महानदी कोलफील्ड्स लिमिटेड के ५ मिलियन घन मीटर (कोल+ अधिभार) से अधिक उत्पादन क्षमतावाले १६ खुली खदानें की भूमि पुनरुद्धार हेतु २०२३ के उपग्रह डाटा के आधार पर निगरानी का वार्षिक प्रतिवेदन

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 2023

Submitted to

Mahanadi Coalfields Limited

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March 2024

Remote Sensing Cell
Geomatics Division
CMPDI, Ranchi

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List of Photographs

कार्यकारी सारांश

१.० परियोजना

महानदी कोलफील्ड्स लिमिटेड के ५ मिलियन घन मीटर (कोल+ अधिभार) से अधिक उत्पादन क्षमतावाले १६ खुली खदानें के भूमि पुनरुद्धार हेतु वर्ष २०२३ के उपग्रह डाटा पर आधारित प्रत्येक साल का नियमित निगरानी।

२.० उद्देश्य

भूमि पुनरुद्धार (लैंड रिक्लेमेशन) का उद्देश्य कुल पट्टाक्षेत्र में बैकफील, वृक्षारोपण, सामाजिक वानिकी, सक्रिय खनन क्षेत्र, जल निकाय (वाटर ड्रेनेज) बंजर भूमि, कृषि भूमि और जंगल के विभिन्न प्रकार के वितरण प्रणाली के क्षेत्र का आकलन करने के लिए है। यह अध्ययन न केवल उपरोक्त सभी खुली खदानों के भूमि पुनरुद्धार (लैंड रिक्लेमेशन) का निगरानी के प्रगति का आकलन में मदद करेगा बल्कि पर्यावरण संरक्षण के लिए आवश्यक उपचारात्मक उपायों को क्रियान्वित करने में भी सहायता करेगा।

३.० मुख्य निष्कर्ष

- २०२३-२४ के दौरान निगरानी के लिए एमसीएल की १६ ओपनकास्ट परियोजनाओं में कुल खदान पट्टा क्षेत्र १८२.१२ वर्ग किलोमीटर है, जिसमे से कुल उत्खनन क्षेत्र ६८.५१ वर्ग किलोमीटर है, जिसके ३२. ८९ वर्ग किलोमीटर क्षेत्र (४८.०१%) बैकफिलिंग (तकनीकी रूप से पुनर्ग्रहण के तहत), ७.९४ वर्ग किलोमीटर क्षेत्र (११.५९%) वृक्षारोपण (जैविक रूप से पुनर्ग्रहण) के तहत और २७.६८ वर्ग किलोमीटर क्षेत्र (४०.४०%) सक्रिय खनन के तहत है। विश्लेषण से यह स्पष्ट है कि उपर्युक्त १६ ओपनकास्ट परियोजनाओं की कुल उत्खनन भूमि का संचयी रूप से ५९.६०% पहले से ही पुनर्ग्रहण के अधीन है और कुल उत्खनन क्षेत्र का शेष ४०.४०% सक्रिय खनन के अंतर्गत है। परियोजनावार विवरण तालिका-१ में दिया गया है और चित्र-१ में ग्राफिक रूप से दर्शाया गया है।

- एमसीएल में जैविक पुनर्ग्रहण (बैकफ़िलिंग पर वृक्षारोपण) का क्षेत्र ८.०६ वर्ग किलोमीटर (वर्ष २०२२) से घटकर ७.९४ वर्ग किलोमीटर (वर्ष २०२३) हो गया है और तकनीकी पुनर्ग्रहण का क्षेत्र (बैकफिलिंग के तहत क्षेत्र) २९.५८ वर्ग किलोमीटर (वर्ष २०२२) से बढ़कर ३२. ८९ वर्ग किलोमीटर (वर्ष २०२३) हो गया है। भूमि पुनर्ग्रहण के कुल क्षेत्र में ३.१९ वर्ग किमी की वृद्धि भूमि पुनर्ग्रहण और पर्यावरण संरक्षण की दिशा में किए गए महानदी कोलफील्ड्स लिमिटेड के प्रयासों का परिणाम है।

- उपरोक्त चयनित १६ परियोजनाओं में वर्ष २०२२ के संबंध में वर्ष २०२३ के लिए भूमि पुनर्ग्रहण की स्थिति की तुलना करने पर, विश्लेषण से यह स्पष्ट है कि भूमि पुनर्ग्रहण के तहत कुल क्षेत्र ३७.६४ वर्ग किलोमीटर (वर्ष २०२२) से बढ़कर ४०.८३ वर्ग किलोमीटर (वर्ष २०२३) हो गया है। एमसीएल की १६ परियोजनाओं में से, बेलपहाड़ ओसी भूमि पुनर्ग्रहण (**७५.९०**%) के लिए शीर्ष पर है, इसके बाद बलराम ओसी (७०.३७%) और समलेश्वरी ओसी (७०.०२%) है।

- ज् कुछ परियोजनाओं में फील्ड दौरे के दौरान यह देखा गया है कि एमसीएल द्वारा किए गए पौधरोपण के अलावा मिट्टी की उर्वरता अधिक होने के कारण पुराने और स्थिर बैकफिल क्षेत्र और डम्पों पर प्राकृतिक वनस्पति भी उगनी शुरू हो गई है। कुछ परियोजनाओं में नए वृक्षारोपण किए गए हैं लेकिन कम ऊंचाई के कारण यह उपग्रह डेटा में स्पष्ट नहीं है।

Executive Summary

1.0 Projects

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

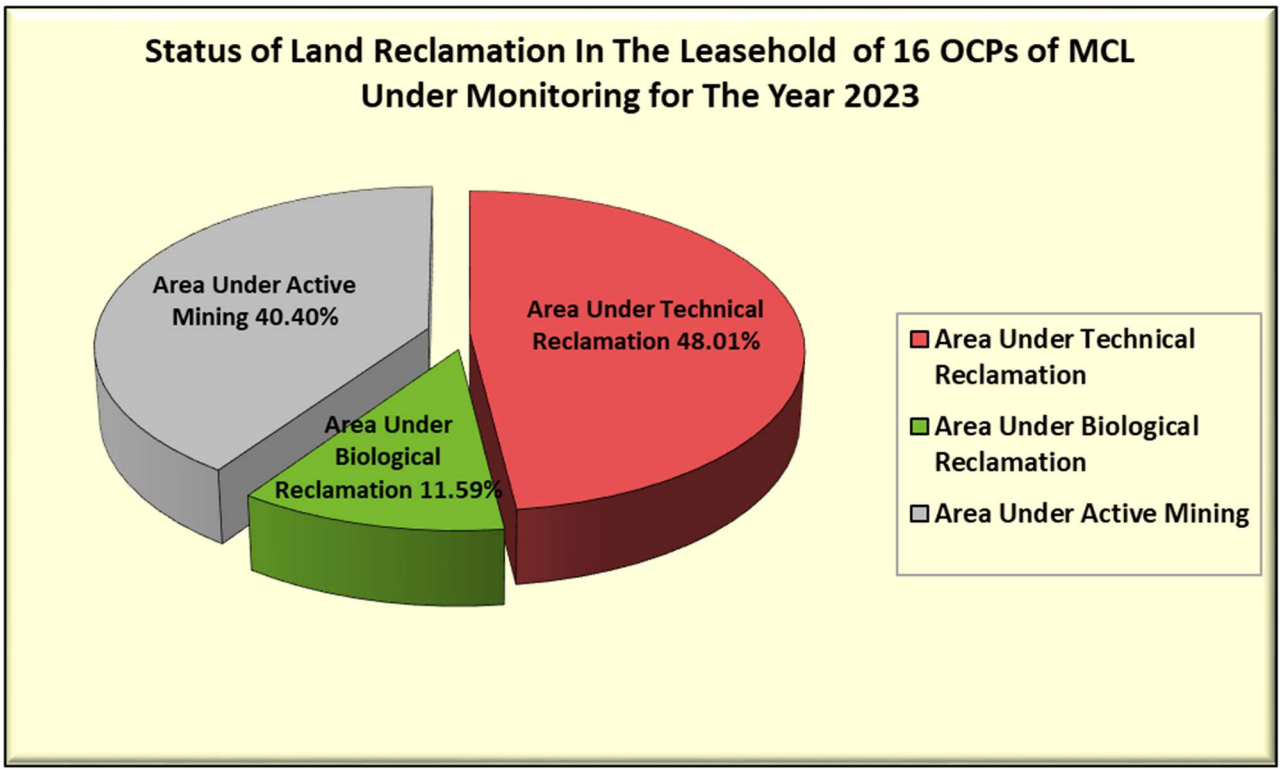
- Out of the total mine leasehold area of 182.12 Km^2 of the 16 opencast projects of MCL viz. Ananta, Balram, Lingaraj, Bharatpur, Bhubaneshwari, Jagannath, Hingula, Belpahar, Lakhanpur, Samleswari, Lajkura, Siarmal, Basundhara W. Extn., Garjanbahal, Kulda and Kahina considered for monitoring during 2023-24; total excavated area is 68.51 Km^2, out of which 7.94 Km^2 area (11.59%) has been planted, 32.89 Km^2 area (48.01%) is under backfilling and 27.68 Km^2 area (40.40%) is under active mining. It is evident from the analysis that 59.60% areas of the OC projects is under reclamation (biological and technical) and balance 40.40% 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 2023 with respect to the year 2022 in different projects, it is evident from the analysis that total area under land reclamation has increased from 37.64 Km^2 (Yr.2022) to 40.83 Km^2 (Yr.2023). Out of 16 projects of MCL, Belpahar OC ranks on top for land reclamation (75.90%) followed by Balram OC (70.37%) and Samleswari OC (70.02%).

- Area of biological reclamation (plantation on backfill) has been decreased nominally from 8.06 Km^2 (Yr.2022) to 7.94 Km^2 (Yr. 2023) and area of technical reclamation (area under backfilling) has increased from 29.58 Km^2 (Yr.2022) to 32.89 Km^2 (Yr.2023) in MCL. The increase of 3.19 Km^2 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. New plantation has been carried out in some projects but due to low height it's signature not clear in satellite data.



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 2023 (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	
						Biological Reclamation		Other Plantation											
				Area under Backfilling		Plantation on Excavated/Backfilled Area		Plantation on External Over Burden Dump		Social Forestry, Avenue Plantation Etc.									
1	2	3	4	5		6		7		8		9		10(=5+6+9)		11(=6+7+8)		12(=5+6)	
				2022	2023	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023
1	Ananta	14.20	14.20	2.62	3.18	1.05	0.97	0.10	0.08	0.22	0.21	1.95	2.12	5.62	6.27	1.37	1.26	3.67	4.15
				46.62%	50.72%	18.68%	15.47%					34.70%	33.81%			9.65%	8.87%	65.30%	66.19%
2	Balram	13.09	13.09	2.98	3.05	0.98	0.94	0.22	0.22	0.35	0.32	1.58	1.68	5.54	5.67	1.55	1.48	3.96	3.99
				53.79%	53.79%	17.69%	16.58%					28.52%	29.63%			11.84%	11.31%	71.48%	70.37%
3	Lingaraj	11.73	14.10	1.98	2.52	0.16	0.16	0.52	0.56	0.44	0.45	2.68	3.04	4.82	5.72	1.12	1.17	2.14	2.68
				41.08%	44.06%	3.32%	2.80%					55.60%	53.15%			9.55%	8.30%	44.40%	46.85%
4	Bharatpur	9.27	9.27	2.83	2.84	1.63	1.63	0.45	0.45	0.16	0.15	1.76	2.00	6.22	6.47	2.24	2.23	4.46	4.47
				45.50%	43.89%	26.21%	25.19%					28.30%	30.91%			24.16%	24.06%	71.70%	69.09%
5	Bhubaneswari	6.58	6.58	2.29	2.45	0.02	0.06	0.01	0.01	0.09	0.06	2.17	2.11	4.48	4.62	0.12	0.13	2.31	2.51
				51.12%	53.03%	0.45%	1.30%					48.44%	45.67%			1.82%	1.98%	51.56%	54.33%
6	Jagannath	5.54	5.54	1.05	1.11	1.80	1.78	0.00	0.00	0.15	0.11	1.13	1.31	3.98	4.20	1.95	1.89	2.85	2.89
				26.38%	26.43%	45.23%	42.38%					28.39%	31.19%			35.20%	34.12%	71.61%	68.81%
7	Hingula	15.75	15.75	1.69	1.85	0.04	0.05	0.18	0.17	0.29	0.29	2.47	2.50	4.20	4.40	0.51	0.51	1.73	1.90
				40.24%	42.05%	0.95%	1.14%					58.81%	56.82%			3.24%	3.24%	41.19%	43.18%
8	Kaniha	7.18	7.18	0.36	0.49	0.00	0.00	0.00	0.00	0.07	0.09	1.48	1.57	1.84	2.06	0.07	0.09	0.36	0.49
				19.57%	23.79%	0.00%	0.00%					80.43%	76.21%			0.97%	1.25%	19.57%	23.79%
9	Belpahar	14.44	14.44	3.50	3.80	0.66	0.61	0.48	0.35	0.50	0.50	1.33	1.40	5.49	5.81	1.64	1.46	4.16	4.41
				63.75%	65.40%	12.02%	10.50%					24.23%	24.10%			11.36%	10.11%	75.77%	75.90%
10	Lakhanpur	22.40	22.40	4.76	5.26	0.89	0.99	0.59	0.59	0.38	0.35	3.99	4.48	9.64	10.73	1.86	1.93	5.65	6.25
				49.38%	49.02%	9.23%	9.23%					41.39%	41.75%			8.30%	8.62%	58.61%	58.25%
11	Samleswari	13.35	13.35	3.12	3.22	0.66	0.61	0.49	0.49	0.48	0.47	1.45	1.64	5.23	5.47	1.63	1.57	3.78	3.83
				59.66%	58.87%	12.62%	11.15%					27.72%	29.98%			12.21%	11.76%	72.28%	70.02%
12	Lajkura	7.21	7.21	1.32	1.52	0.16	0.13	0.19	0.12	0.16	0.16	1.07	1.14	2.55	2.79	0.51	0.41	1.48	1.65
				51.76%	54.48%	6.27%	4.66%					41.96%	40.86%			7.07%	5.69%	58.04%	59.14%
13	Siarmal	22.90	22.90	0.00	0.00	0.00	0.00	0.00	0.00	0.61	0.59	0.00	0.00	0.00	0.00	0.61	0.59	0.00	0.00
				0.00%	0.00%	0.00%	0.00%					0.00%	0.00%			2.66%	2.58%	–	–
14	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%	–	–
15	Garjanbahal	6.54	6.54	0.17	0.43	0.00	0.00	0.00	0.00	0.03	0.02	0.79	0.98	0.96	1.41	0.03	0.02	0.17	0.43
				17.71%	30.50%	0.00%	0.00%					82.29%	69.50%			0.46%	0.31%	17.71%	30.50%
16	Kulda	6.34	6.34	0.91	1.17	0.01	0.01	0.01	0.01	0.03	0.03	1.76	1.71	2.68	2.89	0.05	0.05	0.92	1.18
				33.96%	40.48%	0.37%	0.35%					65.67%	59.17%			0.79%	0.79%	34.33%	40.83%
	Total	179.75	182.12	29.58	32.89	8.06	7.94	3.24	3.05	3.99	3.83	25.61	27.68	63.25	68.51	15.29	14.82	37.64	40.83
				46.77%	48.01%	12.74%	11.59%					40.49%	40.40%			8.51%	8.14%	59.51%	59.60%

***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"*

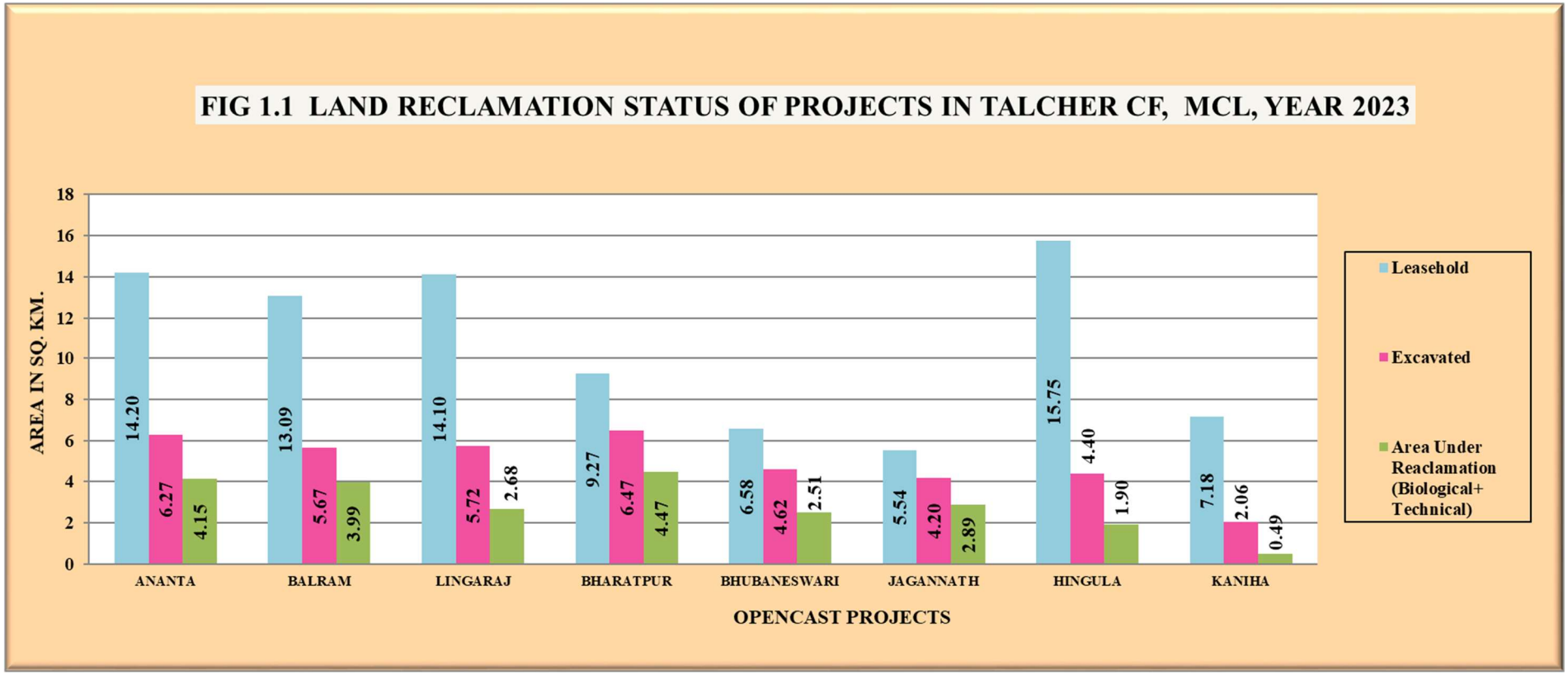


Fig.1.1: Land reclamation status of OC projects in Talcher CF, MCL for the year 2023

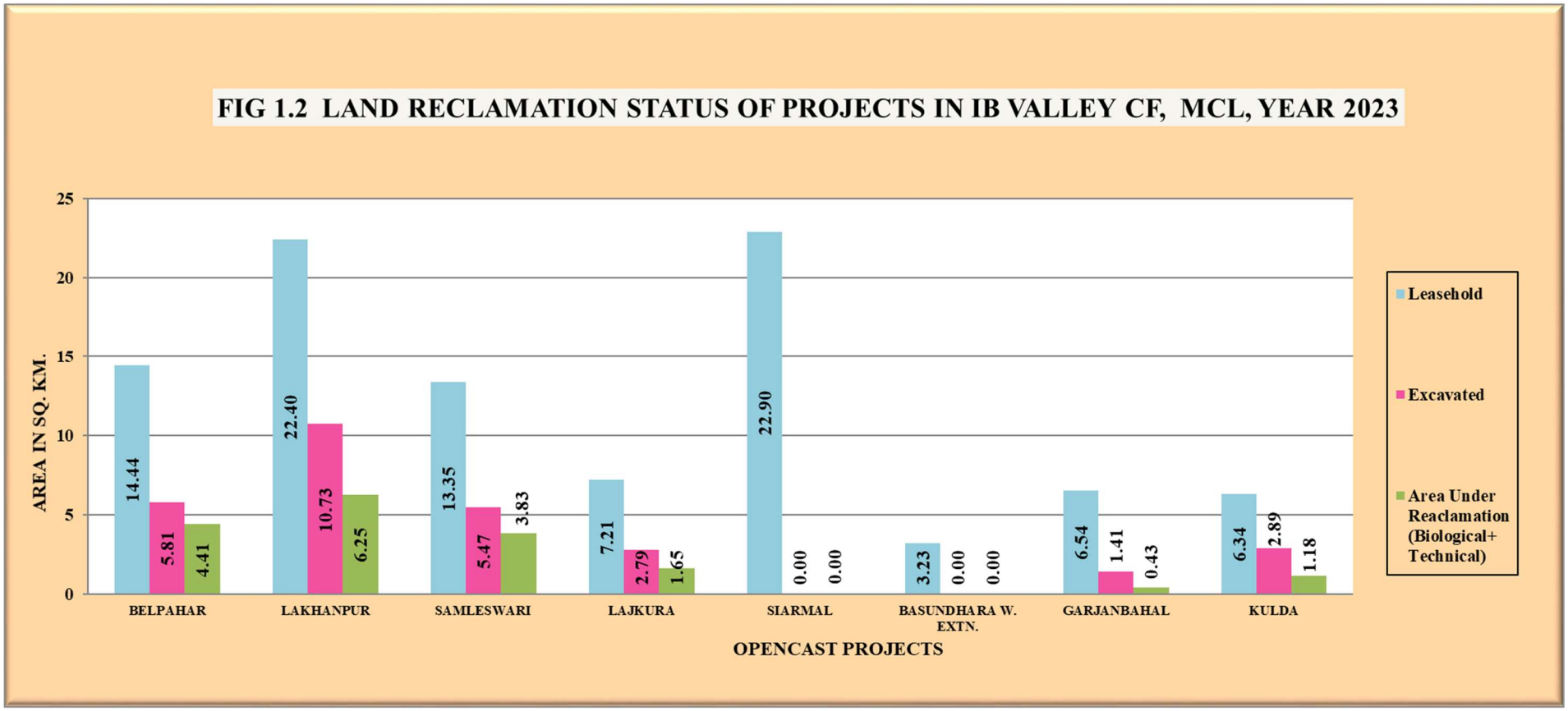


Fig.1.2: Land reclamation status of OC projects in Ib Valley CF, MCL for the year 2023

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 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 and another work order on CIL/ENVT/2022-23/W.O./10899 dated 06.07.2022 for land reclamation monitoring of 110 opencast projects and vegetation cover monitoring of 13 major coalfields for the period 2022-2024. 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. Total 13 number of coalfields in CIL shall also be monitored between 2022-2024. 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 Land reclamation monitoring of all opencast coal mining projects would also comply the statutory requirements of Ministry of Environment, Forest and 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 2023 carried out for 16 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:

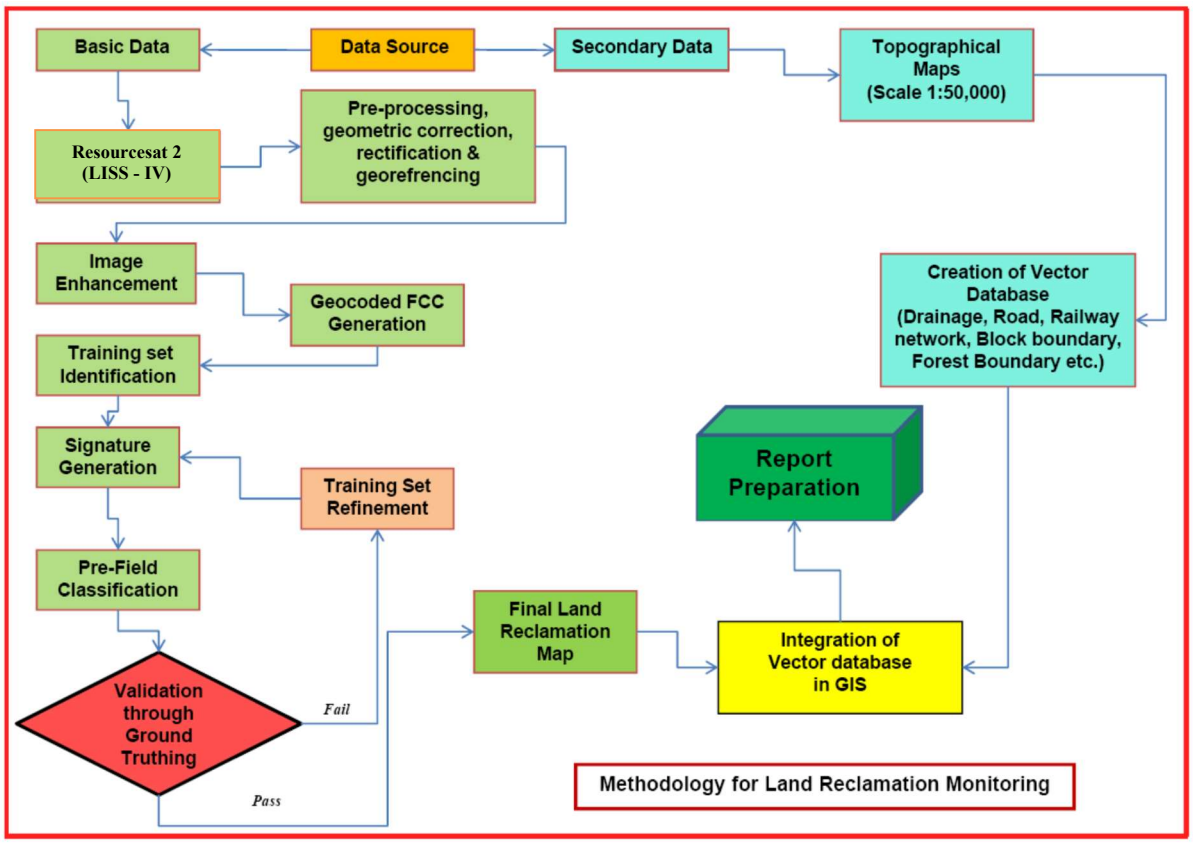


Figure: 2 - ***Methodology for Land Reclamation Monitoring***

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,

IRS-R2/LISS-IV data of 5th March, 2023 for mines of Talcher Coalfield and

IRS-R2A/LISS-IV data of 16th February, 2023 for mines of Ib Valley Coalfield.

3.2 Satellite Data Processing: Satellite data are processed using ERDAS IMAGINE 2022 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 2022 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.2022 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 10.8 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 sixteen 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 2023.

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

4.2 Area statistics of different land use class present in the mine leasehold of the above projects for the year 2023 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 2023. Year wise changes in the different land use classes based on satellite data are depicted in Bar Charts in Fig. 3 - 18.

4.3 Study reveals that out of total 68.51 Km^2 excavated area; 40.83 Km^2 area (59.60%) is under reclamation. Out of which 7.94 Km^2 (11.59%) area has been re-vegetated and 32.89 Km^2 (48.01%) area is under backfilling.

4.4 Total Area under active mining has increased from 25.61 Km^2 (Yr. 2022) to 27.68 Km^2 (Yr. 2023).

4.5 Analysis of satellite data indicates that plantation on backfill has reduced in some projects as Ananta, Balram, Jagannath, Belpahar, Samleswari and Lajkura for fresh backfilling activities and for construction of roads, camp, silo and railway connectivity projects.

4.6 Plantation on External OB dump has marginally reduced in Ananta, Hingula, Belpahar and Lajkura OCP due to construction of camp, silo and roads. Area of Social forestry has reduced marginally in some projects due to mine advancement.

4.7 Study also reveals that area under barren backfilling (Technical Reclamation) has increased from 29.58 Km^2 in 2022 to 32.89 Km^2 in 2023.

4.8 It was observed that Green Cover has reduced in some projects of MCL due to reduction in plantation and social forestry in the leasehold areas resulted from mining activities.

4.9 On comparing the status of land reclamation for the year 2023 with respect to the year 2022 in different projects, it is evident that area of land reclamation has increased from 37.64 Km^2 (Yr.2022) to 40.83 Km^2 (Yr.2023).

4.11 Out of 16 projects of MCL, Belpahar OC ranks on top for land reclamation (75.90%) followed by Balram OC (70.37%) and Samleswari OC (70.02%).

Table 2.1: STATUS OF LAND RESTORATION / RECLAMATION IN MAHANADI COALFIELDS LIMITED BASED ON SATELLITE DATA OF THE YEAR 2023

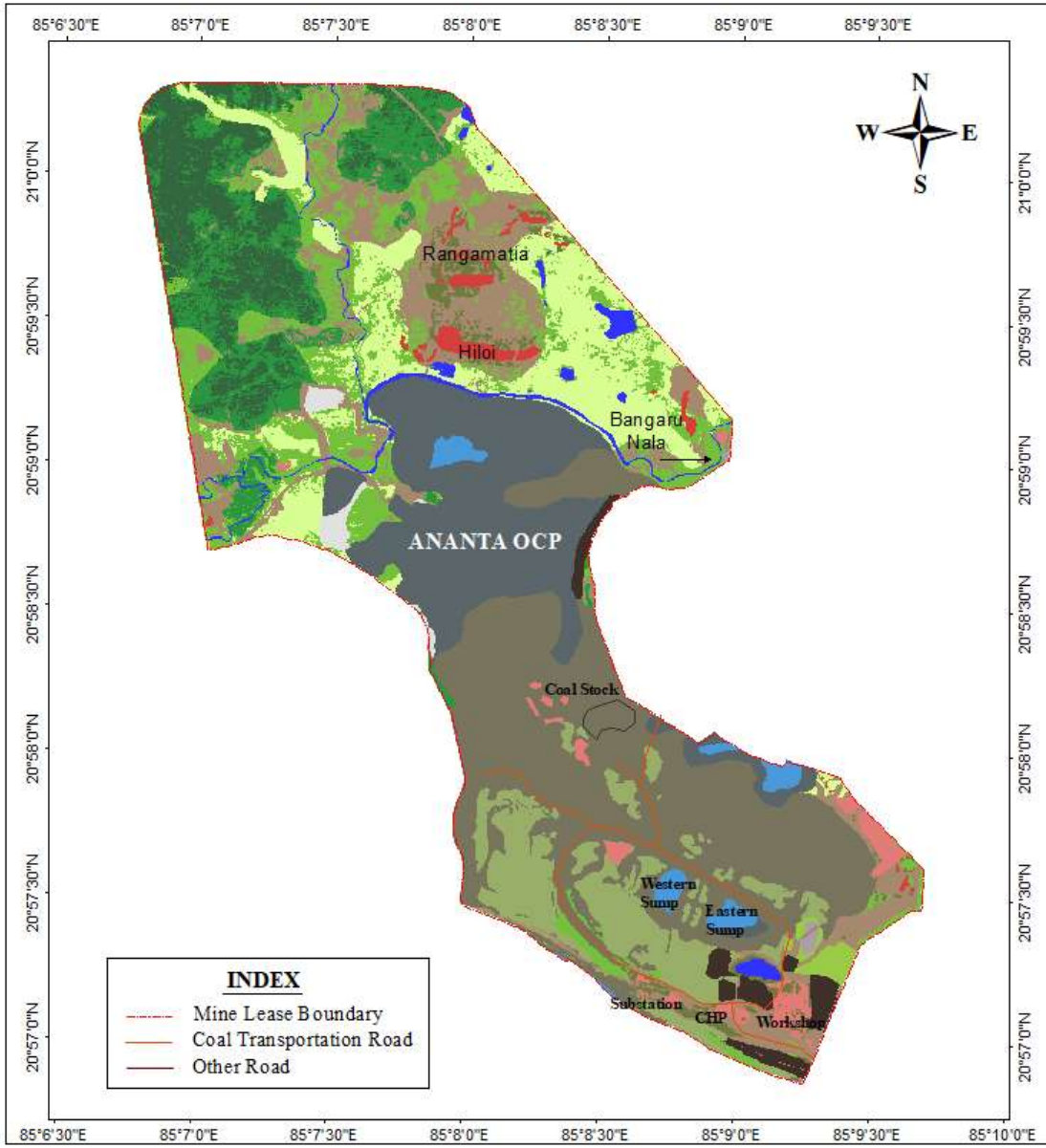
(Area in Sq. Kms.)

		ANANTA		BALRAM		LINGARAJ		BHARATPUR		BHUBANESHWARI		JAGANNATH		HINGULA		KANIHA		TOTAL	
		Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%			Area	%
FORESTS	Dense Forest	1.00	7.04	0.00	0.00	0.00	0.00	0.01	0.11	0.00	0.00	0.00	0.00	1.00	6.35	0.00	0.00	2.01	2.35
	Open Forest	1.06	7.46	0.57	4.35	0.31	2.20	0.00	0.00	0.20	3.04	0.02	0.36	1.51	9.59	0.00	0.00	3.67	4.28
	Total Forest (A)	2.06	14.51	0.57	4.35	0.31	2.20	0.01	0.11	0.20	3.04	0.02	0.36	2.51	15.94	0.00	0.00	5.68	6.63
SCRUBS	**Scrubs (B)**	1.55	10.92	2.00	15.28	1.96	13.90	0.39	4.21	0.33	5.02	0.24	4.33	2.72	17.27	0.65	10.17	9.84	11.48
PLANTATION	Social Forestry	0.21	1.48	0.32	2.44	0.45	3.19	0.15	1.62	0.06	0.91	0.11	1.99	0.29	1.84	0.09	0.97	1.68	1.96
	Plantation on External OB Dump	0.08	0.56	0.22	1.68	0.56	3.97	0.45	4.85	0.01	0.08	0.00	0.00	0.17	1.08	0.00	0.00	1.49	1.73
	Plantation on Backfill/Excavated Area(Biological Reclamation)	0.97	6.83	0.94	7.18	0.16	1.13	1.63	17.58	0.06	0.91	1.78	32.13	0.05	0.32	0.00	0.00	5.59	6.52
	Total Plantation (Green Cover) (C)	**1.26**	**8.87**	**1.48**	**11.31**	**1.17**	**8.30**	**2.23**	**24.06**	**0.13**	**1.90**	**1.89**	**34.12**	**0.51**	**3.24**	**0.09**	**0.97**	**8.76**	**10.22**
	Total Vegetation (A+B+C)	**4.87**	**34.30**	**4.05**	**30.94**	**3.44**	**24.40**	**2.63**	**28.37**	**0.66**	**9.96**	**2.15**	**38.81**	**5.74**	**36.44**	**0.74**	**11.14**	**24.28**	**28.32**
ACTIVE MINING	Coal Dump	0.22	1.55	0.28	2.14	0.36	2.55	0.18	1.94	0.06	0.91	0.09	1.62	0.40	2.54	0.18	1.67	1.77	2.07
	Coal Quarry	1.85	13.03	0.88	6.72	2.64	18.72	1.08	11.65	1.80	27.38	0.58	10.47	1.52	9.65	1.49	16.29	11.84	13.82
	Advance Quarry Site	0.09	0.63	0.22	1.68	0.20	1.42	0.16	1.73	0.13	1.98	0.14	2.53	0.13	0.83	0.03	0.14	1.10	1.29
	Quarry Filled with Water	0.18	1.27	0.58	4.43	0.20	1.42	0.76	8.20	0.18	2.74	0.59	10.65	0.85	5.40	0.05	0.84	3.39	3.96
	Total Area under *Active Mining*	**2.12**	**14.93**	**1.68**	**12.83**	**3.04**	**21.56**	**2.00**	**21.57**	**2.11**	**32.09**	**1.31**	**23.65**	**2.50**	**15.87**	**1.57**	**17.27**	**16.33**	**19.06**
	Barren OB dump	0.02	0.14	0.13	0.99	0.76	5.39	0.05	0.54	0.81	12.32	0.00	0.00	0.97	6.16	0.55	5.85	3.29	3.84
	Area Under Backfilling(Technical Reclamation)	3.18	22.39	3.05	23.30	2.52	17.87	2.84	30.64	2.45	37.26	1.11	20.04	1.85	11.75	0.49	4.32	17.49	20.41
	Total Area under Mine Operation	**5.54**	**39.01**	**5.14**	**39.27**	**6.68**	**47.38**	**5.07**	**54.69**	**5.43**	**82.59**	**2.51**	**45.31**	**5.72**	**36.32**	**2.79**	**29.11**	**38.88**	**43.31**
WASTELANDS	Waste Lands	1.70	11.97	0.97	7.41	2.05	14.54	0.64	6.90	0.21	3.19	0.36	6.50	1.62	10.29	0.90	13.93	8.45	9.86
	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	**1.70**	**11.97**	**0.97**	**7.41**	**2.05**	**14.54**	**0.64**	**6.90**	**0.21**	**3.19**	**0.47**	**8.48**	**1.68**	**10.67**	**0.90**	**13.93**	**8.62**	**10.06**
WATER	Reservoir, nallah, ponds etc.	0.21	1.48	0.26	1.99	0.07	0.50	0.04	0.43	0.01	0.15	0.04	0.72	0.31	1.97	0.07	0.97	1.01	1.18
	Total Waterbodies	**0.21**	**1.48**	**0.26**	**1.99**	**0.07**	**0.50**	**0.04**	**0.43**	**0.01**	**0.15**	**0.04**	**0.72**	**0.31**	**1.97**	**0.07**	**0.97**	**1.01**	**1.18**
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	0.18	2.79	0.18	0.21
	Fallow Lands	1.52	10.70	1.95	14.90	0.80	5.67	0.60	6.47	0.17	2.59	0.23	4.15	2.07	13.14	2.19	37.74	9.53	11.12
	Total Agriculture	**1.52**	**10.70**	**1.95**	**14.90**	**0.80**	**5.67**	**0.60**	**6.47**	**0.17**	**2.59**	**0.23**	**4.15**	**2.07**	**13.14**	**2.37**	**40.53**	**9.71**	**11.33**
SETTLEMENTS	Urban Settlement	0.00	0.00	0.00	0.00	0.45	3.19	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.06	0.00	0.00	0.46	0.54
	Rural Settlement	0.15	1.06	0.30	2.29	0.24	1.70	0.04	0.43	0.04	0.61	0.03	0.54	0.19	1.21	0.25	3.48	1.24	1.45
	Industrial Settlement	0.21	1.48	0.42	3.21	0.37	2.62	0.25	2.70	0.06	0.91	0.11	1.99	0.03	0.19	0.05	0.84	1.50	1.75
	Total Settlements	**0.36**	**2.54**	**0.72**	**5.50**	**1.06**	**7.52**	**0.29**	**3.13**	**0.10**	**1.52**	**0.14**	**2.53**	**0.23**	**1.46**	**0.30**	**4.32**	**3.20**	**3.74**
	GRAND TOTAL	**14.20**	**100.00**	**13.09**	**100.00**	**14.10**	**100.00**	**9.27**	**100.00**	**6.58**	**100.00**	**5.54**	**100.00**	**15.75**	**100.00**	**7.18**	**100.00**	**85.70**	**100.00**

Table 2.2: STATUS OF LAND RESTORATION / RECLAMATION IN MAHANADI COALFIELDS LIMITED BASED ON SATELLITE DATA OF THE YEAR 2023

(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	1.19	5.31	0.16	1.20	0.48	6.66	0.00	0.00	0.00	0.00	0.18	2.75	0.00	0.00	2.01	2.08	4.02	2.21
	Open Forest	0.85	5.89	1.90	8.48	0.51	3.82	0.51	7.07	0.87	3.80	0.78	24.15	0.57	8.72	0.04	0.63	6.03	6.25	9.70	5.33
	Total Forest (A)	0.85	5.89	3.09	13.79	0.67	5.02	0.99	13.73	0.87	3.80	0.78	24.15	0.75	11.47	0.04	0.63	8.00	8.34	13.68	7.51
SCRUBS	**Scrubs (B)**	2.84	19.67	2.28	10.18	2.36	17.67	0.82	11.37	6.07	26.51	1.35	41.80	0.94	14.37	1.08	17.03	17.74	18.40	27.58	15.14
PLANTATION	Social Forestry	0.50	3.46	0.35	1.56	0.47	3.52	0.16	2.22	0.59	2.58	0.03	0.93	0.02	0.31	0.03	0.47	2.15	2.23	3.83	2.10
	Plantation on External OB Dump	0.35	2.42	0.59	2.63	0.49	3.67	0.12	1.66	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.16	1.56	1.62	3.05	1.67
	Plantation on Backfill/Excavated Area(Biological Reclamation)	0.61	4.22	0.99	4.42	0.61	4.57	0.13	1.80	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.16	2.35	2.44	7.94	4.36
	Total Plantation (Green Cover) (C)	**1.46**	**10.11**	**1.93**	**8.62**	**1.57**	**11.76**	**0.41**	**5.69**	**0.59**	**2.58**	**0.03**	**0.93**	**0.02**	**0.31**	**0.05**	**0.79**	**6.06**	**6.29**	**14.82**	**8.13**
	Total Vegetation (A+B+C)	**5.15**	**35.66**	**7.30**	**32.59**	**4.60**	**34.45**	**2.22**	**30.79**	**7.53**	**32.88**	**2.16**	**66.87**	**1.71**	**26.15**	**1.17**	**18.45**	**31.84**	**33.02**	**56.12**	**30.81**
ACTIVE MINING	Coal Dump	0.13	0.90	0.30	1.34	0.21	1.57	0.05	0.69	0.00	0.00	0.00	0.00	0.22	3.36	0.08	1.26	0.99	1.03	2.76	1.52
	Coal Quarry	1.04	7.20	3.39	15.13	1.36	10.19	0.91	12.62	0.00	0.00	0.00	0.00	0.71	10.86	1.44	22.71	8.85	9.18	20.69	11.36
	Advance Quarry Site	0.05	0.35	0.84	3.75	0.15	1.12	0.20	2.77	0.00	0.00	0.00	0.00	0.16	2.45	0.08	1.26	1.48	1.54	2.58	1.42
	Quarry Filled with Water	0.31	2.15	0.25	1.12	0.13	0.97	0.03	0.42	0.00	0.00	0.00	0.00	0.11	1.68	0.19	3.00	1.02	1.06	4.41	2.42
	Total Area under *Active Mining*	**1.40**	**9.70**	**4.48**	**20.00**	**1.64**	**12.28**	**1.14**	**15.81**	**0.00**	**0.00**	**0.00**	**0.00**	**0.98**	**14.98**	**1.71**	**26.97**	**11.35**	**11.77**	**27.68**	**15.20**
	Barren OB dump	0.30	2.08	0.16	0.71	0.14	1.05	0.51	7.07	0.00	0.00	0.00	0.00	0.46	7.03	0.62	9.78	2.19	2.27	5.48	3.01
	Area Under Backfilling(Technical Reclamation)	3.80	26.32	5.26	23.48	3.22	24.11	1.52	21.08	0.00	0.00	0.00	0.00	0.43	6.57	1.17	18.45	15.40	15.97	32.89	18.06
	Total Area under Mine Operation	**5.63**	**38.99**	**10.20**	**45.54**	**5.21**	**39.02**	**3.22**	**44.66**	**0.00**	**0.00**	**0.00**	**0.00**	**2.09**	**31.96**	**3.58**	**56.47**	**29.93**	**30.02**	**68.81**	**37.79**
WASTELANDS	Waste Lands	2.33	16.14	1.20	5.36	1.79	13.41	0.92	12.76	3.82	16.68	0.64	19.81	0.49	7.49	0.69	10.88	11.88	12.32	20.33	11.16
	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	**2.33**	**16.14**	**1.20**	**5.36**	**1.79**	**13.41**	**0.92**	**12.76**	**3.82**	**16.68**	**0.64**	**19.81**	**0.49**	**7.49**	**0.69**	**10.88**	**11.88**	**12.32**	**20.50**	**11.26**
WATER	Reservoir, nallah, ponds etc.	0.22	1.52	0.25	1.12	0.27	2.02	0.06	0.83	0.21	0.92	0.03	0.93	0.03	0.46	0.13	2.05	1.20	1.24	2.21	1.21
	Total Waterbodies	**0.22**	**1.52**	**0.25**	**1.12**	**0.27**	**2.02**	**0.06**	**0.83**	**0.21**	**0.92**	**0.03**	**0.93**	**0.03**	**0.46**	**0.13**	**2.05**	**1.20**	**1.24**	**2.21**	**1.21**
AGRICULTURE	Crop Lands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.54	6.72	0.00	0.00	0.00	0.00	0.15	2.37	1.69	1.75	1.87	1.03
	Fallow Lands	0.52	3.60	3.08	13.75	1.07	8.01	0.47	6.52	9.14	39.91	0.38	11.76	2.00	30.58	0.57	8.99	17.23	17.87	26.76	14.69
	Total Agriculture	**0.52**	**3.60**	**3.08**	**13.75**	**1.07**	**8.01**	**0.47**	**6.52**	**10.68**	**46.64**	**0.38**	**11.76**	**2.00**	**30.58**	**0.72**	**11.36**	**18.92**	**19.62**	**28.63**	**15.72**
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	0.58	0.32
	Rural Settlement	0.17	1.18	0.10	0.45	0.19	1.42	0.03	0.42	0.64	2.79	0.02	0.62	0.07	1.07	0.01	0.16	1.23	1.28	2.47	1.36
	Industrial Settlement	0.40	2.77	0.27	1.21	0.22	1.65	0.21	2.91	0.00	0.00	0.00	0.00	0.15	2.29	0.04	0.63	1.29	1.34	2.79	1.53
	Total Settlements	**0.59**	**4.09**	**0.37**	**1.65**	**0.413**	**3.09**	**0.32**	**4.44**	**0.66**	**2.88**	**0.02**	**0.62**	**0.22**	**3.36**	**0.05**	**0.79**	**2.64**	**2.74**	**5.84**	**3.21**
	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**	**182.12**	**100.00**



Area Statistics - Ananta OCP (2023)

Classes		Colour	Area	
Level-I	Level-II		Area (Km^2)	% of Total
Forest Area	Dense Forest		1.00	7.04
	Open Forest		1.06	7.46
	Total Forest (A)		**2.06**	**14.51**
Scrubs	**Scrubs (B)**		**1.55**	**10.92**
Plantation	Social Forestry		0.21	1.48
	Plantation on Backfill		0.97	6.83
	Plantation on OB Dump		0.08	0.56
	Total Plantation (C)		**1.26**	**8.87**
	Total Vegetation(A+B+C)		**4.87**	**34.30**
Agriculture	**Agriculture Land**		**1.52**	**10.70**
Waste Land	**Waste Land**		**1.70**	**11.97**
Mining Area	Coal Quarry		1.85	13.03
	Area Under Backfilling		3.18	22.39
	Barren OB Dump		0.02	0.14
	Water Filled Quarry		0.18	1.27
	Coal Dump		0.22	1.55
	Advance Quarry Site		0.09	0.63
	Total Mining Area		**5.54**	**39.01**
Settlements	Rural Settlement		0.15	1.06
	Industrial Settlement		0.21	1.48
	Total Settlement Area		**0.36**	**2.54**
Water Body	**River, Ponds**		**0.21**	**1.48**
		Total	**14.20**	**100.00**

Customer	Mahanadi Coalfields Limited				
Title	Land Reclamation Monitoring of OC Projects				Job No. 564922120
Subject Land Reclamation Status of Ananta OCP based on Satellite Data (RS-2/L-IV) of the year 2023	Activity	Name	Designation	Signature	Date
	Prepared	A. Biswas	Sr. Mgr.(Geology)		
	Checked	R.Ranjan	GM (Excv.)		
	Approved	M.Rastogi	GM (Geomatics)		
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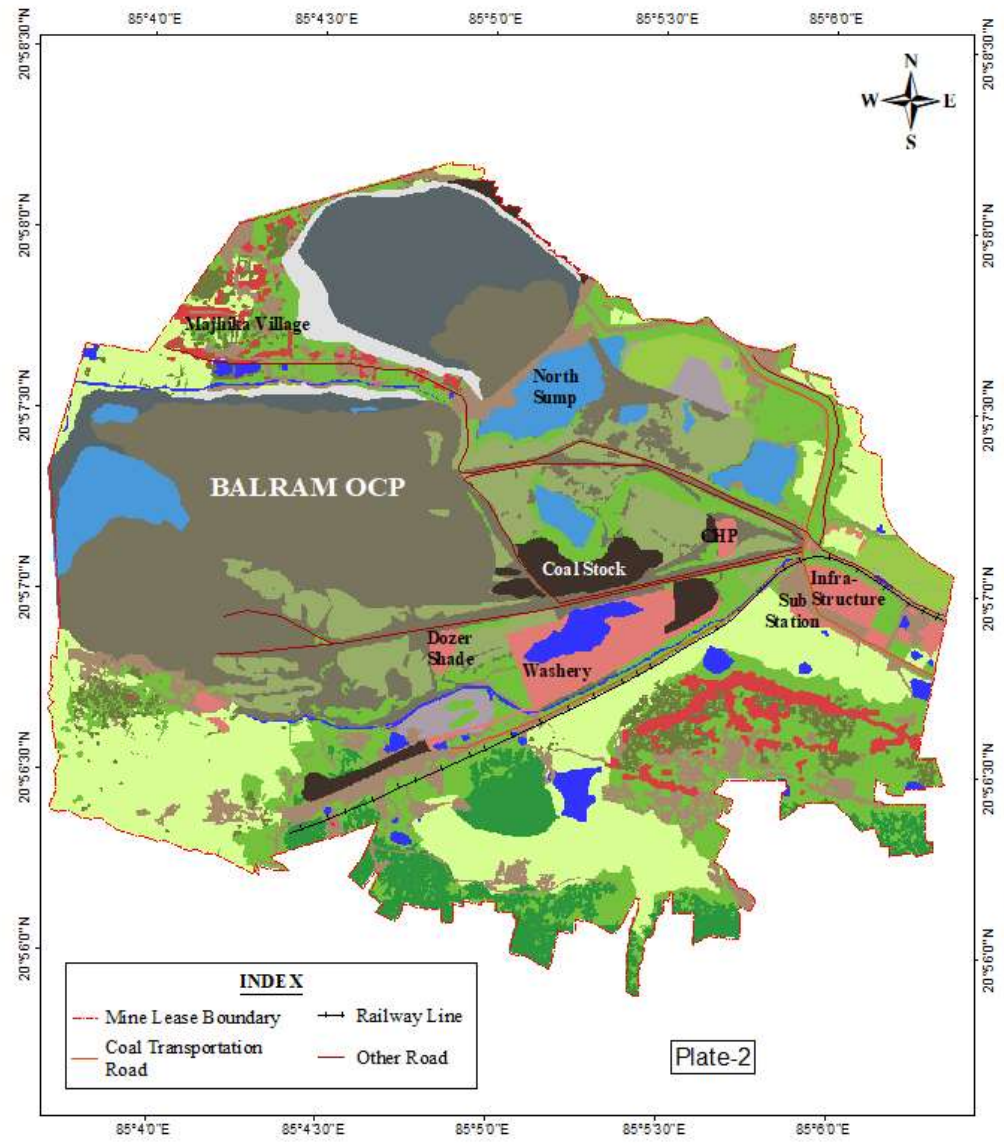

Area Statistics - Balram OCP (2023)

Classes		Colour	Area	
Level-I	Level-II		Area (Km^2)	% of Total
	Open Forest (A)		**0.57**	**4.35**
Scrubs	**Scrubs (B)**		**2.00**	**15.28**
Plantation	Social Forestry		0.32	2.44
	Plantation on Backfill		0.94	7.18
	Plantation on OB Dump		0.22	1.68
	Total Plantation (C)		**1.48**	**11.31**
	Total Vegetation(A+B+C)		**4.05**	**30.94**
Agriculture	**Agriculture Land**		**1.95**	**14.90**
Waste Land	**Waste Land**		**0.97**	**7.41**
Mining Area	Coal Quarry		0.88	6.72
	Barren OB Dump		0.13	0.99
	Area Under Backfilling		3.05	23.30
	Water Filled Quarry		0.58	4.43
	Coal Dump		0.28	2.14
	Advance Quarry Site		0.22	1.68
	Total Mining Area		**5.14**	**39.27**
Settlements	Rural Settlement		0.30	2.29
	Urban Settlement		0.00	0.00
	Industrial Settlement		0.42	3.21
	Total Settlement Area		**0.72**	**5.50**
Water Body	**River, Ponds**		**0.26**	**1.99**
		Total	**13.09**	**100.00**

Customer	Mahanadi Coalfields Limited				
Title	Land Reclamation Monitoring of OC Projects				Job No. 564922120
Subject Land Reclamation Status of Balram OCP based on Satellite Data (IRS-R2/L-IV) of the year 2023	Activity	Name	Designation	Signature	Date
	Prepared	A. Biswas	Sr. Mgr.(Geology)	ABiswas	
	Checked	R.Ranjan	GM(Excv.)		
	Approved	M Rastogi	GM(Geomatics)		
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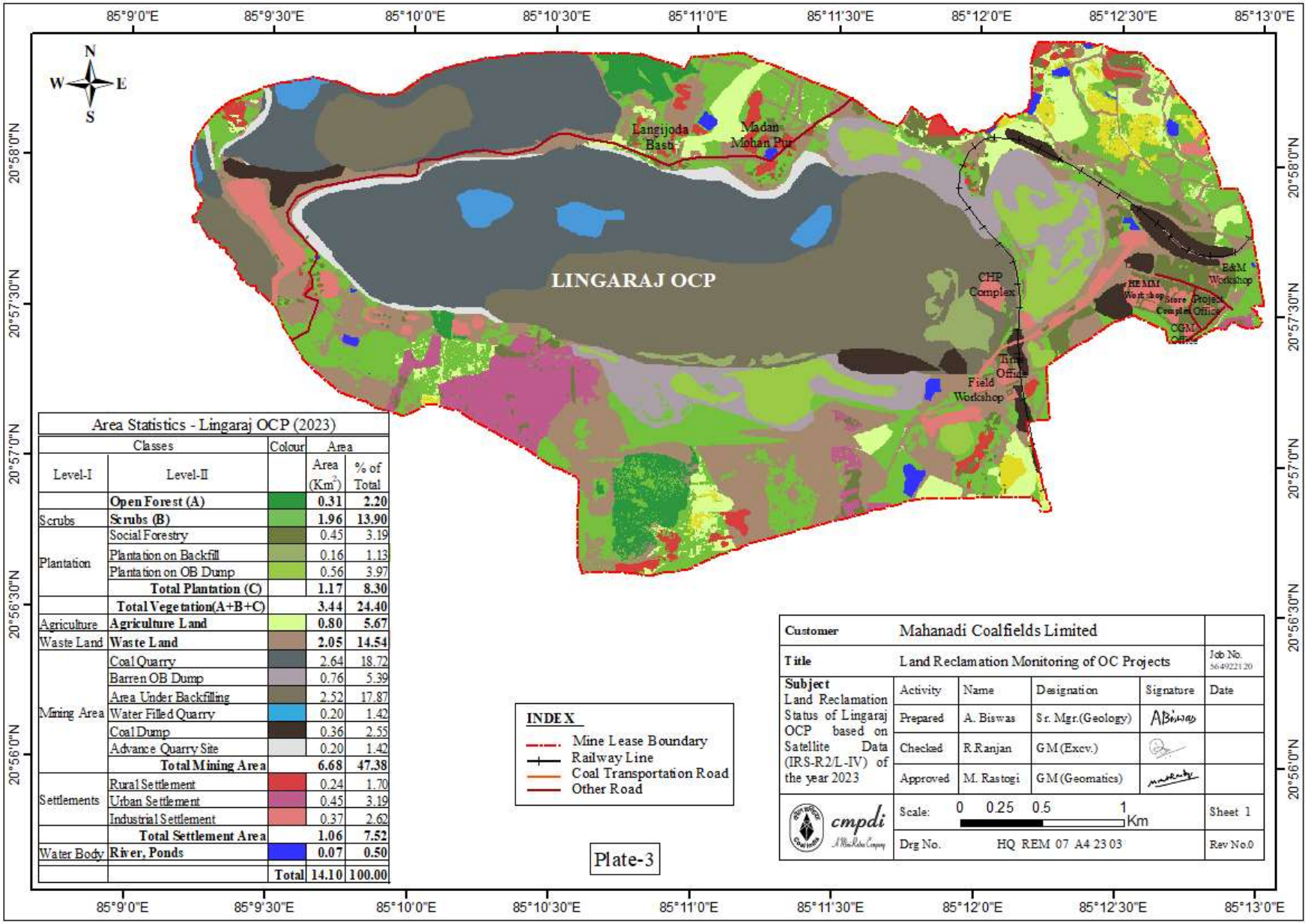

Area Statistics - Lingaraj OCP (2023)

Classes		Colour	Area	
Level-I	Level-II		Area (Km²)	% of Total
	Open Forest (A)		**0.31**	**2.20**
Scrubs	**Scrubs (B)**		**1.96**	**13.90**
Plantation	Social Forestry		0.45	3.19
	Plantation on Backfill		0.16	1.13
	Plantation on OB Dump		0.56	3.97
	Total Plantation (C)		**1.17**	**8.30**
	Total Vegetation(A+B+C)		**3.44**	**24.40**
Agriculture	**Agriculture Land**		**0.80**	**5.67**
Waste Land	**Waste Land**		**2.05**	**14.54**
Mining Area	Coal Quarry		2.64	18.72
	Barren OB Dump		0.76	5.39
	Area Under Backfilling		2.52	17.87
	Water Filled Quarry		0.20	1.42
	Coal Dump		0.36	2.55
	Advance Quarry Site		0.20	1.42
	Total Mining Area		**6.68**	**47.38**
Settlements	Rural Settlement		0.24	1.70
	Urban Settlement		0.45	3.19
	Industrial Settlement		0.37	2.62
	Total Settlement Area		**1.06**	**7.52**
Water Body	**River, Ponds**		**0.07**	**0.50**
		Total	**14.10**	**100.00**

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- Mine Lease Boundary
- Railway Line
- Coal Transportation Road
- Other Road

Plate-3

Customer	Mahanadi Coalfields Limited				
Title	Land Reclamation Monitoring of OC Projects				Job No. 564922120
Subject Land Reclamation Status of Lingaraj OCP based on Satellite Data (IRS-R2/L-IV) of the year 2023	Activity	Name	Designation	Signature	Date
	Prepared	A. Biswas	Sr. Mgr.(Geology)		
	Checked	R.Ranjan	GM (Excv.)		
	Approved	M. Rastogi	GM (Geomatics)		
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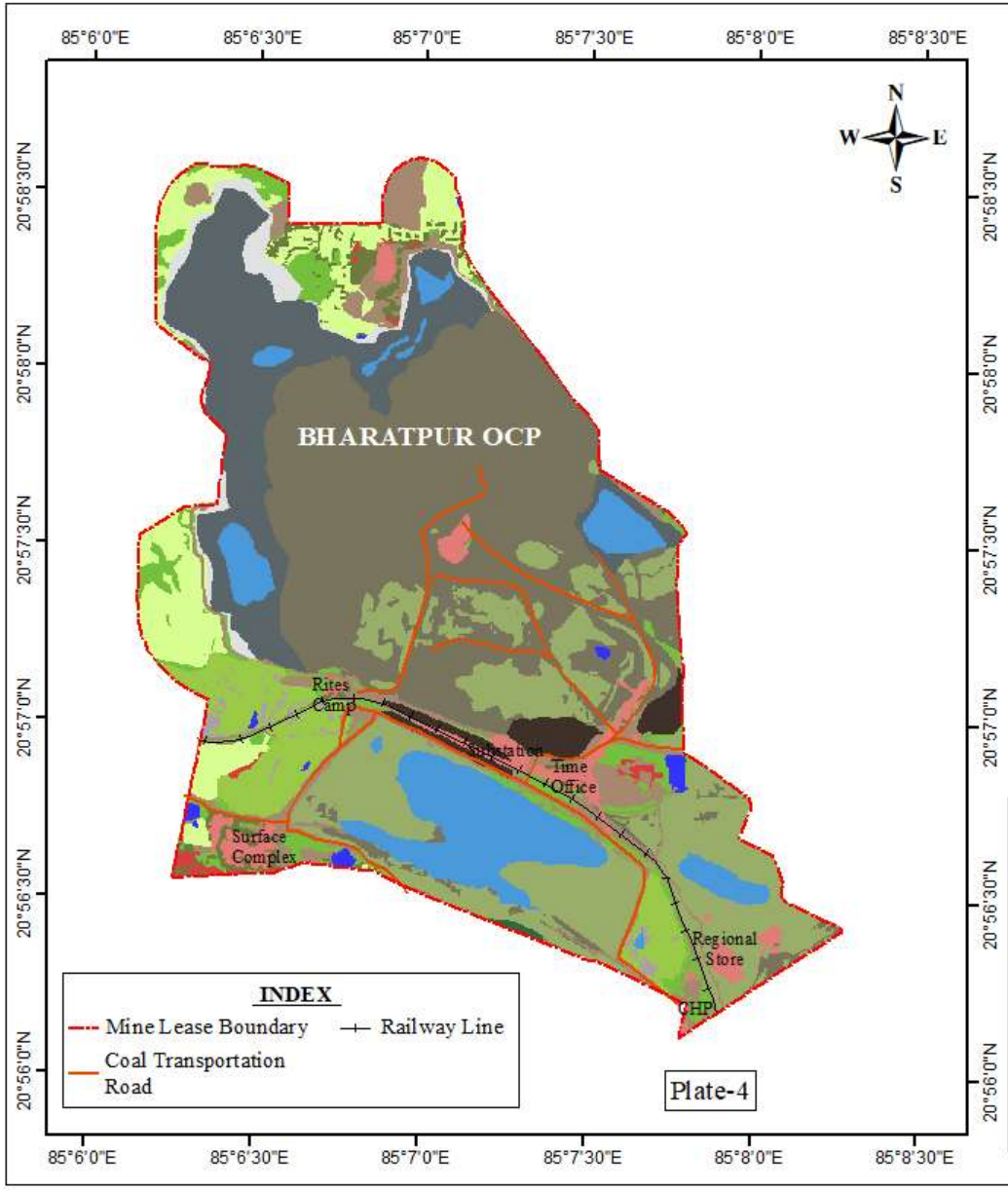

Area Statistics - Bharatpur OCP (2023)

Classes		Colour	Area	
Level-I	Level-II		Area (Km^2)	% of Total
Forest Area	**Dense Forest(A)**		**0.01**	**0.11**
Scrubs	**Scrubs (B)**		**0.39**	**4.21**
Plantation	Social Forestry		0.15	1.62
	Plantation on Backfill		1.63	17.58
	Plantation on OB Dump		0.45	4.85
	Total Plantation (C)		**2.23**	**24.06**
	Total Vegetation(A+B+C)		**2.63**	**28.37**
Agriculture	**Agriculture Land**		**0.60**	**6.47**
Waste Land	**Waste Land**		**0.64**	**6.90**
Mining Area	Coal Quarry		1.09	11.76
	Barren OB Dump		0.05	0.54
	Area Under Backfilling		2.83	30.53
	Water Filled Quarry		0.76	8.20
	Coal Dump		0.18	1.94
	Advance Quarry Site		0.16	1.73
	Total Mining Area		**5.07**	**54.69**
Settlements	Rural Settlement		0.04	0.43
	Industrial Settlement		0.25	2.70
	Total Settlement Area		**0.29**	**3.13**
Water Body	**River, Ponds**		**0.04**	**0.43**
		Total	**9.27**	**100.00**

Customer	Mahanadi Coalfields Limited				
Title	Land Reclamation Monitoring of OC Projects				Job No. 564922120
Subject Land Reclamation Status of Bharatpur OCP based on Satellite Data (IRS-R2/L-IV) of the year 2023	Activity	Name	Designation	Signature	Date
	Prepared	A. Biswas	Sr. Mgr.(Geology)	ABiswas	
	Checked	R.Ranjan	GM(Excv.)		
	Approved	M. Rastogi	GM(Geomatics)		
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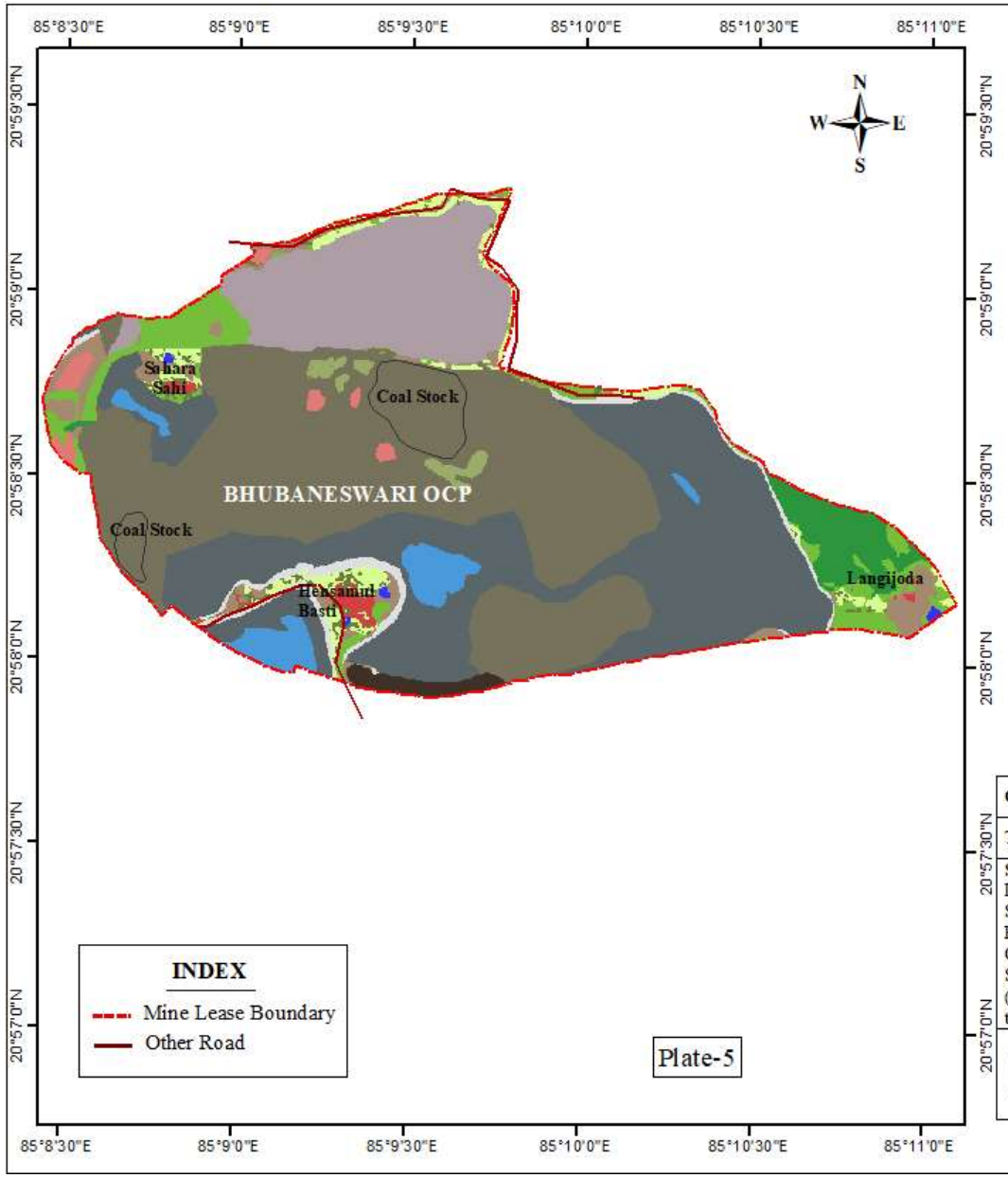

Area Statistics - Bhubaneswari OCP (2023)				
Classes		Colour	Area	
Level-I	Level-II		Area (Km^2)	% of Total
	Open Forest (A)		**0.20**	**3.04**
Scrubs	**Scrubs (B)**		**0.33**	**5.02**
Plantation	Social Forestry		0.06	0.91
	Plantation on Backfill		0.06	0.91
	Plantation on OB Dump		0.01	0.08
	Total Plantation (C)		**0.13**	**1.90**
	Total Vegetation(A+B+C)		**0.66**	**9.96**
Agriculture	**Agriculture Land**		**0.17**	**2.59**
Waste Land	**Waste Land**		**0.21**	**3.19**
Mining Area	Coal Quarry		1.80	27.38
	Barren OB Dump		0.81	12.32
	Area Under Backfilling		2.45	37.26
	Water Filled Quarry		0.18	2.74
	Coal Dump		0.06	0.91
	Advance Quarry Site		0.13	1.98
	Total Mining Area		**5.43**	**82.59**
Settlements	Rural Settlement		0.04	0.61
	Industrial Settlement		0.06	0.91
	Total Settlement Area		**0.10**	**1.52**
Water Body	**River, Ponds**		**0.01**	**0.15**
		Total	**6.58**	**100.00**

Customer	Mahanadi Coalfields Limited				
Title	Land Reclamation Monitoring of OC Projects				Job No. 564922120
Subject Land Reclamation Status of Bhubaneswari OCP based on Satellite Data (IRS-R2/L-IV) of the year 2023	Activity	Name	Designation	Signature	Date
	Prepared	A. Biswas	Sr. Mgr.(Geology)	ABiswas	
	Checked	R. Ranjan	GM(Excv.)		
	Approved	M. Rastogi	GM(Geomatics)		
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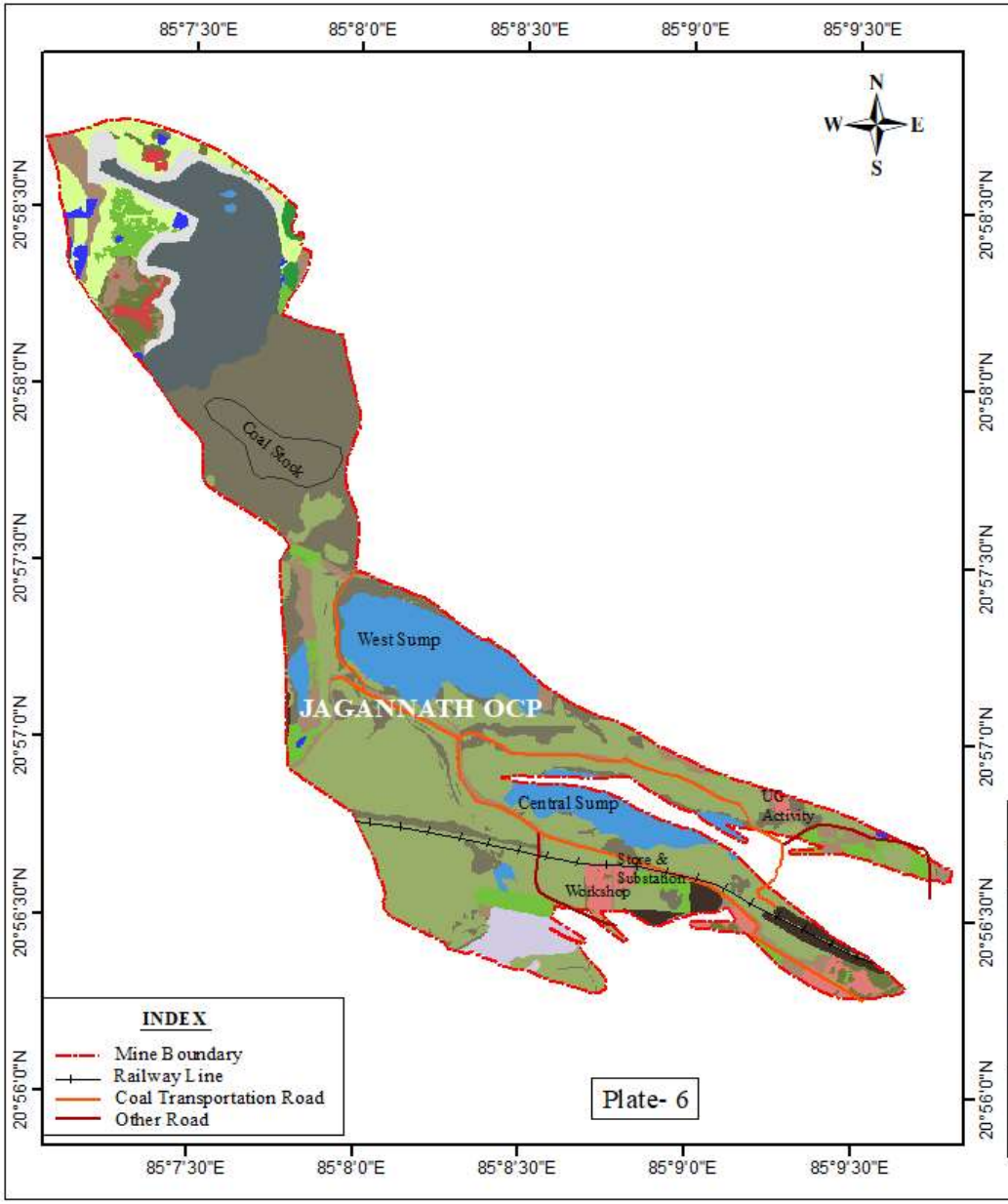

Area Statistics - Jagannath OCP (2023)

Classes		Colour	Area	
Level-I	Level-II		Area (Km^2)	% of Total
	Open Forest (A)		**0.02**	**0.36**
Scrubs	**Scrubs (B)**		**0.24**	**4.33**
Plantation	Social Forestry		0.11	1.99
	Plantation on Backfill		1.78	32.13
	Total Plantation (C)		**1.89**	**34.12**
	Total Vegetation(A+B+C)		**2.15**	**38.81**
Agriculture	**Agriculture Land**		**0.23**	**4.15**
Waste Land	Waste Land		0.36	6.50
	Ash Pond		0.11	1.99
	Total Waste Land		**0.47**	**8.48**
Mining Area	Coal Quarry		0.58	10.47
	Area Under Backfilling		1.11	20.04
	Water Filled Quarry		0.59	10.65
	Coal Dump		0.09	1.62
	Advance Quarry Site		0.14	2.53
	Total Mining Area		**2.51**	**45.31**
	Rural		0.03	0.54
Settlement	Industrial		0.11	1.99
	Total Settlement Area		**0.14**	**2.53**
Water Body	**River, Ponds**		**0.04**	**0.72**
		Total	**5.54**	**100.00**

Customer	Mahanadi Coalfields Limited				
Title	Land Reclamation Monitoring of OC Projects				Job No. 564922120
Subject Land Reclamation Status of Jagannath OCP based on Satellite Data (IRS-R2/L-IV) of the year 2023	Activity	Name	Designation	Signature	Date
	Prepared	A. Biswas	Sr. Mgr.(Geology)	ABiswas	
	Checked	R. Ranjan	GM (Excv.)		
	Approved	M Rastogi	GM (Geomatics)		
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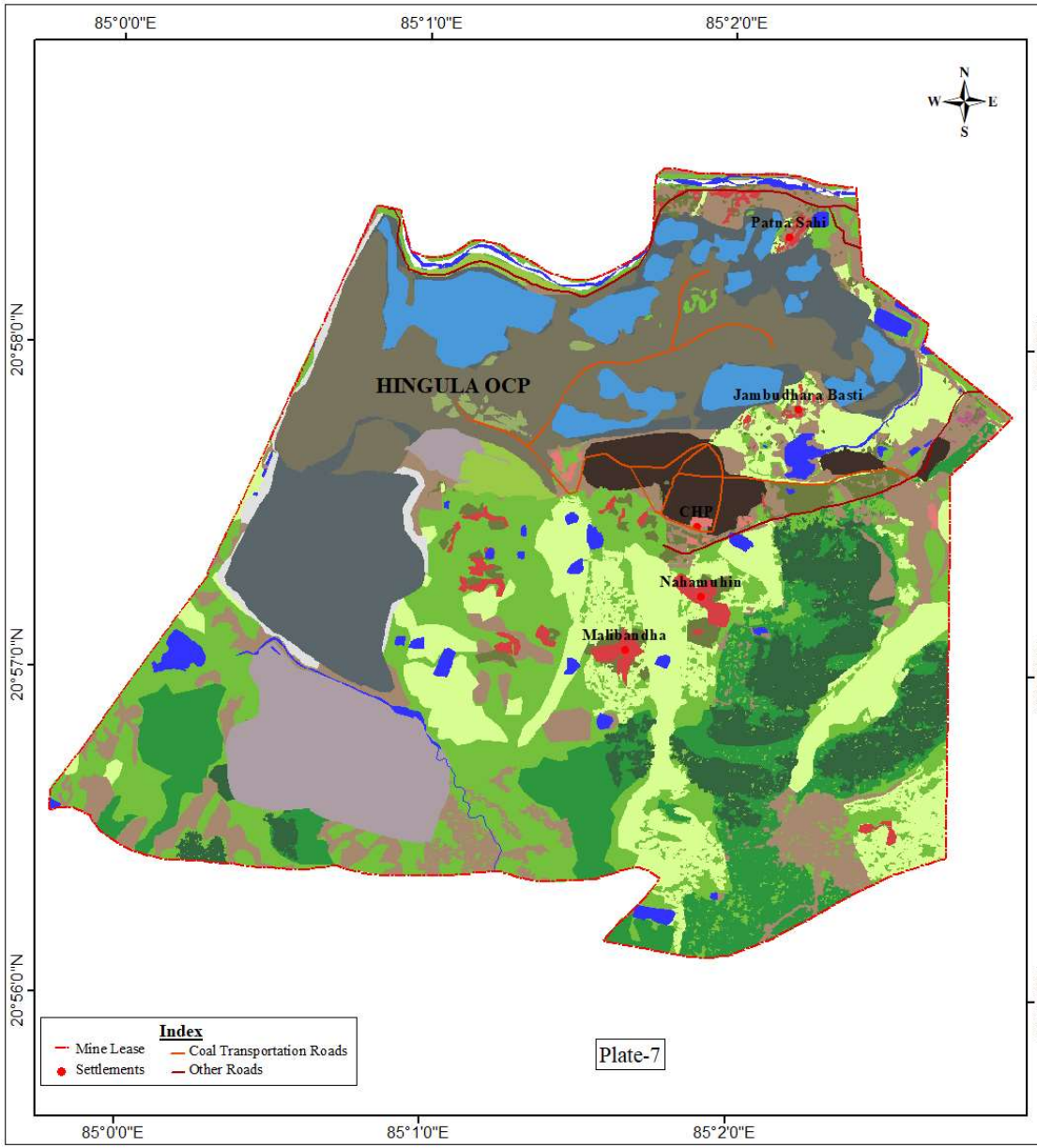

Area Statistics - Hingula OCP (2023)				
Classes		Colour	Area	
Level-I	Level-II		Area (Km^2)	% of Total
Forest	Dense Forest		1.00	6.35
	Open Forest		1.51	9.59
	Total Forest(A)		**2.51**	**15.94**
Scrubs	**Scrubs (B)**		**2.72**	**17.27**
Plantation	Social Forestry		0.29	1.84
	Plantation on Backfill		0.05	0.32
	Plantation on OB Dump		0.17	1.08
	Total Plantation (C)		**0.51**	**3.24**
	Total Vegetation(A+B+C)		**5.74**	**36.44**
Agriculture	**Agriculture Land**		2.07	13.14
Waste Land	Waste Land		1.62	10.29
	Sand Body		0.06	0.38
	Total Waste Land		**1.68**	**10.67**
Mining Area	Coal Quarry		1.52	9.65
	Barren OB Dump		0.97	6.16
	Area Under Backfilling		1.85	11.75
	Water Filled Quarry		0.85	5.40
	Coal Dump		0.40	2.54
	Advance Quarry Site		0.13	0.83
	Total Mining Area		**5.72**	**36.32**
Settlements	Rural Settlement		0.19	1.21
	Urban Settlement		0.01	0.06
	Industrial Settlement		0.03	0.19
	Total Settlement Area		**0.23**	**1.46**
Water Body	**River, Ponds**		**0.31**	**1.97**
		Total	**15.75**	**100.00**

Customer	Mahanadi Coalfields Limited				
Title	Land Reclamation Monitoring of OC Projects				Job No. 564922120
Subject Land Reclamation Status of Hingula OCP based on Satellite Data (IRS-R2/L-IV) of the year 2023	Activity	Name	Designation	Signature	Date
	Prepared	A. Biswas	Sr. Mgr.(Geology)	ABiswas	
	Checked	R. Ranjan	GM (Excv.)		
	Approved	M. Rastogi	GM (Geomatics)		
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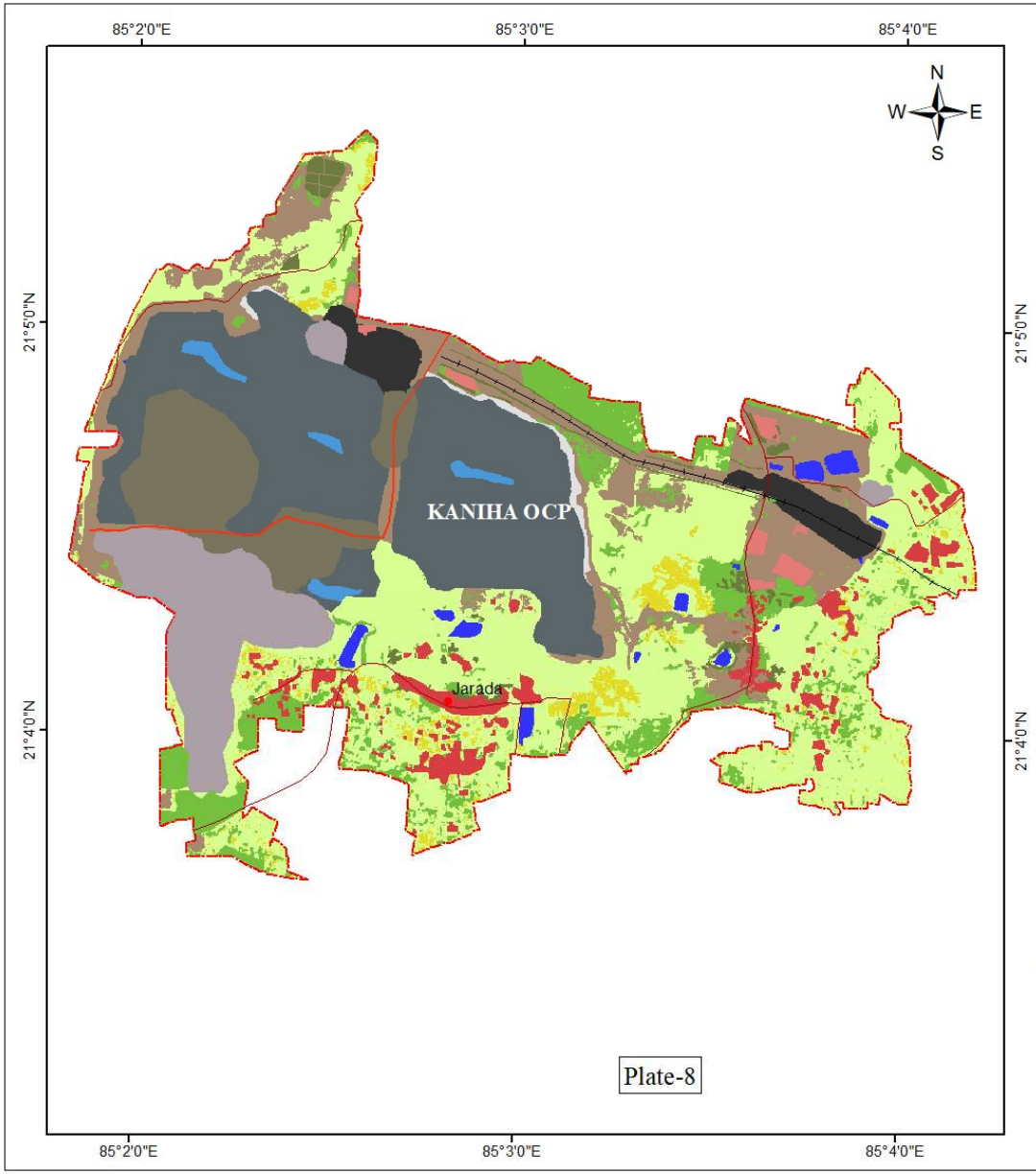

Area Statistics - Kaniha OC (2023)

Classes		Colour	Core Zone	
Level-I	Level-II		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)		**0.65**	**10.17**
Plantation Area	Social Forestry		0.09	0.97
	Plantation on OB		0.00	0.00
	Plantation on Backfill		0.00	0.00
	Total Plantation (C)		**0.09**	**0.97**
	Total Vegetation (A+B+C)		**0.74**	**11.14**
Agriculture Land	Crop land		0.18	2.79
	Fallow Land		2.19	37.74
	Total Agriculture Land		**2.37**	**40.53**
Waste Land	Waste Land		0.90	13.93
	Fly Ash Pond		0.00	0.00
	Total Waste Land		**0.90**	**13.93**
Mining Area	Advance Quarry Area		0.03	0.14
	Coal Quarry		1.49	16.29
	Barren OB Dump		0.55	5.85
	Back Fill		0.49	4.32
	Coal Dump		0.18	1.67
	Water Filled Qry		0.05	0.84
	Total Mining Area		**2.79**	**29.11**
Settlements	Urban Settlements		0.00	0.00
	Rural Settlements		0.25	3.48
	Industrial Settlements		0.05	0.84
	Total Settlement Area		**0.30**	**4.32**
Water Body	**River/ Ponds**		**0.07**	**0.97**
	Total Area		**7.18**	**100.00**

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Mine Lease — Coal Transportation Roads
Settlements — Other Roads

Customer	Mahanadi Coalfields Limited				
Title	Land Reclamation Monitoring of OC Projects				Job No. 564922120
Subject Land Reclamation Status of Kaniha OCP based on Satellite Data (IRS-R2/L-IV) of the year 2023	Activity	Name	Designation	Signature	Date
	Prepared	A. Biswas	Sr. Mgr.(Geology)	ABiswas	
	Checked	R.Ranjan	GM (Excv.)		
	Approved	M. Rastogi	GM (Geomatics)		
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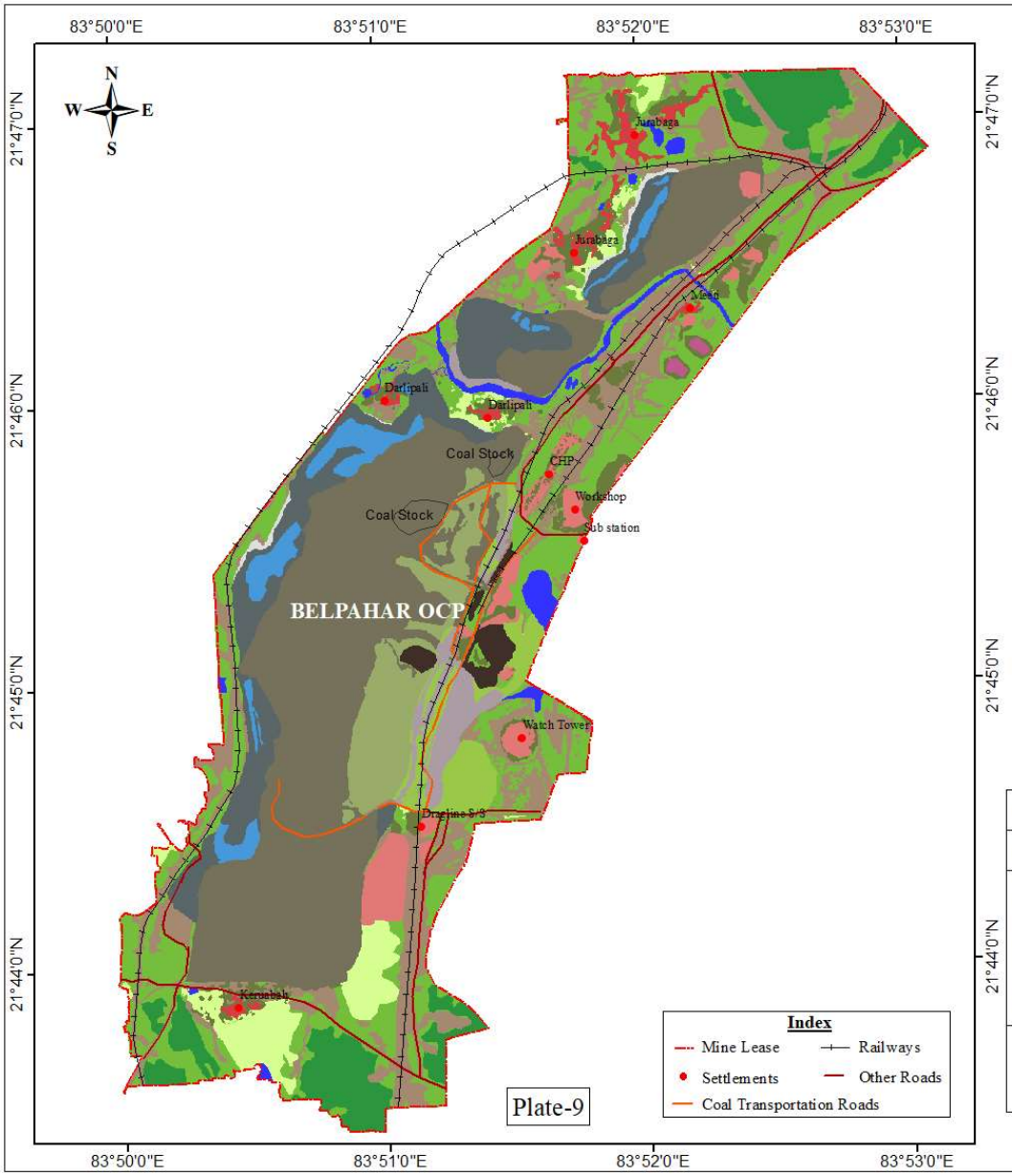

Area Statistics - Belpahar OCP (2023)				
Classes		Colour	Area	
Level-I	Level-II		Area (Km^2)	% of Total
Forest	**Open Forest(A)**		**0.85**	**5.89**
Scrubs	**Scrubs (B)**		**2.84**	**19.67**
Plantation	Social Forestry		0.50	3.46
	Plantation on Backfill		0.61	4.22
	Plantation on OB Dump		0.35	2.42
	Total Plantation (C)		**1.46**	**10.11**
	Total Vegetation(A+B+C)		**5.15**	**35.66**
Agriculture	**Agriculture Land**		**0.52**	**3.60**
Waste Land	**Waste Land**		**2.33**	**16.14**
Mining Area	Coal Quarry		1.04	7.20
	Barren OB Dump		0.30	2.08
	Area Under Backfilling		3.80	26.32
	Water Filled Quarry		0.31	2.15
	Coal Dump		0.13	0.90
	Advance Quarry Site		0.05	0.35
	Total Mining Area		**5.63**	**38.99**
Settlements	Rural Settlement		0.17	1.18
	Urban Settlement		0.02	0.14
	Industrial Settlement		0.40	2.77
	Total Settlement Area		**0.59**	**4.09**
Water Body	**River, Ponds**		**0.22**	**1.52**
		Total	**14.44**	**100.00**

Customer	Mahanadi Coalfields Limited				
Title	Land Reclamation Monitoring of OC Projects				Job No. 564922120
Subject Land Reclamation Status of Belpahar OCP based on Satellite Data (IRS-R2A/L-IV) of the year 2023	Activity	Name	Designation	Signature	Date
	Prepared	A. Biswas	Sr. Mgr.(Geology)	ABiswas	
	Checked	R. Ranjan	GM (Excv.)		
	Approved	M. Rastogi	GM(Geomatics)		
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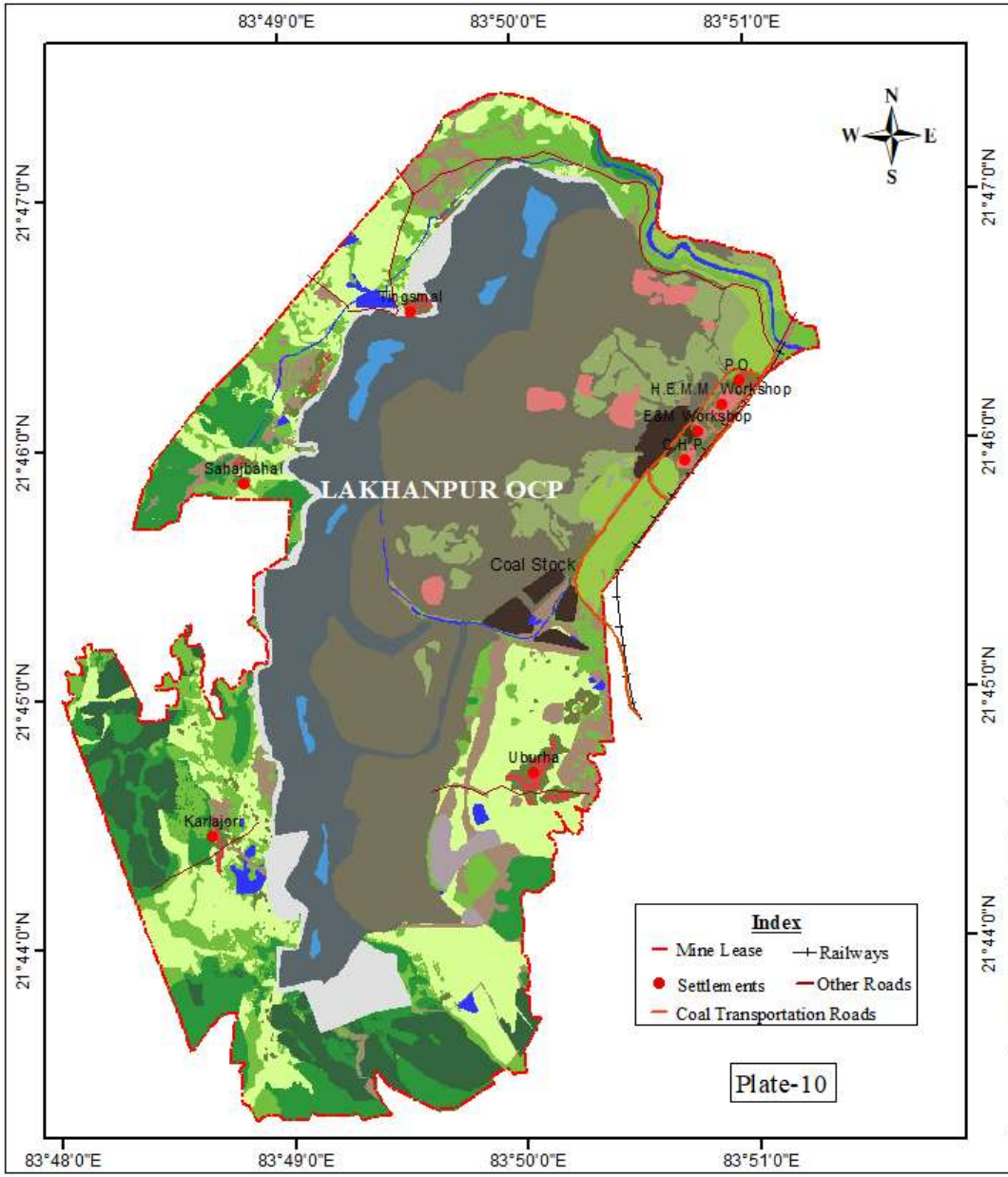

Area Statistics - Lakhanpur OCP (2023)

Classes		Colour	Area	
Level-I	Level-II		Area (Km^2)	% of Total
Forest Area	Dense Forest		1.19	5.31
	Open Forest		1.90	8.48
	Total Forest Area (A)		**3.09**	**13.79**
Scrubs	**Scrubs (B)**		**2.28**	**10.18**
Plantation	Social Forestry		0.35	1.56
	Plantation on Backfill		0.99	4.42
	Plantation on OB Dump		0.59	2.63
	Total Plantation (C)		**1.93**	**8.62**
	Total Vegetation(A+B+C)		**7.30**	**32.59**
Agriculture	**Agriculture Land**		**3.08**	**13.75**
Waste Land	**Waste Land**		**1.20**	**5.36**
Mining Area	Coal Quarry		3.39	15.13
	Barren OB Dump		0.16	0.71
	Area Under Backfilling		5.26	23.48
	Water Filled Quarry		0.25	1.12
	Coal Dump		0.30	1.34
	Advance Quarry Site		0.84	3.75
	Total Mining Area		**10.20**	**45.54**
Settlements	Rural Settlement		0.10	0.45
	Industrial Settlement		0.27	1.21
	Total Settlement Area		**0.37**	**1.65**
Water Body	**River, Ponds**		**0.25**	**1.12**
		Total	**22.40**	**100.00**

Customer	Mahanadi Coalfields Limited				
Title	Land Reclamation Monitoring of OC Projects				Job No. 564922120
Subject Land Reclamation Status of Lakhanpur OCP based on Satellite Data (IRS-R2A/L-IV) of the year 2023	Activity	Name	Designation	Signature	Date
	Prepared	A. Biswas	Sr.Mgr.(Geology)	ABiswas	
	Checked	R. Ranjan	GM(Excv.)		
	Approved	M Rastogi	GM(Geomatics)		
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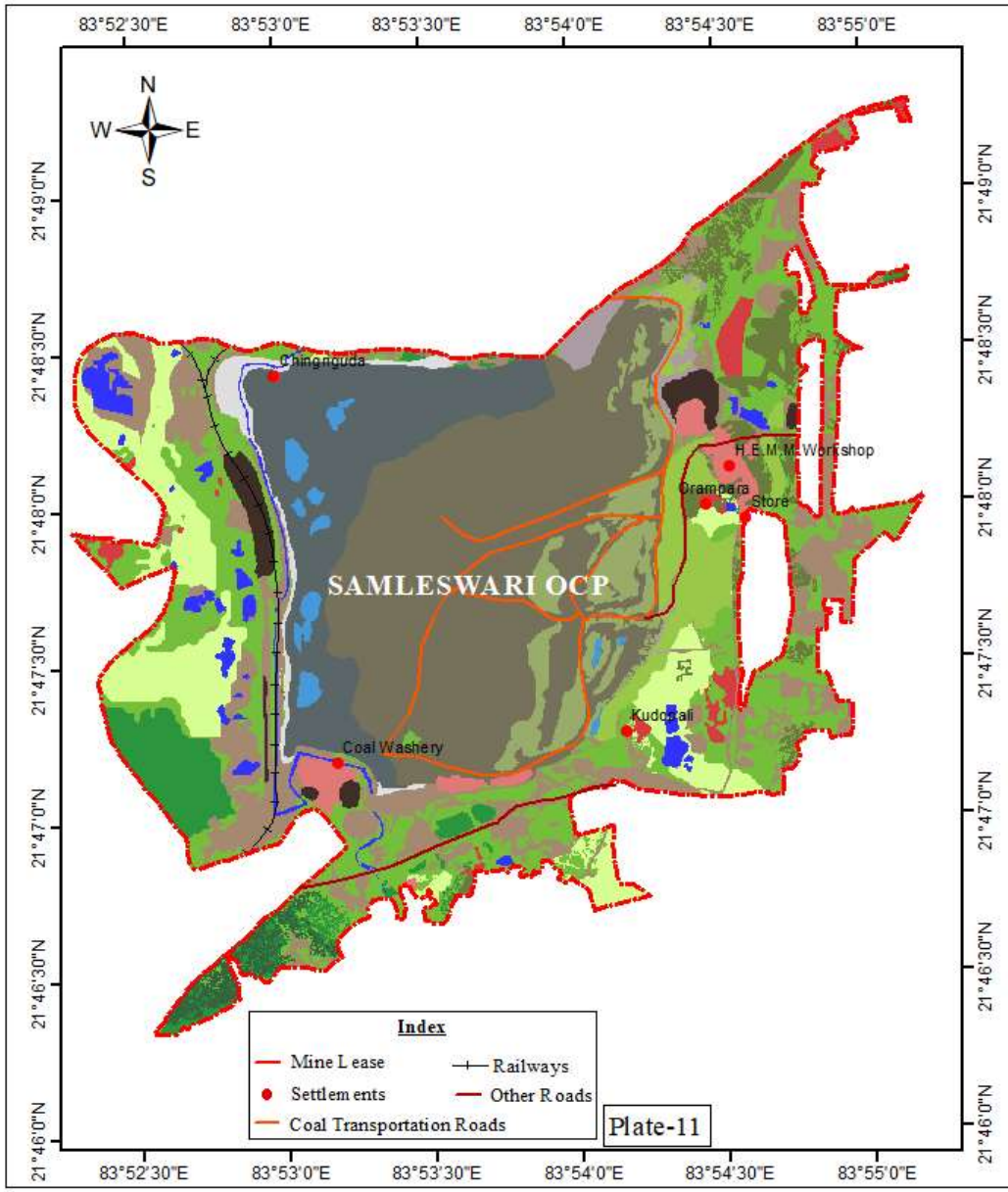

Area Statistics - Samleswari OCP (2023)

Classes		Colour	Area	
Level-I	Level-II		Area (Km^2)	% of Total
Forest Area	Dense Forest		0.16	1.20
	Open Forest		0.51	3.82
	Total Forest Area (A)		**0.67**	**5.02**
Scrubs	**Scrubs (B)**		**2.36**	**17.67**
Plantation	Social Forestry		0.47	3.52
	Plantation on Backfill		0.61	4.57
	Plantation on OB Dump		0.49	3.67
	Total Plantation (C)		**1.57**	**11.76**
	Total Vegetation(A+B+C)		**4.60**	**34.45**
Agriculture	**Agriculture Land**		**1.07**	**8.01**
Waste Land	**Waste Land**		**1.79**	**13.41**
Mining Area	Coal Quarry		1.36	10.19
	Barren OB Dump		0.14	1.05
	Area Under Backfilling		3.22	24.11
	Water Filled Quarry		0.13	0.97
	Coal Dump		0.21	1.57
	Advance Quarry Site		0.15	1.12
	Total Mining Area		**5.21**	**39.02**
Settlements	Urban Settlement		0.003	0.02
	Rural Settlement		0.19	1.42
	Industrial Settlement		0.22	1.65
	Total Settlement Area		**0.41**	**3.09**
Water Body	**River, Ponds**		**0.27**	**2.02**
		Total	**13.35**	**100.00**

Customer	Mahanadi Coalfields Limited				
Title	Land Reclamation Monitoring of OC Projects				Job No. 564922120
Subject: Land Reclamation Status of Samleswari OCP based on Satellite Data (IRS-R2A/L-IV) of the year 2023.	Activity	Name	Designation	Signature	Date
	Prepared	A. Biswas	SM (Geology)	ABiswas	
	Checked	R. Ranjan	GM(Excv.)		
cmpdi A Mine Reclamation Company	Approved	M. Rastogi	GM(Geomatics)		
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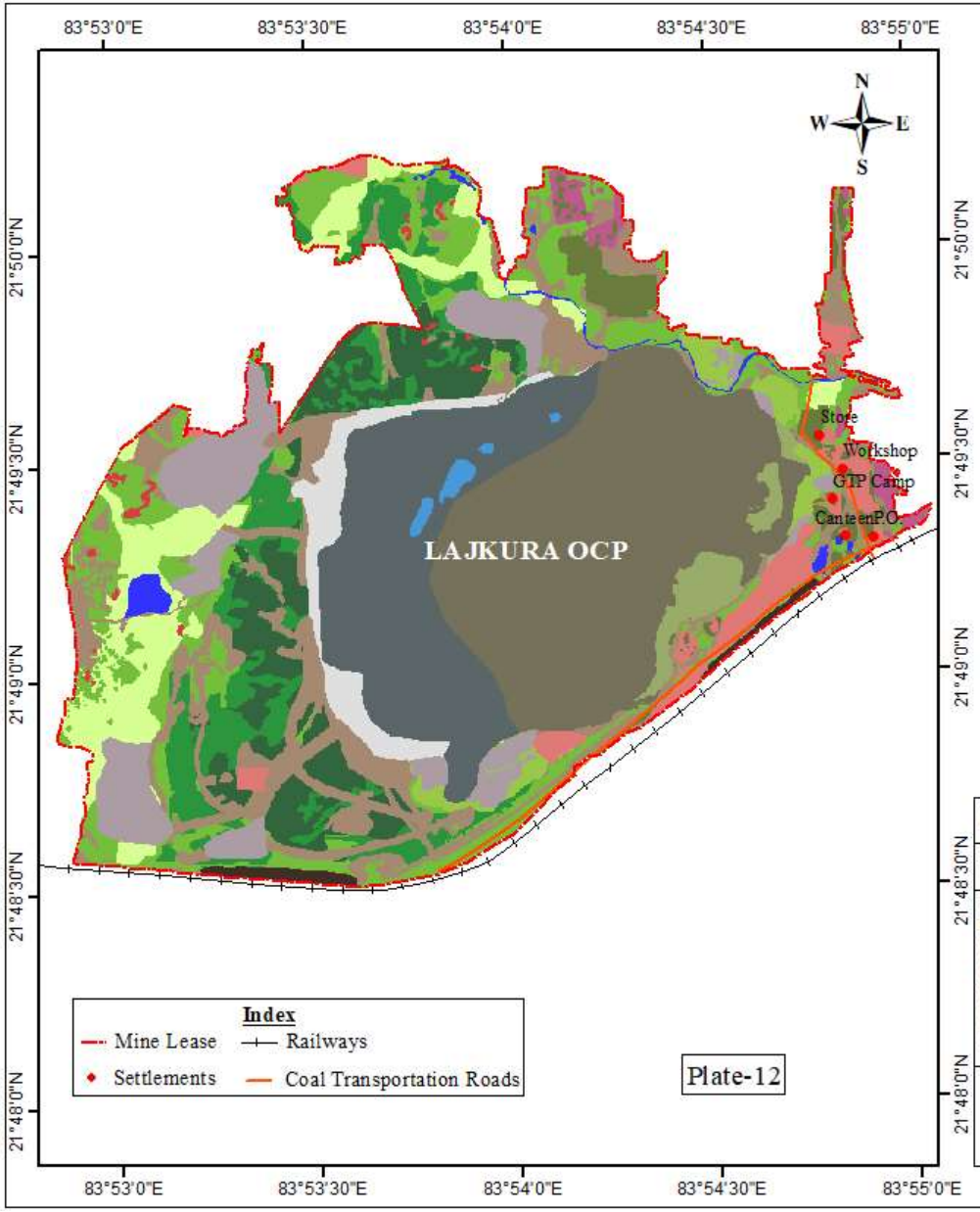
	Drg No. HQ REM 07 A4 23 11				REV No. 0



Area Statistics - Lajkura OCP (2023)				
Classes		Colour	Area	
Level-I	Level-II		Area (Km^2)	% of Total
Forest Area	Dense Forest		0.48	6.66
	Open Forest		0.51	7.07
	Total Forest Area (A)		**0.99**	**13.73**
Scrubs	**Scrubs (B)**		**0.82**	**11.37**
Plantation	Social Forestry		0.16	2.22
	Plantation on Backfill		0.13	1.80
	Plantation on OB Dump		0.12	1.66
	Total Plantation (C)		**0.41**	**5.69**
	Total Vegetation(A+B+C)		**2.22**	**30.79**
Agriculture	**Agriculture Land**		**0.47**	**6.52**
Waste Land	**Waste Land**		**0.92**	**12.76**
Mining Area	Coal Quarry		0.91	12.62
	Barren OB Dump		0.51	7.07
	Area Under Backfilling		1.52	21.08
	Water Filled Quarry		0.03	0.42
	Coal Dump		0.05	0.69
	Advance Quarry Site		0.20	2.77
	Total Mining Area		**3.22**	**44.66**
Settlement	Urban Settlement		0.08	1.11
	Rural Settlement		0.03	0.42
	Industrial		0.21	2.91
	Total Settlement Area		**0.32**	**4.44**
Water Body	**River, Ponds**		**0.06**	**0.83**
		Total	**7.21**	**100.00**

Customer	Mahanadi Coalfields Limited				
Title	Land Reclamation Monitoring of OC Projects				Job No. 564922120
Subject Land Reclamation Status of Lajkura OCP based on Satellite Data (IRS-R2A/L-IV) of the year 2023	Activity	Name	Designation	Signature	Date
	Prepared	A. Biswas	Sr.Mgr.(Geology)	ABiswas	
	Checked	R. Ranjan	GM (Excv.)		
	Approved	M. Rastogi	GM (Geomatics)		
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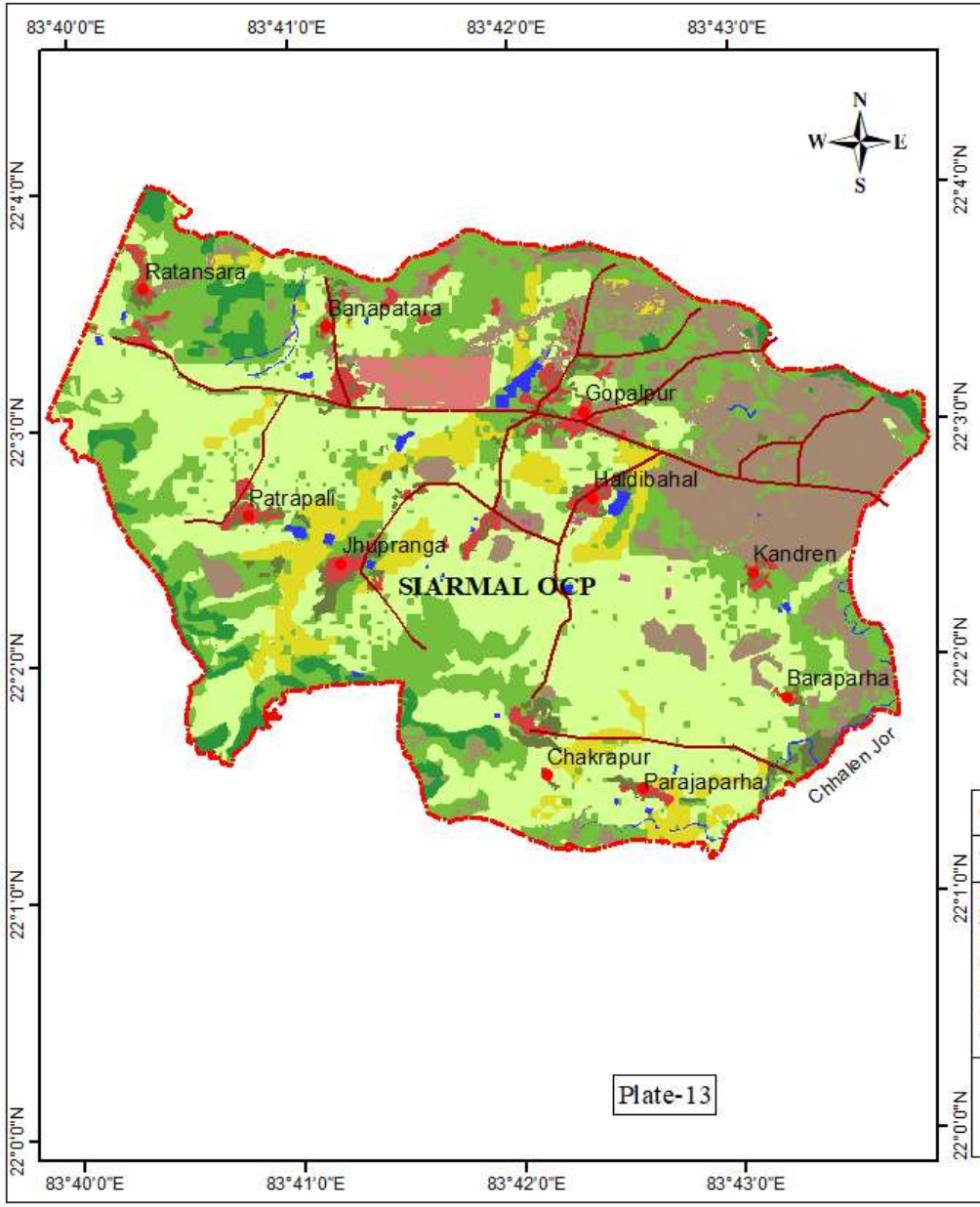

Area Statistics - Siarmal OCP (2023)				
Classes		Colour	Area	
Level-I	Level-II		Area (Km^2)	% of Total
	Open Forest		0.87	3.80
Scrubs	Scrubs		6.07	26.51
Plantation	Social Forestry		0.59	2.58
	Total Vegetation Cover		**7.53**	**32.88**
Agriculture	Fallow Land		9.14	39.91
	Crop Land		1.54	6.72
	Total Agriculture Land		**10.68**	**46.64**
Waste Land	**Waste Land**		**3.82**	**16.68**
Settlement	Rural Settlement		0.64	2.79
	Urban settlemant		0.02	0.09
	Total Settlement Area		**0.66**	**2.88**
Water Body	**River, Ponds**		**0.21**	**0.92**
		Total	**22.90**	**100.00**

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Customer	Mahanadi Coalfields Limited				
Title	Land Reclamation Monitoring of OC Projects				Job No. 564922120
Subject Land Reclamation Status of Siarmal OCP based on Satellite Data (IRS-R2A/L-IV) of the year 2023	Activity	Name	Designation	Signature	Date
	Prepared	A. Biswas	Sr. Mgr.(Geology)	ABiswas	
	Checked	R. Ranjan	GM (Excv.)		
	Approved	M. Rastogi	GM (Geomatics)		
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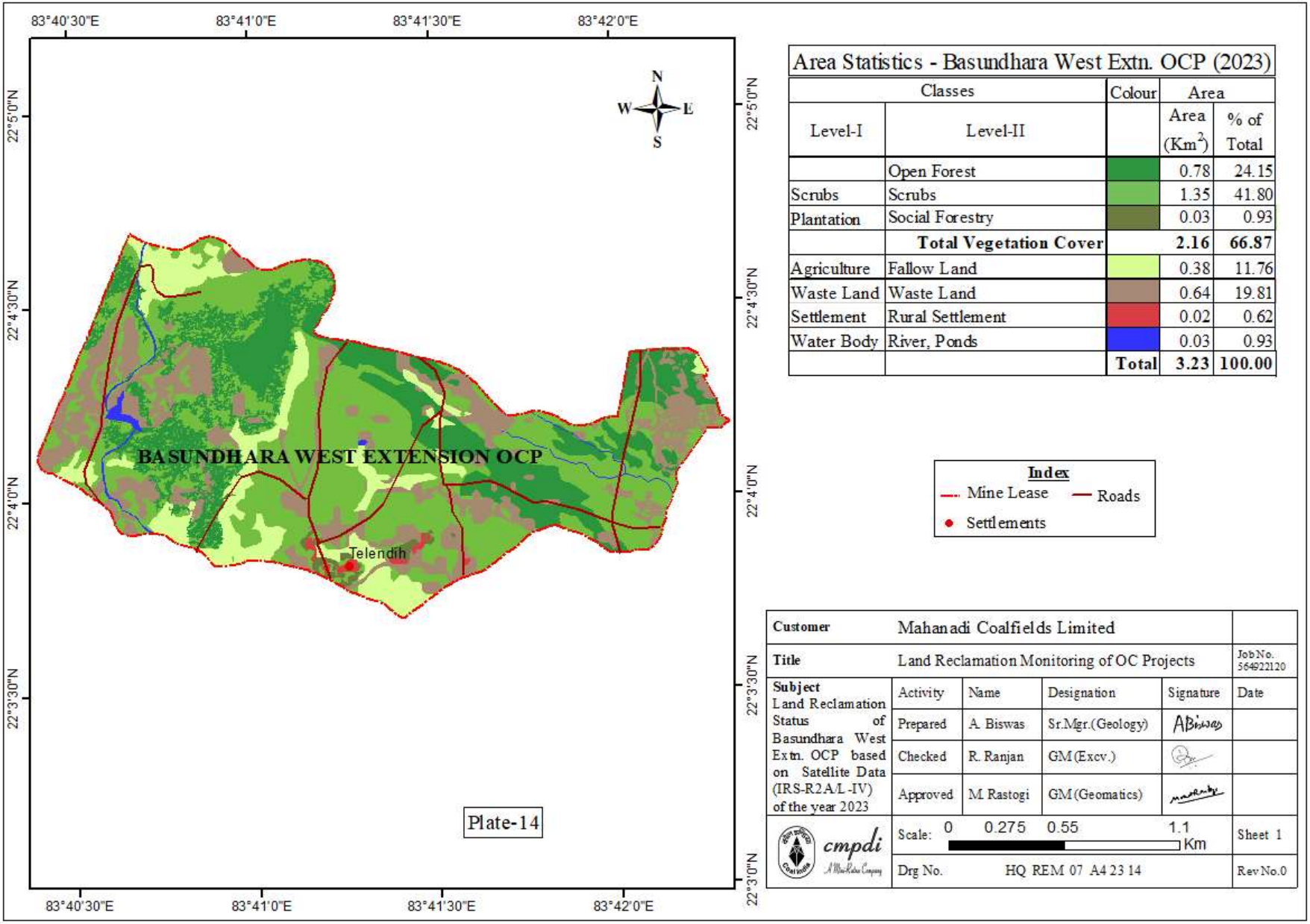

Area Statistics - Basundhara West Extn. OCP (2023)

Classes		Colour	Area	
Level-I	Level-II		Area (Km^2)	% of Total
	Open Forest		0.78	24.15
Scrubs	Scrubs		1.35	41.80
Plantation	Social Forestry		0.03	0.93
	Total Vegetation Cover		**2.16**	**66.87**
Agriculture	Fallow Land		0.38	11.76
Waste Land	Waste Land		0.64	19.81
Settlement	Rural Settlement		0.02	0.62
Water Body	River, Ponds		0.03	0.93
		Total	**3.23**	**100.00**

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Customer	Mahanadi Coalfields Limited				
Title	Land Reclamation Monitoring of OC Projects				Job No. 564922120
Subject Land Reclamation Status of Basundhara West Extn. OCP based on Satellite Data (IRS-R2A/L-IV) of the year 2023	Activity	Name	Designation	Signature	Date
	Prepared	A. Biswas	Sr.Mgr.(Geology)	ABiswas	
	Checked	R. Ranjan	GM(Excv.)		
	Approved	M. Rastogi	GM(Geomatics)		
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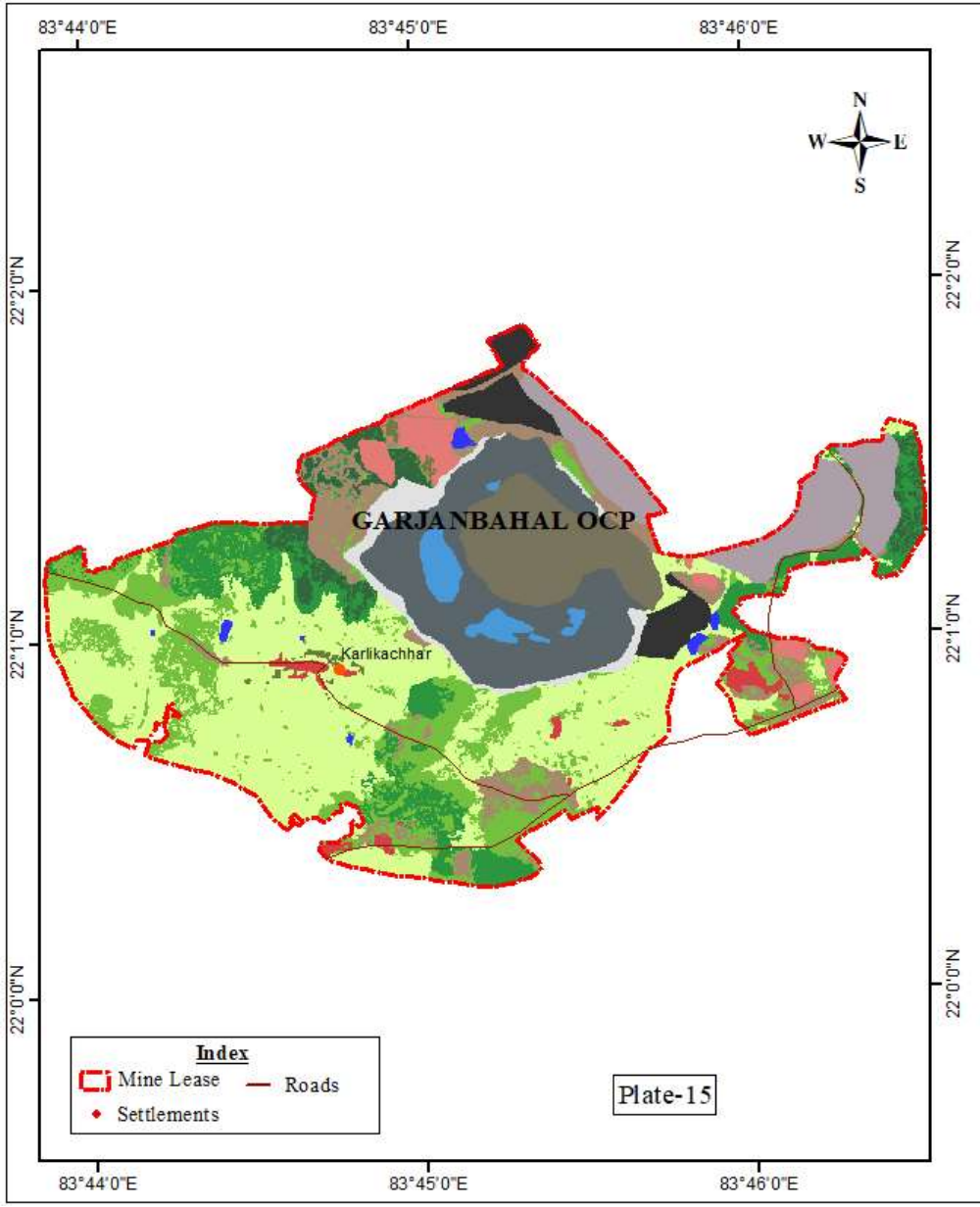

Area Statistics - Garjanbahal OCP (2023)				
Classes		Colour	Area	
Level-I	Level-II		Area (Km^2)	% of Total
Forest Area	Dense Forest		0.18	2.75
	Open Forest		0.57	8.72
	Total Forest Area (A)		**0.75**	**11.47**
Scrubs	**Scrubs (B)**		**0.94**	**14.37**
Plantation	Social Forestry		0.02	0.31
	Plantation on Backfill		0.00	0.00
	Plantation on OB Dump		0.00	0.00
	Total Plantation (C)		**0.02**	**0.31**
	Total Vegetation(A+B+C)		**1.71**	**26.15**
Agriculture	**Agriculture Land**		**2.00**	**30.58**
Waste Land	**Waste Land**		**0.49**	**7.49**
Mining Area	Coal Quarry		0.71	10.86
	Barren OB Dump		0.46	7.03
	Area Under Backfilling		0.43	6.57
	Water Filled Quarry		0.11	1.68
	Coal Dump		0.22	3.36
	Advance Quarry Site		0.16	2.45
	Total Mining Area		**2.09**	**31.96**
Settlements	Rural Settlement		0.07	1.07
	Industrial Settlement		0.15	2.29
	Total Settlement Area		**0.22**	**3.36**
Water Body	**River, Ponds**		**0.03**	**0.46**
		Total	**6.54**	**100.00**

Customer	Mahanadi Coalfields Limited				
Title	Land Reclamation Monitoring of OC Projects				Job No. 564922120
Subject Land Reclamation Status of Garjanbahal OCP based on Satellite Data (IRS-R2A/L-IV) of the year 2023	Activity	Name	Designation	Signature	Date
	Prepared	A. Biswas	Sr.Mgr.(Geology)	ABiswas	
	Checked	R. Ranjan	GM (Excv.)		
	Approved	M. Rastogi	GM (Geomatics)		
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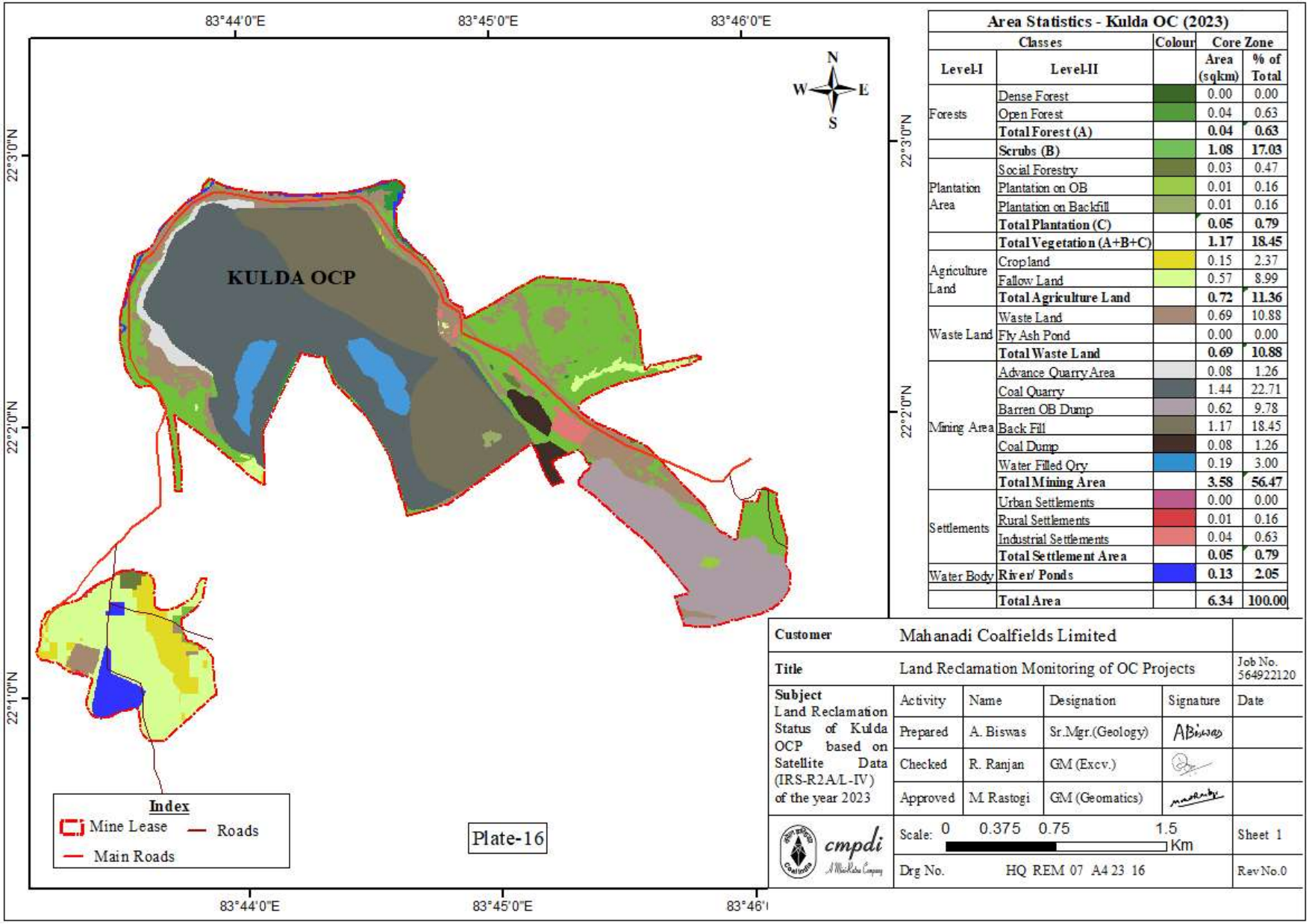

Area Statistics - Kulda OC (2023)

Classes		Colour	Core Zone	
Level-I	Level-II		Area (sqkm)	% of Total
Forests	Dense Forest		0.00	0.00
	Open Forest		0.04	0.63
	Total Forest (A)		**0.04**	**0.63**
	Scrubs (B)		**1.08**	**17.03**
Plantation Area	Social Forestry		0.03	0.47
	Plantation on OB		0.01	0.16
	Plantation on Backfill		0.01	0.16
	Total Plantation (C)		**0.05**	**0.79**
	Total Vegetation (A+B+C)		**1.17**	**18.45**
Agriculture Land	Cropland		0.15	2.37
	Fallow Land		0.57	8.99
	Total Agriculture Land		**0.72**	**11.36**
Waste Land	Waste Land		0.69	10.88
	Fly Ash Pond		0.00	0.00
	Total Waste Land		**0.69**	**10.88**
Mining Area	Advance Quarry Area		0.08	1.26
	Coal Quarry		1.44	22.71
	Barren OB Dump		0.62	9.78
	Back Fill		1.17	18.45
	Coal Dump		0.08	1.26
	Water Filled Qry		0.19	3.00
	Total Mining Area		**3.58**	**56.47**
Settlements	Urban Settlements		0.00	0.00
	Rural Settlements		0.01	0.16
	Industrial Settlements		0.04	0.63
	Total Settlement Area		**0.05**	**0.79**
Water Body	**River/ Ponds**		**0.13**	**2.05**
	Total Area		**6.34**	**100.00**

Customer	Mahanadi Coalfields Limited				
Title	Land Reclamation Monitoring of OC Projects				Job No. 564922120
Subject Land Reclamation Status of Kulda OCP based on Satellite Data (IRS-R2A/L-IV) of the year 2023	Activity	Name	Designation	Signature	Date
	Prepared	A. Biswas	Sr.Mgr.(Geology)	ABiswas	
	Checked	R. Ranjan	GM (Excv.)		
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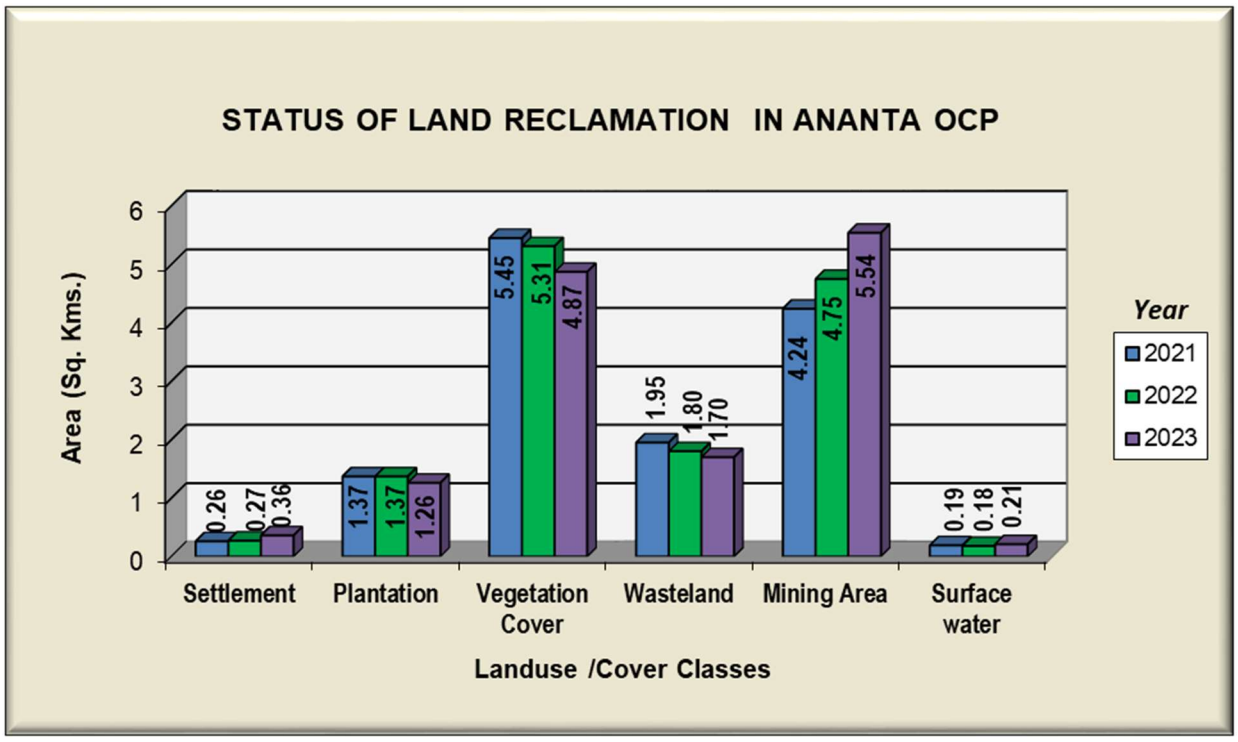

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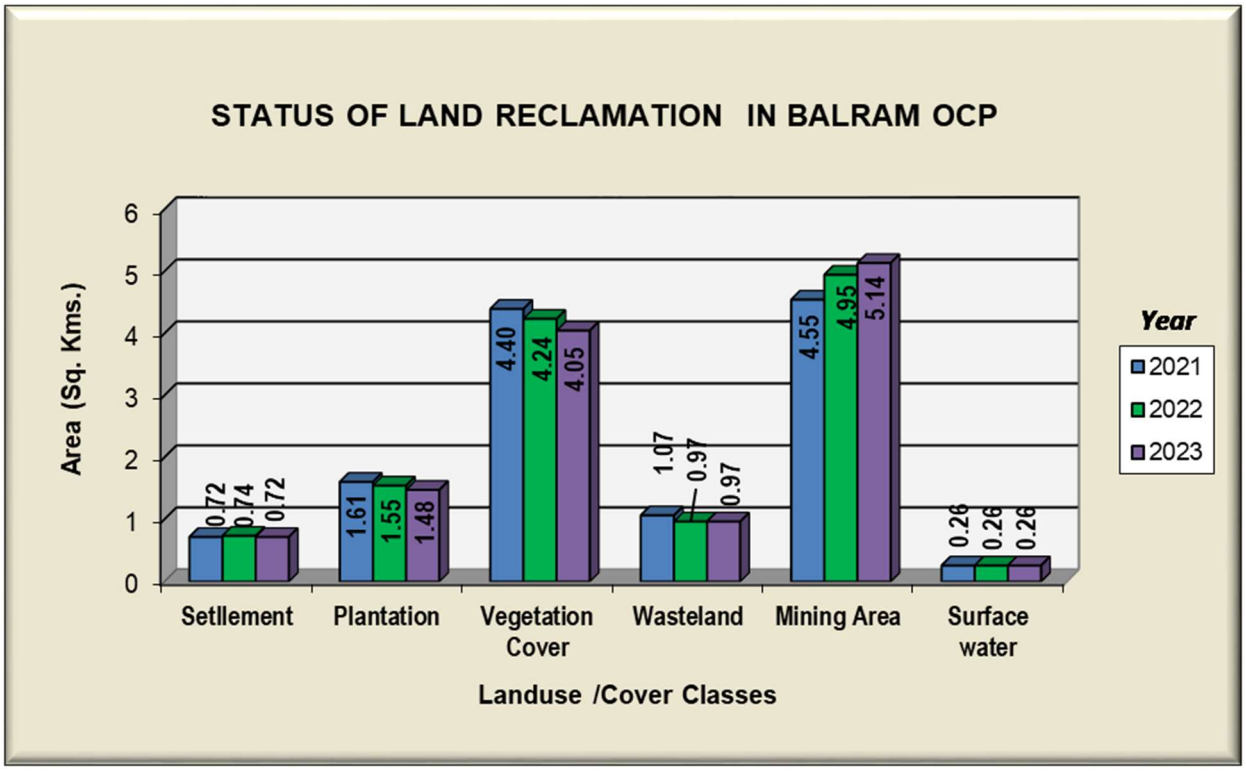

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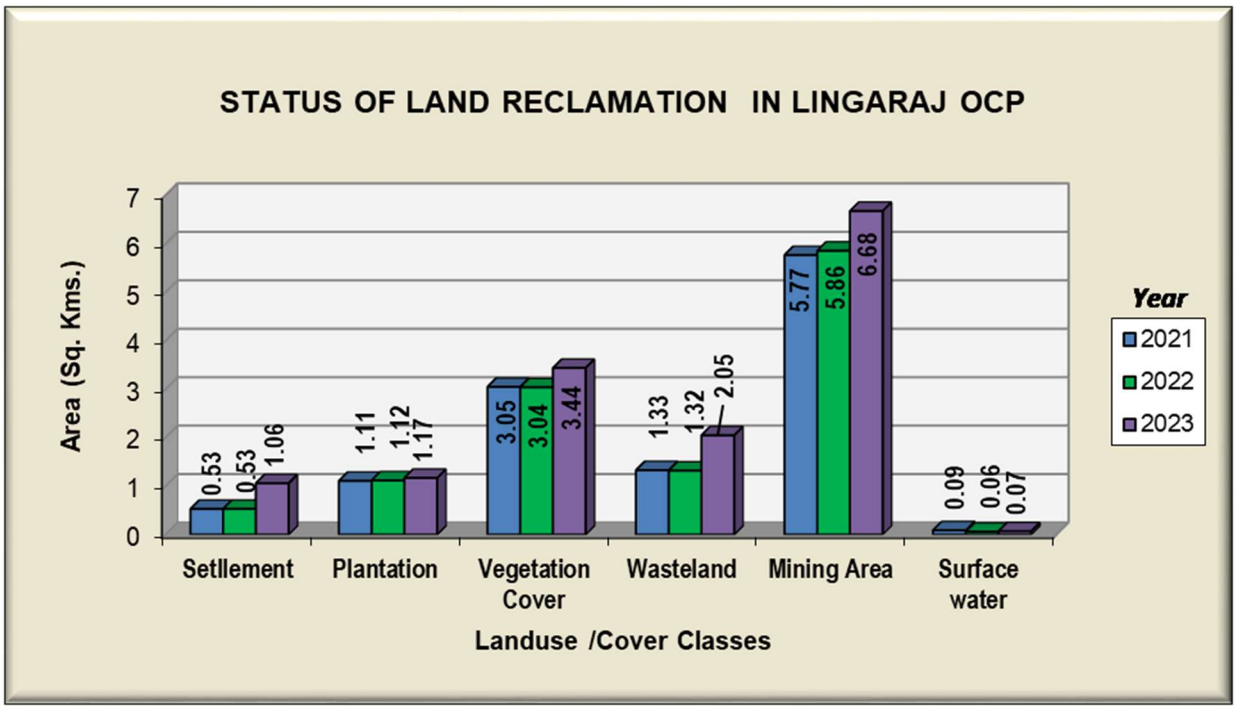

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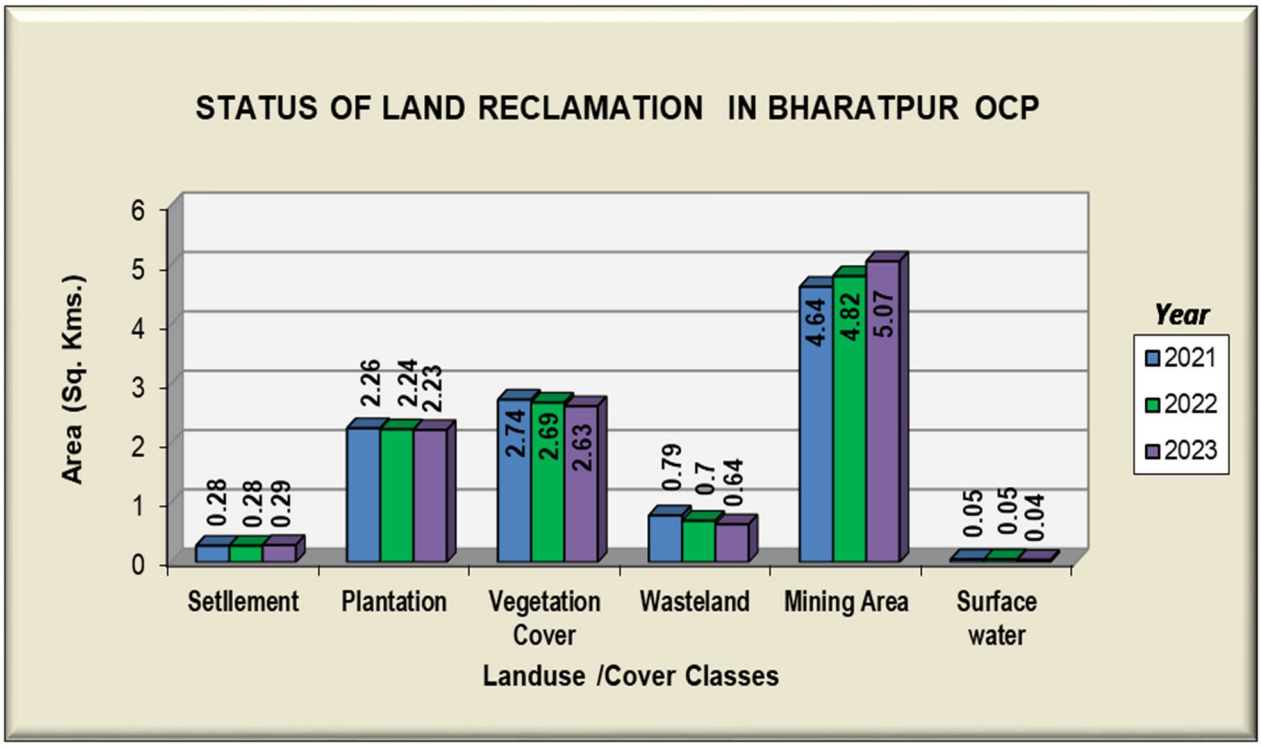

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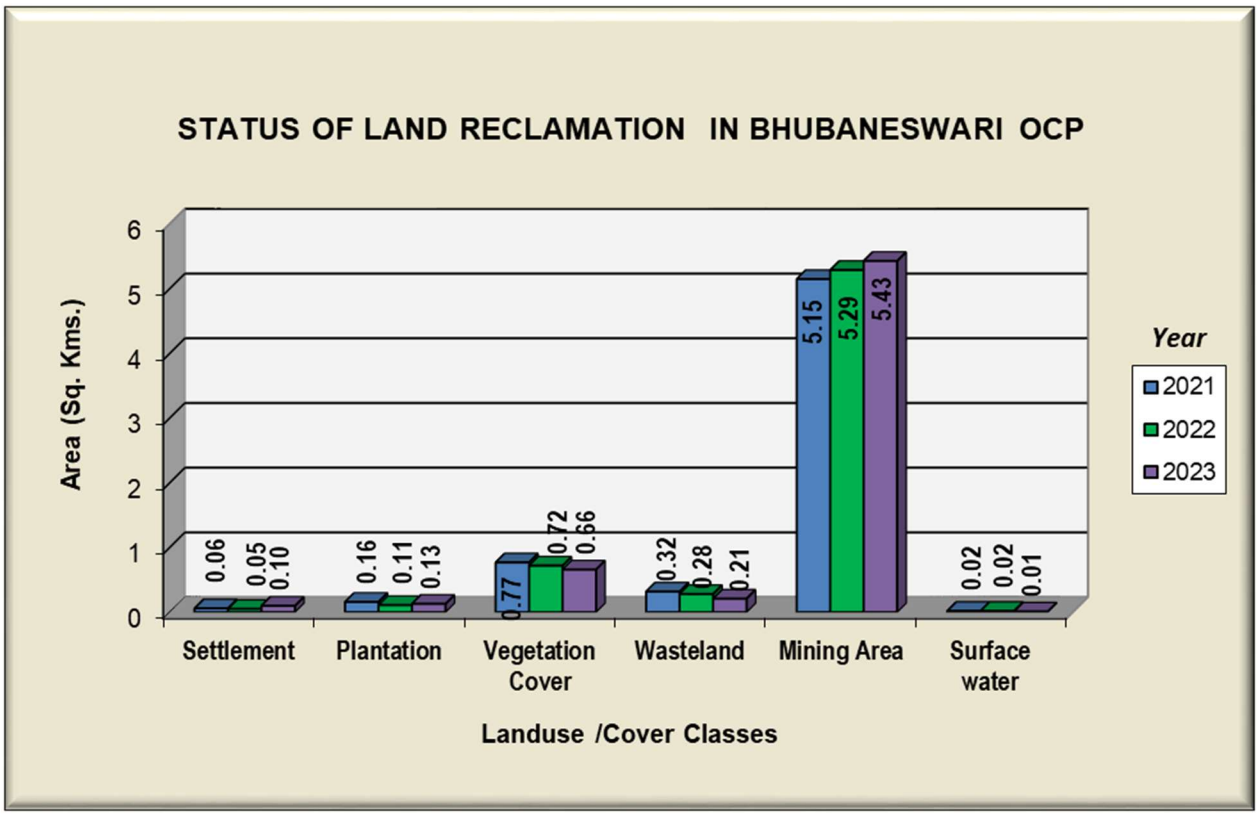

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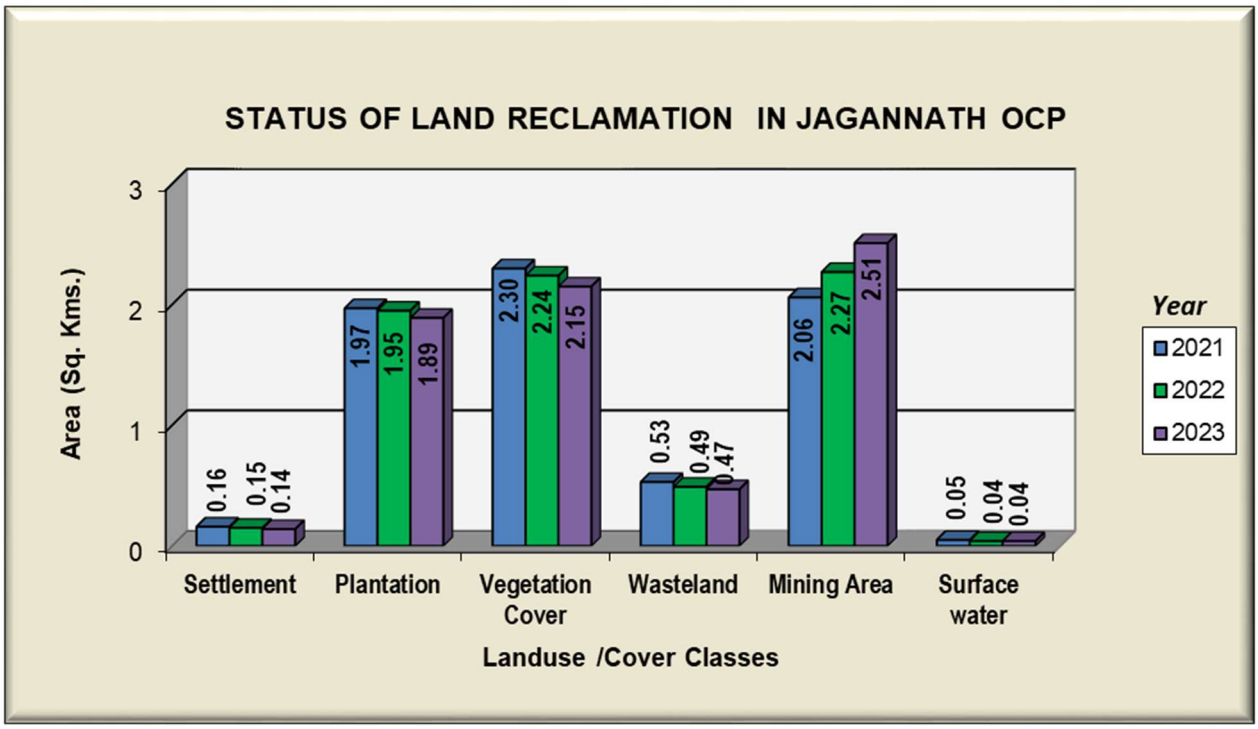

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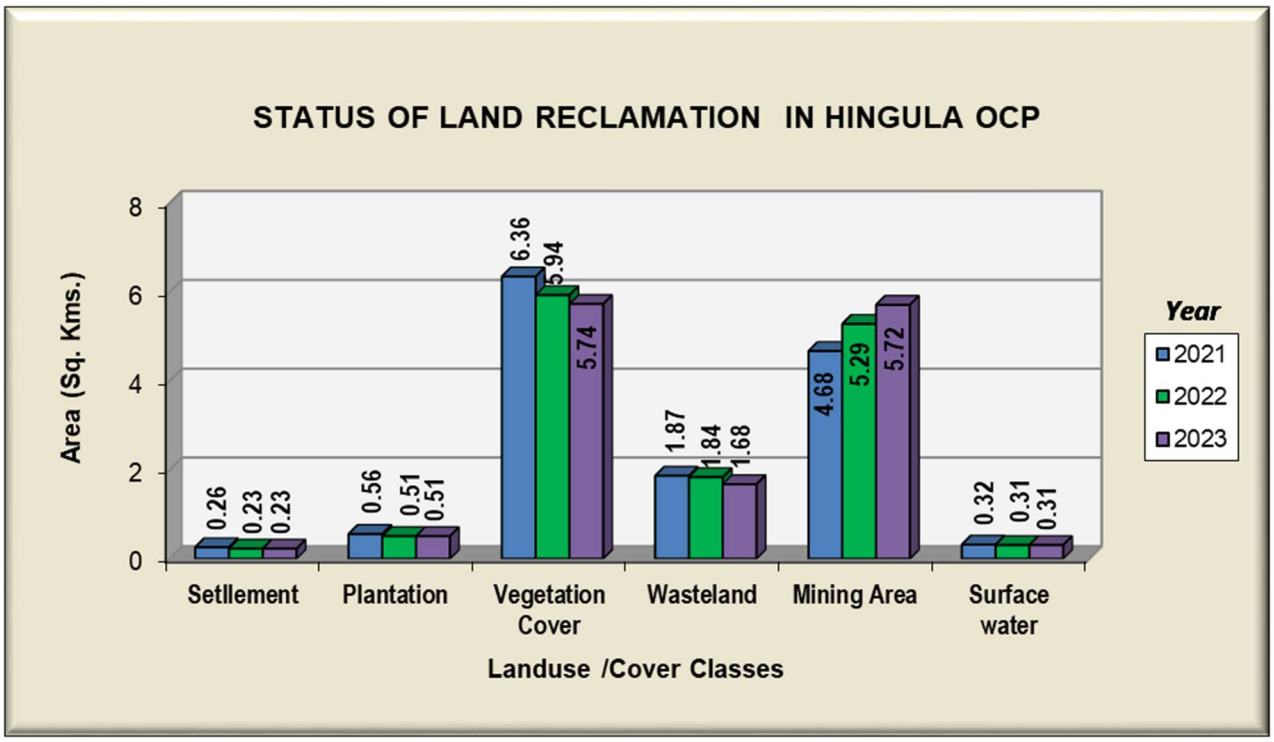

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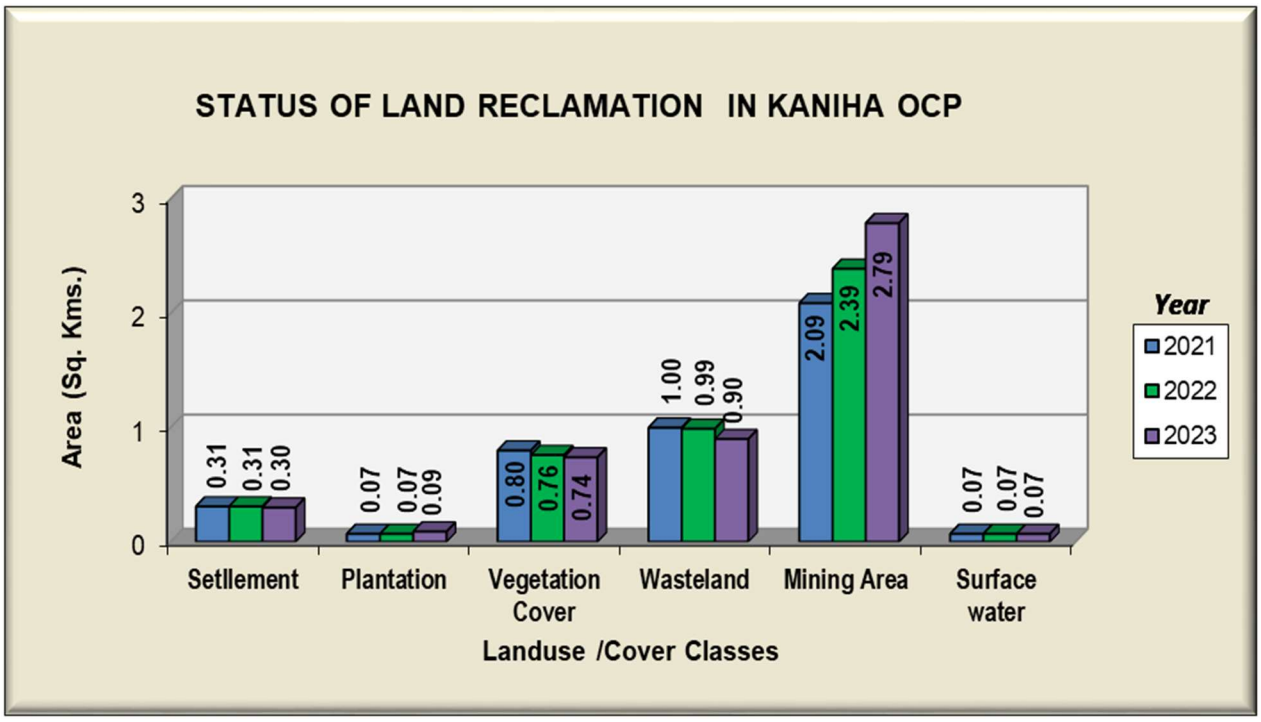

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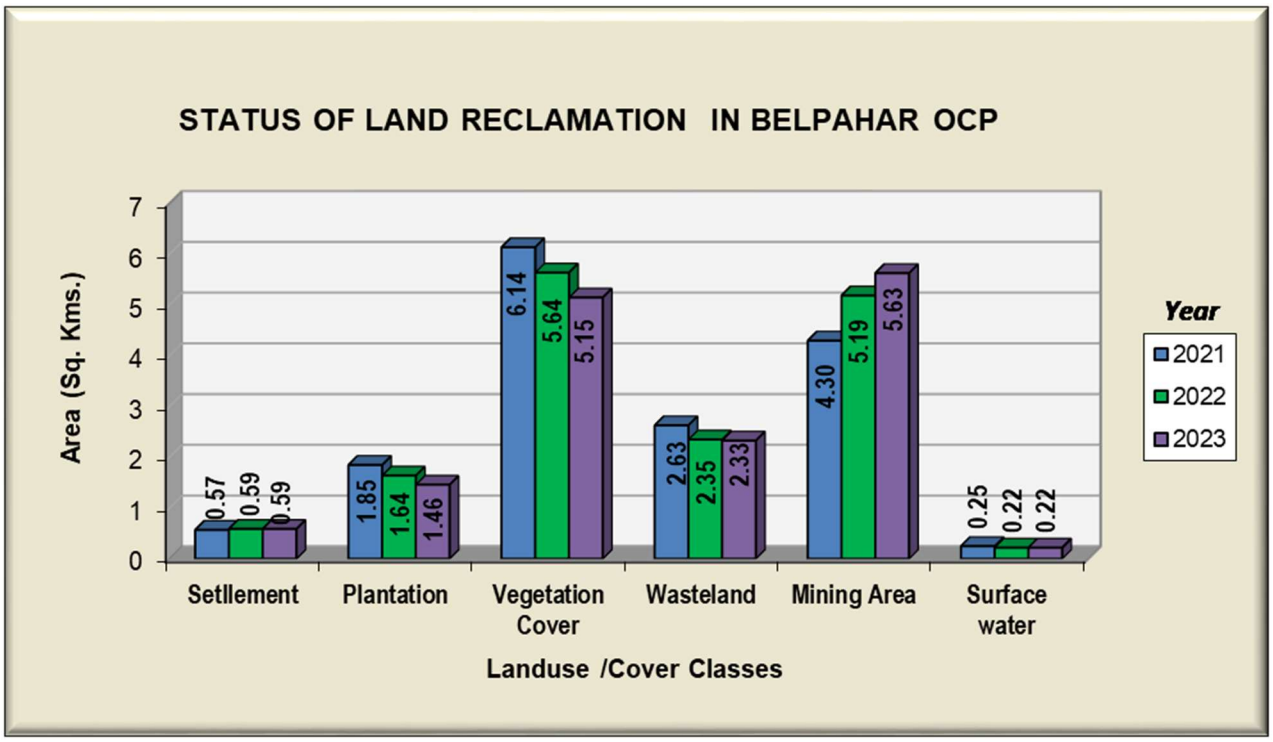

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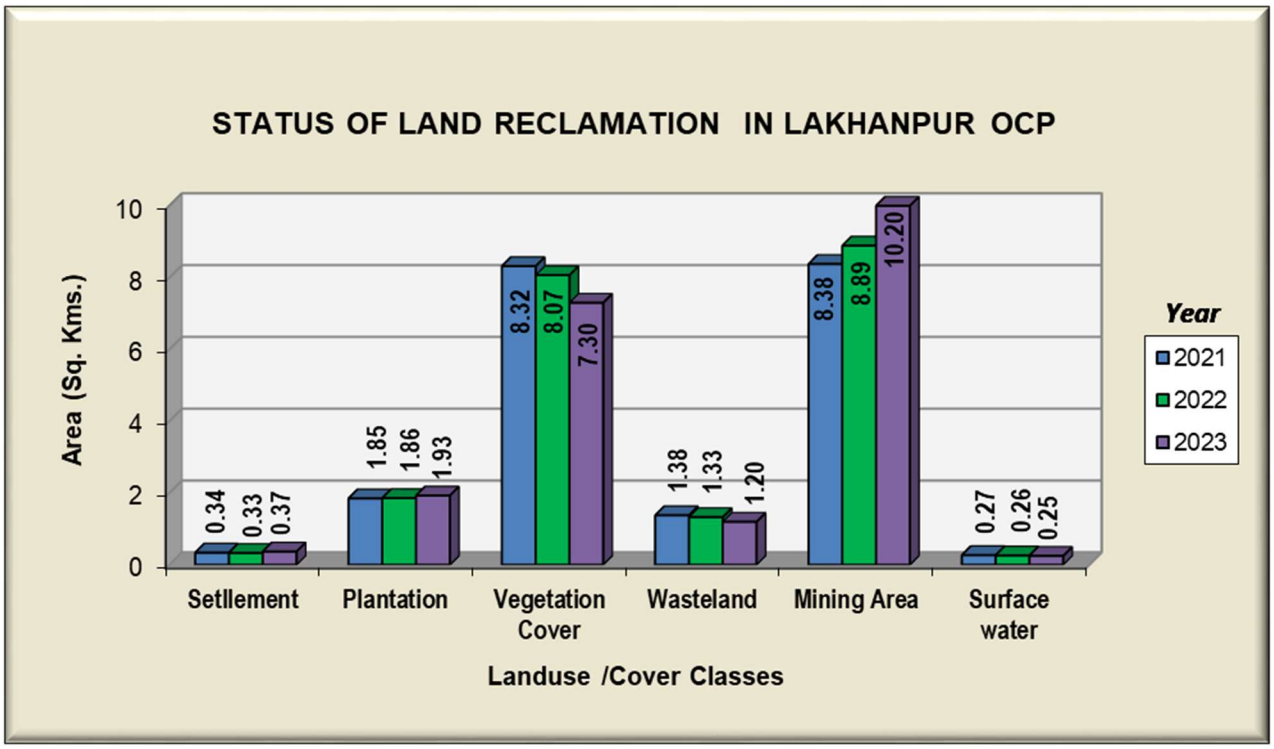

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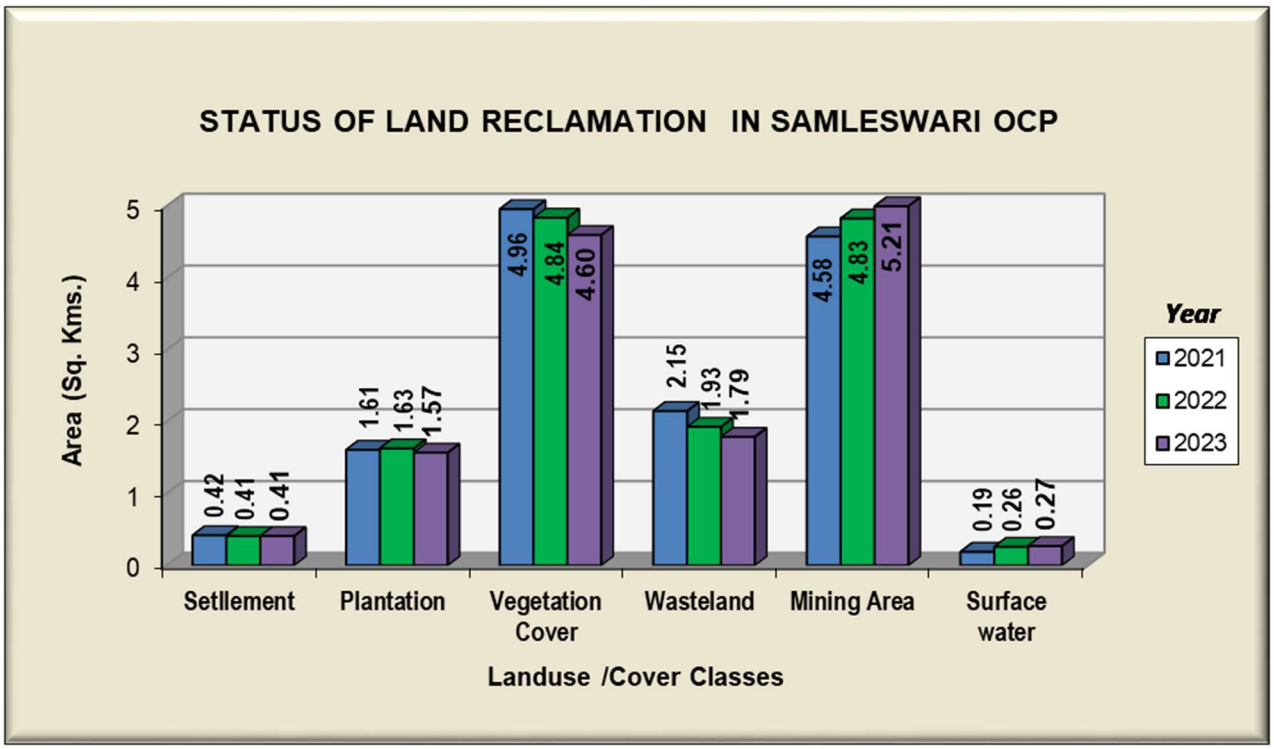

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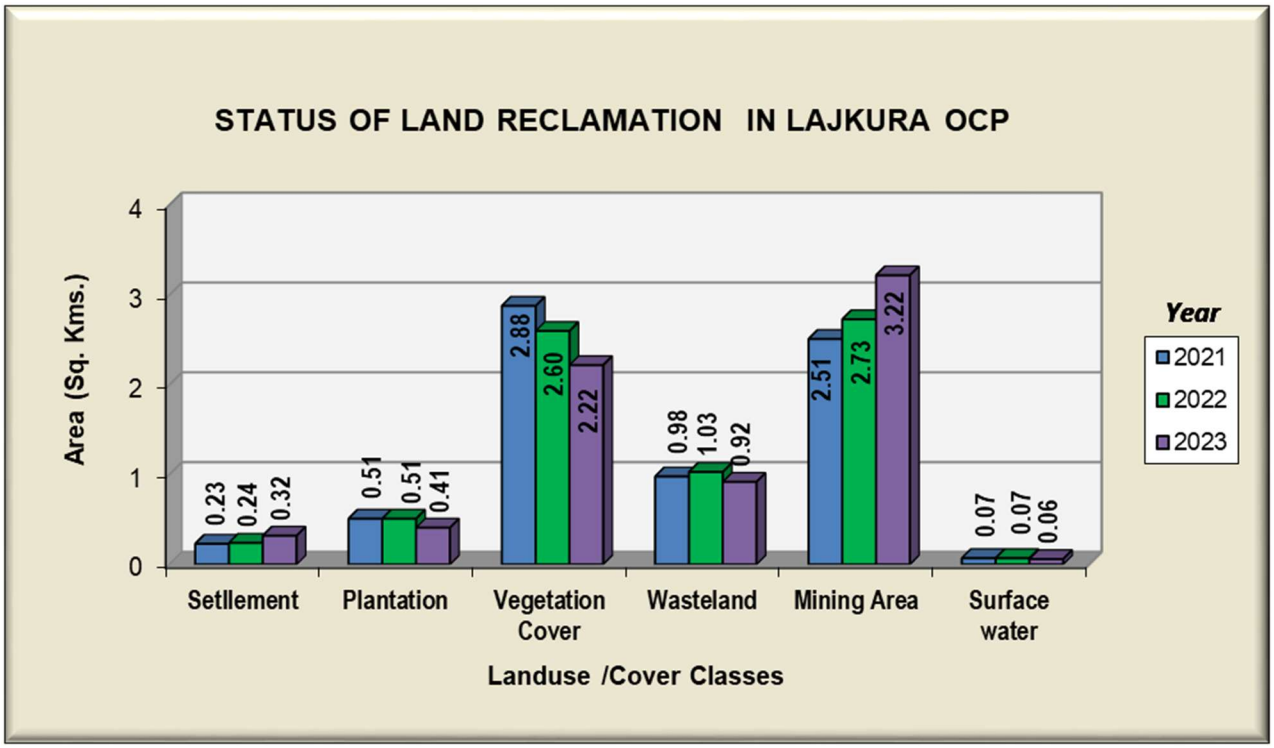

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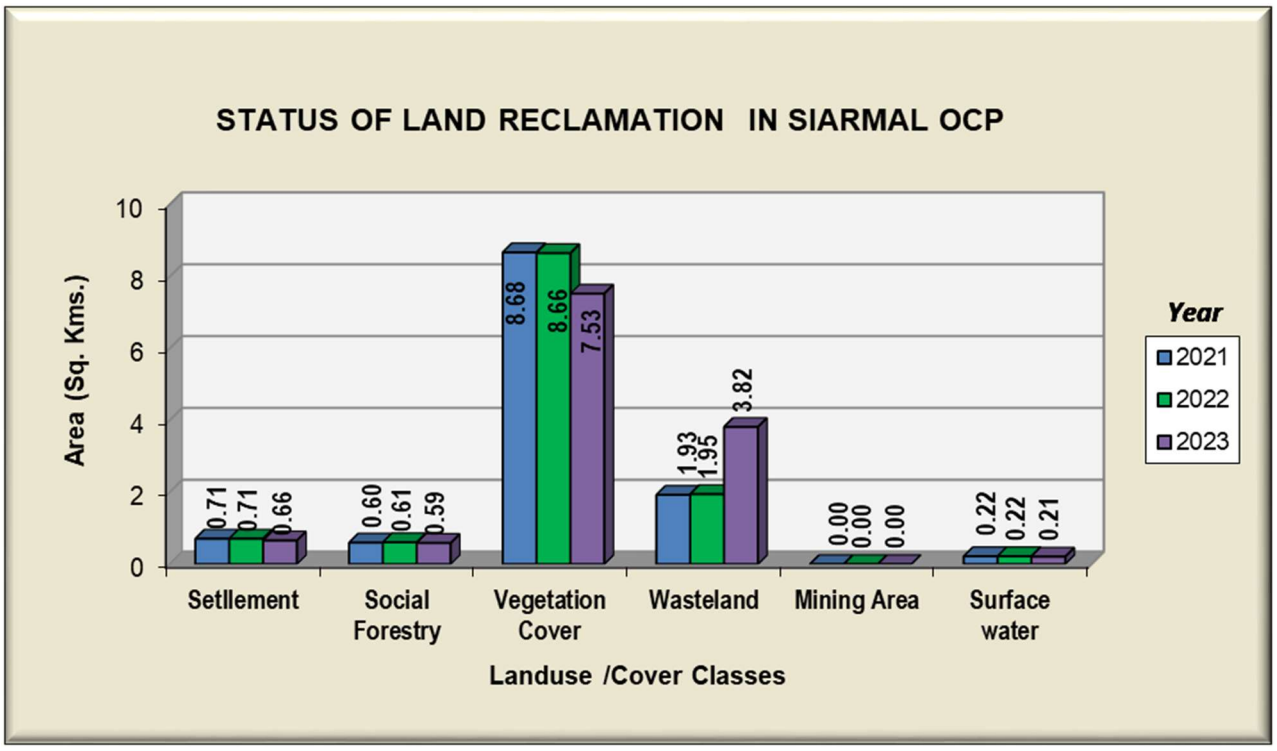

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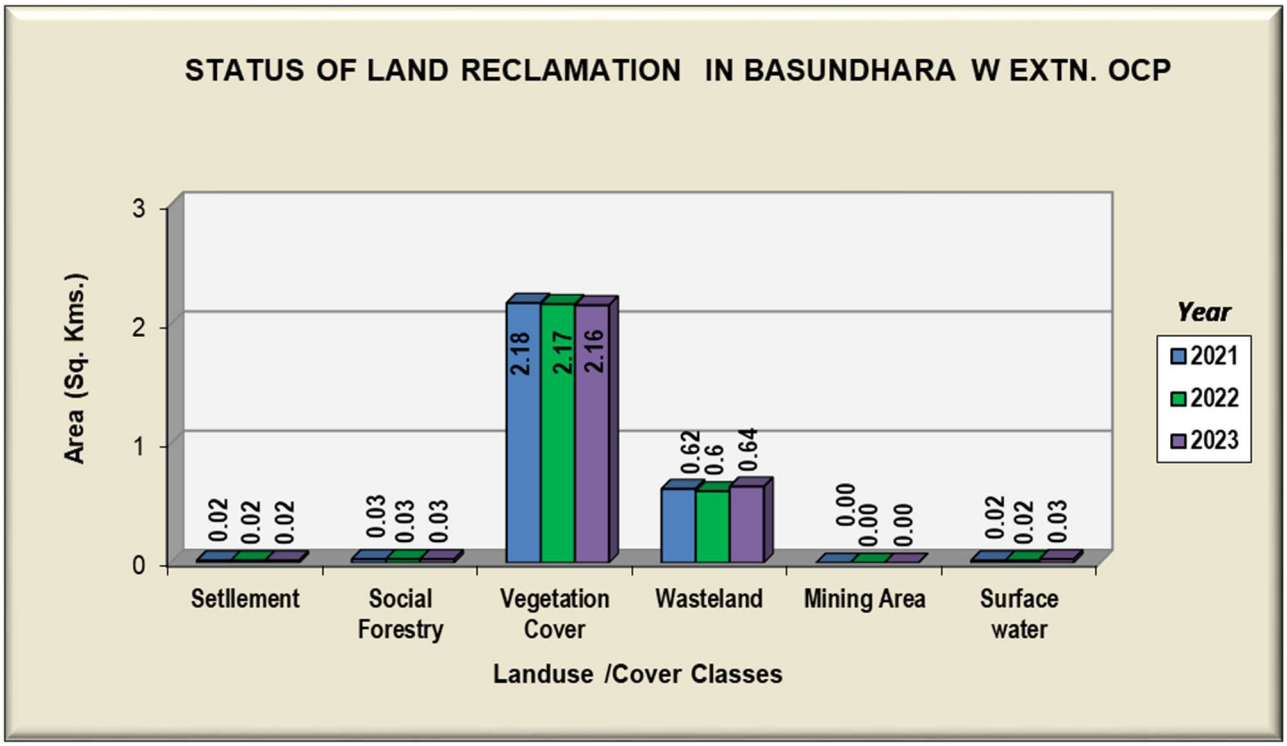

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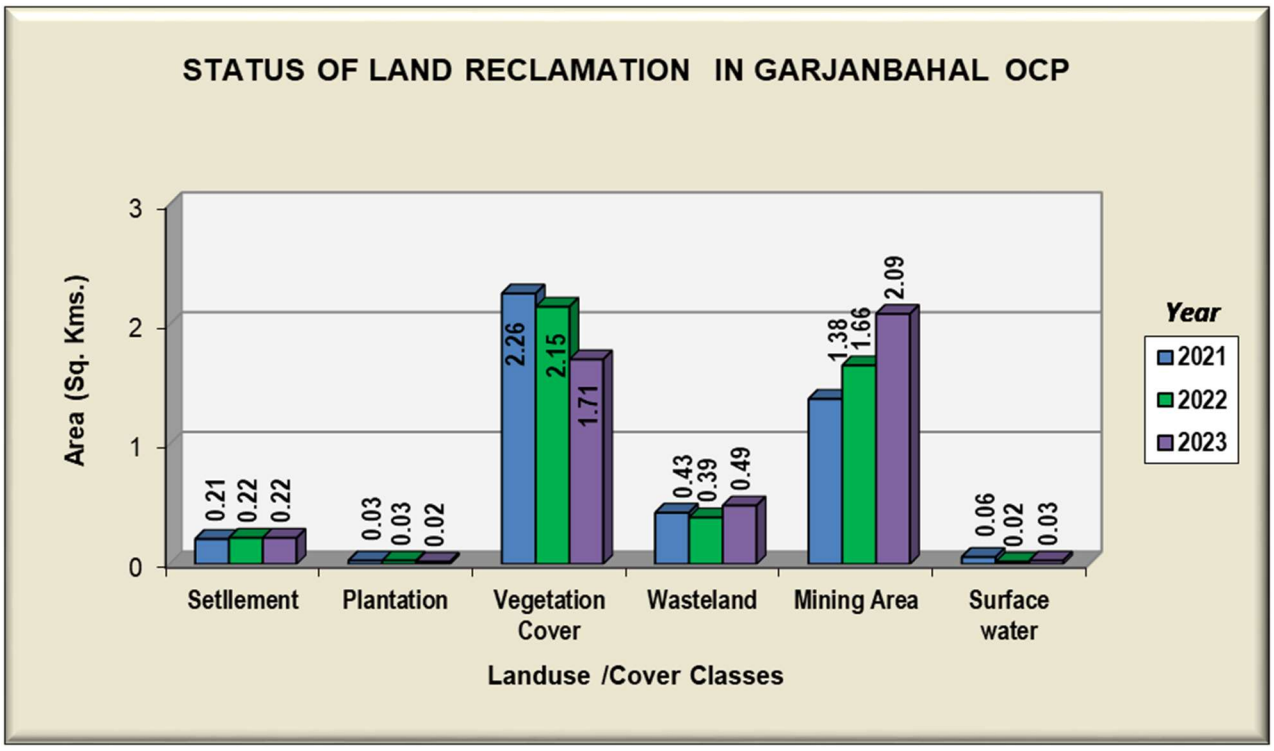

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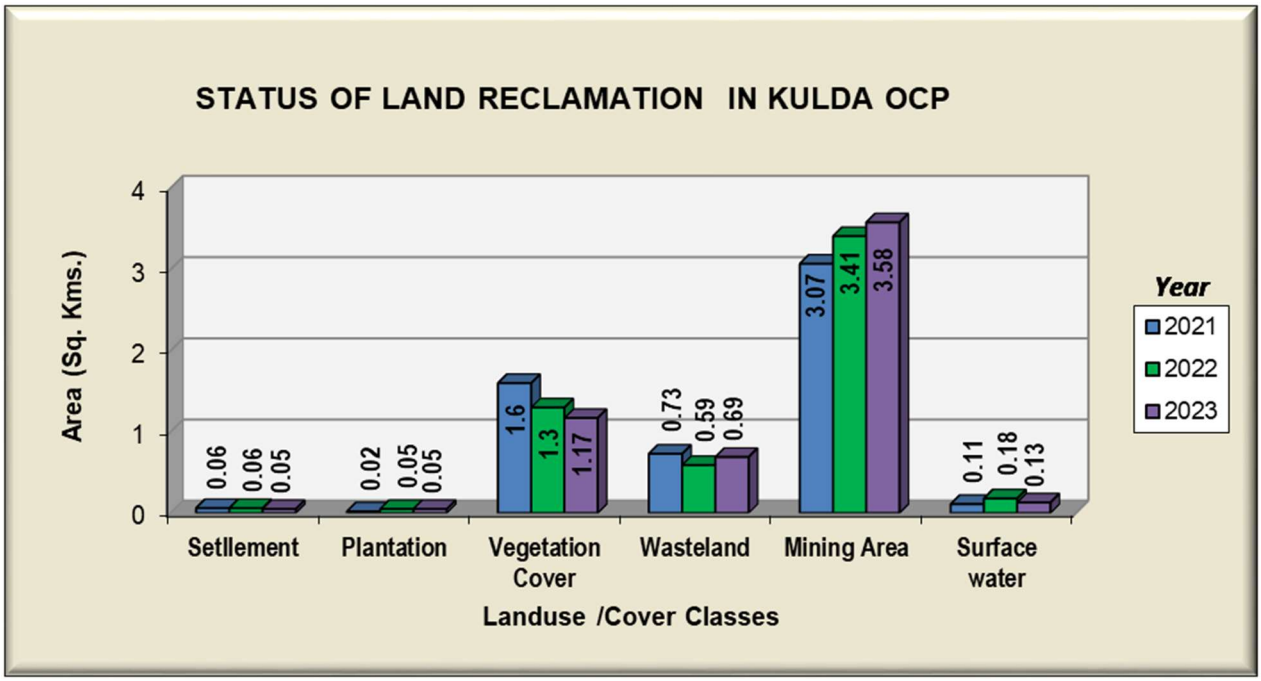
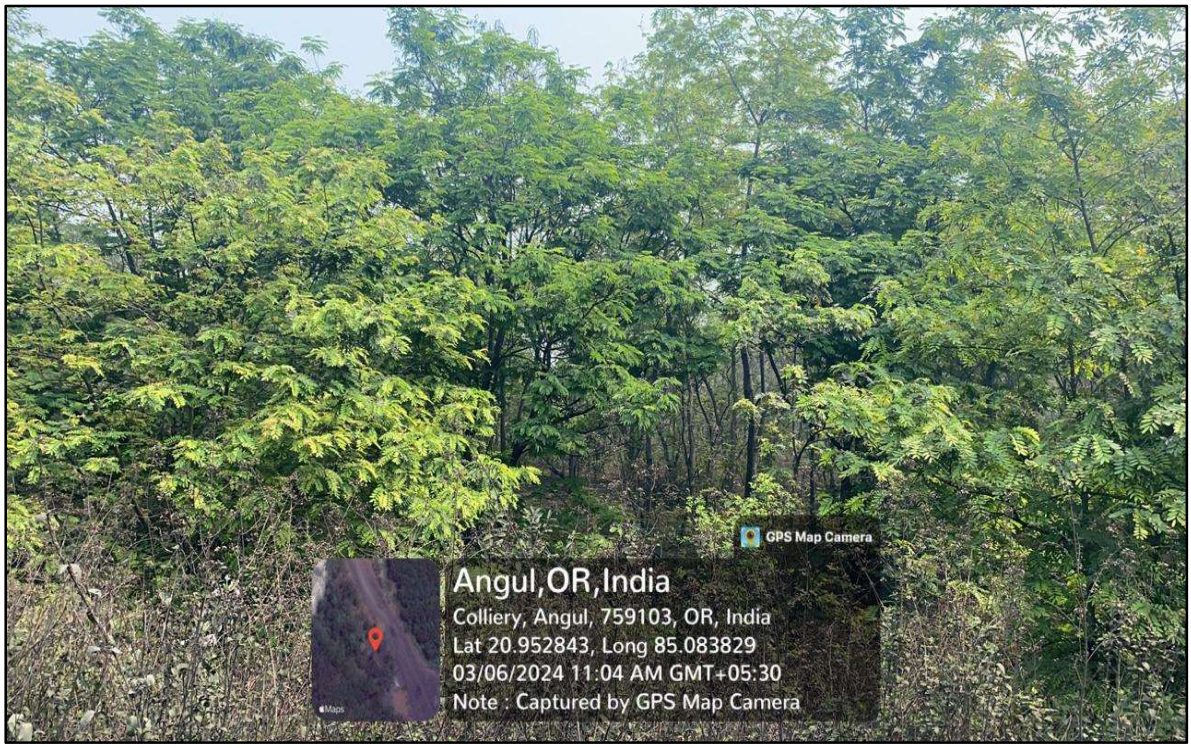


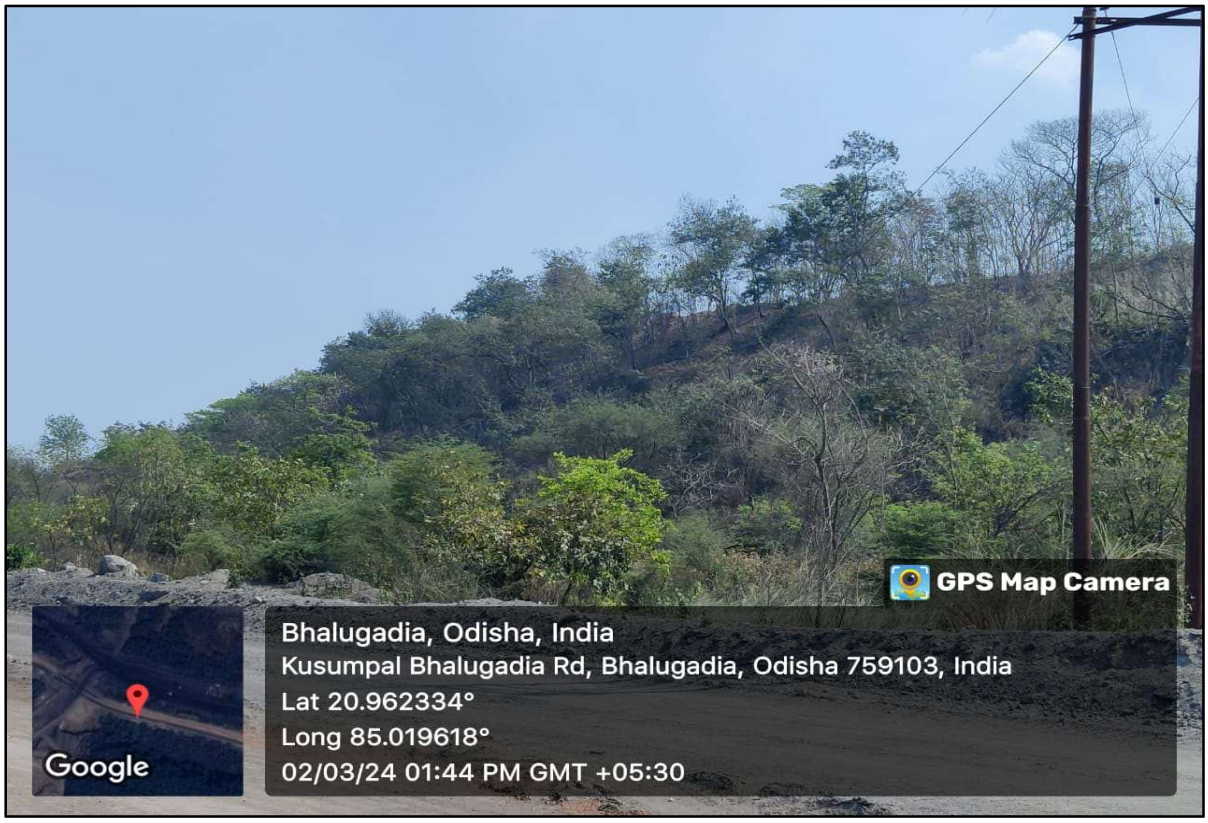
Figure 18

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



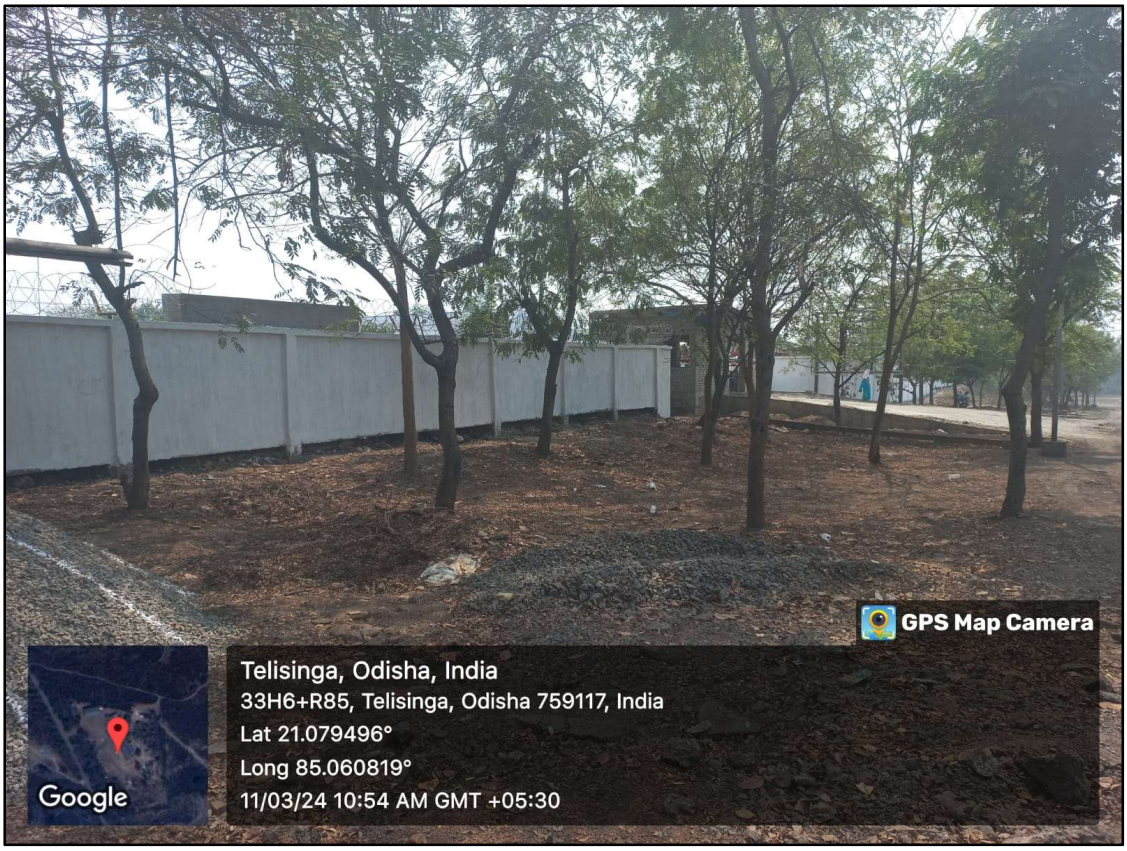
Photograph-2: Plantation on Internal OB/Backfill (Balram OC Mine)

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



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

Photograph-5: Plantation under Social Forestry (Kaniha OC Mine)



Photograph-6: Plantation under Social Forestry (Kaniha OC Mine)

Photograph-7: Plantation under Social Forestry (Lingaraj OC Mine)

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

Photograph-9: Plantation on Internal OB/Backfill (Lakhanpur OC Mine)

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

Photograph-11: Plantation on External OB (Lajkura OC Mine)

Photograph-12: Plantation on External OB (Kulda OC Mine)

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66	Maximum	अधिकतम
67	Coal field	कोयला क्षेत्र
68	Design	परिकल्पना
69	Superimpose	आरोपित
70	Update	अद्यतनीकरण/नवीनीकरण
71	Cumulative	संचयित
72	Embankment	तटबंध
73	Cluster	खुली तथा भूमिगत खदानों के समूह

ABBREVIATIONS

SoI	Survey of India
MoEF&CC	Ministry of Environment, Forest & Climate Change
CIL	Coal India Limited
ECL	Eastern Coalfields Limited
BCCL	Bharat Coking Coal Limited
CCL	Central Coalfields Limited
WCL	Western Coalfields Limited
SECL	South Eastern Coalfields Limited
NCL	Northern Coalfields Limited
MCL	Mahanadi Coalfields Limited
NEC	North Eastern Coalfields
CMPDIL	Central Mine Planning & Design Institute Ltd
NRSC	National Remote Sensing Centre
R2/ R2A	Resource-Sat Satellites
LISS - 4	Linear Imaging and Self Scanning Sensor
FCC	False Colour Composite
OCP	Opencast Project
UGP	Underground Project
OB	Over Burden
GCP	Ground Control points
GIS	Geographic Information System
WGS-84	World Geodetic System
UTM	Universal Transverse Mercator

GLOSSARY

Sl.	Term	Definition
1.	Land Reclamation	To manage, reclaim and restore mined out/ degraded land as close as possible to its original stage
2.	Over Burden	The material that lies above the coal seam/ deposit
3.	Monitoring	A process of evaluation to check or keep record for a period of time.
4.	Opencast Coal Mine	Open-pit mining, also known as opencast mining, is a surface mining technique that extracts minerals from an open pit in the ground.
5.	Social Forestry	Social forestry is the management and protection of forests and afforestation of barren and deforested lands with the purpose of helping environmental, social and rural development. Plantation (Social/ Avenue or other) carried out outside mining area.
6.	Biological Reclamation	Plantation on Backfilled areas (Stabilized Internal Dumps)
7.	Technical Reclamation	Area under backfilling (Over burden dumped inside the mine voids) in mining area.
8.	Green Cover Generation	Total Plantation carried out in the lease area of Project. This include Plantation on Backfill, Plantation on OB and Social Forestry
9.	Leasehold Area	The area, for which lease is granted for the purpose of undertaking mining and allied operations
10.	Excavated area	Mined out area which includes active mining, area under backfilling and plantation on backfilled areas
11.	Active Mining	Mining areas which include Coal Quarry, Advance Quarry, Quarry Filled with Water etc.
12.	Environmental Protection	It is the practice of protecting the natural environment by individuals, organizations and governments. Its objectives are to conserve natural resources and the existing natural environment and, where possible, to mitigate damage and reverse trends.
13.	Remedial Measure	Any measure or action required or undertaken to investigate, monitor, clean up, remove, treat, prevent, contain or otherwise remediate the presence or release of any hazardous substance or activity.

14.	Systematic Error	Every measurement differing from the true measurement in the same direction, and even by the same amount in some cases
15.	Geometric Distortion	It refers to the improper positioning of any image with respect to their true geographic position when viewed in a properly scaled common image display plane.
16.	Land Use/Cover Class	Land cover is what covers the surface of the earth and land use describes how the land is used.
17.	Accuracy	The closeness of agreement between a measured quantity value and a true quantity value.
18.	Environmental Clearance	Environmental Clearance (EC) for any developmental projects like coal mining projects etc. has been made mandatory by the Ministry of Environment, Forests and Climate Change (MoEF&CC) through its Notification issued on 27.01.1994 under the provisions of Environment (Protection) Act, 1986.
19.	Rectification and Geo-referencing	Geo-referencing is the assigning of absolute location of a data point or data points. Geo-rectification refers to the removal of geometric distortions between sets of data points, most often the removal of terrain, platform, and sensor induced distortions from remote sensing imagery
20.	Image Enhancement	It is the process of modifying digital images so that the results are more suitable for processing or further image analysis.
21.	Training set selection	It is a portion of a data set used to fit or train a model for prediction or classification of values that are known in the training set, but unknown in other (future) data
22.	Image Classification	It refers to the task of extracting information classes from a multiband raster image. The resulting raster from image classification can be used to create thematic maps.
23.	Temporal Changes	The 'temporal change' means the change in any entity with a period of time.
24.	Ground Truthing	Collection of primary/ basic information from ground realities for satellite image interpretation and thematic mapping.
25.	Cluster	Group of opencast and/ or underground minesclubbed together for administrative purposes.
26	Arc GIS	GIS Software used for Map preparation
27	ERDAS IMAGINE	Satellite Image Data Classification Software

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