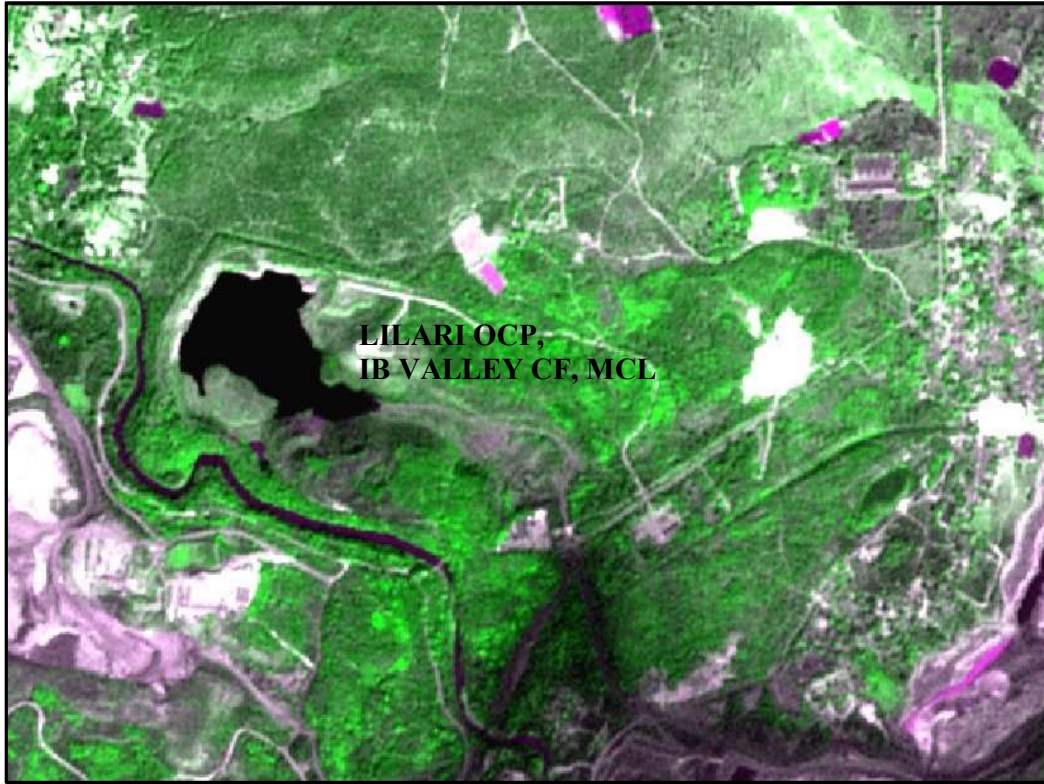


महानदी कोल्फील्ड्स लिमिटेड के ५ मिलियन घन मीटर (कोल + अधिभार) प्रतिवर्ष से कम उत्पादन क्षमतावाले ४ खुली खदानों और ३ भूमिगत खदानों का भूमि पुनरुद्धार हेतु २०२३ के उपग्रह डाटा के आधार पर निगरानी का प्रतिवेदन

Land Restoration / Reclamation Monitoring of less than 5 million cu.m. (Coal+OB) p.a. capacity Open Cast & Under Ground Coal Mines of Mahanadi Coalfields Limited based on Satellite Data for the Year 2023



Submitted to:

Mahanadi Coalfields Limited



महानदी कोल्फील्ड्स लिमिटेड के ५ मिलियन घन मीटर (कोल + अधिभार) प्रतिवर्ष से कम उत्पादन क्षमतावाले ४ खुली खदानों और ३ भूमिगत खदानों का भूमि पुनरुद्धार हेतु २०२३ के उपग्रह डाटा के आधार पर निगरानी का प्रतिवेदन

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March - 2024

Remote Sensing Cell
Geomatics Division
CMPDI, Ranchi



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कार्यकारी सारांश

१.० परियोजना महानदी कोल्फील्ड्स लिमिटेड के ५ मिलियन घन मीटर (कोल+ अधिभार) प्रतिवर्ष से कम उत्पादन क्षमतावाले ४ खुली खदानों और ३ भूमिगत खदानों के पुनरुद्धार हेतु वर्ष २०२३ के उपग्रह डाटा पर आधारित तीन साल के अन्तराल पर सलाना 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 उपरोक्त सभी खुली खदानों के भूमि पुनरुद्धार (लैंड रिक्लेमेशन) का निगरानी के प्रगति का आकलन करने में सहायता करेगा तथा इसके अतिरिक्त पर्यावरण संरक्षण के लिए आवश्यक उपचारात्मक उपायों को क्रियान्वित करने में भी सहायता करेगा।

३.० मुख्य निष्कर्ष

- वर्ष २०२३-२४ में भूमि पुनरुद्धार (लैंड रिक्लेमेशन) हेतु चयन किये गए कुल ४ खुली खदानों और ३ भूमिगत खदान परियोजनाओं यथा: लिलारी खुली खदान, बलंडा खुली खदान, छेंडीपदा खुली खदान, सुभद्रा खुली खदान, ओरिएंट १ और २ भूमिगत खदान, ओरिएंट ३ भूमिगत खदान और नंदिरा भूमिगत खदान के कुल पट्टाक्षेत्र अथवा माइन लीज होल्ड एरिया ४१८४.४९ हेक्टेयर है जिसमें ३२७.८० हेक्टेयर उत्खनन क्षेत्र के अंतर्गत है तथा इस उत्खनन क्षेत्र में से २३०.८२ हेक्टेयर (७०.४१%) क्षेत्र में जैविक पुनरुद्धार (बैकफील पर बृक्षारोपण) किया गया है तथा ६९.२८ हेक्टेयर (२१.१३%) क्षेत्र में तकनीकी पुनरुद्धार (बैकफीलिंग) का कार्य प्रगति पर है और शेष २७.७० हेक्टेयर (८.४५%) क्षेत्र सक्रिय खनन के अन्तर्गत है। विश्लेषण से स्पष्ट है कि वर्ष २०२३-२४ के अध्ययन के लिए ली गई ४ खुली खदानों और ३ भूमिगत खदान परियोजनाओं का ९१.५५% भूमि पुनरुद्धार के अधीन है और शेष ८.४५% क्षेत्र सक्रिय खनन के

अन्तर्गत है। परियोजनावार भूमि पुनरुद्धार (लैंड रिक्लेमेशन) के निगरानी का वर्णन विस्तार रूप से तालिका संख्या ०१, बार चार्ट चित्र संख्या ०१ में दर्शाया गया है।

- वर्ष २०२०-२१ में भूमि सुधार निगरानी के लिए आठ परियोजनाएं शुरू की गईं। उन आठ परियोजनाओं में से कुल्डा ओसीपी को वर्ष २०२१ से ५ मिलियन घन मीटर (कोल+ अधिभार) से अधिक के श्रेणी की निगरानी में शामिल किया गया था। इसलिए वर्ष २०२३-२४ में कुल ७ परियोजनाओं को निगरानी के लिए विचार किया गया है।
- वर्ष २०२० के संबंध में वर्ष २०२३ के लिए भूमि पुनरुद्धार की स्थिति की तुलना करने पर विश्लेषण से स्पष्ट है कि भूमि पुनरुद्धार के तहत कुल क्षेत्रफल ३ साल की अवधि में स्थिर बना हुआ है जो कि ३००.१० हेक्टेयर है।

Executive Summary

- 1.0 Project** Land restoration / reclamation monitoring of 4 opencast coal mines and 3 underground coal mines of Mahanadi Coalfields Ltd. (MCL) producing less than 5 million cu. m. (Coal + OB) per year based on satellite data on three-year interval.
- 2.0 Objective** Objective of the land restoration / reclamation monitoring is to assess the area of backfilling, plantation, social forestry, active mining area, water bodies and 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 4184.49 Ha. of the 4 opencast projects and 3 underground projects of MCL viz. Lilari OC, Balanda OC, Chhendipada OC, Subhadra OC, Orient 1 & 2 UG, Orient 3 UG and Nandira UG considered for monitoring during 2023-24; total excavated area is 327.80 Ha. out of which 69.28 Ha. (21.13%) area is under backfilling (Technical Reclamation), 230.82 Ha. (70.41%) area has been planted on backfilled areas (Biological Reclamation), and 27.70 Ha. (8.45%) area is under active mining. It is evident from the analysis that 91.55% area of the OC projects is under reclamation (biological and technical) and balance 8.45% is under active mining. Project wise details are given in Table-1 & Fig-1.
 - In the year 2020-21 eight projects were taken up for land reclamation monitoring. Out of those 8 projects Kulda OCP was included in monitoring of more than 5 mcm (Coal+OB) category from the year 2021. So there are 7 projects which are considered for monitoring in the year 2023-24.
 - On comparing the status of land reclamation for the year 2023 with respect to the year 2020 it is evident from the analysis that total area under land reclamation has remained static that is 300.10 Ha. in the 3-year duration.

Table 1: Project wise Land Reclamation Status of 4 OC and 3 UG Mines of MCL based on Satellite Data of the Year 2023

(Area in Ha.)

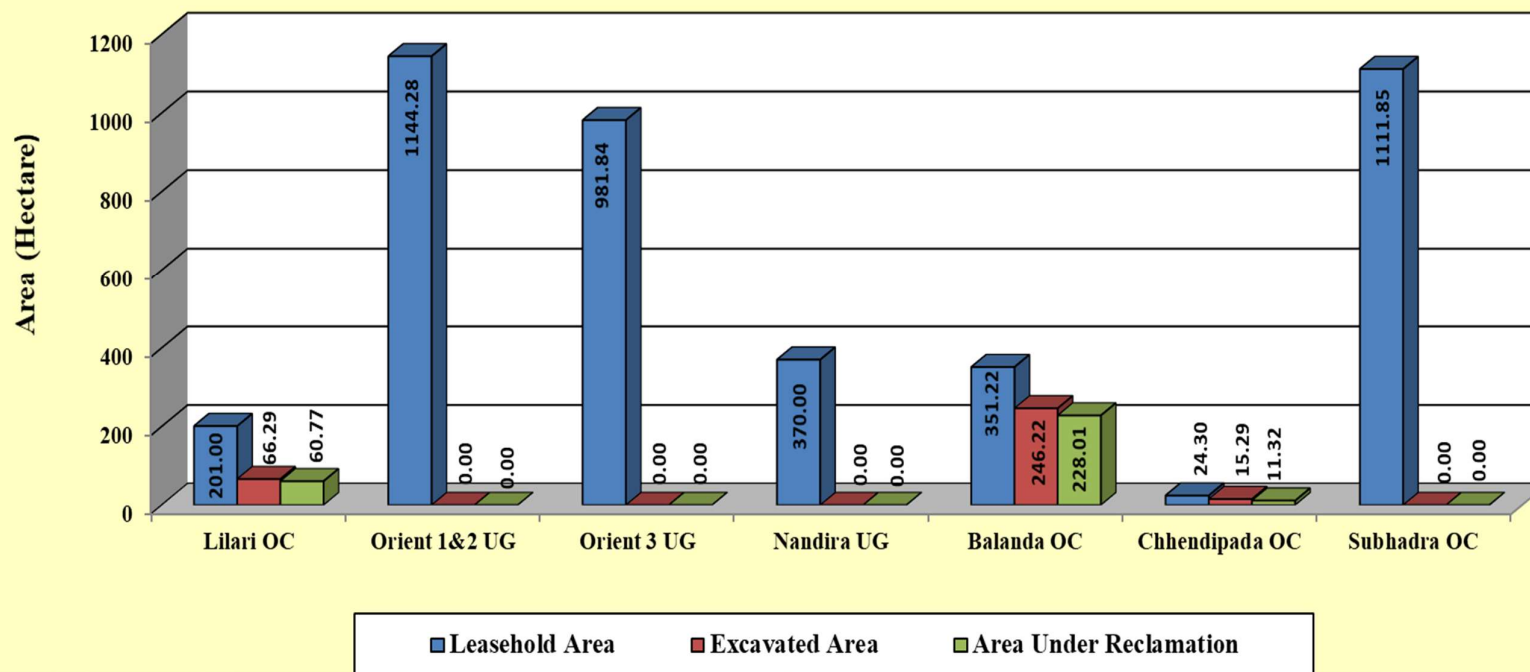
Sl. No.	Project	Total Leasehold Area		Technical Reclamation		Plantation						Area under Active Mining		Total Excavated Area		Total Area under Plantation (% Green Cover Generated in Leasehold)		Total Area under Reclamation	
						Biological Reclamation		Other Plantations											
						Area under Backfilling		Plantation on Excavated / Backfilled Area		Plantation on External OB Dumps									
1	2	3		4		5		6		7		8		9 (=4+5+8)		10 (=5+6+7)		11(=4+5)	
		2020	2023	2020	2023	2020	2023	2020	2023	2020	2023	2020	2023	2020	2023	2020	2023	2020	2023
1	Lilari OC	201.00	201.00	35.97	35.97	24.80	24.80	23.85	23.42	2.53	2.53	5.52	5.52	66.29	66.29	51.18	50.75	60.77	60.77
				54.26%	54.26%	37.41%	37.41%					8.33%	8.33%			25.46%	25.25%	91.67%	91.67%
2	Orient 1&2 UG	1144.28	1144.28	0.00	0.00	0.00	0.00	0.00	0.00	21.73	21.73	0.00	0.00	0.00	0.00	21.73	21.73	0.00	0.00
				0.00%	0.00%	0.00%	0.00%					0.00%	0.00%			1.90%	1.90%	0.00%	0.00%
3	Orient 3 UG	981.84	981.84	0.00	0.00	0.00	0.00	0.00	0.00	18.31	18.31	0.00	0.00	0.00	0.00	18.31	18.31	0.00	0.00
				0.00%	0.00%	0.00%	0.00%					0.00%	0.00%			1.86%	1.86%	0.00%	0.00%
4	Nandira UG	474.00	370.00	0.00	0.00	0.00	0.00	0.00	0.00	4.15	3.42	0.00	0.00	0.00	0.00	4.15	3.42	0.00	0.00
				0.00%	0.00%	0.00%	0.00%					0.00%	0.00%			0.88%	0.92%	0.00%	0.00%
5	Balanda OC	351.22	351.22	31.11	32.79	196.90	195.22	0.00	0.00	6.66	6.66	18.21	18.21	246.22	246.22	203.56	201.88	228.01	228.01
				12.64%	13.32%	79.97%	79.29%					7.40%	7.40%			57.96%	57.48%	92.60%	92.60%
6	Chhendipada OC	24.30	24.30	6.86	0.52	4.46	10.80	2.84	2.84	2.07	2.07	3.97	3.97	15.29	15.29	9.37	15.71	11.32	11.32
				44.87%	3.40%	29.17%	70.63%					25.96%	25.96%			38.56%	64.65%	74.04%	74.04%
7	Subhadra OC	1111.85	1111.85	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%	0.00%	0.00%					0.00%	0.00%			0.00%	0.00%	0.00%	0.00%
	TOTAL	4288.49	4184.49	73.94	69.28	226.16	230.82	26.69	26.26	55.45	54.72	27.70	27.70	327.80	327.80	308.30	311.80	300.10	300.10
				22.56%	21.13%	68.99%	70.41%					8.45%	8.45%			7.19%	7.45%	91.55%	91.55%

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

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

1. Area under Biological Reclamation includes Areas under Plantation done on Backfilled Area Only.
2. Area under Technical Reclamation includes Area under Barren Backfilling only
3. Area under Active Mining Includes Coal Quarry, Advance Quarry Site, and Quarry filled with water etc., if any.
4. Social Forestry and Plantation on External OB Dumps are not included in Biological Reclamation and are put under separate categories as shown in the 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 area shown in (Sl. 2 & 3) in the above Table is the net area of these Projects after deducting the common Leasehold area of Lajkura OCP as the leasehold boundaries of these mines are overlapping.
7. The total leasehold area of the above mentioned 7 OC & UG projects without deducting the common leasehold area of Lajkura OC is 5420.17 Ha.

Fig 1: Project Wise Land Reclamation Status of MCL in 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 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, 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. Further, a revised work order was issued vide letter no. CIL/ENVT/2022-23/W.O./10899 dated 06.07.2022 from Coal India Limited for the period 2022-23 to 2023-24. According to this work order, 76 OC projects having more than 5 million cu. m (Coal + OB) per annum capacity shall be monitored every year alongwith 80 OCPs having less than 5 million cu. m (Coal + OB) per annum capacity to be monitored at an interval of three years in phase wise manner. 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 open cast projects will have to comply the statutory requirements of Ministry of Environment, Forest & Climate Change (MoEF & CC). 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 2023 carried out for 4 no. of OC & 3 no. of UG projects of capacity less than 5 mcm (Coal + OB) p.a. for Mahanadi Coalfields Ltd.

2.0 Objective

Objective of the land reclamation/restoration monitoring is to assess the area of backfilling, plantation, OB dumps, social forestry, active mining area, settlements, 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:

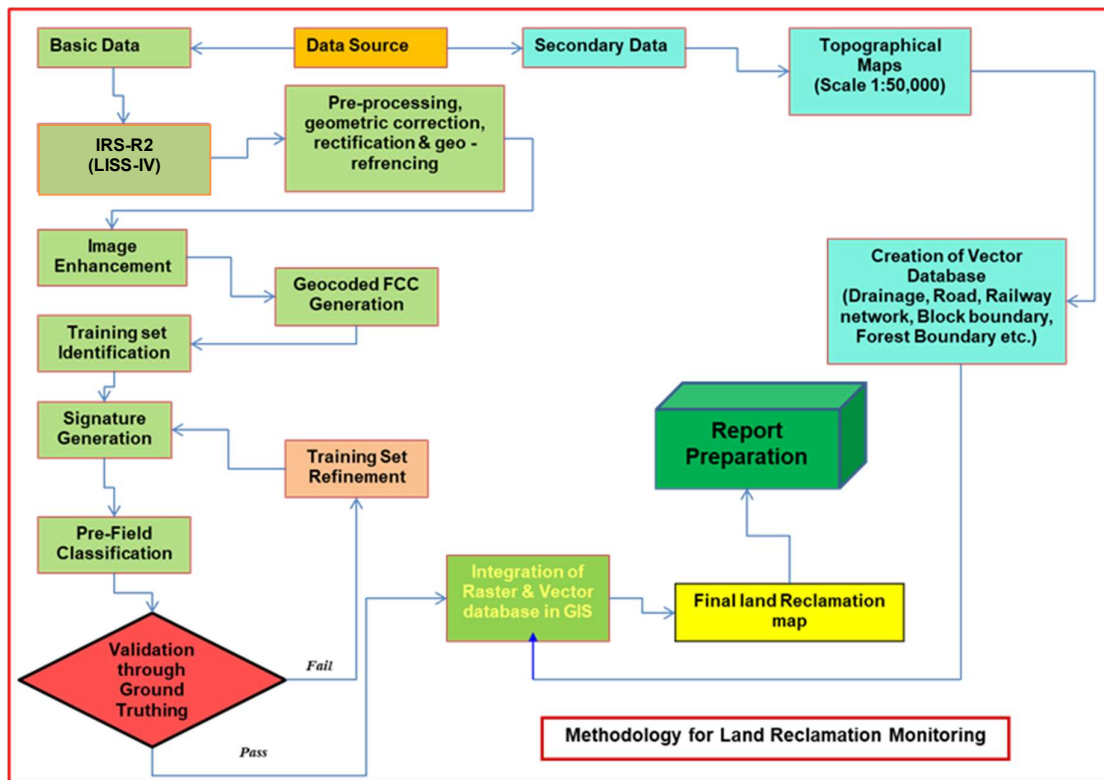


Figure: 2 Methodology for Land Reclamation Monitoring

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 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 topo sheet.

- **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 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 4 OC & 3 UG projects producing less than 5 million m³ (Coal + OB) per annum of Mahanadi Coalfields Ltd. have been taken up for land reclamation monitoring based on Satellite data during the year 2023-24:
- Lilari OC
 - Balanda OC
 - Chhendipada OC
 - Subhadra OC
 - Orient 1 & 2 UG
 - Orient 3 UG
 - Nandira UG
- 4.2** Area statistics of different land use classes present in OC & UG projects in the year 2023 is given in Table-2. Land use maps derived from the satellite data is given in Plate no. 1 to 7. Land use status of above OC as well as UG mines are shown in Fig. 3 - 9 and field photographs showing plantation on backfilled area in mining projects are shown in photos. 1 - 8.
- 4.3** Study reveals that 300.10 Ha (91.55%) of excavated area has already been put under reclamation by MCL, out of which 230.82 Ha (70.41%) area has been revegetated and 69.28 Ha (21.13%) area is under backfilling.
- 4.4** It is important to mention here that the leasehold boundary of Nandira UGP is updated as per EC. This updation of EC boundary has resulted in a decrease in area under social forestry due to decrease in leasehold area.
- 4.5** After analyzing the satellite data of year 2020 vs. 2023 it is evident that total area under plantation (Green Cover) carried out on backfilled area, OB dumps as well as under social forestry in above OC and UG mines of MCL has increased from 308.30 Ha (Yr 2020) to 311.80 Ha (Yr 2023). This increase of 3.50 Ha. plantation area in three years is due to increase in biological reclamation in Chhendipada OC.

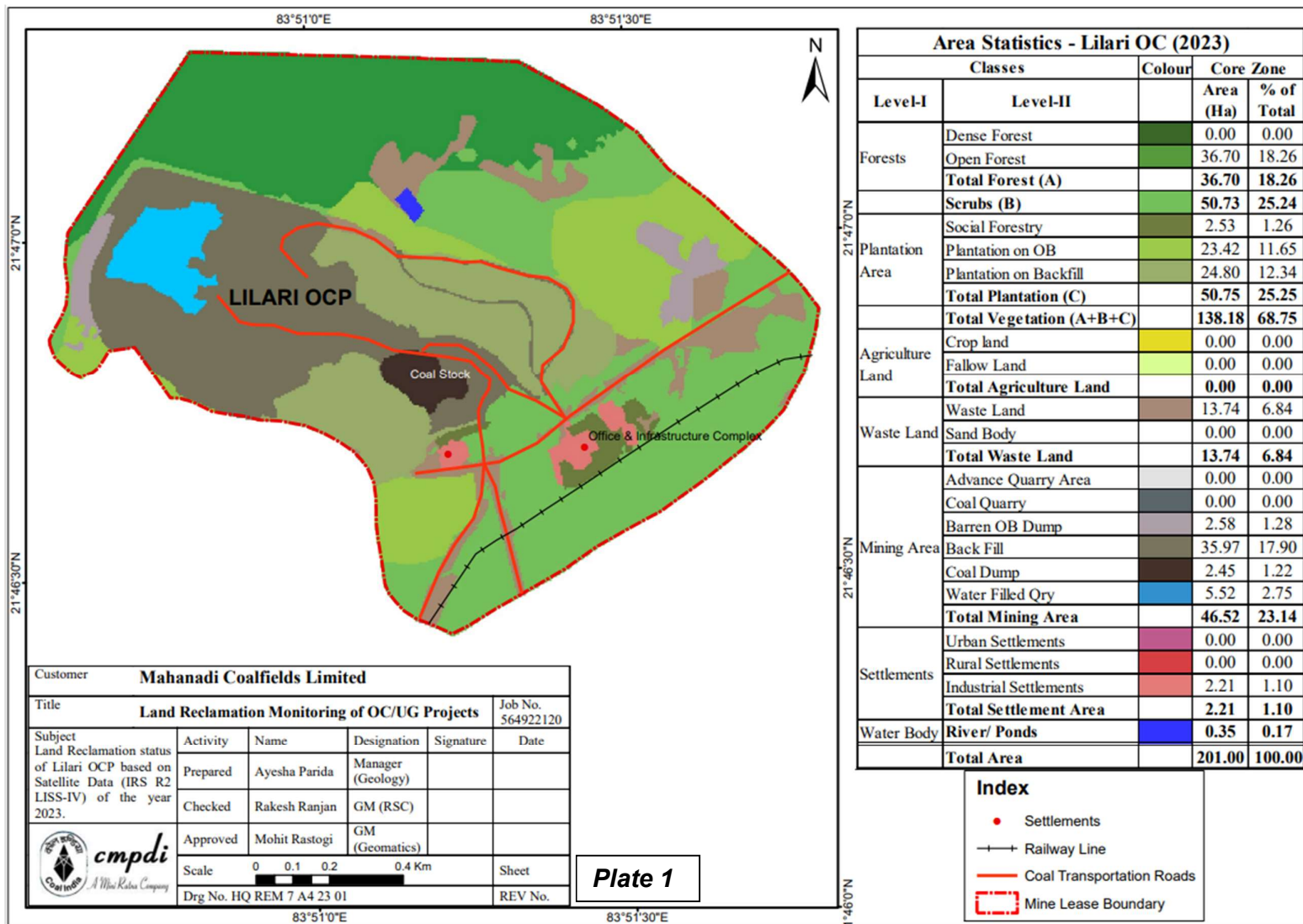
- 4.6** In Chhendipada OCP, total area under plantation increased from 9.37 Ha. (Yr 2020) to 15.71 Ha. (Yr 2023) which indicate that MCL is committed for reclamation of mined land for maintaining the ecological balance in the region.
- 4.7** It is important to mention here that leasehold boundary of Orient 1 & 2 UG overlaps with the leasehold boundary of Lajkura OCP and Orient 3 UG. Therefore, to avoid data duplicity in terms of surface features/classes pertaining to Lajkura OCP reflecting in the Area Statistics of Orient 1&2 UG and Orient 3 UG, the overlapping leasehold area of Lajkura OCP has been deducted as per request from MCL. (Letter No. MCL/GM/OA/ENVT/2021/675 dtd. 31.05.2021). Furthermore, the leasehold boundaries of Orient 1&2 and Orient 3 UG mines were also found to be overlapping. Moreover, it may be noted that Land Reclamation monitoring of Lajkura OC based on Satellite Data of year 2023 has been carried out under more than 5 mcm category.
- 4.8** Out of the above mentioned projects taken up for monitoring, Subhadra OC is an upcoming project and the current status can be used as base data for comparing the status of land reclamation monitoring during next cycle of three years.
- 4.9** The area under total plantation (Green Cover) is maximum in Chhendipada OC (64.65%) followed by Balanda OC with (57.48%) and Lilari OC with (25.25%).
- 4.10** Out of the 8 projects of MCL, Balanda OCP ranks on top for land reclamation (92.60%) followed by Lilari OCP (91.67%), Chhendipada OCP (74.04%) in the year 2023.

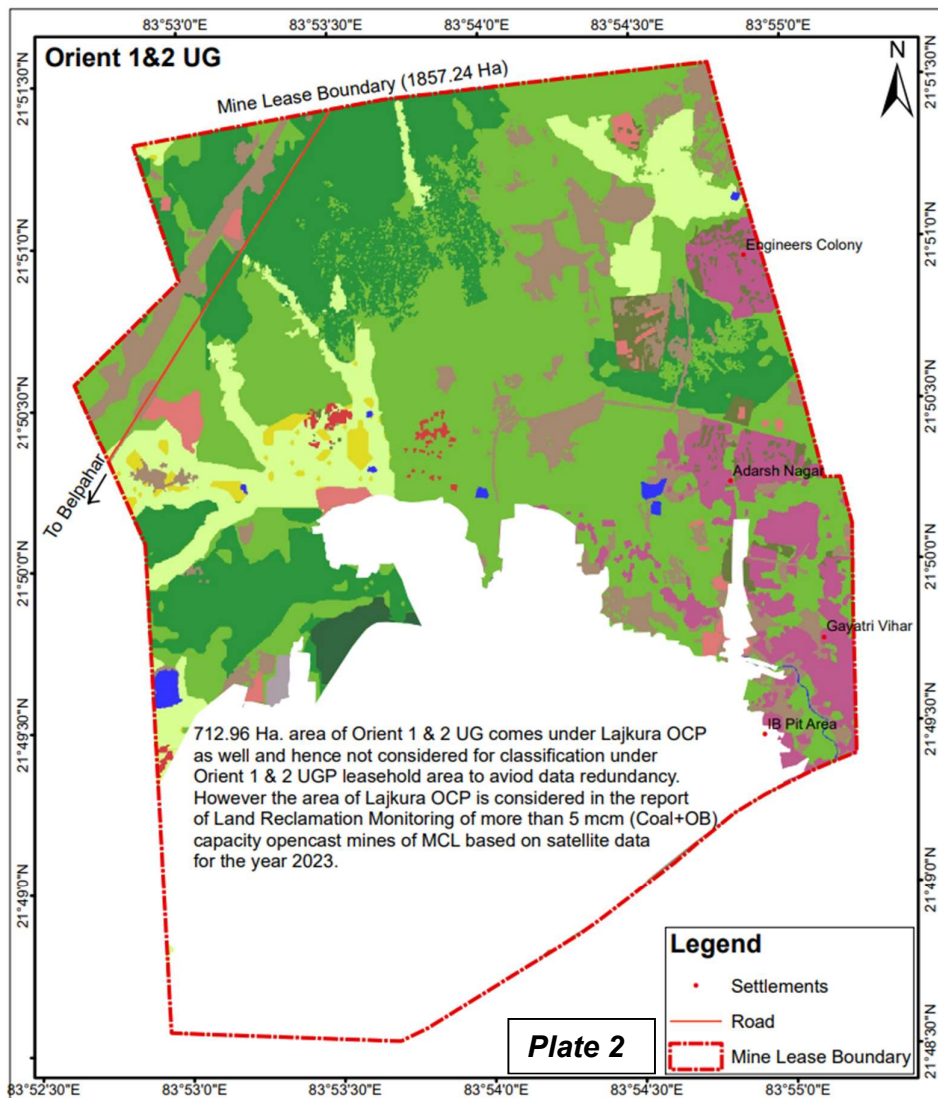
Table 2: AREA STATISTICS OF LAND USE / COVER CLASSES IN MINES OF MCL BASED ON SATELLITE DATA OF THE YEAR 2023

(Area in Ha.)

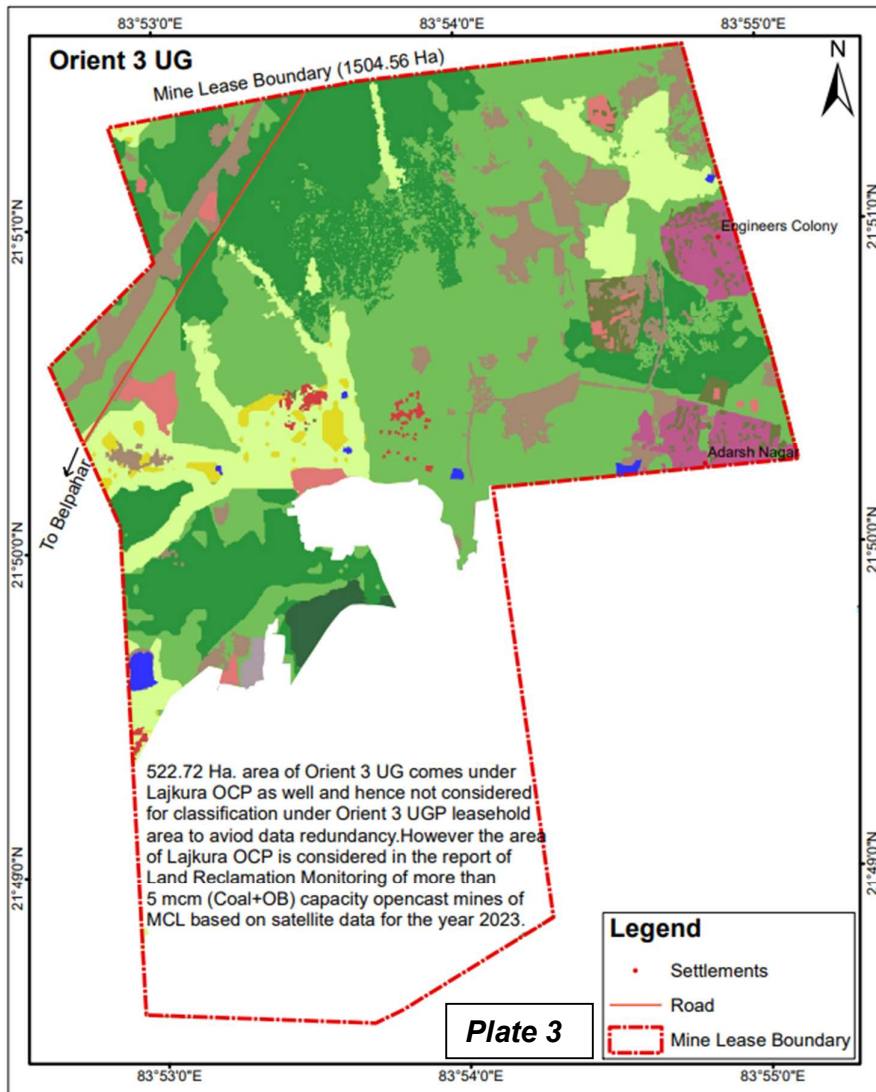
Land Use Cover Classes	Color Code	Lilari OC		Orient 1&2 UG		Orient 1&2 UG without Lajkura OCP common area*		Orient 3 UG		Orient 3 UG without Lajkura OCP common area**		Nandira UG		Balanda OC		Chhendipada OC		Subhadra OC		TOTAL	
		Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%
Dense Forest		0.00	0.00	59.63	3.21	10.95	0.96	58.89	3.91	10.28	1.05	153.19	41.40	0.00	0.00	1.57	6.46	0.00	0.00	273.28	5.04
Open Forest		36.70	18.26	307.53	16.56	255.99	22.37	307.59	20.44	256.11	26.08	149.18	40.32	0.00	0.00	0.00	0.00	62.31	5.60	863.31	15.93
Total Forest		36.70	18.26	367.16	19.77	266.94	23.33	366.48	24.36	266.39	27.13	302.37	81.72	0.00	0.00	1.57	6.46	62.31	5.60	1136.59	20.97
Scrubs		50.73	25.24	547.83	29.50	473.22	41.36	454.50	30.21	399.21	40.66	35.23	9.52	9.12	2.60	2.13	8.77	589.20	52.99	1688.74	31.16
Social Forestry/Avenue Plantation		2.53	1.26	37.84	2.04	21.73	1.90	18.55	1.23	18.31	1.86	3.42	0.92	6.66	1.90	2.07	8.52	0.00	0.00	71.07	1.31
Plantation on OB Dump		23.42	11.65	11.76	0.63	0.00	0.00	3.56	0.24	0.00	0.00	0.00	0.00	0.00	0.00	2.84	11.69	0.00	0.00	41.58	0.77
Plantation on Backfill (Biological Reclamation)		24.80	12.34	12.74	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	195.22	55.58	10.80	44.44	0.00	0.00	243.56	4.49
Total Plantation		50.75	25.25	62.34	3.36	21.73	1.90	22.11	1.47	18.31	1.86	3.42	0.92	201.88	57.48	15.71	64.65	0.00	0.00	356.21	6.57
Total Vegetation		138.18	68.75	977.33	52.62	761.89	66.58	843.09	56.04	683.91	69.66	341.02	92.17	211.00	60.08	19.41	79.88	651.51	58.60	3181.54	58.70
Coal Dump		2.45	1.22	2.51	0.14	0.00	0.00	1.16	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.12	0.11
Coal Quarry		0.00	0.00	92.08	4.96	0.00	0.00	90.76	6.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	182.84	3.37
Advance Quarry Site		0.00	0.00	20.36	1.10	0.00	0.00	20.32	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	40.68	0.75
Quarry Filled With Water		5.52	2.75	2.82	0.15	0.00	0.00	2.82	0.19	0.00	0.00	0.00	0.00	18.21	5.18	3.97	16.34	0.00	0.00	33.34	0.62
Total Area under Active Mining		5.52	2.75	115.26	6.21	0.00	0.00	113.90	7.57	0.00	0.00	0.00	0.00	18.21	5.18	3.97	16.34	0.00	0.00	256.86	4.74
Barren OB Dump		2.58	1.28	54.33	2.93	2.92	0.26	51.33	3.41	2.92	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	108.24	2.00
Area Under Backfilling (Technical Reclamation)		35.97	17.90	152.68	8.22	0.00	0.00	73.77	4.90	0.00	0.00	0.00	0.00	32.79	9.34	0.52	2.14	0.00	0.00	295.73	5.46
Total Area under Technical Reclamation		35.97	17.90	152.68	8.22	0.00	0.00	73.77	4.90	0.00	0.00	0.00	0.00	32.79	9.34	0.52	2.14	0.00	0.00	295.73	5.46
Total Area under Mining Activity		46.52	23.14	324.78	17.49	2.92	0.26	240.16	15.96	2.92	0.30	0.00	0.00	51.00	14.52	4.49	18.48	0.00	0.00	666.95	12.30
Waste Lands		13.74	6.84	221.77	11.94	129.30	11.30	171.97	11.43	100.39	10.22	16.35	4.42	13.41	3.82	0.40	1.65	27.51	2.47	465.15	8.58
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	74.98	21.35	0.00	0.00	3.84	0.35	78.82	1.45
Total Wasteland		13.74	6.84	221.77	11.94	129.30	11.30	171.97	11.43	100.39	10.22	16.35	4.42	88.39	25.17	0.40	1.65	31.35	2.82	543.97	10.04
Reservoir, Nallah, Ponds		0.35	0.17	11.72	0.63	5.82	0.51	8.47	0.56	4.73	0.48	1.02	0.28	0.14	0.04	0.00	0.00	23.78	2.14	45.48	0.84
Total Waterbodies		0.35	0.17	11.72	0.63	5.82	0.51	8.47	0.56	4.73	0.48	1.02	0.28	0.14	0.04	0.00	0.00	23.78	2.14	45.48	0.84
Crop Lands		0.00	0.00	10.86	0.58	10.85	0.95	10.86	0.72	10.85	1.11	0.13	0.04	0.00	0.00	0.00	0.00	0.00	0.00	21.85	0.40
Fallow Lands		0.00	0.00	170.04	9.16	124.30	10.86	167.93	11.16	124.29	12.66	5.31	1.44	0.00	0.00	0.00	0.00	380.67	34.24	723.95	13.36
Total Agriculture		0.00	0.00	180.90	9.74	135.15	11.81	178.79	11.88	135.14	13.76	5.44	1.47	0.00	0.00	0.00	0.00	380.67	34.24	745.80	13.76
Urban Settlement		0.00	0.00	93.40	5.03	85.52	7.47	34.04	2.26	34.04	3.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	127.44	2.35
Rural Settlement		0.00	0.00	6.91	0.37	4.54	0.40	6.90	0.46	4.54	0.46	2.23	0.60	0.00	0.00	0.00	0.00	24.54	2.21	40.58	0.75
Industrial Settlement		2.21	1.10	40.43	2.18	19.14	1.67	21.14	1.41	16.17	1.65	3.94	1.06	0.69	0.20	0.00	0.00	0.00	0.00	68.41	1.26
Total Settlements		2.21	1.10	140.74	7.58	109.20	9.54	62.08	4.13	54.75	5.58	6.17	1.67	0.69	0.20	0.00	0.00	24.54	2.21	236.43	4.36
Grand Total		201.00	100.00	1857.24	100.00	1144.28	100.00	1504.56	100.00	981.84	100.00	370.00	100.00	351.22	100.00	24.30	100.00	1111.85	100.00	5420.17	100.00

Note: The Area of Orient 1&2 and Orient 3** indicated here is excluding the common area of Lajkura OC as the leasehold areas of Orient 1 & 2, Orient 3 UG Mines and Lajkura OC overlap with each other. Moreover, it may be noted that monitoring of Lajkura OC based on Satellite Data of 2023 has been carried out under more than 5 mcm category.*

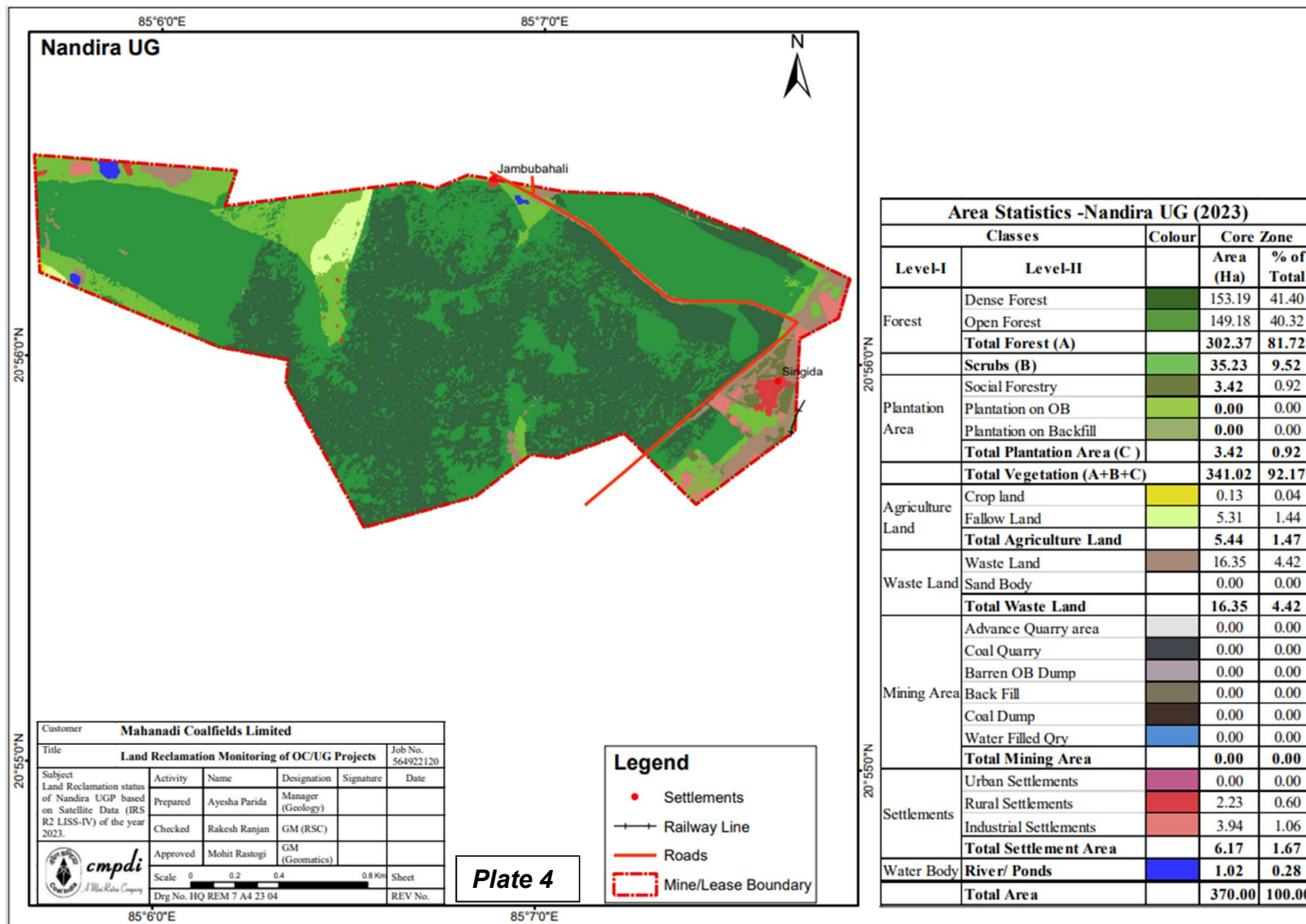


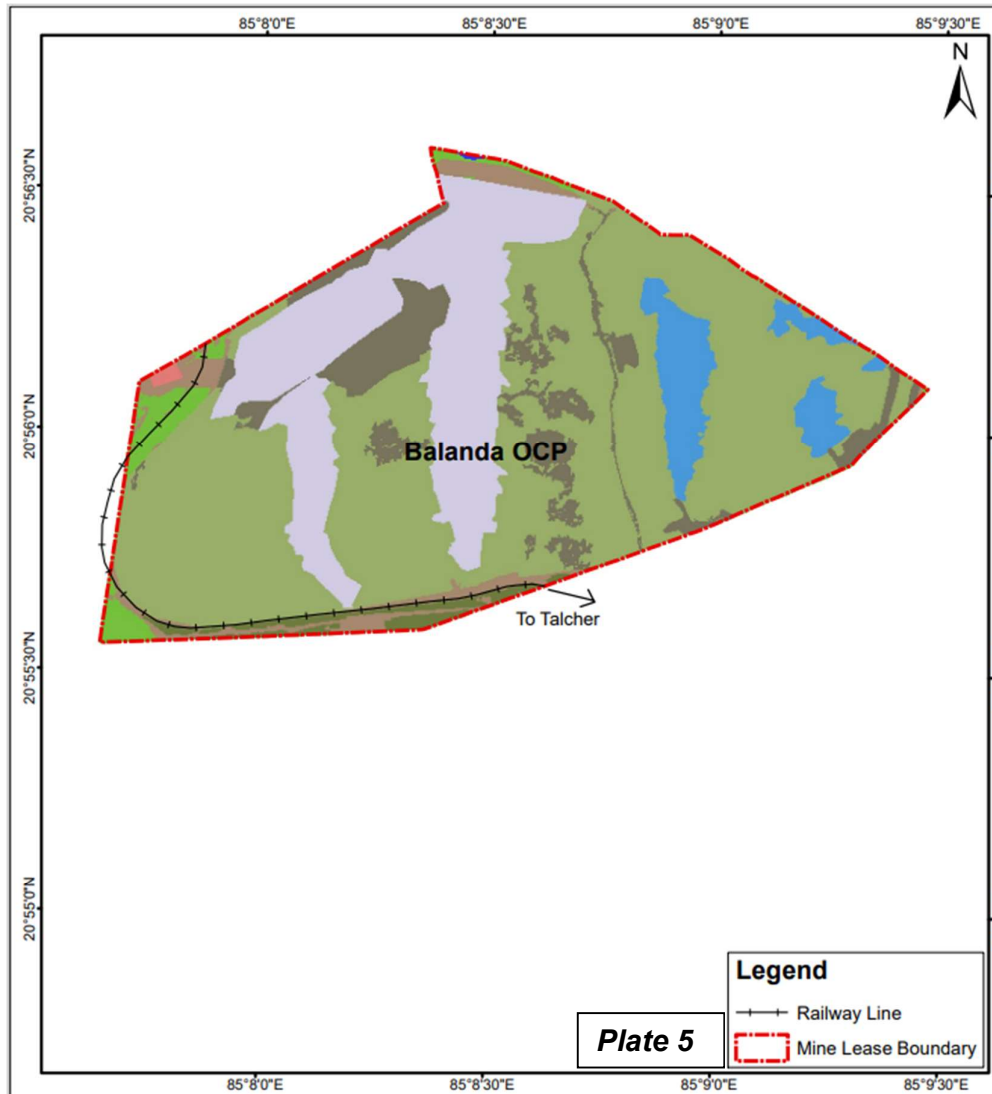


Area Statistics - Orient 1&2 UG (2023)				
Classes		Colour	Core Zone	
Level-I	Level-II		Area (Ha)	% of Total
Forests	Dense Forest		10.95	0.96
	Open Forest		255.99	22.37
	Total Forest (A)		266.94	23.33
	Scrubs (B)		473.22	41.36
Plantation Area	Social Forestry		21.73	1.90
	Plantation on OB		0.00	0.00
	Plantation on Backfill		0.00	0.00
	Total Plantation (C)		21.73	1.90
	Total Vegetation (A+B+C)		761.89	66.58
Agriculture Land	Crop land		10.85	0.95
	Fallow Land		124.30	10.86
	Total Agriculture Land		135.15	11.81
Waste Land	Waste Land		129.30	11.30
	Sand Body		0.00	0.00
	Total Waste Land		129.30	11.30
Mining Area	Advance Quarry Area		0.00	0.00
	Coal Quarry		0.00	0.00
	Barren OB Dump		2.92	0.26
	Back Fill		0.00	0.00
	Coal Dump		0.00	0.00
	Water Filled Qry		0.00	0.00
	Total Mining Area		2.92	0.26
Settlements	Urban Settlements		85.52	7.47
	Rural Settlements		4.54	0.40
	Industrial Settlements		19.14	1.67
	Total Settlement Area		109.20	9.54
Water Body	River/ Ponds		5.82	0.51
	Area (without Lajkura OCP)		1144.28	100.00
	Area under Lajkura OCP		712.96	
	Total area of Orient 1 & 2 UGP		1857.24	
Customer: Mahanadi Coalfields Limited				
Title: Land Reclamation Monitoring of OC/UG Projects				
Subject: Land Reclamation status of Orient 1 & 2 UGP based on Satellite Data (IRS R2 LISS-IV) of the year 2023.				Job No. 564922120
Activity	Name	Designation	Signature	Date
Prepared	Ayesha Parida	Manager (Geology)		
Checked	Rakesh Ranjan	GM (RSC)		
Approved	Mohit Rastogi	GM (Geomatics)		
Scale: 0 0.25 0.5 1 Km				Sheet
Drg No. HQ REM 7 A4 23 02				REV No.



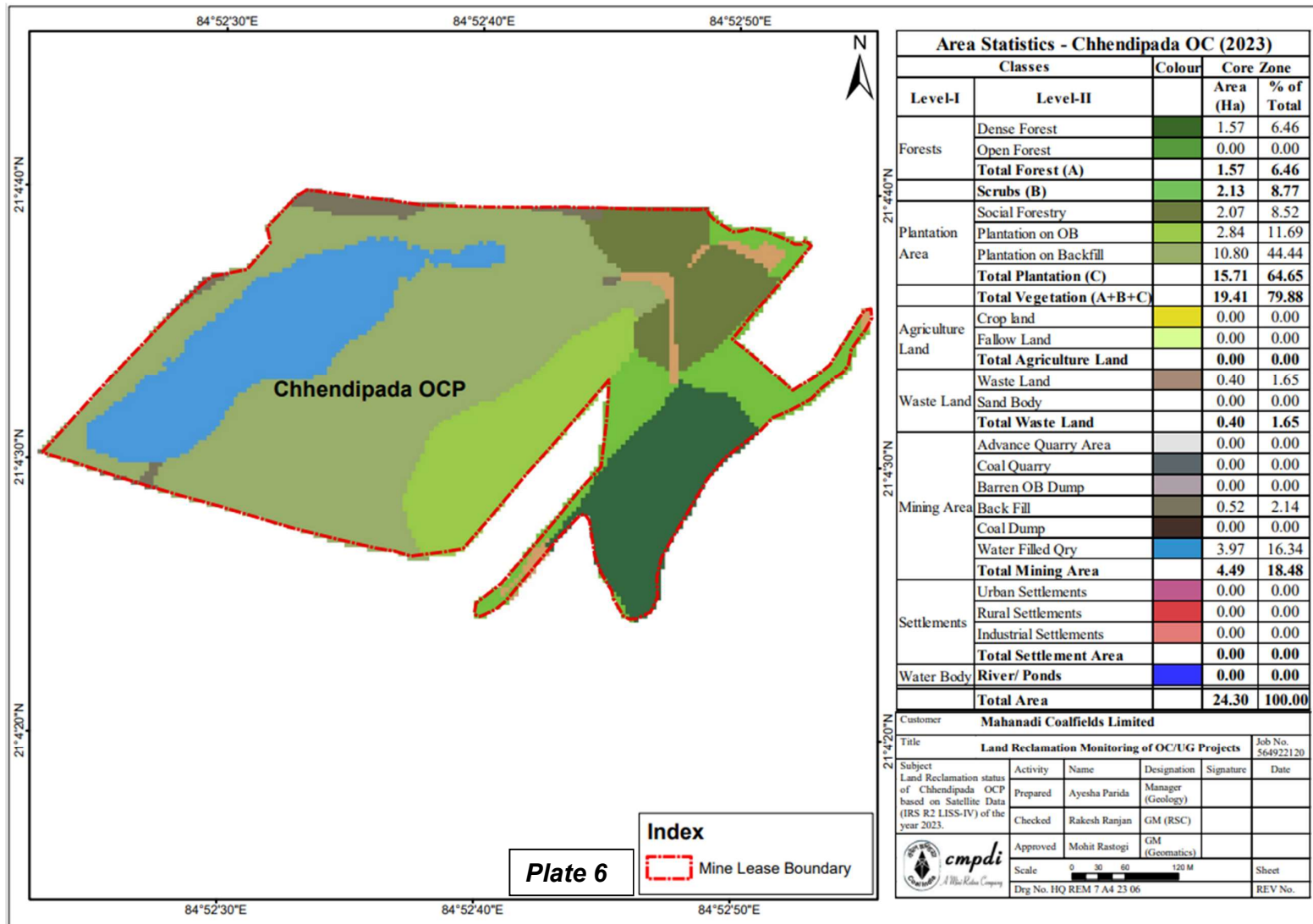
Area Statistics - Orient 3 UG (2023)						
Classes		Colour	Core Zone			
Level-I	Level-II		Area (Ha)	% of Total		
Forests	Dense Forest		10.28	1.05		
	Open Forest		256.11	26.08		
	Total Forest (A)		266.39	27.13		
	Scrubs (B)		399.21	40.66		
Plantation Area	Social Forestry		18.31	1.86		
	Plantation on OB		0.00	0.00		
	Plantation on Backfill		0.00	0.00		
	Total Plantation (C)		18.31	1.86		
	Total Vegetation (A+B+C)		683.91	69.66		
Agriculture Land	Crop land		10.85	1.11		
	Fallow Land		124.29	12.66		
	Total Agriculture Land		135.14	13.76		
Waste Land	Waste Land		100.39	10.22		
	Sand Body		0.00	0.00		
	Total Waste Land		100.39	10.22		
Mining Area	Advance Quarry Area		0.00	0.00		
	Coal Quarry		0.00	0.00		
	Barren OB Dump		2.92	0.30		
	Back Fill		0.00	0.00		
	Coal Dump		0.00	0.00		
	Water Filled Qry		0.00	0.00		
	Total Mining Area		2.92	0.30		
Settlements	Urban Settlements		34.04	3.47		
	Rural Settlements		4.54	0.46		
	Industrial Settlements		16.17	1.65		
	Total Settlement Area		54.75	5.58		
Water Body	River/ Ponds		4.73	0.48		
	Area (without Lajkura OCP)		981.84	100.00		
	Area under Lajkura OCP		522.72			
	Total Area of Orient 3 UGP		1504.56			
Customer: Mahanadi Coalfields Limited						
Title: Land Reclamation Monitoring of OC/UG Projects						
Subject: Land Reclamation status of Orient 3 UGP based on Satellite Data (IRS R2 LISS-IV) of the year 2023.		Activity	Name	Designation	Signature	Date
	Prepared	Ayesha Parida	Manager (Geology)			
	Checked	Rakesh Ranjan	GM (RSC)			
	Approved	Mohit Rastogi	GM (Geomatics)			
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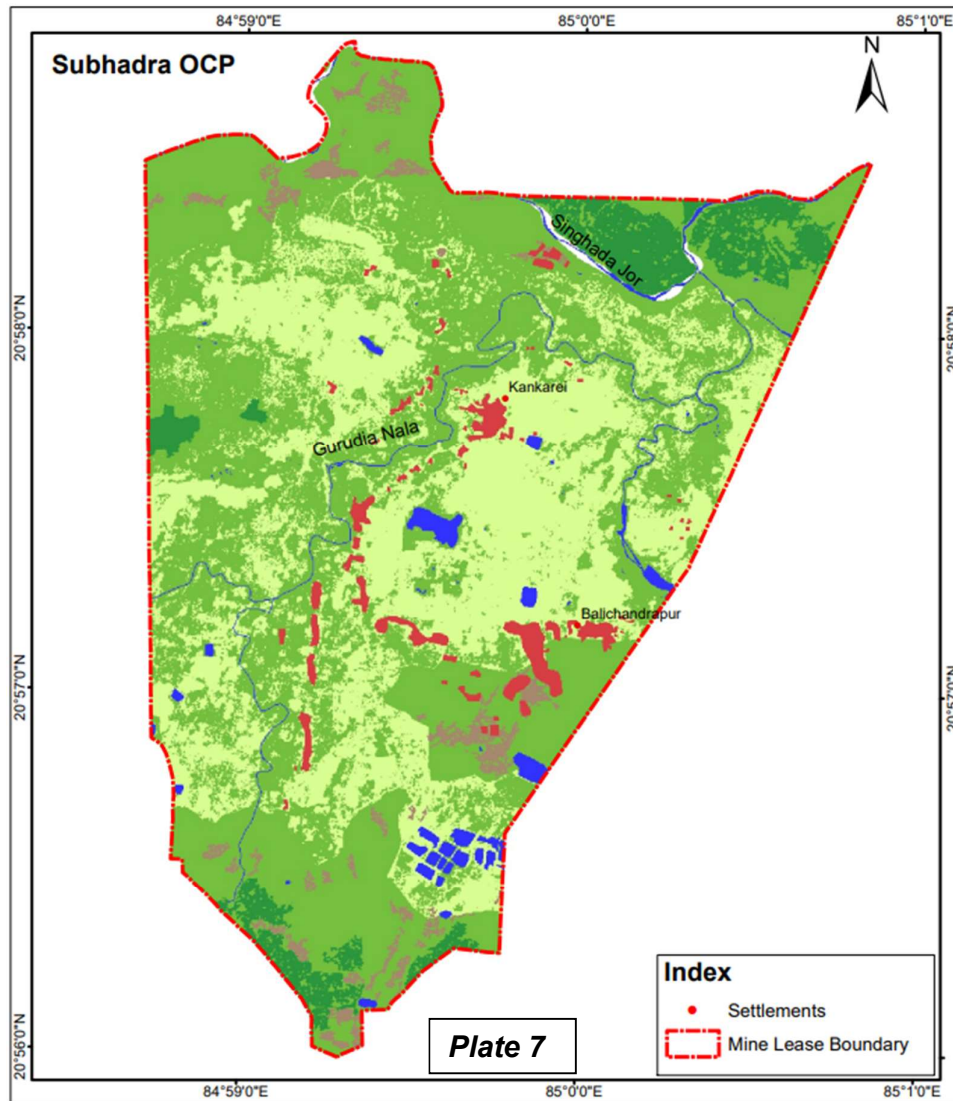




Area Statistics - Balanda OCP (2023)				
Classes		Colour	Core Zone	
Level-I	Level-II		Area (Ha)	% of Total
Forest	Dense Forest		0.00	0.00
	Open Forest		0.00	0.00
	Total Forest (A)		0.00	0.00
Scrubs (B)			9.12	2.60
Plantation Area	Social Forestry		6.66	1.90
	Plantation on OB		0.00	0.00
	Plantation on Backfill		195.22	55.58
Total Plantation Area (C)			201.88	57.48
Total Vegetation (A+B+C)			211.00	60.08
Agriculture Land	Crop land		0.00	0.00
	Fallow Land		0.00	0.00
	Total Agriculture Land		0.00	0.00
Waste Land	Waste Land		13.41	3.82
	Fly Ash Pond		74.98	21.35
	Total Waste Land		88.39	25.17
Mining Area	Advance Quarry area		0.00	0.00
	Coal Quarry		0.00	0.00
	Barren OB Dump		0.00	0.00
	Back Fill		32.79	9.34
	Coal Dump		0.00	0.00
	Water Filled Qry		18.21	5.18
Total Mining Area			51.00	14.52
Settlements	Urban Settlements		0.00	0.00
	Rural Settlements		0.00	0.00
	Industrial Settlements		0.69	0.20
Total Settlement Area			0.69	0.20
Water Body	River/ Ponds		0.14	0.04
Total Area			351.22	100.00

Customer	Mahanadi Coalfields Limited			
Title	Land Reclamation Monitoring of OC/UG Projects			Job No. 564922120
Subject	Activity	Name	Designation	Signature
Land Reclamation status of Balanda OCP based on Satellite Data (IRS R2 LISS-IV) of the year 2023.	Prepared	Ayesha Parida	Manager (Geology)	
	Checked	Rakesh Ranjan	GM (RSC)	
	Approved	Mohit Rastogi	GM (Geomatics)	
Scale		0 0.2 0.4 0.8 Km		Sheet
Drg No. HQ REM 7 A4 23 05		REV No.		





Area Statistics - Subhadra OC (2023)				
Classes		Colour	Core Zone	
Level-I	Level-II		Area (Ha)	% of Total
Forests	Dense Forest		0.00	0.00
	Open Forest		62.31	5.60
	Total Forest (A)		62.31	5.60
	Scrubs (B)		589.20	52.99
Plantation Area	Social Forestry		0.00	0.00
	Plantation on OB		0.00	0.00
	Plantation on Backfill		0.00	0.00
	Total Plantation (C)		0.00	0.00
	Total Vegetation (A+B+C)		651.51	58.60
Agriculture Land	Crop land		0.00	0.00
	Fallow Land		380.67	34.24
	Total Agriculture Land		380.67	34.24
Waste Land	Waste Land		27.51	2.47
	Sand Body		3.84	0.35
	Total Waste Land		31.35	2.82
Mining Area	Advance Quarry Area		0.00	0.00
	Coal Quarry		0.00	0.00
	Barren OB Dump		0.00	0.00
	Back Fill		0.00	0.00
	Coal Dump		0.00	0.00
	Water Filled Qry		0.00	0.00
	Total Mining Area		0.00	0.00
Settlements	Urban Settlements		0.00	0.00
	Rural Settlements		24.54	2.21
	Industrial Settlements		0.00	0.00
	Total Settlement Area		24.54	2.21
Water Body	River/ Ponds		23.78	2.14
	Total Area		1111.85	100.00

Customer	Mahanadi Coalfields Limited				
Title	Land Reclamation Monitoring of OC/UG Projects				Job No. 564922120
Subject	Activity	Name	Designation	Signature	Date
Land Reclamation status of Subhadra OCP based on Satellite Data (IRS R2 LISS-IV) of the year 2023.	Prepared	Ayesha Parida	Manager (Geology)		
	Checked	Rakesh Ranjan	GM (RSC)		
	Approved	Mohit Rastogi	GM (Geomatics)		
Scale		0 0.2 0.4 0.8 Km			Sheet
Drg No. HQ REM 7 A4 23 07					REV No.

Plate 7

Index
 • Settlements
 [Red dashed line] Mine Lease Boundary

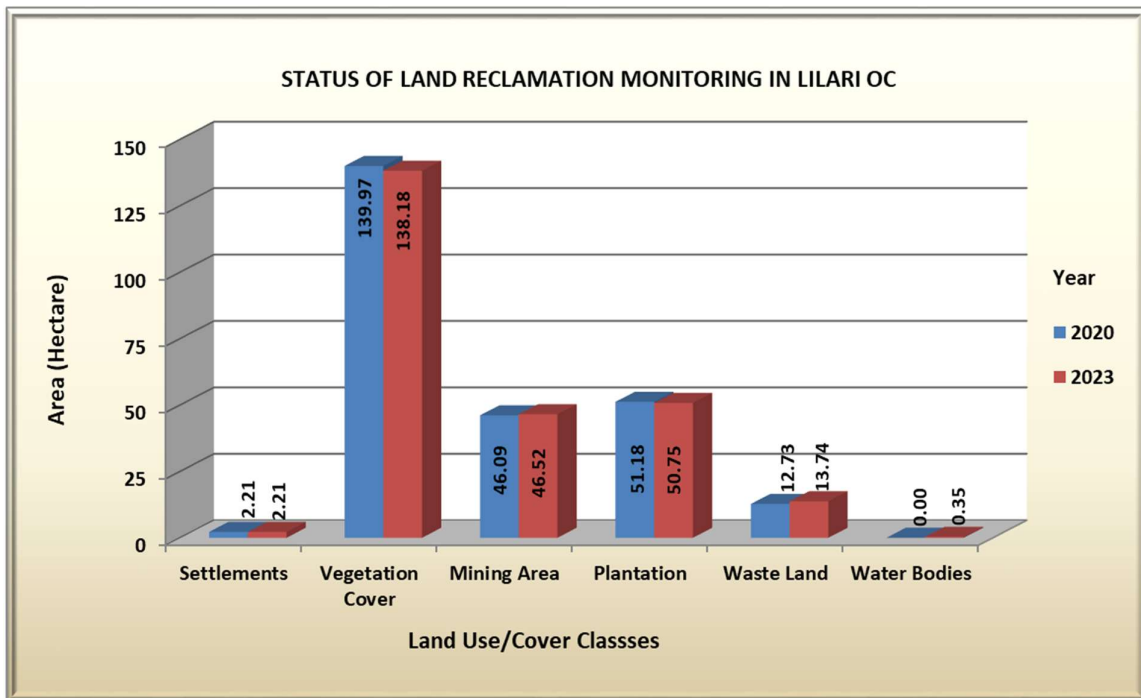


FIGURE – 3

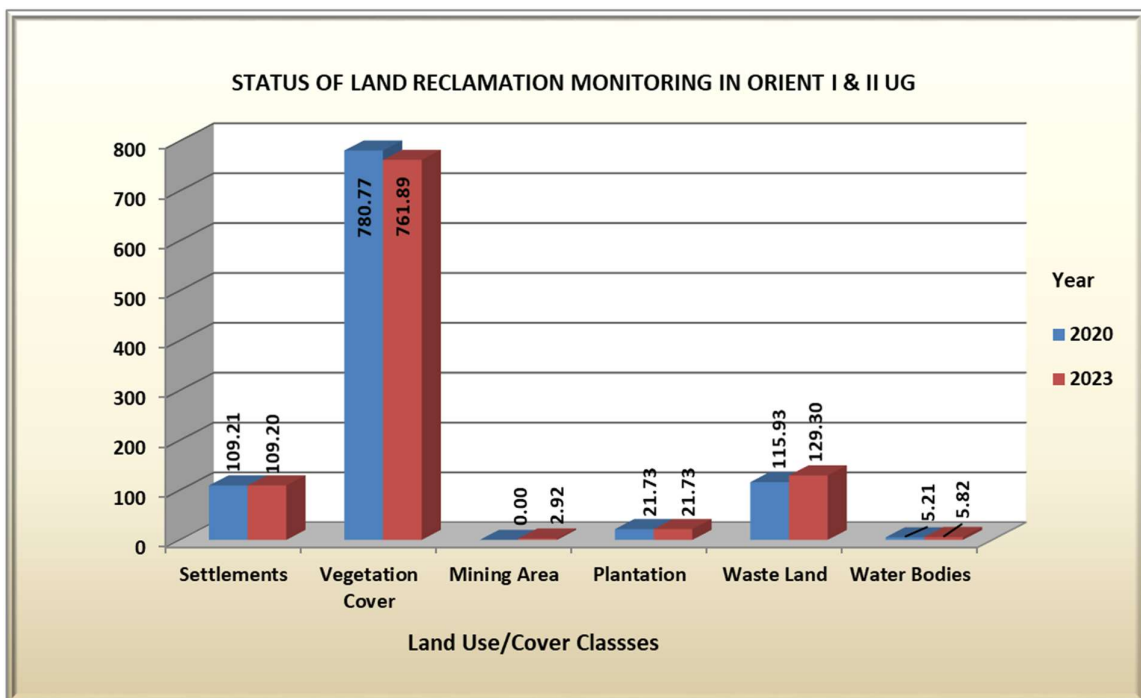


FIGURE - 4

Note:

It may be noted that mining area coming under Orient I & II UG is the part of OB Dump of Lajkura OC which comes within the boundary of Orient I & II UG.

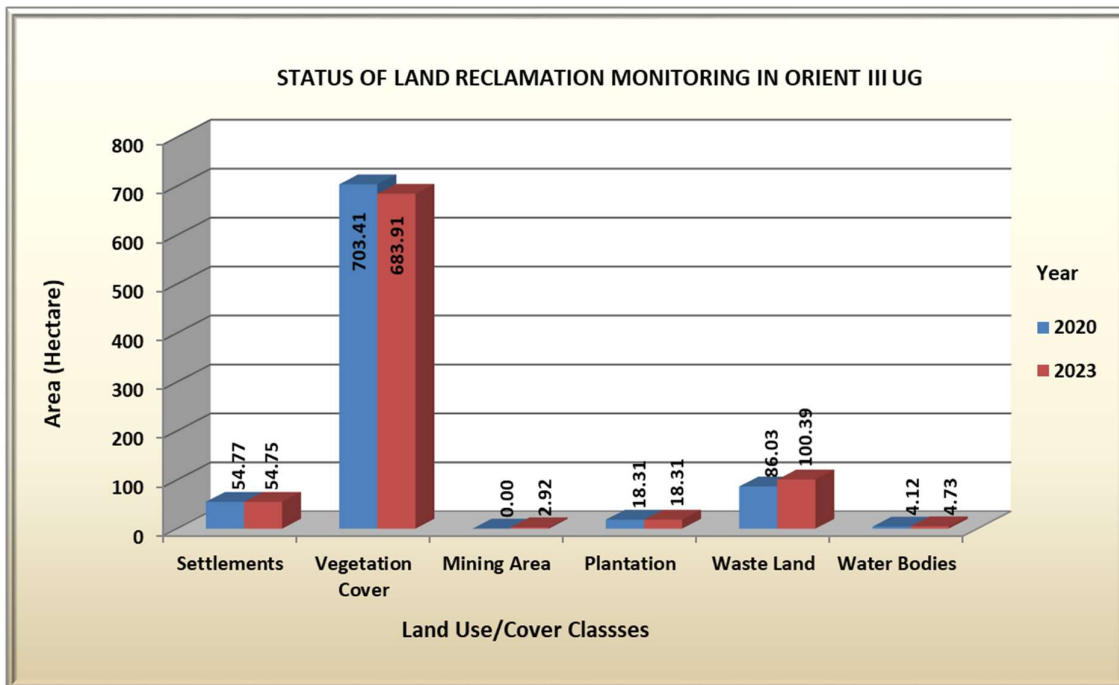


FIGURE -5

Note:

It may be noted that mining area coming under Orient III UG is the part of OB Dump of Lajkura OC which comes within the boundary of Orient III UG.

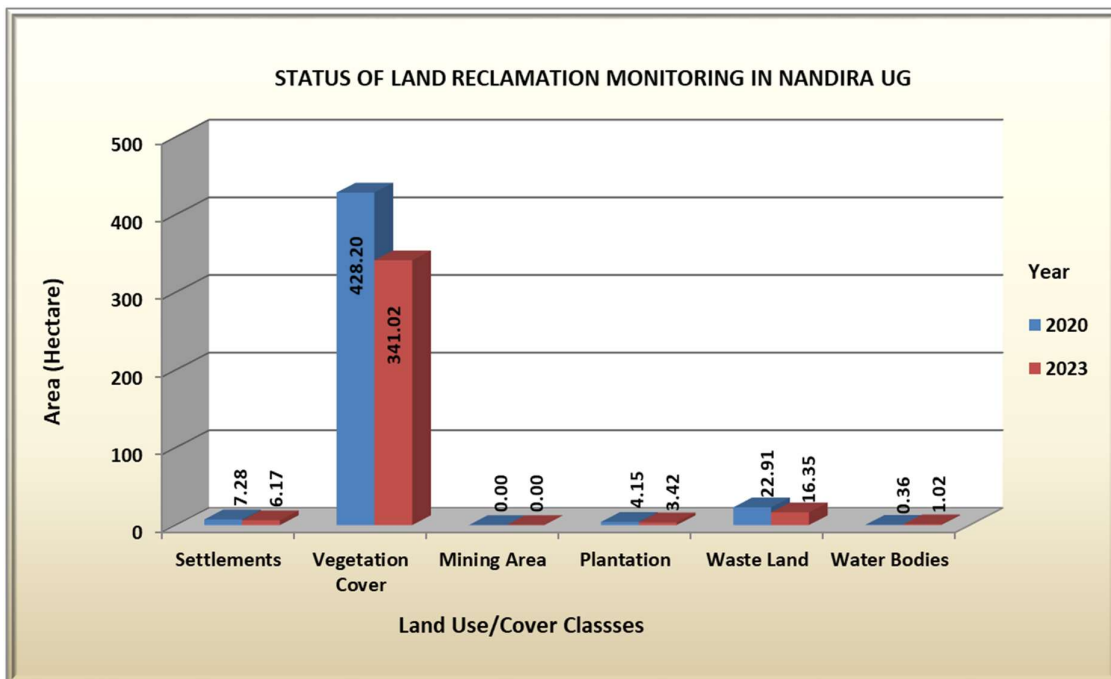


FIGURE -6

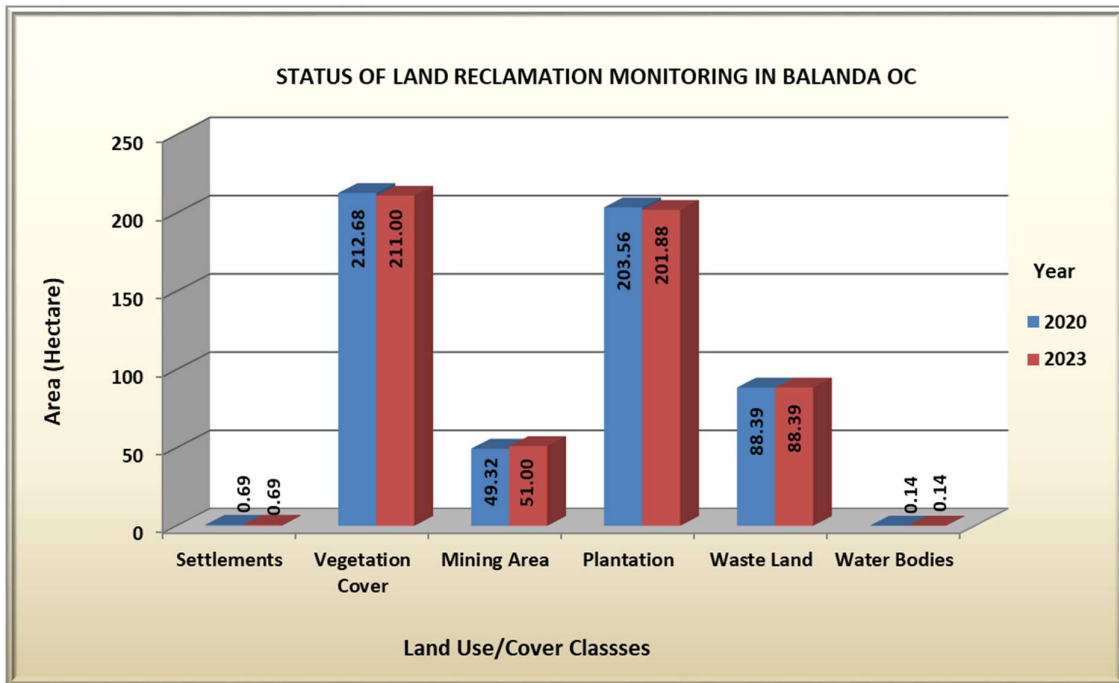


FIGURE -7

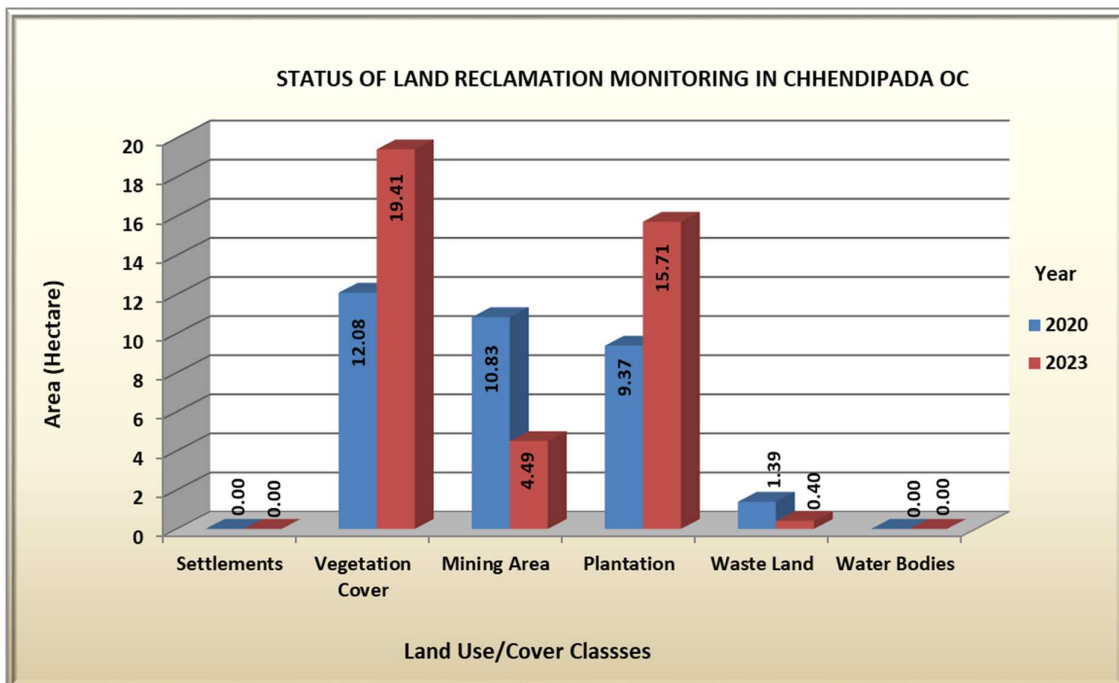


FIGURE -8

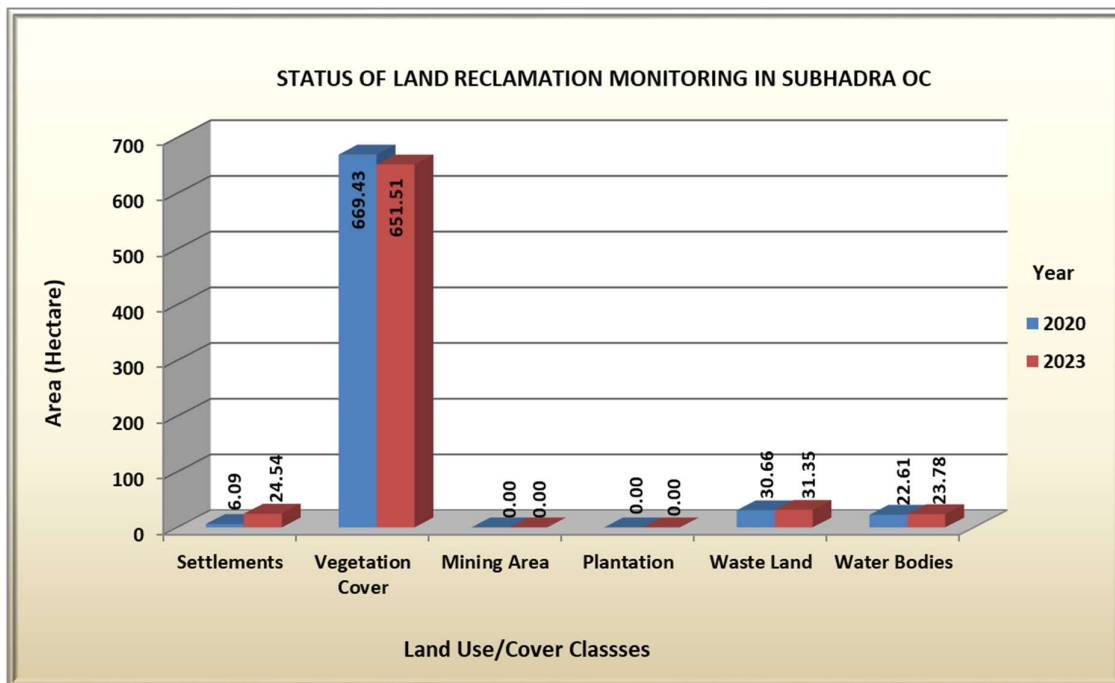


FIGURE -9

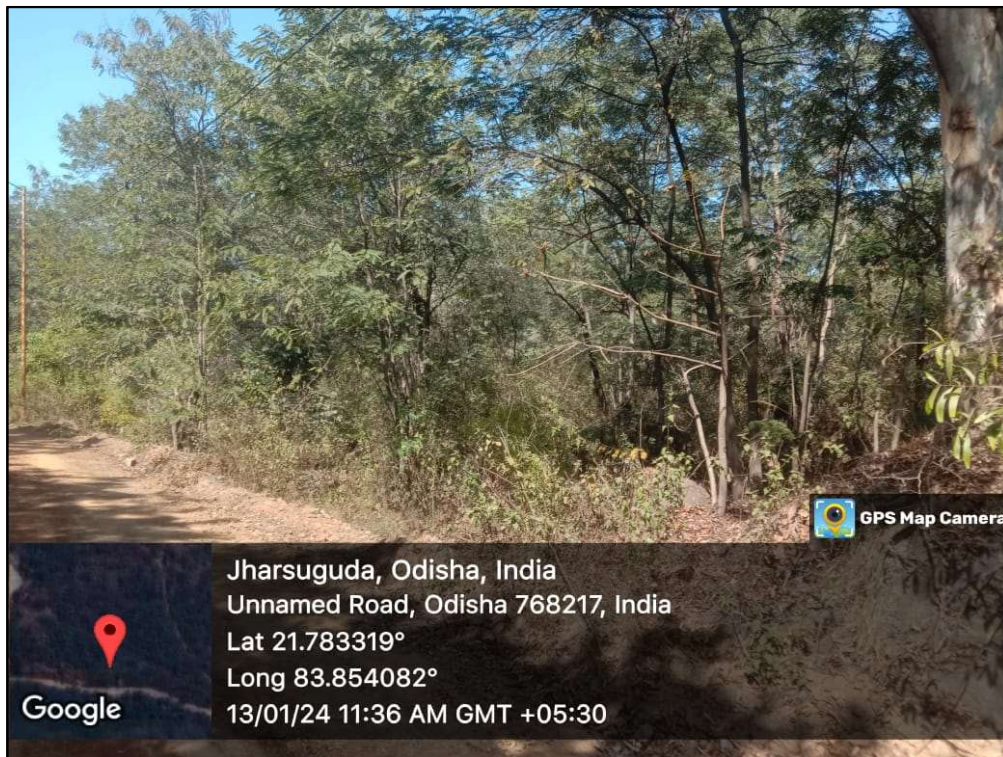


Photo 1: Plantation on OB Dump (Lilari OCP)

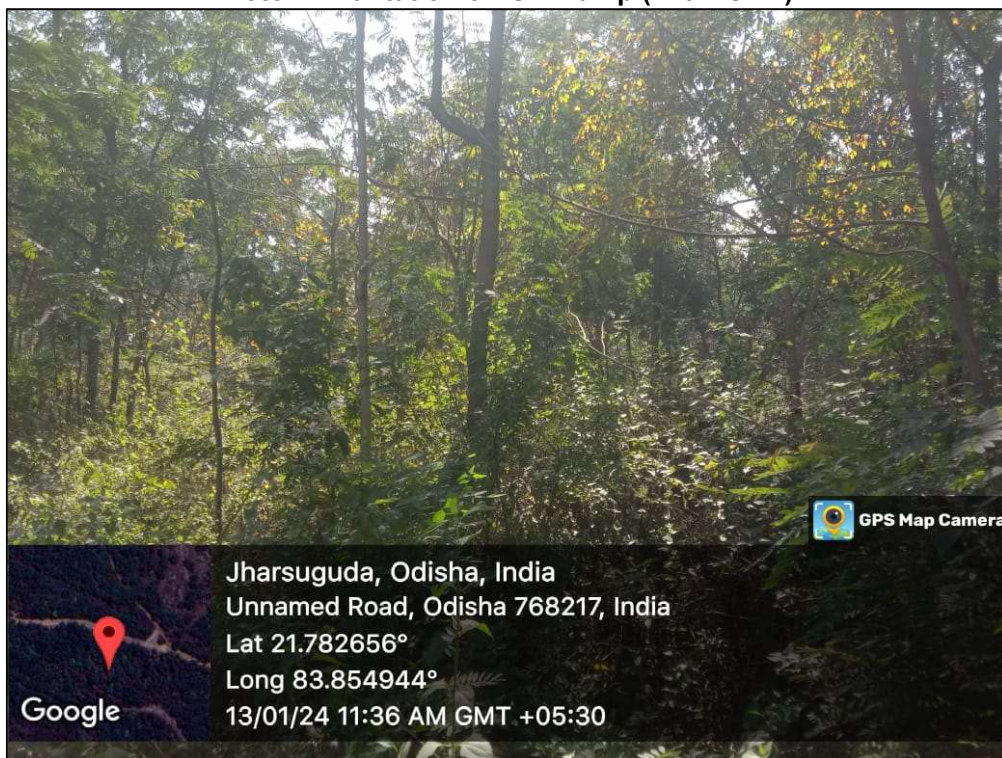


Photo 2: Plantation on backfill (Lilari OCP)



Photo 3: Plantation under social forestry (Orient 1 & 2 UGP)



Photo 4: Plantation under social forestry (Orient 3 UGP)



Photo 5: Incline No.-1 (Nandira Colliery)



Photo 6: Plantation on backfill (Balanda OCP)



Photo 7: Plantation on backfill (Chhendipada OCP)

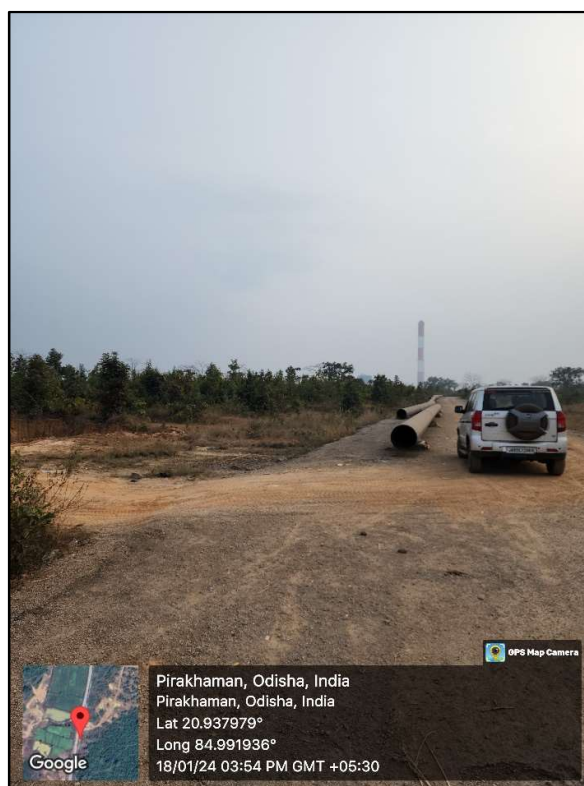


Photo 8: Within the lease boundary of Subhadra OCP

शब्द-कोष

1	Land Reclamation	भूमि पुनरुद्धार
2	Over Burden	अधिभार
3	Monitoring	निगरानी
4	Report	प्रतिवेदन
5	Executive Summary	कार्यकारी सारांश
6	Opencast Mine	खुली खदान
7	Objective	उद्देश्य
8	Methodology	कार्य प्रणाली अथवा प्रक्रिया
9	Table	तालिका
10	List of Tables	तालिकाओं की सूची
11	Map	मानचित्र
12	Social Forestry	सामाजिक वानिकी
13	Plantation	पौधारोपण
14	Million	घनमीटर
15	Background	पृष्ठभूमि
16	Planning	योजनाबद्ध
17	Asses	आकलन
18	Status	स्थिति
19	Regularly	निरंतर
20	Satellite	उपग्रह
21	Subsidiary	अनुषांगिक
22	Production	उत्पादन
23	Biological Reclamation	जैविक पुनरुद्धार
24	Technical Reclamation	तकनीकी पुनरुद्धार
25	Leasehold Area	पट्टाक्षेत्र
26	Excavated Area	उत्खनन क्षेत्र
27	Active mining	सक्रिय खनन
28	Environmental Protection	पर्यावरण संरक्षण
29	Remedial Measure	उपचारात्मक उपाय
30	Interval	अंतराल
31	Systematic Error	व्यवस्थित त्रुटियाँ।
32	Error	अशुद्धियाँ
33	Curvature	वक्रता
34	Geometric	ज्यामितिक
35	Distortion	विरूपण
36	Plantation	पौधारोपण

37	Capacity	क्षमता
38	Software	सॉफ्टवेयर
39	Class	वर्ग
40	Accuracy	सटीकता
41	Statistical Separation	सांख्यिकीय पृथक्करण
42	Cubic meter	घनमीटर
43	Depicted	दर्शाया गया
44	Percentage	प्रतिशत
45	Salient Findings	मुख्य निष्कर्ष
46	Methodology	पद्धति
47	Data Procurement	डाटाक्रय
48	Satellite data Processing	उपग्रह डाटा प्रसंस्करण
49	Rectification and geo-referencing	सुधार और भूसन्दर्भ-
50	Image enhancement	छवि गुण वृद्धि
51	Training set selection	प्रशिक्षण सेट का चयन
52	Classification and Accuracy assessment	वर्गीकरण और मूल्यांकन की सटीकता
53	Area calculation	क्षेत्र गणना
54	Temporal	लौकिक
55	Processing	प्रसंस्करण
56	Overlay of Vector data base	वेक्टर डाटाबेस का अरोपन
57	Pre-field map preparation	क्षेत्र जाने के पहले नक्शे की तैयारी
58	Ground Truthing	भू-सत्यापन
59	Ground Information	भू-सूचना
60	Interpretation	व्याख्या
61	Eco-system	पारिस्थितिकी तंत्र
62	Minor	मामुली
63	Water Drainage	जलनिकाय
64	Interval	अंतराल
65	Maximum	अधिकतम
66	Coal field	कोयला क्षेत्र
67	Design	परिकल्पना
68	Superimpose	आरोपित
69	Update	अद्यतनीकरण/नवीनीकरण
70	Cumulative	संचयित
71	Embankment	तटबंध
72	Cluster	खुली तथा भूमिगत खदानों के समूह

ABBREVIATIONS

Sol	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 Color 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 Generated	Total Plantation carried out in the lease area of Project. This includes 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 mines clubbed 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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