

Land Restoration/ Reclamation Monitoring of more than 5 million cu. m (Coal+OB) Capacity Opencast Coal Mines of Eastern Coalfields Limited based on Satellite Data of the Year 2018



Submitted to
Eastern Coalfields Limited



cmpdi
A Mini-Ratna Company

**Land Restoration/ Reclamation Monitoring of more than 5 million cu. m
(Coal+OB) Capacity Opencast Coal Mines of Eastern Coalfields Limited
based on Satellite Data of the Year 2018**

March-2019



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

CONTENTS

	Executive Summary	iii
1.0	Background	1
2.0	Objective	2
3.0	Methodology	2
4.0	Land Reclamation in ECL	6
	List of Tables	
Table-1	Project wise Land Reclamation Status	iv
Table-2	Area Statistics of Land Use Classes in OC Mines	7
	List of Figures	
Figure-1	Bar-Chart of Project wise Status	iv
Figure-2	Methodology of Land Reclamation Monitoring	2
Figure-3	Bar-Chart of Land Reclamation Status of Rajmahal OCP	10
Figure-4	Bar-Chart of Land Reclamation Status of Sonepur Bazari OCP	10
	List of Plates	
Plate-1	Land Use Map of Rajmahal OCP	8
Plate -2	Land Use Map of Sonepur Bazari OCP	9
	List of Photographs	
Pic-1	New Plantation on Backfilled area in Sonepur Bazari OCP	11
Pic-2	Old Plantation on Backfilled area in Sonepur Bazari OCP	11

Executive Summary

1.0 Project Land restoration / reclamation monitoring of two opencast coal mines of Eastern Coalfields Ltd. (ECL) producing 5 million cu. m. 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

- Total leasehold area has been modified from 39.44 to 40.69 km² in 2018. Two OCPs, namely, Rajmahal and Sonepur Bazari were considered for monitoring during 2018-19. The total excavated area is only 15.12 Km², of which 2.22 Km² area (14.68%) has been planted, 7.68 Km² area (50.79%) is under backfilling and 5.22 Km² area (34.52%) is under active mining. It is evident from the analysis that 65.48% area of the excavated area has come under reclamation and balance 34.52% 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 2018 with respect to the year 2017, it is evident from the analysis that the area of land reclamation has increased from 9.46 Km² (Yr. 2017) to 9.90 Km² (Yr. 2018). This increase of an area of 0.44 Km² of land reclamation is mainly because of the increase in backfilling areas and plantation areas, as the result of the efforts taken up by ECL towards land reclamation processes and environmental protection.
- Analysis of satellite data indicates that 77.64% excavated area has come under reclamation in Rajmahal OC and 53.59% in Sonepur Bazari OC till 2018.

Table 1
Status of Land Reclamation in Eastern Coalfields Limited based on Satellite Data for the Year 2018
(Projects producing more than 5 mcm of Coal+OB annually)

(Area in Sq. Kms.)

Sl. No.	Project	Total Lease hold 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									
1	2	3	4		5		6		-		8		9 (4-5-8)		10 (-5-6-7)		11(-4-5)		
		2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
1	Rajmahal	16.38	17.75	3.72	4.10	1.70	1.70	0.00	0.06	0.41	0.45	1.36	1.67	6.78	7.47	2.11	2.21	5.42	5.80
				54.87%	54.89%	25.07%	22.76%					20.06%	22.36%			12.88%	12.45%	79.94%	77.64%
2	Sonepur Bazari	23.06	22.94	3.54	3.58	0.50	0.52	0.13	0.42	0.84	0.82	3.31	3.55	7.35	7.65	1.47	1.76	4.04	4.10
				48.16%	46.80%	6.80%	6.80%					45.03%	46.41%			6.37%	7.67%	54.97%	53.59%
	TOTAL	39.44	40.69	7.26	7.68	2.20	2.22	0.13	0.48	1.25	1.27	4.67	5.22	14.13	15.12	3.58	3.97	9.46	9.90
				51.38%	50.79%	15.57%	14.68%					33.05%	34.52%			9.08%	9.76%	66.95%	65.48%

(% 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.

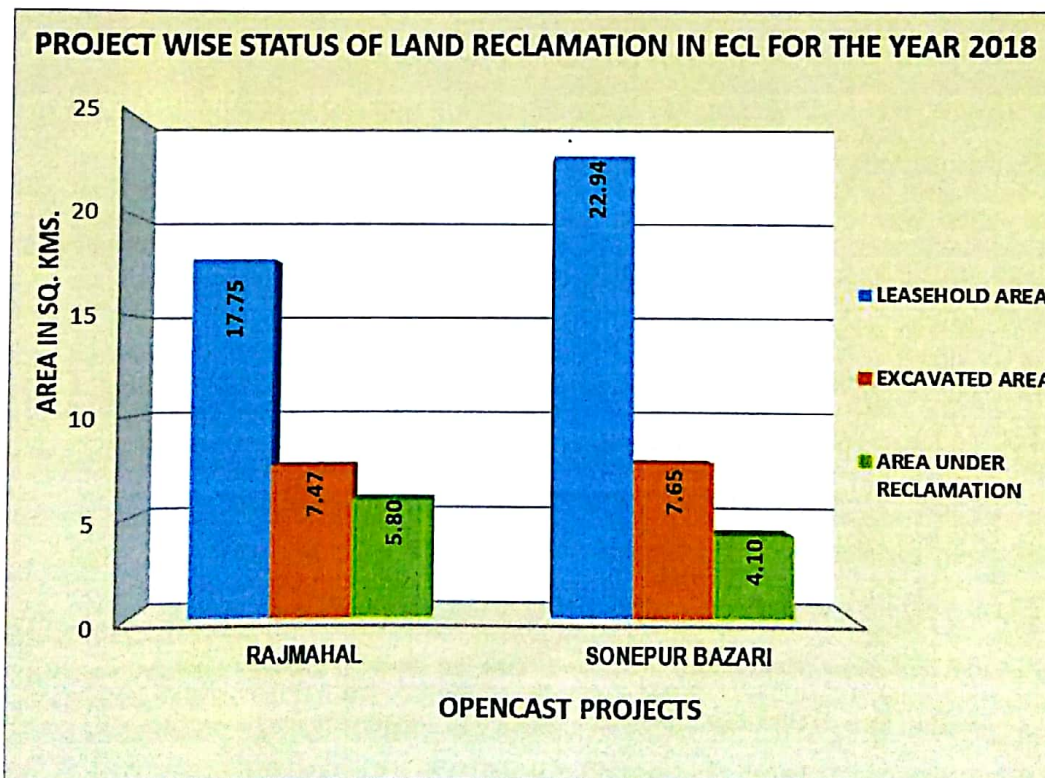


Fig. 1 Project wise Land Reclamation Status-2018 (ECL)

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 above in view, 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 is 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 2018, carried out for all the OC projects producing more than 5 mcm (Coal+OB) for Eastern 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:

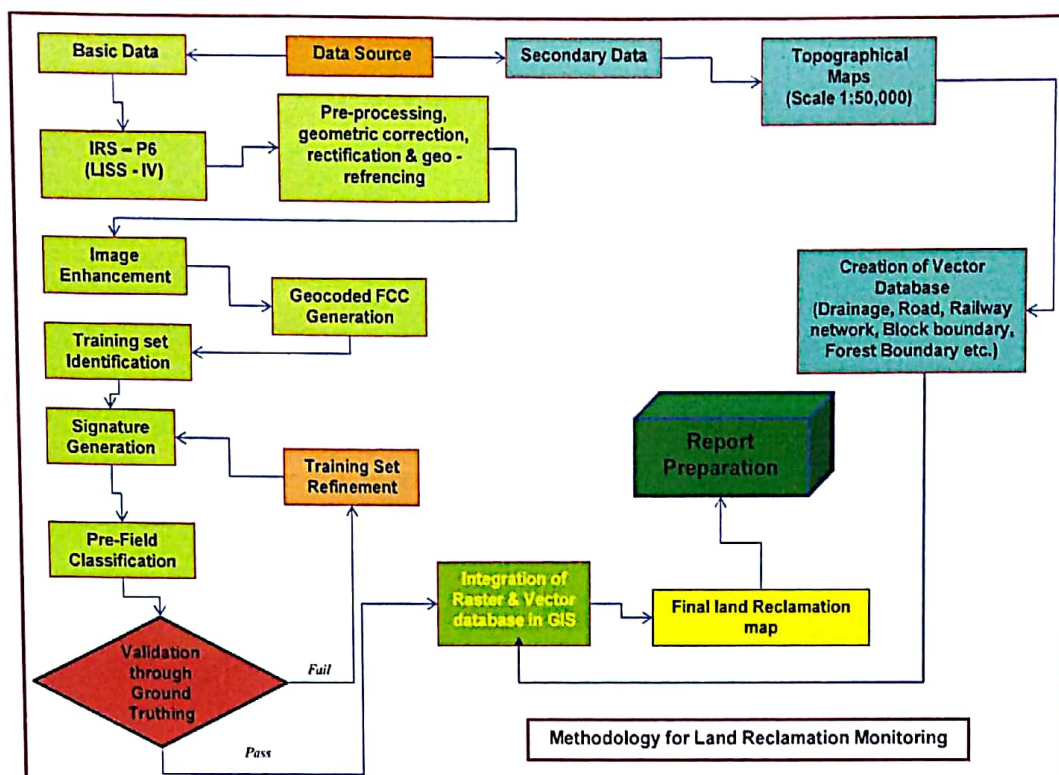


Fig. 2 : *Methodology of Land Reclamation Monitoring*

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 results.

3.3 Ground Truthing:





















Selective ground verification of the land use classes are carried out in the field and necessary corrections where ever required, are incorporated before final map preparation.

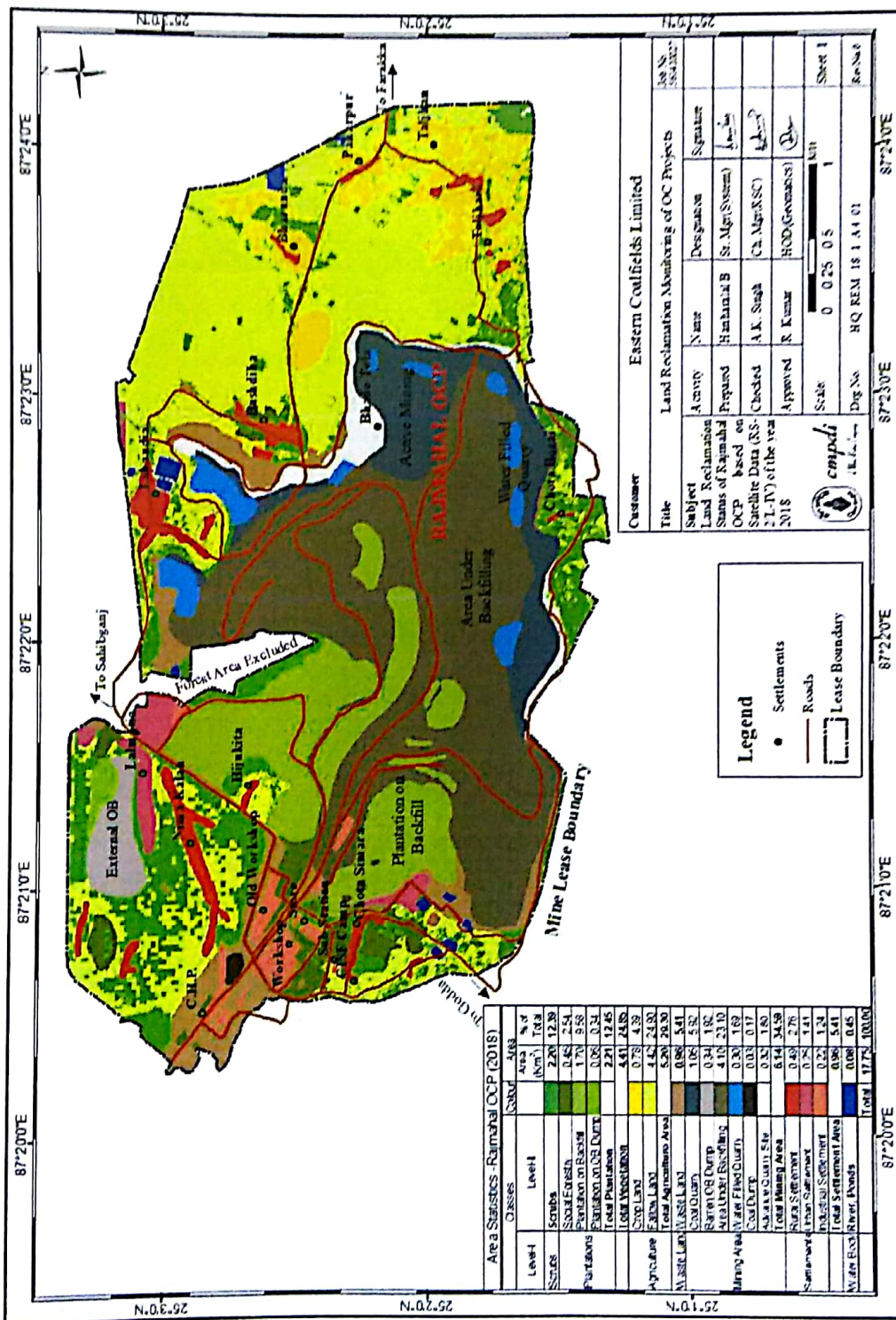
3.4 Land reclamation database on GIS:

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 Eastern Coalfields Ltd.

- 4.1 Following two OC projects producing 5 million cubic m. or more (Coal + OB together) of Eastern Coalfields Ltd. have been taken up for land reclamation monitoring on annual basis:
- Rajmahal
 - Sonepur Bazari
- 4.2 Both the above projects, have been mapped during the year 2017 & 2018 for assessing the progress of land reclamation. Total mine leasehold area has been modified from 39.44 to 40.69 km² from 2017, considering the EC parameters and boundary.
- 4.3 Forest area (Open forest) of 20 ha. has been excluded from the boundary and analysis in Rajmahal OCP, as permission for the same is still awaited.
- 4.4 Project wise Land Reclamation status in ECL for the year 2018 is given in Table-1 and also shown graphically in Fig-1. Area statistics of different land use classes present in OC projects for the year 2018 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.
- 4.5 Study reveals that 65.48% of excavated area is under reclamation in ECL out of which 14.68% area has been revegetated and 50.79% area is under backfilling (technical reclamation).
- 4.6 On comparing the status of land reclamation for the year 2018 with respect to the year 2017, it is evident from the analysis that the total area of land reclamation has increased from 9.46 km² (Yr. 2017) to 9.90 Km² (Yr. 2018).
- 4.7 Out of two projects in ECL, Rajmahal OCP tops with 77.64% reclamation followed by Sonepur Bazari OCP with 53.59 % reclamation.

		RAJMAHAL		SONEPUR BAZARI		TOTAL	
		Area	%	Area	%	Area	%
FORESTS	Dense Forest 	0.00	0.00	0.00	0.00	0.00	0.00
	Open Forest 	0.00	0.00	0.32	1.39	0.32	0.79
	Total Forest(A)	0.00	0.00	0.32	1.39	0.32	0.79
	Scrubs(B) 	2.20	12.39	4.86	21.19	7.06	17.35
PLANTATION	Social Forestry 	0.45	2.54	0.82	3.57	1.27	3.12
	Plantation on OB Dump 	0.06	0.34	0.42	1.83	0.48	1.18
	Plantation on Backfill(Biological Reclamation) 	1.70	9.58	0.52	2.27	2.22	5.46
	Total Plantation (C)	2.21	12.45	1.76	7.67	3.97	9.76
	Total Vegetation (A+B+C)	4.41	24.85	6.94	30.25	11.35	27.89
ACTIVE MINING	Coal Quarry 	1.05	5.92	3.00	13.08	4.05	9.95
	Advance Quarry Site 	0.32	1.80	0.38	1.66	0.70	1.72
	Quarry Filled With Water 	0.30	1.69	0.17	0.74	0.47	1.16
	Area under Active Mining (D)	1.67	9.41	3.55	15.48	5.22	12.83
E	Coal Dump 	0.03	0.17	0.07	0.31	0.10	0.25
	Barren OB Dump 	0.34	1.92	2.90	12.64	3.24	7.96
	Area Under Backfilling(Technical Reclamation) 	4.10	23.1	3.58	15.61	7.68	18.87
	Total Area under Mining Operation (D+E)	6.14	34.59	10.10	44.03	16.24	39.91
WASTELANDS	Waste Lands 	0.96	5.41	1.15	5.01	2.11	5.19
	Fly Ash Pond / Sand Body 	0.00	0.00	0.00	0.00	0.00	0.00
	Total Wasteland	0.96	5.41	1.15	5.01	2.11	5.19
WATERBODIES	Reservoir, Nallah, Ponds 	0.08	0.45	0.30	1.31	0.38	0.93
	Total Waterbodies	0.08	0.45	0.30	1.31	0.38	0.93
AGRICULTURE	Crop Lands 	0.78	4.39	0.02	0.09	0.80	1.97
	Fallow Lands 	4.42	24.9	3.76	16.39	8.18	20.10
	Total Agriculture	5.2	29.30	3.78	16.48	8.98	22.07
SETTLEMENTS	Urban Settlement 	0.25	1.41	0.31	1.35	0.56	1.38
	Rural Settlement 	0.49	2.76	0.13	0.57	0.62	1.52
	Industrial Settlement 	0.22	1.24	0.23	1.00	0.45	1.11
	Total Settlement	0.96	5.41	0.67	2.92	1.63	4.01
	Grand Total	17.75	100.00	22.94	100.00	40.69	100.00



Area Statistics - Raimahal OCP (2018)

Classes	Area (Hectare)	% of Total
Level 4	2.28	12.39
Level 3	0.45	2.54
Level 2	1.79	9.58
Level 1	0.26	1.34
Total Plantation	2.78	12.45
Level 1	4.41	24.85
Level 2	0.78	4.39
Level 3	4.45	24.80
Level 4	0.98	5.41
Total Agricultural Area	10.62	59.45
Level 1	0.34	1.82
Level 2	4.15	23.10
Level 3	0.30	1.69
Level 4	0.03	0.17
Total Area Under Backfilling	4.82	26.78
Level 1	6.14	34.58
Level 2	0.49	2.76
Level 3	0.34	1.91
Level 4	0.22	1.24
Total Settlement Area	7.19	40.49
Level 1	0.08	0.45
Level 2	0.08	0.45
Level 3	0.08	0.45
Level 4	0.08	0.45
Total River Ponds	11.75	65.00

Customer: Eastern Coalfields Limited

Title: Land Reclamation Monitoring of OC Projects

Activity	Name	Designation	Signature
Prepared	Hambalal B	Sr. Mgr (System)	[Signature]
Checked	A.A. Singh	Ch. Mgr (ESC)	[Signature]
Approved	R. Kumar	HO (Operations)	[Signature]

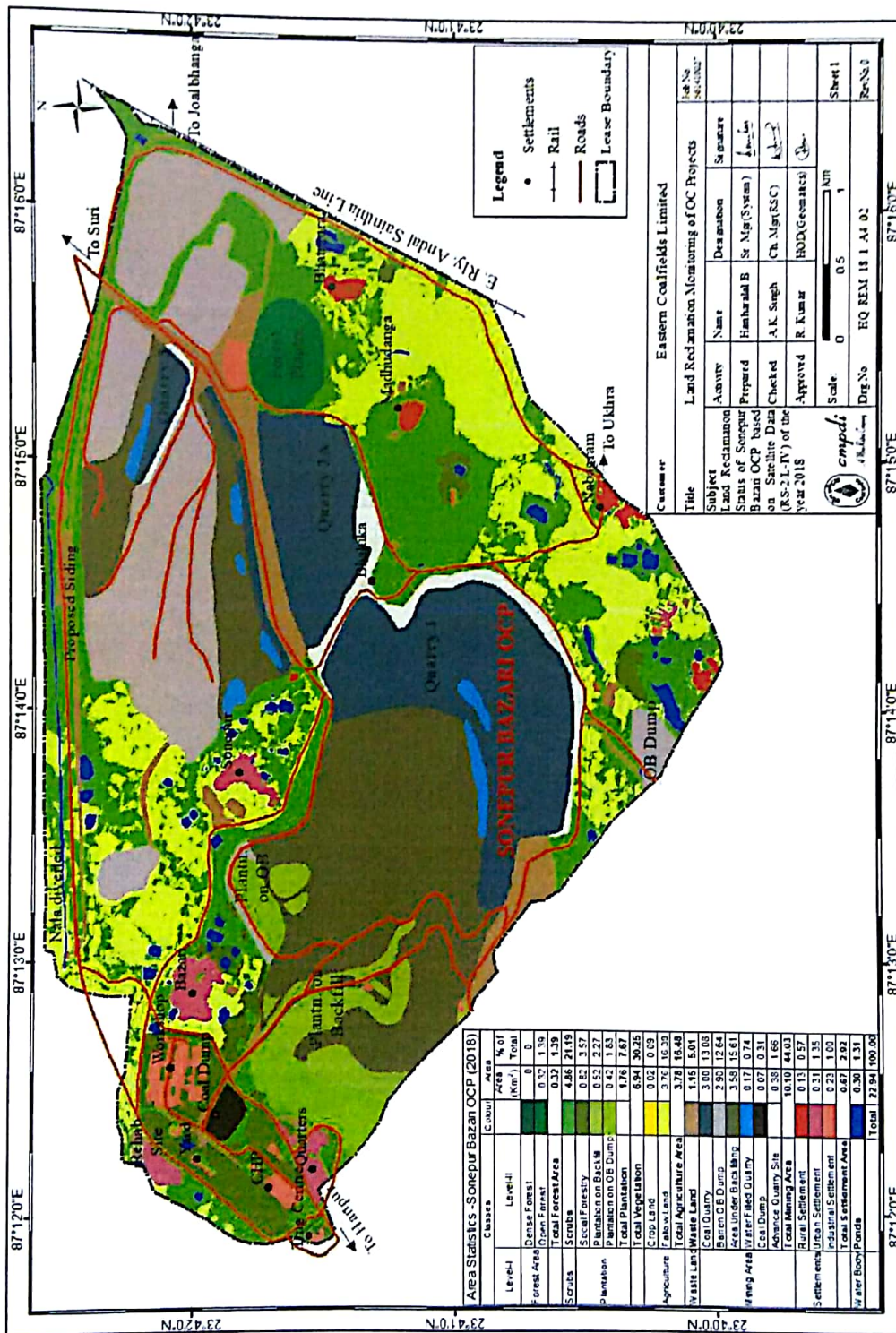
Scale: 0 0.25 0.5 1 KM

Dwg No: HQ REM 18 1 A 1 C1

Sheet 1 of 2

Legend

- Settlements
- Roads
- ▭ Lease Boundary



Area Statistics - Sonapur Bazar OCP (2018)

Classes	Class	Area (km ²)	% of Total
Forest	Dense Forest	0	0
	Open Forest	0.32	1.39
Scrubs	Total Forest Area	4.86	21.19
	Scrubs	0.52	3.37
Plantation	Plantation Backfill	0.52	2.37
	Plantation on OB Dumps	0.42	1.83
Total Vegetation	Total Plantation	1.78	7.67
	Total Vegetation	6.84	30.25
Agriculture	Crop Land	0.02	0.09
	Barren Land	3.76	16.33
Waste Land	Total Agriculture Area	3.78	16.68
	Waste Land	1.15	5.01
Mining Area	Coal Quarry	3.00	13.03
	Barren OB Dump	2.90	12.64
Mining Area	Area Under Backfilling	3.58	15.61
	Water-filled Quarry	0.17	0.74
Advance Quarry Site	Coal Dump	0.07	0.31
	Advance Quarry Site	0.38	1.66
Settlements	Total Mining Area	10.10	44.03
	Rural Settlement	0.13	0.57
Settlements	Urban Settlement	0.31	1.35
	Industrial Settlement	0.23	1.00
Water Body/Ponds	Total Settlement Area	0.67	2.92
	Water Body/Ponds	0.30	1.31
Total		27.94	100.00

Customer: Eastern Coalfields Limited

Title: Land Reclamation on Monitoring of OCP Projects

Sl. No.	Project Name	Designation	Signature
1	Himabala B	Sr Mgt (System)	[Signature]
2	A.K. Singh	Ch. Mgt (RSC)	[Signature]
3	R. Kumar	HOD, Geomatics	[Signature]

Scale: 0 0.5 1 KM

Sheet 1 of 1

Job No: HQ REM 18 1 AM 02

Plate 2

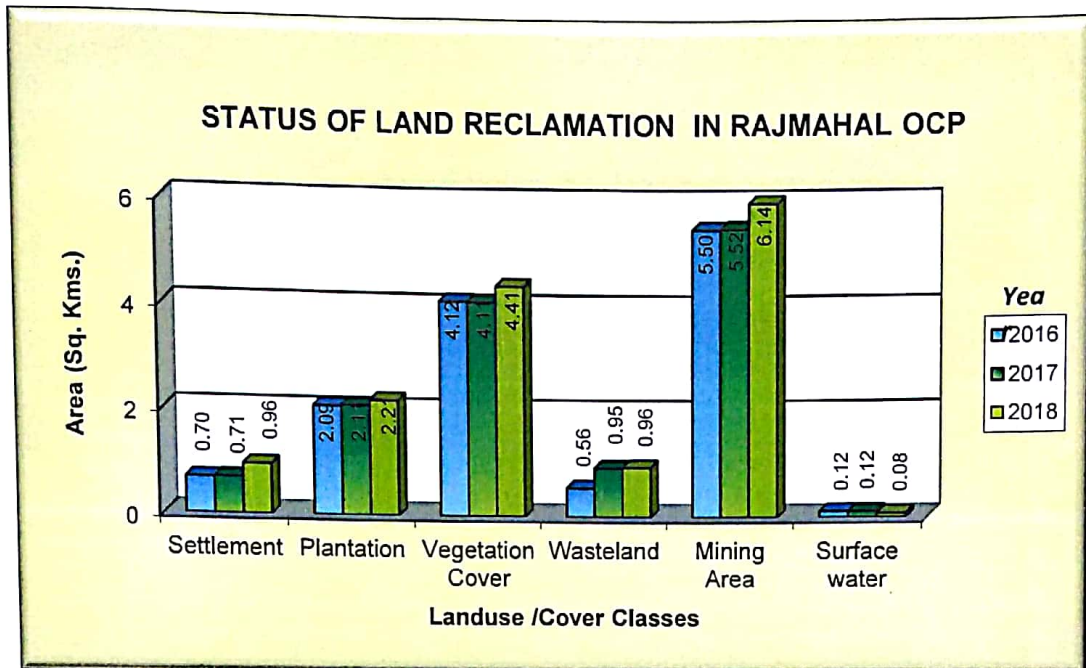


Figure 3

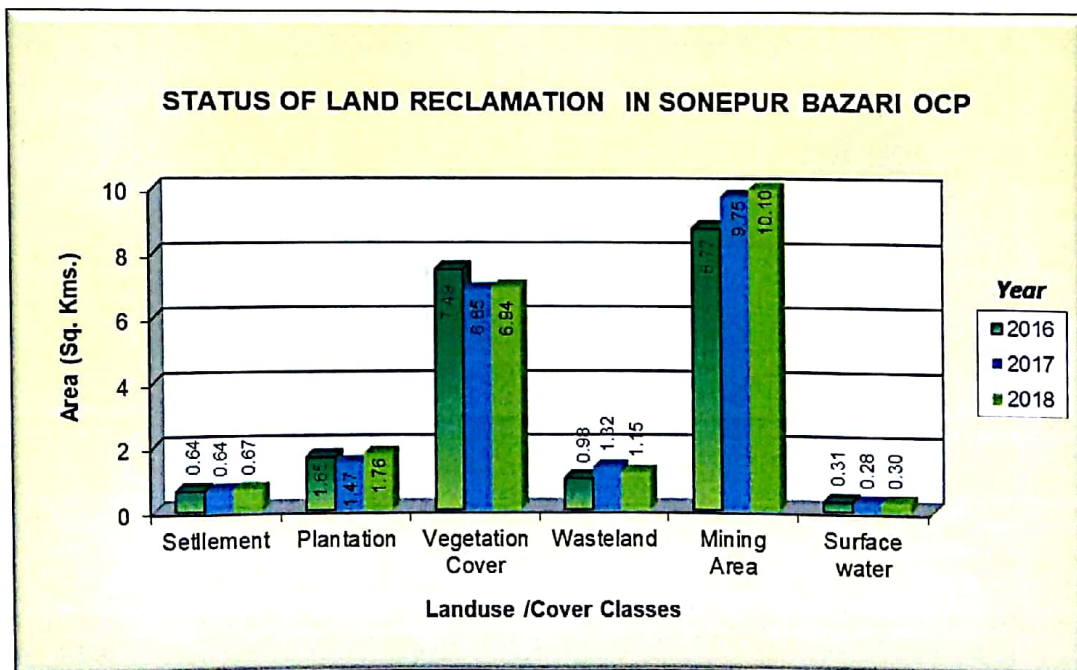


Figure 4



Pic-1 New Plantation on Backfilled area in Sonapur Bazari OCP, ECL



Pic-2 Old Plantation on backfilled area in Sonapur Bazari OCP, ECL