfield area. In year 2013 the scrubs covered 122.50 sq km which were 31.20% of the coalfield area. There is a decrease of 16.63 sq km which is 4.25% of the coalfield area .The decrease is due to increase in mining areas and conversion of underground mine into open cast ones & also increase in agricultural land & waste land.

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 19.52 sq km, which is 4.97% of the coalfield area. In 2013 the area covered under social forestry was 19.41 sq km (4.94%) . there is an increase of 0.11 sq km (0.03%). This increase is due to creation of some ecological restoration sites.

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 plantation on the OB dumps and backfilled areas are estimated to be 8.59 sq km, i.e. 2.19% of the coalfield area. In year 2013 the plantation on OB Dumps were estimated to cover an area of 11.94 sq km which was 3.04% of the coalfield area. There is a decrease of 3.35 sq km (0.85%) in plantation over OB dumps. This is due to increase in mining activity & conversion of UG mines into OC mines.

3.3.2 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

The overall area where mining operations are being carried out has increased significantly by 5.31 sq km which is 1.35% of the total area. In the year 2013 this area was estimated to be 35.22 sq km (8.97%) which has increased to 40.53 sq km (10.32%) in the year 2016. This increase is due to increase in production of coal from Open cast areas. The status of land Use in the mining area over the Jharia Coalfield is shown in the table 3.4 below.

TABLE – 3.4

Status of change in Mining Area in Jharia Coalfield during the year 2013 & 2016

	2013		2016		Change	
MINING AREA	**Area (Sq km)**	**%**	**Area (Sq km)**	**%**	**Area (Sq km)**	**%**
Coal Quarry	6.98	1.78	11.36	2.89	4.38	1.11
Coal Dump	1.30	0.33	0.23	0.06	-1.07	-0.27
Quarry filled with water	0.25	0.06	0.77	0.20	0.52	0.14
Barren OB Dump	19.06	4.85	12.55	3.20	-6.51	-1.65
Area Under Backfilling	7.36	1.87	15.62	3.97	8.26	2.10
Total Mining Area	**35.22**	**8.97**	**40.53**	**10.32**	**5.31**	**1.35**

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 44.39 sq km in year 2016, which is 11.31 % of the coalfield area.. in year 2013 the total agricultural area was estimated to be 39.79 sq km which was 10.12% of the coalfield area. There is an increase on 4.60 sq km which is 1.19% of the coalfield area. The details are shown below in Table 3.5**.**

TABLE – 3.5

Status of change in Agricultural land in Jharia Coalfield during the year 2013 & 2016

	2013		2016		Change	
AGRICULTURE	**Area (Sq km)**	**%**	**Area (Sq km)**	**%**	**Area (Sq km)**	**%**
Crop Lands	3.94	1.00	3.71	0.95	-0.23	-0.05
Fallow Lands	35.85	9.12	40.68	10.36	4.83	1.24
Total Agriculture	**39.79**	**10.12**	**44.39**	**11.31**	4.60	1.19

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. The waste land was estimated to be 101.84 sq km (25.93%) in the year 2013. This has increased by 16.98 sq km (4.32%) to 118.82 sq km (30.24%) over the 3 year period because some scrubland has been converted to wasteland.

TABLE – 3.6

Status of Change in Wastelands in Jharia Coalfield during the year 2013 & 2016

	2013		2016		Change	
WASTELANDS	**Area (Sq km)**	**%**	**Area (Sq km)**	**%**	**Area (Sq km)**	**%**
Wastelands	100.05	25.47	113.97	29.01	13.92	3.54
Ash pond/Slurry/ Tailing Ponds	0.26	0.07	0.00	0.00	-0.26	-0.07
Sand Body	1.53	0.39	4.85	1.23	3.32	0.85
Total Wastelands	**101.84**	**25.93**	**118.82**	**30.24**	16.98	4.32

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. In the year 2013 the total area covered by settlements were estimated to be 41.57 sq km (10.58%). In year 2016 the estimated area under settlements has grown to 41.08 sq km (10.45%). There is a decrease in settlements by 0.49 sq km which is about 0.12% of the total area. This decrease is due to decrease in industrial settlement which may be due to dismantling of some establishments.

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

TABLE 3.7

Status of Change in Settlements in Jharia Coalfield during the year 2013 & 2016

	2013		2016		Change	
SETTLEMENTS	Area (Sq km)	%	Area (Sq km)	%	Area (Sq km)	%
Urban Settlement	35.05	8.92	35.05	8.92	0.00	0.00
Rural Settlement	3.17	0.81	3.74	0.95	0.57	0.15
Industrial Settlement	3.35	0.85	2.29	0.58	-1.06	-0.27
Total Settlements	**41.57**	**10.58**	**41.08**	**10.45**	-0.49	-0.12

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 11.78 sq km in year 2013, which is 3.00% of the coalfield area. In 2016 there is a reduction in the area of water bodies 4.30 sq km (1.10%) of the total area.

3.4 Data Analysis of clusters under Jharia Coalfield

Land use and vegetation cover classes present in each cluster (Cluster I to Cluster XV) falling under the Jharia coalfield has also been prepared. The map of each cluster is included in this report under pages 31 to 45. Each map contains the area statistics of Land use/cover classes present in them. The cluster wise Land Use/Cover statistics for cluster I to cluster XV falling under Jharia Coalfield is given under Table 3.8.

Table-3.8

(Area in Hectare)

		CLUSTER I		CLUSTER II		CLUSTER III		CLUSTER IV		CLUSTER V		CLUSTER VI		CLUSTER VII		CLUSTER VIII		CLUSTER IX		CLUSTER X		CLUSTER XI		CLUSTER XII		CLUSTER XIII		CLUSTER XIV		CLUSTER XV		TOTAL	
		Area	%	Area	%	Area	%	Area	%																					Area	%	Area	%
FORESTS	Dense Forest	14.56	2.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.56	0.06
	Open Forest	15.11	2.43	0.00	0.00	32.73	2.11	0.00	0.00	0.00	0.00	0.00	0.00	0.38	0.02	0.00	0.00	0.00	0.00	65.50	3.16	0.00	0.00	0.00	0.00	172.73	9.23	0.00	0.00	63.05	3.46	349.50	1.38
	Total Forest	29.67	4.77	0.00	0.00	32.73	2.11	0.00	0.00	0.00	0.00	0.00	0.00	0.38	0.02	0.00	0.00	0.00	0.00	65.50	3.16	0.00	0.00	0.00	0.00	172.73	9.23	0.00	0.00	63.05	3.46	364.06	1.44
SCRUBS	Scrubs	182.00	29.24	233.14	10.31	274.77	17.70	87.26	7.04	237.06	13.74	63.71	7.66	301.39	14.59	117.43	8.82	275.34	14.00	482.12	23.25	1470.72	40.79	256.27	29.60	583.41	31.19	494.37	34.86	610.87	33.58	5669.86	22.45
PLANTATION	Social Forestry	16.60	2.67	150.07	6.64	110.03	7.09	82.10	6.62	60.01	3.48	33.83	4.07	99.35	4.81	12.99	0.97	163.31	8.30	136.29	6.57	269.08	7.46	24.30	2.81	125.11	6.69	54.94	3.87	138.17	7.59	1476.18	5.85
	Plantation on OB Dump	47.32	7.60	105.98	4.69	23.17	1.49	38.25	3.08	20.80	1.21	21.03	2.53	20.08	0.97	23.80	1.79	30.68	1.56	92.78	4.47	0.12	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	424.01	1.68
	Plantation on Backfill	10.65	1.71	81.89	3.62	12.96	0.83	0.01	0.00	30.64	1.78	31.36	3.77	60.62	2.93	33.98	2.55	57.92	2.94	44.31	2.14	1.18	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	365.52	1.45
	Total Plantation *(Biological Reclamation)*	74.57	11.98	337.94	14.95	146.16	9.41	120.36	9.70	111.45	6.47	86.22	10.37	180.05	8.71	70.77	5.31	251.91	12.80	273.38	13.18	270.38	7.50	24.30	2.81	125.11	6.69	54.94	3.87	138.17	7.59	2265.71	8.97
	Total Vegetation	286.24	45.99	571.08	25.26	453.66	29.22	207.62	16.74	348.51	20.21	149.93	18.03	481.82	23.32	188.20	14.13	527.25	26.80	821.00	39.59	1741.10	48.29	280.57	32.41	881.25	47.11	549.31	38.73	812.09	44.63	8299.63	32.87
ACTIVE MINING	Coal Quarry	11.60	1.86	148.85	6.58	82.36	5.30	178.26	14.37	117.63	6.82	57.63	6.93	86.60	4.19	180.71	13.57	112.86	5.74	31.34	1.51	34.83	0.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1042.67	4.13
	Coal Face	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Coal Dump	0.00	0.00	9.32	0.41	1.94	0.13	0.62	0.05	1.03	0.06	0.65	0.08	2.99	0.14	3.13	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19.68	0.08
	Advance Quarry Site	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Quarry Filled With Water	7.30	1.17	20.45	0.91	13.26	0.85	0.00	0.00	8.62	0.50	1.18	0.14	4.13	0.20	0.70	0.05	4.82	0.25	3.68	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	64.14	0.25
	Total Area under *Active Mining*	18.90	3.03	178.62	7.90	97.56	6.28	178.88	14.42	127.28	7.38	59.46	7.15	93.72	4.53	184.54	13.85	117.68	5.99	35.02	1.69	34.83	0.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1126.49	4.46
RECLAIMED	Barren OB Dump	16.32	2.62	194.48	8.60	93.67	6.03	181.14	14.61	150.31	8.72	64.88	7.80	81.38	3.94	112.23	8.42	135.88	6.91	94.20	4.54	18.22	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1142.71	4.53
	Area Under Backfilling	28.54	4.58	393.74	17.42	77.77	5.01	66.69	5.38	181.89	10.55	99.13	11.92	312.89	15.15	162.24	12.18	106.51	5.41	107.49	5.18	18.20	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1555.09	6.16
	Total Area under *Technical Reclamation*	44.86	7.20	588.22	26.02	171.44	11.04	247.83	19.99	332.20	19.27	164.01	19.72	394.27	19.09	274.47	20.60	242.39	12.32	201.69	9.72	36.42	1.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2697.80	10.68
	Total Area under Mine Operation	63.76	10.23	766.84	33.92	269.00	17.32	426.71	34.41	459.48	26.65	223.47	26.87	487.99	23.62	459.01	34.45	360.07	18.31	236.71	11.41	71.25	1.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3824.29	15.15
WASTELAND	Waste Lands	133.62	21.47	624.95	27.65	503.68	32.44	350.38	28.25	585.22	33.93	318.55	38.29	528.08	25.56	415.58	31.20	683.07	34.72	404.11	19.48	917.12	25.44	275.00	31.76	705.27	37.71	504.15	35.55	640.16	35.19	7588.94	30.05
	Sand Body	10.66	1.71	4.00	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.55	4.85	7.03	0.19	0.00	0.00	22.18	1.18	42.35	2.99	0.00	0.00	186.77	0.74
	Total Wasteland	144.28	23.18	628.95	27.83	503.68	32.44	350.38	28.25	585.22	33.93	318.55	38.29	528.08	25.56	415.58	31.20	683.07	34.72	504.66	24.33	924.15	25.63	275.00	31.76	727.45	38.89	546.50	38.54	640.16	35.19	7775.71	30.79
WATERBODIES	Reservoir, nallah, ponds	14.75	2.37	20.39	0.90	14.71	0.95	8.82	0.71	5.45	0.32	8.97	1.08	13.55	0.66	8.11	0.61	16.01	0.81	126.31	6.09	33.20	0.92	19.37	2.24	25.94	1.39	18.24	1.29	19.94	1.09	353.76	1.40
	Total Waterbodies	14.75	2.37	20.39	0.90	14.71	0.95	8.82	0.71	5.45	0.32	8.97	1.08	13.55	0.66	8.11	0.61	16.01	0.81	126.31	6.09	33.20	0.92	19.37	2.24	25.94	1.39	18.24	1.29	19.94	1.09	353.76	1.40
AGRICULTURE	Crop Lands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.88	0.40	0.00	0.00	39.16	1.89	16.12	1.21	0.31	0.02	19.11	0.92	94.10	2.61	2.90	0.33	60.45	3.23	6.88	0.48	6.51	0.36	252.42	1.00
	Fallow Lands	91.85	14.76	77.09	3.41	58.05	3.74	53.69	4.33	40.02	2.32	1.02	0.12	20.38	0.99	65.11	4.89	42.59	2.16	62.64	3.02	323.90	8.98	254.61	29.40	93.18	4.98	224.53	15.83	211.56	11.63	1620.22	6.42
	Total Agriculture	91.85	14.76	77.09	3.41	58.05	3.74	53.69	4.33	46.90	2.72	1.02	0.12	59.54	2.88	81.23	6.10	42.90	2.18	81.75	3.94	418.00	11.59	257.51	29.73	153.63	8.21	231.41	16.31	218.07	11.99	1872.64	7.42
SETTLEMENTS	Urban Settlement	0.00	0.00	163.66	7.24	243.23	15.67	192.99	15.56	269.93	15.65	113.08	13.59	475.46	23.02	169.76	12.75	332.56	16.91	243.91	11.76	375.11	10.40	23.83	2.75	26.10	1.40	0.00	0.00	83.80	4.61	2713.42	10.75
	Rural Settlement	20.73	3.33	24.84	1.10	8.33	0.54	0.00	0.00	0.00	0.00	0.00	0.00	1.35	0.07	0.00	0.00	0.00	0.00	41.47	2.00	12.11	0.34	9.64	1.11	54.28	2.90	72.37	5.10	42.38	2.33	287.50	1.14
	Industrial Settlement	0.87	0.14	7.69	0.34	1.87	0.12	0.00	0.00	9.03	0.52	16.81	2.02	17.90	0.87	10.06	0.76	5.36	0.27	18.27	0.88	30.76	0.85	0.00	0.00	1.82	0.10	0.42	0.03	2.86	0.16	123.72	0.49
	Total Settlement	21.60	3.47	196.19	8.68	253.43	16.33	192.99	15.56	278.96	16.17	129.89	15.61	494.71	23.96	179.82	13.51	337.92	17.18	303.65	14.64	417.98	11.59	33.47	3.86	82.20	4.40	72.79	5.13	129.04	7.10	3124.64	12.37
	Grand Total	622.48	100.00	2260.54	100.00	1552.53	100.00	1240.21	100.00	1724.52	100.00	831.83	100.00	2065.69	100.00	1331.95	100.00	1967.22	100.00	2074.08	100.00	3605.68	100.00	865.92	100.00	1870.47	100.00	1418.25	100.00	1819.30	100.00	25250.67	100.00

Chapter 4

Conclusion & Recommendations

4.1 Conclusion

In the present study, land use/ vegetation cover mapping has been carried out based on IRS-R2/ L4FMX satellite data of January, 2016 in order to monitor the impact of coal mining on land environment which may helps in formulating the mitigation measures required, if any.

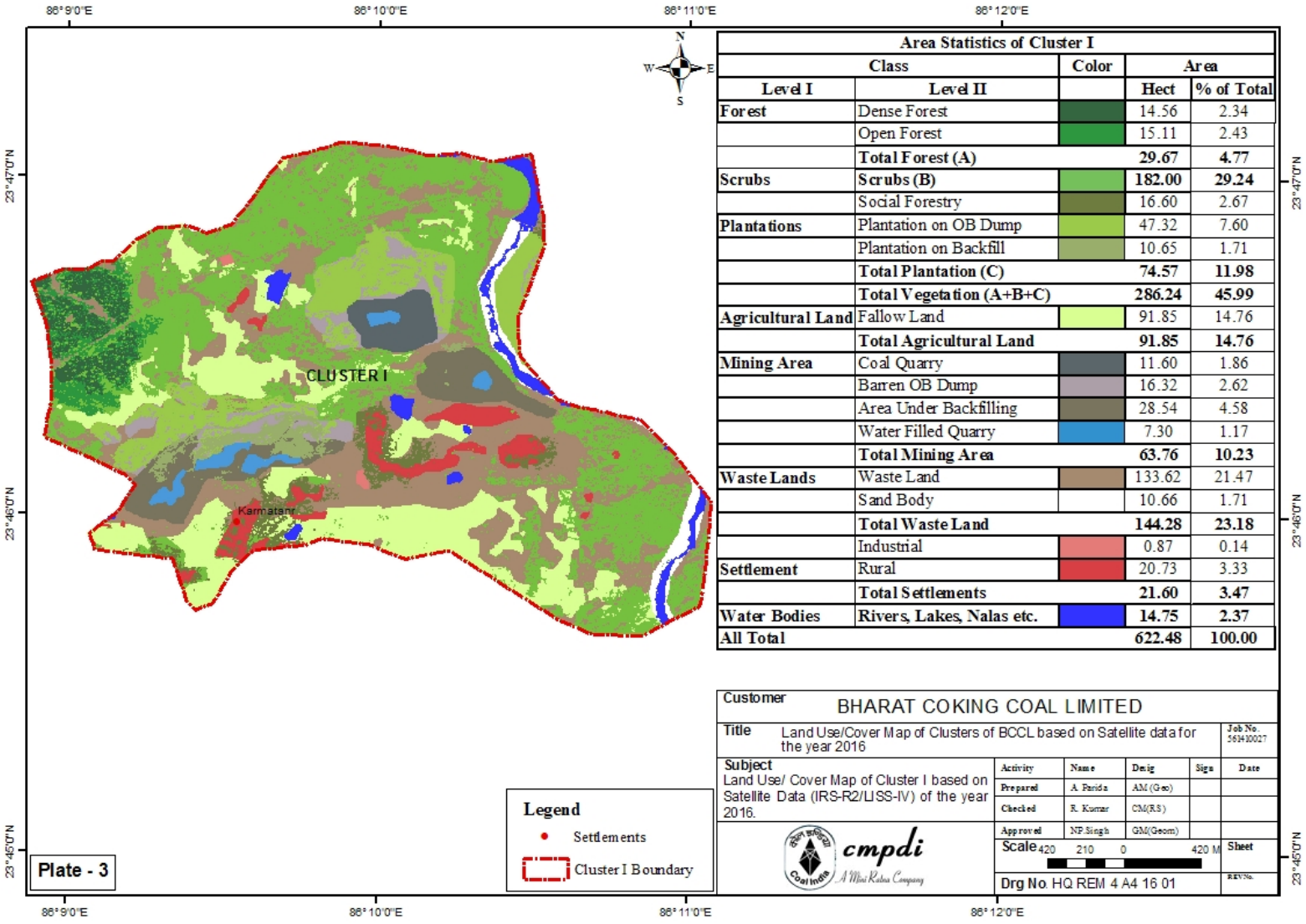
Study reveals that the total area of settlements which includes urban, rural and industrial settlements in the Jharia coalfields covers 41.08 km^2 (10.45%) area. There is a decrease in settlements by 0.49 sq km over the 2013 study primarily because dismantling of some industrial establishments. Vegetation cover which includes dense forests, open forests, scrubs, avenue plantation & plantation on over-burden dumps, covers an area of 140.54 km^2 (35.78%). As compared to 2013 study there is a decrease in overall vegetation cover by 22.11 sq km (5.62%) this is mainly because there is a reduction in scrubs areas. Area of scrubs has decreased by 16.63 sq km. because of its use in opencast mines and use of scrub land for agriculture. The analysis further indicates that total agricultural land which includes both crop and fallow land covers an area of 44.39km^2 (11.31%) has increased 4.60 sq km (1.19%) from that was in 2013. The increase in 4.60 sq km is due to some scrubland getting converted into agricultural land. The mining area which includes coal quarry, advance quarry site, barren OB dump, area under backfilling, covers 40.53 km^2 (10.32%). There is a significant increase in areas under mining operations because large areas have now been taken up for Open cast mining in BCCL. As compared to 2013 there is an increase of 5.31 sq km (1.35%) in the areas under mining operation. Wasteland covers 118.82 km^2

(30.24%). Waste lands have increased because some scrubland has been converted to wasteland. Surface water bodies covered area of 7.48 km^2 (1.90).

The detail statistical analysis is given under Table-3.2.

4.2 Recommendations

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



Area Statistics of Cluster I

Class		Color	Area	
Level I	Level II		Hect	% of Total
Forest	Dense Forest		14.56	2.34
	Open Forest		15.11	2.43
	Total Forest (A)		**29.67**	**4.77**
Scrubs	**Scrubs (B)**		**182.00**	**29.24**
	Social Forestry		16.60	2.67
Plantations	Plantation on OB Dump		47.32	7.60
	Plantation on Backfill		10.65	1.71
	Total Plantation (C)		**74.57**	**11.98**
	Total Vegetation (A+B+C)		**286.24**	**45.99**
Agricultural Land	Fallow Land		91.85	14.76
	Total Agricultural Land		**91.85**	**14.76**
Mining Area	Coal Quarry		11.60	1.86
	Barren OB Dump		16.32	2.62
	Area Under Backfilling		28.54	4.58
	Water Filled Quarry		7.30	1.17
	Total Mining Area		**63.76**	**10.23**
Waste Lands	Waste Land		133.62	21.47
	Sand Body		10.66	1.71
	Total Waste Land		**144.28**	**23.18**
	Industrial		0.87	0.14
Settlement	Rural		20.73	3.33
	Total Settlements		**21.60**	**3.47**
Water Bodies	**Rivers, Lakes, Nalas etc.**		**14.75**	**2.37**
All Total			**622.48**	**100.00**

Customer: BHARAT COKING COAL LIMITED

Title: Land Use/Cover Map of Clusters of BCCL based on Satellite data for the year 2016

Job No. 561410027

Subject: Land Use/ Cover Map of Cluster I based on Satellite Data (IRS-R2/LISS-IV) of the year 2016.

Activity	Name	Desig	Sign	Date
Prepared	A. Farida	AM (Geo)		
Checked	R. Kumar	CM(RS)		
Approved	NP.Singh	GM(Geom)		

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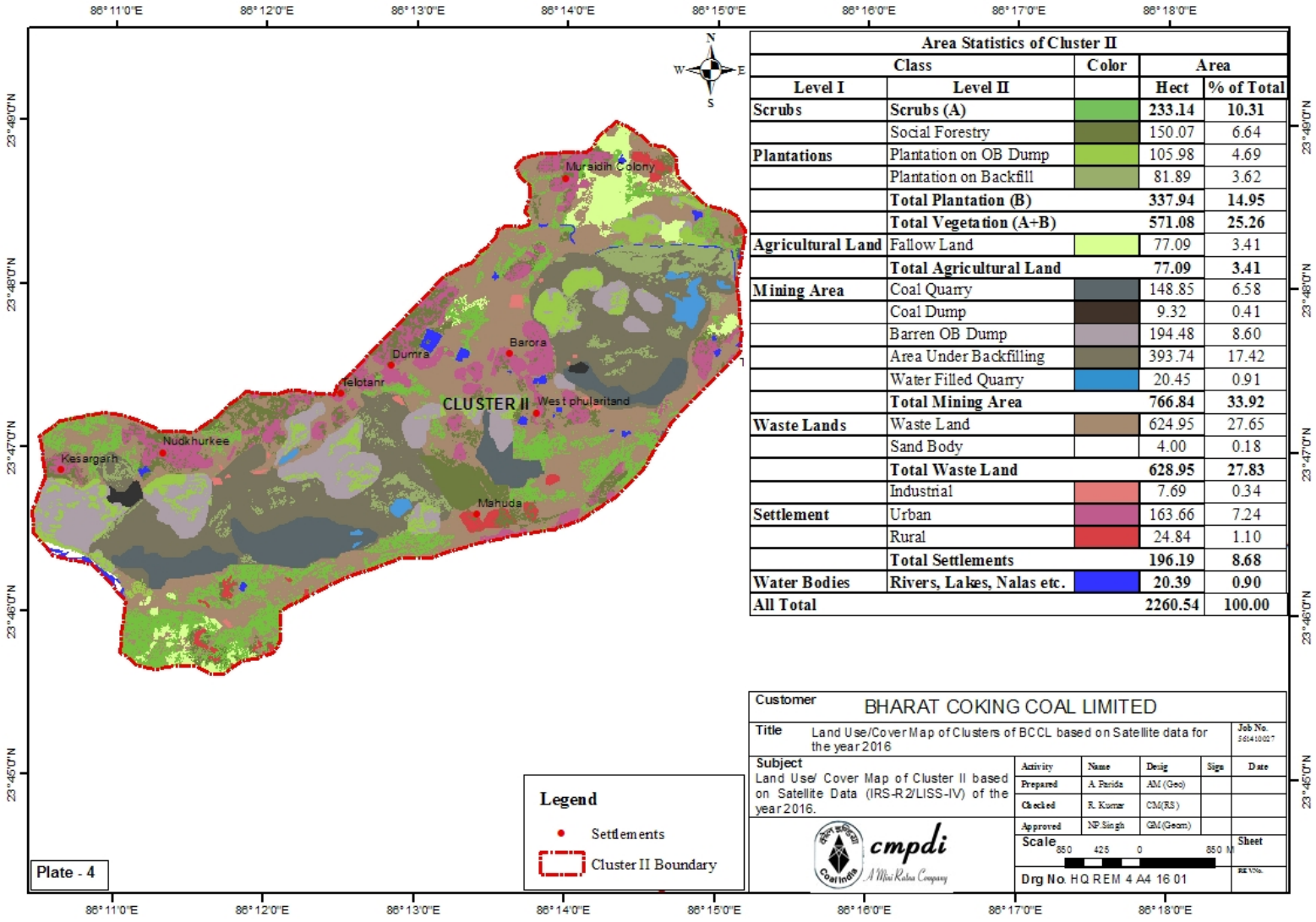

Area Statistics of Cluster II				
Class		Color	Area	
Level I	Level II		Hect	% of Total
Scrubs	Scrubs (A)		233.14	10.31
	Social Forestry		150.07	6.64
Plantations	Plantation on OB Dump		105.98	4.69
	Plantation on Backfill		81.89	3.62
	Total Plantation (B)		**337.94**	**14.95**
	Total Vegetation (A+B)		**571.08**	**25.26**
Agricultural Land	Fallow Land		77.09	3.41
	Total Agricultural Land		**77.09**	**3.41**
Mining Area	Coal Quarry		148.85	6.58
	Coal Dump		9.32	0.41
	Barren OB Dump		194.48	8.60
	Area Under Backfilling		393.74	17.42
	Water Filled Quarry		20.45	0.91
	Total Mining Area		**766.84**	**33.92**
Waste Lands	Waste Land		624.95	27.65
	Sand Body		4.00	0.18
	Total Waste Land		**628.95**	**27.83**
	Industrial		7.69	0.34
Settlement	Urban		163.66	7.24
	Rural		24.84	1.10
	Total Settlements		**196.19**	**8.68**
Water Bodies	Rivers, Lakes, Nalas etc.		20.39	0.90
All Total			2260.54	100.00

Customer	BHARAT COKING COAL LIMITED				
Title	Land Use/Cover Map of Clusters of BCCL based on Satellite data for the year 2016				Job No. 561410027
Subject	Land Use/ Cover Map of Cluster II based on Satellite Data (IRS-R2/LISS-IV) of the year 2016.	Activity	Name	Desig	Sign / Date
		Prepared	A. Parida	AM (Geo)	
		Checked	R. Kumar	CM(RS)	
		Approved	NP.Singh	GM(Geom)	
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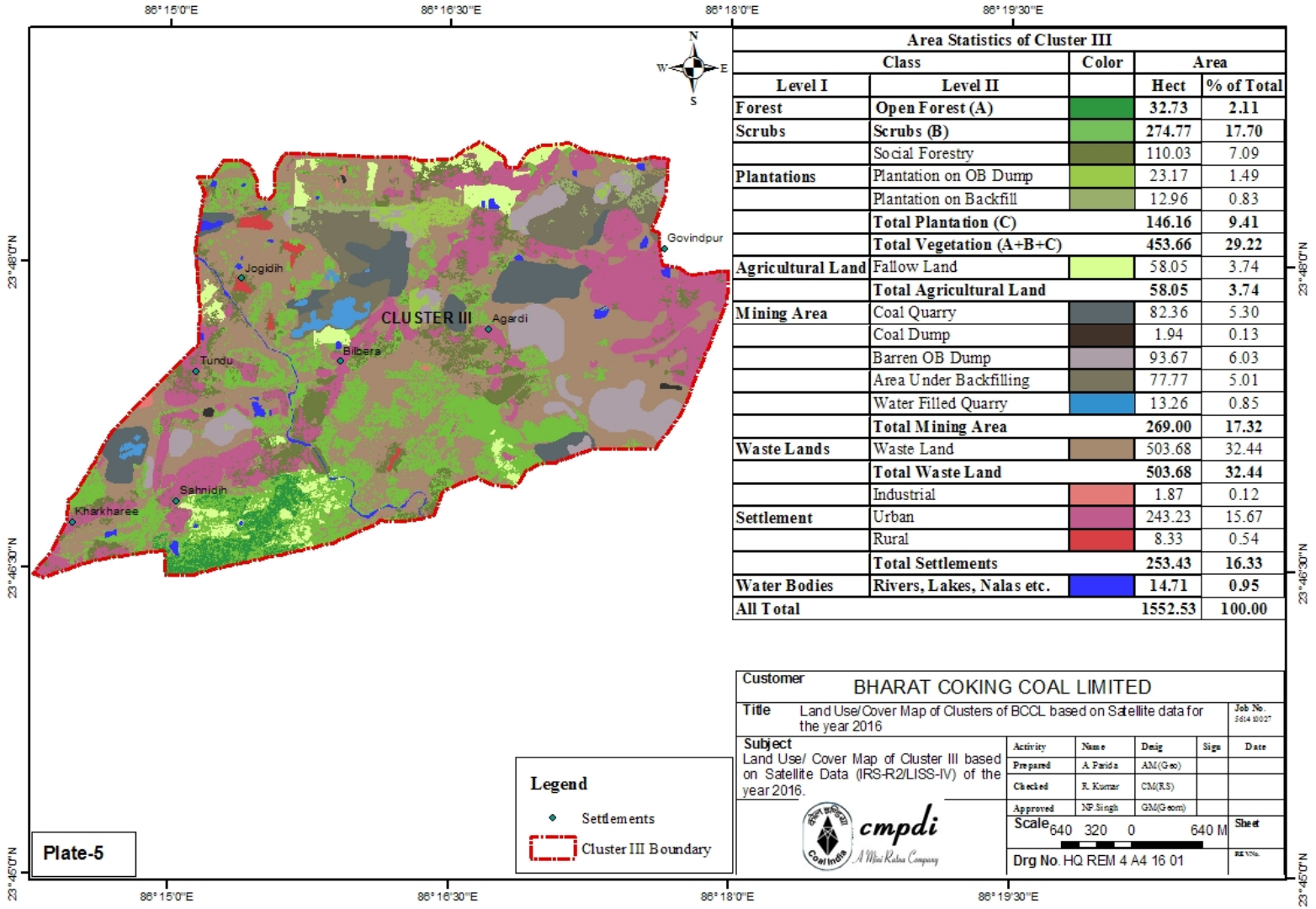

Area Statistics of Cluster III

Class		Color	Area	
Level I	**Level II**		**Hect**	**% of Total**
Forest	**Open Forest (A)**		**32.73**	**2.11**
Scrubs	**Scrubs (B)**		**274.77**	**17.70**
	Social Forestry		110.03	7.09
Plantations	Plantation on OB Dump		23.17	1.49
	Plantation on Backfill		12.96	0.83
	Total Plantation (C)		**146.16**	**9.41**
	Total Vegetation (A+B+C)		**453.66**	**29.22**
Agricultural Land	Fallow Land		58.05	3.74
	Total Agricultural Land		**58.05**	**3.74**
Mining Area	Coal Quarry		82.36	5.30
	Coal Dump		1.94	0.13
	Barren OB Dump		93.67	6.03
	Area Under Backfilling		77.77	5.01
	Water Filled Quarry		13.26	0.85
	Total Mining Area		**269.00**	**17.32**
Waste Lands	Waste Land		503.68	32.44
	Total Waste Land		**503.68**	**32.44**
	Industrial		1.87	0.12
Settlement	Urban		243.23	15.67
	Rural		8.33	0.54
	Total Settlements		**253.43**	**16.33**
Water Bodies	**Rivers, Lakes, Nalas etc.**		**14.71**	**0.95**
All Total			**1552.53**	**100.00**

Customer: BHARAT COKING COAL LIMITED

Title: Land Use/Cover Map of Clusters of BCCL based on Satellite data for the year 2016

Job No. 5614 10027

Subject: Land Use/ Cover Map of Cluster III based on Satellite Data (IRS-R2/LISS-IV) of the year 2016.

Activity	Name	Desig	Sign	Date
Prepared	A. Parida	AM(Geo)		
Checked	R. Kumar	CM(RS)		
Approved	NP.Singh	GM(Geom)		

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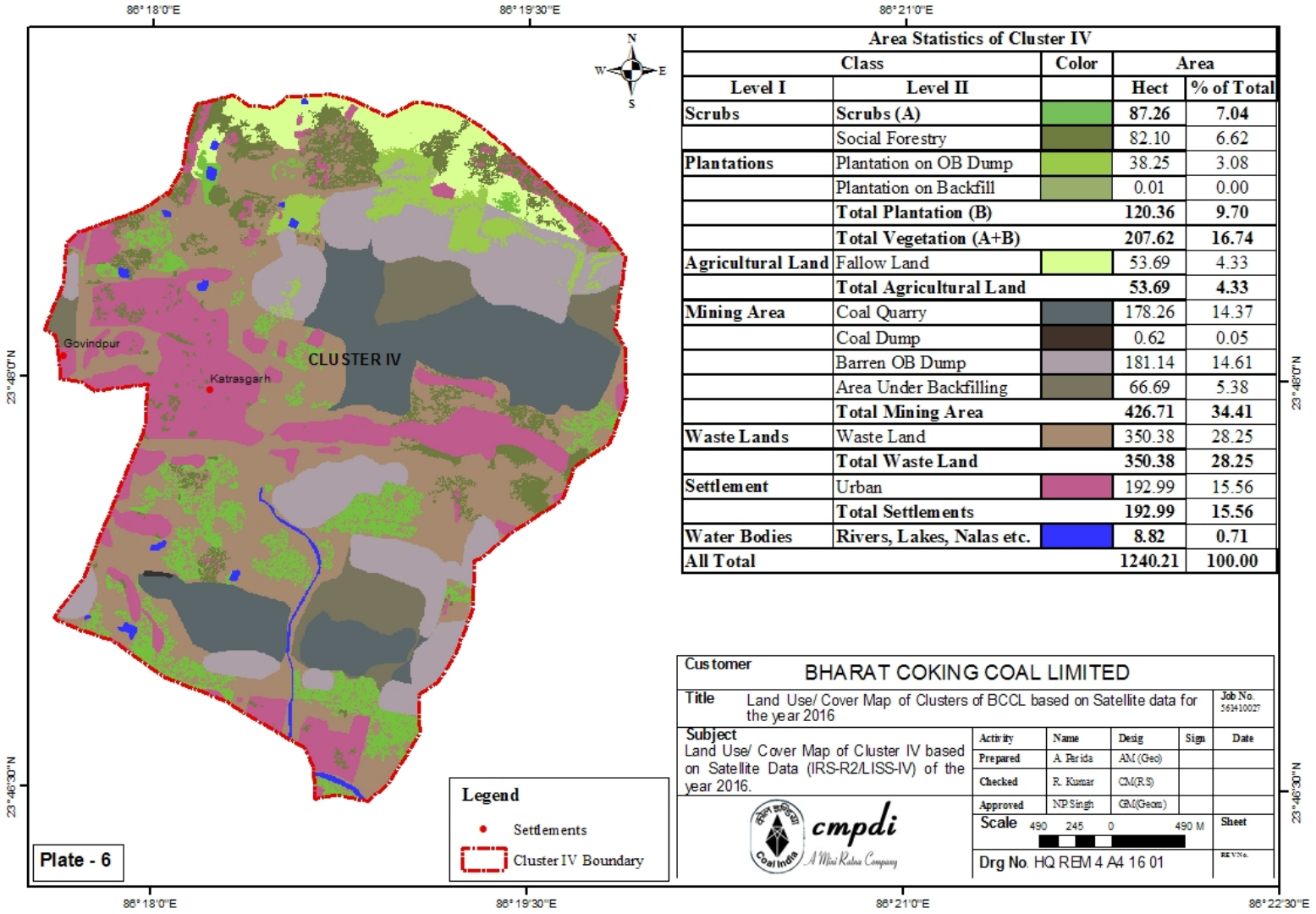

Area Statistics of Cluster IV

Class		Color	Area	
Level I	Level II		Hect	% of Total
Scrubs	Scrubs (A)		87.26	7.04
	Social Forestry		82.10	6.62
Plantations	Plantation on OB Dump		38.25	3.08
	Plantation on Backfill		0.01	0.00
	Total Plantation (B)		**120.36**	**9.70**
	Total Vegetation (A+B)		**207.62**	**16.74**
Agricultural Land	Fallow Land		53.69	4.33
	Total Agricultural Land		**53.69**	**4.33**
Mining Area	Coal Quarry		178.26	14.37
	Coal Dump		0.62	0.05
	Barren OB Dump		181.14	14.61
	Area Under Backfilling		66.69	5.38
	Total Mining Area		**426.71**	**34.41**
Waste Lands	Waste Land		350.38	28.25
	Total Waste Land		**350.38**	**28.25**
Settlement	Urban		192.99	15.56
	Total Settlements		**192.99**	**15.56**
Water Bodies	Rivers, Lakes, Nalas etc.		8.82	0.71
All Total			1240.21	100.00

Customer: BHARAT COKING COAL LIMITED

Title: Land Use/ Cover Map of Clusters of BCCL based on Satellite data for the year 2016

Job No. 561410027

Subject: Land Use/ Cover Map of Cluster IV based on Satellite Data (IRS-R2/LISS-IV) of the year 2016.

Activity	Name	Desig	Sign	Date
Prepared	A. Parida	AM (Geo)		
Checked	R. Kumar	CM(RS)		
Approved	NP Singh	GM(Geom)		

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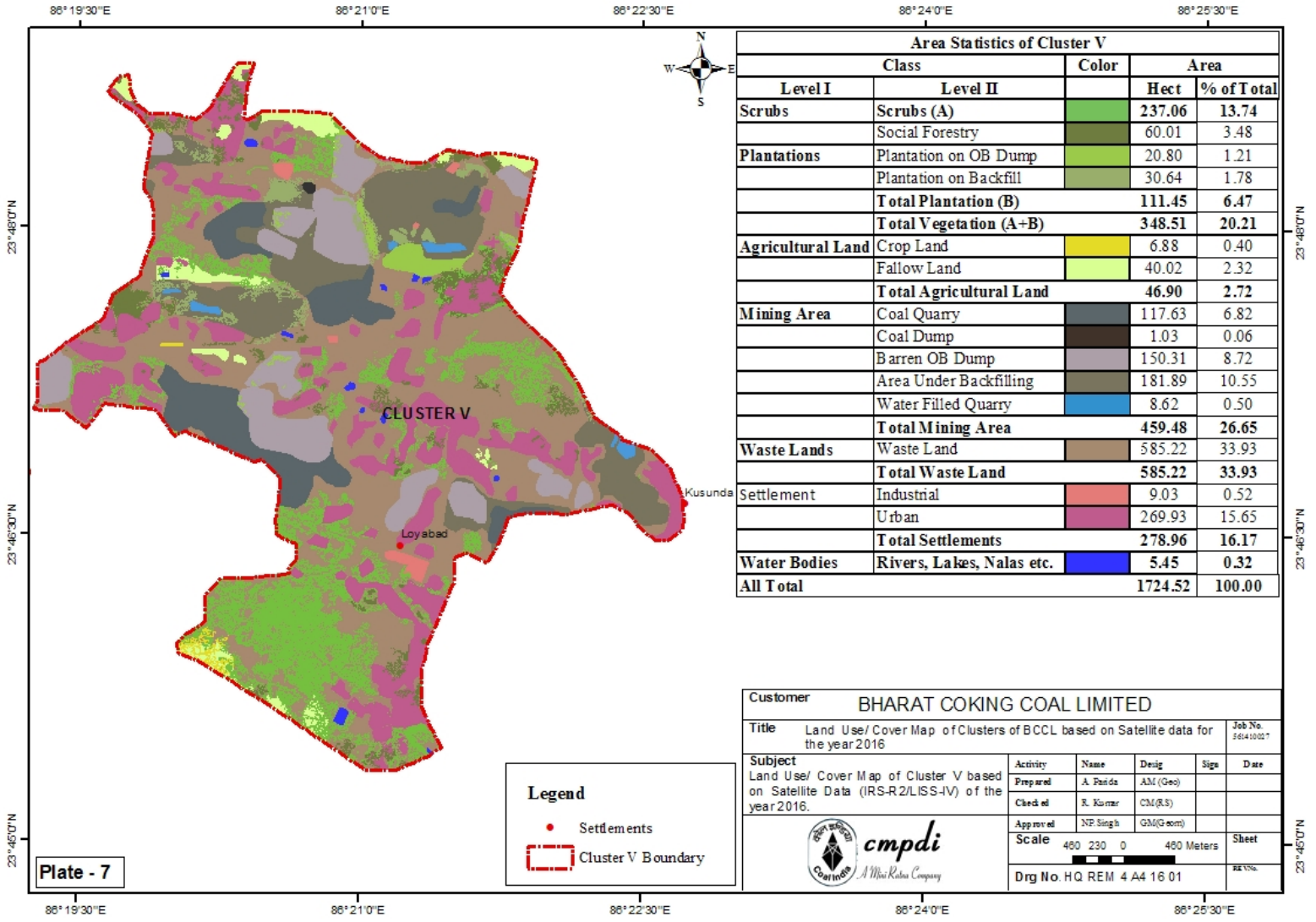

Area Statistics of Cluster V				
Class		Color	Area	
Level I	Level II		Hect	% of Total
Scrubs	Scrubs (A)		237.06	13.74
	Social Forestry		60.01	3.48
Plantations	Plantation on OB Dump		20.80	1.21
	Plantation on Backfill		30.64	1.78
	Total Plantation (B)		**111.45**	**6.47**
	Total Vegetation (A+B)		**348.51**	**20.21**
Agricultural Land	Crop Land		6.88	0.40
	Fallow Land		40.02	2.32
	Total Agricultural Land		**46.90**	**2.72**
Mining Area	Coal Quarry		117.63	6.82
	Coal Dump		1.03	0.06
	Barren OB Dump		150.31	8.72
	Area Under Backfilling		181.89	10.55
	Water Filled Quarry		8.62	0.50
	Total Mining Area		**459.48**	**26.65**
Waste Lands	Waste Land		585.22	33.93
	Total Waste Land		**585.22**	**33.93**
Settlement	Industrial		9.03	0.52
	Urban		269.93	15.65
	Total Settlements		**278.96**	**16.17**
Water Bodies	Rivers, Lakes, Nalas etc.		5.45	0.32
All Total			1724.52	100.00

Customer: BHARAT COKING COAL LIMITED

Title: Land Use/ Cover Map of Clusters of BCCL based on Satellite data for the year 2016

Job No. 561410027

Subject: Land Use/ Cover Map of Cluster V based on Satellite Data (IRS-R2/LISS-IV) of the year 2016.

Activity	Name	Desig	Sign	Date
Prepared	A. Farida	AM (Geo)		
Checked	R. Kumar	CM(RS)		
Approved	NP.Singh	GM(Geom)		

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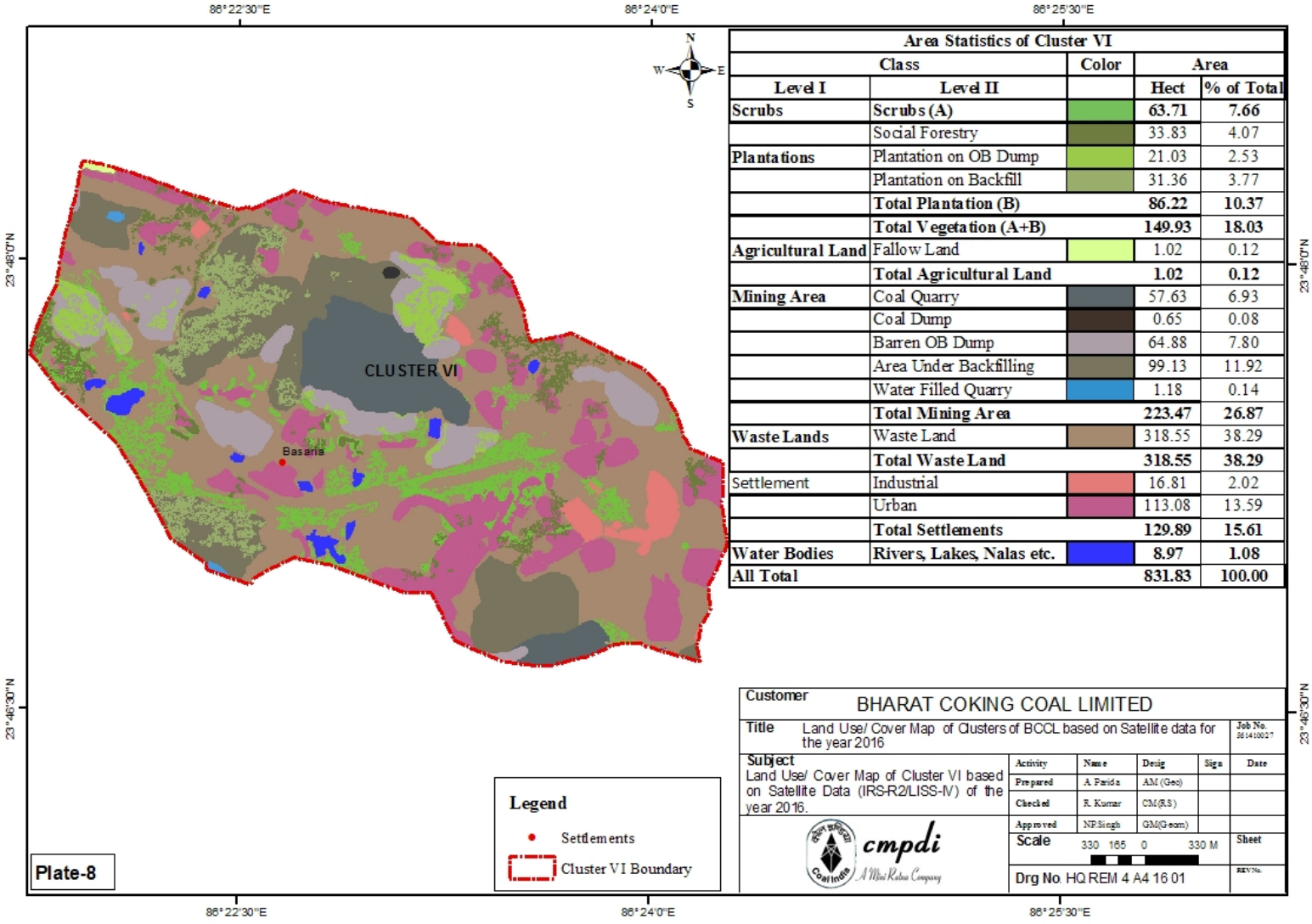

Area Statistics of Cluster VI				
Class		Color	Area	
Level I	Level II		Hect	% of Total
Scrubs	Scrubs (A)		63.71	7.66
	Social Forestry		33.83	4.07
Plantations	Plantation on OB Dump		21.03	2.53
	Plantation on Backfill		31.36	3.77
	Total Plantation (B)		86.22	10.37
	Total Vegetation (A+B)		149.93	18.03
Agricultural Land	Fallow Land		1.02	0.12
	Total Agricultural Land		1.02	0.12
Mining Area	Coal Quarry		57.63	6.93
	Coal Dump		0.65	0.08
	Barren OB Dump		64.88	7.80
	Area Under Backfilling		99.13	11.92
	Water Filled Quarry		1.18	0.14
	Total Mining Area		223.47	26.87
Waste Lands	Waste Land		318.55	38.29
	Total Waste Land		318.55	38.29
Settlement	Industrial		16.81	2.02
	Urban		113.08	13.59
	Total Settlements		129.89	15.61
Water Bodies	Rivers, Lakes, Nalas etc.		8.97	1.08
All Total			831.83	100.00

Customer: BHARAT COKING COAL LIMITED

Title: Land Use/ Cover Map of Clusters of BCCL based on Satellite data for the year 2016

Job No. 561410027

Subject: Land Use/ Cover Map of Cluster VI based on Satellite Data (IRS-R2/LISS-IV) of the year 2016.

Activity	Name	Desig	Sign	Date
Prepared	A. Parida	AM (Geo)		
Checked	R. Kumar	CM (RS)		
Approved	NP.Singh	GM(Geom)		

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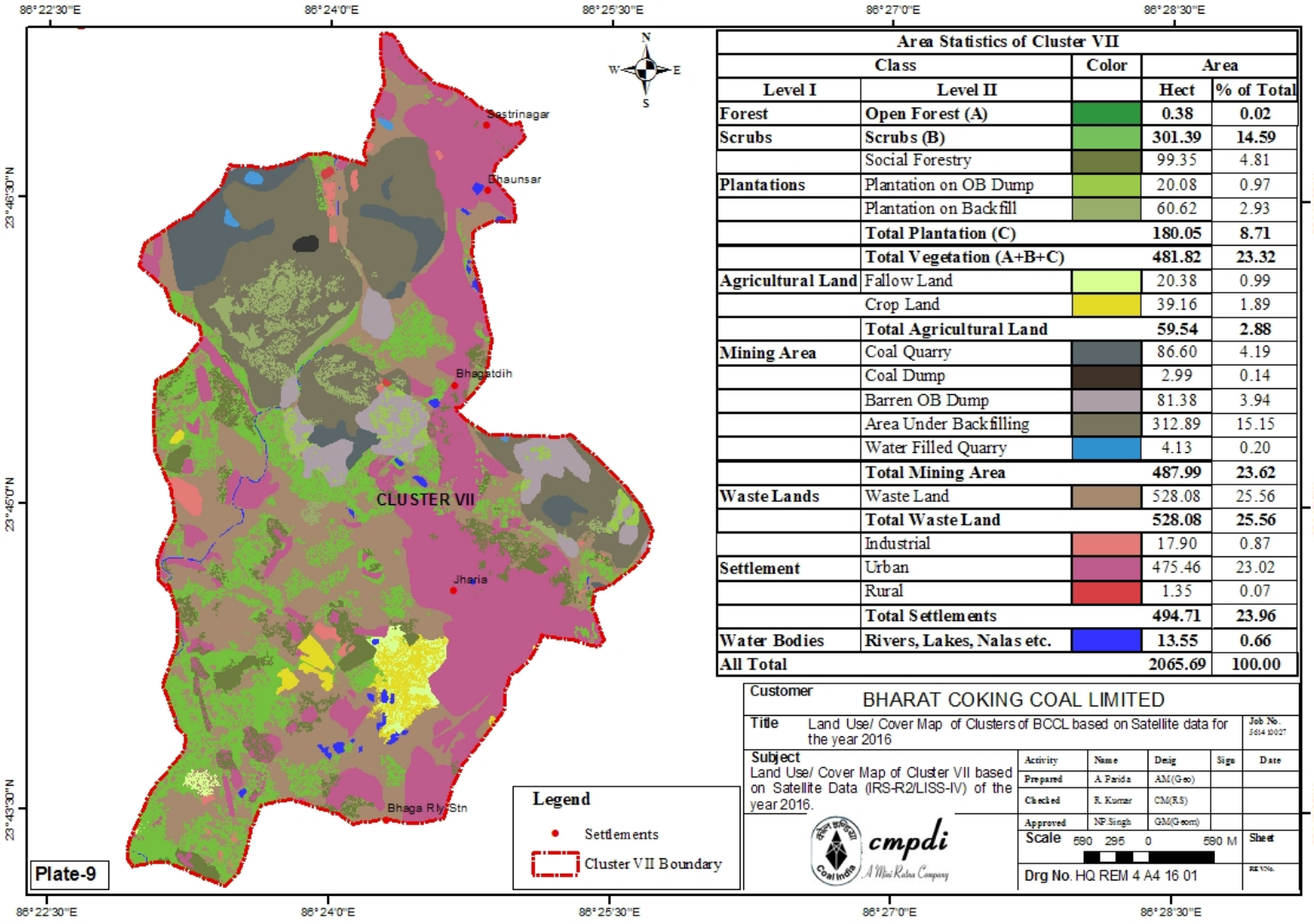

Area Statistics of Cluster VII				
Class		Color	Area	
Level I	Level II		Hect	% of Total
Forest	Open Forest (A)		0.38	0.02
Scrubs	Scrubs (B)		301.39	14.59
	Social Forestry		99.35	4.81
Plantations	Plantation on OB Dump		20.08	0.97
	Plantation on Backfill		60.62	2.93
	Total Plantation (C)		180.05	8.71
	Total Vegetation (A+B+C)		481.82	23.32
Agricultural Land	Fallow Land		20.38	0.99
	Crop Land		39.16	1.89
	Total Agricultural Land		59.54	2.88
Mining Area	Coal Quarry		86.60	4.19
	Coal Dump		2.99	0.14
	Barren OB Dump		81.38	3.94
	Area Under Backfilling		312.89	15.15
	Water Filled Quarry		4.13	0.20
	Total Mining Area		487.99	23.62
Waste Lands	Waste Land		528.08	25.56
	Total Waste Land		528.08	25.56
	Industrial		17.90	0.87
Settlement	Urban		475.46	23.02
	Rural		1.35	0.07
	Total Settlements		494.71	23.96
Water Bodies	Rivers, Lakes, Nalas etc.		13.55	0.66
All Total			2065.69	100.00

Customer: BHARAT COKING COAL LIMITED

Title: Land Use/ Cover Map of Clusters of BCCL based on Satellite data for the year 2016

Job No. 5614 10027

Subject: Land Use/ Cover Map of Cluster VII based on Satellite Data (IRS-R2/LISS-IV) of the year 2016.

Activity	Name	Desig	Sign	Date
Prepared	A. Parida	AM(Geo)		
Checked	R. Kumar	CM(RS)		
Approved	NP.Singh	GM(Geom)		

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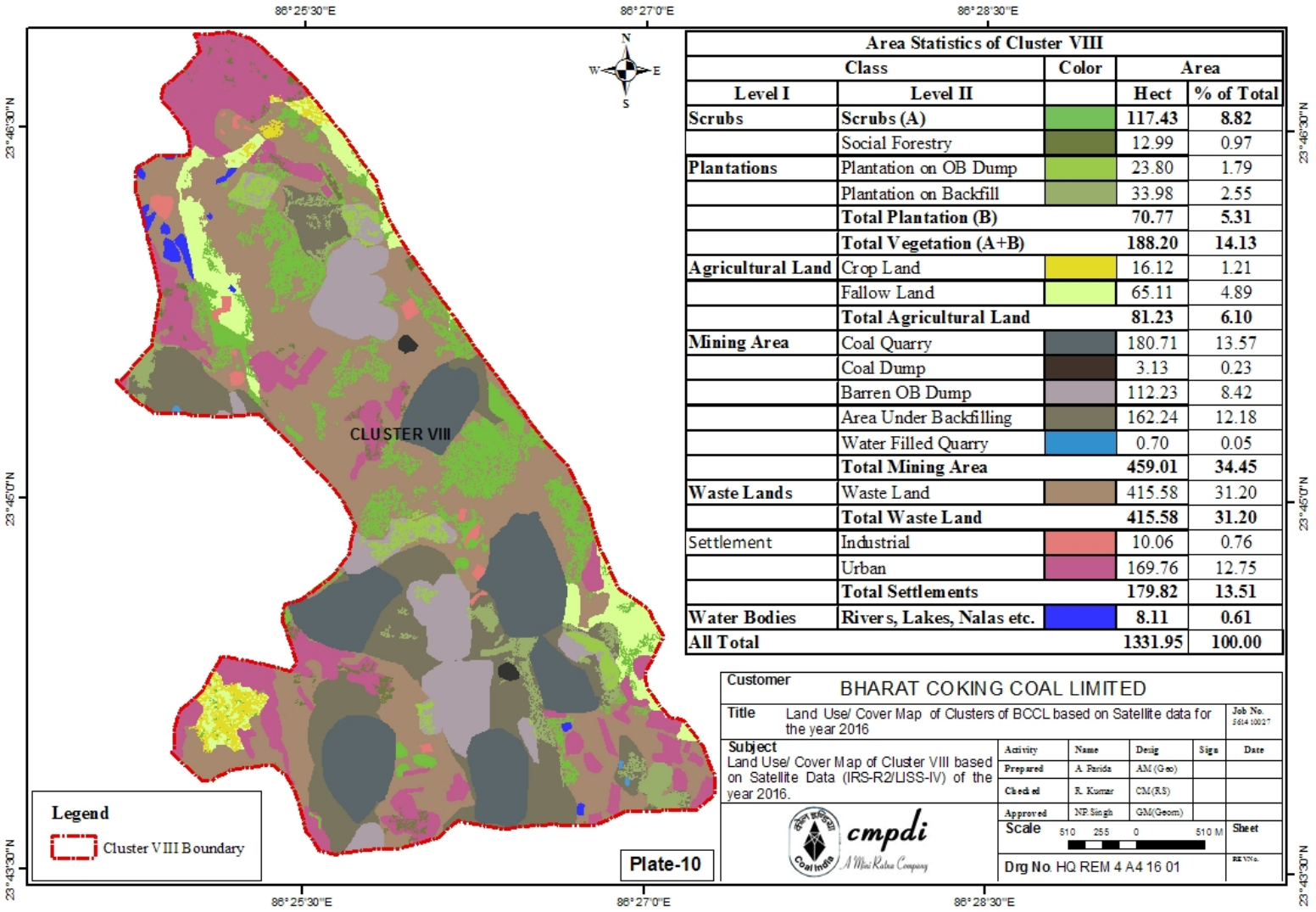

Area Statistics of Cluster VIII				
Class		Color	Area	
Level I	Level II		Hect	% of Total
Scrubs	Scrubs (A)		117.43	8.82
	Social Forestry		12.99	0.97
Plantations	Plantation on OB Dump		23.80	1.79
	Plantation on Backfill		33.98	2.55
	Total Plantation (B)		**70.77**	**5.31**
	Total Vegetation (A+B)		**188.20**	**14.13**
Agricultural Land	Crop Land		16.12	1.21
	Fallow Land		65.11	4.89
	Total Agricultural Land		**81.23**	**6.10**
Mining Area	Coal Quarry		180.71	13.57
	Coal Dump		3.13	0.23
	Barren OB Dump		112.23	8.42
	Area Under Backfilling		162.24	12.18
	Water Filled Quarry		0.70	0.05
	Total Mining Area		**459.01**	**34.45**
Waste Lands	Waste Land		415.58	31.20
	Total Waste Land		**415.58**	**31.20**
Settlement	Industrial		10.06	0.76
	Urban		169.76	12.75
	Total Settlements		**179.82**	**13.51**
Water Bodies	Rivers, Lakes, Nalas etc.		8.11	0.61
All Total			1331.95	100.00

Customer: BHARAT COKING COAL LIMITED

Title: Land Use/ Cover Map of Clusters of BCCL based on Satellite data for the year 2016

Job No. 5614 10027

Subject: Land Use/ Cover Map of Cluster VIII based on Satellite Data (IRS-R2/LISS-IV) of the year 2016.

Activity	Name	Desig	Sign	Date
Prepared	A. Farida	AM (Geo)		
Checked	R. Kumar	CM(RS)		
Approved	NP. Singh	GM(Geom)		

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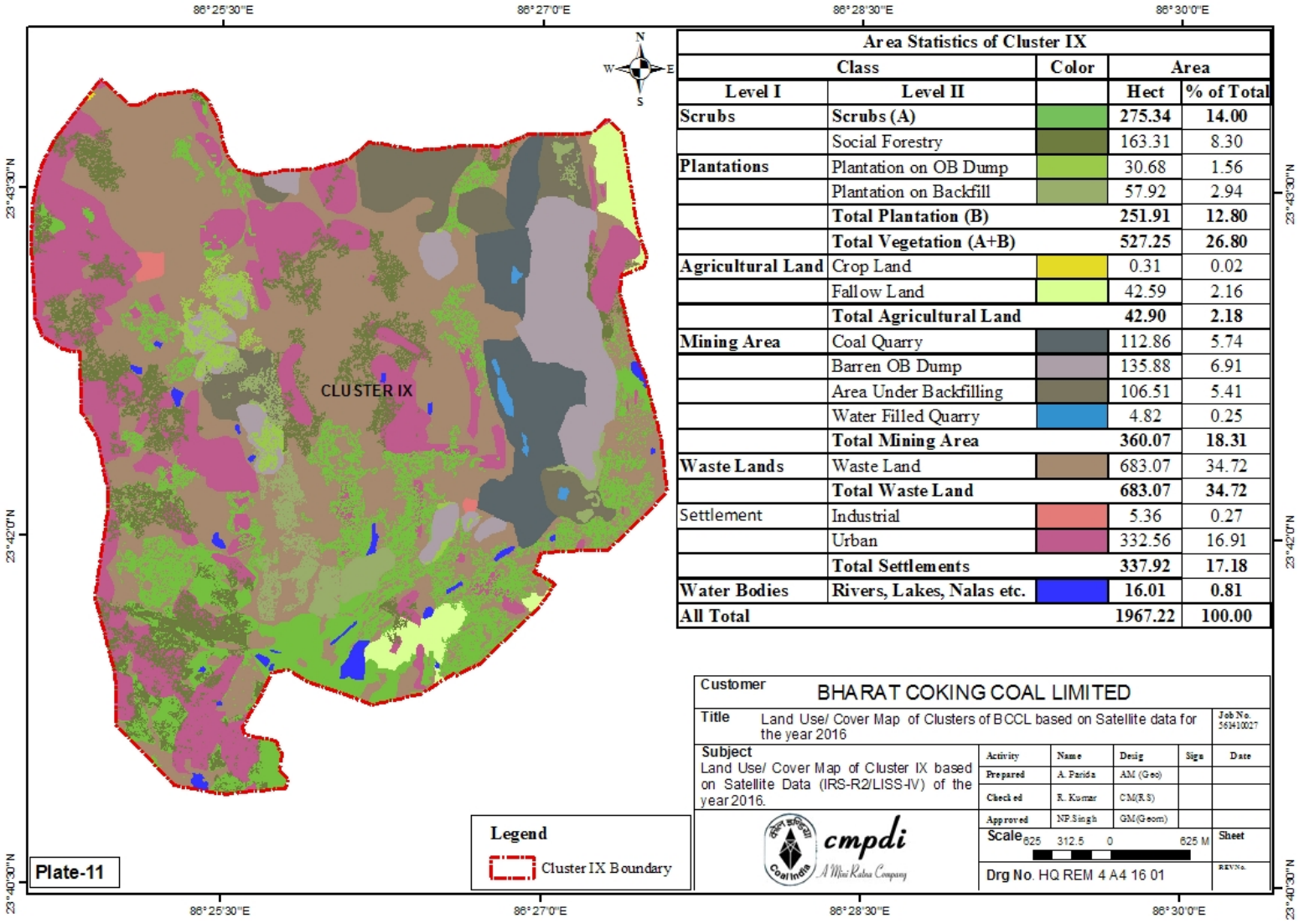

Area Statistics of Cluster IX

Class		Color	Area	
Level I	Level II		Hect	% of Total
Scrubs	Scrubs (A)		275.34	14.00
	Social Forestry		163.31	8.30
Plantations	Plantation on OB Dump		30.68	1.56
	Plantation on Backfill		57.92	2.94
	Total Plantation (B)		**251.91**	**12.80**
	Total Vegetation (A+B)		**527.25**	**26.80**
Agricultural Land	Crop Land		0.31	0.02
	Fallow Land		42.59	2.16
	Total Agricultural Land		**42.90**	**2.18**
Mining Area	Coal Quarry		112.86	5.74
	Barren OB Dump		135.88	6.91
	Area Under Backfilling		106.51	5.41
	Water Filled Quarry		4.82	0.25
	Total Mining Area		**360.07**	**18.31**
Waste Lands	Waste Land		683.07	34.72
	Total Waste Land		**683.07**	**34.72**
Settlement	Industrial		5.36	0.27
	Urban		332.56	16.91
	Total Settlements		**337.92**	**17.18**
Water Bodies	Rivers, Lakes, Nalas etc.		16.01	0.81
All Total			1967.22	100.00

Customer	BHARAT COKING COAL LIMITED				
Title	Land Use/ Cover Map of Clusters of BCCL based on Satellite data for the year 2016				Job No. 561410027
Subject	Land Use/ Cover Map of Cluster IX based on Satellite Data (IRS-R2/LISS-IV) of the year 2016.	Activity	Name	Desig	Sign / Date
		Prepared	A. Farida	AM (Geo)	
		Checked	R. Kumar	CM(RS)	
		Approved	NP Singh	GM(Geom)	
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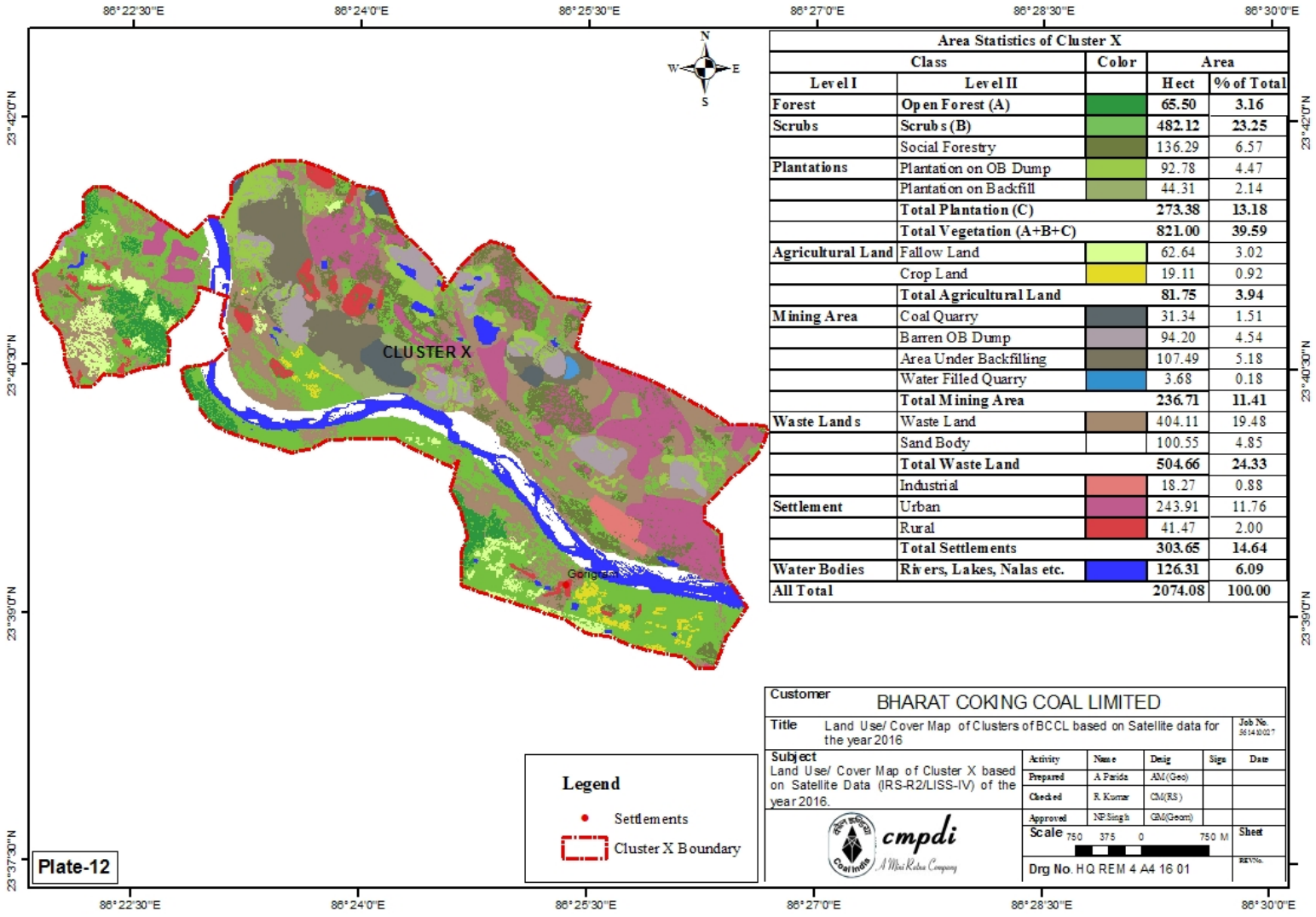

Area Statistics of Cluster X				
Class		Color	Area	
Level I	Level II		Hect	% of Total
Forest	Open Forest (A)		65.50	3.16
Scrubs	Scrubs (B)		482.12	23.25
	Social Forestry		136.29	6.57
Plantations	Plantation on OB Dump		92.78	4.47
	Plantation on Backfill		44.31	2.14
	Total Plantation (C)		273.38	13.18
	Total Vegetation (A+B+C)		821.00	39.59
Agricultural Land	Fallow Land		62.64	3.02
	Crop Land		19.11	0.92
	Total Agricultural Land		81.75	3.94
Mining Area	Coal Quarry		31.34	1.51
	Barren OB Dump		94.20	4.54
	Area Under Backfilling		107.49	5.18
	Water Filled Quarry		3.68	0.18
	Total Mining Area		236.71	11.41
Waste Lands	Waste Land		404.11	19.48
	Sand Body		100.55	4.85
	Total Waste Land		504.66	24.33
	Industrial		18.27	0.88
Settlement	Urban		243.91	11.76
	Rural		41.47	2.00
	Total Settlements		303.65	14.64
Water Bodies	Rivers, Lakes, Nalas etc.		126.31	6.09
All Total			2074.08	100.00

Customer: BHARAT COKING COAL LIMITED

Title: Land Use/ Cover Map of Clusters of BCCL based on Satellite data for the year 2016

Job No. 561410027

Subject: Land Use/ Cover Map of Cluster X based on Satellite Data (IRS-R2/LISS-IV) of the year 2016.

Activity	Name	Desig	Sign	Date
Prepared	A Parida	AM (Geo)		
Checked	R. Kumar	CM(RS)		
Approved	NP Singh	GM(Geom)		

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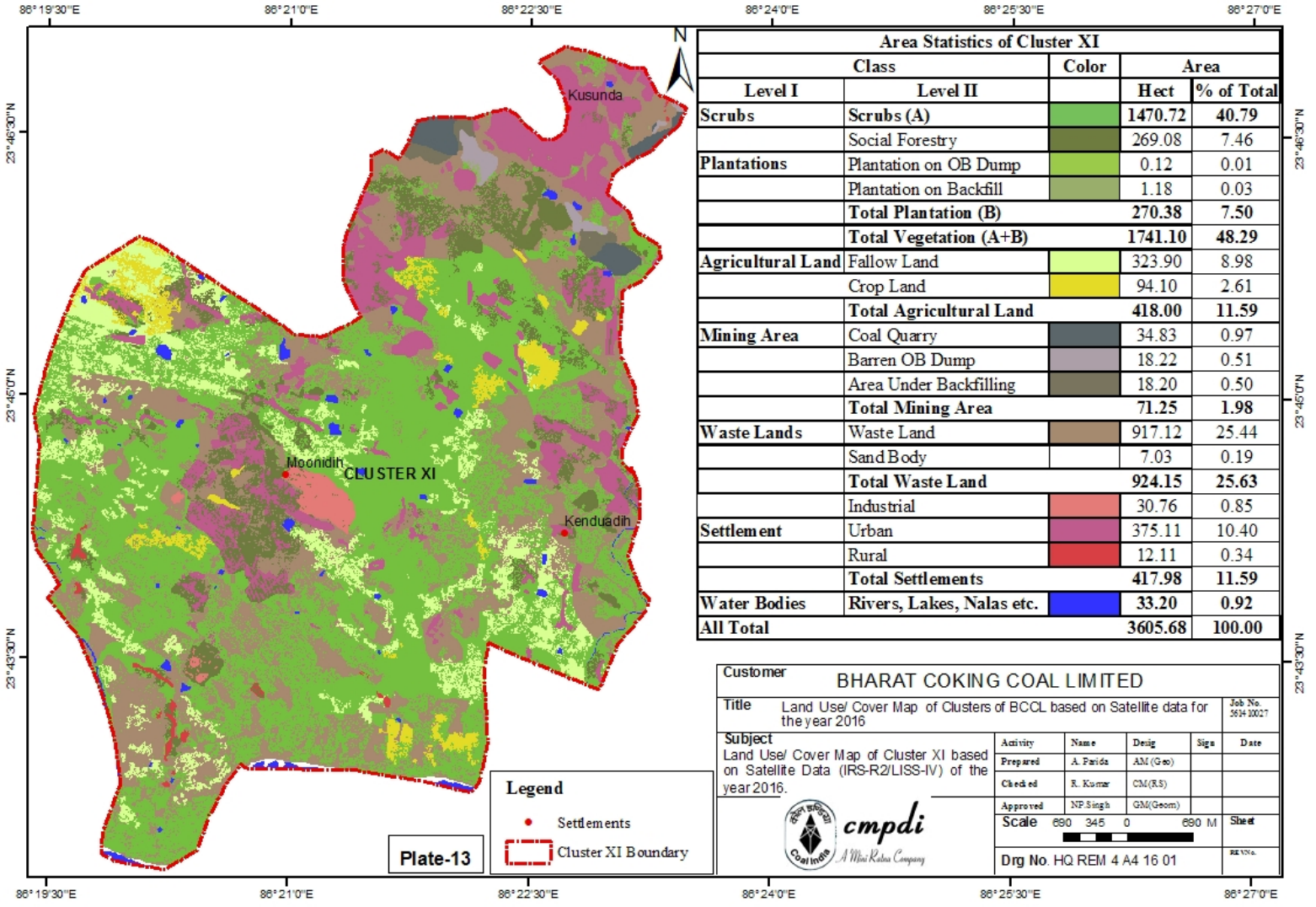

Area Statistics of Cluster XI				
Class		Color	Area	
Level I	Level II		Hect	% of Total
Scrubs	Scrubs (A)		1470.72	40.79
	Social Forestry		269.08	7.46
Plantations	Plantation on OB Dump		0.12	0.01
	Plantation on Backfill		1.18	0.03
	Total Plantation (B)		**270.38**	**7.50**
	Total Vegetation (A+B)		**1741.10**	**48.29**
Agricultural Land	Fallow Land		323.90	8.98
	Crop Land		94.10	2.61
	Total Agricultural Land		**418.00**	**11.59**
Mining Area	Coal Quarry		34.83	0.97
	Barren OB Dump		18.22	0.51
	Area Under Backfilling		18.20	0.50
	Total Mining Area		**71.25**	**1.98**
Waste Lands	Waste Land		917.12	25.44
	Sand Body		7.03	0.19
	Total Waste Land		**924.15**	**25.63**
	Industrial		30.76	0.85
Settlement	Urban		375.11	10.40
	Rural		12.11	0.34
	Total Settlements		**417.98**	**11.59**
Water Bodies	Rivers, Lakes, Nalas etc.		33.20	0.92
All Total			3605.68	100.00

Customer: BHARAT COKING COAL LIMITED

Title: Land Use/ Cover Map of Clusters of BCCL based on Satellite data for the year 2016

Job No. 5614 10027

Subject: Land Use/ Cover Map of Cluster XI based on Satellite Data (IRS-R2/LISS-IV) of the year 2016.

Activity	Name	Desig	Sign	Date
Prepared	A. Parida	AM (Geo)		
Checked	R. Kumar	CM (RS)		
Approved	NP.Singh	GM(Geom)		

Scale 690 345 0 690 M

Sheet

Drg No. HQ REM 4 A4 16 01

REV No.

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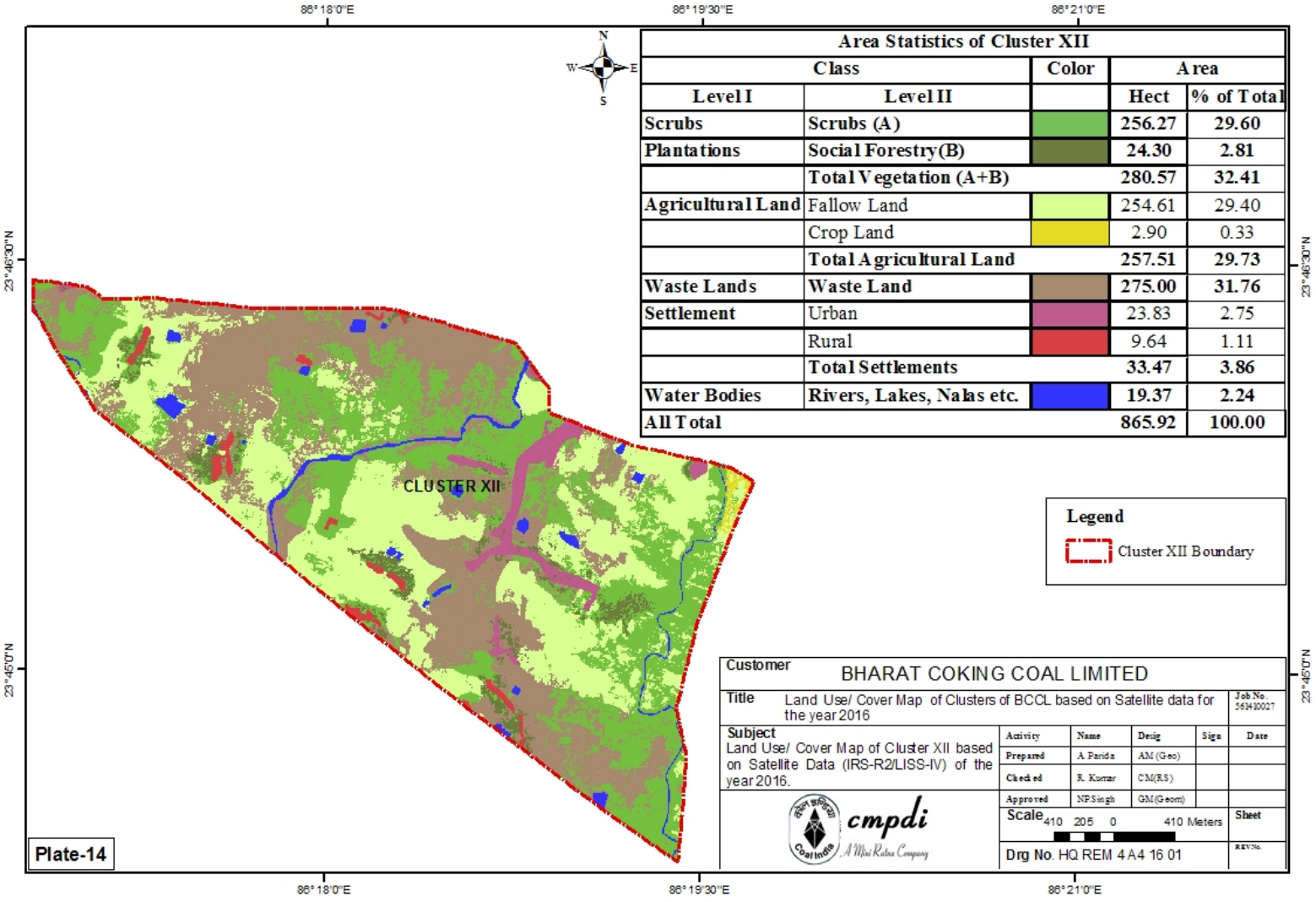

Area Statistics of Cluster XII

Class		Color	Area	
Level I	Level II		Hect	% of Total
Scrubs	Scrubs (A)		256.27	29.60
Plantations	Social Forestry(B)		24.30	2.81
	Total Vegetation (A+B)		280.57	32.41
Agricultural Land	Fallow Land		254.61	29.40
	Crop Land		2.90	0.33
	Total Agricultural Land		257.51	29.73
Waste Lands	Waste Land		275.00	31.76
Settlement	Urban		23.83	2.75
	Rural		9.64	1.11
	Total Settlements		33.47	3.86
Water Bodies	Rivers, Lakes, Nalas etc.		19.37	2.24
All Total			865.92	100.00

Legend

Cluster XII Boundary

Customer: BHARAT COKING COAL LIMITED

Title: Land Use/ Cover Map of Clusters of BCCL based on Satellite data for the year 2016

Job No. 561410027

Subject: Land Use/ Cover Map of Cluster XII based on Satellite Data (IRS-R2/LISS-IV) of the year 2016.

Activity	Name	Desig	Sign	Date
Prepared	A Farida	AM (Geo)		
Checked	R. Kumar	CM(RS)		
Approved	NP Singh	GM(Geom)		

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Scale 410 205 0 410 Meters

Sheet

Drg No. HQ REM 4 A4 16 01

REV No.

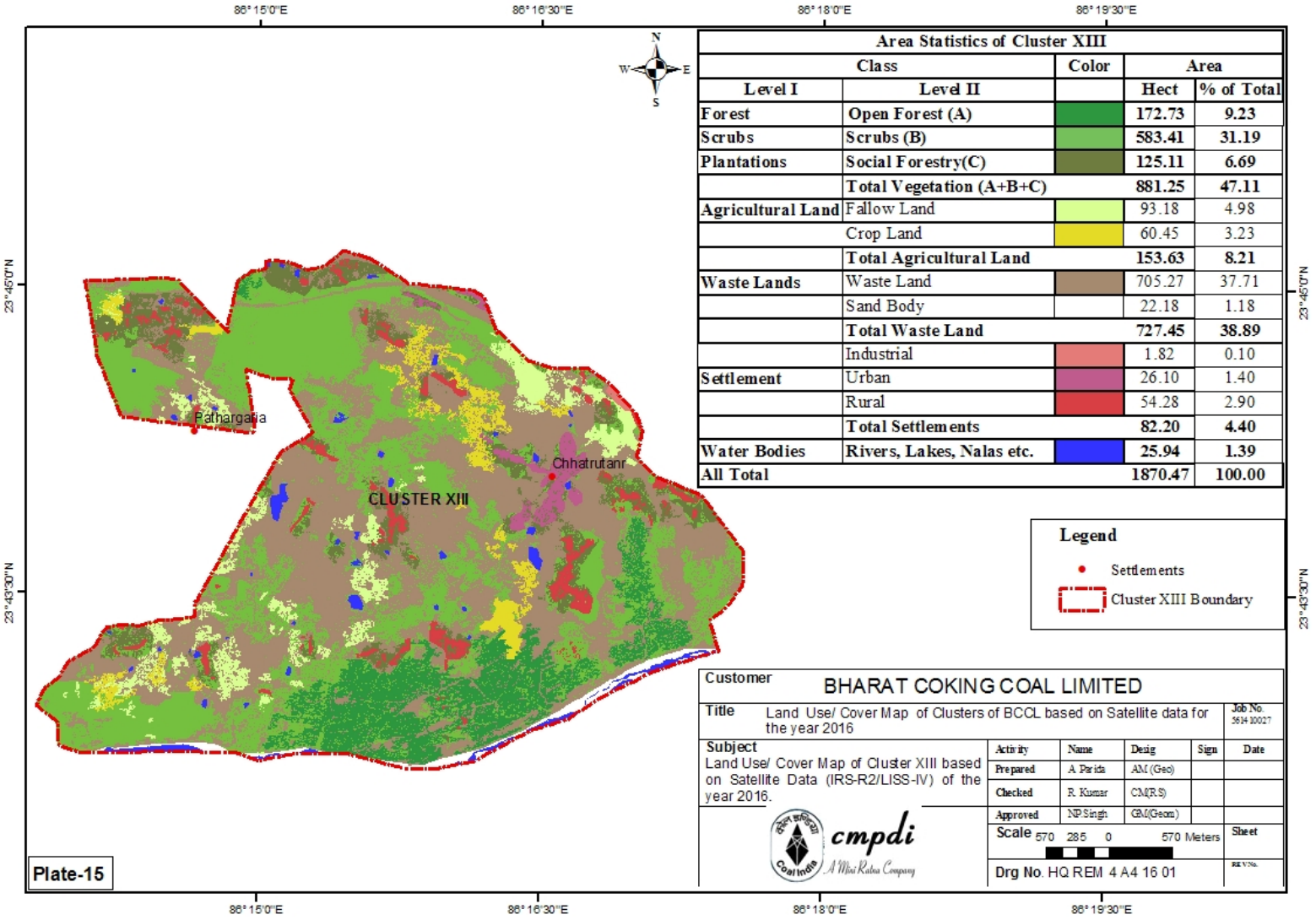
86°15'0"E
86°16'30"E
86°18'0"E
86°19'30"E
23°45'0"N
23°43'30"N
N
W
E
S
Pathargatia
Chhatrutanr
CLUSTER XIII
Area Statistics of Cluster XIII
Class
Color
Area
Level I
Level II
Hect
% of Total
Forest
Open Forest (A)
172.73
9.23
Scrubs
Scrubs (B)
583.41
31.19
Plantations
Social Forestry(C)
125.11
6.69
Total Vegetation (A+B+C)
881.25
47.11
Agricultural Land
Fallow Land
93.18
4.98
Crop Land
60.45
3.23
Total Agricultural Land
153.63
8.21
Waste Lands
Waste Land
705.27
37.71
Sand Body
22.18
1.18
Total Waste Land
727.45
38.89
Industrial
1.82
0.10
Settlement
Urban
26.10
1.40
Rural
54.28
2.90
Total Settlements
82.20
4.40
Water Bodies
Rivers, Lakes, Nalas etc.
25.94
1.39
All Total
1870.47
100.00
Legend
Settlements
Cluster XIII Boundary
Customer
BHARAT COKING COAL LIMITED
Title
Land Use/ Cover Map of Clusters of BCCL based on Satellite data for the year 2016
Job No.
5614 10027
Subject
Land Use/ Cover Map of Cluster XIII based on Satellite Data (IRS-R2/LISS-IV) of the year 2016.
Activity
Name
Desig
Sign
Date
Prepared
A Parida
AM (Geo)
Checked
R. Kumar
CM(RS)
Approved
NP Singh
GM(Geom)
Scale 570 285 0 570 Meters
Sheet
Drg No. HQ REM 4 A4 16 01
REV No.
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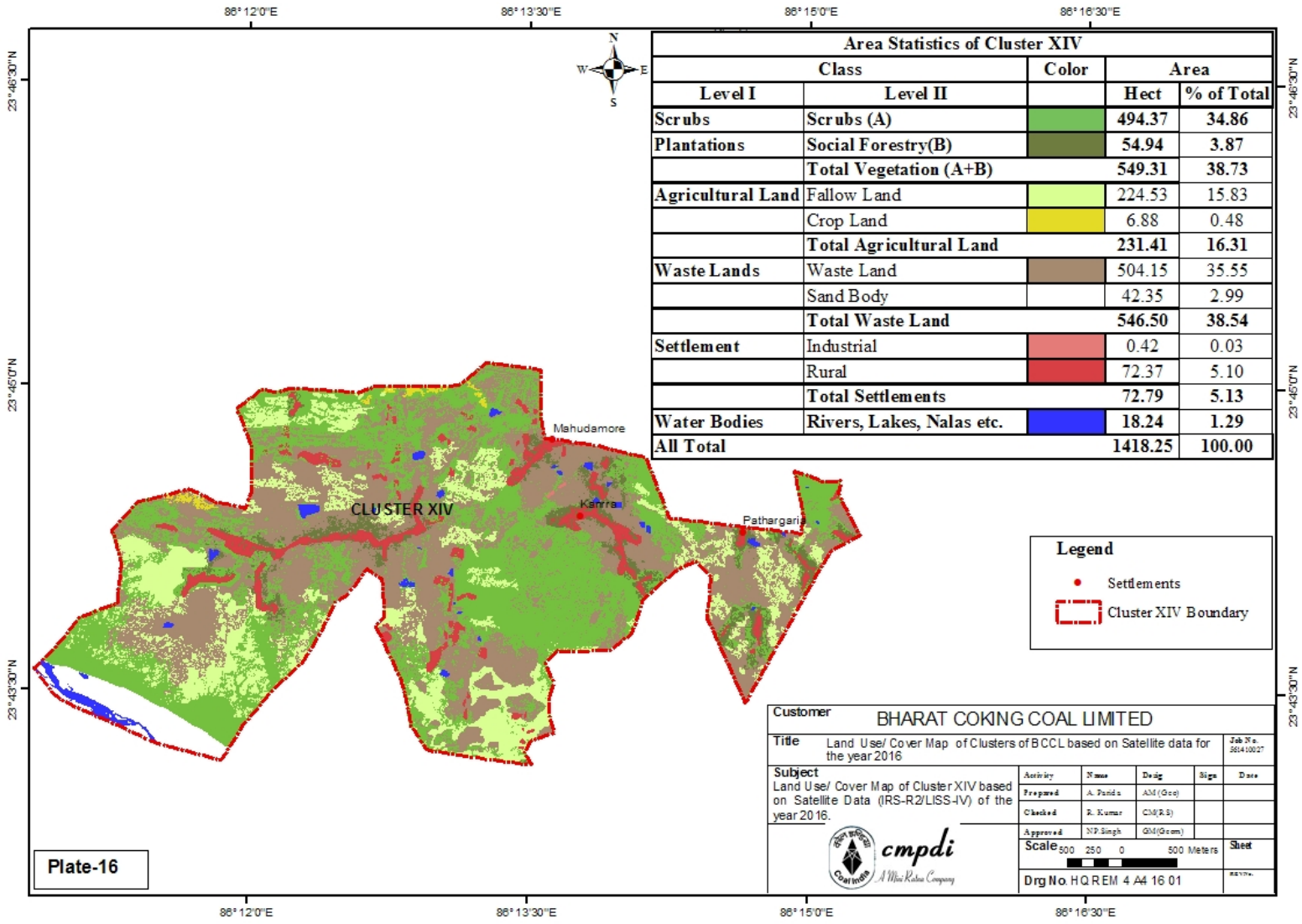
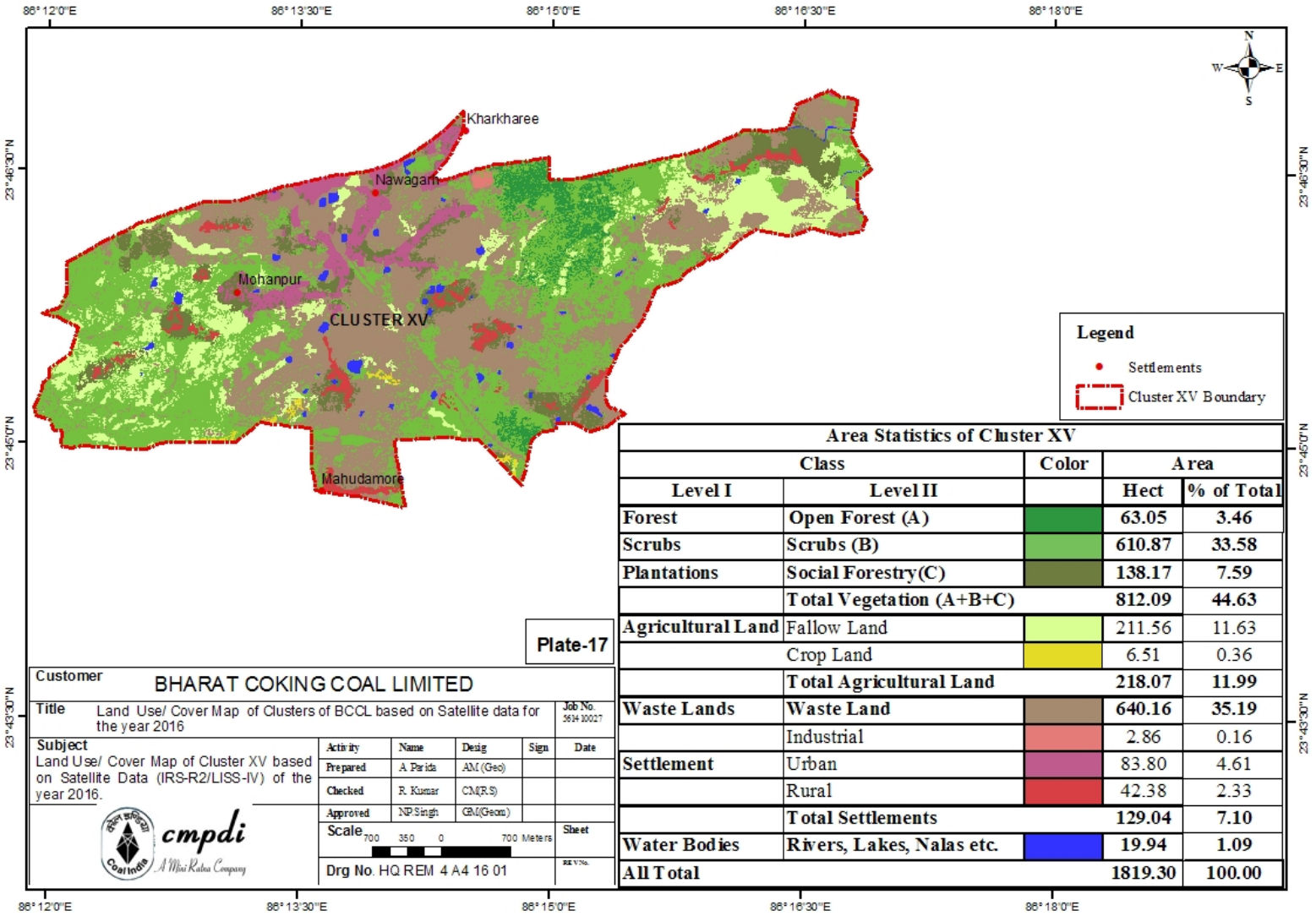
Plate-15



Area Statistics of Cluster XIV

Class		Color	Area	
Level I	Level II		Hect	% of Total
Scrubs	Scrubs (A)		494.37	34.86
Plantations	Social Forestry(B)		54.94	3.87
	Total Vegetation (A+B)		549.31	38.73
Agricultural Land	Fallow Land		224.53	15.83
	Crop Land		6.88	0.48
	Total Agricultural Land		231.41	16.31
Waste Lands	Waste Land		504.15	35.55
	Sand Body		42.35	2.99
	Total Waste Land		546.50	38.54
Settlement	Industrial		0.42	0.03
	Rural		72.37	5.10
	Total Settlements		72.79	5.13
Water Bodies	Rivers, Lakes, Nalas etc.		18.24	1.29
All Total			1418.25	100.00



Area Statistics of Cluster XV

Class		Color	Area	
Level I	Level II		Hect	% of Total
Forest	Open Forest (A)		63.05	3.46
Scrubs	Scrubs (B)		610.87	33.58
Plantations	Social Forestry(C)		138.17	7.59
	Total Vegetation (A+B+C)		812.09	44.63
Agricultural Land	Fallow Land		211.56	11.63
	Crop Land		6.51	0.36
	Total Agricultural Land		218.07	11.99
Waste Lands	Waste Land		640.16	35.19
	Industrial		2.86	0.16
Settlement	Urban		83.80	4.61
	Rural		42.38	2.33
	Total Settlements		129.04	7.10
Water Bodies	Rivers, Lakes, Nalas etc.		19.94	1.09
All Total			1819.30	100.00

Plate-17

Customer: BHARAT COKING COAL LIMITED

Title: Land Use/ Cover Map of Clusters of BCCL based on Satellite data for the year 2016

Job No. 5614 10027

Subject: Land Use/ Cover Map of Cluster XV based on Satellite Data (IRS-R2/LISS-IV) of the year 2016.

Activity	Name	Desig	Sign	Date
Prepared	A. Parida	AM (Geo)		
Checked	R. Kumar	CM(RS)		
Approved	NP Singh	GM(Geom)		

Scale 700 350 0 700 Meters

Sheet

Drg No. HQ REM 4 A4 16 01

REV No.

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Central Mine Planning & Design Institute Ltd.
(A Subsidiary of Coal India Ltd.)
Gondwana Place, Kanke Road, Ranchi - 834 008,India
Phone : (+91-0651) 2230001, 2230002, 2230483, Fax (91-0651) 2231851, 2231447
Email : cmpdi2@hub.nic.in, cmpdihq@cmpdi.co.in

86°10'0"E 86°15'0"E 86°20'0"E 86°25'0"E

23°45'0"N 23°40'0"N 23°35'0"N

N

Muraidih Colony
Kesaipur west mudidih
Block IV Koodidih
(AKWMC) Eco Park
Eco Rest Park
Govindpur
Salanpur
Tetulmari
Nichitpur
East Bussuriya
Gondudih
Gondudih Rest. Park
Dhanbad
Muraidih
Jogidih
Cluster IV
Angarpathra
Madhuband Washery
Barora
Dumra
New Akaskinar
Agrik
Bibora
Cluster III
Shatabdi OCP
Tundu
Mudidih
Sendrabansjora
Cluster VI
Bussuriya Bunara
Khaskusunda
Telo
Phularitand Eco Park
Phularitand OC
West phularitand
South Govindpur
Teturiya
Katraschoitudih
Cluster V
Cluster II
Nuckhurkee
Kesargarh
Gaslitand
Sijua
Godhur
Sasterdanga
Dumdua Eco Rest. Park
Maheshpur
Kharkharee
Malkera
Bansdeopur
Kusunda
Dhansar
Mahuda
Kankanee
Kendwadih
Dhanbar
Block II proj.area
Loyabad
Siaharpura
Adarshnagar colony
Gopalichuck
Cluster I
Damoda
Dharmaband
Bhelatand colony
Alkusa
Kusunda
Karmatand
Bastacolla
Bera
Industry
Cluster XV
Kharkharee
Madhuband
Phularitand UG
Gawan Mandhu Line
Loyabad
Pootkee
Cluster XII
Kapuria
Kachhiballari
Bhagatdih
Dugda
PB Project
Kustore
Ena
Dobari
South Jharia OCP Eco
Cluster VII
Cluster VIII
S.Jharia OCP
Eastbhuggatdih
Jharia
Ghanoodih
Kuya
Muchhiraidih colliery
Bhurungia colliery
Hantoodih colliery
Mahudamore
Meonidih
Moonidih
Cluster XI
Moonidih Washery
Mahuda Washery
Hedugoda colly
Dugda 1 Washery
Dugda II Washery
Kenduadih
Bhagabandh
Burragarh
Kenduadih
Simlabahal
Kujama
Goluckdih
Cluster XIV
Lohapatty colliery
Chhatabani
Cluster XIII
Murulidih 20/21 pits
Singra
Bhutgoria
Orissa Rly Sid
Lodna
N Tisra
S Tisra
Murulidih colliery
Moonidih washery
Bhaktdee colliery
Damodar River
Jealgora
Cluster X
Bagdigi
Joyrampur
Jeenagora
TATA officers colony
Barapee
Bhowrah north
Amlabad project
Patherdih
Patherdih Washery
Cluster X
Bhowrah south
Bhowrah Eco Park
Sudamdih INB
Amlabad basti
Patherdih
Sudamdih Washery
Sudamdih shaft
Gongram
Broudih Jn
Broudih Washery

Legend

- Coal washeries
- Eco restoration park
- Settlements
- Stream
- Road
- Railway line
- Block boundary
- Cluster boundary
- Jharia coalfiled boundary

Customer	BHARAT COKING COAL LIMITED
Title	Vegetation Cover Map of Jharia Coalfield based on Satellite data for the year 2016
Job No.	5614 10027
Subject	FCC of Jharia Coalfield based on Satellite Data (IRS-R2/LISS-IV) of the year 2016.

Activity	Name	Desig	Sign	Date
Prepared A.	A. Parida	AM (Geo)		
Checked	R. Kumar	CM(RS)		
Approved	NP.Singh	GM(Geom)		

Scale 2 1 0 2 Km

Sheet

Drg No. HQ REM 4 A1 16 01

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Coalfield boundary is as per map provided by BCCL

Area Statistics				
Class		Color	Area	
Level I	Level II		Sq km	% of Total
Forest	Dense Forest		0.29	0.07
	Open Forest		6.27	1.60
	Total Forest (A)		**6.56**	**1.67**
Scrubs	**Scrubs (B)**		**105.87**	**26.95**
	Social Forestry		19.52	4.97
Plantations	Plantation on OB Dump		4.91	1.25
	Plantation on Backfill		3.68	0.94
	Total Plantation (C)		**28.11**	**7.16**
	Total Vegetation (A+B+C)		**140.54**	**35.78**
Agricultural Land	Fallow Land		40.68	10.36
	Crop Land		3.71	0.95
	Total Agricultural Land		**44.39**	**11.31**
Mining Area	Coal Quarry		11.36	2.89
	Coal Dump		0.23	0.06
	Barren OB Dump		12.55	3.20
	Barren Backfilled Area		15.62	3.97
	Water Filled Quarry		0.77	0.20
	Total Mining Area		**40.53**	**10.32**
Waste Lands	Waste Land		113.97	29.01
	Sand Body		4.85	1.23
	Total Waste Land		**118.82**	**30.24**
	Industrial		2.29	0.58
Settlement	Urban		35.05	8.92
	Rural		3.74	0.95
	Total Settlements		**41.08**	**10.45**
Water Bodies	**Rivers, Lakes, Nalas etc.**		**7.48**	**1.90**
All Total			**392.85**	**100.00**

Legend

- Coal washeries
- Eco restoration park
- Settlements
- Stream
- Road
- Railway line
- Block boundary
- Cluster boundary
- Jharia coalfield boundary

Customer BHARAT COKING COAL LIMITED

Title Vegetation Cover Map of Jharia Coalfield based on Satellite data for the year 2016

Job No. 561410027

Subject
Land Use/ Vegetation Cover Map of Jharia Coalfield based on Satellite Data (IRS-R2/LISS-IV) of the year 2016.

Activity	Name	Desig	Sign	Date
Prepared	A. Parida	AM (Geo)		
Checked	R. Kumar	CM(RS)		
Approved	NP.Singh	GM(Geom)		

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Scale 2 1 0 2 Km

Sheet

Drg No. HQ REM 4 A1 16 02

REV No.

Coalfield boundary is as per map provided by BCCL