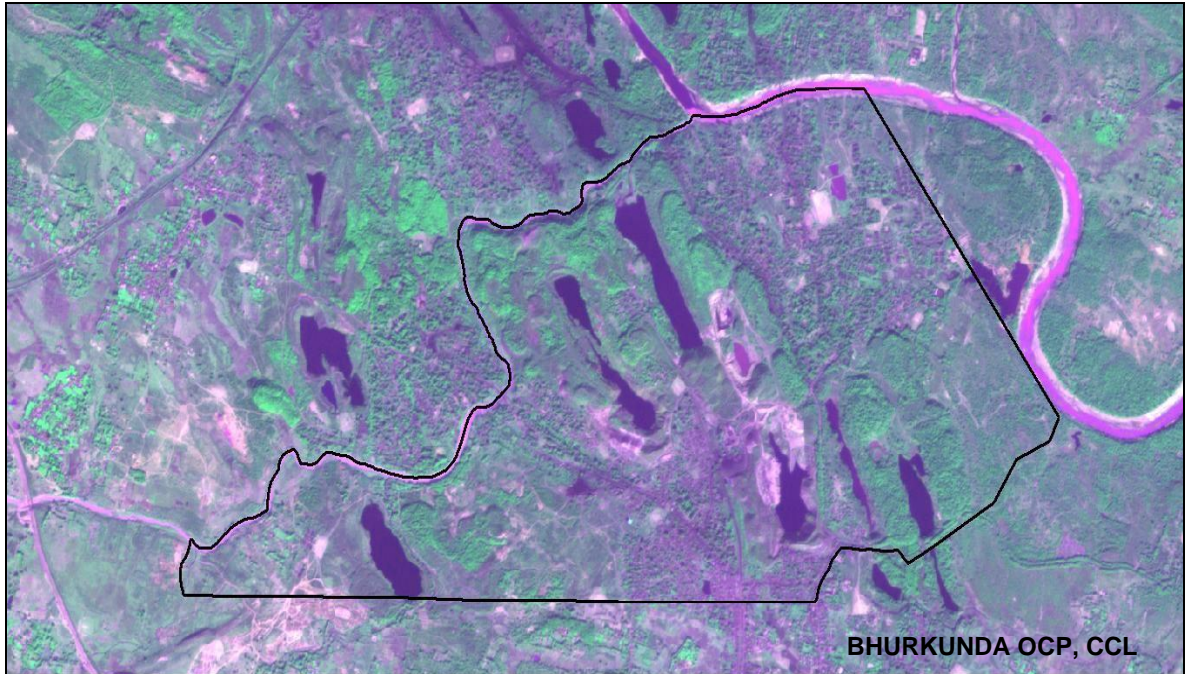


ARA OCP

2013-14

Land Restoration / Reclamation Monitoring of Open Cast Coal Mines of
Central Coalfields Limited producing less than 5 m cu m. (Coal+ OB)
based on Satellite Data for the Year 2013



Submitted to
Central Coalfields Limited

March 2014

Land Restoration / Reclamation Monitoring of Open Cast Coal Mines of
Central Coalfields Limited producing less than 5 m cu m. (Coal+ OB)
based on Satellite Data for the Year 2013

March 2014



Remote Sensing Cell
Geomatics Division
CMPDI, Ranchi

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(8) Aim of the Report	To prepare land use/cover map of leasehold area of 11 opencast mine projects based on high resolution satellite data (IRS-R2-L4MX) of the year 2013 using digital image processing technique.
(9) Executing Unit	Remote Sensing Cell, Geomatics Division, Central Mine Planning & Design Institute Limited, Gondwana Place, Kanke Road, Ranchi 834008
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Executive summary

- 1.0 Project** Land restoration/reclamation monitoring of 11 opencast coal mines of Central Coalfields Ltd. (CCL) 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 opencast 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 5576.06 hectares of the 11 OC projects Viz. Ara, Bhurkunda, Pichri, Pindra, Sirka, Dhori, Bokaro, Kargali, Rajhara, Religera and Sarubera considered for monitoring during year 2013; total excavated area is only 1917.04 hec. Out of which 793.87 ha area (41.41%) has been planted, 551.35 ha area (28.76%) has been backfilled and 571.82 ha area (29.83%) is under active mining. It is evident from the analysis that 70.17% area of the OC projects have already been reclaimed and balance 29.83% area is under active mining. Project wise details are given in Table-1 & Fig.-1.
 - Of the total area reclaimed by CCL, 41.41% is under biological reclamation (plantation) and 28.76% is under technical reclamation. Out of 11 projects of CCL, Bokaro OCP ranks on top for land reclamation (83.35%) followed by Bhurkunda OCP (78.57%) and Kargali OCP (76.54%).

Table - 1

**Projectwise Land Reclamation Status in Opencast Projects of CCL
based on Satellite Data of the year 2013**

(% Calculated in terms of Total Excavated Area)

(Area in Hectares)

Sl. No.	Project		Plantation/ Vegetation	Under Backfilling	Active Mining	Total Excavated Area	Total Area under Reclamation
	Name	Leasehold (i)	(ii)	(iii)	(iv)	(ii+iii+iv)	(ii+iii)
			2013	2013	2013	2013	2013
1	Ara	525.75	86.03	32.50	50.89	169.42	118.53
			50.78	19.18	30.04		69.96
2	Bhurkunda	910.16	220.43	77.70	81.32	379.45	298.13
			58.09	20.48	21.43		78.57
3	Pichri	40.13	8.25	0.00	13.19	21.44	8.25
			38.48	0.00	61.52		38.48
4	Pindra	326.54	3.85	9.76	24.71	38.32	13.61
			10.05	25.47	64.48		35.52
5	Sirka	362.4	10.61	20.16	91.09	121.86	30.77
			8.71	16.54	74.75		25.25
6	Dhori	294.32	22.82	43.88	30.91	97.61	66.70
			23.38	44.95	31.67		68.33
7	Bokaro	607.3	165.27	79.36	48.86	293.49	244.63
			56.31	27.04	16.65		83.35
8	Kargali	785	178.22	154.72	102.07	435.01	332.94
			40.97	35.57	23.46		76.54
9	Rajhara	736.36	0.00	7.12	46.71	53.83	7.12
			0.00	13.23	86.77		13.23
10	Religera	301.75	42.88	75.41	54.51	172.80	118.29
			24.81	43.64	31.55		68.45
11	Sarubera	686.35	55.51	50.74	27.56	133.81	106.25
			41.48	37.92	20.60		79.40
TOTAL (CCL)		5576.06	793.87	551.35	571.82	1917.04	1345.22
			41.41	28.76	29.83	34.38	70.17

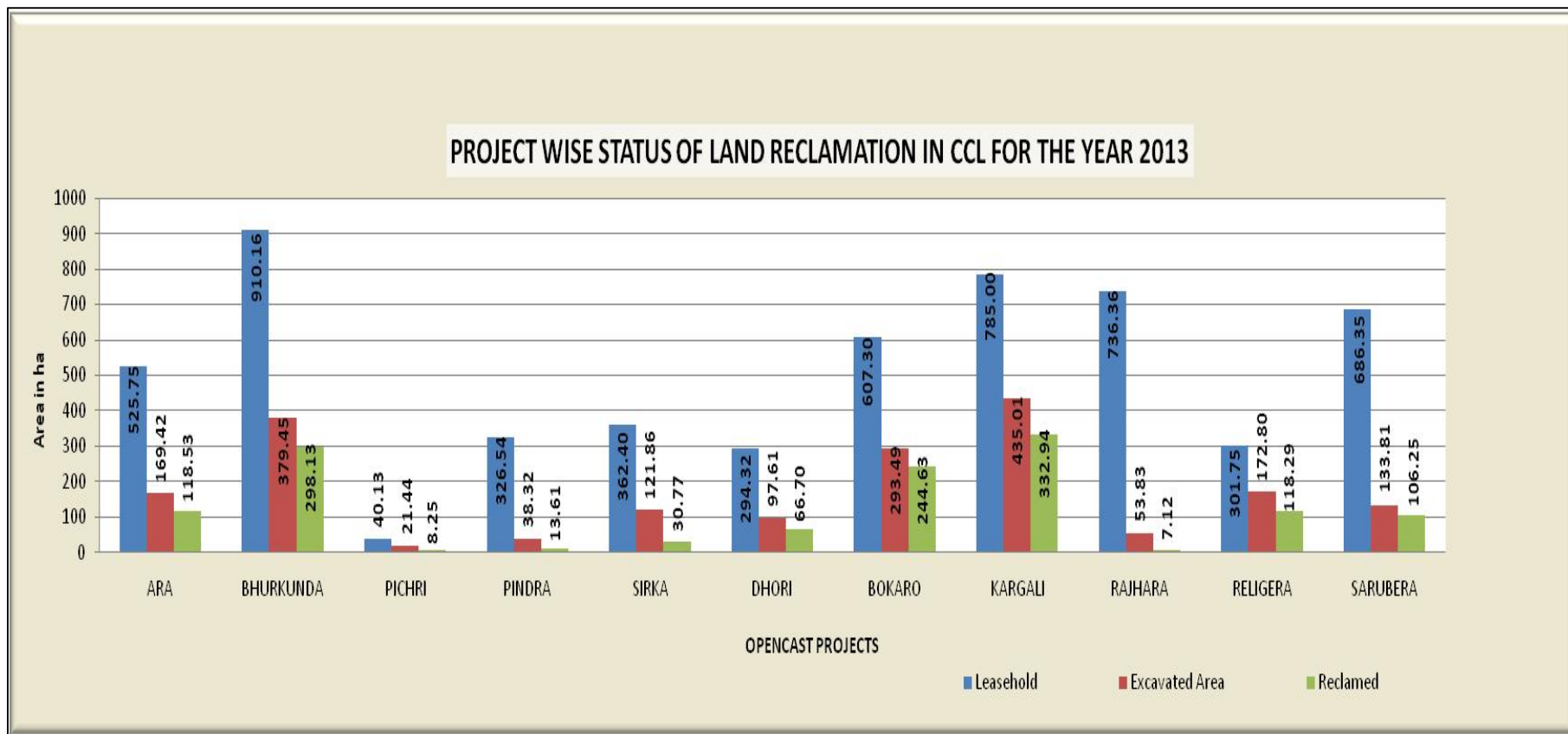


Figure 1: Project wise status of Land Reclamation in CCL for the year 2013

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 affect 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 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 12.10.2012 for monitoring of opencast mines of less than 5 million m³ per annum capacity (Coal + OB) from the year 2012 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 opencast coal mining projects would also comply the statutory requirements of Ministry of Environment & Forest (MoEF). Such monitoring would not only facilitate in taking timely mitigation measures against environmental degradation, but would also enable coal companies to utilize the reclaimed land for larger 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 2013 carried out for 11 OC projects of Central Coalfields Ltd. Producing less than 5 m.c.m (Coal + OB) per annum.

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, 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 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:

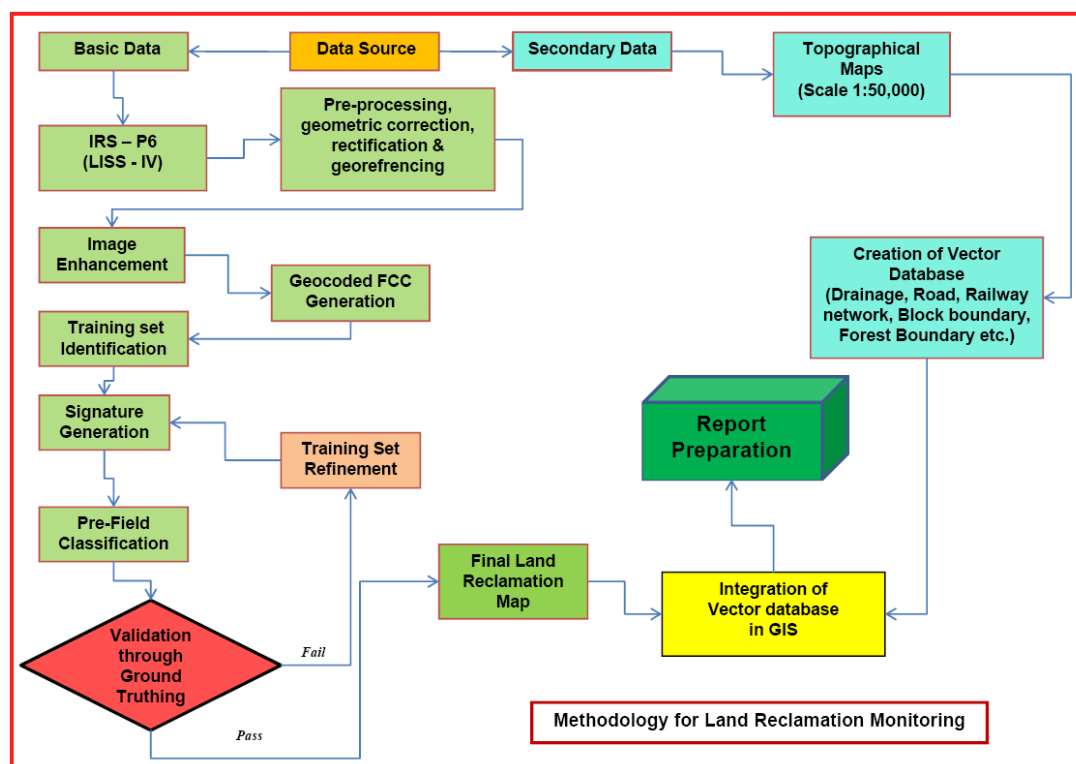


Figure-2: Methodology of Land Reclamation Monitoring

3.1 Data Procurement:

After browsing the data quality and date of pass on NRSC site, data order 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 digital image processing s/w v2012. Methodology involves the following major steps:

- **Rectification & Geo-referencing:**

Inaccuracies in digital imagery may occur due to 'systematic errors' attributed to earth curvature and rotation as well as 'non-systematic errors' attributed to satellite receiving station itself. Raw digital images contain geometric distortions, which make them unusable as maps. Therefore, geo-referencing is required for correction of image data using ground control points (GCP) to make it compatible to SOI topo-sheet.

- **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 9.3 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 are 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 v2012 s/w and given in table 2.

- **Overlay of Vector database**

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

- **Pre-field map preparation**

Pre-field map is prepared for validation of 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 of Central Coalfields Ltd.

Following 11 OC Projects producing less than 5 million m³ (Coal +OB) of Central Coalfields Ltd. Have been taken up during the year 2013 for land reclamation monitoring:

- Ara
- Bhurkunda
- Pichri
- Pindra
- Sirka
- Dhori
- Bokaro
- Kargali
- Rajhara
- Religera
- Sarubera

4.1 Area statistics of different land use classes present in OC projects in the year 2013 is given in table 2. Land use maps derived from the satellite data is given in Plate No. 1 to 11. Land use statuses are shown in fig. 3-13 and field photographs showing plantation and backfilled area in mining project is shown in Photos 1-6.

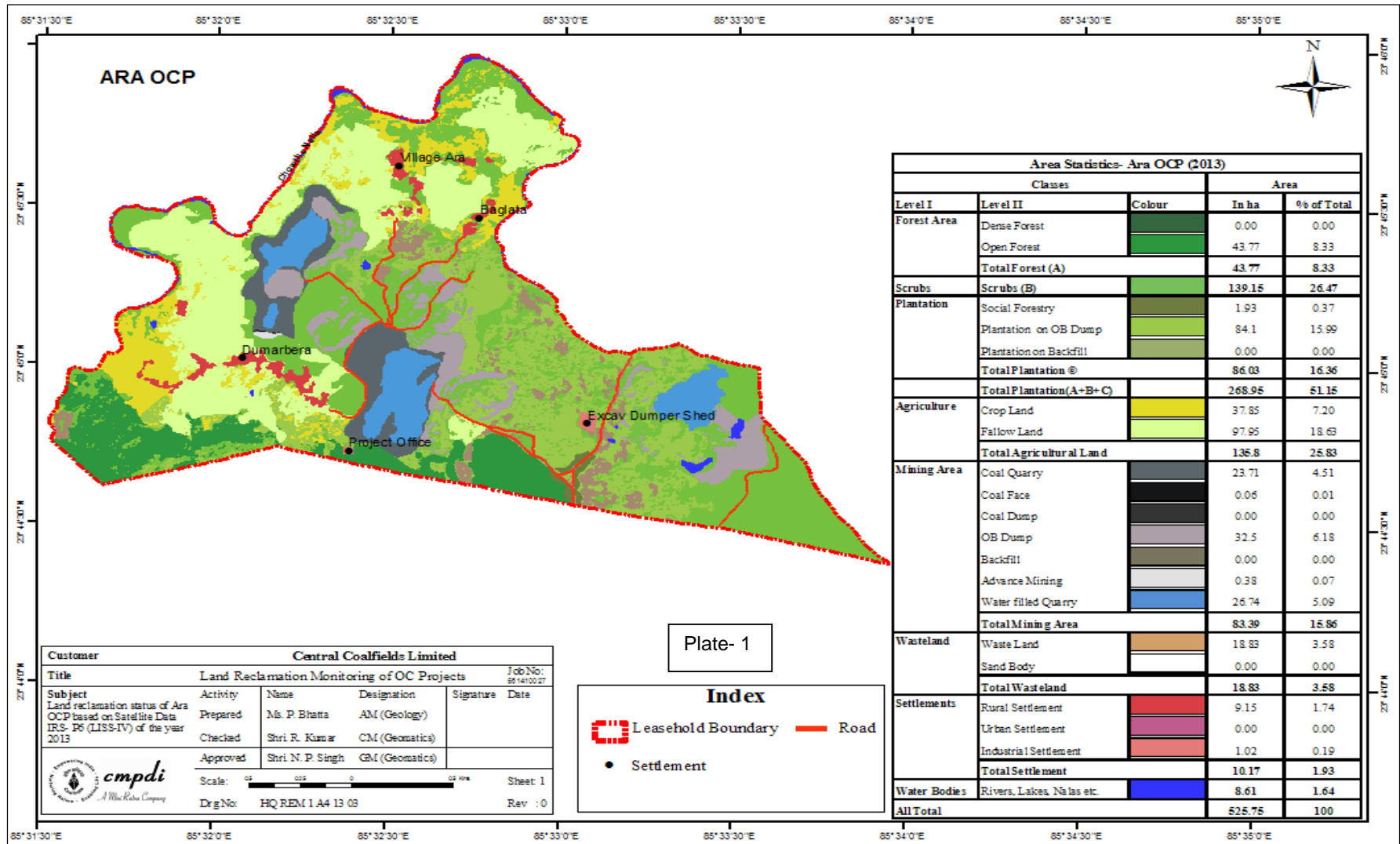
4.2 Study reveals that 70.17% of excavated area has already been reclaimed by CCL in the OC Projects, out of which 41.41% area has been planted and 28.76% area are backfilled.

4.3 After analyzing the satellite data of the year 2013, it is evident that plantation carried out on backfilled area, OB dumps as well as under social forestry in all the 11 mines of CCL taken for study, has reached 41.41% till now. It can also be seen from table 1 that the total area of reclamation has reached 70.17% till the year 2013.

Table 2: STATUS OF LAND RECLAMATION IN CENTRAL COALFIELDS LIMITED BASED ON SATELLITE DATA OF THE YEAR 2013

		ARA		BHURKUNDA		PICHRI		PINDRA		SIRKA		DHORI	
		Area	%	Area	%	Area	%	Area	%	Area	%	Area	%
FORESTS	Dense Forest	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Open Forest	43.77	8.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total Forest (A)	43.77	8.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SCRUBS	Scrubs (B)	139.15	26.47	290.01	31.86	2.65	6.60	103.03	31.55	108.93	30.06	100.92	34.29
PLANTATION	Social Forestry	1.93	0.37	94.36	10.36	8.25	20.57	3.85	1.18	6.08	1.67	0.00	0.00
	Plantation on OB Dump	84.10	15.99	126.07	13.84	0.00	0.00	0.00	0.00	4.53	1.25	6.66	2.26
	Plantation on Backfill	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.16	5.49
	Total Plantation (Biological Reclamation C)	86.03	16.36	220.43	24.20	8.25	20.57	3.85	1.18	10.61	2.92	22.82	7.75
	Total Vegetation (A+B+C)	268.95	51.15	510.44	56.06	10.90	27.17	106.88	32.73	119.54	32.98	123.74	42.04
ACTIVE MINING	Coal Quarry	23.71	4.51	29.93	3.29	6.03	15.02	19.44	5.95	76.44	21.10	13.09	4.45
	Coal Face	0.06	0.01	0.00	0.00	0.15	0.38	0.00	0.00	1.48	0.41	0.12	0.04
	Coal Dump	0.00	0.00	1.63	0.18	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.34
	Advance Quarry Site	0.38	0.07	0.84	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Quarry Filled with Water	26.74	5.09	48.92	5.37	7.01	17.46	5.27	1.61	13.17	3.63	16.70	5.67
	Total Area under Active Mining	50.89	9.68	81.32	8.93	13.19	32.86	24.71	7.56	91.09	25.14	30.91	10.50
RECLAIMED	Barren OB dump	32.50	6.18	77.70	8.53	0.00	0.00	9.76	3.00	20.16	5.56	25.96	8.82
	Area Under Backfilling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.92	6.09
	Total Area under Technical Reclamation	32.50	6.18	77.70	8.53	0.00	0.00	9.76	3.00	20.16	5.56	43.88	14.91
	Total Area under Mine Operation	83.39	15.86	159.02	17.46	13.19	32.86	34.47	10.56	111.25	30.70	74.79	25.41
WASTELANDS	Waste Lands	18.83	3.58	65.83	7.23	0	0	46.87	14.35	3.89	1.07	7.99	2.71
	Fly Ash Pond/Sand Body	0.00	0.00	4.30	0.46	1.08	2.69	0.00	0.00	0.20	0.06	4.97	1.69
	Total Wastelands	18.83	3.58	70.13	7.69	1.08	2.69	46.87	14.35	4.09	1.13	12.96	4.4
WATER	Reservoir, nallah, ponds etc.	8.61	1.64	16.53	1.81	1.79	4.46	1.41	0.44	13.57	3.76	5.05	1.72
	Total Waterbodies	8.61	1.64	16.53	1.81	1.79	4.46	1.41	0.44	13.57	3.76	5.05	1.72
AGRICULTURE	Crop Lands	37.85	7.20	0.00	0.00	0.00	0.00	6.51	1.99	13.80	3.81	0.00	0.00
	Fallow Lands	97.95	18.63	12.01	1.30	13.17	32.82	125.86	38.54	68.73	18.96	7.94	2.70
	Total Agriculture	135.80	25.83	12.01	1.30	13.17	32.82	132.37	40.53	82.53	22.77	7.94	2.70
SETTLEMENTS	Urban Settlement	0.00	0.00	133.89	14.71	0.00	0.00	3.35	1.03	23.04	6.36	62.57	21.26
	Rural Settlement	9.15	1.74	0.00	0.00	0.00	0.00	0.76	0.23	6.95	1.91	5.70	1.94
	Industrial Settlement	1.02	0.19	8.96	0.97	0.00	0.00	0.43	0.13	1.43	0.39	1.57	0.53
	Total Settlements	10.17	1.93	142.85	15.68	0.00	0.00	4.54	1.39	31.42	8.66	69.84	23.73
	GRAND TOTAL	525.75	100.00	910.16	100.00	40.13	100.00	326.54	100.00	362.40	100.00	294.32	100.00

		BOKARO		KARGALI		RAJHARA		RELIGERA		SARUBERA		TOTAL	
		Area	%	Area	%	Area	%	Area	%	Area	%	Area	%
FORESTS	Dense Forest	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Open Forest	0.00	0.00	0.00	0.00	0.00	0.00	3.35	1.11	54.32	7.91	101.44	1.82
	Total Forest (A)	0.00	0.00	0.00	0.00	0.00	0.00	3.35	1.11	54.32	7.91	101.44	1.82
SCRUBS	Scrubs (B)	118.46	19.51	175.39	22.34	113.49	15.41	96.58	32.00	135.35	19.72	1383.96	24.82
PLANTATION	Social Forestry	58.51	9.63	72.95	9.29	0.00	0.00	33.15	10.99	6.01	0.88	285.09	5.11
	Plantation on OB Dump	5.80	0.96	103.53	13.19	0.00	0.00	9.73	3.22	49.50	7.21	389.92	6.99
	Plantation on Backfill	100.96	16.62	1.74	0.22	0.00	0.00	0.00	0.00	0.00	0.00	118.86	2.13
	Total Plantation(Biological Reclamation C)	165.27	27.21	178.22	22.70	0.00	0.00	42.88	14.21	55.51	8.09	793.87	14.23
Total Vegetation (A+B+C)		283.73	46.72	353.61	45.04	113.49	15.41	142.81	47.32	245.18	35.72	2279.27	40.87
ACTIVE MINING	Coal Quarry	6.44	1.06	76.24	9.71	23.10	3.14	23.50	7.79	16.83	2.45	314.75	5.64
	Coal Face	0.00	0.00	0.00	0.00	0.35	0.05	0.00	0.00	0.00	0.00	2.16	0.04
	Coal Dump	0.00	0.00	0.00	0.00	0.00	0.00	3.56	1.18	0.00	0.00	6.19	0.11
	Advance Quarry Site	0.00	0.00	0.00	0.00	0.51	0.07	0.00	0.00	0.00	0.00	1.73	0.03
	Quarry Filled with Water	42.42	6.99	25.83	3.29	22.75	3.08	27.45	9.10	10.73	1.56	246.99	4.43
	Total Area under Active Mining	48.86	8.05	102.07	13.00	46.71	6.34	54.51	18.07	27.56	4.01	571.82	10.25
RECLAIMED	Barren OB dump	10.08	1.66	154.60	19.70	7.12	0.97	75.41	24.99	49.25	7.18	462.54	8.29
	Area Under Backfilling	69.28	11.41	0.12	0.01	0.00	0.00	0.00	0.00	1.49	0.22	88.81	1.59
	Total Area under Technical Reclamation	79.36	13.07	154.72	19.71	7.12	0.97	75.41	24.99	50.74	7.40	551.35	9.88
Total Area under Mine Operation		128.22	21.12	256.79	32.71	53.83	7.31	129.92	43.06	78.30	11.41	1123.17	20.13
WASTELANDS	Waste Lands	15	2.47	2.49	0.32	118.89	16.14	4.59	1.52	165.91	24.17	450.29	8.08
	Fly Ash Pond/Sand Body	42.07	6.93	0.04	0.01	10.22	1.38	0.00	0.00	0.00	0.00	62.88	1.13
	Total Wastelands	57.07	9.4	2.53	0.33	129.11	17.52	4.59	1.52	165.91	24.17	513.17	9.21
WATER	Reservoir, nallah, ponds etc.	20.79	3.42	3.31	0.45	59.11	8.02	0.38	0.13	8.41	1.23	138.96	2.49
	Total Waterbodies	20.79	3.42	3.31	0.42	59.11	8.02	0.38	0.13	8.41	1.23	138.96	2.49
AGRICULTURE	Crop Lands	0.00	0.00	0.00	0.00	14.88	2.02	0.00	0.00	30.17	4.40	103.21	1.85
	Fallow Lands	71.14	11.71	4.22	0.54	348.83	47.37	3.58	1.19	136.66	19.91	890.09	15.95
	Total Agriculture	71.14	11.71	4.22	0.54	363.71	49.39	3.58	1.19	166.83	24.31	993.30	17.80
SETTLEMENTS	Urban Settlement	30.48	5.02	125.94	16.04	0.00	0.00	12.26	4.06	0.00	0.00	391.53	7.02
	Rural Settlement	14.18	2.33	24.10	3.07	17.74	2.35	6.87	2.28	9.23	1.34	94.68	1.70
	Industrial Settlement	1.69	0.28	14.50	1.85	0.00	0.00	1.34	0.44	12.49	1.82	43.43	0.78
	Total Settlements	46.35	7.63	164.54	20.96	17.74	2.35	20.47	6.78	21.72	3.16	529.64	9.50
GRAND TOTAL		607.30	100.00	785.00	100.00	736.36	100.00	301.75	100.00	686.35	100.00	5576.06	100.00



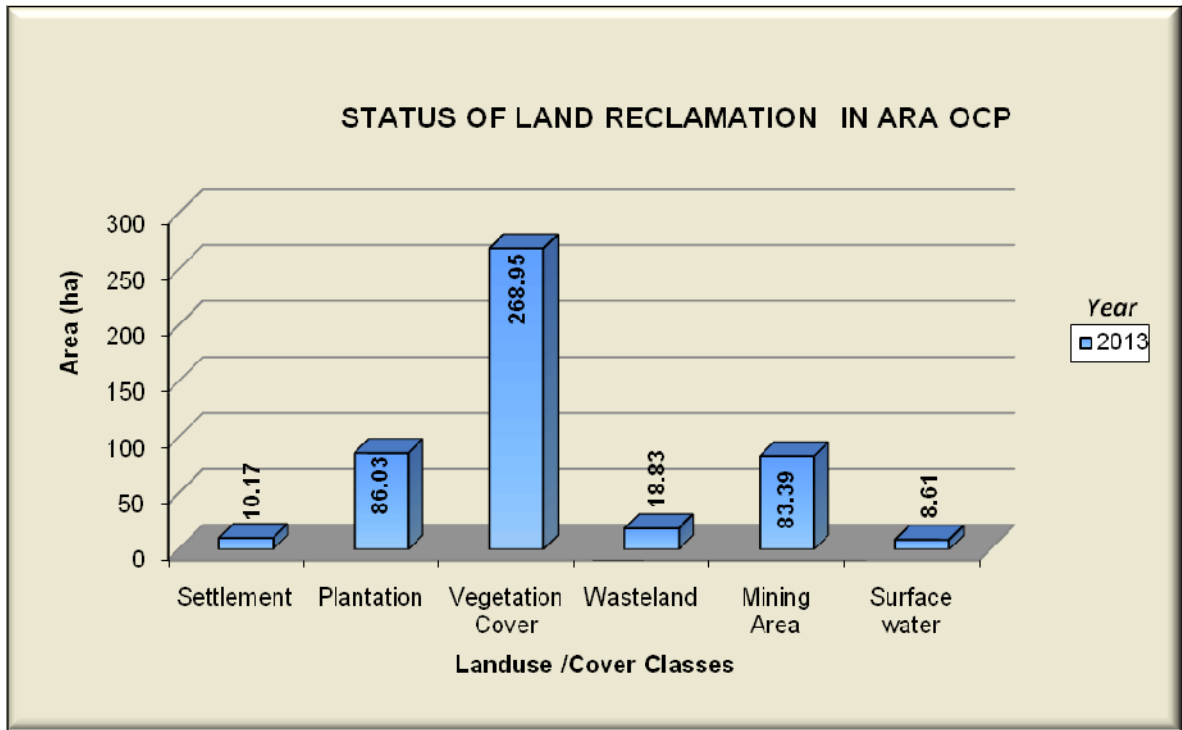


Figure - 3

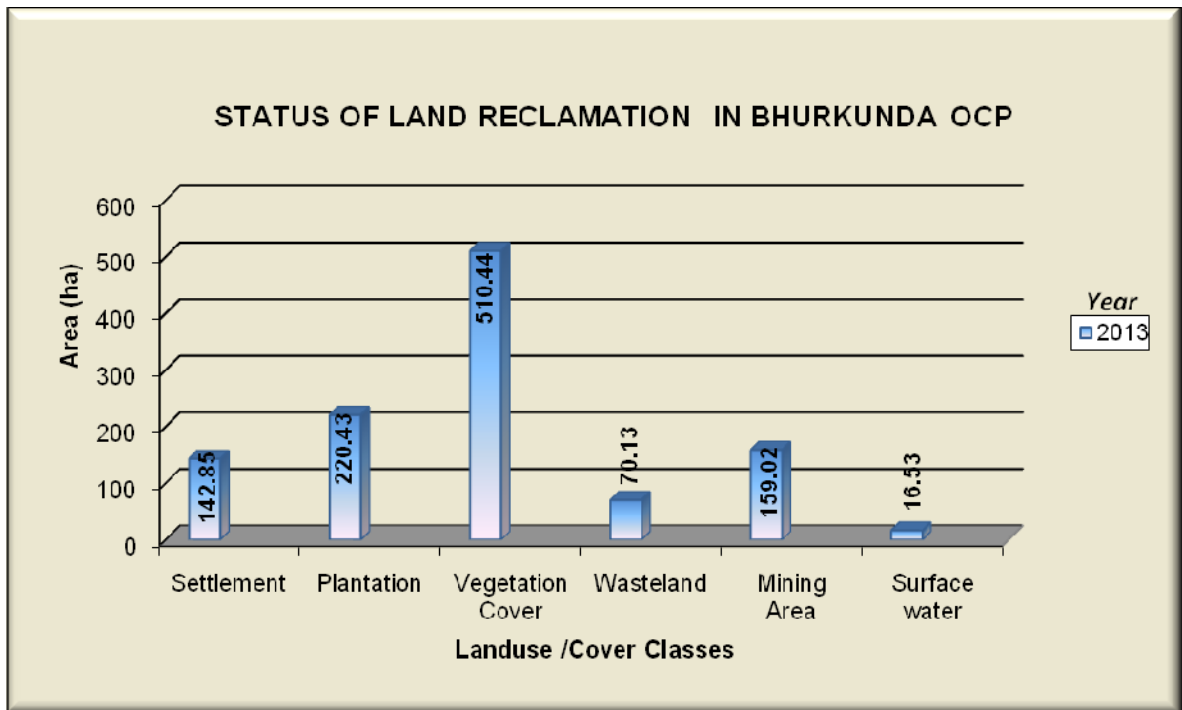


Figure - 4



Photo 1: Plantation on OB Dump (Ara OCP)



Photo 2: Plantation on OB Dump (Bhurkunda OCP)

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