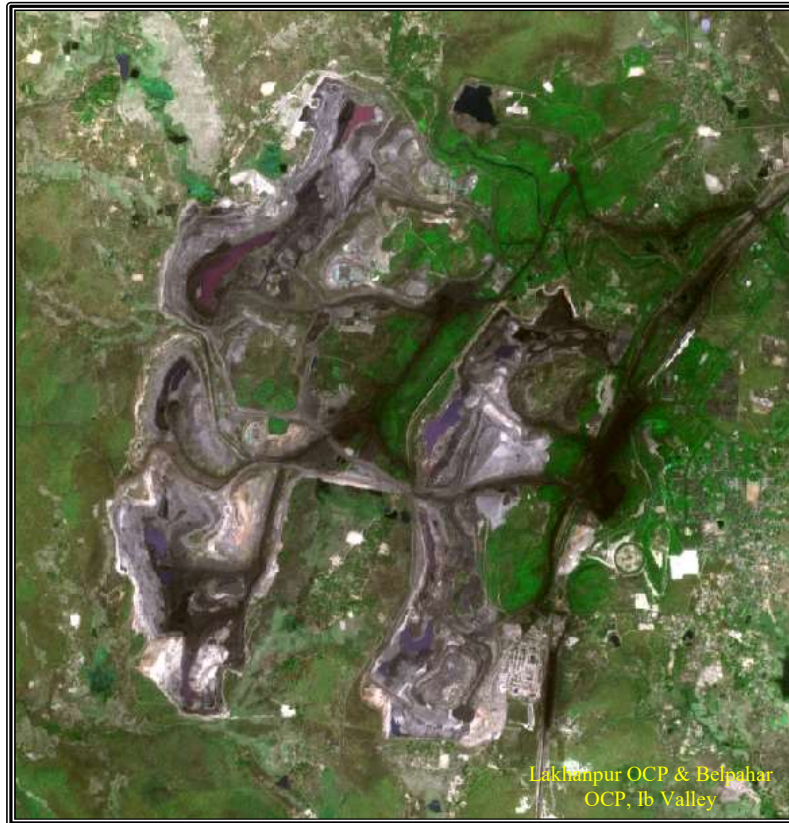


Land Restoration / Reclamation Monitoring of 16 opencast coal mines of Mahanadi Coalfields Ltd. (MCL) producing more than 5 million cu.m. (Coal+OB) per annum based on satellite data of the Year 2021



Submitted to
Mahanadi Coalfields Limited



cmpdi
A Mini-Ratna Company

Land Restoration / Reclamation monitoring of 16 opencast coal mines of Mahanadi Coalfields Ltd. (MCL) producing more than 5 million cu.m. (Coal+OB) per annum based on satellite data of the Year 2021

February 2022



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

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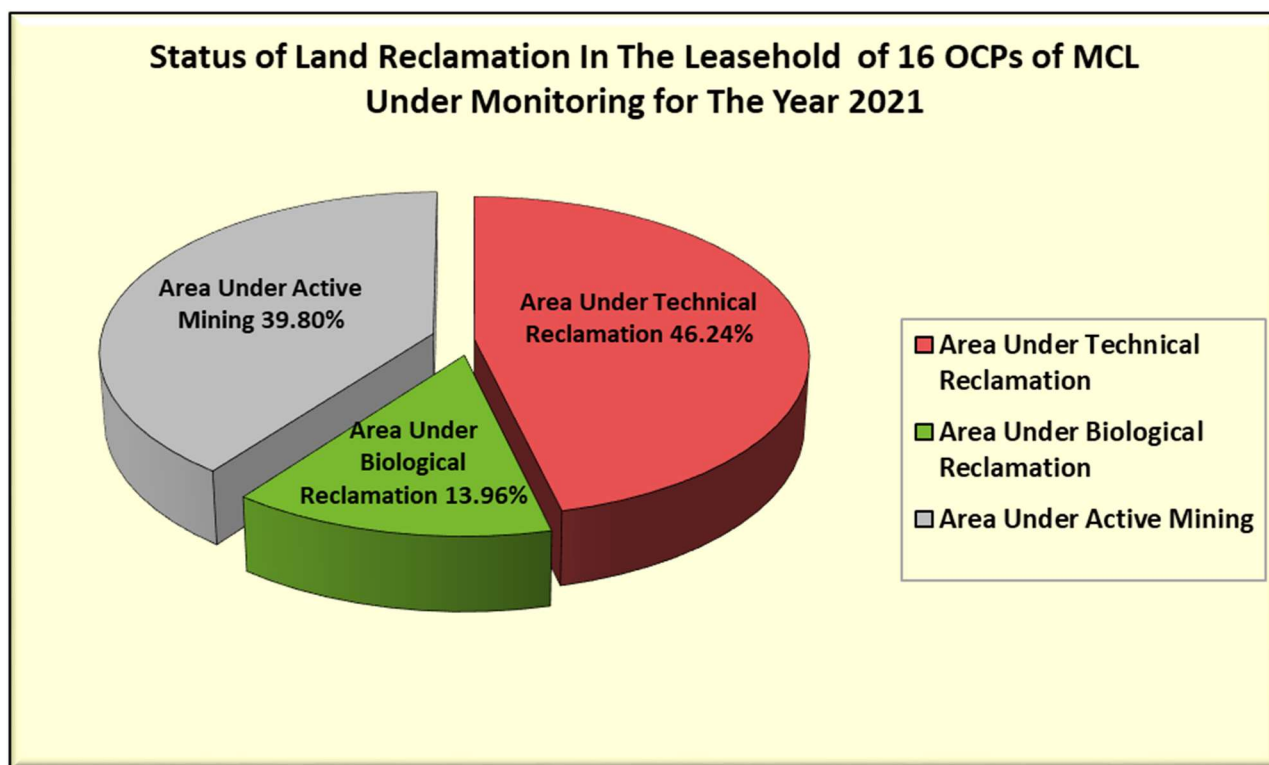
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Executive Summary

- 1.0 Project** Land restoration / reclamation monitoring of 16 opencast coal mines of Mahanadi Coalfields Ltd. (MCL) producing 5 million cu.m. and more (Coal+OB) per annum based on satellite data on annual basis.
- 2.0 Objective** Objective of the land restoration / reclamation monitoring is to assess the area under backfilling, plantation, social forestry, active mining area, water bodies, 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 179.75 Km² of the 16 opencast projects of MCL viz. Ananta, Balram, Lingaraj, Bharatpur, Bhubaneshwari, Jagannath, Hingula, Belpahar, Lakhanpur, Samleswari, Lajkura, Siarmal, Basundhara W. Extn., Garjanbahal, Kulda and Kahina considered for monitoring during 2021-22; total excavated area is 59.02 Km², out of which 8.24 Km² area (13.96%) has been planted, 27.29 Km² area (46.24%) is under backfilling and 23.49 Km² area (39.80%) is under active mining. It is evident from the analysis that 60.20% areas of the OC projects is under reclamation (biological and technical) and balance 39.80% 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 2021 with respect to the year 2020 in different projects, it is evident from the analysis that area under land reclamation has increased from 33.63 Km² (Yr.2020) to 35.53 Km² (Yr.2021). Out of 16 projects of MCL, Jagannath OC ranks on top for land reclamation (74.07%) followed by Samleswari OC (73.99%) and Balram OC (73.18%).
 - Area of biological reclamation (plantation on backfill) has been decreased nominally from 8.37Km² (Yr.2020) to 8.24 Km² (Yr. 2021) and area of technical reclamation (area under backfilling) has increased from 25.26 Km² (Yr.2020) to 27.29 Km² (Yr.2021) in MCL. The increase of 1.90 Km² in total area of reclamation is the result of the efforts of the Mahanadi Coalfields Ltd. taken up towards land reclamation and environmental protection.

- In some of the projects it has been observed during field visit that natural vegetation has also started growing on the old and stabilized backfilled area and dumps due to high soil fertility besides plantation carried out by MCL, resulting in higher vegetation cover than plantation done.
- It is important to note that from the year 2021-22 Kulda OC and Kaniha OC are included for annual satellite monitoring as their capacity has increased from <5 mcm (Coal+OB) to > 5 mcm (Coal+OB). Previously they were monitored in an interval of three years as per the prevailing practice for projects under less than 5 mcm category.
- The boundaries of Lingaraj and Kaniha project have been modified as provided by respective projects.



Pie Chart indicating distribution of reclamation activities in OC mines of MCL

Table 1: Project wise Land Reclamation Status in Opencast Projects of MCL based on Satellite Data of the year 2021															(Area in Sq.km.)								
Sl. No.	Project	Total Leasehold Area 2020	Total Leasehold Area 2021	Technical Reclamation		Plantation						Area Under Active Mining	Total Excavated Area		Total Area Under Plantation (%Green Cover Generated in Leasehold)		Total Area Under Reclamation						
				Area under Backfilling	Plantation on Excavated/Backfilled Area	Biological Reclamation		Other Plantation					2020	2021	2020	2021	2020	2021	2020	2021			
						2020	2021	2020	2021	2020	2021										2020	2021	
1	2	3	4	5		6		7				8		9				10(=5+6+9)		11(=6+7+8)		12(=5+6)	
1	Ananta	14.20	14.20	2.40	2.46	1.05	1.05	0.10	0.10	0.22	0.22	1.45	1.60	4.90	5.11	1.37	1.37	3.45	3.51				
				48.98%	48.14%	21.43%	20.55%					29.59%	31.31%			9.65%	9.65%	70.41%	68.69%				
2	Balram	13.09	13.09	2.80	2.78	1.06	1.04	0.22	0.22	0.35	0.35	1.03	1.40	4.89	5.22	1.63	1.61	3.86	3.82				
				57.26%	53.26%	21.68%	19.92%					21.06%	26.82%			12.45%	12.30%	78.94%	73.18%				
3	Lingaraj	7.26	11.73	1.70	1.90	0.15	0.15	0.32	0.52	0.33	0.44	2.19	2.67	4.04	4.72	0.80	1.11	1.85	2.05				
				42.08%	40.25%	3.71%	3.18%					54.21%	56.57%			11.02%	9.46%	45.79%	43.43%				
4	Bharatpur	9.27	9.27	2.63	2.66	1.66	1.65	0.45	0.45	0.16	0.16	1.66	1.75	5.95	6.06	2.27	2.26	4.29	4.31				
				44.20%	43.89%	27.90%	27.23%					27.90%	28.88%			24.49%	24.38%	72.10%	71.12%				
5	Bhubaneswari	6.58	6.58	1.86	2.15	0.01	0.02	0.00	0.01	0.15	0.13	1.77	2.17	3.64	4.34	0.16	0.16	1.87	2.17				
				51.10%	49.54%	0.27%	0.46%					48.63%	50.00%			2.43%	2.43%	51.37%	50.00%				
6	Jagannath	5.54	5.54	0.84	1.00	1.79	1.80	0.00	0.00	0.17	0.17	0.97	0.98	3.60	3.78	1.96	1.97	2.63	2.80				
				23.33%	26.46%	49.72%	47.62%					26.94%	25.93%			35.38%	35.56%	73.06%	74.07%				
7	Hingula	15.75	15.75	1.48	1.50	0.07	0.06	0.21	0.21	0.28	0.29	2.02	2.25	3.57	3.81	0.56	0.56	1.55	1.56				
				41.46%	39.37%	1.96%	1.57%					56.58%	59.06%			3.56%	3.56%	43.42%	40.94%				
8	Belpahar	14.44	14.44	2.36	2.71	0.90	0.82	0.57	0.51	0.52	0.52	1.33	1.29	4.59	4.82	1.99	1.85	3.26	3.53				
				51.42%	56.22%	19.61%	17.01%					28.98%	26.76%			13.78%	12.81%	71.02%	73.24%				
9	Lakhanpur	22.40	22.40	4.32	4.66	0.83	0.86	0.59	0.59	0.44	0.40	2.99	3.58	8.14	9.10	1.86	1.85	5.15	5.52				
				53.07%	51.21%	10.20%	9.45%					36.73%	39.34%			8.30%	8.26%	63.27%	60.66%				
10	Samleswari	13.35	13.35	2.94	3.03	0.70	0.64	0.49	0.49	0.50	0.48	1.27	1.29	4.91	4.96	1.69	1.61	3.64	3.67				
				59.88%	61.09%	14.26%	12.90%					25.87%	26.01%			12.66%	12.06%	74.13%	73.99%				
11	Lajkura	7.21	7.21	1.20	1.24	0.15	0.15	0.23	0.20	0.16	0.16	0.89	1.02	2.24	2.41	0.54	0.51	1.35	1.39				
				53.57%	51.45%	6.70%	6.22%					39.73%	42.32%			7.49%	7.07%	60.27%	57.68%				
12	Siarmal	22.90	22.90	0.00	0.00	0.00	0.00	0.00	0.00	0.56	0.60	0.00	0.00	0.00	0.00	0.56	0.60	0.00	0.00				
				0.00%	0.00%	0.00%	0.00%					0.00%	0.00%			2.45%	2.62%	-	-				
13	Basundhara W Extn.	3.23	3.23	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.03	0.03	0.00	0.00				
				0.00%	0.00%	0.00%	0.00%					0.00%	0.00%			0.93%	0.93%	-	-				
14	Garjanbahal	6.54	6.54	0.03	0.14	0.00	0.00	0.00	0.00	0.02	0.03	0.47	0.58	0.50	0.72	0.02	0.03	0.03	0.14				
				6.00%	19.44%	0.00%	0.00%					94.00%	80.56%			0.31%	0.46%	6.00%	19.44%				
	Total (A)	161.76	166.23	24.56	26.23	8.37	8.24	3.18	3.30	3.89	3.98	18.04	20.58	50.97	55.05	15.44	15.52	32.93	34.47				
				48.19%	47.65%	16.42%	14.97%					35.39%	37.38%			9.55%	9.34%	64.61%	62.62%				
		2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021				
15	Kulda	6.34	6.34	0.52	0.75	0.00	0.00	0.00	0.00	0.01	0.02	1.31	1.67	1.83	2.42	0.01	0.02	0.52	0.75				
				28.42%	30.99%	0.00%	0.00%					71.58%	69.01%			0.16%	0.32%	0.00%	30.99%				
		2018	2021	2018	2021	2018	2021	2018	2021	2018	2021	2018	2021	2018	2021	2018	2021	2018	2021				
16	Kaniha	6.77	7.18	0.18	0.31	0.00	0.00	0.00	0.00	0.10	0.07	1.04	1.24	1.22	1.55	0.10	0.07	0.18	0.31				
				14.75%	20.00%	0.00%	0.00%					85.25%	80.00%			1.48%	0.97%	0.00%	20.00%				
	Total (B)	13.11	13.52	0.70	1.06	0.00	0.00	0.00	0.00	0.11	0.09	2.35	2.91	3.05	3.97	0.11	0.09	0.70	1.06				
				22.95%	26.70%	0.00%	0.00%					77.05%	73.30%			0.84%	0.67%	22.95%	26.70%				
	All Total (A+B)	174.87	179.75	25.26	27.29	8.37	8.24	3.18	3.30	4.00	4.07	20.39	23.49	54.02	59.02	15.55	15.61	33.63	35.53				
				46.76%	46.24%	15.49%	13.96%					37.75%	39.80%			8.89%	8.68%	62.25%	60.20%				

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

1. Area under **Biological Reclamation** includes Area 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, Quarry Filled with Water, if any. Areas under coal dump have been excluded from Active Mining in this table.
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 Table above.
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"
6. The leasehold boundaries of Lingaraj and Kaniha project have been modified as provided by the projects.
7. Kaniha and Kulda projects, having the capacity > 5 mcm (Coal+OB), are included for annual satellite monitoring.

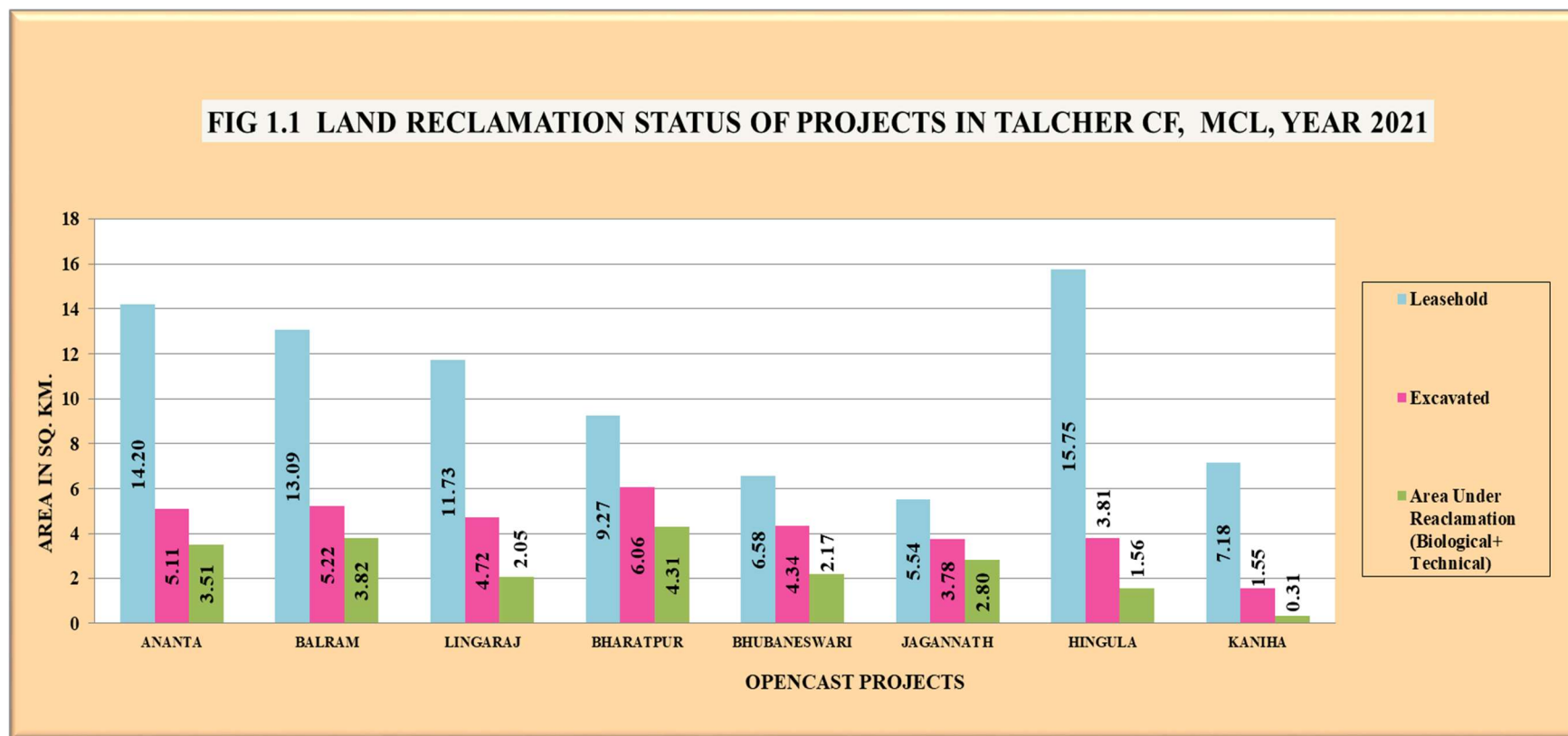


Fig.1.1: Land reclamation status of OC projects in Talcher CF, MCL for the year 2021

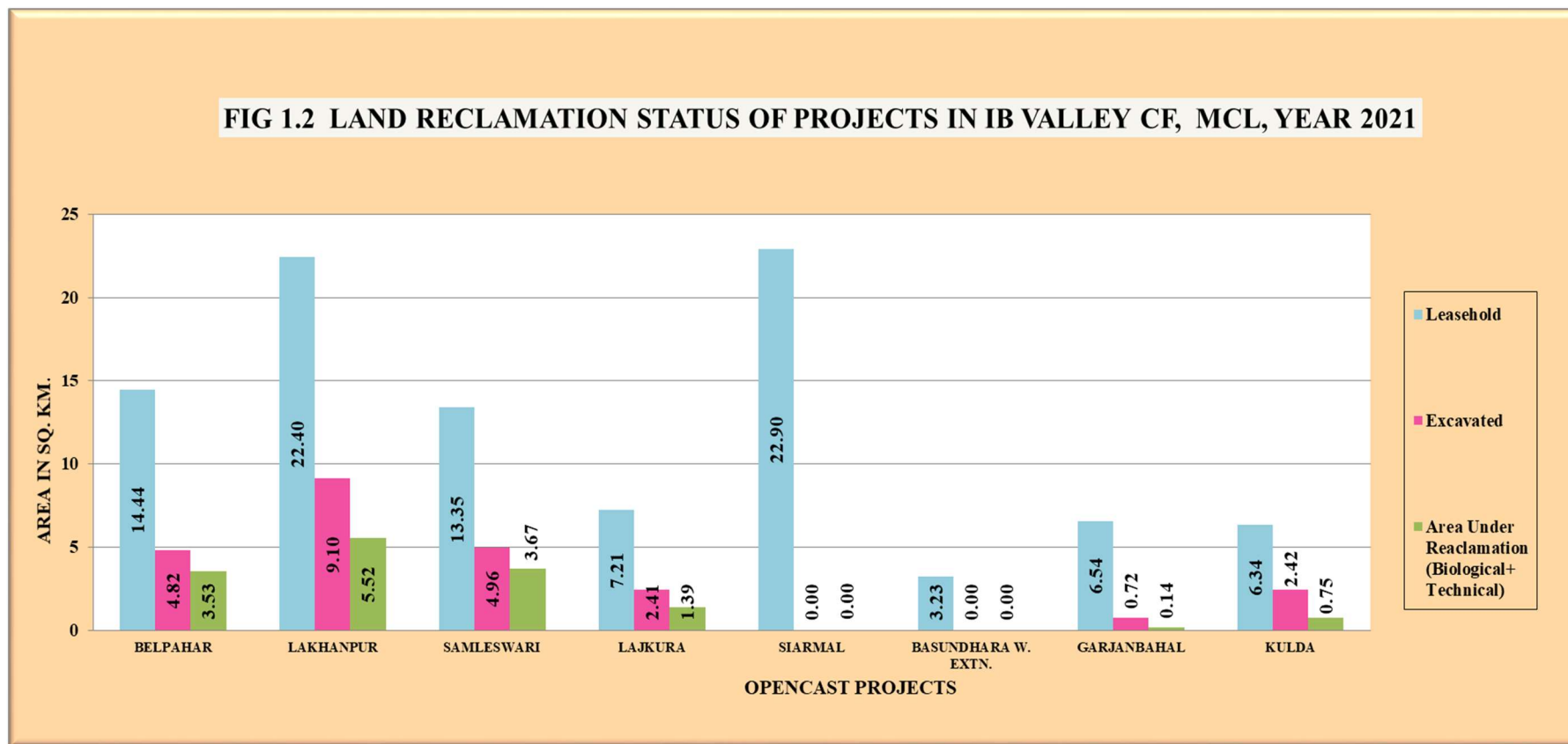


Fig.1.2: Land reclamation status of OC projects in Ib Valley CF, MCL for the year 2021

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/2009/2428 dated 29.12.2009 to Central Mine Planning & Design Institute (CMPDI), Ranchi, for monitoring 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) based on remote sensing satellite data, regularly on annual basis for sustainable development of mining. Further, a revised work order was issued vide letter no. CIL/WBP/Env/2011/4706 dated 12.10.2012 from Coal India Limited for the period 2012-13 to 2016-17 which was subsequently followed by another work order vide letter no. CIL/WBP/Env/2017/DP/8477 dated 21.09.2017 from Coal India Limited for the period 2017-18 to 2021-22 for land reclamation monitoring of opencast projects and vegetation cover monitoring of 19 major coalfields. According to this work order, all mines in CIL with output capacity of 5 million cu. m (Coal +OB) shall be monitored every year and all mines below this capacity shall be monitored at an interval of 3 years. All coalfields in CIL shall also be monitored at an interval of 3 years as per a defined plan. The result of land reclamation status of all such mines to be put on the website of CIL, (www.coalindia.in), CMPDI (www.cmpdi.co.in) and the concerned coal companies in public domain. Detail report to be submitted to Coal India and respective subsidiaries.

- 1.3 Coal India issued another work order vide letter no. CIL/ENV/2021/10628 dated 11.05.2021 stating that two opencast mines of MCL, namely Kulda oc and Kaniha oc are to be monitored during 2021-22 for Satellite based land reclamation as the composite production of each of the OCP exceeds 5 Mcm per annum (Coal+OB).
- 1.4 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.
- 1.5 Present report is embodying the finding of the study based on satellite data of the year 2021 carried out for all the OC projects producing more 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:

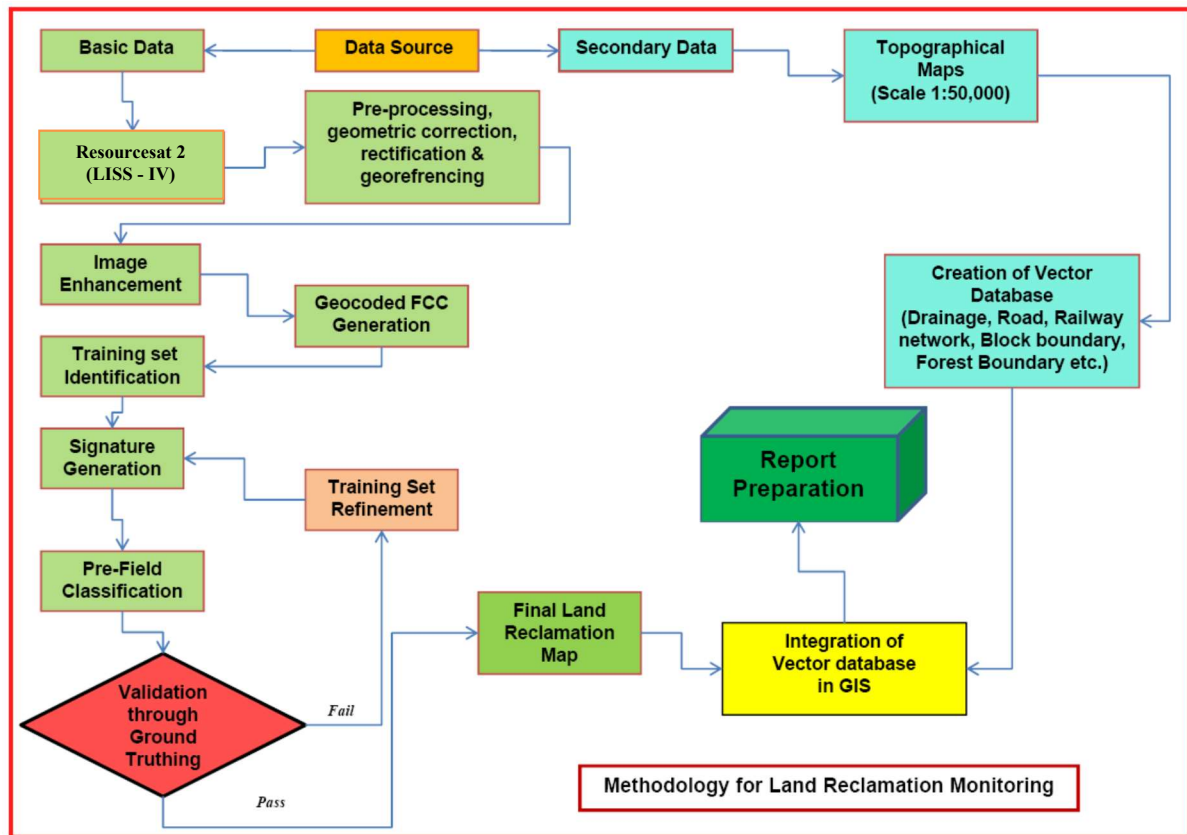


Figure: 2 - **Methodology for Land Reclamation Monitoring**

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.

Satellite Data Used: The following data are used in the current study, R2A/LISS-IV data of 2nd February, 2021 for mines of Talcher Coalfield and R2A/LISS-IV data of 17th March, 2021 for mines of Ib Valley Coalfield.

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 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 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.

- **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 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 Mahanadi Coalfields Limited

4.1 Following fourteen opencast projects of MCL producing more than 5 million cubic meter and more (Coal + OB) were taken up for land reclamation monitoring based on satellite data of the year 2021.

- Ananta
- Balram
- Lingaraj
- Bharatpur
- Bhubaneswari
- Jagannath
- Hingula
- Kaniha
- Belpahar
- Lakhanpur
- Samleswari
- Lajkura
- Siarmal
- Basundhara West Extension
- Garjanbahal
- Kulda

4.2 From the year 2021-2022 Kulda and Kaniha OCP have been considered in more than 5mcm (Coal+OB) category and will be monitored each year. Previously they were in less than 5 mcm (Coal+OB) category and were monitored in an interval of 3 years. The leasehold boundaries of Lingaraj and Kaniha projects have been modified as provided by respective projects (refer Table 1).

4.3 Area statistics of different land use class present in the mine leasehold of the above projects for the year 2021 are shown in the Table -1. Land use maps derived from satellite data are shown in Plate 1 - 16. Land reclamation status of the above

mentioned 16 projects, are mentioned in the tables 2.1 and 2.2 for the year 2021. Year wise changes in the different land use classes based on satellite data are depicted in Bar Charts in Fig. 3 - 18.

- 4.4** Study reveals that out of total 59.02 Km² excavated area; 35.53 Km² area (60.20%) is under reclamation. Out of which 8.24 Km² (13.96%) area has been re-vegetated and 27.29 Km² (46.24%) area is under backfilling.
- 4.5** Total Area under active mining has increased from 20.39 (Yr. 2020) to 23.49 (Yr. 2021). Though in Belpahar project it has reduced due to increase in area under backfilling.
- 4.6** Area under backfilling in Balram project has been reduced marginally due to increase in mine water.
- 4.7** Analysis of satellite data indicates that plantation on backfill has reduced in Balram, Bharatpur, Hingula, Belpahar and Samleswari because of fresh backfilling activities.
- 4.8** Plantation on External OB dump has marginally reduced in Belpahar and Samleswari OCP due to construction of silo and road. Area of Social forestry has reduced marginally in some projects due to mine advancement.
- 4.9** Study also reveals that area under barren backfilling (Technical Reclamation) has increased from 25.26 Km² in 2020 to 27.29 Km² in 2021.
- 4.10** It was also observed that overall total area under plantation (Green Cover) has increased from 15.55 Km² in 2020 to 15.61 Km² in 2021(refer All Total in Table 1). Green Cover has reduced in some projects of MCL due to change in mine boundary and reduction in plantation and social forestry in the leasehold areas resulted from mining activities.

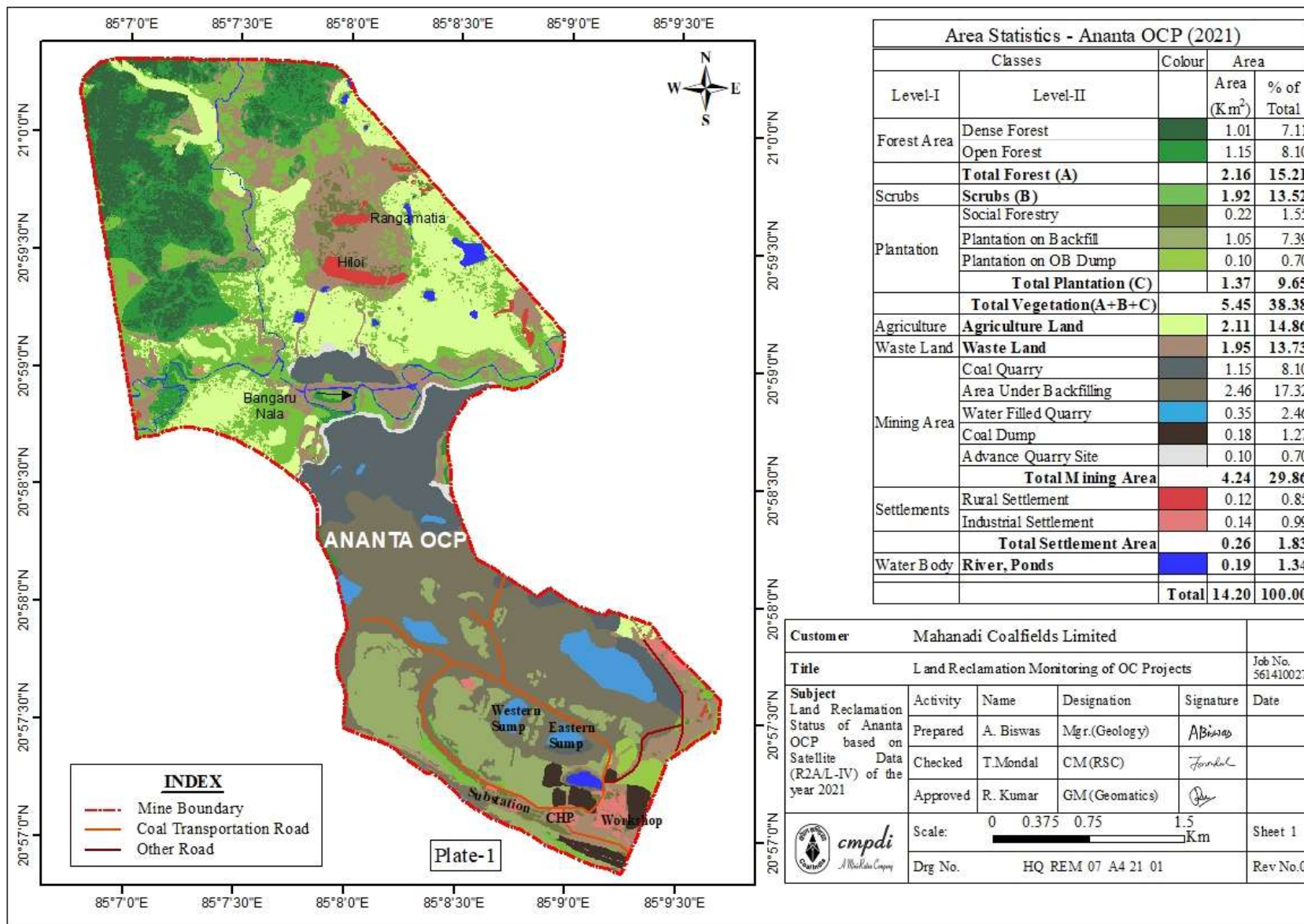
- 4.11** On comparing the status of land reclamation for the year 2021 with respect to the year 2020 in different projects, it is evident that area of land reclamation has increased from 33.63 Km² (Yr. 2020) to 35.53 Km² (Yr.2021).
- 4.12** In Kulda OCP and Bharatpur OCP plantation has been done on internal OB dump but because of low height of the plants its signature is not available/visible in satellite image of 2021.
- 4.13** Out of 16 projects of MCL, Jagannath OC ranks on top for land reclamation (74.07%) followed by Samleswari OC (73.99%) and Balram OC (73.18%)
- 4.14** The Kaniha and Kulda OC projects were previously monitored under Less than 5mcm (Coal+OB) per annum category at an interval of three years. The previous cycle of land reclamation monitoring of Kaniha OCP was done in 2018-19 and for Kulda OCP the previous cycle of monitoring was 2020-21.

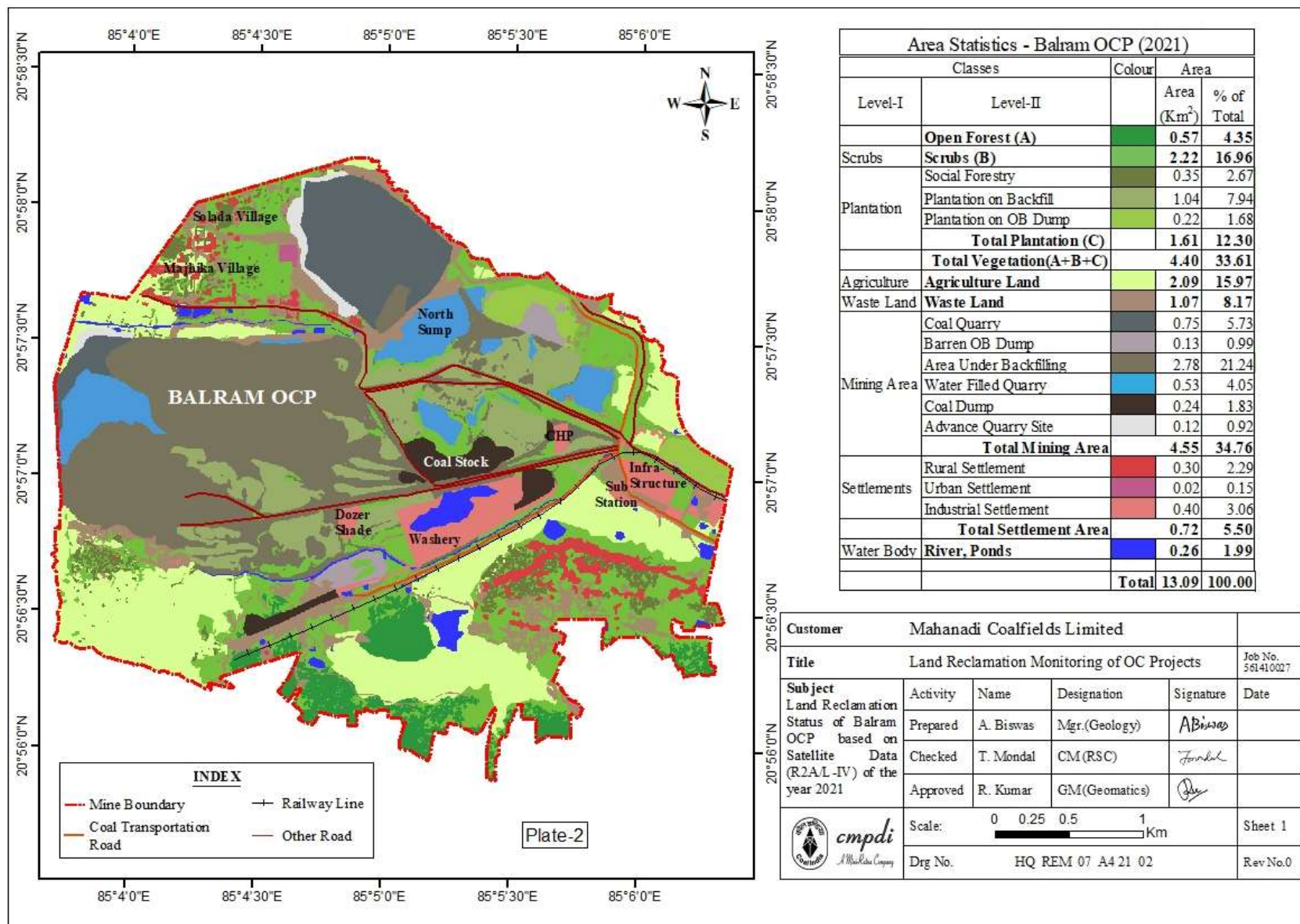
Table 2.1: STATUS OF LAND RESTORATION / RECLAMATION IN MAHANADI COALFIELDS LIMITED BASED ON SATELLITE DATA OF THE YEAR 2021

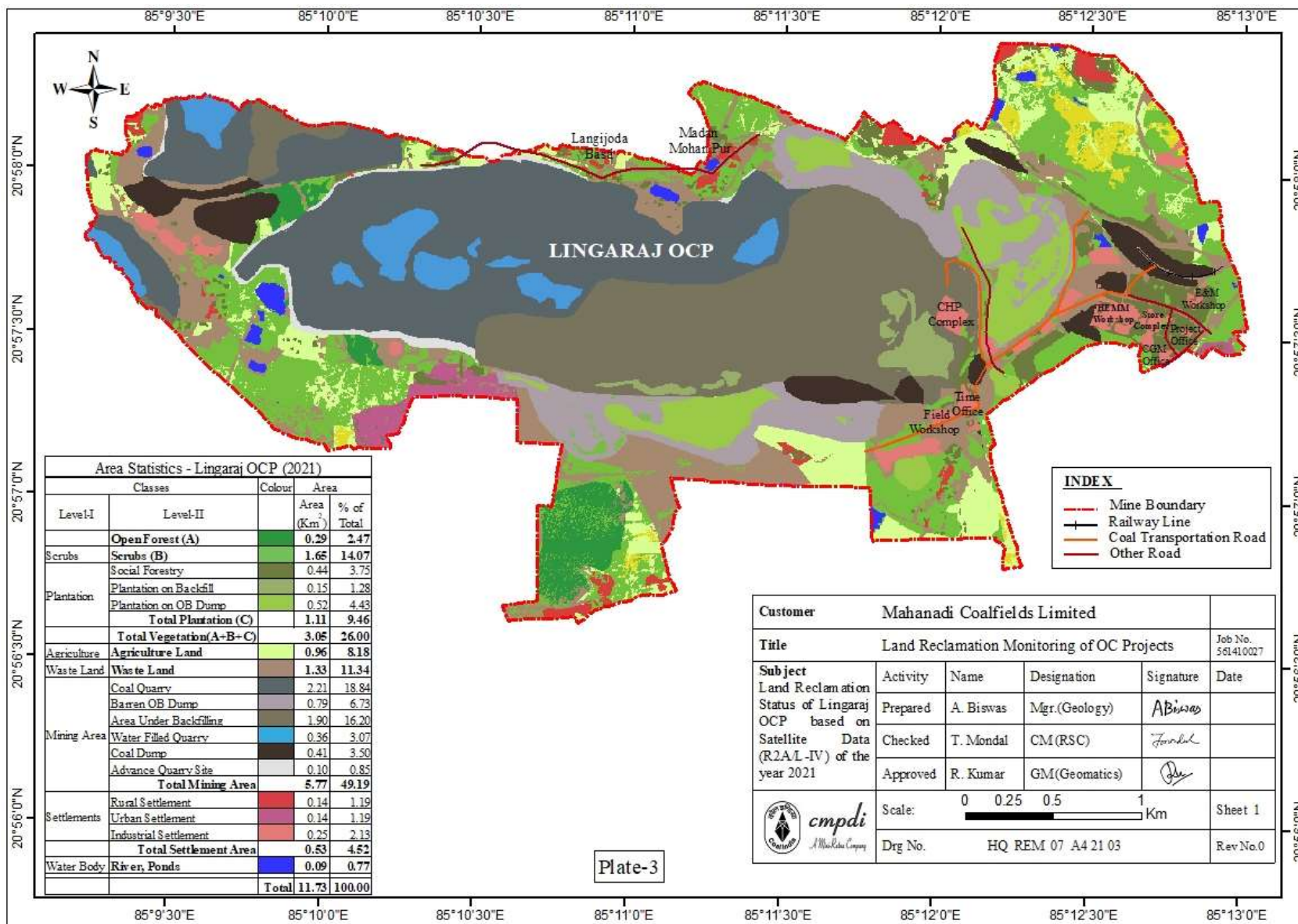
		(Area in Sq. Kms.)																	
		ANANTA		BALRAM		LINGARAJ		BHARATPUR		BHUBANESHWARI		JAGANNATH		HINGULA		KANIHA		TOTAL	
		Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%
FORESTS	Dense Forest	1.01	7.11	0.00	0.00	0.00	0.00	0.01	0.11	0.00	0.00	0.00	0.00	1.15	7.30	0.00	0.00	2.17	2.60
	Open Forest	1.15	8.10	0.57	4.35	0.29	2.47	0.00	0.00	0.22	3.35	0.03	0.54	1.60	10.16	0.00	0.00	3.86	4.63
	Total Forest (A)	2.16	15.21	0.57	4.35	0.29	2.47	0.01	0.11	0.22	3.35	0.03	0.54	2.75	17.46	0.00	0.00	6.03	7.24
SCRUBS	Scrubs (B)	1.92	13.52	2.22	16.96	1.65	14.07	0.47	5.07	0.39	5.93	0.30	5.42	3.05	19.37	0.73	10.17	10.73	12.88
PLANTATION	Social Forestry	0.22	1.55	0.35	2.67	0.44	3.75	0.16	1.73	0.13	1.98	0.17	3.07	0.29	1.84	0.07	0.97	1.83	2.20
	Plantation on External OB Dump	0.10	0.70	0.22	1.68	0.52	4.43	0.45	4.85	0.01	0.08	0.00	0.00	0.21	1.33	0.00	0.00	1.51	1.81
	Plantation on Backfill/Excavated Area(Biological Reclamation)	1.05	7.39	1.04	7.94	0.15	1.28	1.65	17.80	0.02	0.30	1.80	32.49	0.06	0.38	0.00	0.00	5.77	6.92
	Total Plantation (Green Cover) (C)	1.37	9.65	1.61	12.30	1.11	9.46	2.26	24.38	0.16	2.36	1.97	35.56	0.56	3.56	0.07	0.97	9.11	10.93
	Total Vegetation (A+B+C)	5.45	38.38	4.40	33.61	3.05	26.00	2.74	29.56	0.77	11.63	2.30	41.52	6.36	40.38	0.80	11.14	25.87	31.04
ACTIVE MINING	Coal Dump	0.18	1.27	0.24	1.83	0.41	3.50	0.18	1.94	0.04	0.61	0.08	1.44	0.39	2.48	0.12	1.67	1.64	1.97
	Coal Quarry	1.15	8.10	0.75	5.73	2.21	18.84	0.90	9.71	1.68	25.55	0.32	5.78	0.99	6.29	1.17	16.29	9.17	11.00
	Advance Quarry Site	0.10	0.70	0.12	0.92	0.10	0.85	0.11	1.19	0.16	2.43	0.08	1.44	0.12	0.76	0.01	0.14	0.80	0.96
	Quarry Filled with Water	0.35	2.46	0.53	4.05	0.36	3.07	0.74	7.98	0.33	5.02	0.58	10.47	1.14	7.24	0.06	0.84	4.09	4.91
	Total Area under Active Mining	1.60	11.27	1.40	10.70	2.67	22.76	1.75	18.88	2.17	33.00	0.98	17.69	2.25	14.29	1.24	17.27	14.06	16.87
	Barren OB dump	0.00	0.00	0.13	0.99	0.79	6.73	0.05	0.54	0.79	12.02	0.00	0.00	0.54	3.43	0.42	5.85	2.72	3.26
	Area Under Backfilling(Technical Reclamation)	2.46	17.32	2.78	21.24	1.90	16.20	2.66	28.69	2.15	32.70	1.00	18.05	1.50	9.52	0.31	4.32	14.76	17.71
	Total Area under Mine Operation	4.24	29.86	4.55	34.76	5.77	49.19	4.64	50.05	5.15	78.33	2.06	37.18	4.68	29.71	2.09	29.11	33.18	37.85
WASTELANDS	Waste Lands	1.95	13.73	1.07	8.17	1.33	11.34	0.79	8.52	0.32	4.87	0.42	7.58	1.81	11.49	1.00	13.93	8.69	10.43
	Fly Ash Pond/Sand Body	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	1.99	0.06	0.38	0.00	0.00	0.17	0.20
	Total Wastelands	1.95	13.73	1.07	8.17	1.33	11.34	0.79	8.52	0.32	4.87	0.53	9.57	1.87	11.87	1.00	13.93	8.86	10.63
WATER	Reservoir, nallah, ponds etc.	0.19	1.34	0.26	1.99	0.09	0.77	0.05	0.54	0.02	0.30	0.05	0.90	0.32	2.03	0.07	0.97	1.05	1.26
	Total Waterbodies	0.19	1.34	0.26	1.99	0.09	0.77	0.05	0.54	0.02	0.30	0.05	0.90	0.32	2.03	0.07	0.97	1.05	1.26
AGRICULTURE	Crop Lands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	2.79	0.20	0.24
	Fallow Lands	2.11	14.86	2.09	15.97	0.96	8.18	0.77	8.31	0.26	3.95	0.44	7.94	2.26	14.35	2.71	37.74	11.60	13.92
	Total Agriculture	2.11	14.86	2.09	15.97	0.96	8.18	0.77	8.31	0.26	3.95	0.44	7.94	2.26	14.35	2.91	40.53	11.80	14.16
SETTLEMENTS	Urban Settlement	0.00	0.00	0.02	0.15	0.14	1.19	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.06	0.00	0.00	0.17	0.20
	Rural Settlement	0.12	0.85	0.30	2.29	0.14	1.19	0.04	0.43	0.05	0.76	0.05	0.90	0.22	1.40	0.25	3.48	1.17	1.40
	Industrial Settlement	0.14	0.99	0.40	3.06	0.25	2.13	0.24	2.59	0.01	0.15	0.11	1.99	0.03	0.19	0.06	0.84	1.24	1.49
	Total Settlements	0.26	1.83	0.72	5.50	0.53	4.52	0.28	3.02	0.06	0.91	0.16	2.89	0.26	1.65	0.31	4.32	2.58	3.10
	GRAND TOTAL	14.20	100.00	13.09	100.00	11.73	100.00	9.27	100.00	6.58	100.00	5.54	100.00	15.75	100.00	7.18	100.00	83.34	100.00

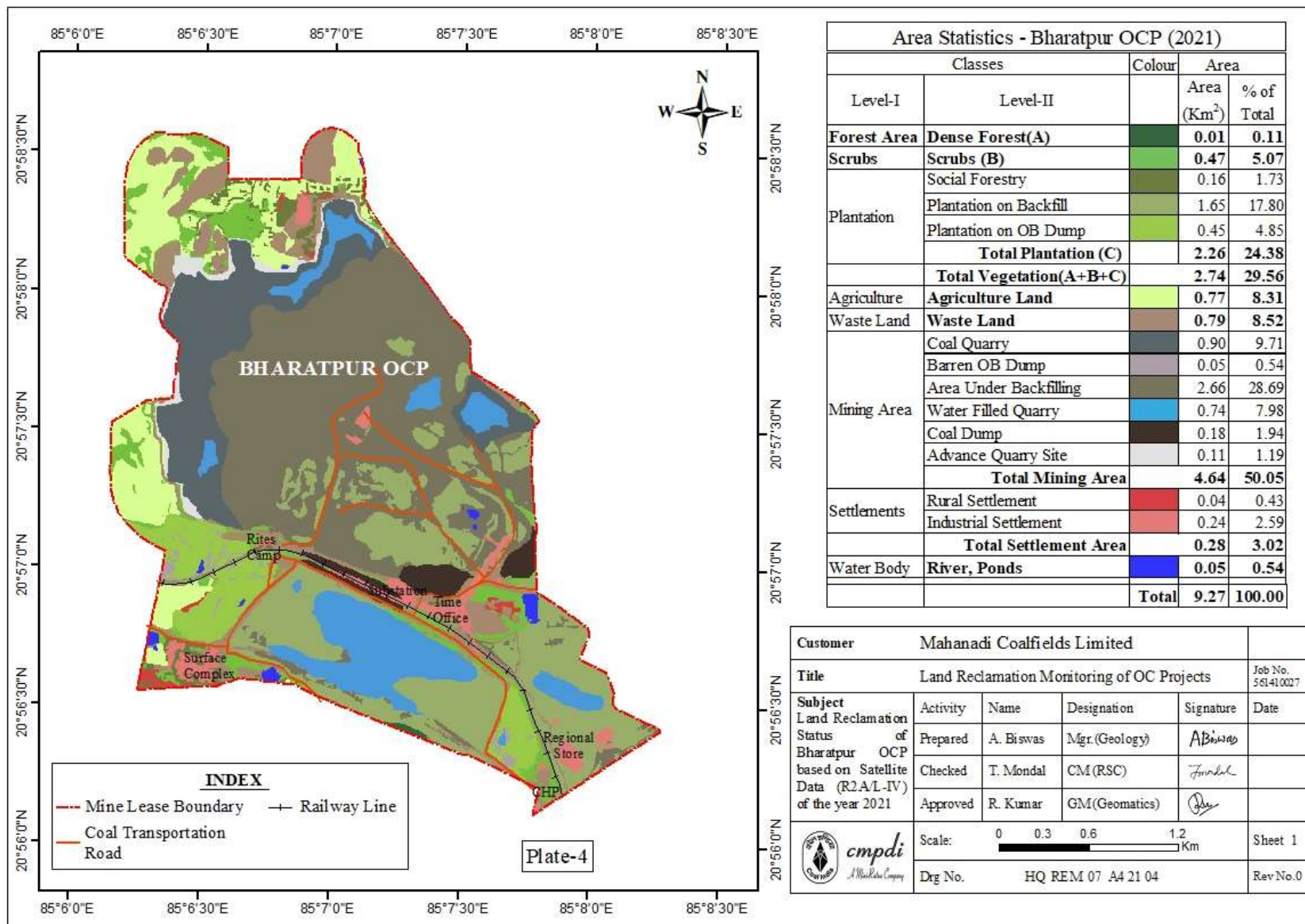
Table 2.2: STATUS OF LAND RESTORATION / RECLAMATION IN MAHANADI COALFIELDS LIMITED BASED ON SATELLITE DATA OF THE YEAR 2021

		(Area in Sq. Kms.)																			
		BELPAHAR		LAKHANPUR		SAMLESWARI		LAJKURA		SIARMAL		BASUNDHARA W EXTN		GARJANBAHAL		KULDA		TOTAL		ALL TOTAL	
		Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%
FORESTS	Dense Forest	0.00	0.00	1.37	6.12	0.21	1.57	0.70	9.71	0.00	0.00	0.00	0.00	0.43	6.57	0.00	0.00	2.71	2.81	4.88	2.71
	Open Forest	0.91	6.30	2.47	11.03	0.56	4.19	0.69	9.57	0.87	3.80	0.79	24.46	0.66	10.09	0.00	0.00	6.95	7.21	10.81	6.01
	Total Forest (A)	0.91	6.30	3.84	17.14	0.77	5.77	1.39	19.28	0.87	3.80	0.79	24.46	1.09	16.67	0.00	0.00	9.66	10.02	15.69	8.73
SCRUBS	Scrubs (B)	3.38	23.41	2.63	11.74	2.58	19.32	0.98	13.59	7.21	31.48	1.36	42.11	1.14	17.43	1.58	24.92	20.86	21.64	31.59	17.57
	Social Forestry	0.52	3.60	0.40	1.79	0.48	3.59	0.16	2.22	0.60	2.62	0.03	0.93	0.03	0.46	0.02	0.32	2.24	2.32	4.07	2.26
PLANTATION	Plantation on External OB Dump	0.51	3.53	0.59	2.63	0.49	3.67	0.20	2.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.79	1.86	3.30	1.83
	Plantation on Backfill/Excavated Area(Biological Reclamation)	0.82	5.68	0.86	3.84	0.64	4.79	0.15	2.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.47	2.56	8.24	4.58
	Total Plantation (Green Cover) (C)	1.85	12.81	1.85	8.26	1.61	12.06	0.51	7.07	0.60	2.62	0.03	0.93	0.03	0.46	0.02	0.32	6.50	6.74	15.61	8.68
	Total Vegetation (A+B+C)	6.14	42.52	8.32	37.14	4.96	37.15	2.88	39.94	8.68	37.90	2.18	67.49	2.26	34.56	1.60	25.24	37.02	38.40	62.89	34.99
ACTIVE MINING	Coal Dump	0.11	0.76	0.12	0.54	0.19	1.42	0.07	0.97	0.00	0.00	0.00	0.00	0.25	3.82	0.07	1.10	0.81	0.84	2.45	1.36
	Coal Quarry	0.97	6.72	2.77	12.37	1.00	7.49	0.85	11.79	0.00	0.00	0.00	0.00	0.43	6.57	1.33	20.98	7.35	7.62	16.52	9.19
	Advance Quarry Site	0.15	1.04	0.55	2.46	0.13	0.97	0.14	1.94	0.00	0.00	0.00	0.00	0.12	1.83	0.19	3.00	1.28	1.33	2.08	1.16
	Quarry Filled with Water	0.17	1.18	0.26	1.16	0.16	1.20	0.03	0.42	0.00	0.00	0.00	0.00	0.03	0.46	0.15	2.37	0.80	0.83	4.89	2.72
	Total Area under Active Mining	1.29	8.93	3.58	15.98	1.29	9.66	1.02	14.15	0.00	0.00	0.00	0.00	0.58	8.87	1.67	26.35	9.43	9.78	23.49	13.07
WASTELANDS	Barren OB dump	0.19	1.32	0.02	0.09	0.07	0.52	0.18	2.50	0.00	0.00	0.00	0.00	0.41	6.27	0.58	9.15	1.45	1.50	4.17	2.32
	Area Under Backfilling(Technical Reclamation)	2.71	18.77	4.66	20.80	3.03	22.69	1.24	17.20	0.00	0.00	0.00	0.00	0.14	2.14	0.75	11.83	12.53	13.00	27.29	15.18
	Total Area under Mine Operation	4.30	29.78	8.38	37.41	4.58	34.30	2.51	34.81	0.00	0.00	0.00	0.00	1.38	21.10	3.07	48.43	24.22	24.28	57.40	31.93
WASTELANDS	Waste Lands	2.63	18.21	1.38	6.16	2.15	16.10	0.98	13.59	1.93	8.43	0.62	19.20	0.43	6.57	0.73	11.51	10.85	11.25	19.54	10.87
	Fly Ash Pond/Sand Body	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.09
	Total Wastelands	2.63	18.21	1.38	6.16	2.15	16.10	0.98	13.59	1.93	8.43	0.62	19.20	0.43	6.57	0.73	11.51	10.85	11.25	19.71	10.97
WATER	Reservoir, nallah, ponds etc.	0.25	1.73	0.27	1.21	0.19	1.42	0.07	0.97	0.22	0.96	0.02	0.62	0.06	0.92	0.11	1.73	1.19	1.23	2.24	1.25
	Total Waterbodies	0.25	1.73	0.27	1.21	0.19	1.42	0.07	0.97	0.22	0.96	0.02	0.62	0.06	0.92	0.11	1.73	1.19	1.23	2.24	1.25
AGRICULTURE	Crop Lands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.74	7.60	0.00	0.00	0.00	0.00	0.00	0.00	1.74	1.80	1.94	1.08
	Fallow Lands	0.55	3.81	3.71	16.56	1.05	7.86	0.54	7.49	9.62	42.01	0.39	12.07	2.20	33.64	0.77	12.14	18.83	19.53	30.43	16.93
	Total Agriculture	0.55	3.81	3.71	16.56	1.05	7.86	0.54	7.49	11.36	49.61	0.39	12.07	2.20	33.64	0.77	12.14	20.57	21.34	32.37	18.01
SETTLEMENTS	Urban Settlement	0.02	0.14	0.00	0.00	0.003	0.02	0.08	1.11	0.02	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.13	0.29	0.16
	Rural Settlement	0.17	1.18	0.12	0.54	0.21	1.57	0.03	0.42	0.69	3.01	0.02	0.62	0.07	1.07	0.01	0.16	1.32	1.37	2.49	1.39
	Industrial Settlement	0.38	2.63	0.22	0.98	0.21	1.57	0.12	1.66	0.00	0.00	0.00	0.00	0.14	2.14	0.05	0.79	1.12	1.16	2.36	1.31
	Total Settlements	0.57	3.95	0.34	1.52	0.423	3.17	0.23	3.19	0.71	3.10	0.02	0.62	0.21	3.21	0.06	0.95	2.56	2.66	5.14	2.86
GRAND TOTAL		14.44	100.00	22.40	100.00	13.35	100.00	7.21	100.00	22.90	100.00	3.23	100.00	6.54	100.00	6.34	100.00	96.41	100.00	179.75	100.00



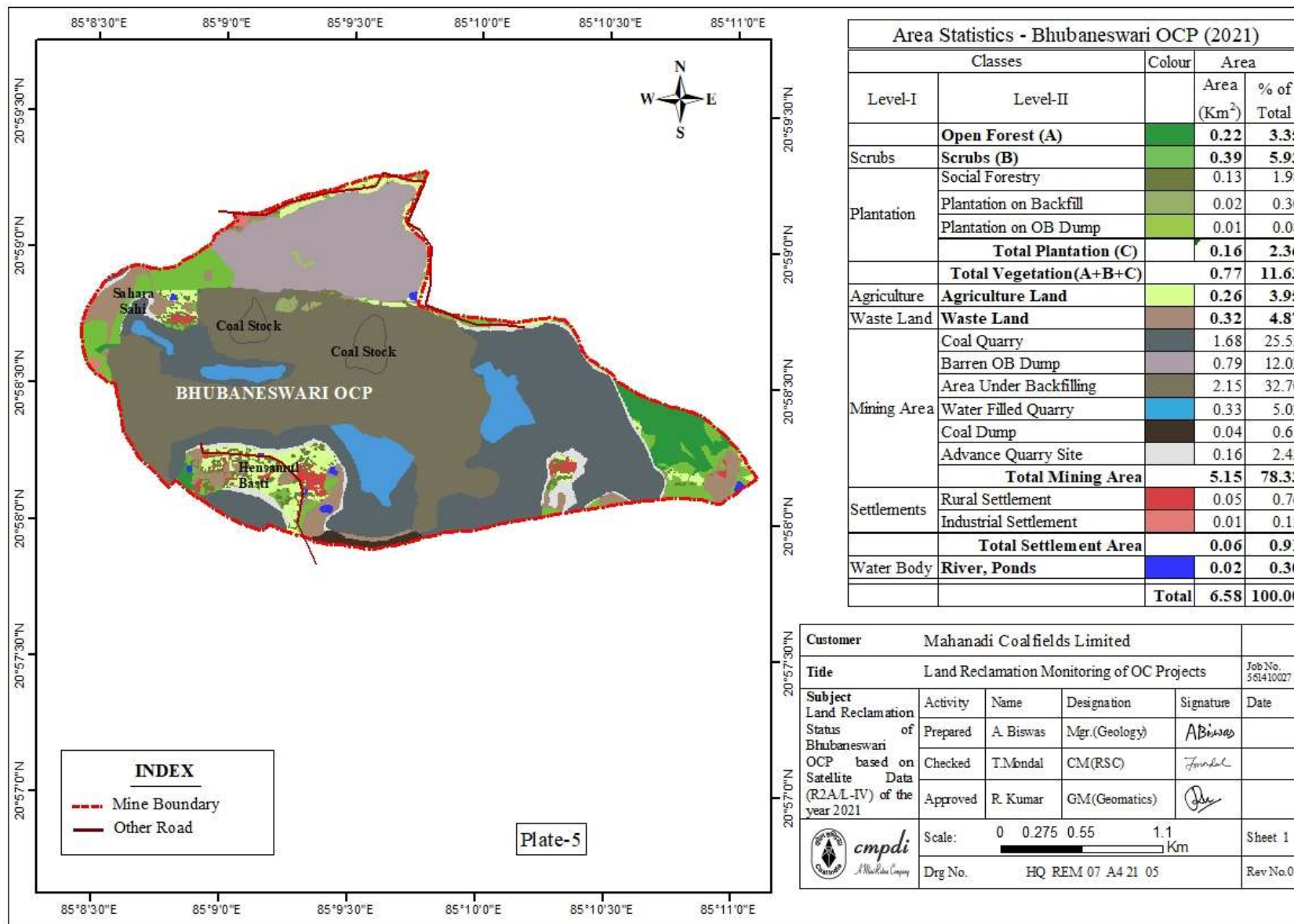






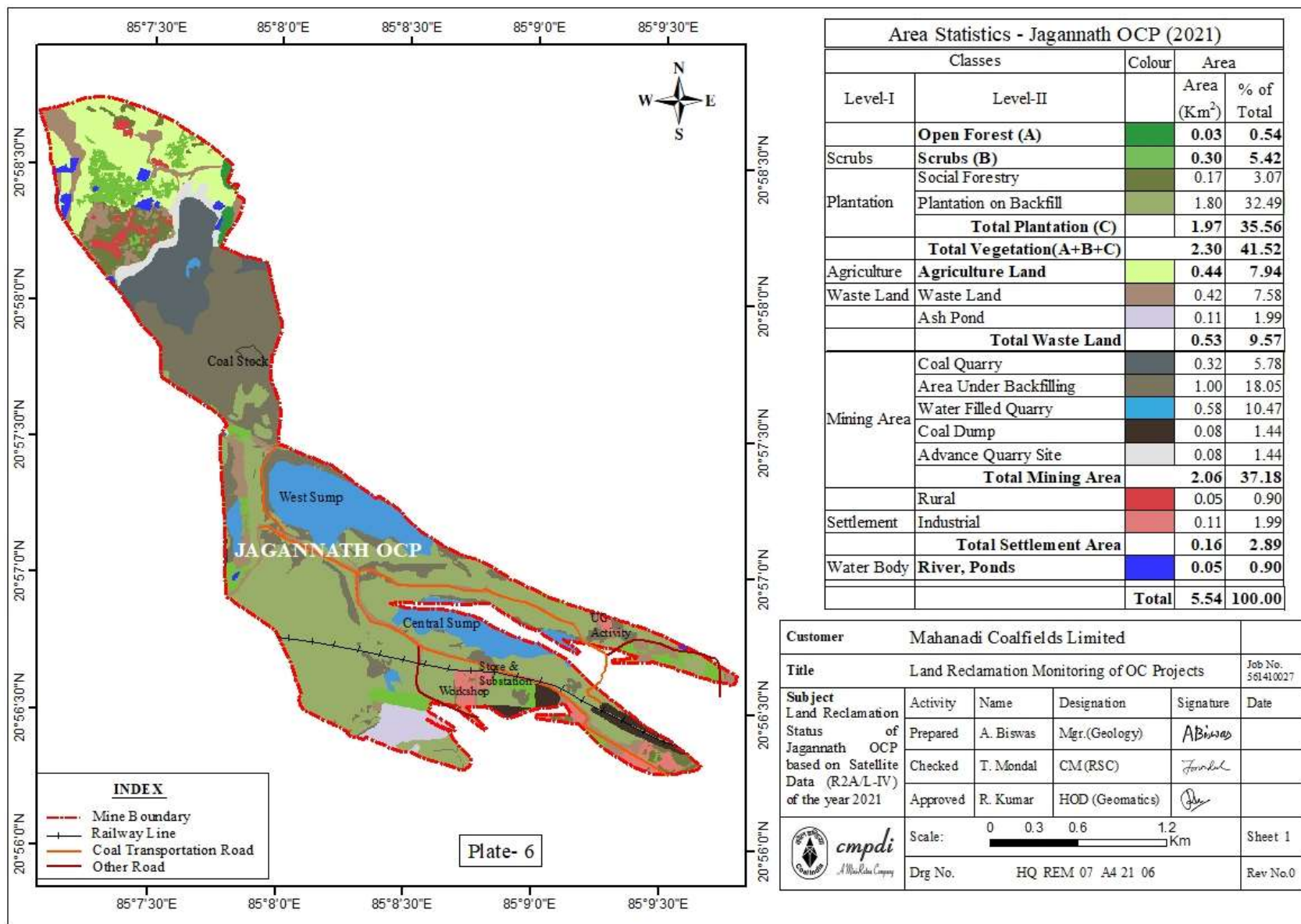
Area Statistics - Bharatpur OCP (2021)				
Classes		Colour	Area	
Level-I	Level-II		Area (Km ²)	% of Total
Forest Area	Dense Forest(A)		0.01	0.11
	Scrubs (B)		0.47	5.07
Plantation	Social Forestry		0.16	1.73
	Plantation on Backfill		1.65	17.80
	Plantation on OB Dump		0.45	4.85
	Total Plantation (C)		2.26	24.38
Total Vegetation(A+B+C)			2.74	29.56
Agriculture	Agriculture Land		0.77	8.31
Waste Land	Waste Land		0.79	8.52
	Coal Quarry		0.90	9.71
Mining Area	Barren OB Dump		0.05	0.54
	Area Under Backfilling		2.66	28.69
	Water Filled Quarry		0.74	7.98
	Coal Dump		0.18	1.94
	Advance Quarry Site		0.11	1.19
	Total Mining Area		4.64	50.05
Settlements	Rural Settlement		0.04	0.43
	Industrial Settlement		0.24	2.59
Total Settlement Area			0.28	3.02
Water Body	River, Ponds		0.05	0.54
Total			9.27	100.00

Customer		Mahanadi Coalfields Limited			
Title		Land Reclamation Monitoring of OC Projects			Job No. 561410027
Subject Land Reclamation Status of Bharatpur OCP based on Satellite Data (R2A/L-IV) of the year 2021	Activity	Name	Designation	Signature	Date
	Prepared	A. Biswas	Mgr.(Geology)	<i>ABiswas</i>	
	Checked	T. Mondal	CM (RSC)	<i>Tmondal</i>	
Approved	R. Kumar	GM(Geomatics)	<i>Rkumar</i>		
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Drg No.		HQ REM 07 A4 21 04			Rev No.0



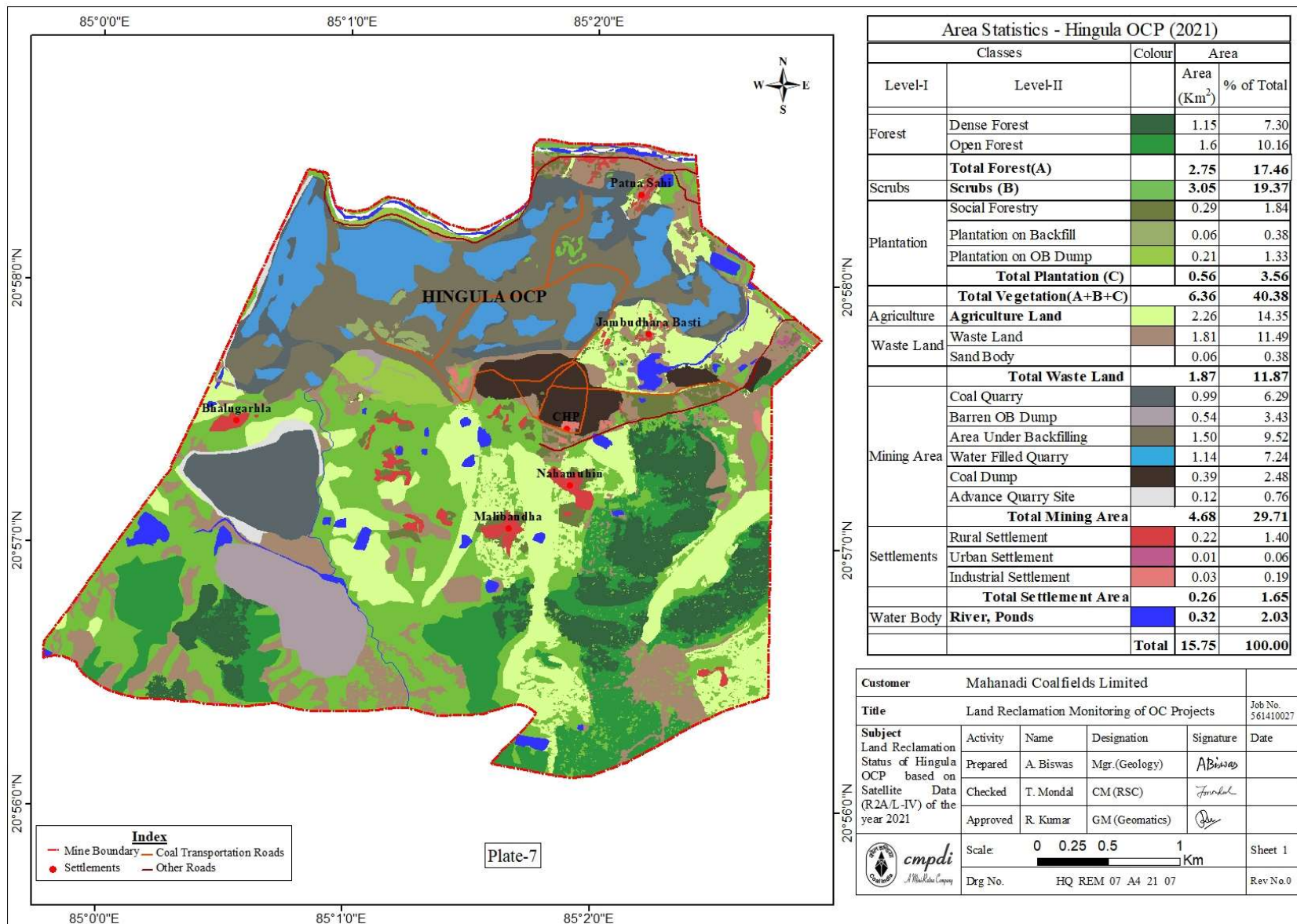
Classes		Colour	Area	
Level-I	Level-II		Area (Km ²)	% of Total
	Open Forest (A)		0.22	3.35
Scrubs	Scrubs (B)		0.39	5.93
	Social Forestry		0.13	1.98
Plantation	Plantation on Backfill		0.02	0.30
	Plantation on OB Dump		0.01	0.08
	Total Plantation (C)		0.16	2.36
	Total Vegetation(A+B+C)		0.77	11.63
Agriculture	Agriculture Land		0.26	3.95
Waste Land	Waste Land		0.32	4.87
Mining Area	Coal Quarry		1.68	25.55
	Barren OB Dump		0.79	12.02
	Area Under Backfilling		2.15	32.70
	Water Filled Quarry		0.33	5.02
	Coal Dump		0.04	0.61
	Advance Quarry Site		0.16	2.43
	Total Mining Area		5.15	78.33
Settlements	Rural Settlement		0.05	0.76
	Industrial Settlement		0.01	0.15
	Total Settlement Area		0.06	0.91
Water Body	River, Ponds		0.02	0.30
	Total		6.58	100.00

Customer	Mahanadi Coal fields Limited				
Title	Land Reclamation Monitoring of OC Projects				Job No. 561410027
Subject	Activity	Name	Designation	Signature	Date
Land Reclamation Status of Bhubaneswari OCP based on Satellite Data (R2A/L-IV) of the year 2021	Prepared	A. Biswas	Mgr.(Geology)	<i>A. Biswas</i>	
	Checked	T.Mondal	CM(RSC)	<i>T.Mondal</i>	
	Approved	R. Kumar	GM(Geomatics)	<i>R. Kumar</i>	
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	Drg No.	HQ REM 07 A4 21 05			Rev No.0



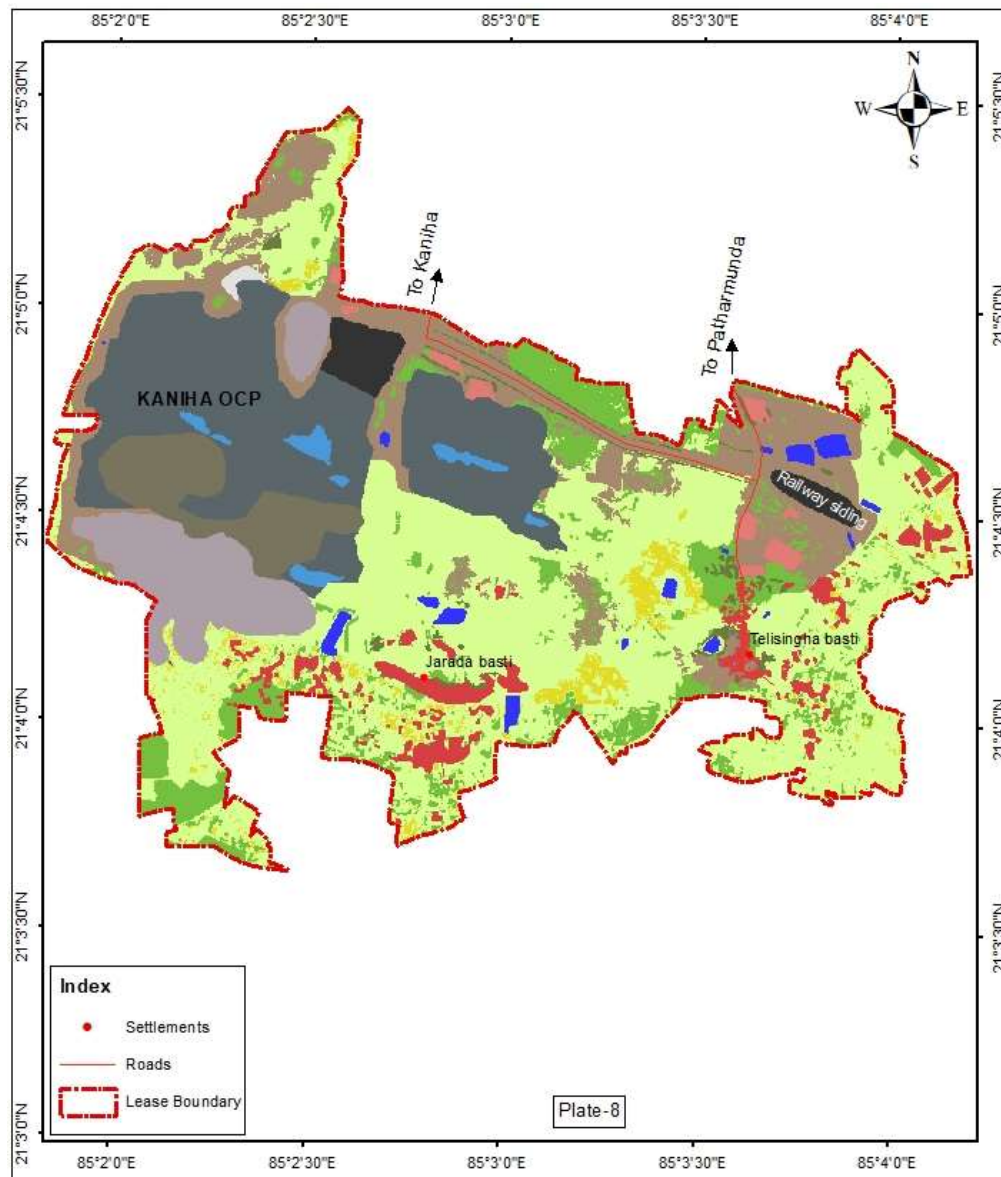
Classes		Colour	Area	
Level-I	Level-II		Area (Km ²)	% of Total
Scrub	Open Forest (A)		0.03	0.54
	Scrub (B)		0.30	5.42
	Social Forestry		0.17	3.07
Plantation	Plantation on Backfill		1.80	32.49
	Total Plantation (C)		1.97	35.56
Total Vegetation(A+B+C)			2.30	41.52
Agriculture	Agriculture Land		0.44	7.94
Waste Land	Waste Land		0.42	7.58
	Ash Pond		0.11	1.99
	Total Waste Land		0.53	9.57
Mining Area	Coal Quarry		0.32	5.78
	Area Under Backfilling		1.00	18.05
	Water Filled Quarry		0.58	10.47
	Coal Dump		0.08	1.44
	Advance Quarry Site		0.08	1.44
Total Mining Area			2.06	37.18
Rural			0.05	0.90
Settlement	Industrial		0.11	1.99
	Total Settlement Area		0.16	2.89
Water Body	River, Ponds		0.05	0.90
Total			5.54	100.00

Customer		Mahanadi Coalfields Limited			
Title		Land Reclamation Monitoring of OC Projects			Job No. 561410027
Subject Land Reclamation Status of Jagannath OCP based on Satellite Data (R2A/L-IV) of the year 2021	Activity	Name	Designation	Signature	Date
	Prepared	A. Biswas	Mgr.(Geology)	<i>ABiswas</i>	
	Checked	T. Mondal	CM(RSC)	<i>Tmondal</i>	
Approved	R. Kumar	HOD (Geomatics)	<i>Rkumar</i>		
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Drg No.		HQ REM 07 A4 21 06			Rev No.0



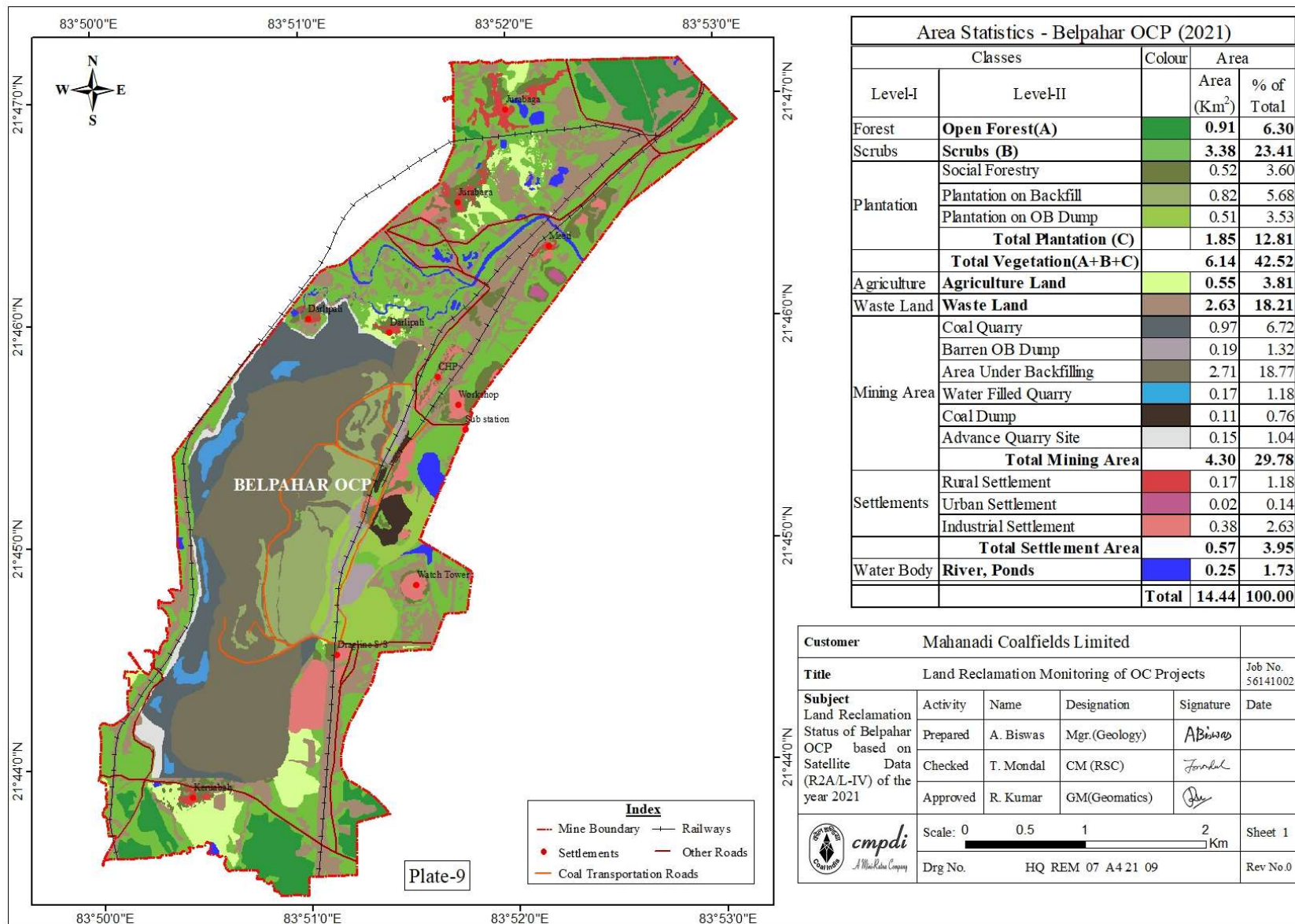
Classes		Colour	Area	
Level-I	Level-II		Area (Km ²)	% of Total
Forest	Dense Forest		1.15	7.30
	Open Forest		1.6	10.16
	Total Forest(A)		2.75	17.46
Scrubs	Scrubs (B)		3.05	19.37
Plantation	Social Forestry		0.29	1.84
	Plantation on Backfill		0.06	0.38
	Plantation on OB Dump		0.21	1.33
	Total Plantation (C)		0.56	3.56
	Total Vegetation(A+B+C)		6.36	40.38
Agriculture	Agriculture Land		2.26	14.35
Waste Land	Waste Land		1.81	11.49
	Sand Body		0.06	0.38
	Total Waste Land		1.87	11.87
Mining Area	Coal Quarry		0.99	6.29
	Barren OB Dump		0.54	3.43
	Area Under Backfilling		1.50	9.52
	Water Filled Quarry		1.14	7.24
	Coal Dump		0.39	2.48
	Advance Quarry Site		0.12	0.76
	Total Mining Area		4.68	29.71
Settlements	Rural Settlement		0.22	1.40
	Urban Settlement		0.01	0.06
	Industrial Settlement		0.03	0.19
	Total Settlement Area		0.26	1.65
Water Body	River, Ponds		0.32	2.03
	Total		15.75	100.00

Customer	Mahanadi Coalfields Limited				
Title	Land Reclamation Monitoring of OC Projects				Job No. 561410027
Subject	Activity	Name	Designation	Signature	Date
Land Reclamation Status of Hingula OCP based on Satellite Data (R2A/L-IV) of the year 2021	Prepared	A. Biswas	Mgr.(Geology)	<i>A. Biswas</i>	
	Checked	T. Mondal	CM (RSC)	<i>T. Mondal</i>	
	Approved	R. Kumar	GM (Geomatics)	<i>R. Kumar</i>	
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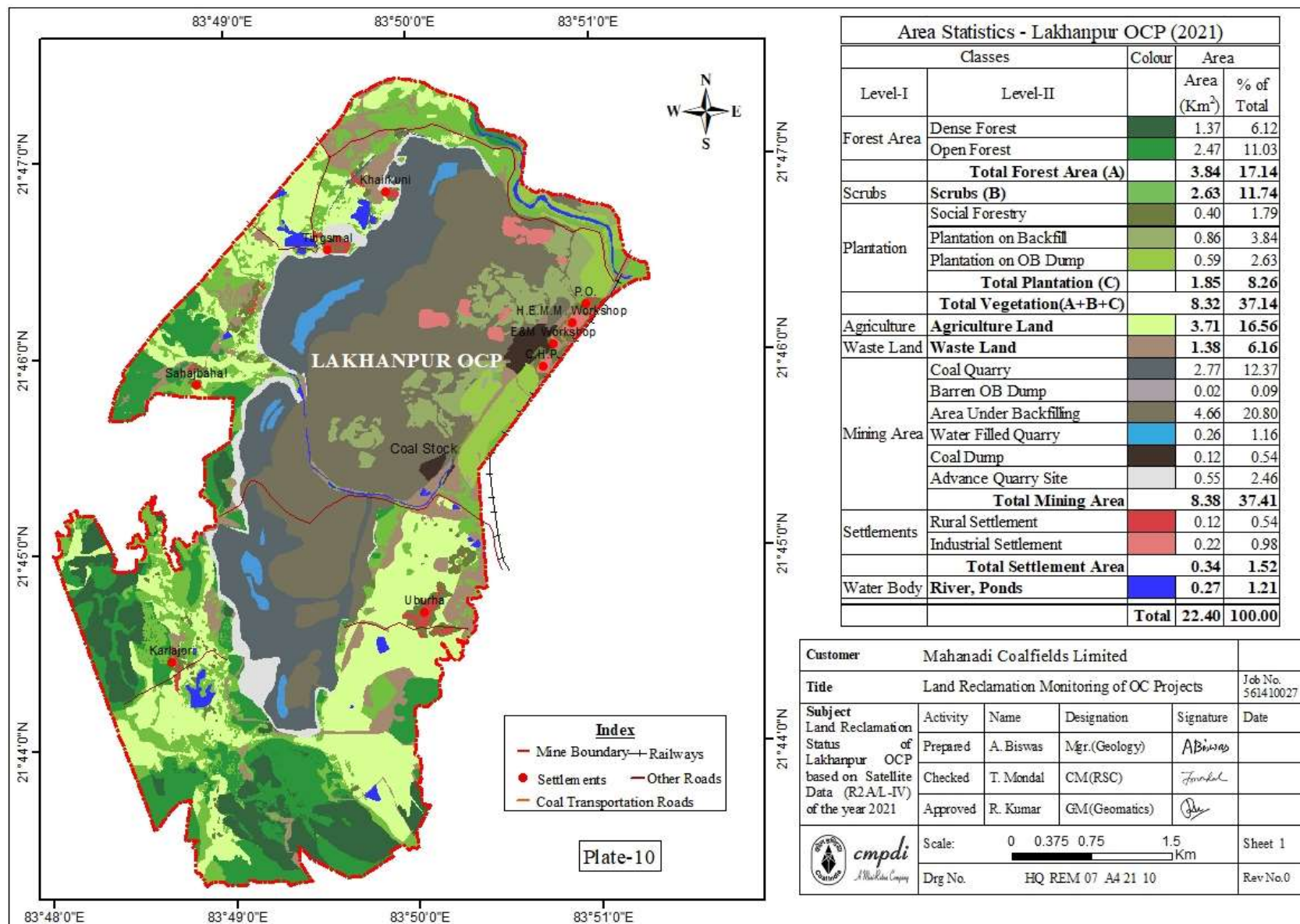


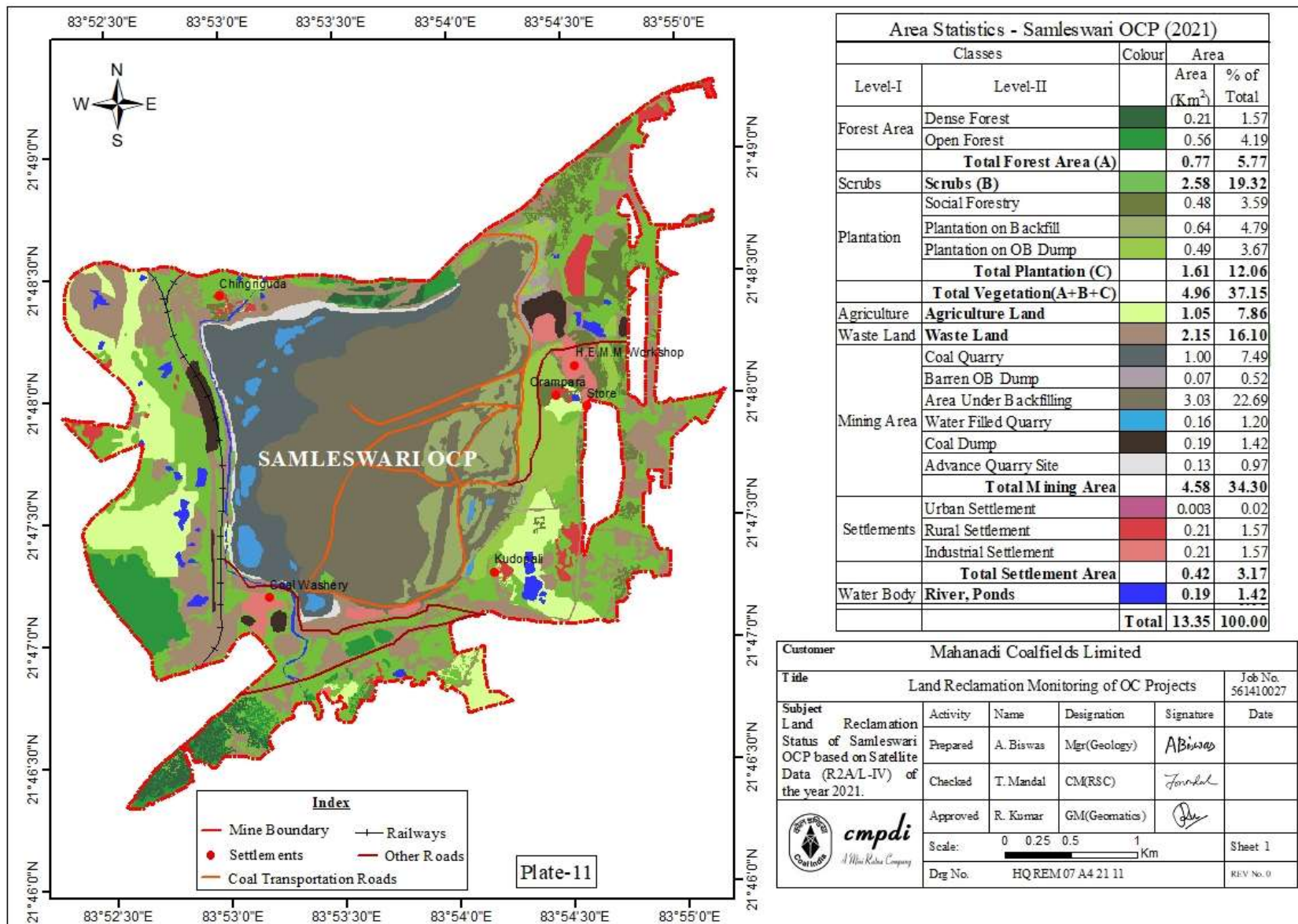
Area Statistics - Kaniha OC (2021)				
Level-I	Level-II	Colour	Core Zone	
			Area (sqkm)	% of Total
Forests	Dense Forest		0.00	0.00
	Open Forest		0.00	0.00
	Total Forest (A)		0.00	0.00
	Scrubs (B)		0.73	10.17
Plantation Area	Social Forestry		0.07	0.97
	Plantation on OB		0.00	0.00
	Plantation on Backfill		0.00	0.00
	Total Plantation (C)		0.07	0.97
	Total Vegetation (A+B+C)		0.80	11.14
Agriculture Land	Crop land		0.20	2.79
	Fallow Land		2.71	37.74
	Total Agriculture Land		2.91	40.53
Waste Land	Waste Land		1.00	13.93
	Fly Ash Pond		0.00	0.00
	Total Waste Land		1.00	13.93
Mining Area	Advance Quarry Area		0.01	0.14
	Coal Quarry		1.17	16.29
	Barren OB Dump		0.42	5.85
	Back Fill		0.31	4.32
	Coal Dump		0.12	1.67
	Water Filled Qry		0.06	0.84
	Total Mining Area		2.09	29.11
Settlements	Urban Settlements		0.00	0.00
	Rural Settlements		0.25	3.48
	Industrial Settlements		0.06	0.84
	Total Settlement Area		0.31	4.32
Water Body	River/ Ponds		0.07	0.97
	Total Area		7.18	100.00

Customer	Mahanadi Coalfields Limited				
Title	Land Reclamation Monitoring of OC Projects				Job No. 561410027
Subject Land	Activity	Name	Designation	Signature	Date
Reclamation Status of Kaniha OCP based on Satellite Data (IRS R2 L-IV) of the year 2021.	Prepared	A. Parida	Dy. Manager (Geology)		
	Checked	B. K Choudhary	CM/RSC		
	Approved	R. Kumar	GM (Geomatics)		
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Customer		Mahanadi Coalfields Limited			
Title		Land Reclamation Monitoring of OC Projects			Job No. 561410027
Subject Land Reclamation Status of Belpahar OCP based on Satellite Data (R2A/L-IV) of the year 2021	Activity	Name	Designation	Signature	Date
	Prepared	A. Biswas	Mgr.(Geology)	<i>ABiswas</i>	
	Checked	T. Mondal	CM (RSC)	<i>Tmondal</i>	
Approved	R. Kumar	GM(Geomatics)	<i>Rkumar</i>		
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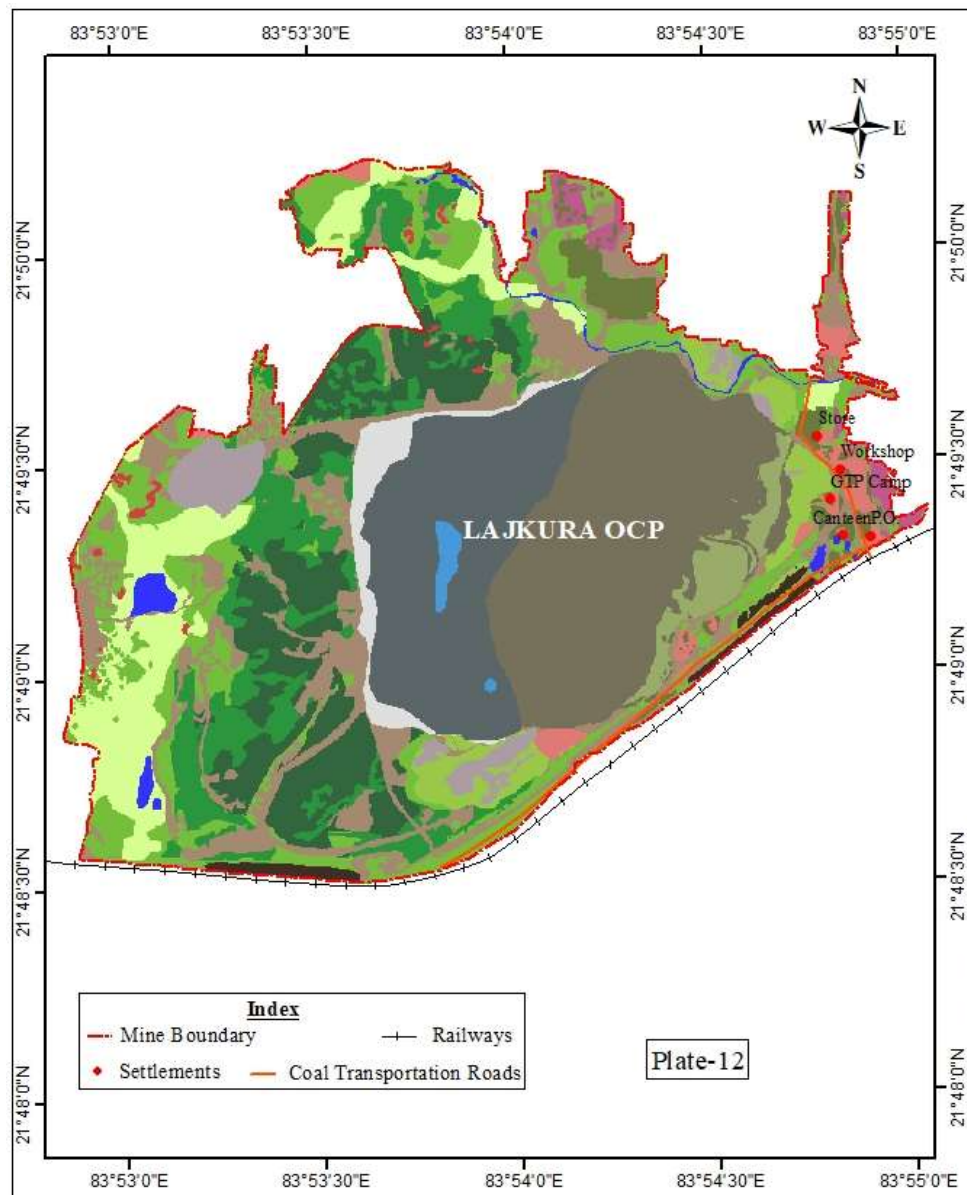



Plate-12

Area Statistics - Lajkura OCP (2021)				
Classes		Colour	Area	
Level-I	Level-II		Area (Km ²)	% of Total
Forest Area	Dense Forest		0.70	9.71
	Open Forest		0.69	9.57
	Total Forest Area (A)		1.39	19.28
Scrubs	Scrubs (B)		0.98	13.59
	Social Forestry		0.16	2.22
Plantation	Plantation on Backfill		0.15	2.08
	Plantation on OB Dump		0.20	2.77
	Total Plantation (C)		0.51	7.07
Total Vegetation(A+B+C)			2.88	39.94
Agriculture	Agriculture Land		0.54	7.49
Waste Land	Waste Land		0.98	13.59
	Coal Quarry		0.85	11.79
Mining Area	Barren OB Dump		0.18	2.50
	Area Under Backfilling		1.24	17.20
	Water Filled Quarry		0.03	0.42
	Coal Dump		0.07	0.97
	Advance Quarry Site		0.14	1.94
	Total Mining Area		2.51	34.81
	Settlement	Urban Settlement		0.08
Rural Settlement			0.03	0.42
Industrial			0.12	1.66
Total Settlement Area			0.23	3.19
Water Body	River, Ponds		0.07	0.97
Total			7.21	100.00

Customer		Mahanadi Coalfields Limited			
Title		Land Reclamation Monitoring of OC Projects			Job No. 561410027
Subject Land Reclamation Status of Lajkura OCP based on Satellite Data (R2A/L-IV) of the year 2021	Activity	Name	Designation	Signature	Date
	Prepared	A. Biswas	Mgr.(Geology)	<i>ABiswas</i>	
	Checked	T. Mondal	CM(RSC)	<i>Tmondal</i>	
	Approved	R. Kumar	GM(Geomatics)	<i>Rkumar</i>	
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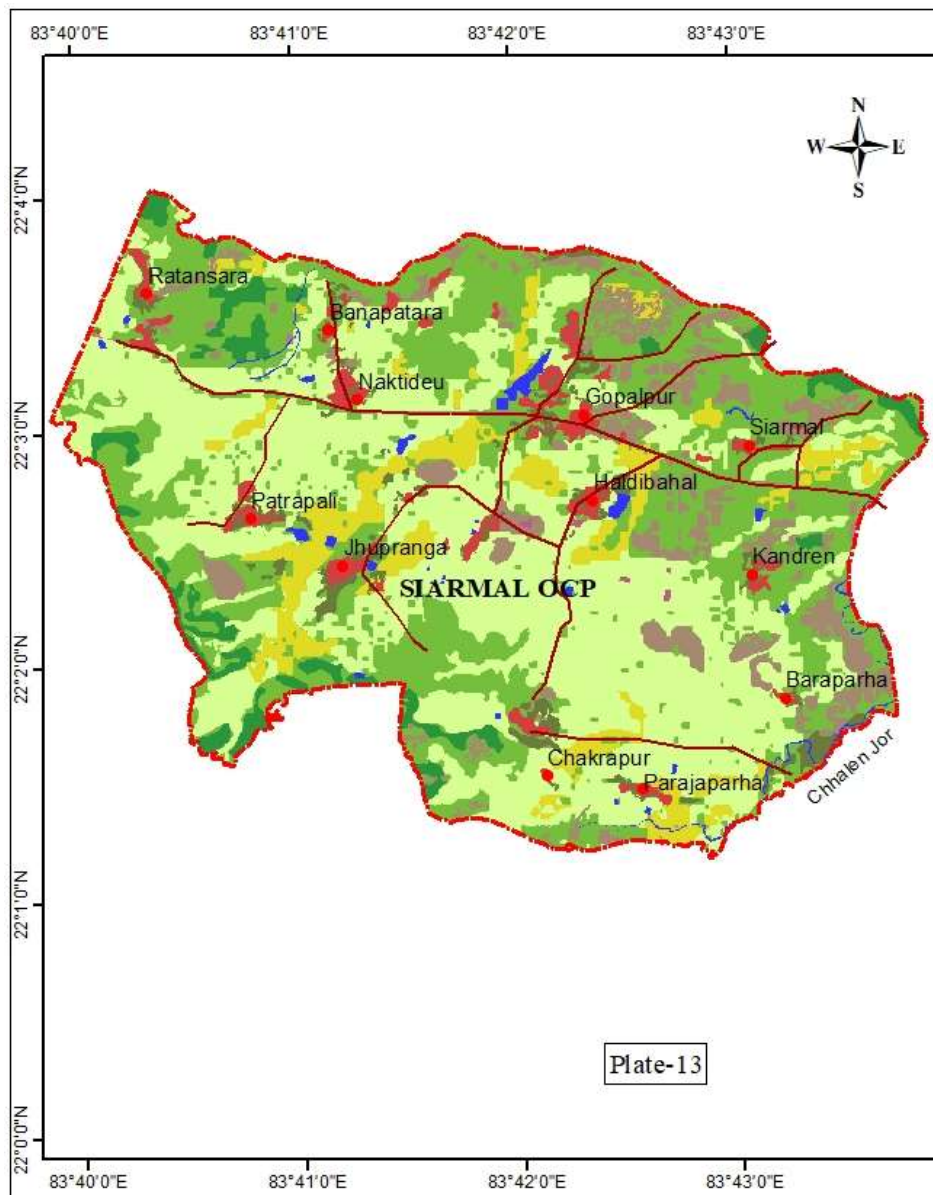
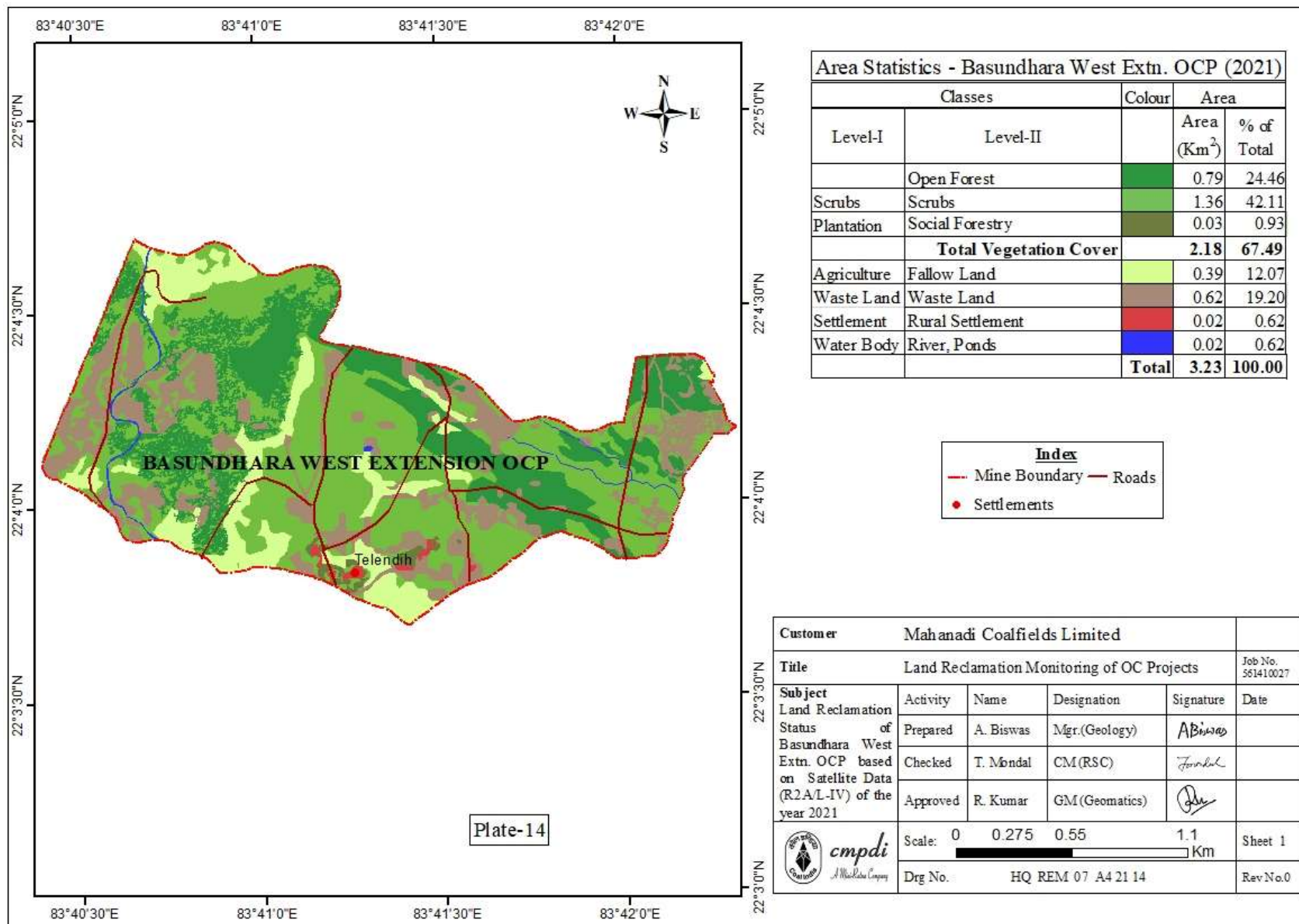


Plate-13

Classes		Colour	Area	
Level-I	Level-II		Area (Km ²)	% of Total
	Open Forest		0.87	3.80
Scrubs	Scrubs		7.21	31.48
Plantation	Social Forestry		0.60	2.62
Total Vegetation Cover			8.68	37.90
Agriculture	Fallow Land		9.62	42.01
	Crop Land		1.74	7.60
Total Agriculture Land			11.36	49.61
Waste Land	Waste Land		1.93	8.43
Settlement	Rural Settlement		0.69	3.01
	Urban settlement		0.02	0.09
Total Settlement Area			0.71	3.10
Water Body	River, Ponds		0.22	0.96
Total			22.90	100.00

	Mine Boundary
	Settlements
	Roads

Customer		Mahanadi Coalfields Limited			
Title		Land Reclamation Monitoring of OC Projects			
		Job No. 561410027			
Subject Land Reclamation Status of Siarmal OCP based on Satellite Data (R2AL-IV) of the year 2021	Activity	Name	Designation	Signature	Date
	Prepared	A. Biswas	Mgr.(Geology)		
	Checked	T. Mondal	CM(RSC)		
Approved	R. Kumar	GM(Geomatics)			
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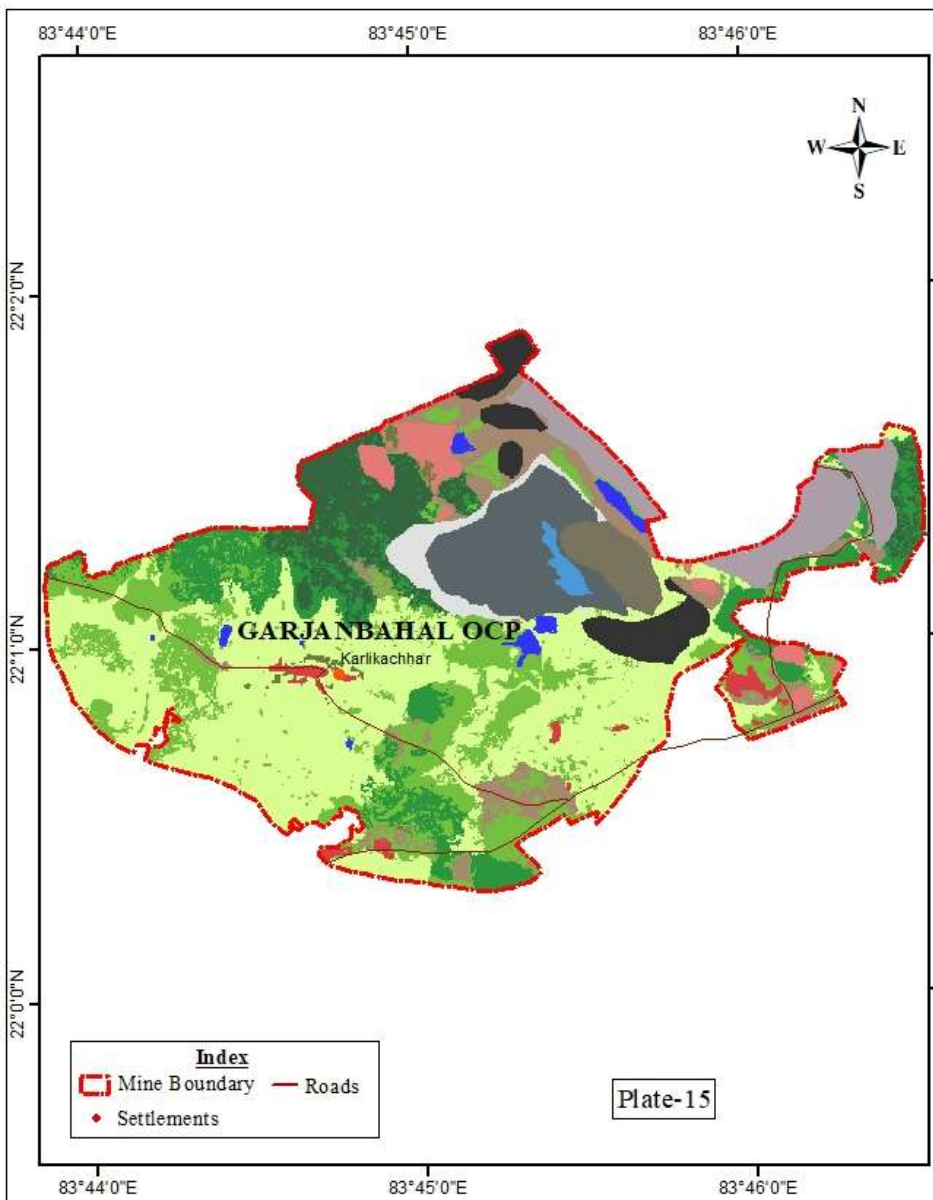

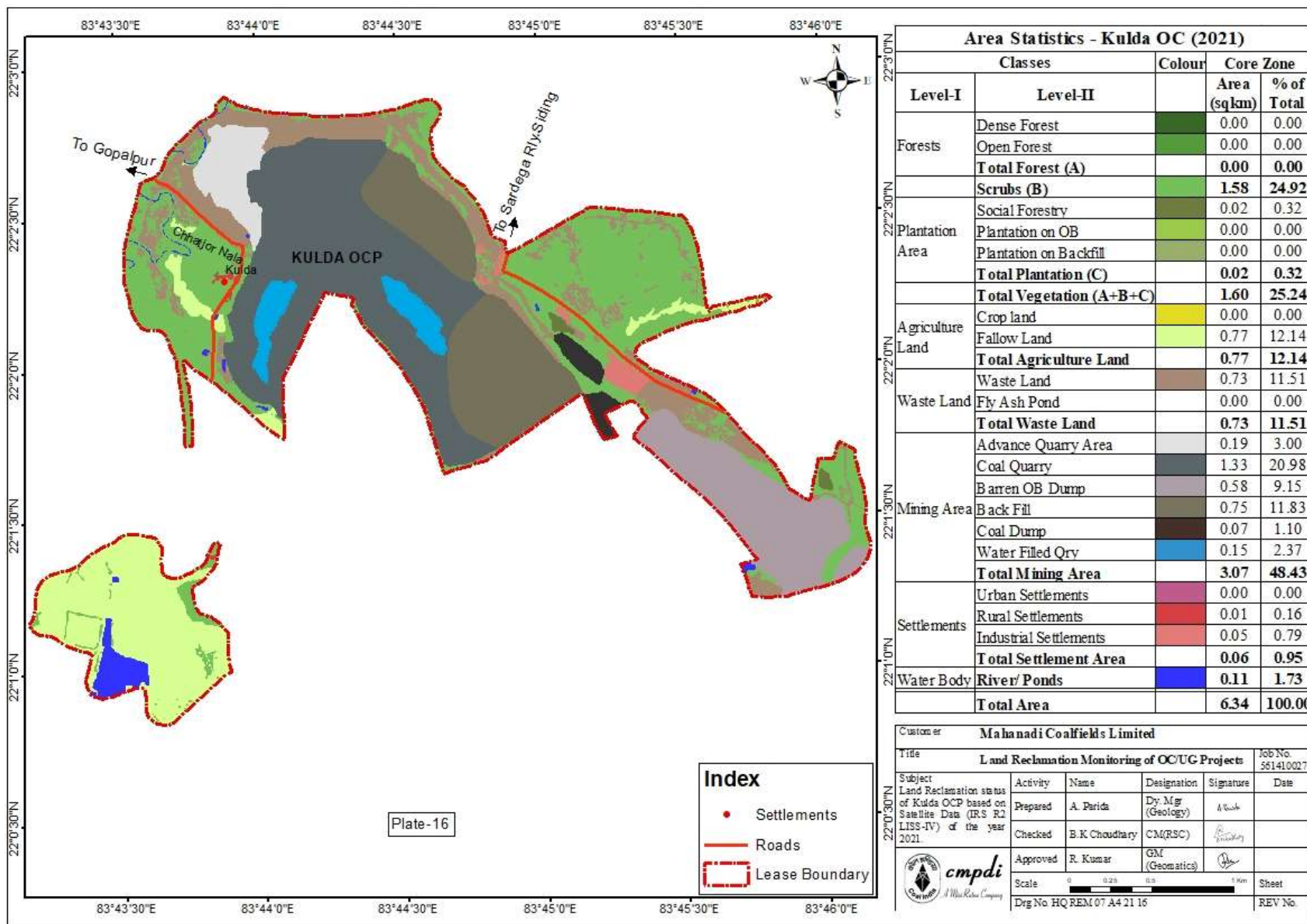


Plate-15

Area Statistics - Garjanbahal OCP (2021)				
Classes		Colour	Area	
Level-I	Level-II		Area (K.m ²)	% of Total
Forest Area	Dense Forest		0.43	6.57
	Open Forest		0.66	10.09
	Total Forest Area (A)		1.09	16.67
Scrubs	Scrubs (B)		1.14	17.43
	Social Forestry		0.03	0.46
Plantation	Plantation on Backfill		0.00	0.00
	Plantation on OB Dump		0.00	0.00
	Total Plantation (C)		0.03	0.46
Total Vegetation(A+B+C)			2.26	34.56
Agriculture	Agriculture Land		2.20	33.64
Waste Land	Waste Land		0.43	6.57
	Coal Quarry		0.43	6.57
Mining Area	Barren OB Dump		0.41	6.27
	Area Under Backfilling		0.14	2.14
	Water Filled Quarry		0.03	0.46
	Coal Dump		0.25	3.82
	Advance Quarry Site		0.12	1.83
	Total Mining Area		1.38	21.10
Settlements	Rural Settlement		0.07	1.07
	Industrial Settlement		0.14	2.14
	Total Settlement Area		0.21	3.21
Water Body	River, Ponds		0.06	0.92
Total			6.54	100.00

Customer		Mahanadi Coalfields Limited			
Title		Land Reclamation Monitoring of OC Projects			Job No. 561410027
Subject Land Reclamation Status of Garjanbahal OCP based on Satellite Data (R2A/L-IV) of the year 2021	Activity	Name	Designation	Signature	Date
	Prepared	A. Biswas	Mgr.(Geology)	<i>ABiswas</i>	
	Checked	T. Mondal	CM(RSC)	<i>Tmondal</i>	
	Approved	R. Kumar	GM(Geomatics)	<i>Rkumar</i>	
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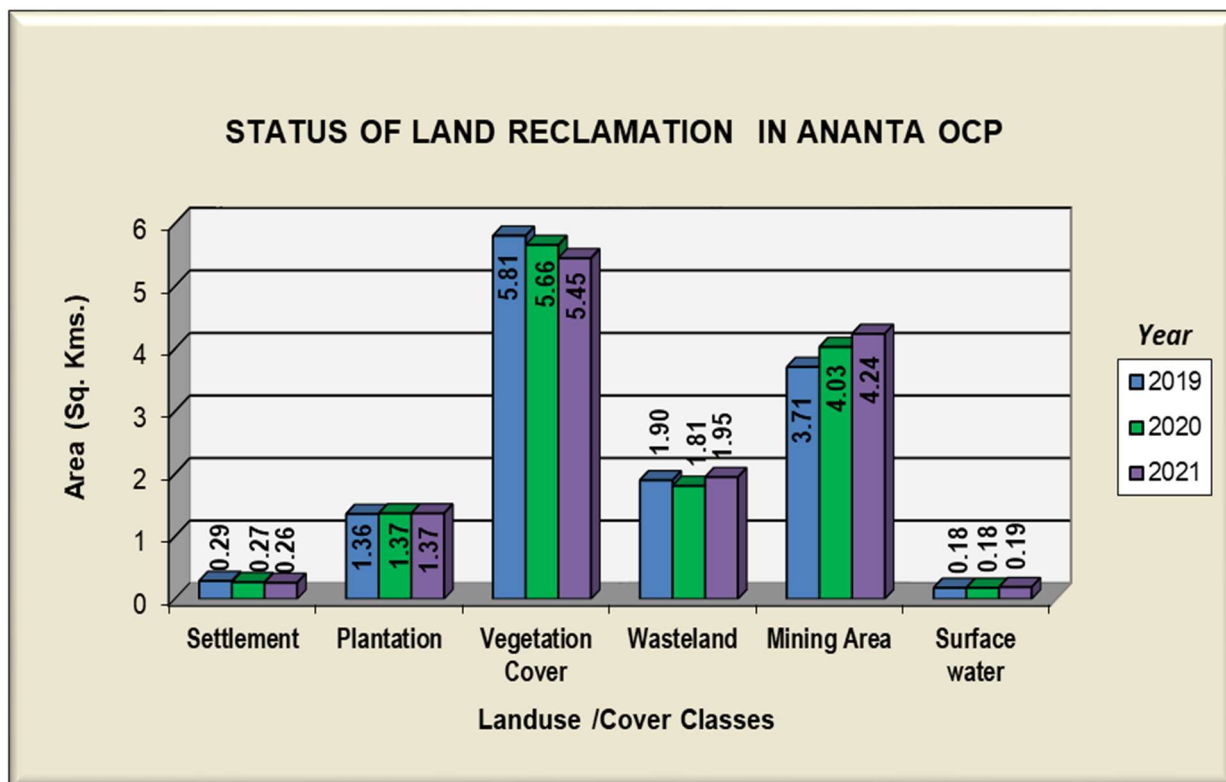


Figure 3

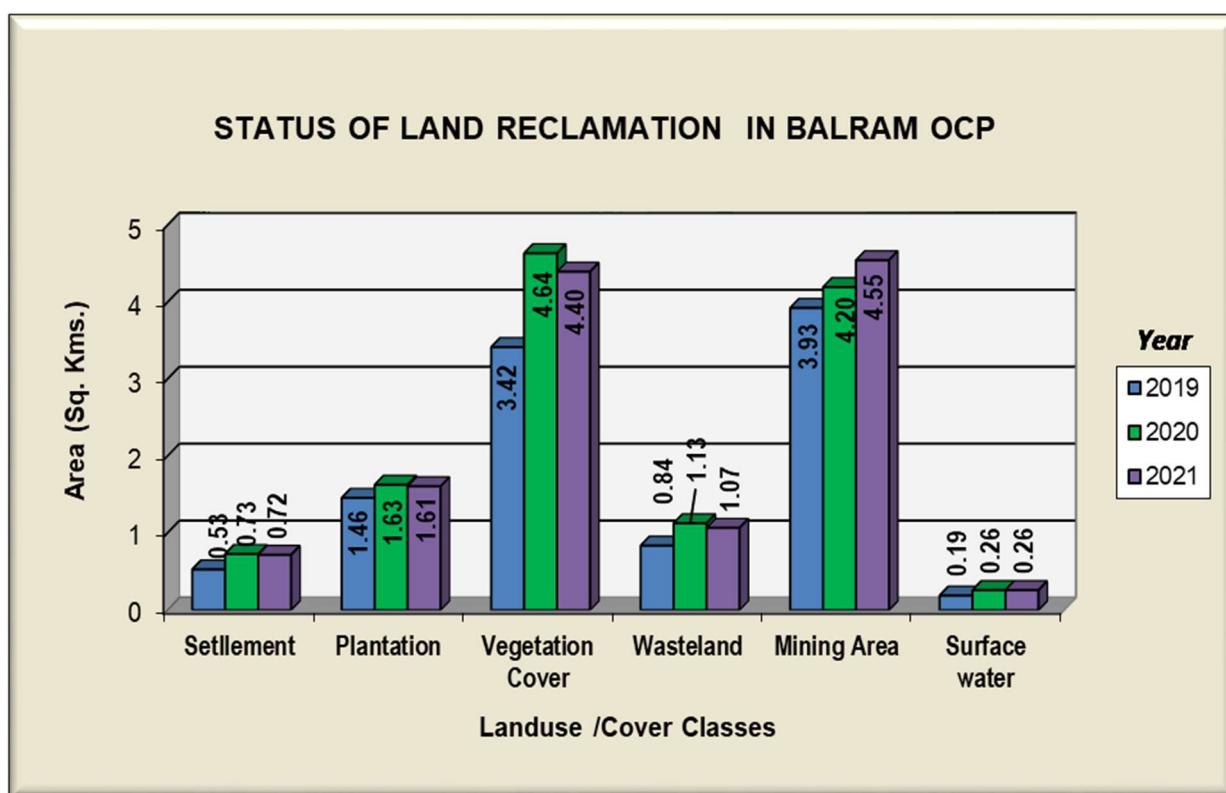


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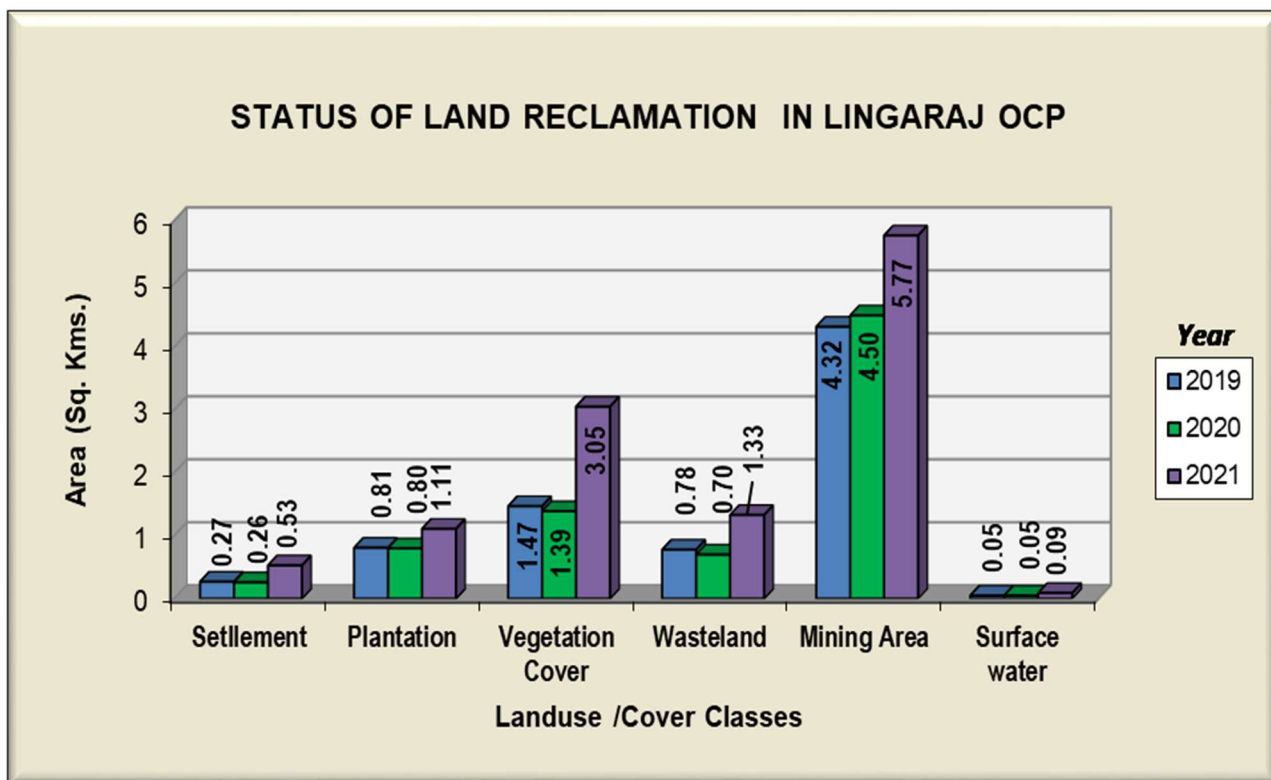


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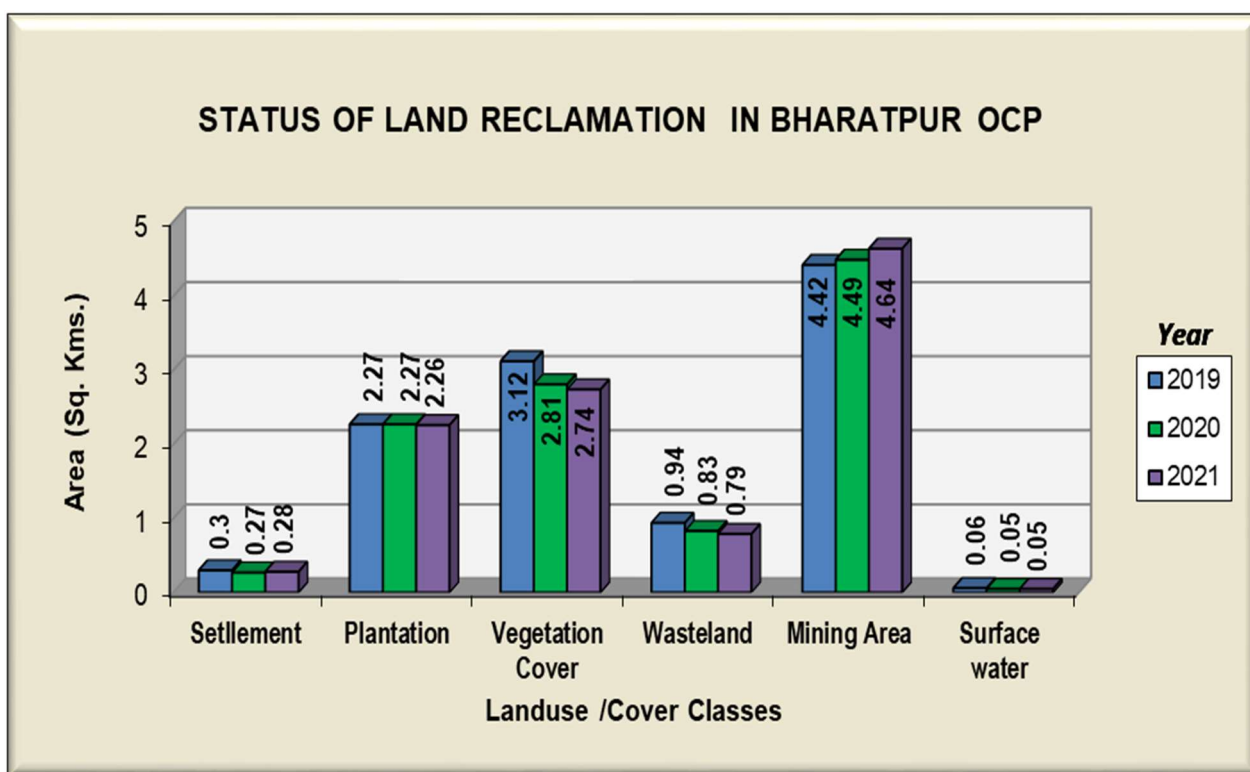


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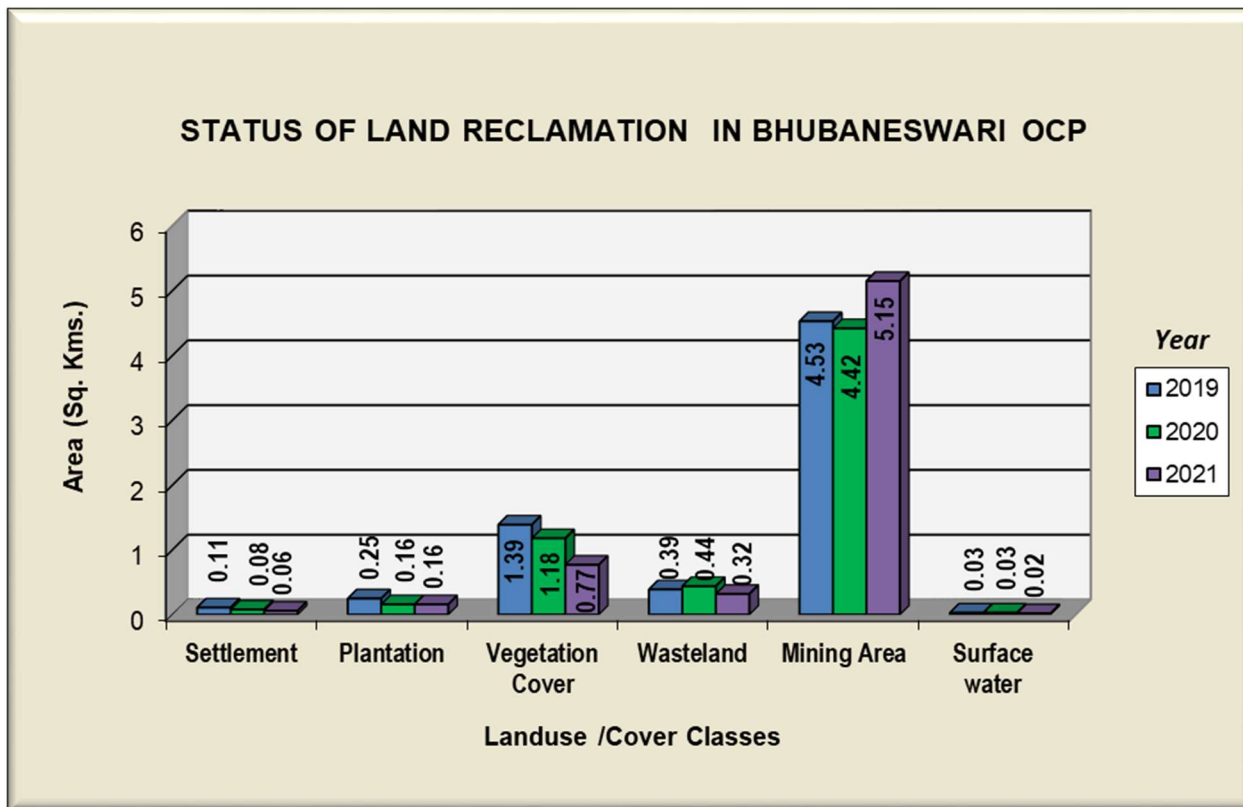


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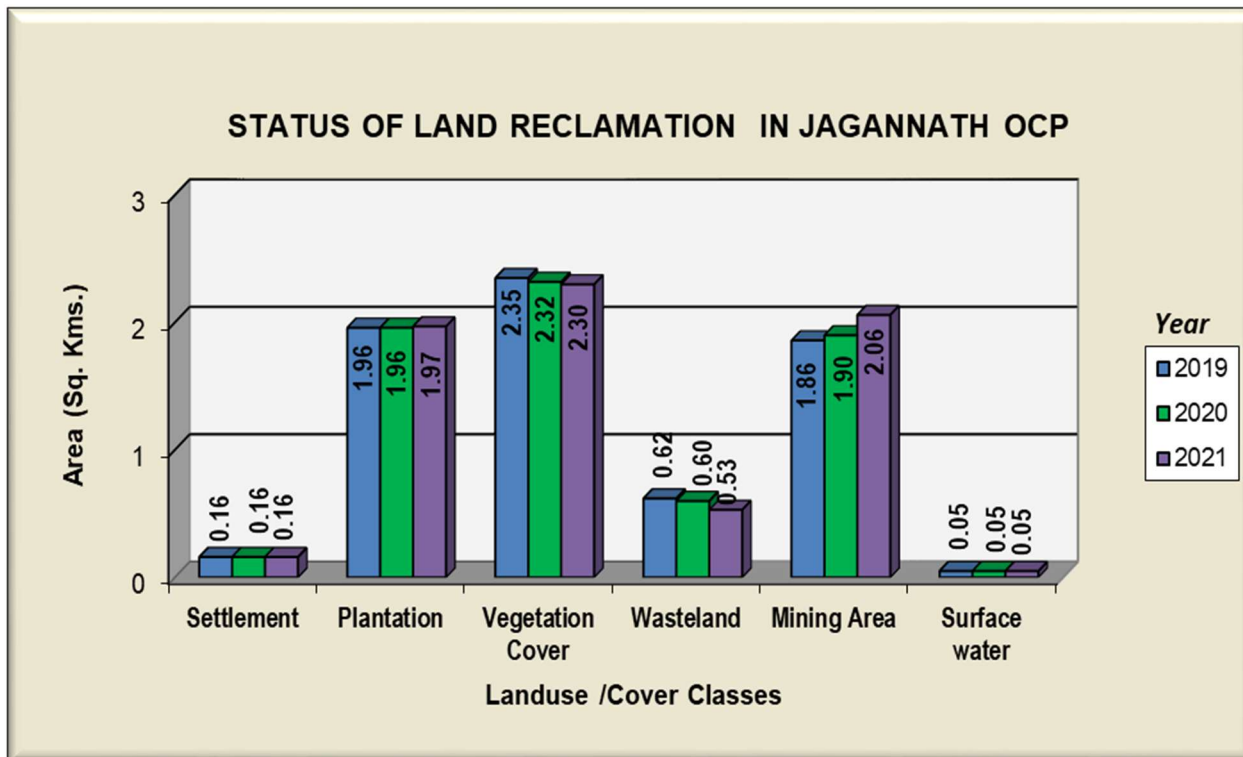


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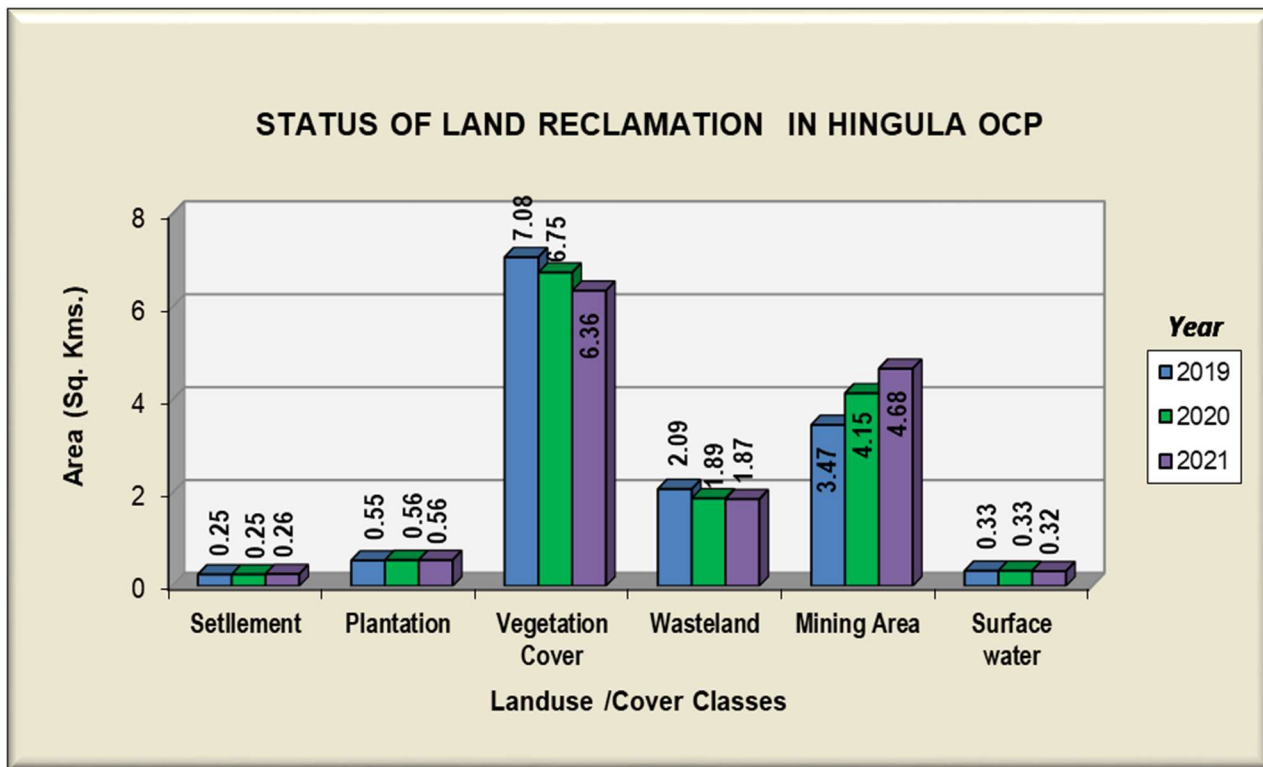


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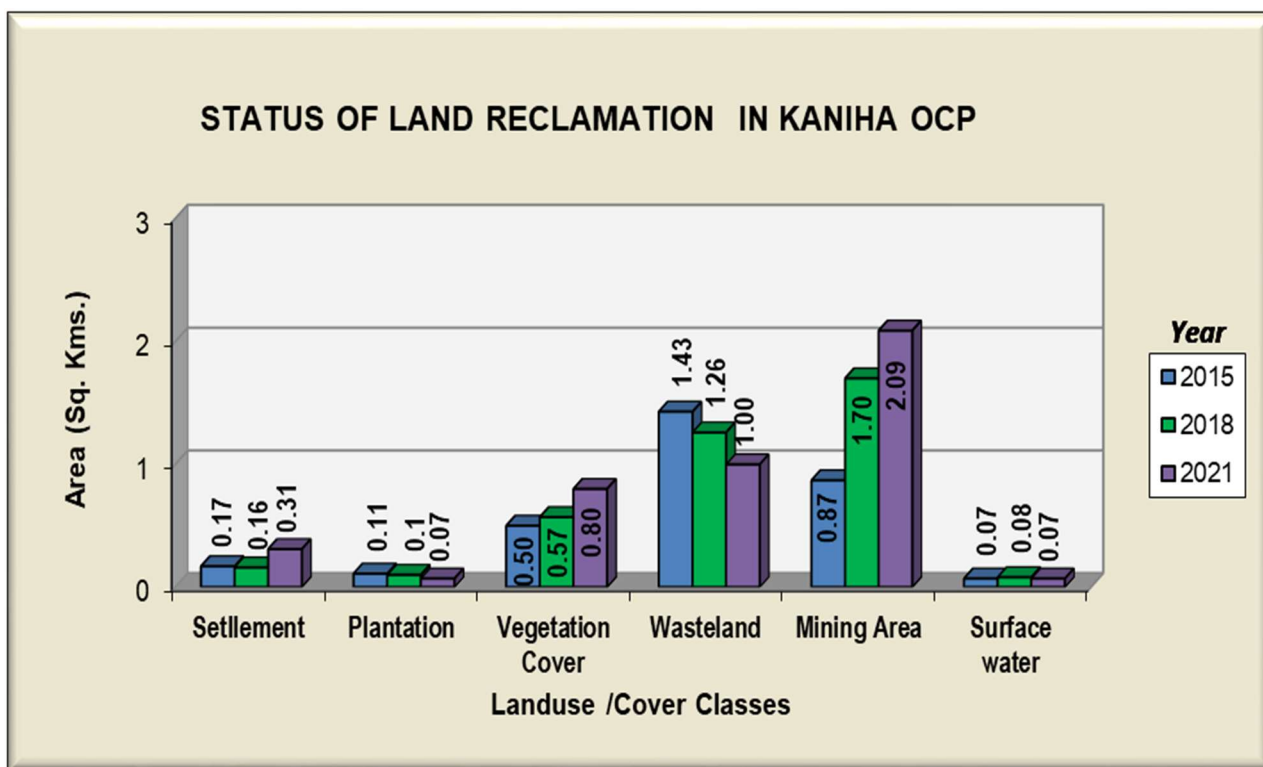


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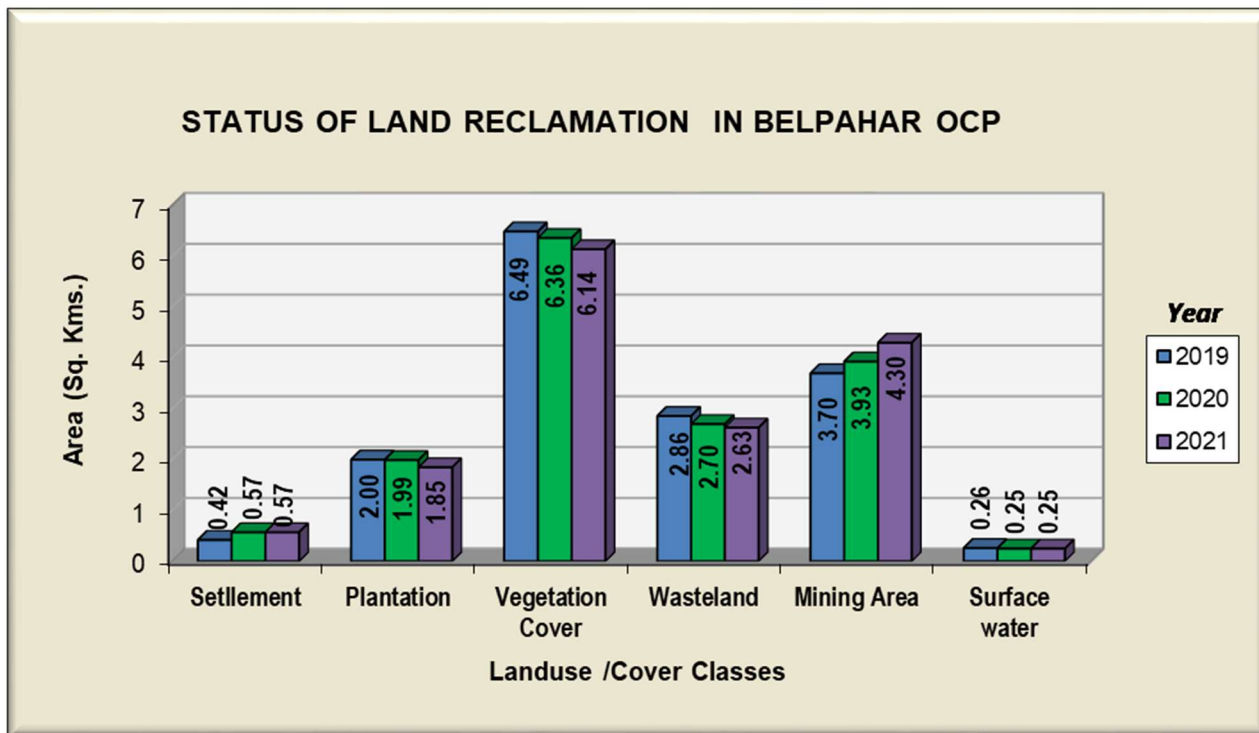


Figure 11

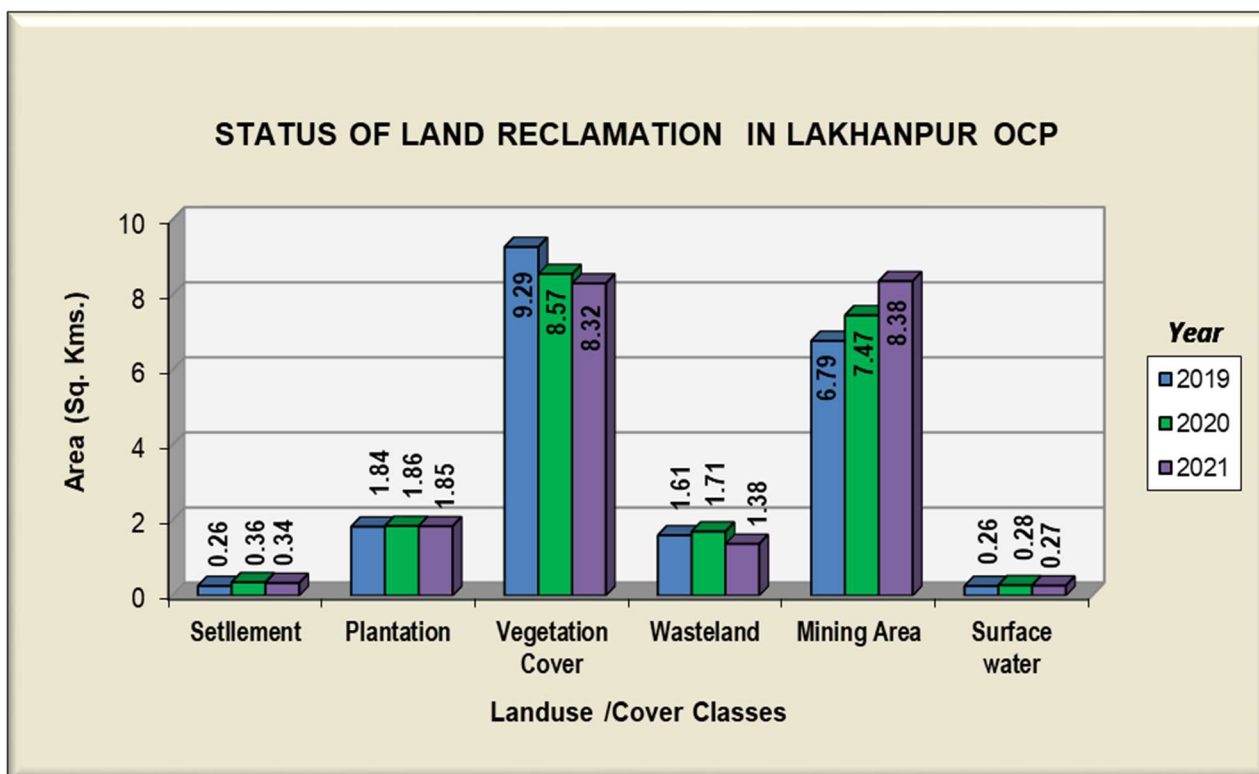


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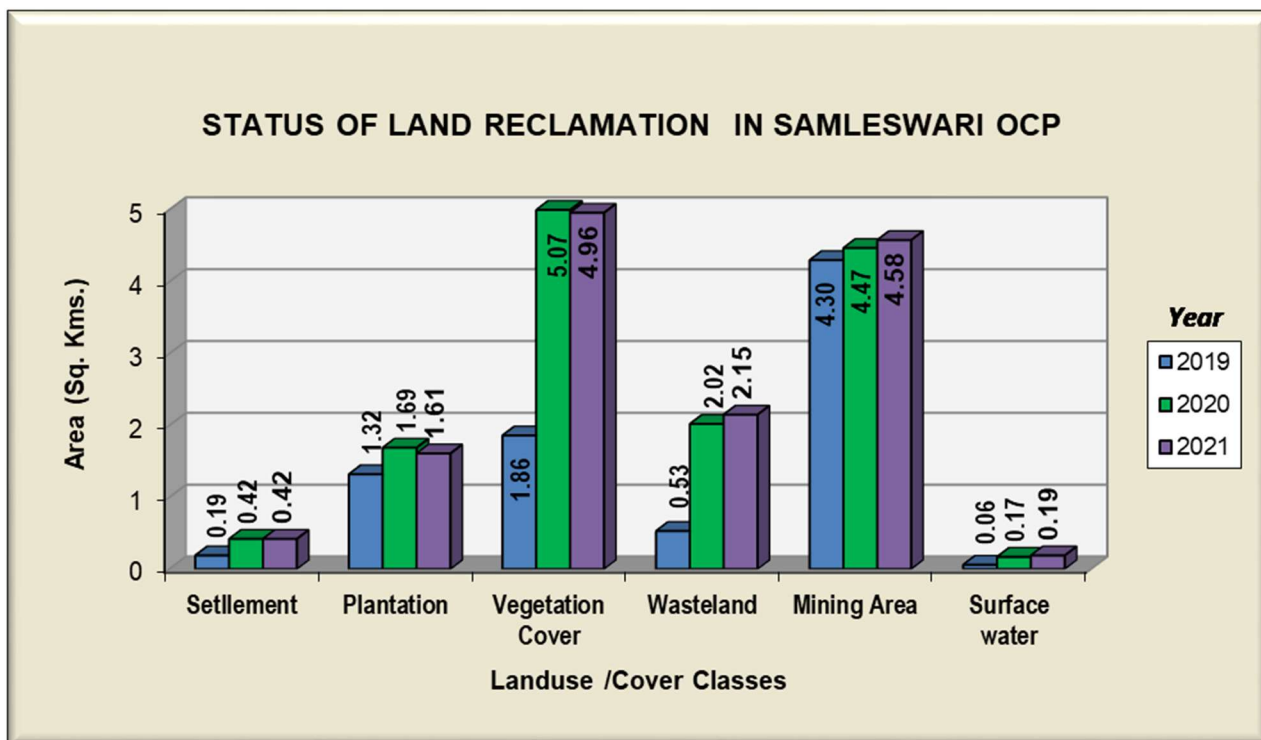


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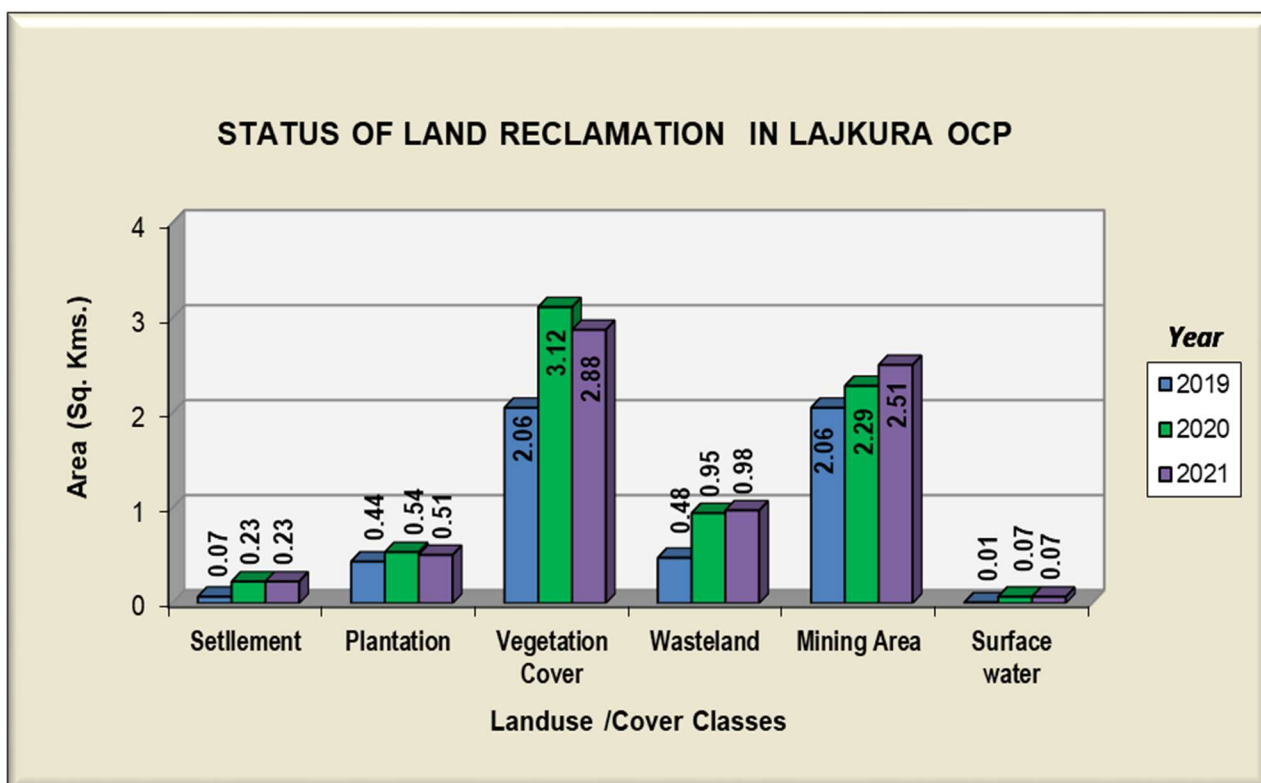


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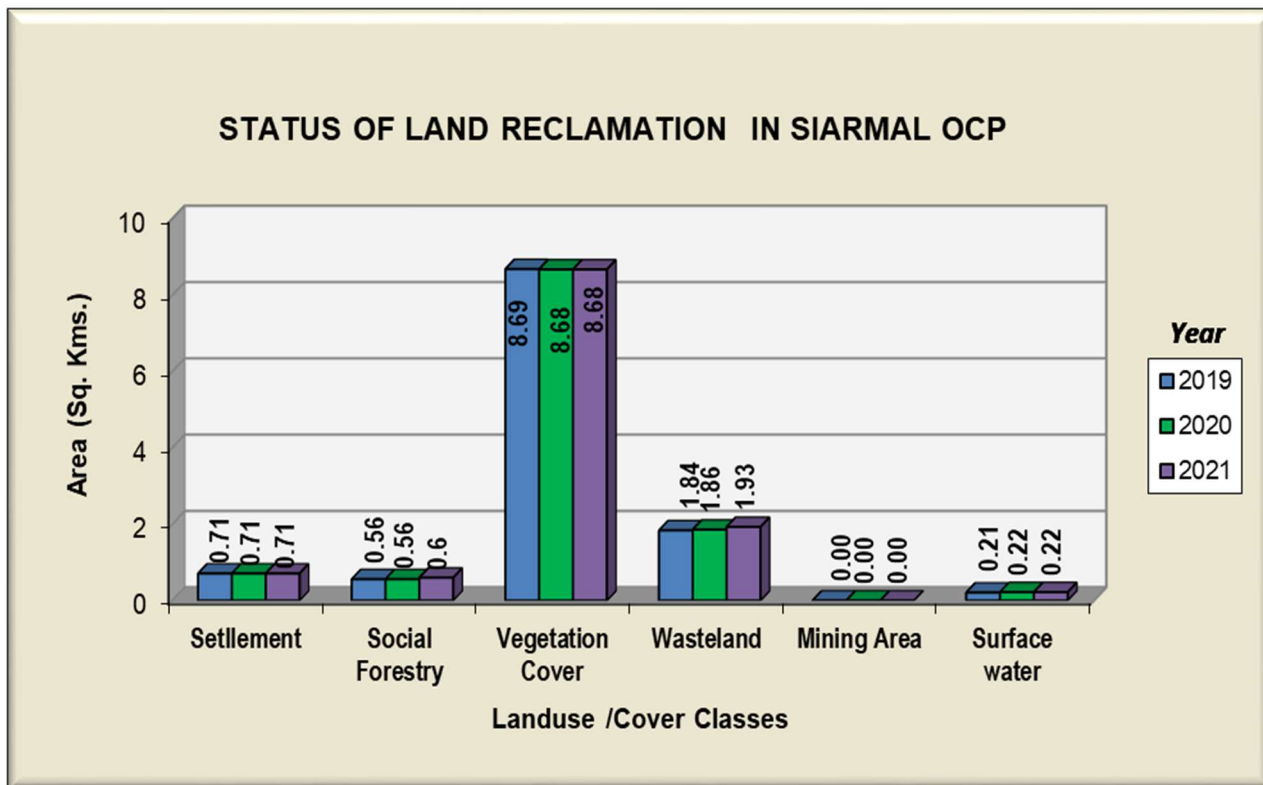


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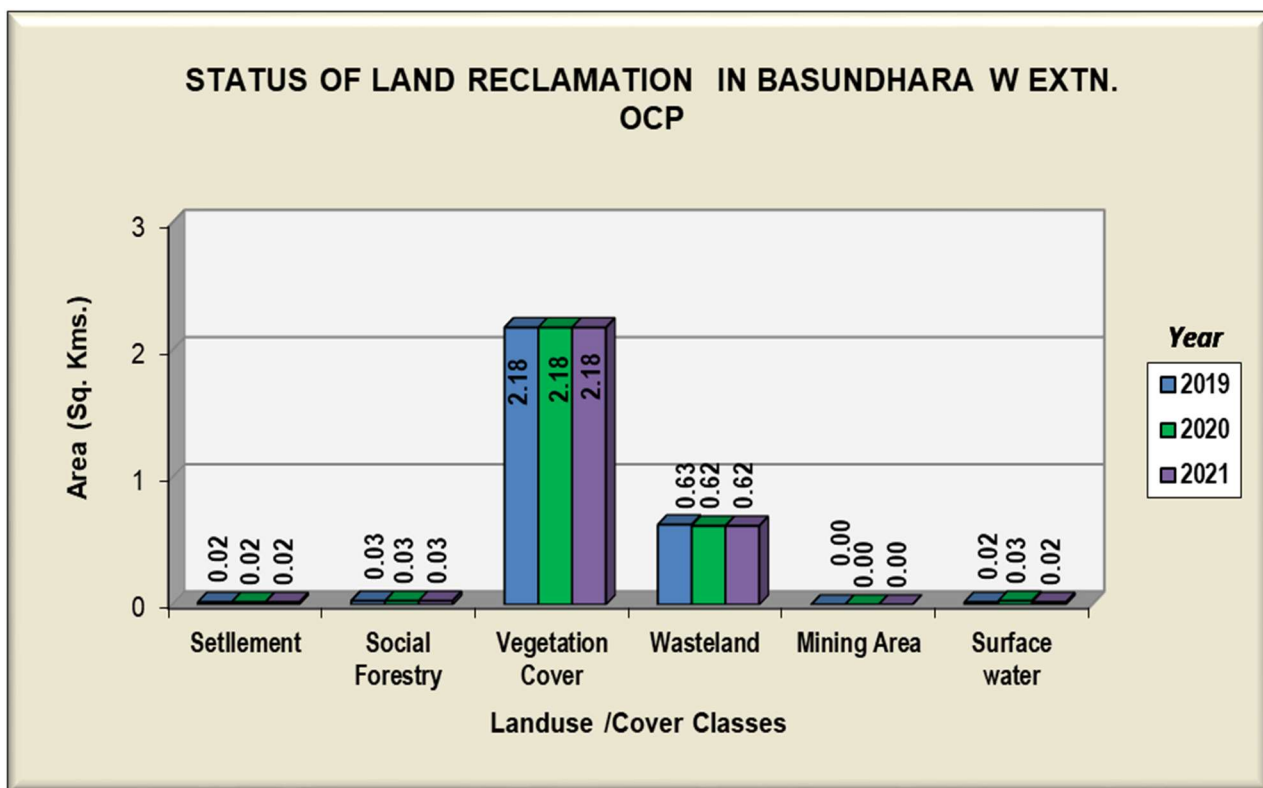


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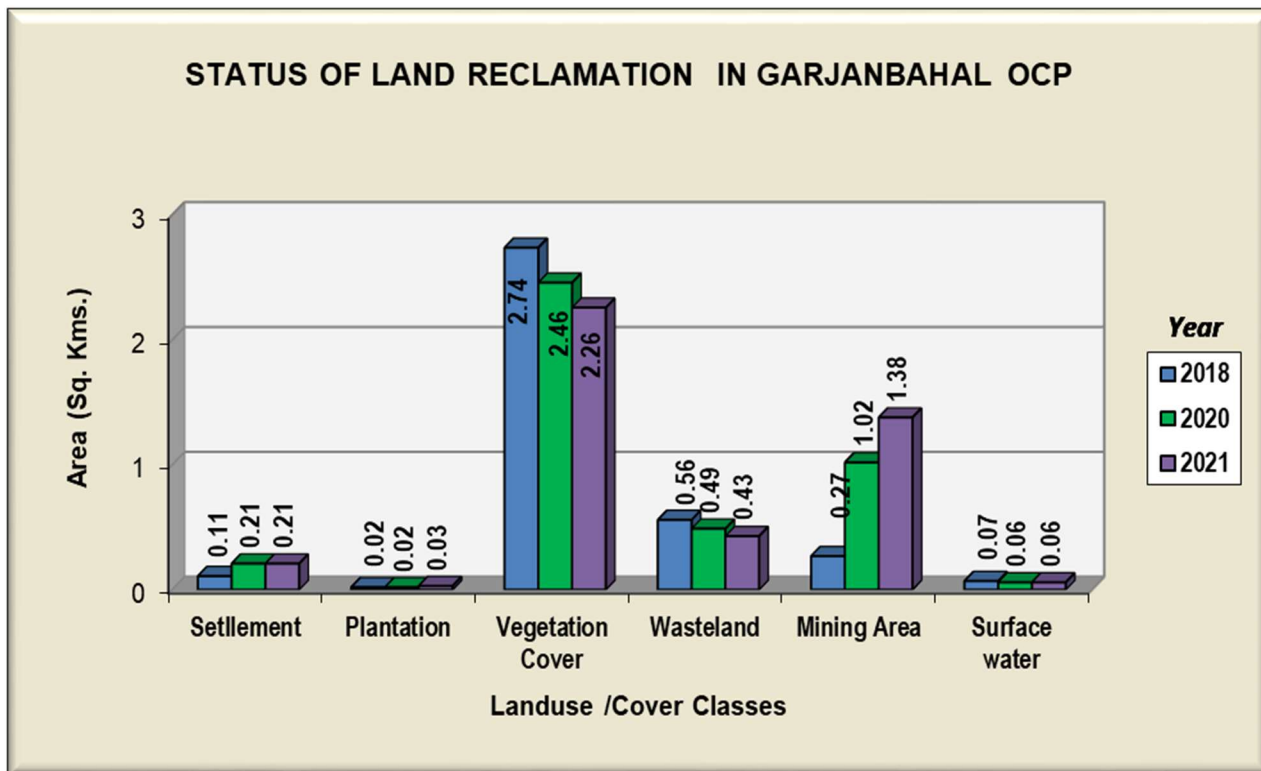


Figure 17

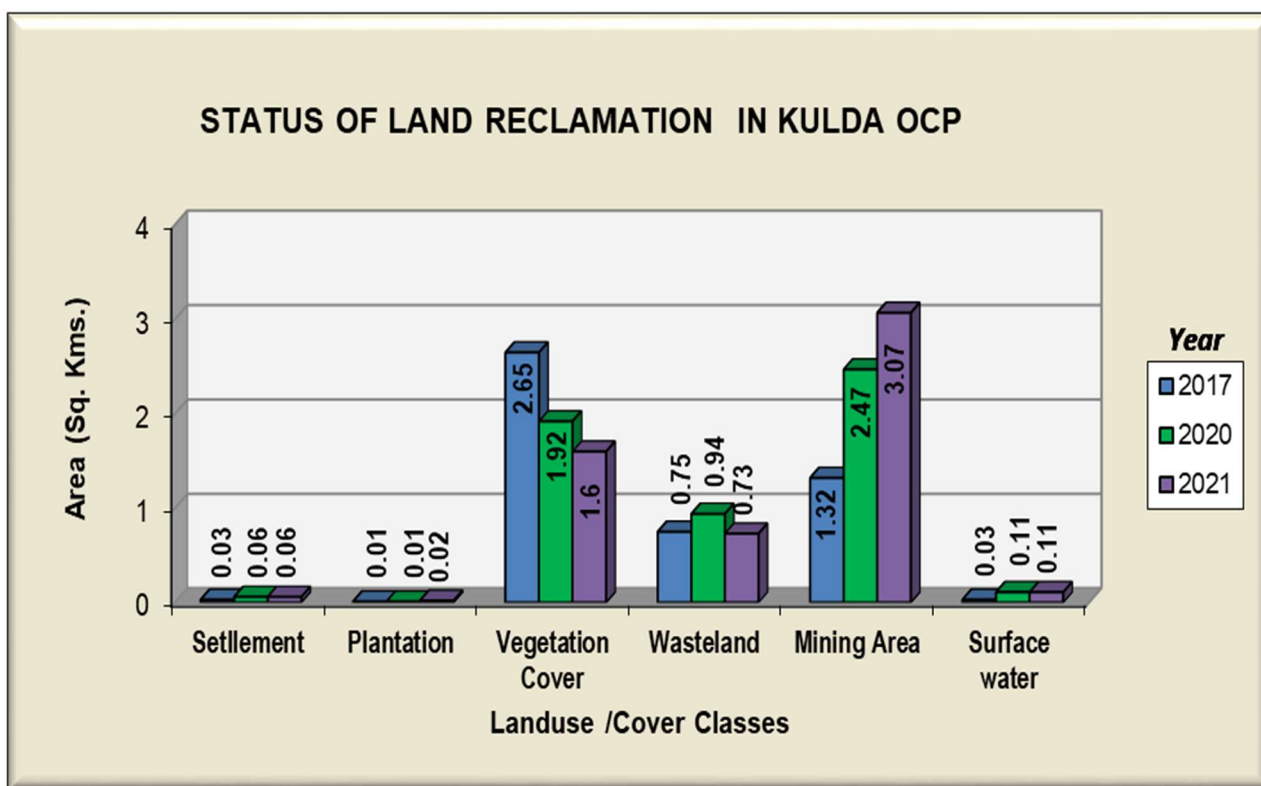


Figure 18



Photograph-1: Plantation on Internal OB/Backfill (Ananta OC mine)



Photograph-2: Plantation on Internal OB/Backfill (Balram OC Mine)



Photograph-3: Plantation on Internal OB/Backfill (Lingaraj OC Mine)



Photograph-4: Plantation on Internal OB/Backfill (Bharatpur OC Mine)



Photograph-5: Plantation on Internal OB/Backfill (Bhubaneswari OC Mine)



Photograph-6: Plantation on External OB (Bhubaneswari OC Mine)



Photograph-7: Plantation on Internal OB/Backfill (Jagannath OC Mine)



Photograph-8: Plantation on Internal OB/Backfill (Hingula OC Mine)



Photograph-9: Avenue Plantation of Kaniha OC Mine



Photograph-10: Plantation on Internal OB/Backfill (Belpahar OC Mine)



Photograph-11: Plantation on Internal OB/Backfill (Lakhanpur OC Mine)



Photograph-12: Plantation on Internal OB/Backfill (Samleswari OC Mine)



Photograph-13: Plantation on Internal OB/Backfill (Lajkura OC Mine)



Photograph-14: Plantation on Internal OB/Backfill (Kulda OC Mine)



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Central Mine Planning & Design Institute Ltd.

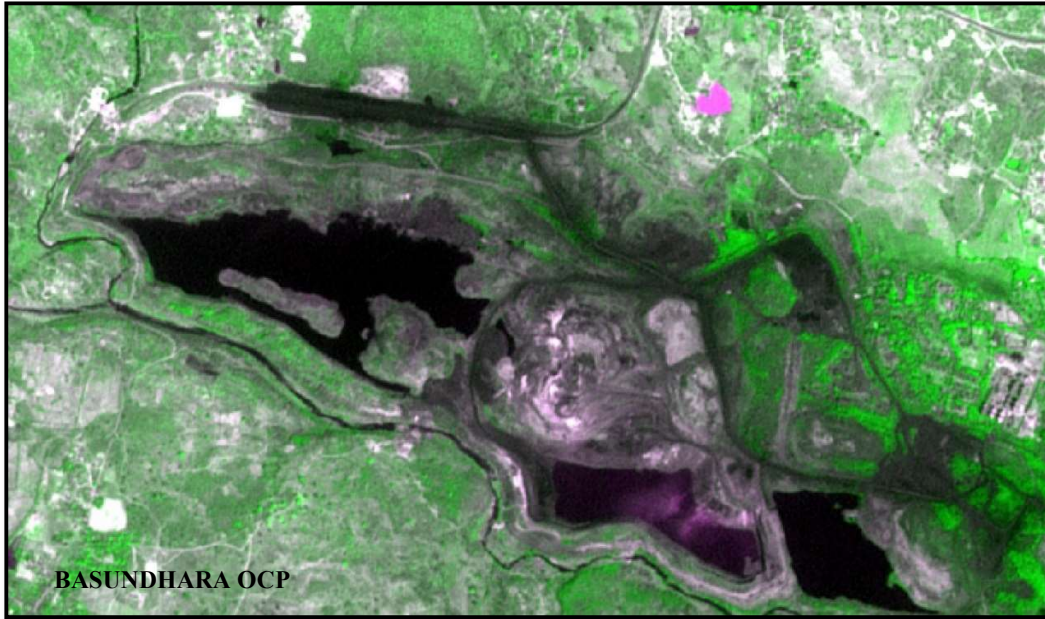
(A Subsidiary of Coal India Ltd.)

Gondwana Place, Kanke Road, Ranchi 834031, Jharkhand

Phone : (+91) 651 2230001, 2230002, 2230483, FAX (+91) 651 2231447, 2231851

Website : www.cmpdi.co.in, Email : cmpdihq@cmpdi.co.in

**Land Restoration / Reclamation Monitoring of less than
5 m.cu.m. (Coal+OB) Capacity Open Cast Coal Mines of Mahanadi
Coalfields Limited Based on Satellite Data for the Year 2021**



Submitted to
Mahanadi Coalfields Limited



cmpdi
A Mini Ratra Company

**Land Restoration / Reclamation Monitoring of less than 5 m. cu. m (Coal + OB) capacity Open Cast Coal Mines of Mahanadi Coalfields Limited
Based on Satellite Data for the Year 2021**

March-2022



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

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Executive Summary

- 1.0 Project** Land restoration / reclamation monitoring of 1 opencast coal mine of Mahanadi Coalfields Ltd. (MCL) producing less than 5 million cu. m. (Coal + OB) per year based on satellite data, on triennial 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, 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 437.10 hectares of the 1 OC project viz. Basundhara OCP considered for monitoring during year 2021; total excavated area is only 201.23 Ha., out of which 143.13 Ha. (71.13%) is under backfilling and 58.10 Ha. (28.87%) is under active mining. It is evident from the analysis that 71.13% area of the OC project has already been under reclamation and balance 28.87% 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 2021 with respect to the year 2018 in Basundhara project, it is evident from the analysis that area under land reclamation has decreased from 147.13 Ha. (Yr. 2018) to 143.13 Ha. (Yr. 2021). Leasehold boundary of Basundhara OCP has been up dated this year as per EC which has resulted in significant change in shape and decrease in area of leasehold boundary. Area of leasehold boundary of Basundhara OCP has decreased from 705.00 Ha. in the year 2018 to 437.10 Ha. in the year 2021. This decrease of 267.90 Ha. area in leasehold boundary of Basundhara OCP has resulted in decrease of 4.00 Ha. area under total reclamation with respect to the year 2018 as evident in Table-1.

TABLE-1

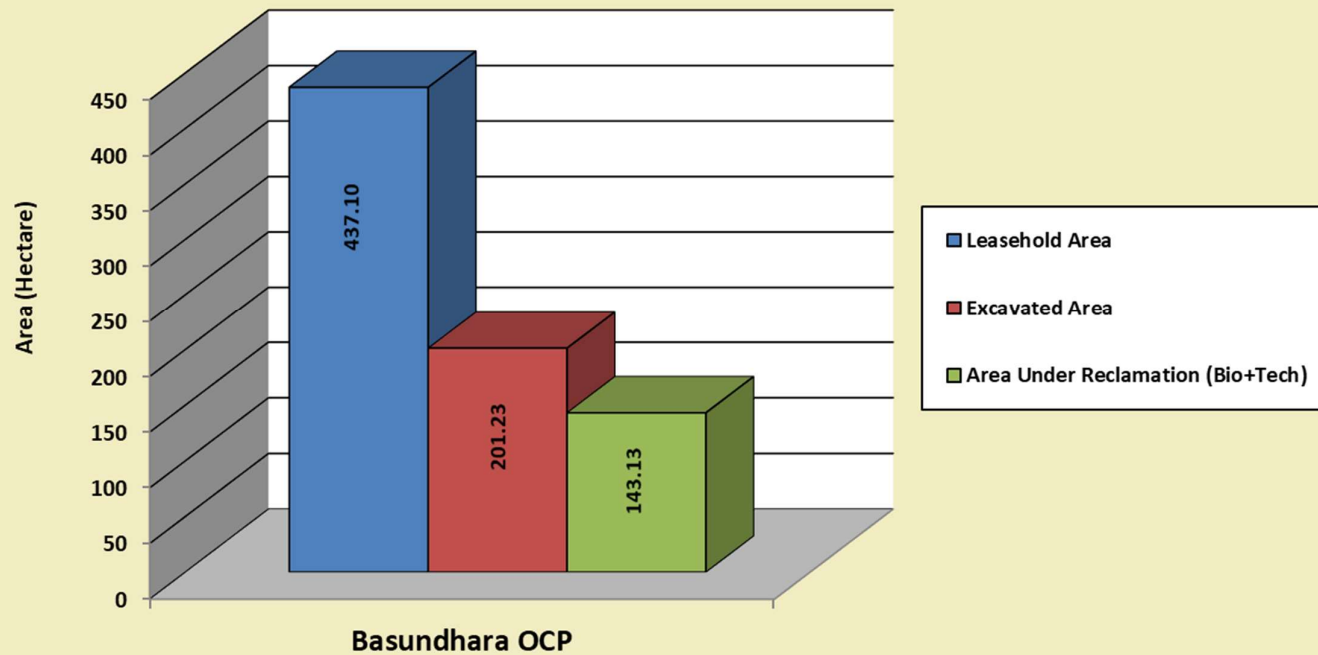
Table - 1 Land Reclamation Status in Basundhara OC mine of MCL based on Satellite Data of the Year 2018 & 2021																			
(Area in Hectare)																			
Sl. No.	Project	Total Leasehold Area		Technical Reclamation		Plantation						Area under Active Mining	Total Excavated Area		Total Area 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 OB 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)	
		2018	2021	2018	2021	2018	2021	2018	2021	2018	2021	2018	2021	2018	2021	2018	2021	2018	2021
1	Basundhara OC	705.00	437.10	146.00	143.13	1.13	0.00	14.30	8.53	15.38	10.13	92.45	58.10	239.58	201.23	30.81	18.66	147.13	143.13
				60.94%	71.13%	0.47%	0.00%					38.59%	28.87%			4.37%	4.27%	61.41%	71.13%
	TOTAL	705.00	437.10	146.00	143.13	1.13	0.00	14.30	8.53	15.38	10.13	92.45	58.10	239.58	201.23	30.81	18.66	147.13	143.13
				60.94%	71.13%	0.47%	0.00%					38.59%	28.87%			4.37%	4.27%	61.41%	71.13%

(% 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, 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 Table above.
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".
6. Leasehold boundary of Basundhara OC has been updated in year 2021 as per EC.

Fig 1: Land Reclamation Status of Basundhara OC in Year 2021



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./2017/DP/8477 dated 21/09/17 for monitoring of opencast mines of less than 5 million m³ per annum capacity (Coal +OB) for the period 2017-18 to 2021-22 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 2021 carried out for Basundhara OC project 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:

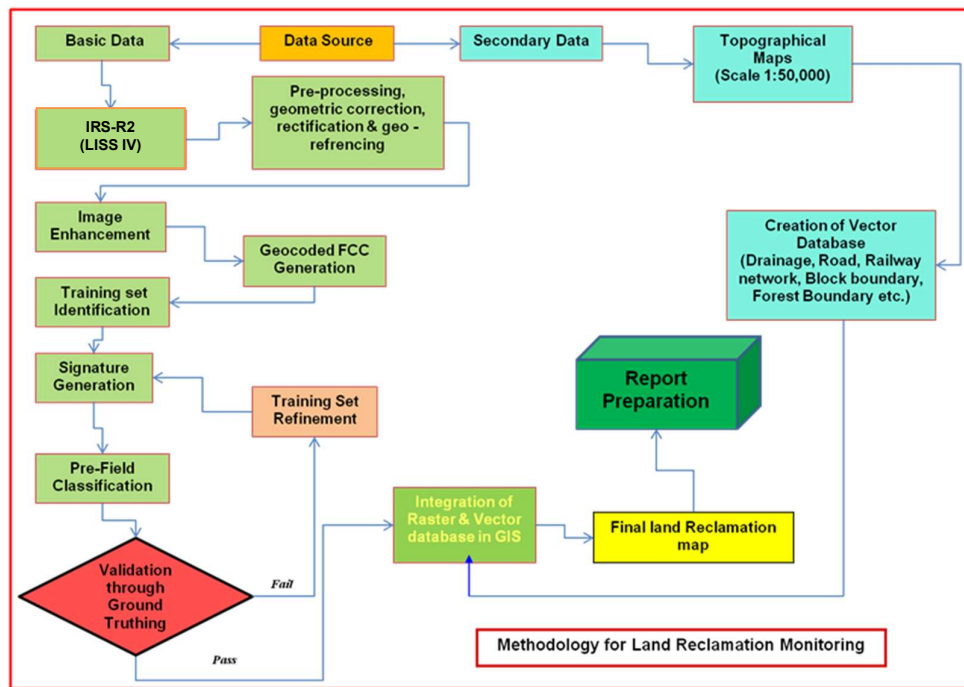


Figure: 2 Methodology for Land Reclamation Monitoring

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 1 OC project producing less than 5 million m³. (Coal + OB together) of Mahanadi Coalfields Ltd. has been taken up during the year 2021 for land reclamation monitoring:

- Basundhara

4.2 Area statistics of different land use classes present in the OC project in the year 2021 is given in Table 2. Land use map derived from the satellite data is given in Plate no.1. Land use status is shown in Fig. 3 and field photographs showing plantation on OB and social forestry plantations in Basundhara project are shown in photo 1 - 4. Land reclamation status of the above mentioned opencast project was also prepared for the year 2018.

4.3 Study reveals that out of the total mine leasehold area of 437.10 Ha. of the 1 OC project of MCL mentioned above taken for this study in 2021-22; total excavated area is 201.23 Ha. out of which 143.13 Ha. (71.13%) is under backfilling (*Technically Reclaimed*) and balance 58.10 Ha. (28.87%) is under active mining.

4.4 Lease hold boundary of Basundhara OCP has been up dated this year as per EC which has resulted in significant change in shape and decrease in area of leasehold boundary. Area of leasehold boundary of Basundhara OCP has decreased from 705.00 Ha. in the year 2018 to 437.10 Ha. in the year 2021. This decrease of 267.90 Ha. area in leasehold boundary of Basundhara OCP has resulted in decrease in technical reclamation and biological reclamation. Area under technical reclamation has decreased from 146.00 Ha. in the year 2018 to 143.13 Ha. in the year 2021, revegetated area (Plantation on backfill) has come down from 1.13 Ha. (Year 2018) to zero (Year 2021) resulting which area under total reclamation has decreased from 147.13 Ha. in the year 2018 to 143.13 Ha. in the year 2021 respectively as evident from Table-1.

4.5 After analyzing the satellite data of the year 2018 and 2021, it is evident that total area of plantation (Green cover) which includes plantation on backfill, OB dump as well as under social forestry has decreased from 30.81 Ha. in the year 2018 to 18.66 Ha. in the year 2021. This decrease of 12.15 Ha. in the area of total plantation during three-year cycle is also due to change in the shape and decrease in area of the leasehold boundary of Basundhara OCP. However, there is minor change in the percentage of Green Cover generated in leasehold boundary of Basundhara OCP. As such percentage calculation of Green Cover is being carried out with respect to leasehold boundary of respective projects.

Table 2: STATUS OF LAND RECLAMATION IN MCL BASED ON SATELLITE DATA OF THE YEAR 2021
(Area in Hectare)

		Basundhara OC		TOTAL	
		Area	%	Area	%
FOREST	Dense Forest	0.00	0.00	0.00	0.00
	Open Forest	0.00	0.00	0.00	0.00
	Total Forest	0.00	0.00	0.00	0.00
SCRUBS	Scrubs	79.49	18.19	79.49	18.19
PLANTATION	Social Forestry/Avenue Plantation	10.13	2.32	10.13	2.32
	Plantation on OB Dump	8.53	1.95	8.53	1.95
	Plantation on Backfill (Biological Reclamation)	0.00	0.00	0.00	0.00
	Total Plantation	18.66	4.27	18.66	4.27
	Total Vegetation	98.15	22.46	98.15	22.46
ACTIVE MINING	Coal Dump	9.27	2.12	9.27	2.12
	Coal Quarry	4.81	1.10	4.81	1.10
	Advance Quarry Site	0.00	0.00	0.00	0.00
	Quarry Filled With Water	53.29	12.19	53.29	12.19
	Total Area under Active Mining	58.10	13.29	58.10	13.29
	Barren OB Dump	38.01	8.70	38.01	8.70
RECLAIMED	Area Under Backfilling (Technical Reclamation)	143.13	32.75	143.13	32.75
	Total Area under Technical Reclamation	143.13	32.75	143.13	32.75
	Total Area under Mine Operation	248.51	56.86	248.51	56.86
WASTELAND	Waste Land	56.73	12.98	56.73	12.98
	Fly Ash Pond / Sand Body	0.00	0.00	0.00	0.00
	Total Wasteland	56.73	12.98	56.73	12.98
WATERBODIES	Reservoir, Nallah, Ponds	2.73	0.62	2.73	0.62
	Total Waterbodies	2.73	0.62	2.73	0.62
AGRICULTURE	Crop Land	1.10	0.25	1.10	0.25
	Fallow Land	13.21	3.02	13.21	3.02
	Total Agriculture	14.31	3.27	14.31	3.27
SETTLEMENTS	Urban Settlement	7.72	1.77	7.72	1.77
	Rural Settlement	0.80	0.18	0.80	0.18
	Industrial Settlement	8.15	1.86	8.15	1.86
	Total Settlements	16.67	3.81	16.67	3.81
	Grand Total	437.10	100.00	437.10	100.00

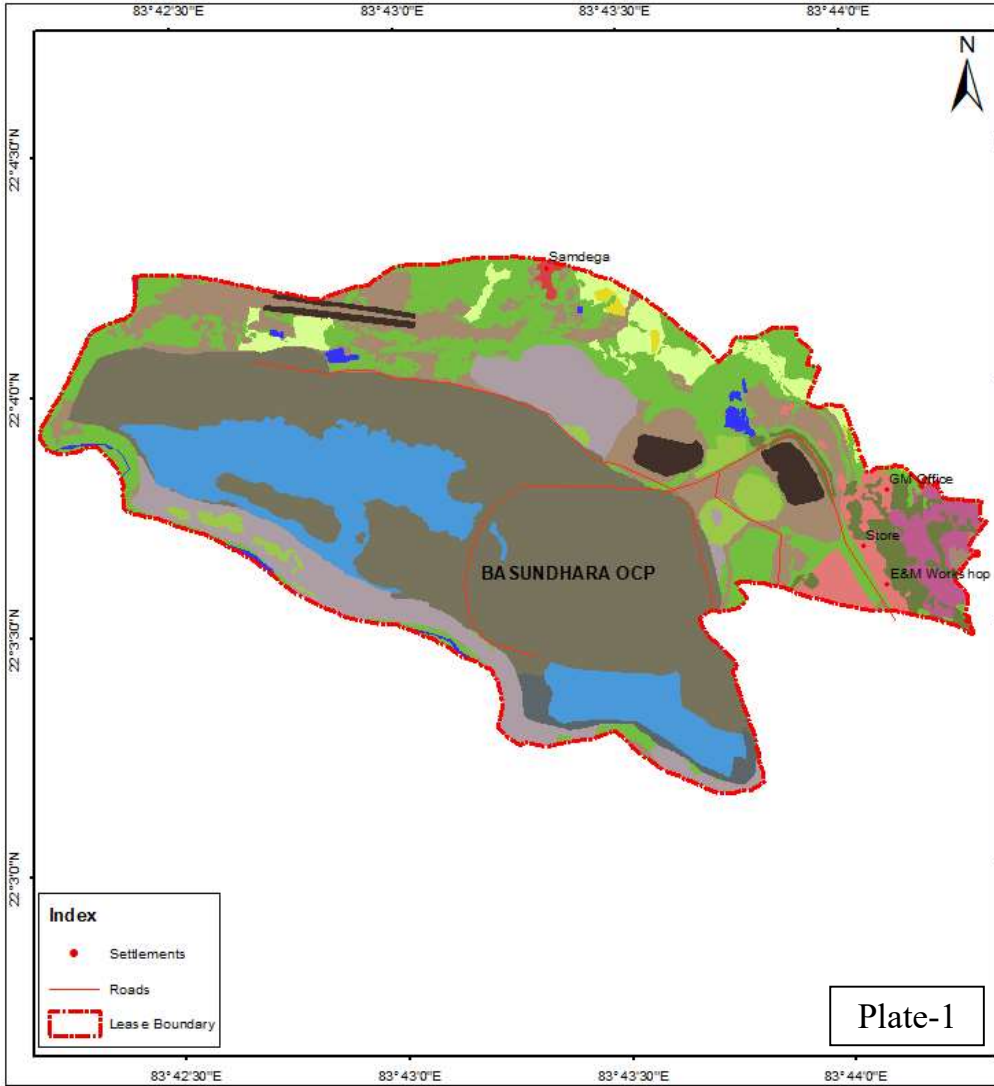


Plate-1

Area Statistics - Basundhara OC (2021)				
Classes		Colour	Core Zone	
Level-I	Level-II		Area (Ha)	% of Total
Forests	Dense Forest		0.00	0.00
	Open Forest		0.00	0.00
	Total Forest (A)		0.00	0.00
	Scrubs (B)		79.49	18.19
Plantation Area	Social Forestry		10.13	2.32
	Plantation on OB		8.53	1.95
	Plantation on Backfill		0.00	0.00
	Total Plantation (C)		18.66	4.27
	Total Vegetation (A+B+C)		98.15	22.46
Agriculture Land	Crop land		1.10	0.25
	Fallow Land		13.21	3.02
	Total Agriculture Land		14.31	3.27
Waste Land	Waste Land		56.73	12.98
	Sand Body		0.00	0.00
	Total Waste Land		56.73	12.98
Mining Area	Advance Quarry Area		0.00	0.00
	Coal Quarry		4.81	1.10
	Barren OB Dump		38.01	8.70
	Back Fill		143.13	32.75
	Coal Dump		9.27	2.12
	Water Filled Qry		53.29	12.19
	Total Mining Area		248.51	56.86
Settlements	Urban Settlements		7.72	1.77
	Rural Settlements		0.80	0.18
	Industrial Settlements		8.15	1.86
	Total Settlement Area		16.67	3.81
Water Body	River/ Ponds		2.73	0.62
	Total Area		437.10	100.00
Customer: Mahanadi Coalfields Limited				
Title: Land Reclamation Monitoring of OC Projects				
Subject: Land Reclamation status of Basundhara OCP based on Satellite Data (IRS R2 LISS-IV) of the year 2021.				
Activity	Name	Designation	Signature	Date
Prepared	A. Parida	Dy. Mgr (Geology)	A Parida	
Checked	B.K Choudhary	CM(RSC)	B.K Choudhary	
Approved	R. Kumar	GM (Geomatics)	R. Kumar	
Scale: 0 0.25 0.5 Km		Sheet		
Drg No: HQ REM 7.A4.21.01				REV No.

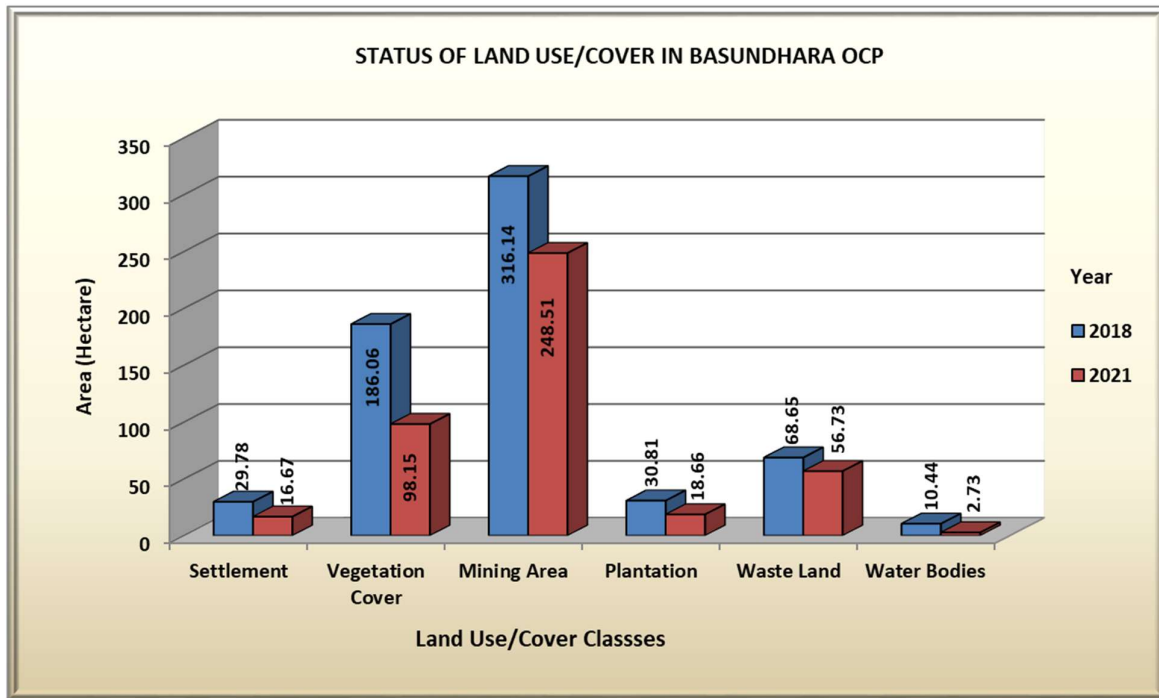


FIGURE - 3



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



Photo 2: Plantation on External OB Dump (Basundhara OCP)



Photo 3: Social forestry Plantation (Basundhara OCP)



Photo 4: Social forestry Plantation (Basundhara OCP)



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