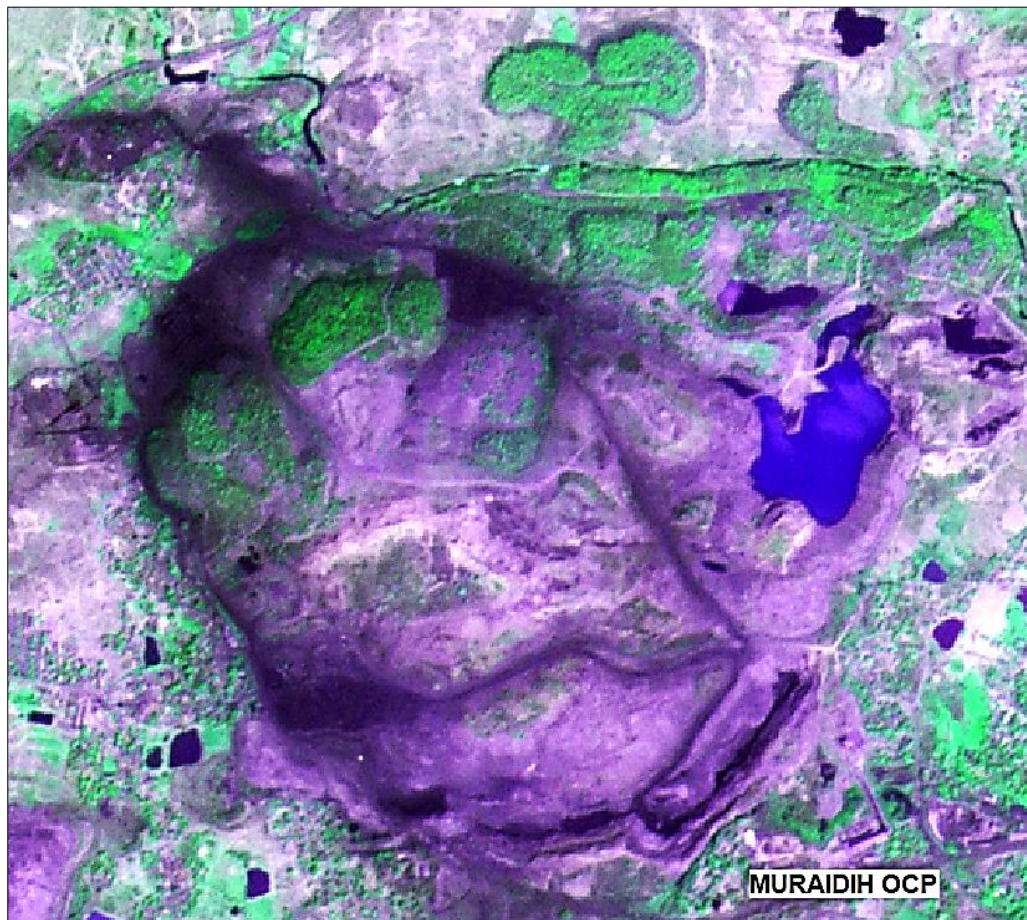


**Land Restoration / Reclamation Monitoring of more than 5 million
cu. m (Coal+OB) Capacity Open Cast Coal Mines of Bharat Coking
Coal Limited Based on Satellite Data of the Year 2017**



Submitted to
Bharat Coking Coal Limited



cmpdi
A Mini-Ratna Company

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Limited based on Satellite Data of the Year- 2017**

March-2018



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

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Executive Summary

- 1.0 Project** Land restoration / reclamation monitoring of two opencast coal mines of Bharat Coking Coal Ltd. (BCCL) producing 5 million cu. mtr and more (Coal+OB) per year based on satellite data, regularly on annual 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 in the leasehold area of the project. This will help in assessing the progressive status of mined 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 16.32 Km² of the two projects viz. Block-II and Muraidih, which were considered for monitoring during 2017-18; total excavated area is only 5.16 Km² of which 0.57 Km² area (11.05%) has been planted, 3.71 Km² area (71.90%) is under backfilling and 0.88 Km² area (17.05%) is under active mining. It is evident from the analysis that 82.95% area of the OC projects has come under reclamation and balance 17.05% 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 2017 with respect to the year 2016, it is evident from the analysis that the area of land reclamation has increased from 3.91 Km² (Yr. 2016) to 4.28 Km² (Yr. 2017). This increase of an area of 0.37 Km² in land reclamation is the result of the efforts of the coal company taken up towards environmental protection. Of the two projects of BCCL considered for monitoring, Block - II has achieved land reclamation of (82.01%) and Muraidih has (84.03%).

Table-1
Status of Land Reclamation in Bharat Coking Coal Limited based on Satellite Data for the Year 2017

(Projects producing more than 5 mcm of Coal+OB annually)

(Area in Sq. Kms.)

Sl. No.	Project	Total Leasehold Area	Technical Reclamation		Plantation						Area under Active Mining		Total Excavated Area		Total Area under Plantation (% Green Cover Generated in Leasehold)		Total Area under Reclamation	
					Biological Reclamation		Other Plantations											
			Area under Backfilling		Plantation on Excavated / Backfilled Area		Plantation on External Over Burden Dumps		Social Forestry, Avaneue Plantation Etc.									
1	2	3	4		5		6		7		8		9 (=4+5+8)		10 (=5+6+7)		11(=4+5)	
			2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
1	Block-II	9.07	2.05	2.15	0.12	0.13	0	0.04	0.57	0.57	0.45	0.5	2.62	2.78	0.69	0.74	2.17	2.28
			78.24%	77.34%	4.58%	4.68%					17.18%	17.99%			7.61%	8.16%	82.82%	82.01%
2	Muraidih	7.25	1.38	1.56	0.36	0.44	0.26	0.27	0.29	0.31	0.36	0.38	2.10	2.38	0.91	1.02	1.74	2.00
			65.71%	65.55%	17.14%	18.49%					17.14%	15.97%			12.55%	14.07%	82.86%	84.03%
	TOTAL	16.32	3.43	3.71	0.48	0.57	0.26	0.31	0.86	0.88	0.81	0.88	4.72	5.16	1.60	1.76	3.91	4.28
			72.67%	71.90%	10.17%	11.05%					17.16%	17.05%			9.80%	10.78%	82.84%	82.95%

(% is calculated with respect to Excavated Area as applicable)

Note In reference of the above Table-1, different parameters are classified as follows:

- 1 Area under **Biological Reclamation** includes Area under Plantation done on Backfill only
- 2 Area under **Technical Reclamation** includes Area under Backfilling only
- 3 Area under **Active Mining** includes Coal Quarry, Quarry filled with water & Advance Quarry Site, if any. Coal dump is excluded
- 4 Social Forestry and Plantation on External OB dumps are not included in Biological Reclamation, and are put under separate categories
- 5 (%) calculated in the above table is in respect of total excavated area except for "Total area under plantation" where % is in terms of leasehold area.

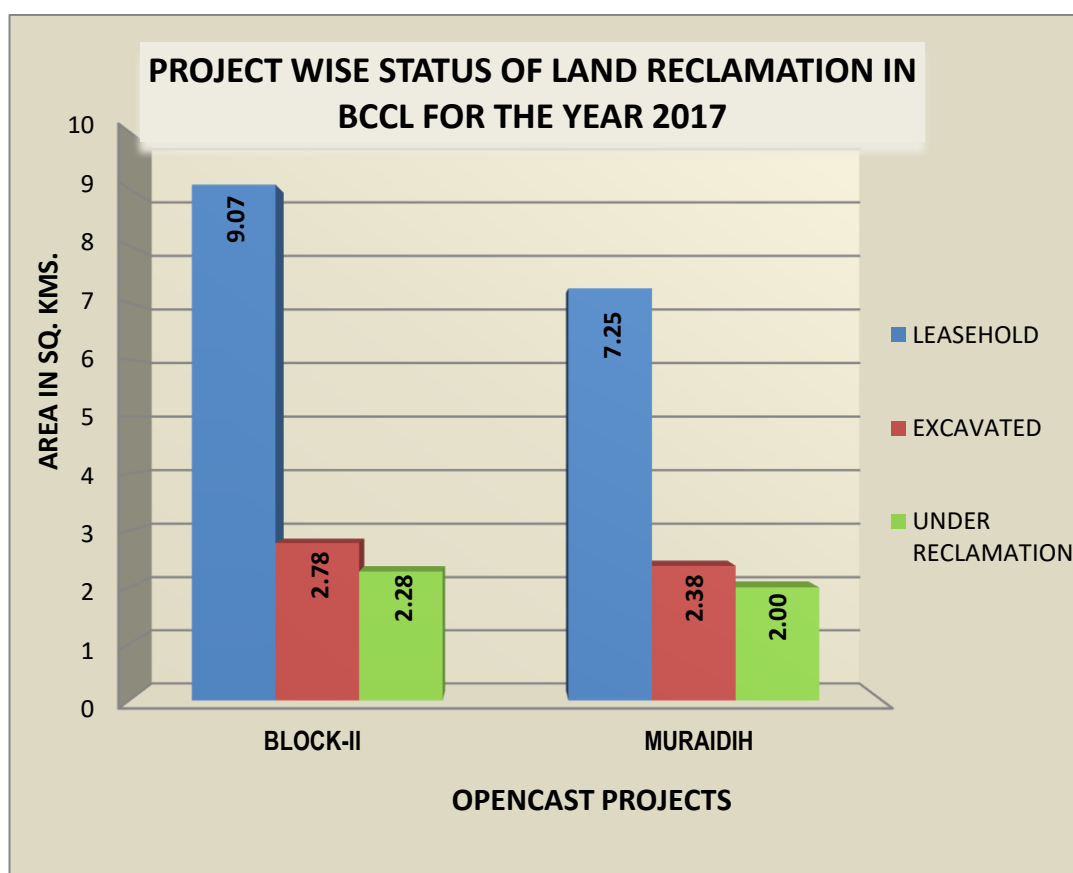


Fig. 1 Project wise Land Reclamation Status for the Year 2017

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 most scarce 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 the above in view, M/s. Coal India Ltd. (CIL) issued a work order vide letter no. CIL/WBP/ENV/2011 dated 12.10.2012 to Central Mine Planning & Design Institute (CMPDI), Ranchi, for monitoring of land reclamation status of all the opencast coal mines having production of more than 5 million m³ per annum (Coal + OB taken together per annum) regularly on annual basis, and for monitoring of less than 5 million m³ per annum capacity (Coal +OB) projects at an interval of three years, based on remote sensing satellite data for sustainable development of mining. The work order was renewed vide letter no. CIL/WBP/ENV/2017/DP/8477 dated 21.09.2017 for a period of 5 more years from 2017-18 to 2021-22. The result of land reclamation status of all such mines are to be put on the website of CIL, (www.coalindia.in), CMPDI (www.cmpdi.co.in) and the concerned coal companies in public domain. Detailed report has to be submitted to Coal India and respective subsidiary companies.
- 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 2017 carried out for all the OC projects producing more than 5 mcm (Coal+OB) for Bharat Coking Coal 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:

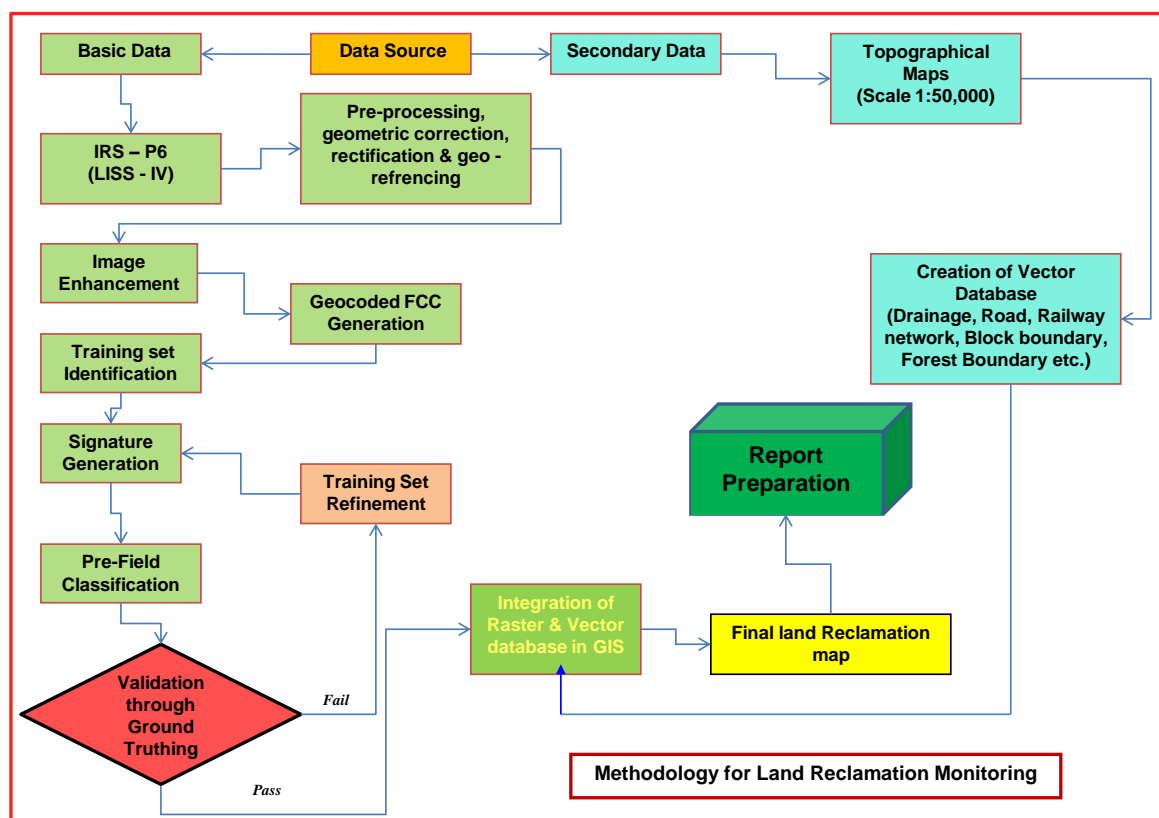


Fig. 2 : *Methodology of Land Reclamation Monitoring*

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 digital image processing s/w. 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 Sol 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 14.0 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 14.0 s/w.

- **Overlay of Vector data base**

Vector data base is 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 10.2 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 - of dates.

4.0 Land Reclamation Status in Bharat Coking Coal Ltd.

- 4.1 Following two OC projects producing 5 million cubic m. or more (Coal + OB together) of Bharat Coking Coal Ltd. have been taken up for land reclamation monitoring on annual basis:

Block-II and Muraidih

- 4.2 Both the above two projects, Block-II OC and Muraidih have been mapped during the year 2016 & 2017 also.
- 4.3 Project wise Land Reclamation status in BCCL for the year 2017 is given in Table-1 and also shown graphically in Fig-1. Area statistics of different land use classes present in OC projects in the year 2017 is given in Table 2. Land use maps derived from the satellite data are given in Plate no. 1 & 2. Changes in land use status are shown in Fig. 3 & 4.
- 4.4 Study reveals that 82.95% of excavated area has come under reclamation by BCCL in the above two projects, out of which 11.05% area has been re-vegetated and 71.90% area is under backfilling.
- 4.5 After analyzing the satellite data of year 2017 vs. 2016, it is seen (from Table-1) that the plantation carried out on backfilled area, OB dumps as well as social forestry has increased from 1.60 Km² (9.8%) to 1.76 Km² (10.78%). Together, an increase of 0.16 Km² area in social forestry/ backfill plantation, underlines the efforts taken up by the coal company (BCCL) towards plantation activities for land reclamation and environmental protection. An eco-restoration site of 3.6 ha has been developed by the company in Block-II from 2015-16. Another eco restoration area, of 3.2 ha is also developed by the company over OB dump behind the coal stock yard.
- 4.6 In collaboration with The Energy and Resources Institute (TERI) School of Advanced Studies, an area of 6.5 ha has also been developed by the company for bio-diversity through forest landscape restoration, over backfilled area of Muraidih OCP. The plants are of good health, maintained well and is a commendable job.

TABLE - 2							
Status of Land Use / Reclamation in OC Mines(>5m.cu.m) of Bharat Coking Coal Ltd. based on Satellite data of the Year 2017							
(Area in Sq Km)							
		BLOCK-II		MURAIIDIH		TOTAL	
		Area	%	Area	%	Area	%
PLANTATION	Scrubs(A)	2.45	27.01	1.44	19.86	3.89	23.84
	Social Forestry	0.57	6.28	0.31	4.28	0.88	5.39
	Plantation on OB Dump	0.04	0.44	0.27	3.72	0.31	1.90
	Plantation on Backfill(Biological Reclamation)	0.13	1.43	0.44	6.07	0.57	3.49
	Total Plantation (B)	0.74	8.15	1.02	14.07	1.76	10.78
Total Vegetation (A+B)		3.19	35.16	2.46	33.93	5.65	34.62
ACTIVE MINING	Coal Quarry	0.42	4.63	0.17	2.34	0.59	3.62
	Advance Quarry Site	0	0	0.03	0.41	0.03	0.18
	Quarry Filled With Water	0.08	0.88	0.18	2.48	0.26	1.59
	Area under Active Mining (D)	0.50	5.51	0.38	5.23	0.88	5.39
E	Coal Dump	0.1	1.1	0.05	0.69	0.15	0.92
	Barren OB Dump	1.38	15.21	0.37	5.1	1.75	10.72
	Area Under Backfilling(Technical Reclamation)	2.15	23.7	1.56	21.52	3.71	22.73
Total Area under Mining Operation (D+E)		4.13	45.52	2.36	32.54	6.49	39.77
WASTELAND	Waste Lands	0.28	3.09	0.46	6.34	0.74	4.53
	Fly Ash Pond / Sand Body	0.00	0.00	0.00	0.00	0.00	0.00
Total Wasteland		0.28	3.09	0.46	6.34	0.74	4.53
WATERBODIES	Reservoir, Nallah, Ponds	0.08	0.88	0.1	1.38	0.18	1.10
	Total Waterbodies	0.08	0.88	0.1	1.38	0.18	1.10
AGRICULTURE	Crop Lands	0.04	0.44	0.00	0	0.04	0.25
	Fallow Lands	0.73	8.05	1.3	17.93	2.03	12.44
	Total Agriculture	0.77	8.49	1.3	17.93	2.07	12.68
SETTLEMENTS	Urban Settlement	0.43	4.74	0.33	4.55	0.76	4.66
	Rural Settlement	0.09	0.99	0.15	2.07	0.24	1.47
	Industrial Settlement	0.1	1.1	0.09	1.24	0.19	1.16
	Total Settlement	0.62	6.83	0.57	7.86	1.19	7.29
Grand Total		9.07	100.00	7.25	100.00	16.32	100.00

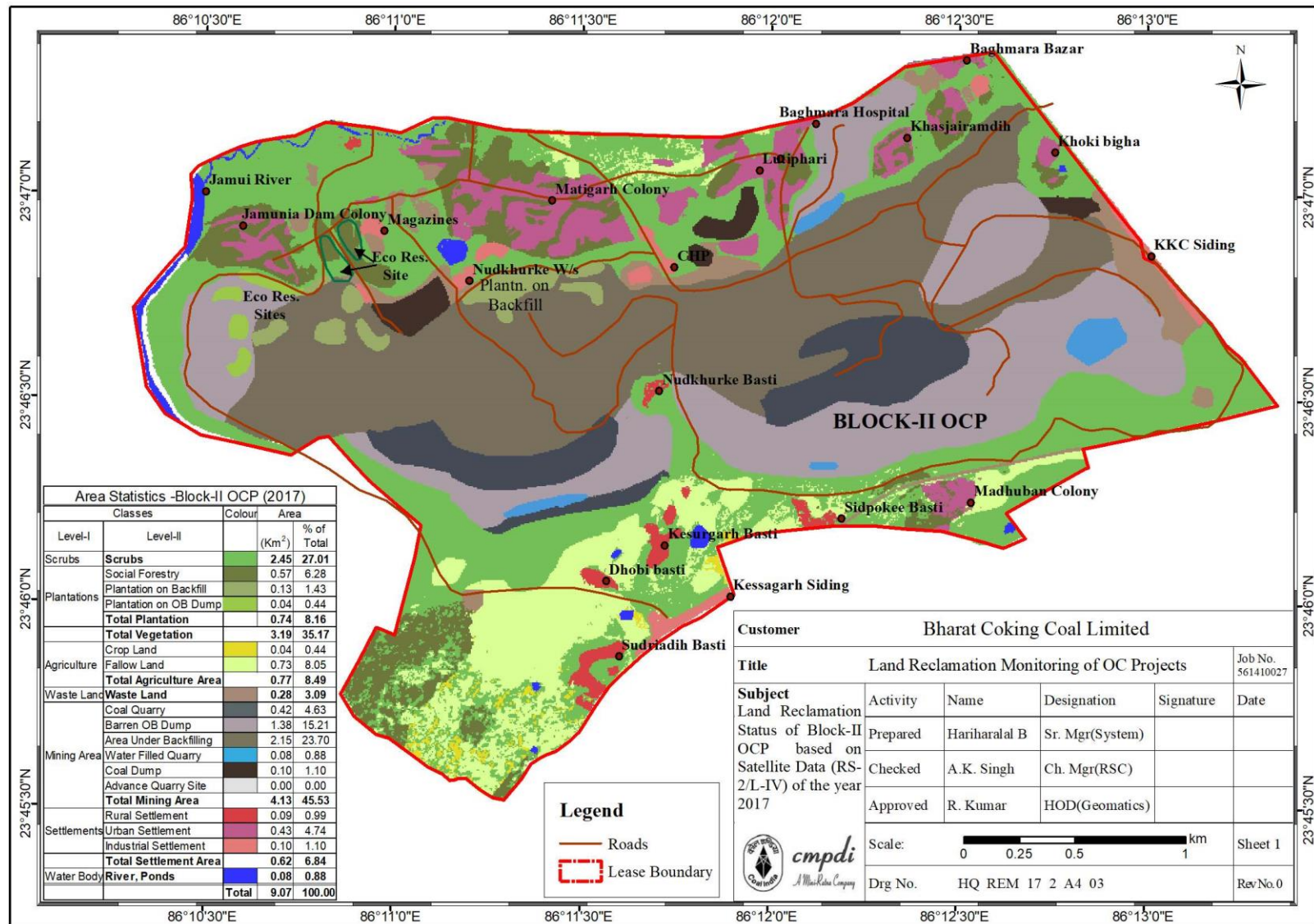


Plate 1

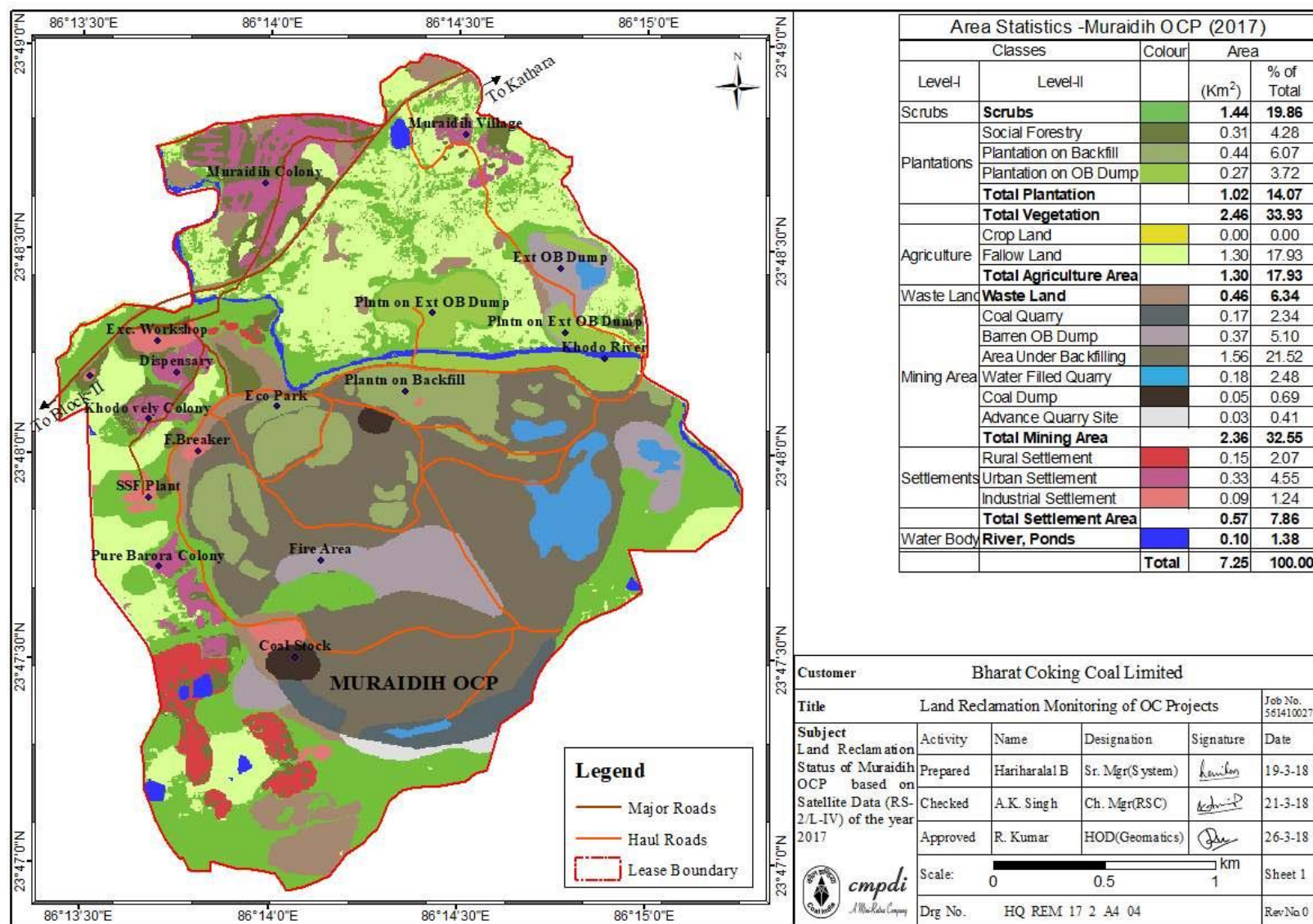


Plate - 2

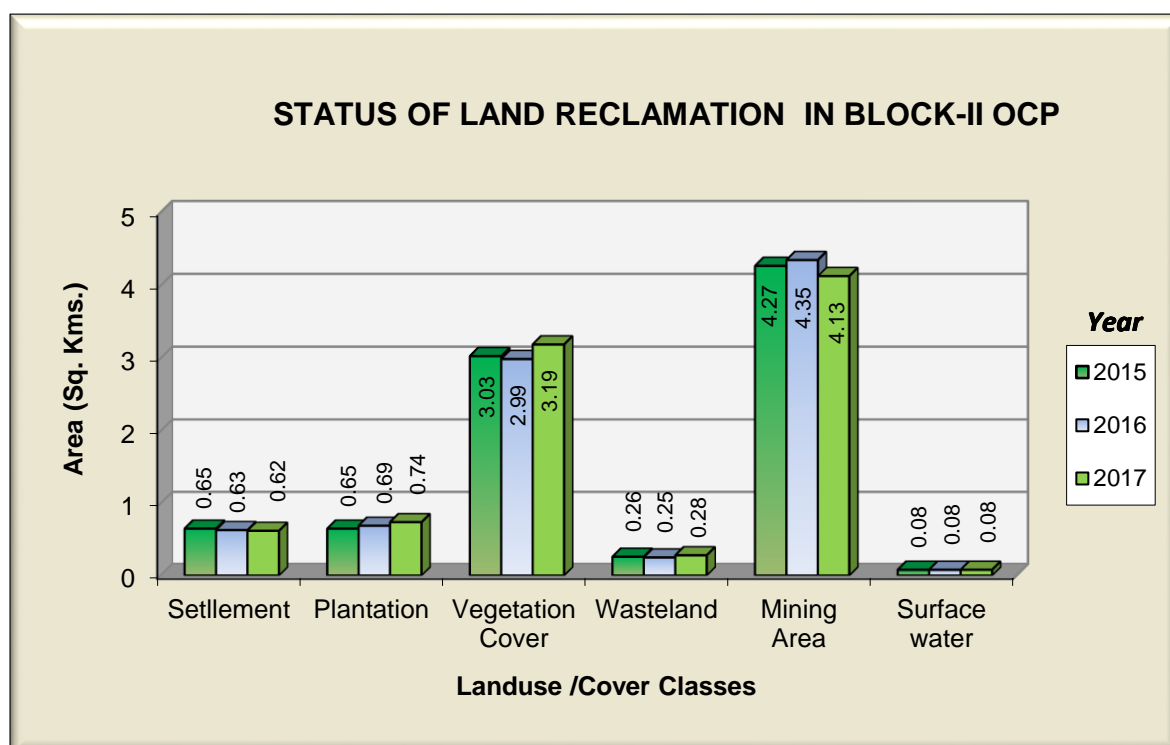


Figure 3 Status of Land Reclamation in Block-II OCP

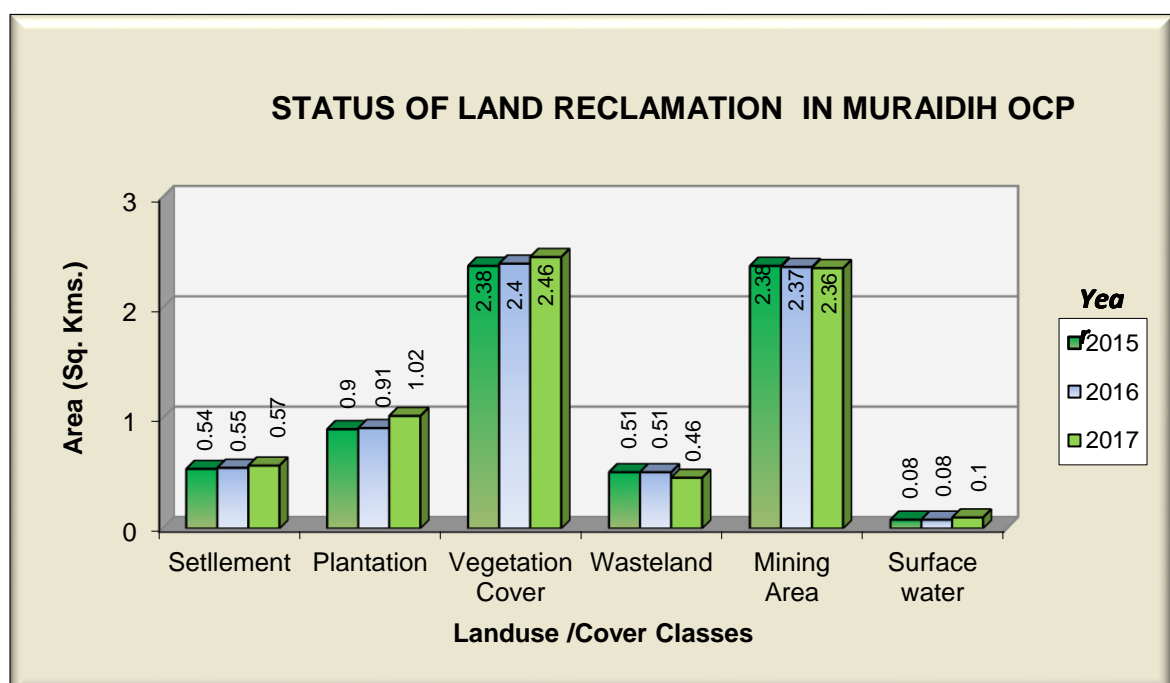


Figure 4 Status of Land Reclamation in Muraidih OCP

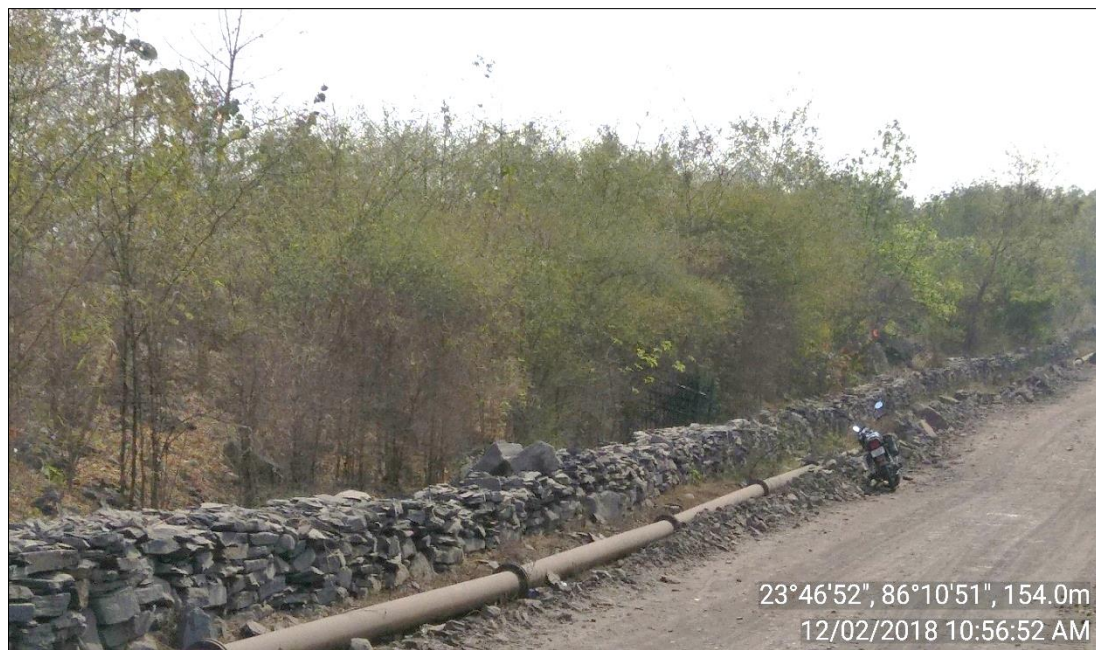


Photo-1. Eco Restoration Park (3.2 ha.) in Block-II OCP



Photo-2. Plantation carried out on backfilled area in Muraidih OCP



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