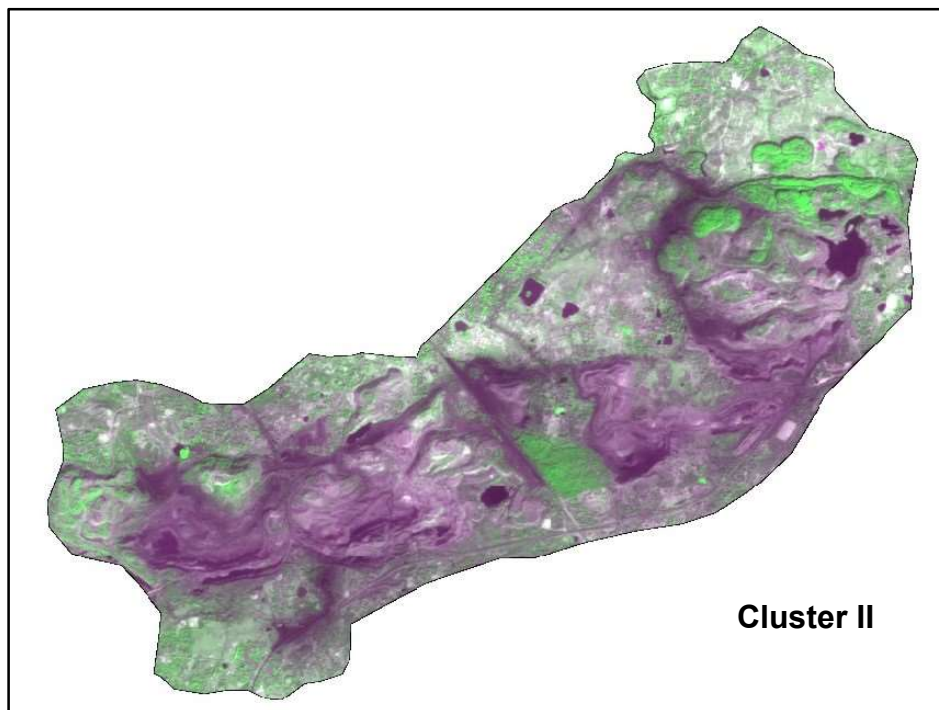


**Land Reclamation/ Restoration Monitoring of four Clusters of
(Opencast + Underground) Coal Mines of Bharat Coking Coal
Limited based on Satellite Data of the Year 2019**



Submitted to
Bharat Coking Coal Limited



cmpdi
A Mini-Ratna Company

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of (Opencast + Underground) Coal Mines of Bharat Coking
Coal Limited based on Satellite Data of the Year 2019**

February-2020



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

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Executive Summary

1. **Project** Land reclamation/ restoration monitoring of four clusters of (Opencast + Underground) coal mines of Bharat Coking Coal Ltd. (BCCL), based on satellite data, on every three year basis.
2. **Objective** Objective of land reclamation/ restoration 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. **Salient Findings**
 - Four Clusters viz. II, VI, XIV, XVI were selected in 2019-20 for land reclamation/ restoration monitoring. These clusters consist of mainly opencast mines.
 - Out of the total leasehold area of 6519.02 Ha., total mined out area is only 1009.51 Ha., belonging to the OC mines.
 - It is evident from the analysis that 61.83% of excavated area is under backfilling (technical reclamation) and 27.09% of the excavated area is under active mining. Cluster wise details are given in Table-1 & Fig-1.
 - 7.38% of total leasehold area has come under plantation (% green cover).
 - This report and the findings will act as the basis for further monitoring and reclamation related activities.
 - Out of the four clusters of BCCL, Cluster II tops the status of land reclamation with (79.66%) followed by Cluster VI (63.31%).

Table 1

Land Reclamation Status in four Clusters (Underground + Opencast Mines) of BCCL based on Satellite Data of the Year 2019

(Area in Hectare)										
Sl. No.	Cluster No.	Total Leasehold Area	Technical Reclamation Area under Backfilling	Plantation			Area under Active Mining	Total Excavated Area	Total Area under Plantation (% Green Cover Generated in Leasehold)	Total Area under Reclamation
				Biological Reclamation Plantation on Excavated / Backfilled Area	Other Plantations 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)
1	Cluster II	2260.54	422.51	86.42	43.28	154.37	129.98	638.91	284.07	508.93
			66.13%	13.53%			20.34%		12.57%	79.66%
2	Cluster VI	831.83	134.15	0.00	5.89	26.79	77.75	211.90	32.68	134.15
			63.31%	0.00%			36.69%		3.93%	63.31%
3	Cluster XIV	1418.25	0.00	0.00	0.00	74.13	0.00	0.00	74.13	0.00
			0.00%	0.00%			0.00%		5.23%	0.00%
4	Cluster XVI	2008.40	67.57	25.36	13.31	51.26	65.77	158.70	89.93	92.93
			42.58%	15.98%			41.44%		4.48%	58.56%
	TOTAL	6519.02	624.23	111.78	62.48	306.55	273.50	1009.51	480.81	736.01
			61.83%	11.07%			27.09%	15.49%	7.38%	72.91%
(% is calculated with respect to Excavated Area as applicable)										

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

1. Area under Biological Reclamation includes Areas under Plantation done on Backfilled Area Only.
2. Area under Technical Reclamation includes Area under Barren Backfilling only.
3. Area under Active Mining Includes Coal Quarry, Advance Quarry Site and Quarry filled with water etc., if any.
4. Social Forestry and Plantation on External OB Dumps are not included in Biological Reclamation and are put under separate categories as shown in the above Table.
5. (%) calculated in the above Table is in respect to Total Excavated Area except for "Total Area under Plantation" where % is in terms of "Leasehold Area".

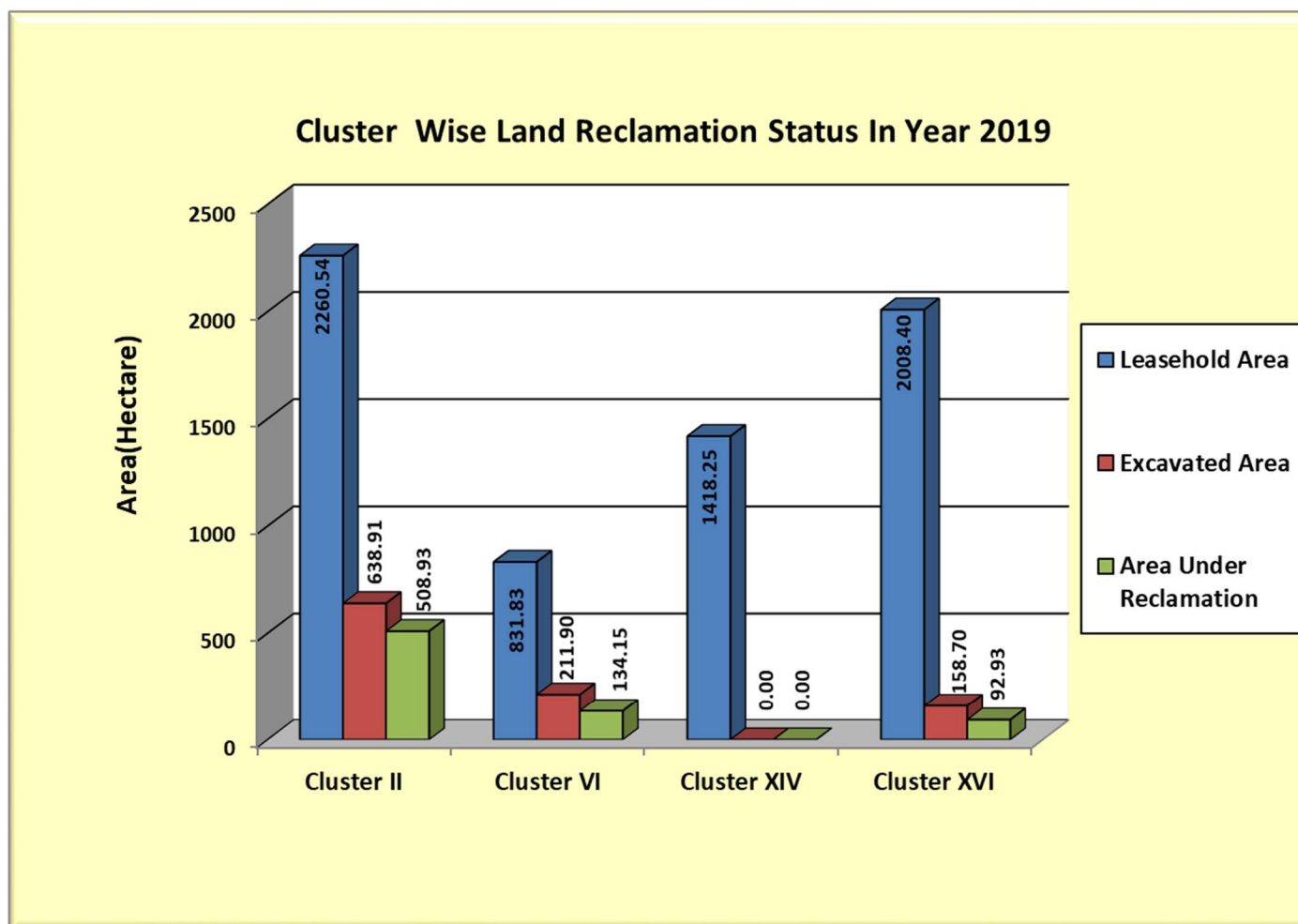


Fig. 1: Cluster wise Land Reclamation Status in four Clusters - 2019 (BCCL)

1. 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 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, Coal India Ltd. (CIL) issued a work order vide letter no. CIL/WBP/ENV/2017/DP/8391 dated 22.06.2017 to Central Mine Planning & Design Institute (CMPDI), Ranchi, for monitoring of clusters with coal mines (both underground and open cast projects) having less than 5 million m³ per annum capacity (Coal +OB) at an interval of three years based on remote sensing satellite data for sustainable development of mining. Earlier, CMPDI used to carry out land reclamation monitoring for individual projects of less than 5 million capacity, but from 2017 the same was carried out cluster wise for mines of BCCL. For operational reasons and convenience, underground and opencast mines (often with multiple overlapping seams), have now been clustered together. The result of land reclamation status of all such mines are hosted on the website of CIL, (www.coalindia.in), CMPDI (www.cmpdi.co.in) and the concerned coal companies in public domain. Detailed report is submitted to Coal India and respective subsidiaries.

- 1.3** Land reclamation monitoring of all cluster coal mining projects would also comply the statutory requirements of Ministry of Environment, Forest & Climate Change (**MoEF&CC**). 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 2019 carried out for four clusters of mines comprising both underground and OC projects for Bharat Coking Coal Ltd.

2. 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. 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:

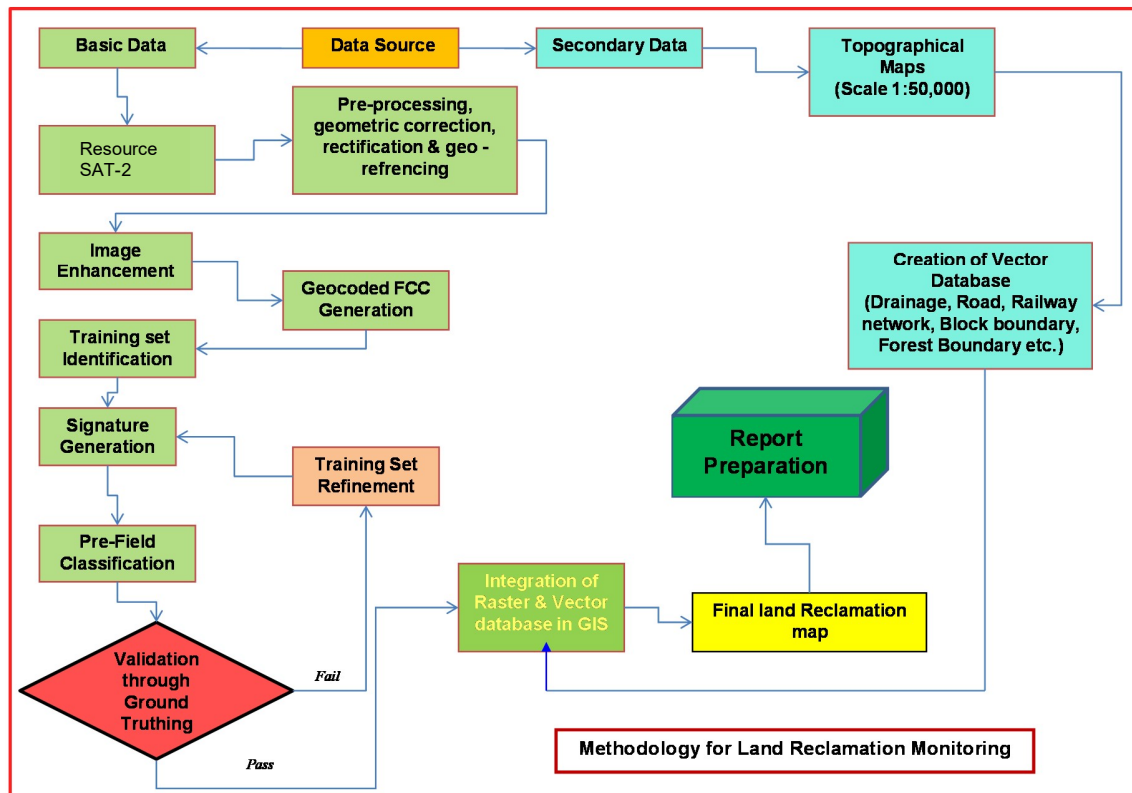


Fig. 2: Methodology of Land Reclamation Monitoring

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, toposheet 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 may 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 with the new series WGS-84 compatible 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 v. 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 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. The database boundary shape files (.shp), kml files and the maps thus prepared confirm to the WGS-84 datum and UTM projected co-ordinate system.

4. Land Reclamation Status in Bharat Coking Coal Ltd.

4.1 Following 4 clusters of mines comprising both underground and opencast projects of Bharat Coking Coal Ltd. have been taken up for land reclamation monitoring during the year 2019-20:

- Cluster II
- Cluster VI
- Cluster XIV
- Cluster XVI

4.2 Cluster wise Land Reclamation status of above mentioned clusters in BCCL is given in Table 1 and also shown graphically in Fig 1. Area statistics of different land use classes present in the mine leasehold of the above projects for the year 2019 are shown in Table 2. Land use maps derived from the satellite data are shown in Plate 1 - 4. Different land use classes based on satellite data are depicted in bar charts in Fig. 3 - 6.

4.3 Study reveals that out of total mine leasehold area of 6519.02 ha. of the 4 clusters of mines (Underground + Opencast) of BCCL mentioned above taken for this study in 2019-20; total excavated area is 1009.51 ha. (15.49%) out of which 111.78 ha. (11.07%) has been planted (*Biologically Reclaimed*), 624.23 ha. (61.83%) is under backfilling (*Technically Reclaimed*) and balance 273.50 ha. (27.09%) is under active mining.

4.4 Land reclamation monitoring for all the above mentioned cluster of mines (Underground + Opencast) of BCCL was taken up for the first time in the year 2019. The data thus generated in the year 2019 will be considered as base data for comparison of land reclamation of above cluster of mines at the interval of every three year.

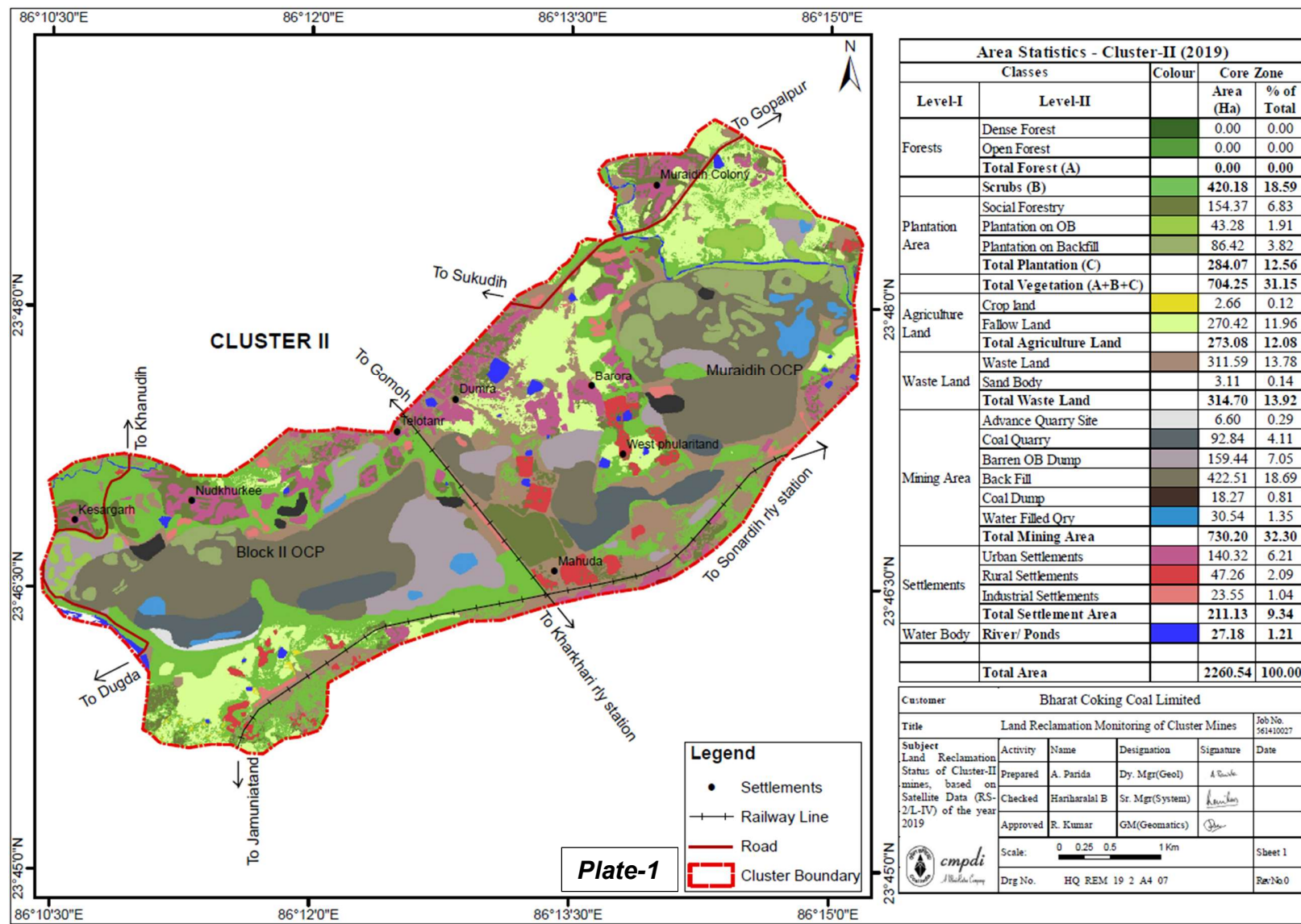
- 4.5** Study reveals that out of four clusters of mines of BCCL considered for reclamation monitoring in 2019, the area under total plantation (Green Cover) is maximum in Cluster II i.e 284.07 ha., followed by Cluster XVI with 89.93 ha., Cluster XIV with 74.13 ha. and Cluster VI with 32.68 ha.
- 4.6** Out of the 4 Clusters in BCCL considered for satellite data based monitoring in 2019, Cluster II tops with 79.66% reclamation followed by Cluster VI with 63.31% and Cluster XVI with 58.56%.
- 4.7** This study will again be carried out after an interval of three years to assess the changes in land reclamation in the above clusters.

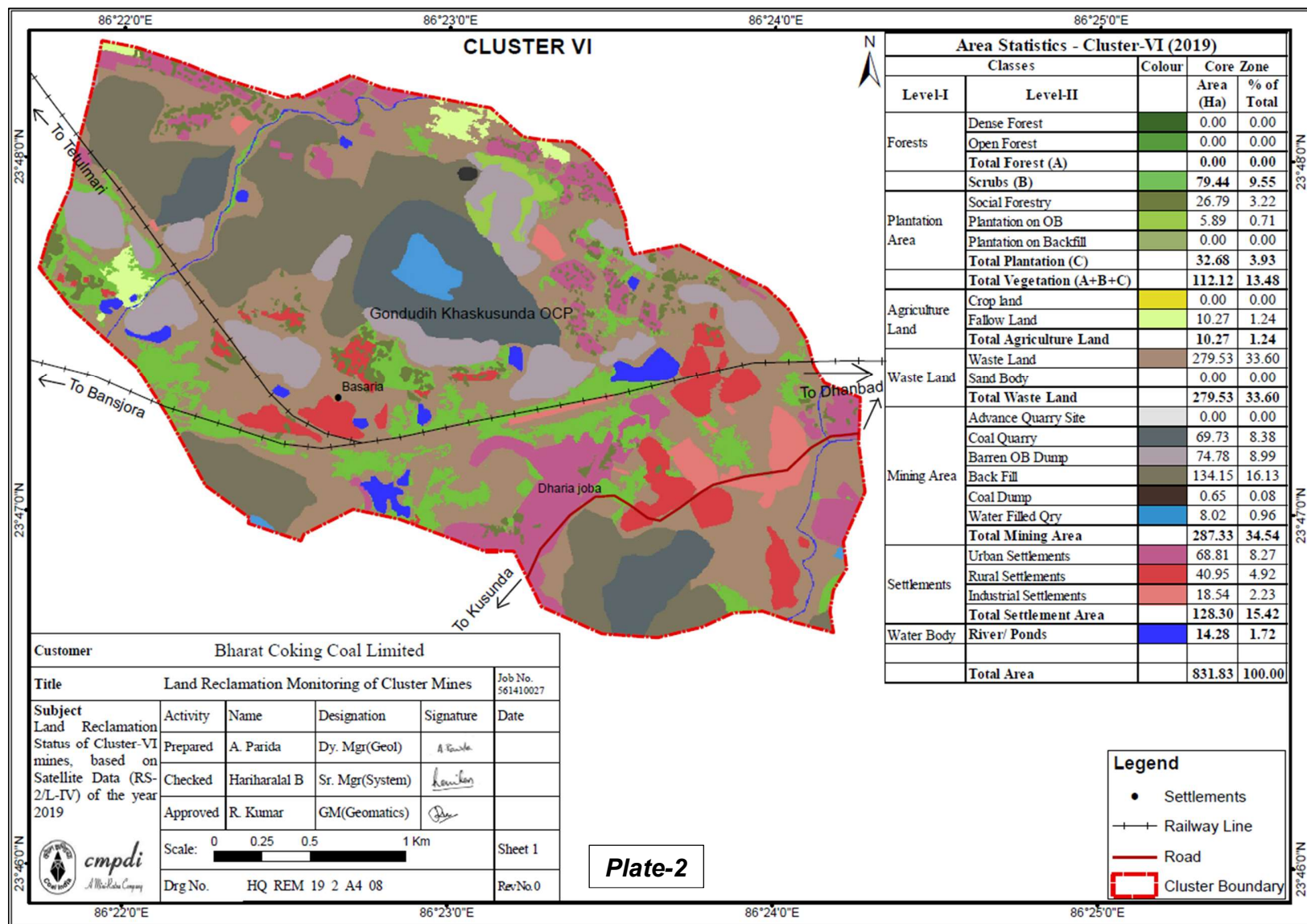
Table 2

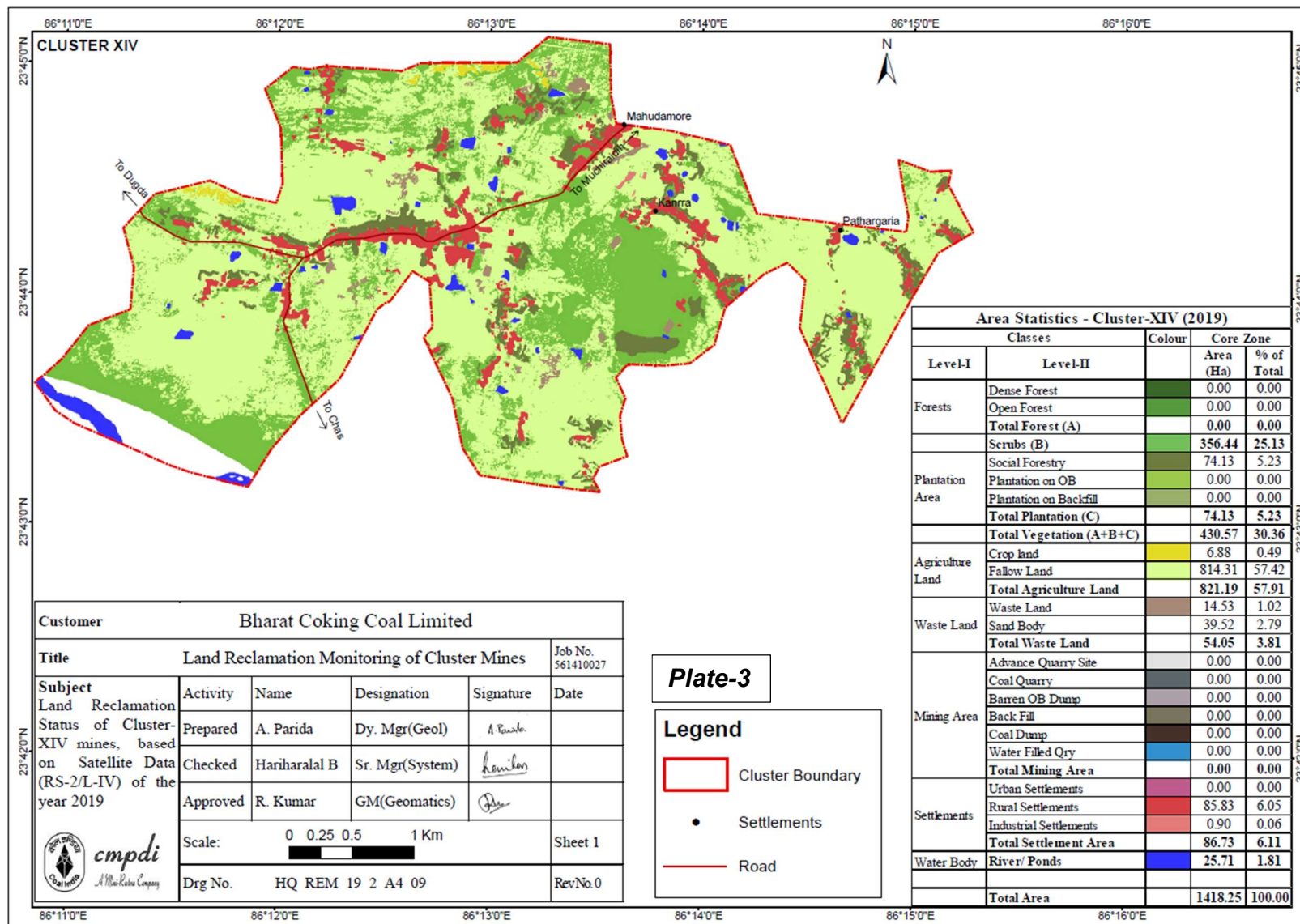
**Status of Land Use/ Reclamation in four Clusters of (OC + UG) mines of
Bharat Coking Coal Limited based on Satellite Data of the year 2019**

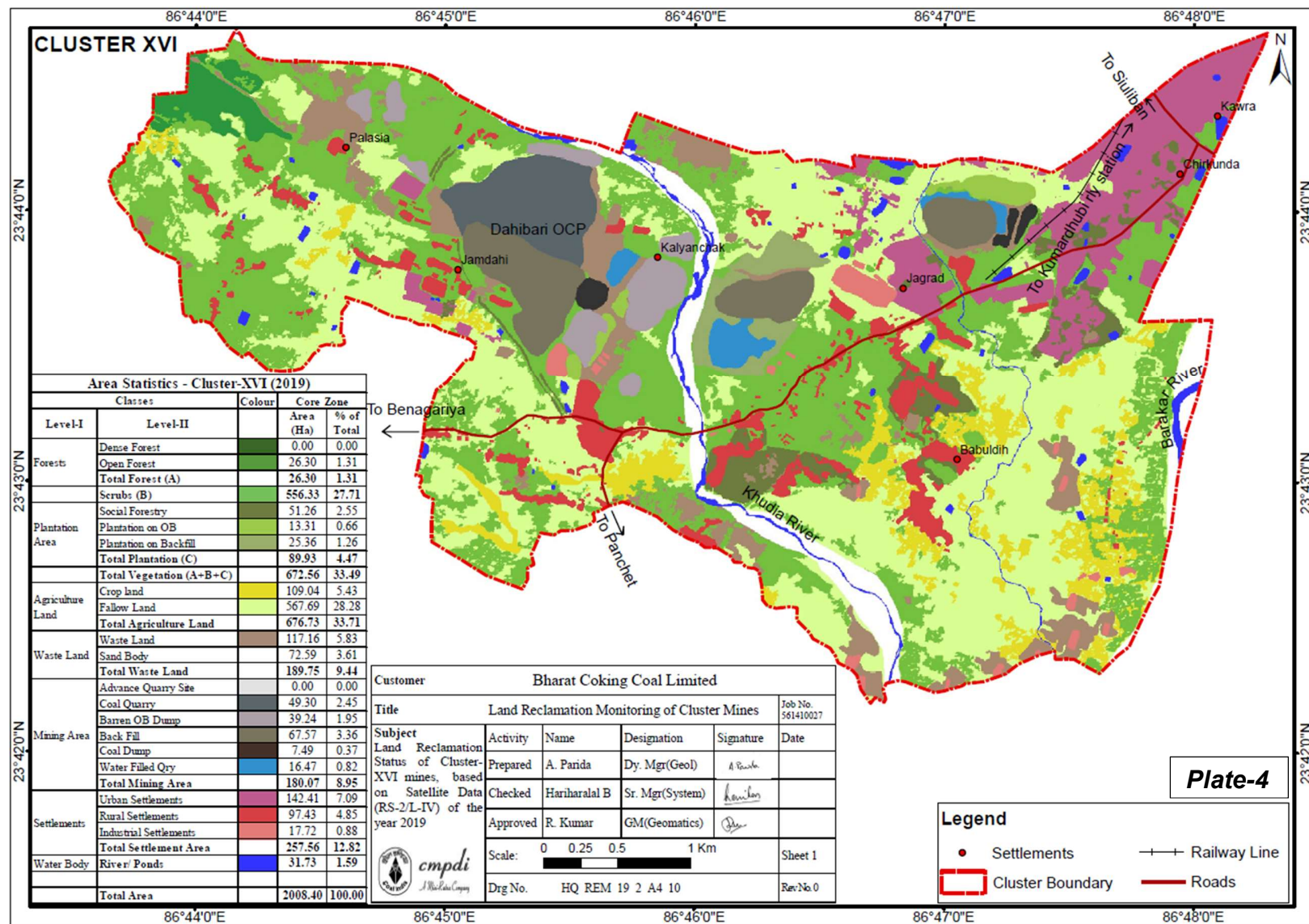
(Area in Hectare)

		CLUSTER II		CLUSTER VI		CLUSTER XIV		CLUSTER XVI		TOTAL	
		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
	Open Forest	0.00	0.00	0.00	0.00	0.00	0.00	26.30	1.31	26.30	0.40
	Total Forest	0.00	0.00	0.00	0.00	0.00	0.00	26.30	1.31	26.30	0.40
SCRUBS	Scrubs	420.18	18.59	79.44	9.55	356.44	25.13	556.33	27.71	1412.39	21.67
PLANTATION	Social Forestry/Avenue Plantation	154.37	6.83	26.79	3.22	74.13	5.23	51.26	2.55	306.55	4.70
	Plantation on OB Dump	43.28	1.91	5.89	0.71	0.00	0.00	13.31	0.66	62.48	0.96
	Plantation on Backfill (Biological Reclamation)	86.42	3.82	0.00	0.00	0.00	0.00	25.36	1.26	111.78	1.71
	Total Plantation	284.07	12.56	32.68	3.93	74.13	5.23	89.93	4.47	480.81	7.37
	Total Vegetation	704.25	31.15	112.12	13.48	430.57	30.36	672.56	33.49	1919.50	29.44
ACTIVE MINING	Coal Dump	18.27	0.81	0.65	0.08	0.00	0.00	7.49	0.37	26.41	0.41
	Coal Quarry	92.84	4.11	69.73	8.38	0.00	0.00	49.30	2.45	211.87	3.25
	Advance Quarry Site	6.60	0.29	0.00	0.00	0.00	0.00	0.00	0.00	6.60	0.10
	Quarry Filled With Water	30.54	1.35	8.02	0.96	0.00	0.00	16.47	0.82	55.03	0.84
	Total Area under Active Mining	129.98	5.75	77.75	9.34	0.00	0.00	65.77	3.27	273.50	4.19
	Barren OB Dump	159.44	7.05	74.78	8.99	0.00	0.00	39.24	1.95	273.46	4.19
RECLAIMED	Area Under Backfilling (Technical Reclamation)	422.51	18.69	134.15	16.13	0.00	0.00	67.57	3.36	624.23	9.58
	Total Area under Technical Reclamation	422.51	18.69	134.15	16.13	0.00	0.00	67.57	3.36	624.23	9.58
	Total Area under Mine Operation	730.20	32.30	287.33	34.54	0.00	0.00	180.07	8.95	1197.60	18.37
WASTELAND	Waste Lands	311.59	13.78	279.53	33.60	14.53	1.02	117.16	5.83	722.81	11.09
	Fly Ash Pond / Sand Body	3.11	0.14	0.00	0.00	39.52	2.79	72.59	3.61	115.22	1.77
	Total Wasteland	314.70	13.92	279.53	33.60	54.05	3.81	189.75	9.44	838.03	12.86
WATERBODIES	Reservoir, nallah, ponds	27.18	1.21	14.28	1.72	25.71	1.81	31.73	1.59	98.90	1.52
	Total Waterbodies	27.18	1.21	14.28	1.72	25.71	1.81	31.73	1.59	98.90	1.52
AGRICULTURE	Crop Lands	2.66	0.12	0.00	0.00	6.88	0.49	109.04	5.43	118.58	1.82
	Fallow Lands	270.42	11.96	10.27	1.24	814.31	57.42	567.69	28.28	1662.69	25.51
	Total Agriculture	273.08	12.08	10.27	1.24	821.19	57.91	676.73	33.71	1781.27	27.33
SETTLEMENTS	Urban Settlement	140.32	6.21	68.81	8.27	0.00	0.00	142.41	7.09	351.54	5.39
	Rural Settlement	47.26	2.09	40.95	4.92	85.83	6.05	97.43	4.85	271.47	4.16
	Industrial Settlement	23.55	1.04	18.54	2.23	0.90	0.06	17.72	0.88	60.71	0.93
	Total Settlement	211.13	9.34	128.30	15.42	86.73	6.11	257.56	12.82	683.72	10.48
	Grand Total	2260.54	100.00	831.83	100.00	1418.25	100.00	2008.40	100.00	6519.02	100.00









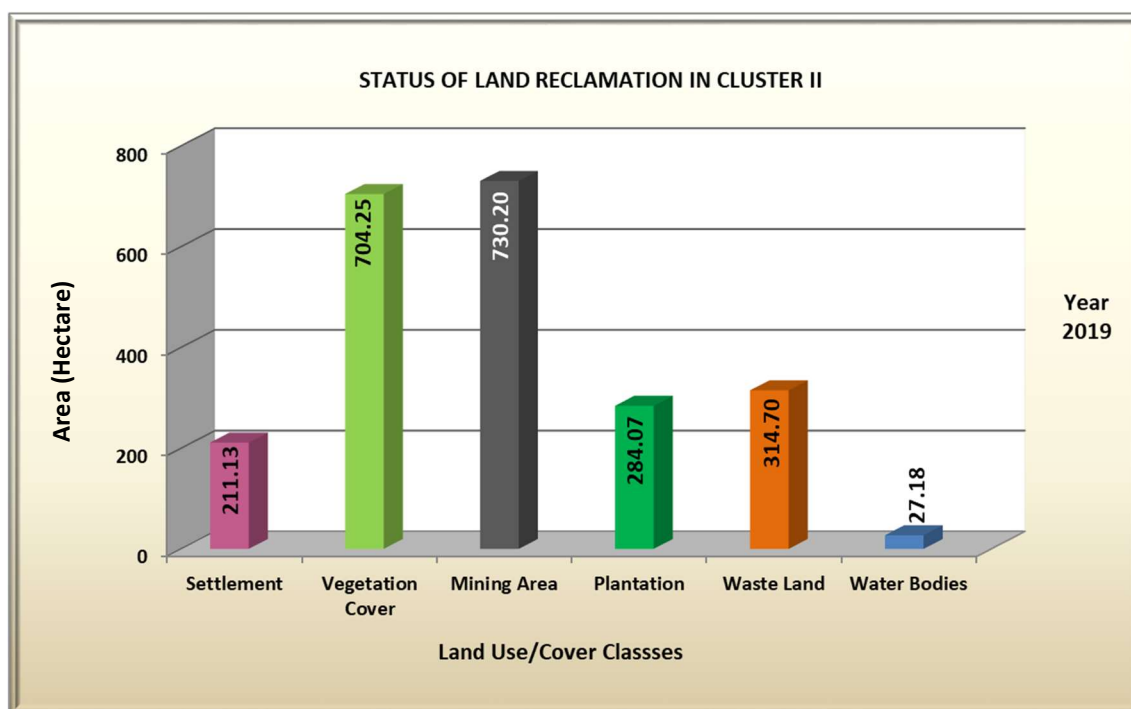


Fig. 3: Land Reclamation status of Cluster II

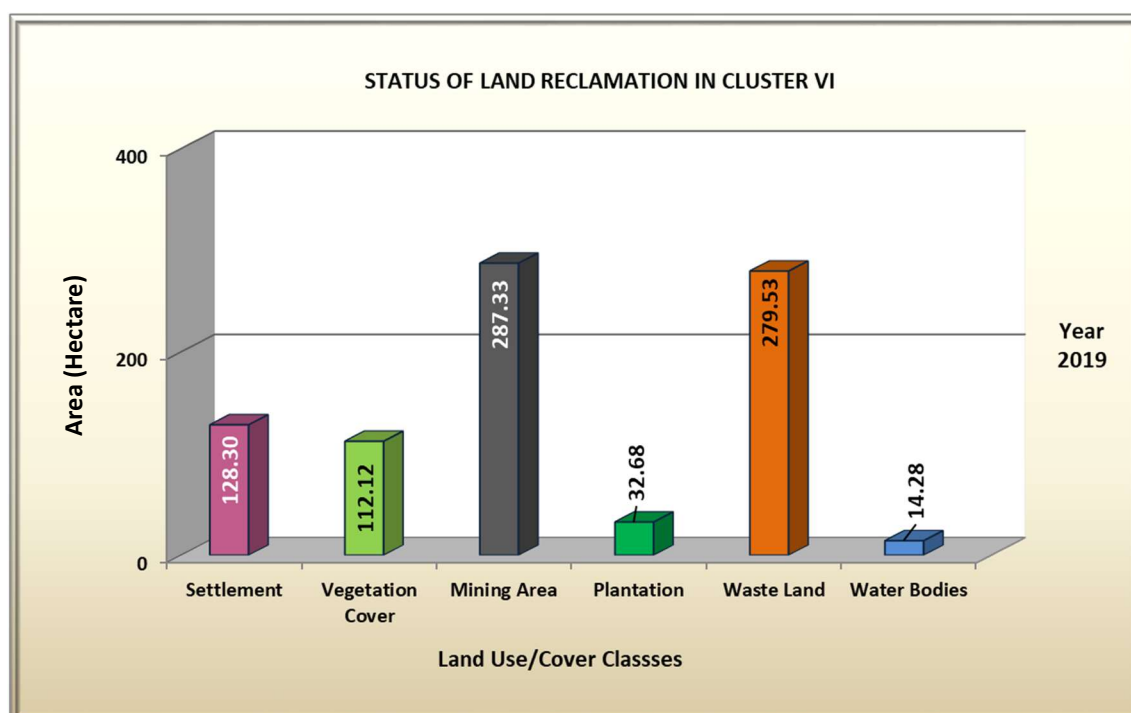


Fig. 4: Land Reclamation status of Cluster VI

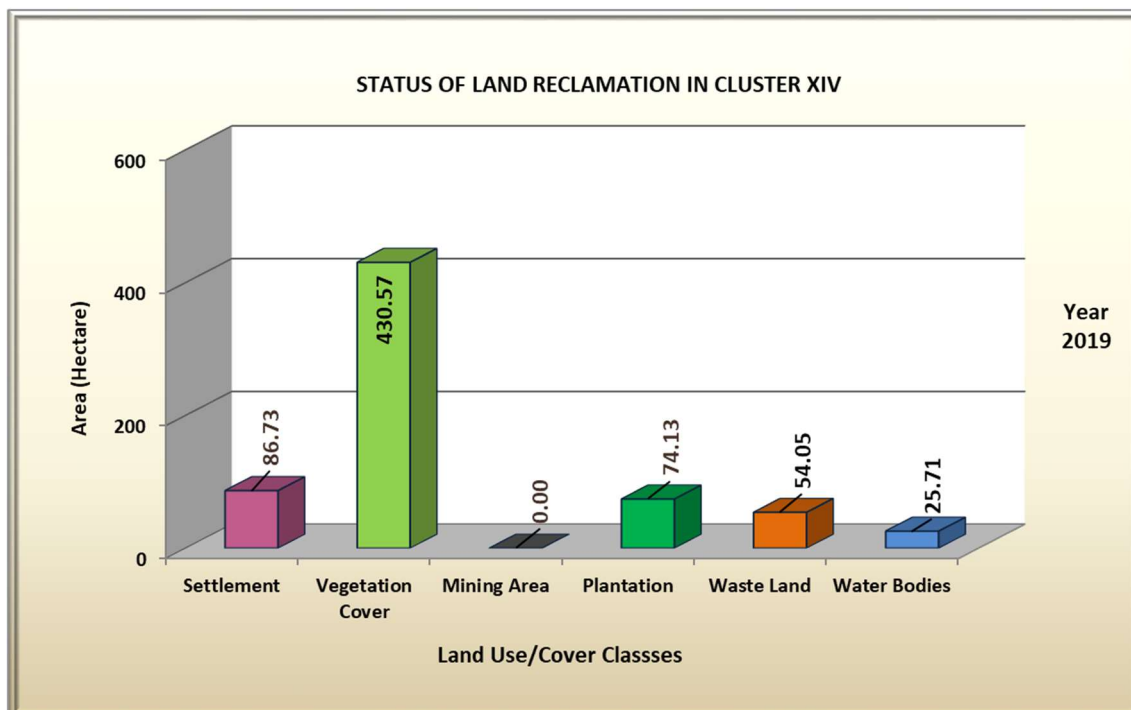


Fig. 5: Land Reclamation status of Cluster XIV

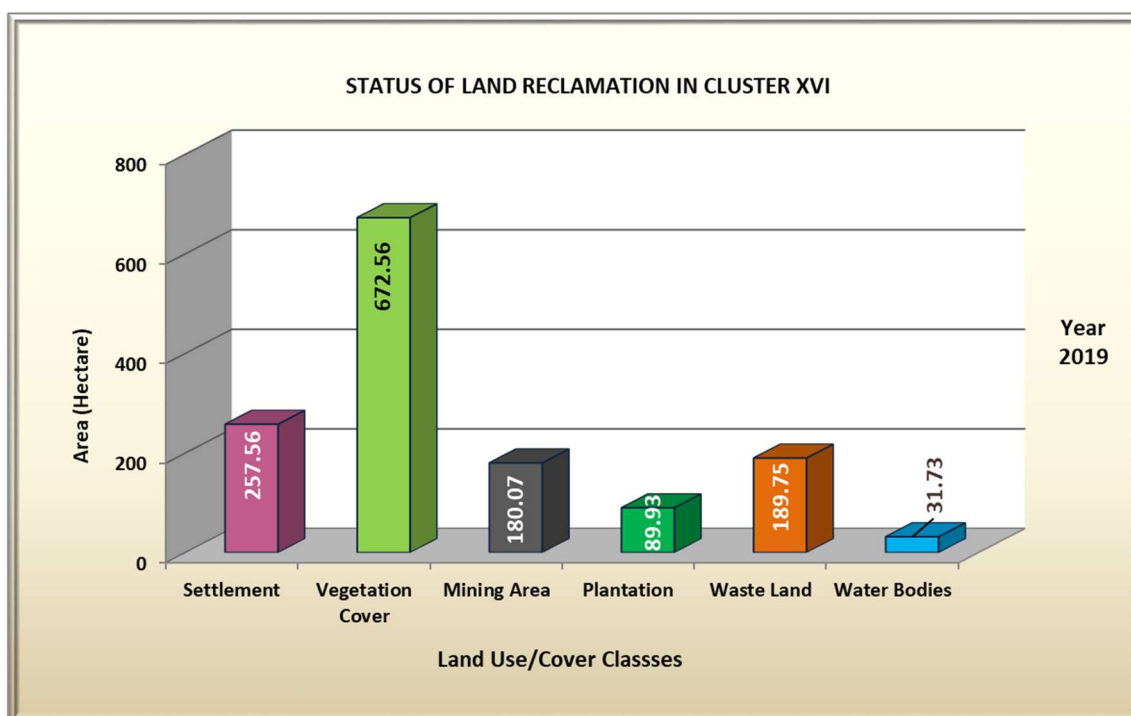


Fig. 6: Land Reclamation status of Cluster XVI



Photo 1: Social Forestry Plantation, Cluster II



Photo 2: Plantation on Backfill, Muraidih Colliery, Cluster II



Photo 3: Plantation on OB Dump, Block II, Cluster II



Photo 4: Ecological Restoration Site in Cluster VI



Photo 5: Social Forestry Plantation in Cluster XIV

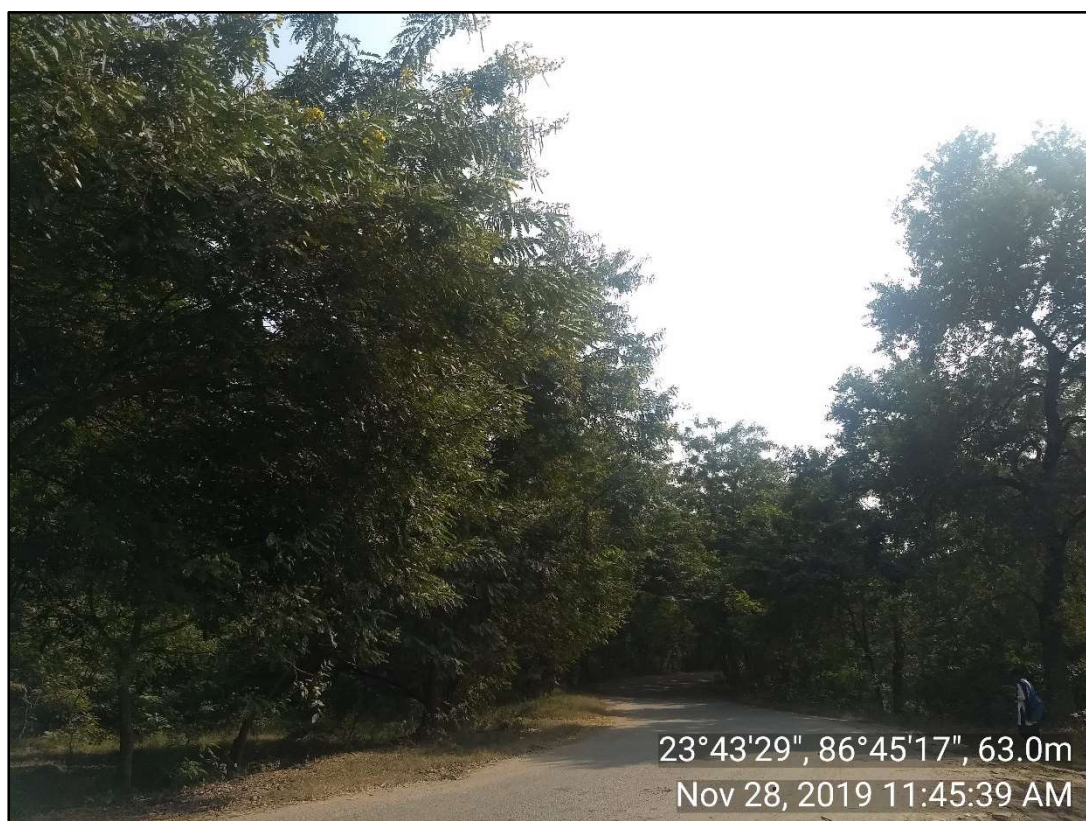


Photo 6: Social Forestry Plantation in Cluster XVI



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