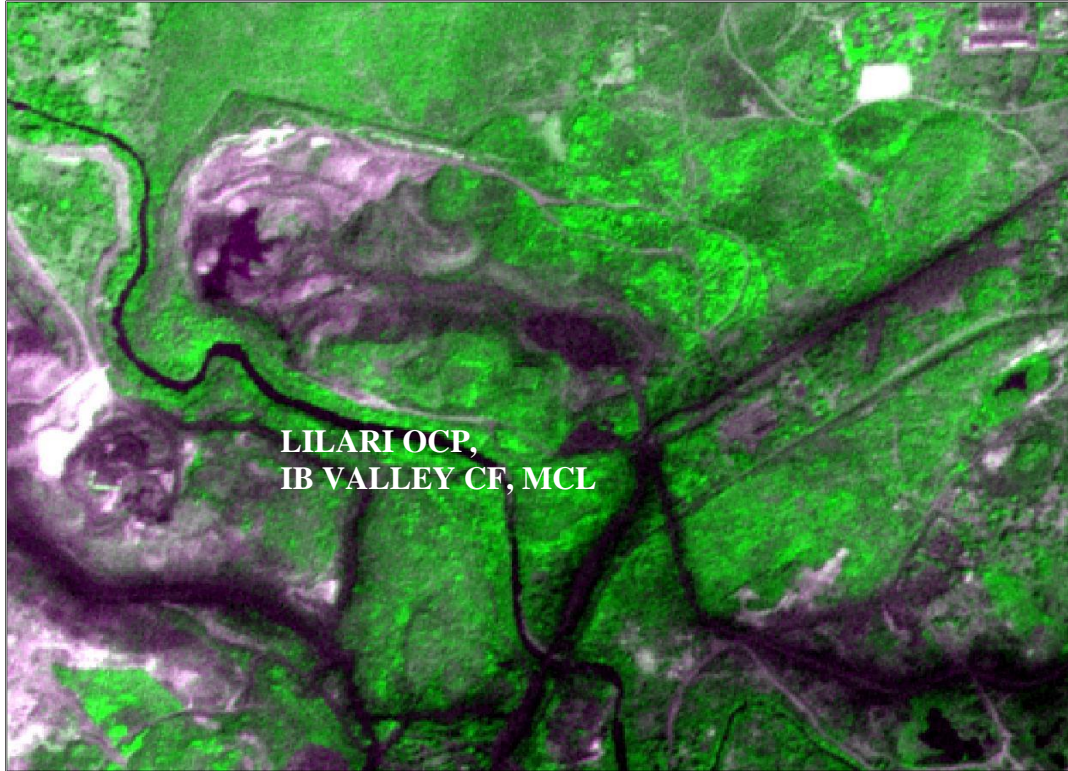


**Land Restoration / Reclamation Monitoring of less than 5 million cu.m.
(Coal+OB) Capacity Open Cast Coal Mines of Mahanadi Coalfields
Limited based on Satellite Data for the Year 2014**



Submitted to:

Mahanadi Coalfields Limited



cmpdi
A Mini Ratna Company

**Land Restoration / Reclamation Monitoring of less than 5 million cu.m.
(Coal+OB) Capacity Open Cast Coal Mines of Mahanadi Coalfields Limited
based on Satellite Data for the Year 2014**

March-2015



**Remote Sensing Cell
Geomatics Division
CMPDI, Ranchi**

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Executive Summary

- 1.0 Project** Land restoration / reclamation monitoring of 3 opencast coal mines of Mahanadi Coalfields Ltd. (MCL) producing less than 5 million cu. m. (Coal + OB) per year based on satellite data, on every three year basis.
- 2.0 Objective** Objective of the land restoration / reclamation monitoring is to assess the area of backfilled, plantation, social forestry, active mining area, water bodies, and distribution of wasteland, agricultural land and forest land in the leasehold area of the various projects. This will help in assessing the progressive status of mined out land reclamation and to take up remedial measures, if any, required for environmental protection.
- 3.0 Salient Findings**
- Out of the total mine leasehold area of 700.22 Ha. of the 3 opencast projects of MCL viz. Chhendipada, Lilari, and Kulda considered for monitoring during 2014-15; total excavated area is 202.53Ha.(28.92%), out of which 49.32Ha.area (24.35%) has been planted, 51.31Ha.area (25.33%) is under backfilling and 101.90Ha.area (50.31%) is under active mining. It is evident from the analysis that 49.69% areas of the OC projects is under reclamation (biological and technical) and balance 50.31% area is under active mining. Project wise details are given in Table-1 & Fig-1.
 - On comparing the status of land reclamation for the year 2014 with respect to the year 2011 in different projects, it is evident from the analysis that area under land reclamation has increased from 83.60Ha. (Yr. 2011) to 100.63Ha.(Yr.2014). Out of 3 projects of MCL, Lilari OC ranks on top for land reclamation (85.85%) followed by Chhendipada OC (56.32%).
 - Area of biological reclamation (plantation) has increased from 48.68Ha. (Yr.2011) to 49.32Ha. (Yr.2014) where as area of technical reclamation (area under backfilling) has increased from 34.92Ha. (Yr. 2011) to 51.31Ha. (Yr.2014) in MCL. This increase of 17.03Ha.in area of plantation and area under backfilling is the result of the efforts of the Mahanadi Coalfields Ltd. taken up towards environmental protection.

TABLE-1

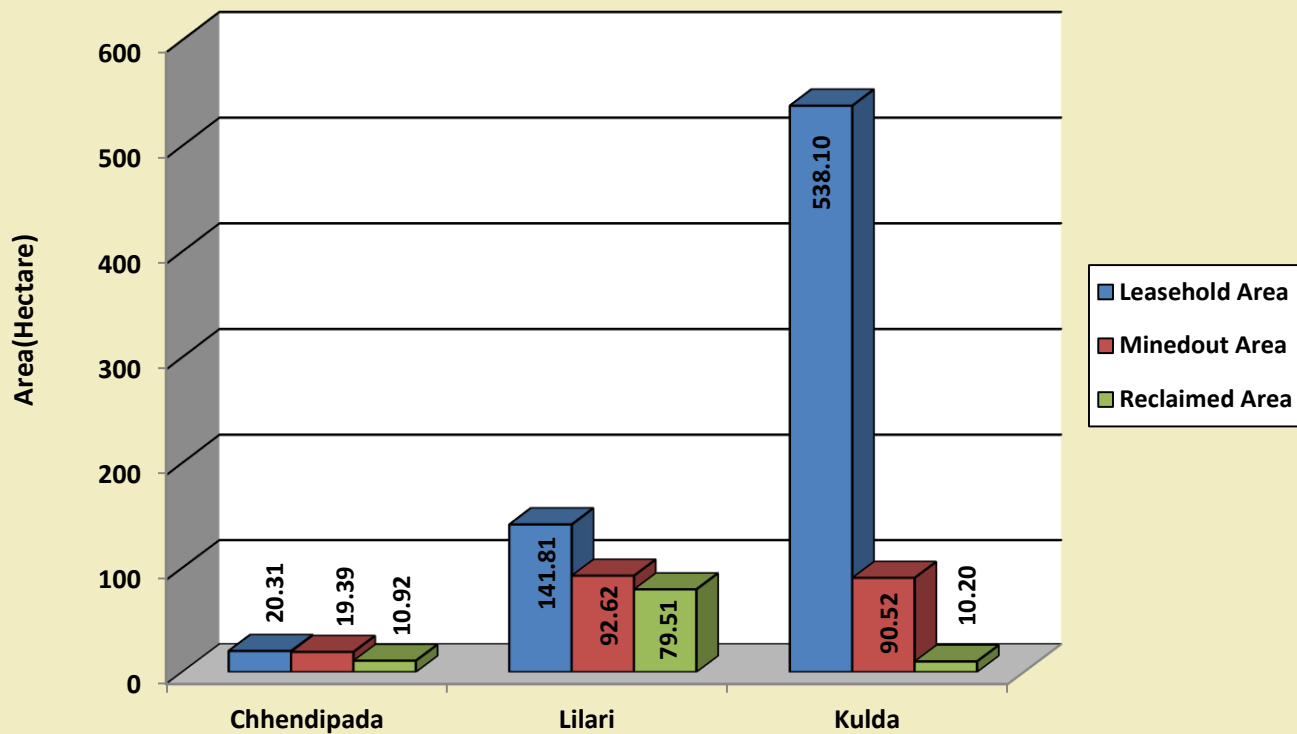
**Project wise Land Reclamation Status in OC projects of Mahanadi Coalfields Ltd
based on Satellite data of the Year 2011 and 2014**

% Calculated in respect of total Excavated area

Area in Hectare

Sl No.	Projects	Leasehold	Plantation/ Vegetation		Under Backfilling		Active Mining Area		Total Excavated		Area under Reclamation	
		(i)	(ii)		(iii)		(iv)		(ii+iii+iv)		(ii+iii)	
			2011	2014	2011	2014	2011	2014	2011	2014	2011	2014
1	Chhendipada	20.31	1.10	1.10	7.87	9.82	9.21	8.47	18.18	19.39	8.97	10.92
			6.06	5.67	43.29	50.64	50.67	43.68			49.34	56.32
2	Lilari	141.81	47.03	47.03	20.00	32.48	26.23	13.11	93.26	92.62	67.03	79.51
			50.43	50.78	21.45	35.07	28.13	14.15			71.87	85.85
3	Kulda	538.10	0.55	1.19	7.05	9.01	47.74	80.32	55.34	90.52	7.60	10.20
			1.00	1.32	12.74	9.95	86.27	88.73			13.73	11.27
	Total	700.22	48.68	49.32	34.92	51.31	83.18	101.90	166.78	202.53	83.60	100.63
			29.19	24.35	20.94	25.33	49.87	50.31	23.82	28.92	50.13	49.69

Fig 1: Project Wise Land Reclamation Status In Year 2014



1.0 Background

- 1.1** Land is the most important natural resource which embodies soil, water, flora, fauna and total ecosystem. All human activities are based on the land which is the scarcest natural resource in our country. Mining is a site specific industry and it could not be shifted anywhere else from the location where mineral occurs. It is a fact that surface mining activities do effect the land environment due to ground breaking. Therefore, there is an urgent need to reclaim and restore the mined out land for its productive use for sustainable development of mining. This will not only mitigate environmental degradation, but would also help in creating a more congenial environment for land acquisition by coal companies in future.
- 1.2** Keeping above in view, M/s. Coal India Ltd. (CIL) issued a work order vide letter no. CIL/WBP/ENV./2011/4706 dated 12/10/12 for monitoring of opencast mines of less than 5 million m³ per annum capacity (Coal +OB) for the period 2012-13 to 2016-17 at intervals of three years. The result of land reclamation status of all such mines is to be published on the website of **CIL**, (www.coalindia.in), **CMPDI** (www.cmpdi.co.in) and the concerned coal companies in public domain. Detailed reports are to be submitted to Coal India and respective subsidiaries.
- 1.3** Land reclamation monitoring of all open cast projects will have to comply the statutory requirements of Ministry of Environment & Forest (MoEF). Such monitoring will not only facilitate in taking remedial measures against environmental degradation, but also enable Coal companies to utilize the reclaimed land for further socio-economic benefits in a planned way.
- 1.4** Present report is embodying the finding of the study based on satellite data of the year 2014 carried out for 3 no. of OC projects of capacity less than 5 mcm (coal +OB) for Mahanadi Coalfields Ltd.

2.0 Objective

Objective of the land reclamation/restoration monitoring is to assess the area of backfilled, plantation, OB dumps, social forestry, active mining area, settlements and water bodies, distribution of wasteland, agricultural land and forest land in the leasehold area of the project. This is an important step taken up for assessing the progressive status of mined land reclamation and for taking up remedial measures, if any, required for environmental protection.

3.0 Methodology

There are number of steps involved between raw satellite data procurement and preparation of final map. National Remote Sensing Centre (NRSC) Hyderabad, being the nodal agency for satellite data supply in India, provides only raw digital satellite data, which needs further digital image processing for extracting the information and map preparation before uploading the same in the website. Methodology for land reclamation monitoring is given in fig 2. Following steps are involved in land reclamation /restoration monitoring:

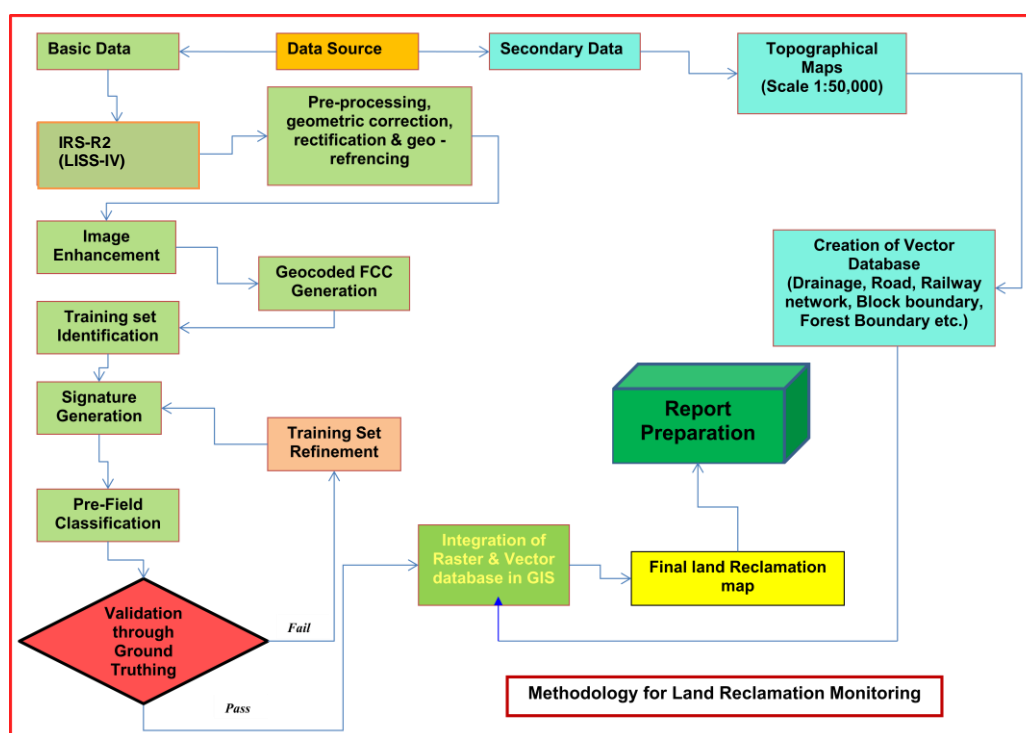


Figure: 2 Methodology for Land Reclamation Monitoring

3.1 Data Procurement:After browsing the data quality and date of pass on internet, supply order for data is placed to NRSC. Secondary data like leasehold boundary, topo sheets are procured for creation of vector database.

3.2 Satellite Data Processing: Satellite data are processed using ERDAS IMAGINE 2014 digital image processing s/w. Methodology involves the following major steps:

- **Rectification &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 satellite receiving station itself. Raw digital images contain geometric distortions, which make them unusable as maps. Therefore, georeferencing is required for correction of image data using ground control points (GCP) to make it compatible to SOI toposheet.
- **Image enhancement:**To improve the interpretability of the raw data, image enhancement is necessary. Local operations modify the value of each pixel based on brightness value of neighbouring pixels using ERDAS IMAGINE 2014 s/w. and enhance the image quality for interpretation.
- **Training set selection**

Training set requires to be selected, so that software can classify the image data accurately. The image data are 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.

- **Classification and Accuracy assessment**

Image classification is carried out using the maximum likelihood algorithm. The classification proceeds through the following steps: (a) calculation of statistics [i.e. signature generation] for the identified training areas, and (b) the decision boundary of maximum probability based on the mean vector, variance, covariance and correlation matrix of the pixels. After evaluating the statistical parameters of the training sets, reliability test of training sets is 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.

- **Area calculation**

The area of each land use class in the leasehold is determined using ERDAS IMAGINE v. 2014 software and given in table 2.

- **Overlay of Vector data base**

Vector data base created based on secondary data. Vector layer like drainage, railway line, leasehold boundary, forest boundary etc. are superimposed on the image as vector layer in the Arc GIS database.

- **Pre-field map preparation**

Pre-field map is prepared for validation of the classification result

3.3 Ground Truthing:

Selective ground verification of the land use classes are carried out in the field and necessary corrections if required, are incorporated before map finalization.

3.4 Land reclamation database on GIS:

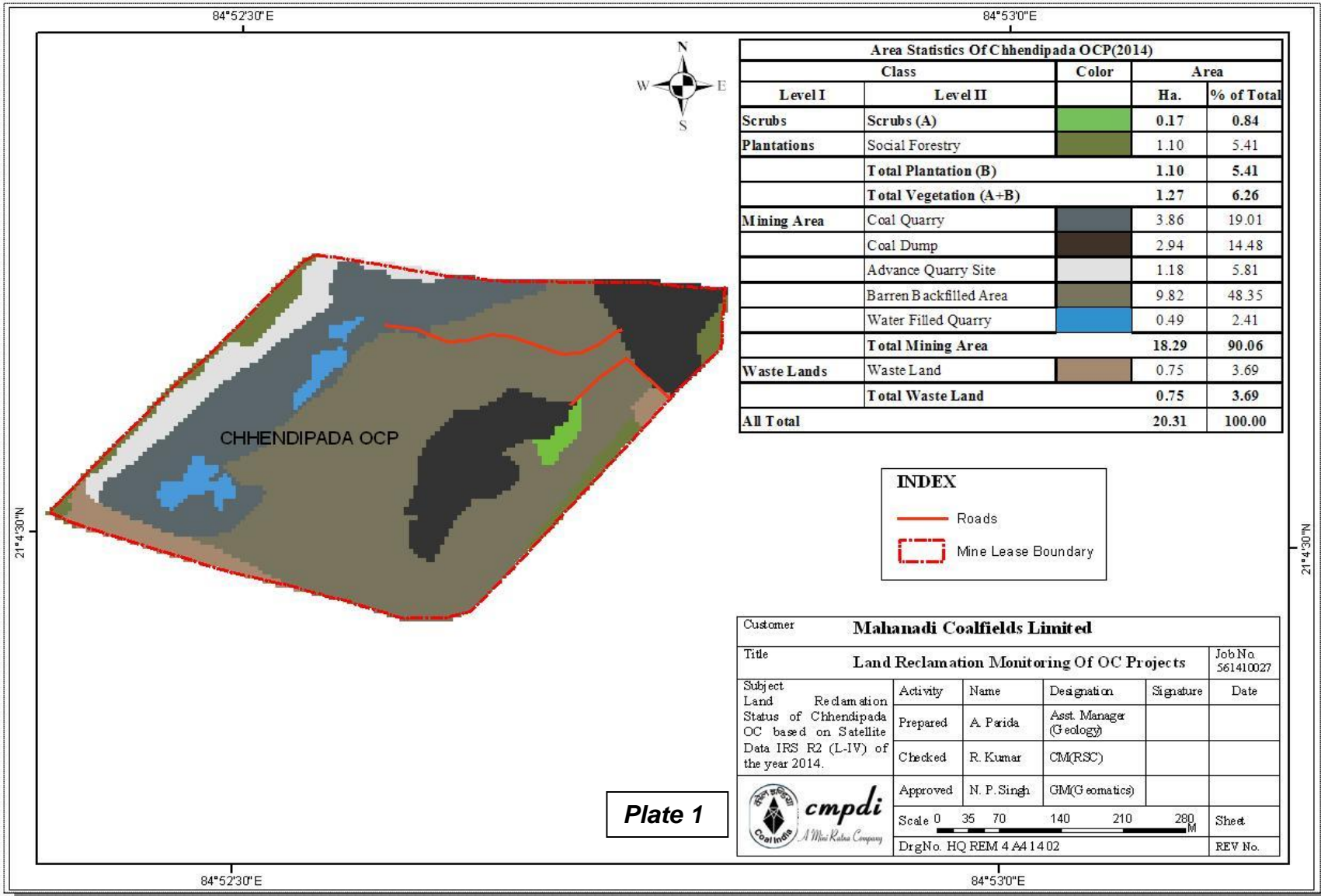
Land reclamation database is created on GIS platform to identify the temporal changes identified from satellite data of different cut-off dates.

4.0 Land Reclamation Status in Mahanadi Coalfields Ltd.

- 4.1** Following 3 OC projects producing less than 5 million m³. (Coal + OB together) of Mahanadi Coalfields Ltd. have been taken up during the year 2014 for land reclamation monitoring:
- Chhendipada
 - Lilari
 - Kulda
- 4.2** Area statistics of different land use classes present in OC projects in the year 2014 is given in Table 2. Land use maps derived from the satellite data is given in Plate no. 1 to 3. Land use statuses are shown in Fig. 3 – 5 and field photographs showing plantation and backfilled area in mining projects are shown in photos 1 & 2.
- 4.3** Study reveals that 49.69% of excavated area has already been reclaimed by MCL in the OC projects, out of which 24.35% area has been revegetated and 25.33% area are backfilled.
- 4.4** Analysis of satellite data indicates that area of plantation has increased from 48.68Ha. (2011) to 49.32Ha. (2014). This increase of 0.64Ha. plantation areas in three years indicate that MCL is committed for reclamation of mine land for maintaining the ecological balance in the region. It has been observed in some of the projects natural vegetation has also started growing on stabilized old backfilled areas and OB dumps due to increase in soil fertility.
- 4.5** On comparing the status of land reclamation for the year 2014 with respect to the year 2011 in different projects, it is evident from the analysis that area of land reclamation has increased from 83.60Ha. (Yr. 2011) to 100.63Ha. (Yr.2014).
- 4.6** Out of 3 projects of MCL, Lilari OCP ranks on top for land reclamation (85.85%) followed by Chhendipada OCP (56.32%).

Table 2: STATUS OF LAND RECLAMATION IN MCL BASED ON SATELLITE DATA OF THE YEAR 2014

		(Area in Hectare)									
		CHHENDIPADA		LILARI		KULDA		TOTAL			
		Area	%	Area	%	Area	%	Area	%		
FORESTS	Dense Forest	0.00	0.00	0.00	0.00	41.50	7.71	41.50	5.93		
	Open Forest	0.00	0.00	4.47	3.15	69.88	12.99	74.35	10.62		
	Total Forest	0.00	0.00	4.47	3.15	111.38	20.70	115.85	16.55		
SCRUBS	Scrubs	0.17	0.84	19.20	13.54	205.43	38.18	224.80	32.10		
PLANTATION	Social Forestry	1.10	5.41	1.80	1.27	1.19	0.22	4.09	0.58		
	Plantation on OB Dump	0.00	0.00	20.10	14.17	0.00	0.00	20.10	2.87		
	Plantation on Backfill	0.00	0.00	25.13	17.72	0.00	0.00	25.13	3.59		
	Total Plantation (Biological Reclamation)	1.10	5.41	47.03	33.16	1.19	0.22	49.32	7.04		
	Total Vegetation	1.27	6.25	70.70	49.85	318.00	59.10	389.97	55.69		
ACTIVE MINING	Coal Quarry	3.86	19.01	9.54	6.74	51.66	9.60	65.06	9.29		
	Coal Face	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
	Coal Dump	2.94	14.48	2.53	1.78	16.92	3.14	22.39	3.20		
	Advance Quarry Site	1.18	5.81	0.00	0.00	11.74	2.18	12.92	1.85		
	Quarry Filled With Water	0.49	2.41	1.04	0.73	0.00	0.00	1.53	0.22		
	Total Area under Active Mining	8.47	41.71	13.11	9.25	80.32	14.92	101.90	14.55		
RECLAIMED	Barren OB Dump	0.00	0.00	1.21	0.85	0.00	0.00	1.21	0.17		
	Area Under Backfilling	9.82	48.35	31.27	22.05	9.01	1.67	50.10	7.15		
	Total Area under Technical Reclamation	9.82	48.35	32.48	22.90	9.01	1.67	51.31	7.33		
	Total Area under Mine Operation	18.29	90.06	45.59	32.15	89.33	16.59	153.21	21.88		
WASTELAND	Waste Lands	0.75	3.69	19.38	13.67	60.76	11.29	80.89	11.55		
	Fly Ash Pond / Sand Body	0.00	0.00	0.10	0.07	0.00	0.00	0.10	0.01		
	Total Wasteland	0.75	3.69	19.48	13.74	60.76	11.29	80.99	11.57		
WATERBODIES	Reservoir, nallah, ponds	0.00	0.00	3.07	2.17	4.44	0.83	7.51	1.07		
	Total Waterbodies	0.00	0.00	3.07	2.17	4.44	0.83	7.51	1.07		
AGRICULTURE	Crop Lands	0.00	0.00	0.00	0.00	2.17	0.41	2.17	0.31		
	Fallow Lands	0.00	0.00	0.02	0.01	60.35	11.21	60.37	8.62		
	Total Agriculture	0.00	0.00	0.02	0.01	62.52	11.62	62.54	8.93		
SETTLEMENTS	Urban Settlement	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
	Rural Settlement	0.00	0.00	0.00	0.00	2.36	0.44	2.36	0.34		
	Industrial Settlement	0.00	0.00	2.95	2.08	0.69	0.13	3.64	0.52		
	Total Settlement	0.00	0.00	2.95	2.08	3.05	0.57	6.00	0.86		
	Grand Total	20.31	100.00	141.81	100.00	538.10	100.00	700.22	100.00		

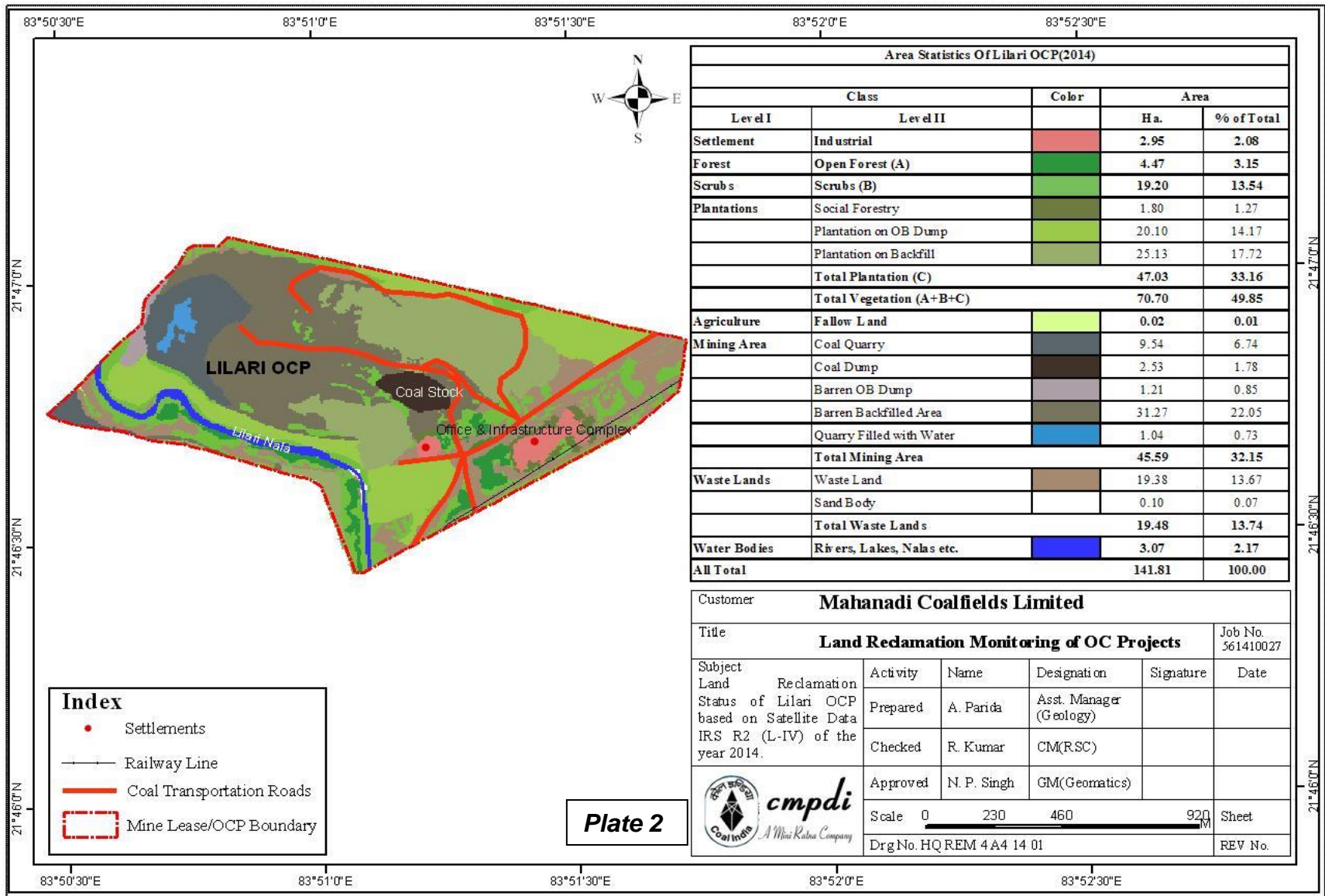


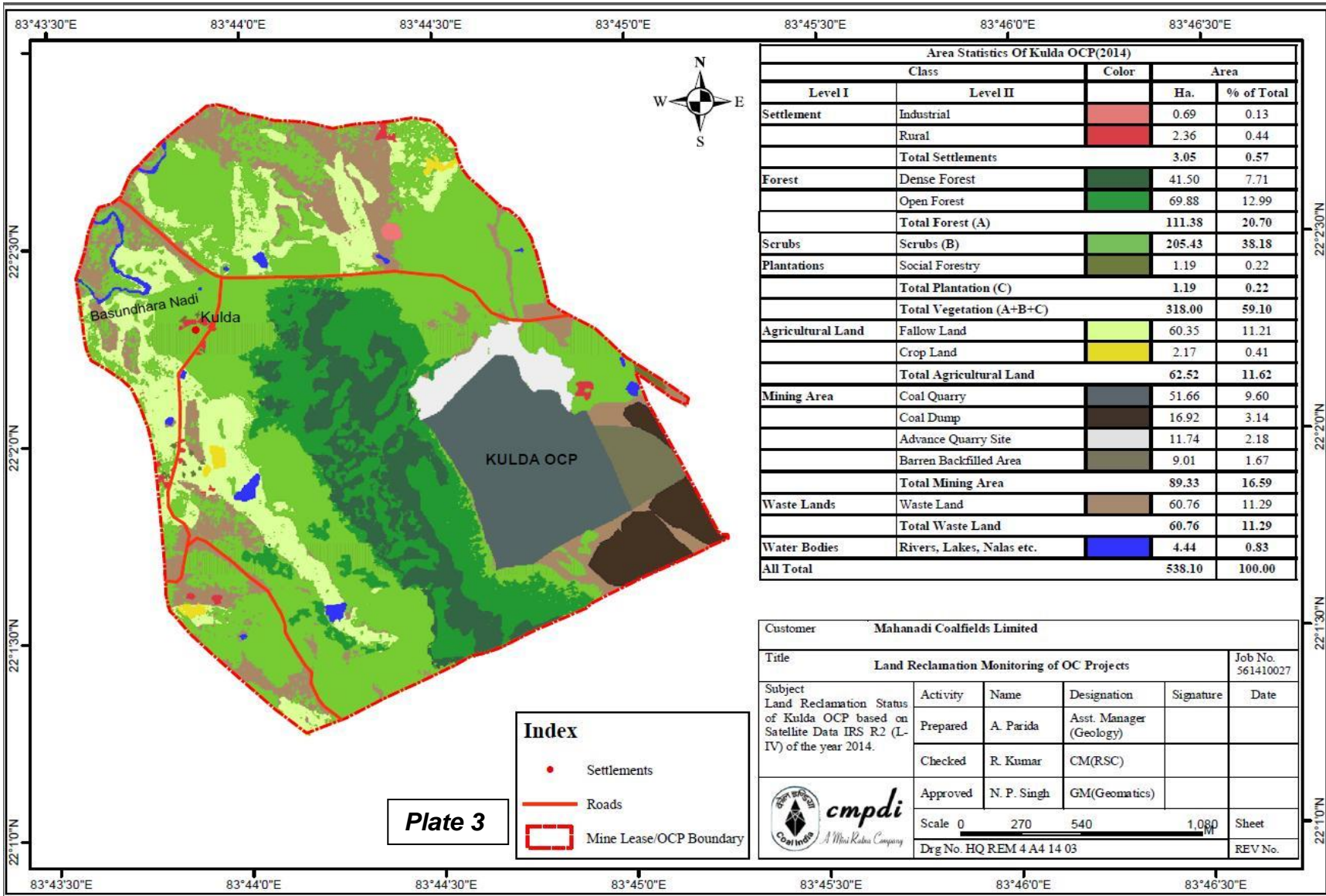
Area Statistics Of Chhendipada OCP(2014)				
Class		Color	Area	
Level I	Level II		Ha.	% of Total
Scrubs	Scrubs (A)		0.17	0.84
Plantations	Social Forestry		1.10	5.41
	Total Plantation (B)		1.10	5.41
Total Vegetation (A+B)			1.27	6.26
Mining Area	Coal Quarry		3.86	19.01
	Coal Dump		2.94	14.48
	Advance Quarry Site		1.18	5.81
	Barren Backfilled Area		9.82	48.35
	Water Filled Quarry		0.49	2.41
	Total Mining Area		18.29	90.06
Waste Lands	Waste Land		0.75	3.69
	Total Waste Land		0.75	3.69
All Total			20.31	100.00

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Customer		Mahanadi Coalfields Limited				
Title		Land Reclamation Monitoring Of OC Projects			Job No.	561410027
Subject Land Status of Chhendipada OC based on Satellite Data IRS R2 (L-IV) of the year 2014.	Activity	Name	Designation	Signature	Date	
	Prepared	A. Parida	Asst. Manager (Geology)			
	Checked	R. Kumar	CM(RSC)			
	Approved	N. P. Singh	GM(Geomatics)			
Scale 0 35 70 140 210 280 M		Sheet			REV No.	
DrgNo. HQ REM 4 A4 14 02						

Plate 1





Area Statistics Of Kulda OCP(2014)				
Class		Color	Area	
Level I	Level II		Ha.	% of Total
Settlement	Industrial	[Red]	0.69	0.13
	Rural		2.36	0.44
	Total Settlements		3.05	0.57
Forest	Dense Forest	[Dark Green]	41.50	7.71
	Open Forest		69.88	12.99
	Total Forest (A)		111.38	20.70
Scrubs	Scrubs (B)	[Light Green]	205.43	38.18
Plantations	Social Forestry	[Dark Green]	1.19	0.22
	Total Plantation (C)		1.19	0.22
Total Vegetation (A+B+C)			318.00	59.10
Agricultural Land	Fallow Land	[Light Yellow]	60.35	11.21
	Crop Land	[Yellow]	2.17	0.41
	Total Agricultural Land		62.52	11.62
Mining Area	Coal Quarry	[Dark Grey]	51.66	9.60
	Coal Dump	[Brown]	16.92	3.14
	Advance Quarry Site	[Light Grey]	11.74	2.18
	Barren Backfilled Area	[Dark Brown]	9.01	1.67
	Total Mining Area		89.33	16.59
Waste Lands	Waste Land	[Brown]	60.76	11.29
	Total Waste Land		60.76	11.29
Water Bodies	Rivers, Lakes, Nalas etc.	[Blue]	4.44	0.83
All Total			538.10	100.00

Customer Mahanadi Coalfields Limited					
Title Land Reclamation Monitoring of OC Projects					Job No. 561410027
Subject Land Reclamation Status of Kulda OCP based on Satellite Data IRS R2 (L-IV) of the year 2014.	Activity	Name	Designation	Signature	Date
	Prepared	A. Parida	Asst. Manager (Geology)		
	Checked	R. Kumar	CM(RSC)		
Approved	N. P. Singh	GM(Geomatics)			
Scale 0 270 540 1,080 M					Sheet
Drg No. HQ REM 4 A4 14 03					REV No.

Plate 3

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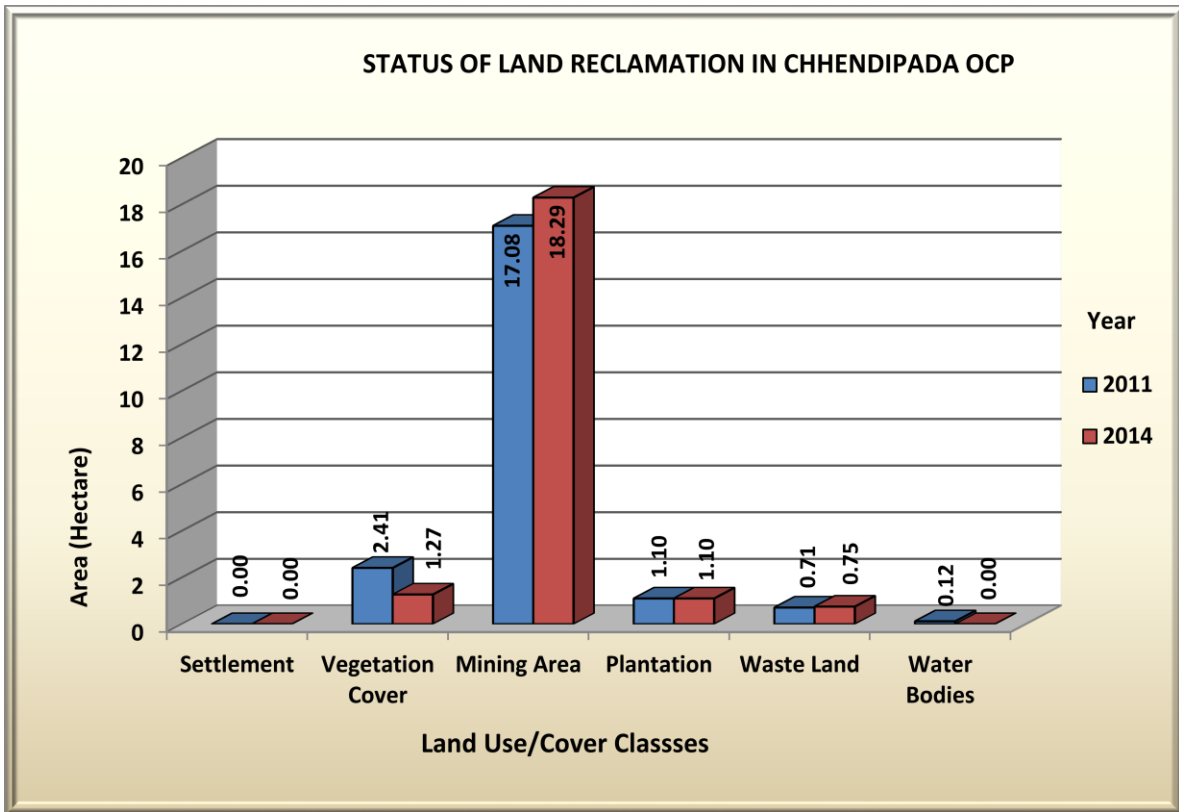


FIGURE - 3

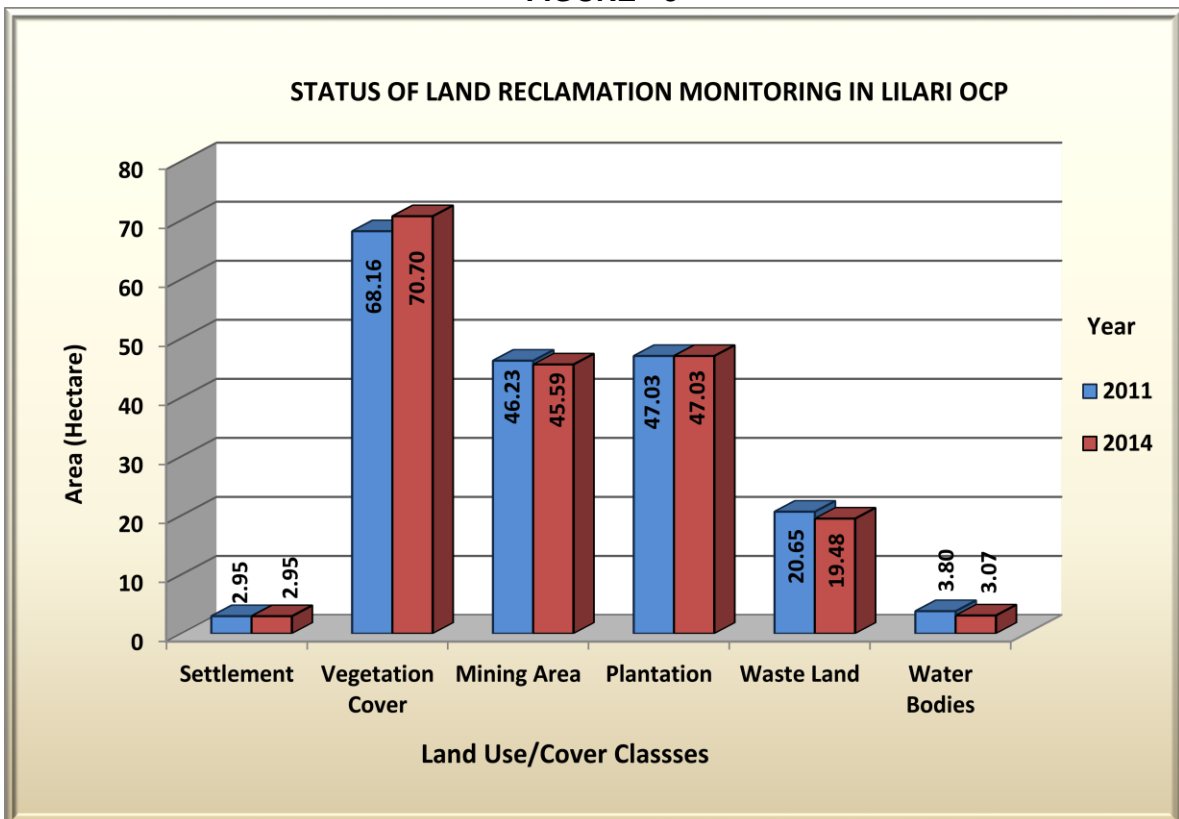


FIGURE - 4

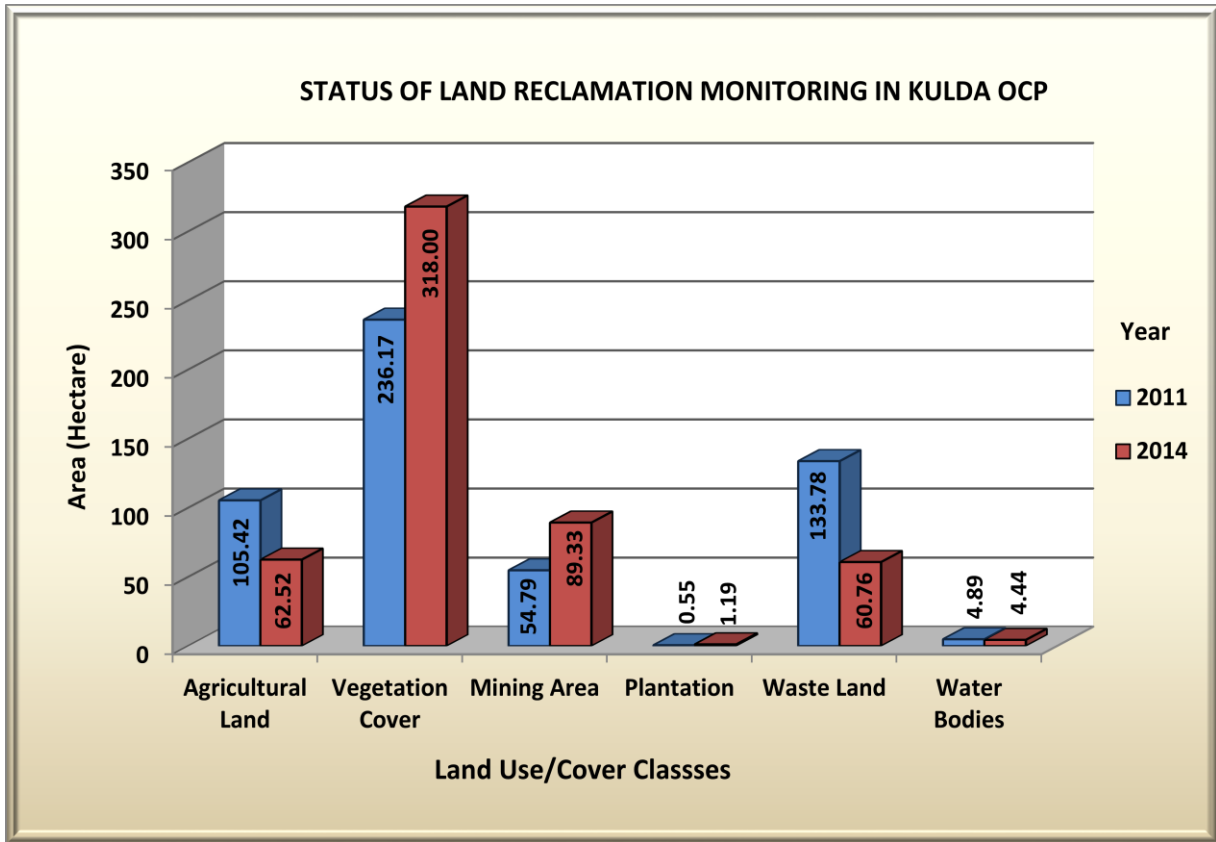


FIGURE -5



Photo 1: Plantation on External OB Dump (Lilari OCP)



Photo 2: Plantation on Backfill (Lilari OCP)