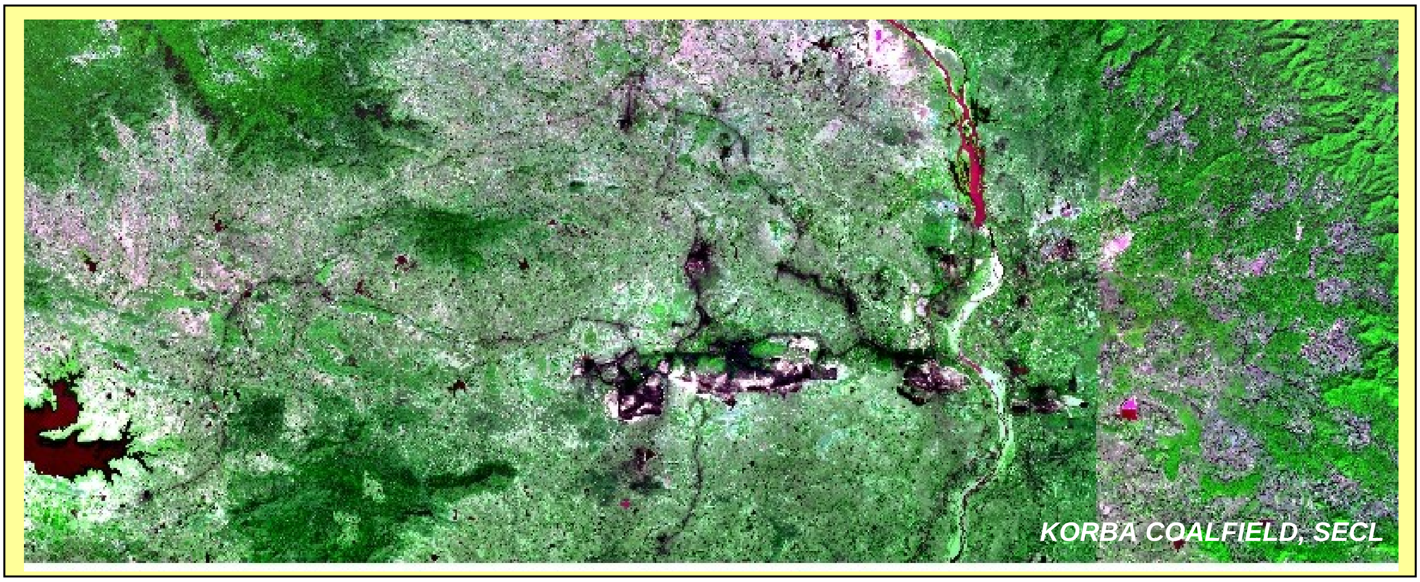
REPORT ON VEGETATION COVER MAPPING OF KORBA COALFIELD BASED ON SATELLITE DATA OF THE YEAR 2012



Submitted to

SOUTH EASTERN COALFIELDS LIMITED, BILASPUR

March 2013

cmpdi

A Mini Ratna Company

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Report on
Vegetation Cover Mapping of Korba Coalfield
based on Satellite date of the year 2012

Submitted to

South Eastern Coalfields Limited

March 2013

Remote Sensing Cell
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Document Control Sheet

(1)	Job No.	RSC-561410027
(2)	Publication Date	March 2013
(3)	Number of Pages	34
(4)	Number of Figures	06
(5)	Number of Tables	05
(6)	Number of Plates	01
(7)	Number of Drawings	01
(8)	Title of the Report	Land use/ Vegetation Cover mapping of Korba Coalfield based on satellite data of the year 2012.
(9)	Aim of the Report	Preparation of land use/vegetation cover map of Korba Coalfields on 1:50,000 scale based on IRS R2 LISS IV satellite data for assessing the impact of coal mining on land use and vegetation cover pattern.
(10)	Executing Unit	Remote Sensing Cell Geomatics Division Central Mine Planning & Design Institute Ltd. Gondwana Place, Kanke Road, Ranchi
(11)	User Agency	South Eastern Coalfields Limited, Bilaspur
(12)	Author	Rakesh Ranjan, Senior Manager (RSC)
(13)	Security Restriction	Restricted Circulation
(14)	No. of Copies	7
(15)	Distribution Statement	Official

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Chapter 1

Introduction

1.1 Project Reference

Coal India Limited requested CMPDI to take up the study based on remote sensing satellite data for creating the geo-environmental data base of coalfields for monitoring the impact of coal mining on land use and vegetation cover. 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 for creating the geo-environmental data base and subsequent monitoring of impact of coal mining land environment at a regular interval of three years. A work order no.CIL/WBP/Env/2009/2428 dated 29.12.2009 was issued by CIL initially for three years. Subsequently, a revised work order was issued vide letter no. CIL/WBP/Env/2011/4706 dated 12.10.2012 from Coal India Limited for the period 2012-13 to 2016-17 for land reclamation monitoring of all the opencast projects as well vegetation cover monitoring of 28 major coalfields including Korba Coalfield as per a defined plan for monitoring the impact of mining on Vegetation Cover.

1.2 Project Background

South Eastern coalfield Ltd. is a Mini Ratna Company, dedicated for maintaining the ecological balance in the region has initiated a massive plantation programme on backfilled area, OB dumps and wasteland. The advent of high resolution, multispectral satellite data has opened a new avenue in the field of mapping and monitoring of vegetation cover. The present study has been taken up to access the impact of coal mining on land use and vegetation cover in Korba Coalfield with respect to the earlier study carried out in the year 2008.

1.3 Objective

The objective of the present study is to prepare a regional land use/ vegetation cover map of Korba Coalfields on 1:50,000 scale based on IRS R2 LISS-IV satellite data of the year 2012 using digital image processing technique for accessing the impact of coal mining and associated industrial activities on the land use/ vegetation cover in Korba Coalfield.

1.4 Location of the Area & Accessibility

The Korba Coalfield covers is in the south central part of the Son-Mahanadi valley bounded by Lat 22^0 15’ and 22^0 30’N and Long 82^0 15’ and 82^0 55’E. The coalfield lies in the Bilaspur district of Chhattisgarh State (Fig 01). The southerly flowing Hasdo River divides the coalfield into two unequal western and eastern parts. The eastern part is partly explored and possesses limited coal potentiality while the western part has vast potentiality in terms of power grade coal availability. Major opencast projects of the Korba Coalfield are mainly concentrated in the western part of the coalfield.

The coalfiled covers an area of about 780 sq km and is well connected by motorable road via Champa township (50 km) and Bilaspur (100 km). The nearest towns are Korba and Champa (50 km). The nearest railway station is Korba, located on Bilaspur – Champa - Korba branch line of South Eastern Railway which passes through South Eastern boundary of the coalfield. The nearest railway station for going to Delhi and Ranchi is Champa, which is on main line. Nearest airstrip is at Raipur (275 km) approachable by road from Korba. A small airstrip has also been constructed at Bilaspur for smaller aircrafts.

1.5 Physiography

Korba coalfield presents a typical erosional landscape with plain and plateau topography. The terrain is undulated with high hills on the eastern side. The highest point (983 m) is located on the eastern side near Pawan Akhar Pahar. The western and northern areas are comparatively flat. The major physiographic units present in this area are dissected plateau, residual hills, undulating pediplains, valley fills and intermontane valleys. The eastern part of the area is mainly drained by Beigar, Dhengur, Pathari and Dom streams which flow towards west and directly discharge into Hasdo River. The western part of this coalfiled is divided into two parts by NW-SE trending watershed. The eastern part is drained by Aharan, Kholar, Saliha and Jhulna streams and discharging into Hasdo River. The western part is drained by Gunjan, Ganjar, Lilagar and Pitni streams. Soil cover is very thin on the plateau. Thick alluvial soil on the pediplain are loamy to sandy in nature.

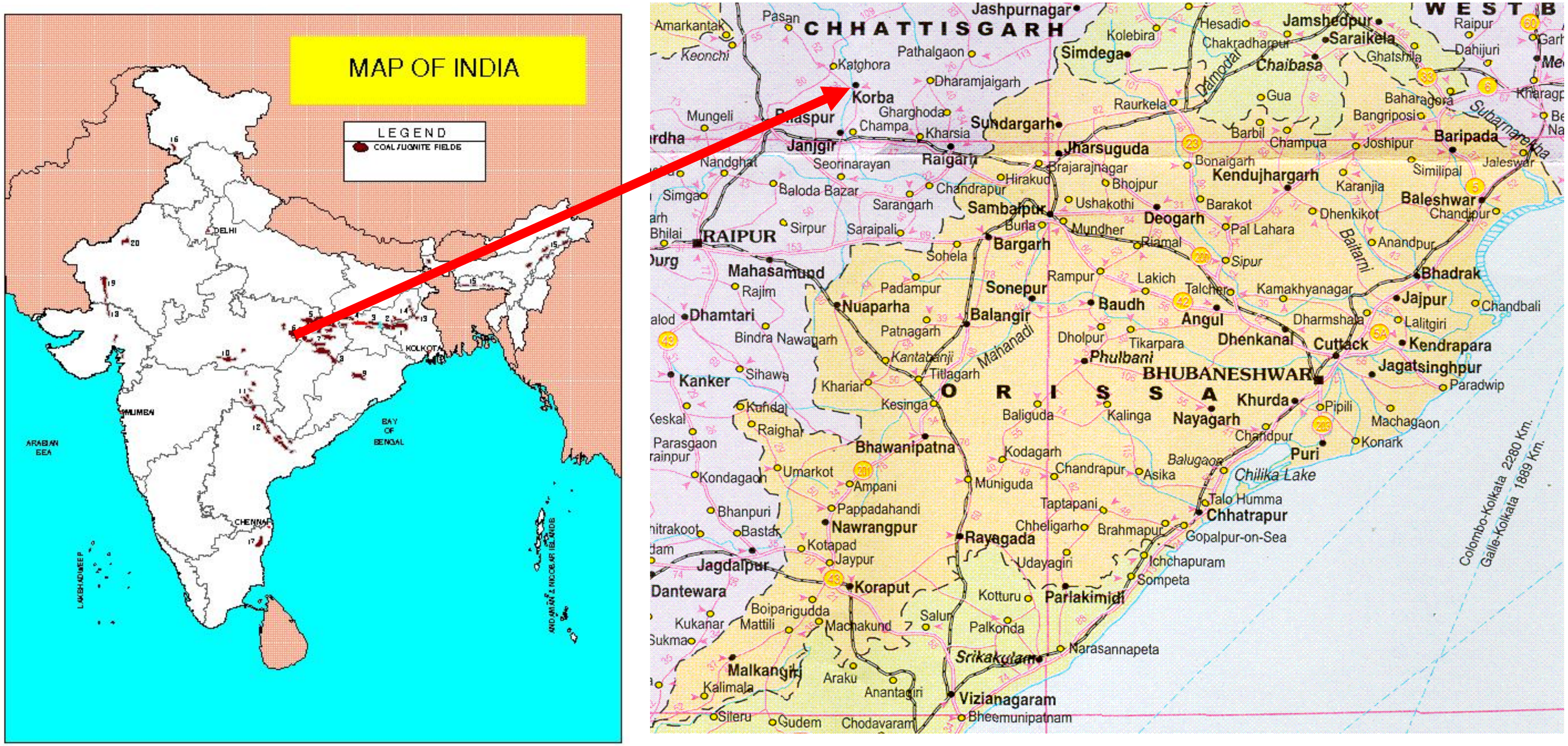

Fig 1.1 : Map of India Showing the Location of Korba Coalfields

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.

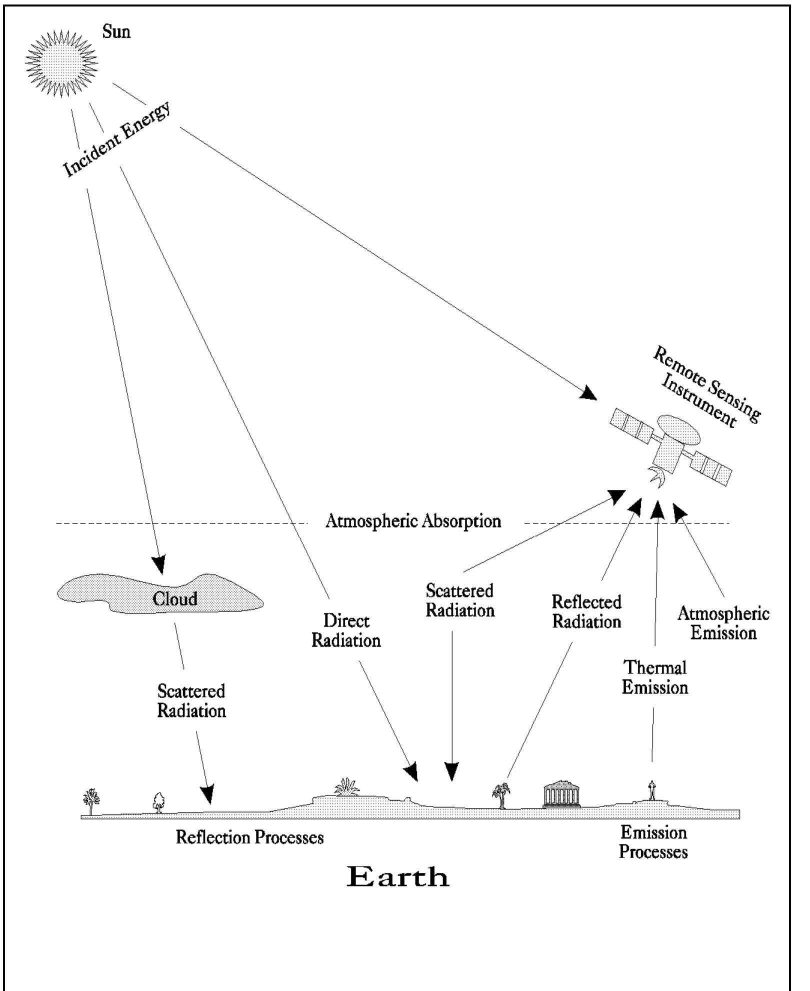

Figure 2.1 Remote sensing radiation system

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.

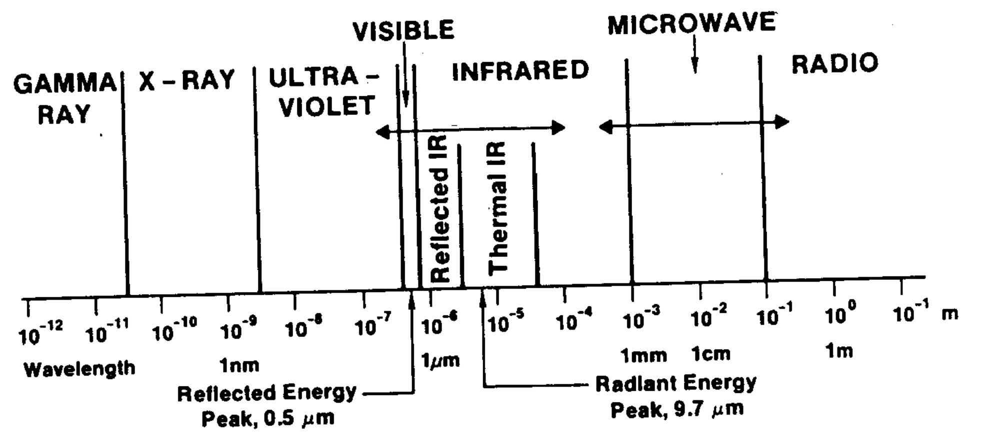

Figure 2.2 Electromagnetic spectrum. Expanded versions of the visible, infrared and microwave regions are shown in Figure 2.3.

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).

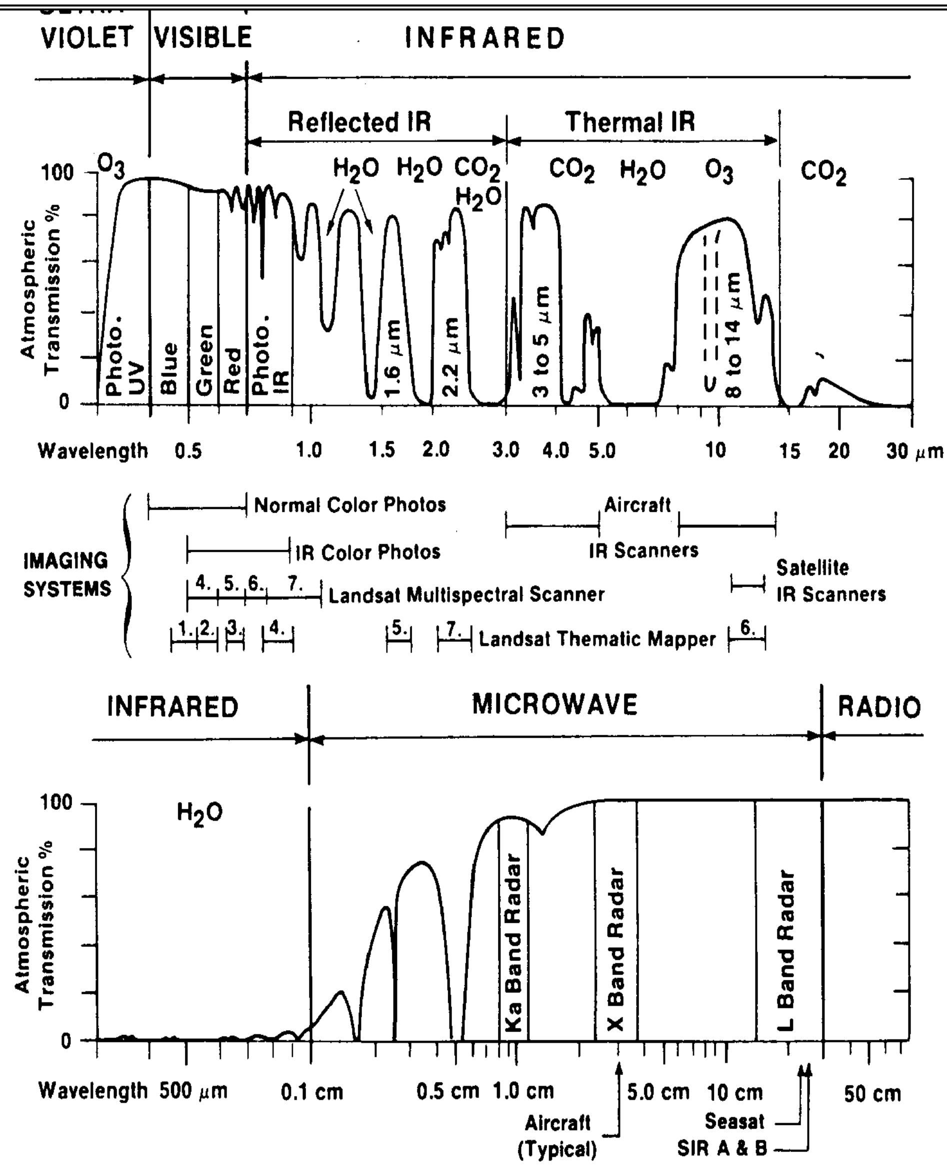

Figure 2.3 Expanded diagrams of the visible and infrared regions (upper) and the microwave regions (lower) showing atmospheric windows. Wavelength bands of commonly used remote sensing systems are indicated. Gases responsible for atmospheric absorption are shown.

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. Includes reflected energy peak of earth at 0.5mm.
Infrared	0.70	to	100.00	**µm**	Interaction with matter varies with wavelength. Absorption bands separate atmospheric transmission windows.
Reflected IR band	0.70	to	3.00	**µm**	Reflected solar radiation that contains no information about thermal properties of materials. The band from 0.7-0.9mm is detectable with film and is called the *photographic IR band*.
Thermal IR band	3.00 8.00	to to	5.00 14.00	**µm** **µm**	Principal atmospheric windows in the thermal region. Images at these wavelengths are acquired by optical-mechanical scanners and special 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 sensors 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 –R2/ (LISS L4FX); Band 2,3,4,5; Path # 102, Row #56C and Path # 103 Row # 056D; Date of pass 18.03.2012. 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/L4FX 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-R2	L4FX	B2 0.52 - 0.59 Green B3 0.62 - 0.68 Red B4 0.77 - 0.86 NIR	16-bit (256-grey levels)	5.8 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.

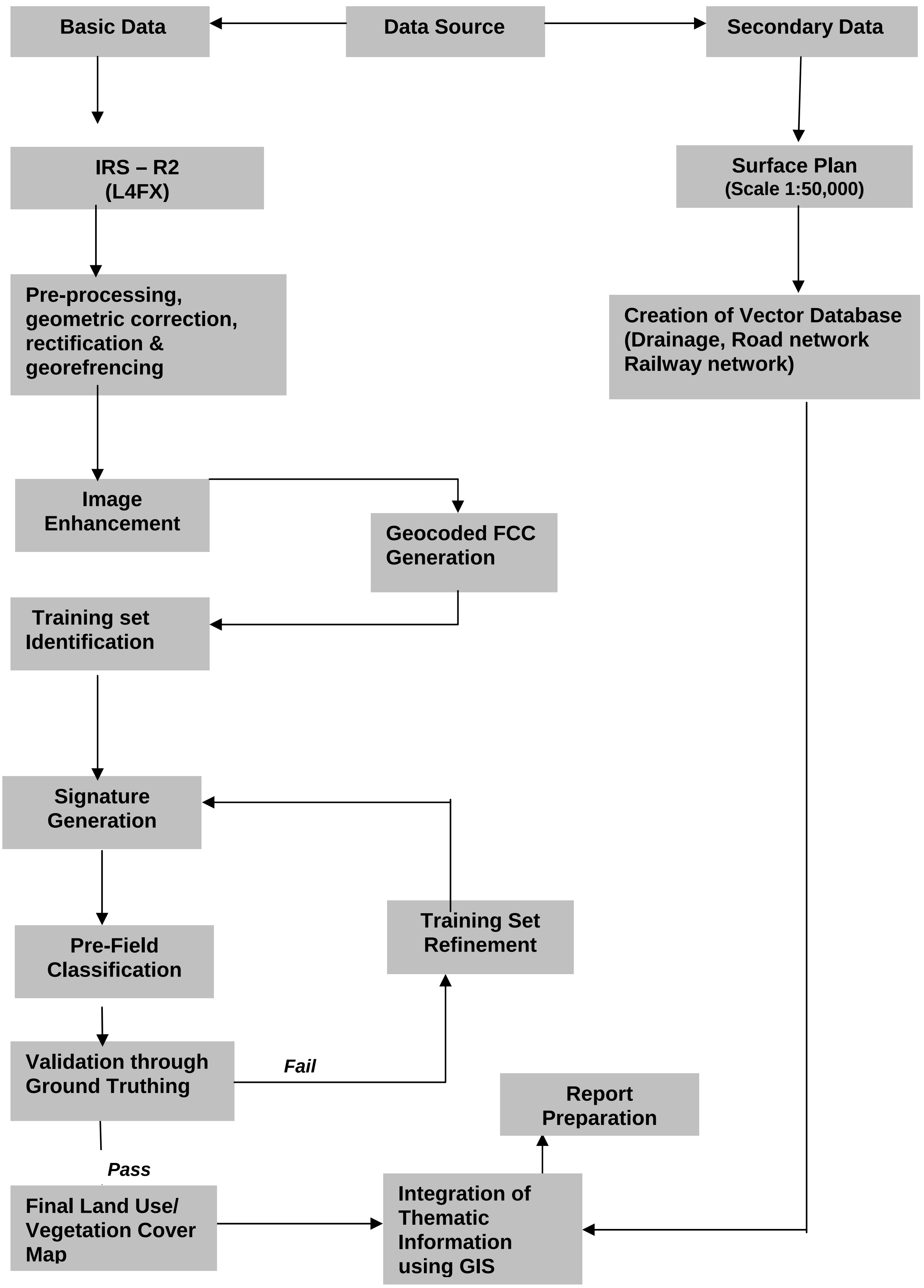

Fig 2.4 : Methodology for Land Use / Vegetation Cover Mapping

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*.

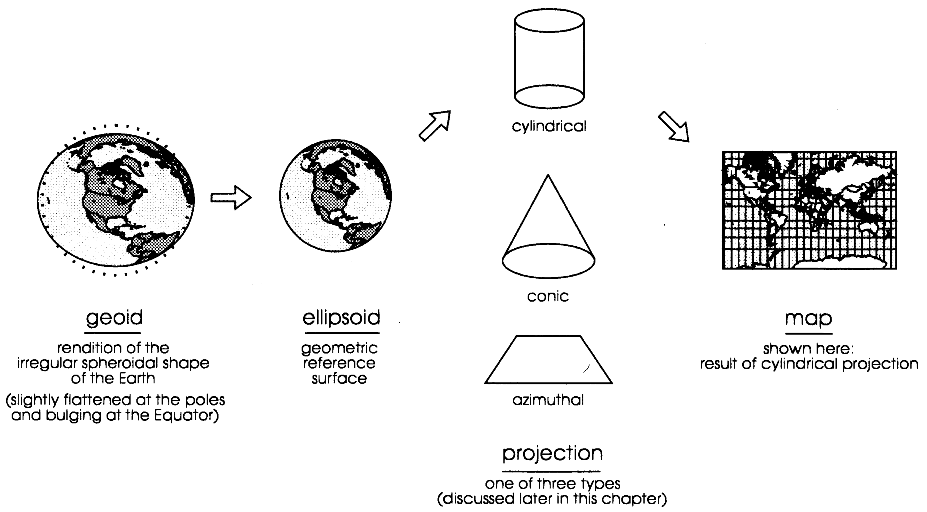

Fig 2.5 : Geoid – Ellipsoid – Projection Relationship

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.

1.6.3 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 PCI Geomatica v10 s/w. The classified image for the year 2012 for Korba Coalfield is shown in Drawing No. HQ/REM/A0/0001.

2.6.5 Creation/overlay of vector database in GIS

Plan showing leasehold areas of mining projects supplied by SECL 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 2012 was found to be 88.59%.

Final Land Use/vegetation cover maps (on 1:50,000 scale) were printed using HP Design jet 4500 PS Colour Plotter scaled to ISO A0 Size due to plotter paper size limitation.

Table 2.3: Classification Accuracy Matrix for Korba Coalfield in the year 2012

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

The need for information on land use/ vegetation cover has gained importance due to the all-round concern on environmental impact of mining. The information on land use/cover inventory that includes spatial distribution, aerial extent, location, rate and pattern of change of each category is of paramount importance for assessing the impact of coal mining on land use / vegetation cover. Moreover, with passage of time, demand for coal has increased many folds and therefore production from the mines has also increased and hence the mining areas also kept on increasing. Therefore, it is important to know the existing land use pattern and the changes that have occurred during previous years, so as to predict the possible changes due to mining in future around the existing coal mines. Remote sensing data with its various spectral and spatial resolutions, offers comprehensive and accurate information for mapping and monitoring of land use/cover over a period of time.

Realising the need of regular monitoring of land use/ vegetation cover in Korba coalfields; Coal India Limited entrusted CMPDI to prepare land use/ vegetation cover map for assessing the impact of coal mining on land use pattern and vegetation cover using remote sensing data at a regular interval of three years, which will help in formulating the mitigative measure, if any required for environmental protection in the coal mining areas.

The present study incorporates the findings on Land use / Vegetation Cover pattern in the Korba Coalfield,, SECL based on satellite data of the year 2012. Similar study has also been done previously in the year 2008.

3.2 Land Use / Vegetation Cover Classification

The array of information available on land use/ vegetation cover requires be arranging or grouping under a suitable framework in order to facilitate the creation of database. Further, to accommodate the changing land use/vegetation cover pattern, it becomes essential to develop a standardised classification system that is not only flexible in nomenclature and definition, but also capable of incorporating information obtained from the satellite data and other different sources.

The present framework of land use/cover classification has been primarily based on the '***Manual of Nationwide Land Use/ Land Cover Mapping Using Satellite Imagery***' developed by National Remote Sensing 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 2012. Following land use/cover classes are identified in the Korba coalfield region (Table 3.1).

-

Table 3.1 Land use / Vegetation Cover classes identified in Korba Coalfield		
	LEVEL –I	**LEVEL-II**
1	**Vegetation Cover**	1.1 Dense Forest 1.2 Open Forest 1.3 Scrub 1.4 Plantation under Social Forestry 1.5 Plantation on OB Dumps 1.6 Plantation over Backfill
2	**Mining Area**	2.1 Coal Quarry 2.2 Advance Quarry Site 2.3 Barren OB Dump 2.4 Barren Backfilled Area 2.5 Coal Dump 2.6 Water Filled Quarry
3	**Agricultural Land**	3.1 Crop Land 3.2 Fallow Land
4	**Wasteland**	4.1 Waste upland with/without scrubs 4.2 Fly Ash Pond 4.3 Barren Rocky Land 4.4 Alumina Sludge Pond
5	**Settlements**	5.1 Urban 5.2 Rural 5.3 Industrial
6	**Water Bodies**	6.1 River/Streams /Reservoir

3.3 Data Analysis

Satellite data of the year 2012 was processed using PCI Geomatica v.10.1 image processing s/w in order to interpret the various land use and vegetation cover classes present in the Korba coalfield. The analysis was carried out for entire coalfield covering about 780 sq. km.

The area of each class was calculated and analysed using PCI Geomatica *Digital Image Processing* s/w and *ArcGIS* s/w. Analysis of land use / vegetation cover pattern in Korba Coalfield for the year 2012 was carried out and details of the analysis are and shown in table 3.2.

TABLE – 3.2

COMPARATIVE STATUS OF LAND USE & VEGETATION COVER PATTERN IN KORBA COALFIELD IN THE YEAR 2008 & 2012

LAND / VEGETATION COVER CLASSES	Year 2008		2012		Changes w.r.t 2008		Remarks
VEGETATION COVER	Area	% of total	Area	% of total	Area	% of total	
Dense forest	66.16	8.48	66.16	8.48	(+) 00.00	(+) 00.00	Overall changes in vegetation cover are in positive side and it indicate massive plantation in mining areas and proper forest conservation.
Open Forest	136.38	17.48	132.24	16.95	(-) 04.14	(-) 00.53	
Scrubs	131.65	16.88	132.10	17.45	(+) 00.45	(+) 00.06	
Plantation under Social Forestry	16.76	2.15	19.52	2.50	(+) 02.76	(+) 00.35	
Plantation over Backfill	1.87	0.24	3.40	0.44	(+) 01.53	(+) 00.20	
Plantation on OB Dump	7.84	1.01	8.24	1.06	(+) 00.40	(+) 00.05	
Sub Total	360.66	46.24	361.66	46.37	(+) 01.00	(+) 00.13	
MINING AREA							
Coal Quarry/Active Mining Area	10.15	1.30	9.90	1.27	(-) 00.25	(-) 00.03	Changes due to expansion of existing mining projects and higher coal production.
Advance Quarry Site	0.39	0.05	0.78	0.10	(+) 00.39	(+) 00.05	
Coal Dump	1.14	0.15	1.21	0.16	(+) 00.07	(+) 00.01	
Barren Backfilled Area	3.35	0.43	8.49	1.09	(+) 05.14	(+) 00.66	
Coal Face	0.46	0.06	0.50	0.06	(+) 00.04	(+) 00.01	
Barren OB Dump	4.06	0.52	3.70	0.47	(-) 00.36	(-) 00.05	
Water Filled Quarry	1.72	0.22	2.04	0.26	(+) 00.32	(+) 00.04	
Sub Total	21.27	2.73	26.62	3.41	(+) 05.35	(+) 00.69	
AGRICULTURAL LAND							
Crop Land	87.79	11.26	32.54	4.17	(-) 55.25	(-) 07.08	Expansion of existing mining projects and conversion agricultural land into wasteland.
Fallow Land	207.89	26.65	254.02	32.57	(+) 46.13	(+) 05.91	
Sub Total	295.68	37.91	286.56	36.74	(-) 09.12	(-) 01.17	
WASTELAND							
Waste upland	51.26	6.57	51.66	6.62	(+) 00.40	(+) 00.05	Due to industrialisation in the area.
Fly-Ash Pond	4.64	0.59	5.99	0.77	(+) 01.35	(+) 00.17	
Sand Body	6.72	0.86	6.37	0.82	(-) 00.35	(-) 00.04	
Barren Rocky Land	0.06	0.01	0.06	0.01	(+) 00.00	(+) 00.00	
Alumina Sludge Pond	0.50	0.06	0.50	0.06	(+) 00.00	(+) 00.00	
Sub Total	63.18	8.10	64.58	8.28	(+) 01.40	(+) 00.18	
SETTLEMENTS							
Urban	10.84	1.39	10.98	1.41	(+) 00.14	(+) 00.02	Changes due to coal mining and associated industrialisation in the coalfield area.
Rural	9.08	1.16	10.31	1.32	(-) 00.52	(-) 00.07	
Industrial	10.83	1.39	10.83	1.39	(+) 01.75	(+) 00.22	
Sub Total	30.75	3.94	32.12	4.12	(+) 01.37	(+) 00.18	
WATER BODIES	8.46	1.08	8.46	1.08	(+) 00.00	(+) 00.00	No Change
TOTAL	780.00	100.00	780.00	100.00			

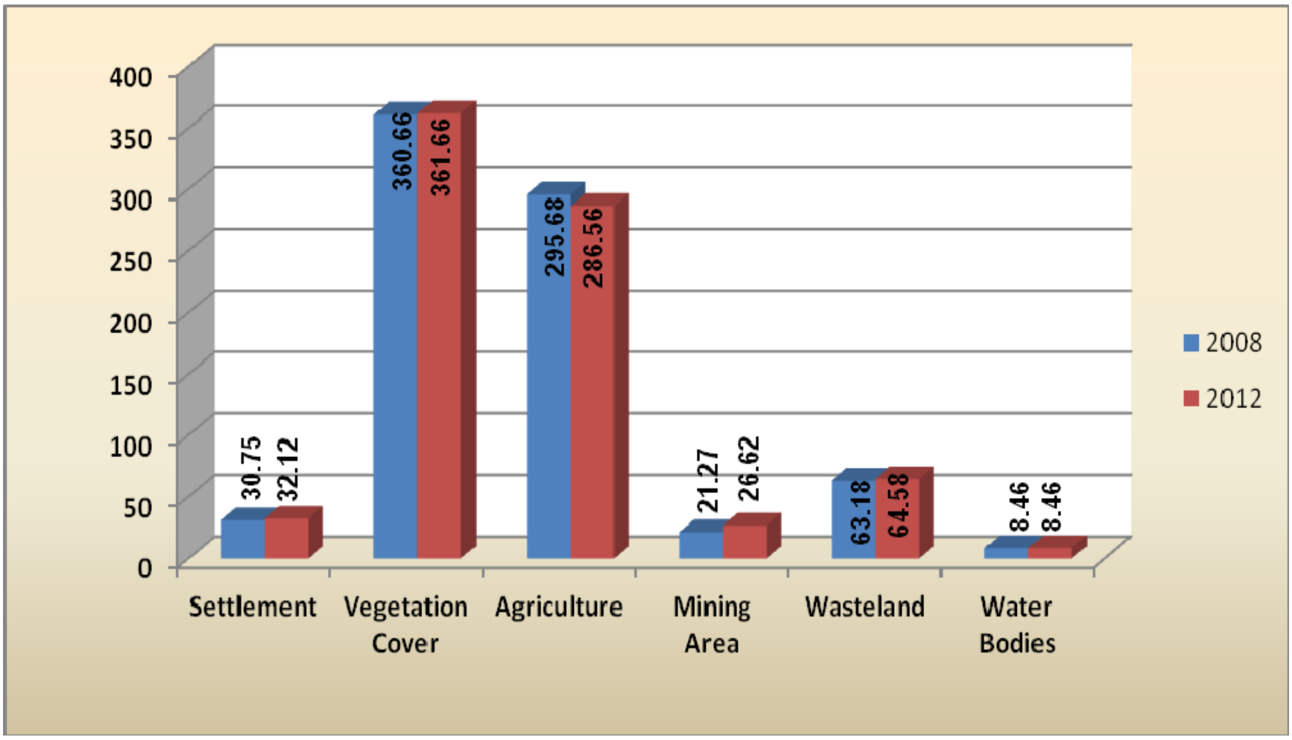

Fig 3.1 : Bar Chart Showing Status of Land Use/ Cover Classes in the Years 2008 & 2012

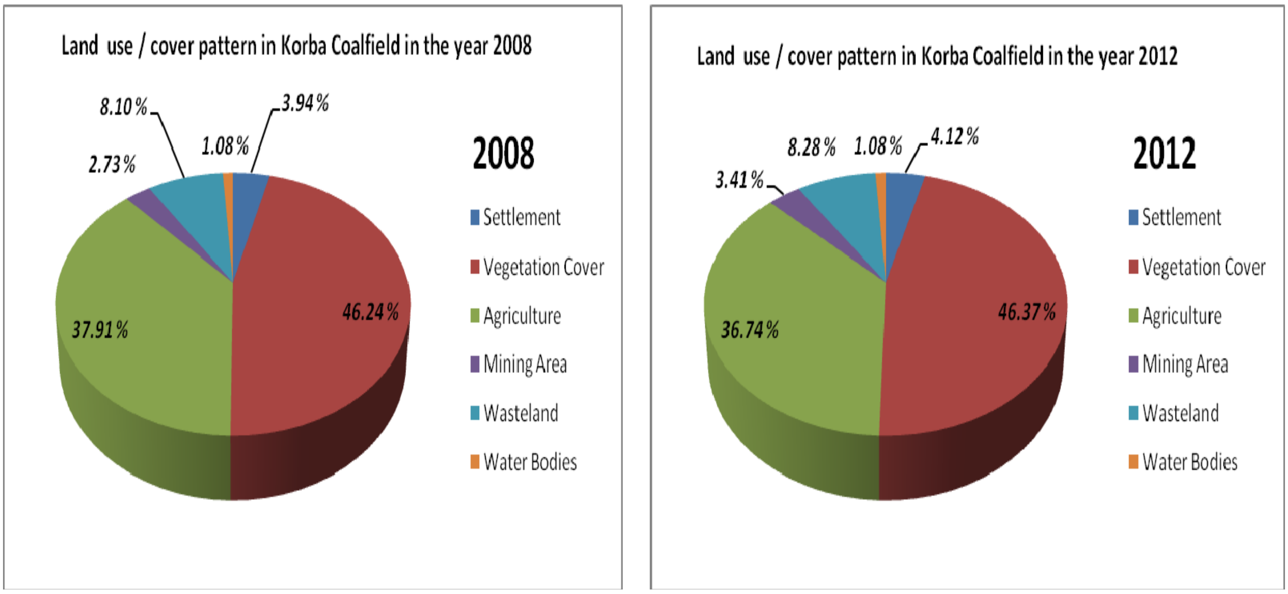

Fig. 3.2 : Pie Charts Showing Land use / cover Distribution Pattern in Korba Coalfield in the 2008 & 2012

3.3.1 Settlements / Built-up land

All the man-made constructions covering the land surface are included under this category. Built-up land has been divided in to rural, urban and industrial classes based on availability of infrastructure facilities. In the present study, industrial settlement indicates only industrial complexes excluding residential facilities. The percentage of settlement shown in the analysis here is in terms of total land use/ cover only.

Settlements in Korba Coalfield covers an area of 32.12 km^2 (4.12%) out of the total coalfield area of 708 km^2. Analysis of the satellite data of the year 2012 indicated that settlement coming under the coalfield boundary of Korba was distributed between *Urban* (10.98 km^2 ; 1.41%), *Rural* (10.31 km^2 ; 1.32%) and *Industrial* (10.83 km^2 ; 1.39%) *(Refer Table 3.2)*. Comparing the result of 2012 with that of 2008, it can be seen that there has been an increase of about 0.18% in the built up area class in Korba Coalfield region between the period 2008 and 2012 due to infrastructural development and associated industrialisation in the coalfield area.

3.3.2 Vegetation cover Analysis

Vegetation cover is an association of trees and other vegetation type capable of producing timber and other forest produce. It is also defined as the percentage of soil which is covered by green vegetation. Leaf area index (LAI) is an alternative expression of the term vegetation cover which gives the area of leaves in m^2 corresponding to an area of one m^2 of ground. Primarily vegetation cover is classified into the following three sub-classes based on crown density as per modified FAO-1963 (Food & Agricultural Organisation of United Nations) norms: (a) dense forest (crown density more than 40%), (b) open/degraded forest (crown density between 10% to 40%), and (c) scrubs (crown density less than 10%). The plantation that has been carried out on wasteland along the roadside and on the overburden dumps / Backfilled areas is also included under vegetation cover as social forestry and plantation on over-burden dumps respectively. The percentage of vegetation cover shown in the analysis here are in terms of total land use cover only.

Analysis of the satellite data of the year 2012 indicated that vegetation cover in the Korba Coalfield boundary occupies 361.66 km^2 (46.37%). Out of which, *dense forest* covers an area of 66.16 km^2 (8.48%), *open forest* covers area of 132.24 km^2 (16.95%) ; *Scrubs* has covered 132.10 km^2 (16.94%), *Plantation under social forestry* occupies 19.52 km^2 (2.50%), Plantation on OB dumps occupies 8.24 km^2 (1.06%) and *Plantation over backfilled areas* has 3.40 km^2 (0.44%) area under its influence in 2012 *(Refer Table 3.2)*. Comparing the result of 2012 with that of 2008, it can be seen that there has been an increase of about 0.13% in the vegetation cover in Korba Coalfield region between the period 2008 and 2012. This is primarily due to massive plantation in the mining areas including social forestry and forest conservation efforts.

3.3.3 Agriculture

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

Agriculture in Korba Coalfield covers an area of 286.56 km^2 (36.74%). Analysis of the satellite data of the year 2012 indicated that agriculture coming under the coalfield boundary of Korba was distributed between *Crop Land* (28.54 km^2 ; 3.66%), and Fallow Land (254.02 km^2 ; 32.57%) *(Refer Table 3.2).* Comparing the result of 2012 with that of 2008, it can be seen that there has been a marginal decrease of about 1.27% in the agricultural land in Korba Coalfield region between the period 2008 and 2012.

3.3.4 Mining

The mining area includes the area of existing quarries, old quarries filled with water, advance quarry sites, Coal Stock/Dumps, Coal Faces, Barren Backfilled areas, Barren over-burden dumps and allied activities.

The mining area in Korba Coalfield covers 26.62 km^2 (3.41%) in the year 2012. *Advanced quarry site* constitutes 0.78 km^2 (0.10%), *Coal quarry* constitutes 9.90 km^2 (1.27%), *Quarry filled with water* constitutes 2.04 km^2 (0.26%), *Coal face* constitutes 0.50 km^2 (0.06%), *Coal dumps / stocks* constitute 1.21 km^2 (0.16%), *Barren backfilled areas* constitute 8.49 km^2 (1.09%) and *Barren over burden dumps* constitutes 3.70 km^2 (0.47%). Comparing the result of 2012 with that of 2008, it can be seen that there has been an increase of about 0.68% in mining areas in Korba Coalfield region between the period 2008 and 2012.

3.3.5 Wasteland

Wasteland is a degraded and under-utilised class of land that has deteriorated on account of natural causes or due to lack of appropriate water and soil management. Wasteland can result from inherent/imposed constraints such as location, environment, chemical and physical properties of the soil or financial or other management constraints (NWDB, 1987).

Analysis of data reveals that waste land in the Korba Coalfield occupies 64.58 km^2 (8.28%) out of which *Waste upland with or without scrubs* occupies 51.66 km^2 (6.62%), *Fly Ash Ponds* constitute 5.99 km^2 (0.77%), *Sand bodies* constitute 6.37 km^2 (0.82%), *Barren Rocky Land* constitutes 0.06 km^2 (0.01%) and *Alumina Sludge Pond* constitutes 0.50 km^2 (0.06%) in 2012. Comparing the result of 2012 with that of 2008, it can be seen that there has been an increase of about 0.18% in the waste land in Korba Coalfield region between 2008 and 2012.

3.3.6 Surface Water bodies

Analysis of data reveals that water bodies in Korba Coalfiled occupy area of 8.46 km^2 (1.08%).

Chapter 4

Conclusion & Recommendations

4.1 Conclusion

In the present study, land use/vegetation cover map of Korba coalfield is prepared based on IRS-R2 L4FX data of March 2012 in order to monitor the changes in vegetation cover and land use pattern for effective natural resource management and its planning. The Land use/vegetation cover analysis will help to analyse and monitor the impact of mining and other industrial activities in the area.

Study reveals that Korba Coalfields covers an area of about 780 km^2. Settlements coming under the coalfield boundary cover area of 32.12 km^2 which is 4.12% of the coalfield area. Vegetation cover constitutes 361.66 km^2 (46.37%), Mining activities is on 26.62 km^2 area which is 3.41% of the total coalfield area whereas agriculture and wasteland are on 286.56 km^2 (36.74%) and 64.58 km^2 (8.28%) respectively. Water bodies cover an area of 8.46 km^2 (1.08%) within the Korba Coalfield Boundary.

On comparing the data of 2012 with that of 2008 for Korba Coalfield, it is evident that vegetation cover has increased by 1.0 Km^2 (0.13%), mining area in 2012 has also increased by 5.35 Km^2 (0.69%), agricultural land has decreased by 9.12 Km^2 (1.17%), wasteland has increased by 1.40 Km^2 (0.18%) and settlements in coalfield area has increased by 1.37 Km^2 (0.18%).

The detail data analysis in respect to 2008 database is given under Table-3.2.

4.2 Recommendations

For eco-friendly sustainable coal mining in the Korba Coalfield, it is recommended that;

a) Similar study should to be carried out regularly at interval of 3 years to monitor the change in land use/vegetation cover in the coalfield for assessing the impact of coal mining and to take the remedial measures required, if any.

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

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