

Land Restoration/Reclamation Monitoring of more than 5 million cu.m (Coal+OB) Capacity Opencast Coal Mines of Mahanadi Coalfields Limited based on Satellite Data of the Year 2015



Submitted to
Mahanadi Coalfields Limited



cmpdi
A Mini-Ratna Company

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cu.m (Coal+OB) Capacity Opencast Coal Mines of Mahanadi
Coalfields Limited based on Satellite Data of the Year 2015**

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Executive Summary

- 1.0 Project** Land restoration / reclamation monitoring of 11 opencast coal mines of Mahanadi Coalfields Ltd. (MCL) producing 5 million cu.m. and more (Coal+OB) per year based on satellite data, regularly on annual basis.
- 2.0 Objective** Objective of the land restoration / reclamation monitoring is to assess the area of backfilled, plantation, social forestry, active mining area, water bodies, and distribution of wasteland, agricultural land and forest in the leasehold area of the project. This will help in assessing the progressive status of mined land reclamation and to take up remedial measures, if any, required for environmental protection.
- 3.0 Salient Findings**
- Out of the total mine leasehold area of 86.36 Km² of the 11 opencast projects of MCL viz. Ananta, Balram, Lingaraj, Bharatpur, Bhubaneshwari, Jagannath, Hingula, Belpahar, Lakhanpur, Samleswari and Lajkura considered for monitoring during 2015-16; total excavated area is 48.77 Km² (56.48%), out of which 14.59 Km² area (29.91%) has been planted, 18.12 Km² area (37.15%) is under backfilling and 16.07 Km² area (32.95%) is under active mining. It is evident from the analysis that 67.05% areas of the OC projects is under reclamation (biological and technical) and balance 32.95% 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 2015 with respect to the year 2014 in different projects, it is evident from the analysis that area under land reclamation has increased from 30.62 Km² (Yr. 2014) to 32.70 Km² (Yr.2015). Out of 11 projects of MCL, Lajkura OC ranks on top for land reclamation (77.46%) followed by Bharatpur OC (76.52%) and Ananta OC (74.62%).
 - Area of biological reclamation (plantation) has increased from 14.57 Km² (Yr.2014) to 14.59 Km² (Yr.2015) where as area of technical reclamation (area under backfilling) has increased from 16.05 Km² (Yr. 2014) to 18.12 Km² (Yr.2015) in MCL. This increase of 2.08 Km² in area of plantation and area under backfilling is the result of the efforts of the Mahanadi Coalfields Ltd. taken up towards environmental protection.

- In some of the projects it has been observed that natural vegetation has also started growing on the old and stabilized backfilled area and dumps due to better soil fertility besides plantation carried out by MCL, resulted in higher vegetation cover than plantation.

Table – 1

**Project wise Land Reclamation Status in
Opencast Projects of MCL based on Satellite Data of the year 2015**

Sl. No.	Project		(% Calculated in terms of Total Excavated Area)								Area are in Km ²	
			Biological Reclamation (Plantation/ Vegetation)		Technical Reclamation (Under Backfilling)		Under Active Mining		Total Excavated Area		Area under Reclamation	
	Name	Leasehold	ii		iii		iv		ii+iii+iv		ii+iii	
		i	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
1	Ananta	4.56	1.05	1.05	1.62	1.81	1.09	0.97	3.76	3.83	2.67	2.86
			27.94	27.40	43.11	47.23	28.95	25.38			71.05	74.62
2	Balram	10.21	1.41	1.43	2.07	2.14	1.22	1.22	4.70	4.79	3.48	3.57
			30.06	29.87	43.95	44.69	25.99	25.44			74.01	74.56
3	Lingaraj	7.26	0.89	0.90	1.32	1.60	1.74	1.92	3.95	4.43	2.21	2.50
			22.53	20.33	33.45	36.25	44.02	43.42			55.98	56.58
4	Bharatpur	9.43	2.55	2.57	1.87	2.11	1.22	1.44	5.64	6.12	4.42	4.68
			45.18	42.01	33.20	34.51	21.62	23.48			78.38	76.52
5	Bhubaneswari	7.33	0.43	0.39	1.02	1.32	2.17	2.24	3.62	3.95	1.45	1.71
			11.89	9.77	28.25	33.46	59.87	56.77			40.13	43.23
6	Jagannath	4.99	2.17	2.17	0.89	0.91	1.12	1.07	4.18	4.16	3.06	3.08
			51.98	52.19	21.27	21.97	26.75	25.83			73.25	74.17
7	Hingula	4.83	0.57	0.57	0.98	1.03	1.64	1.70	3.19	3.30	1.55	1.60
			17.79	17.22	30.74	31.29	51.47	51.48			48.53	48.52
8	Belpahar	9.74	2.16	2.16	0.88	1.08	1.67	1.83	4.70	5.07	3.04	3.24
			45.81	42.62	18.73	21.34	35.46	36.04			64.54	63.96
9	Lakhanpur	16.20	1.50	1.51	2.52	2.89	1.99	1.79	6.01	6.19	4.02	4.40
			24.92	24.41	41.94	46.67	33.15	28.92			66.85	71.08
10	Samleswari	7.13	1.32	1.32	1.89	2.16	1.56	1.43	4.77	4.91	3.22	3.48
			27.70	26.92	39.69	43.94	32.61	29.14			67.39	70.86
11	Lajkura	4.68	0.53	0.52	0.98	1.06	0.52	0.46	2.03	2.04	1.51	1.58
			26.07	25.52	48.36	51.95	25.57	22.54			74.43	77.46
TOTAL (MCL)		86.36	14.57	14.59	16.05	18.12	15.93	16.07	46.55	48.77	30.62	32.70
			31.31	29.91	34.48	37.15	34.22	32.95	53.91	56.48	65.78	67.05

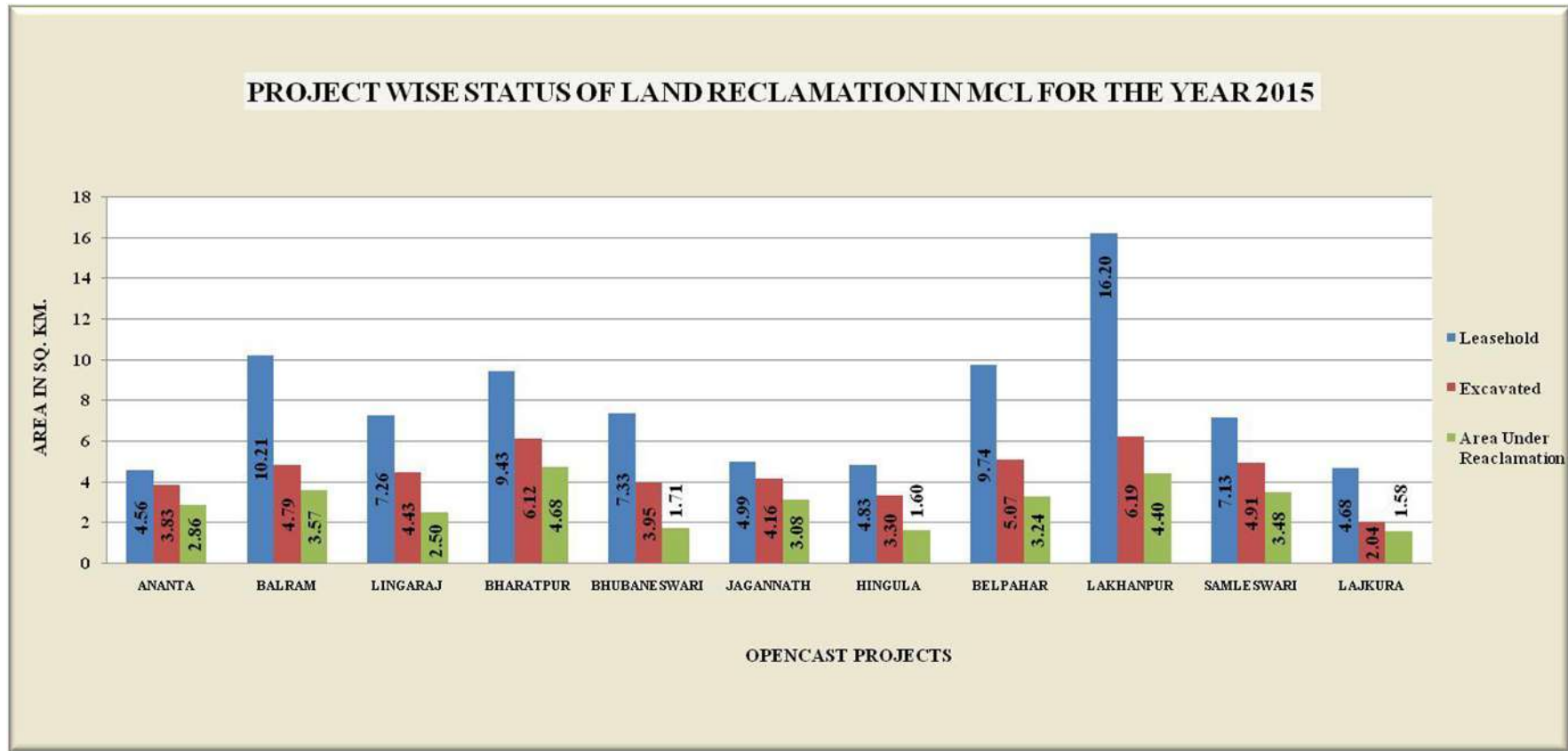


Fig.1: Land reclamation status in OC projects of MCL for the year 2015

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, another work order vide letter no. CIL/WBP/ENV./2011 dated 23/08/11 was issued by CIL for monitoring of less than 5 million m³ per annum capacity (Coal +OB) projects from the year 2011 at interval of three years. This order has been renewed in CIL letter no. CIL/WBP/Env/2011/4706 dated 12.10.2012 for the next five years. The results of land reclamation status of all such mines are uploaded on the website of 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 (MoEF). Such monitoring would not only facilitate in taking timely mitigation measures against environmental degradation, but would also enable coal companies to utilize the reclaimed land for larger socio-economic benefits in a planned way.

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 2015 carried out for all the OC projects producing more than 5 mcm (Coal+OB) for Mahanadi Coalfields Ltd.

2.0 Objective

Objective of the land reclamation/restoration monitoring is to assess the area of backfilled, plantation, OB dumps, social forestry, active mining area, settlements and water bodies, distribution of wasteland, agricultural land and forest land in the leasehold area of the project. This is an important step taken up for assessing the progressive status of mined land reclamation and for taking up remedial measures, if any, required for environmental protection.

3.0 Methodology

There are number of steps involved between raw satellite data procurement and preparation of final map. National Remote Sensing Centre (NRSC) Hyderabad, being the nodal agency for satellite data supply in India, provides only raw digital satellite data, which needs further digital image processing for extracting the information and map preparation before uploading the same in the website. Methodology for land reclamation monitoring is given in given in Fig 1. Following steps are involved in land reclamation /restoration monitoring:

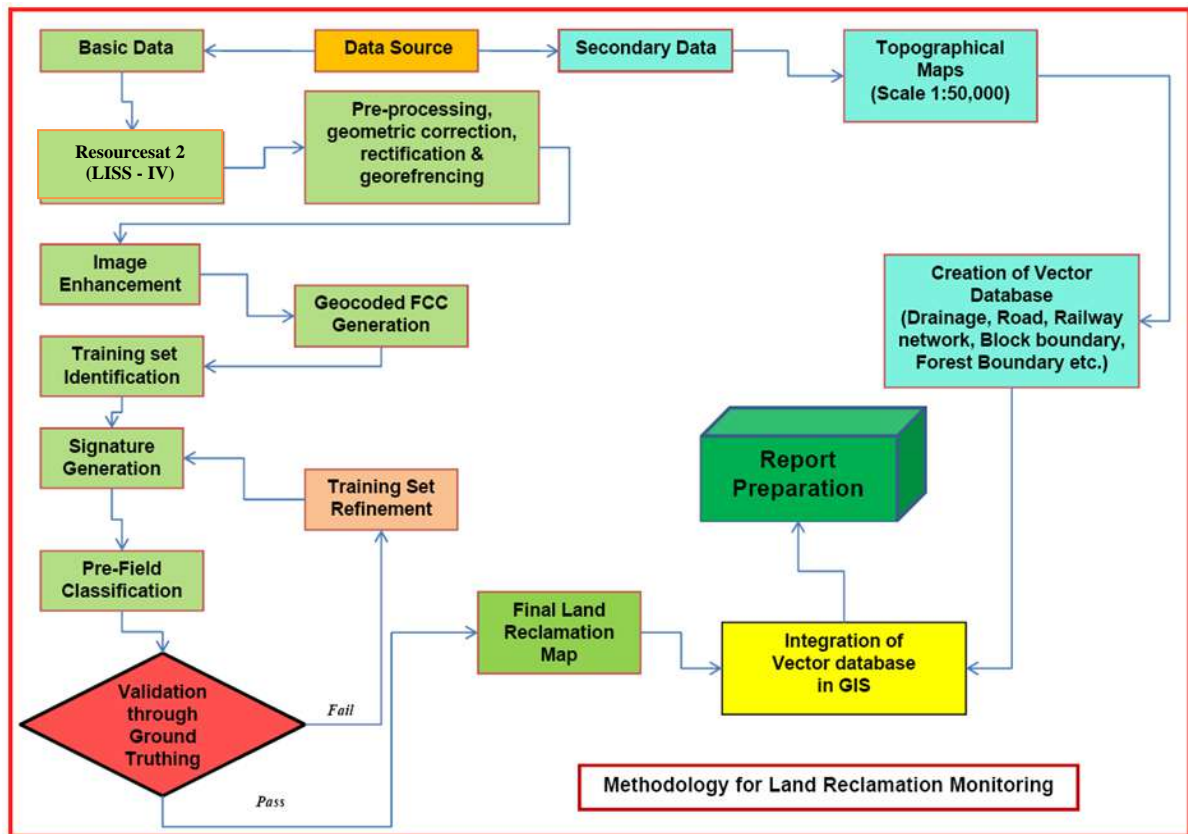


Figure: 2 - **Methodology for Land Reclamation Monitoring**

3.1 Data Procurement: After browsing the data quality and date of pass on internet, supply order for data is placed to NRSC. Secondary data like leasehold boundary, topo sheets are procured for creation of vector database.

3.2 Satellite Data Processing: Satellite data are processed using ERDAS IMAGINE 2014 digital image processing s/w. Methodology involves the following major steps:

- Rectification & Georeferencing:** Inaccuracies in digital imagery may occur due to 'systematic errors' attributed to earth curvature and rotation as well as 'non-systematic errors' attributed to satellite receiving station itself. Raw digital images contain geometric distortions, which make them unusable as maps. Therefore, georeferencing is required for correction of image data using ground control points (GCP) to make it compatible to Sol toposheet.

- **Image enhancement:**

To improve the interpretability of the raw data, image enhancement is necessary. Local operations modify the value of each pixel based on brightness value of neighbouring pixels using ERDAS IMAGINE 2014 s/w. and enhance the image quality for interpretation.

- **Training set selection**

Training set requires to be selected, so that software can classify the image data accurately. The image data are analysed based on the interpretation keys. These keys are evolved from certain fundamental image-elements such as tone/colour, size, shape, texture, pattern, location, association and shadow. Based on the image-elements and other geo-technical elements like land form, drainage pattern and physiography; training sets were selected/identified for each land use/cover class. Field survey was carried out by taking selective traverses in order to collect the ground information (or reference data) so that training sets are selected accurately in the image. This was intended to serve as an aid for classification.

- **Classification and Accuracy assessment**

Image classification is carried out using the maximum likelihood algorithm. The classification proceeds through the following steps: (a) calculation of statistics [i.e. signature generation] for the identified training areas, and (b) the decision boundary of maximum probability based on the mean vector, variance, covariance and correlation matrix of the pixels. After evaluating the statistical parameters of the training sets, reliability test of training sets is conducted by measuring the statistical separation between the classes that resulted from computing divergence matrix. The overall accuracy of the classification was finally assessed with reference to ground truth data.

- **Area calculation**

The area of each land use class in the leasehold is determined using ERDAS IMAGINE v.2014 software.

- **Overlay of Vector data base**

Vector data base created based on secondary data. Vector layer like drainage, railway line, leasehold boundary, forest boundary etc. are superimposed on the image as vector layer in the Arc GIS 10.2 database.

- **Pre-field map preparation**

Pre-field map is prepared for validation of the classification result

3.3 Ground Truthing:

Selective ground verification of the land use classes are carried out in the field and necessary corrections if required, are incorporated before map finalization.

3.4 Land reclamation database on GIS:

Land reclamation database is created on GIS platform to identify the temporal changes identified from satellite data of different cut-of dates.

4.0 Land Reclamation Status in Mahanadi Coalfields Limited

4.1 Following eleven opencast projects of MCL producing more than 5 million cubic meter and more (Coal + OB) were taken up for land reclamation monitoring during year 2015-16 based on satellite data of the year 2015.

- Ananta
- Balram
- Lingaraj
- Bharatpur
- Bhubaneswari
- Jagannath
- Hingula
- Belpahar
- Lakhanpur
- Samleswari
- Lajkura

4.2 Area statistics of different land use class present in the mine leasehold of the above projects for the year 2015 are shown in the Table -1. Land use maps derived from satellite data are shown in Plate 1 - 11. Land reclamation status of the above mentioned 11 projects, were also prepared for the year 2015-2016. Year wise changes in the different land use classes based on satellite data are depicted in Bar Charts in Fig.3 - 13.

4.3 Study reveals that out of total 48.77 Km² excavated area; 32.70 Km² area (67.05%) is under reclamation. Out of which 14.59 Km² (29.91%) area has been re-vegetated and 18.12 Km² (37.15%) area is under backfilling.

4.4 Analysis of satellite data indicates that area of plantation has increased from 14.57 Km² (2014) to 14.59 Km² (2015). This increase of 0.02 Km² plantation areas in one year indicates that MCL is committed for reclamation of mine land for

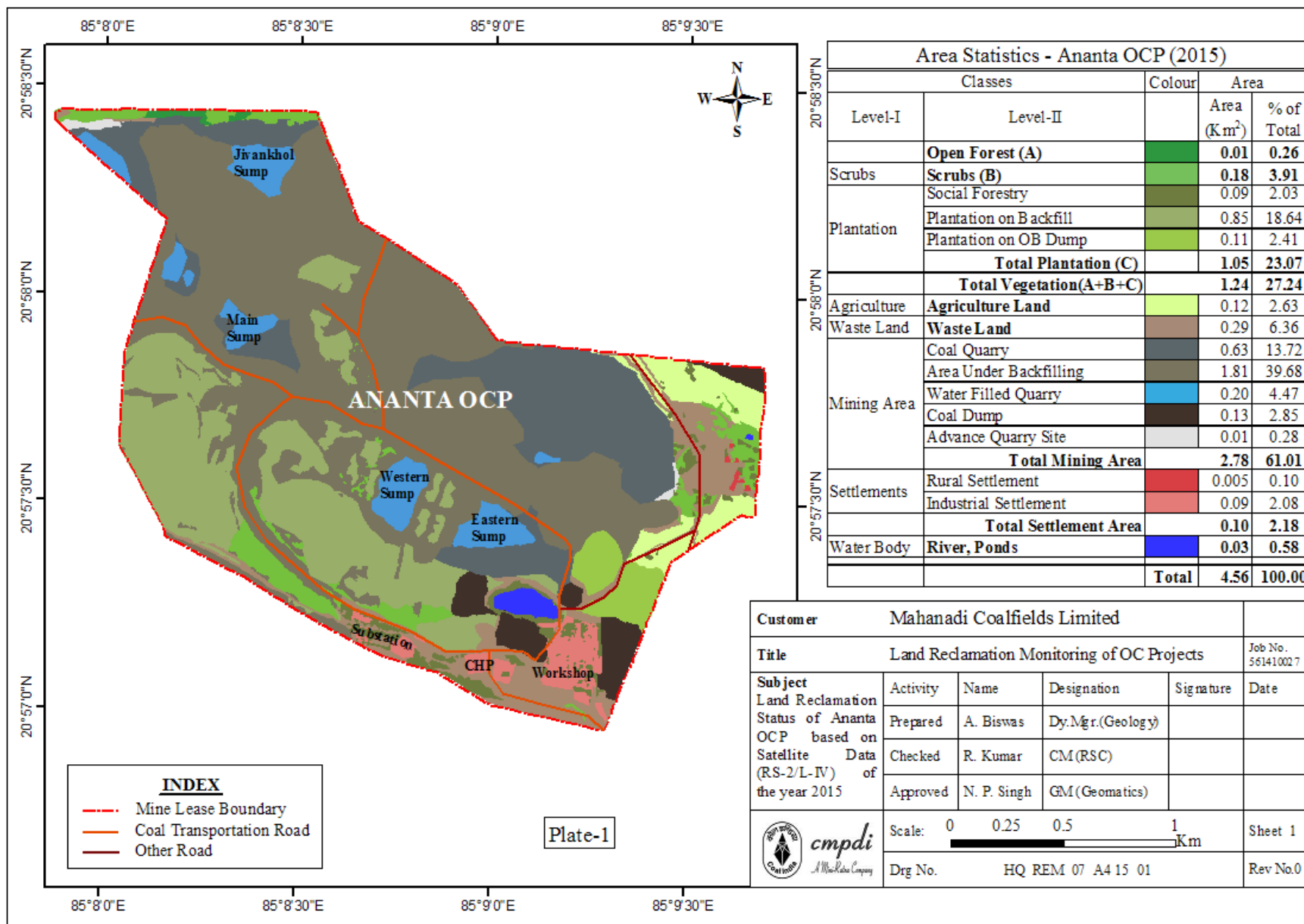
maintaining the ecological balance in the region. It has been observed in some of the projects natural vegetation has also started growing on stabilized old backfilled areas and OB dumps due to increase in soil fertility.

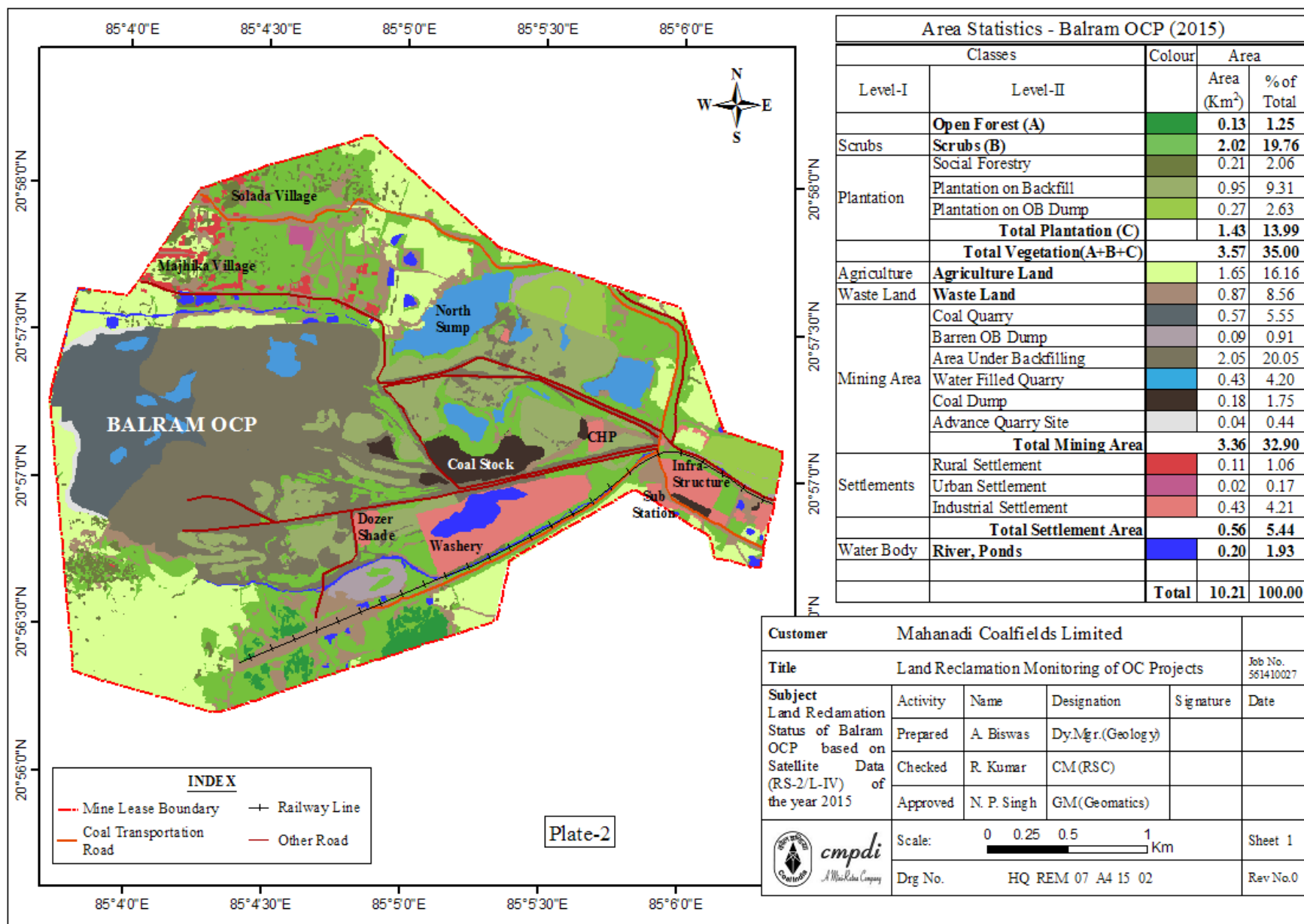
- 4.5** On comparing the status of land reclamation for the year 2015 with respect to the year 2014 in different projects, it is evident that area of land reclamation has increased from 30.62 Km² (Yr. 2014) to 32.70 Km² (Yr.2015).
- 4.6** Out of 11 projects of MCL, Lajkura OC ranks on top for land reclamation (77.46%) followed by Bharatpur OC (76.52%) and Ananta OC (74.62%).

Table 2: STATUS OF LAND RESTORATION / RECLAMATION IN MAHANADI COALFIELDS LIMITED BASED ON SATELLITE DATA OF THE YEAR 2015

(Area in Sq. Kms.)

	ANANTA		BALRAM		LINGARAJ		BHARATPUR		BHUBANESHWARI		JAGANNATH		HINGULA		BELPAHAR		LAKHANPUR		SAMLESWARI		LAJKURA		TOTAL		
	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	
FORESTS	Dense Forest	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.64	10.13	0.07	1.05	1.19	25.36	2.94	3.40
	Open Forest	0.01	0.26	0.13	1.25	0.20	2.73	0.48	5.06	0.79	10.72	0.01	0.21	0.00	0.00	0.01	0.10	2.70	16.67	0.11	1.57	0.61	12.99	5.04	5.84
	Total Forest (A)	0.01	0.26	0.13	1.25	0.20	2.73	0.51	5.44	0.79	10.72	0.01	0.21	0.00	0.00	0.01	0.10	4.34	26.80	0.19	2.61	1.80	38.35	7.98	9.24
SCRUBS	Scrubs (B)	0.18	3.91	2.02	19.76	0.97	13.39	0.96	10.17	0.64	8.72	0.23	4.61	0.23	4.77	2.15	22.07	2.16	13.31	0.59	8.33	0.34	7.26	10.46	12.12
PLANTATION	Social Forestry	0.09	2.03	0.21	2.06	0.42	5.79	0.36	3.82	0.38	5.19	0.14	2.86	0.25	5.26	0.40	4.16	0.43	2.64	0.18	2.47	0.07	1.57	2.94	3.41
	Plantation on Backfill	0.85	18.64	0.95	9.31	0.15	2.07	1.77	18.78	0.01	0.14	2.03	40.70	0.08	1.66	1.05	10.78	0.77	4.75	0.67	9.32	0.17	3.63	8.50	9.84
	Plantation on OB Dump	0.11	2.41	0.27	2.63	0.33	4.55	0.44	4.67	0.00	0.00	0.00	0.00	0.23	4.85	0.71	7.29	0.31	1.91	0.48	6.73	0.28	5.98	3.16	3.66
	Total Plantation (Biological Reclamation C)	1.05	23.07	1.43	13.99	0.90	12.40	2.57	27.27	0.39	5.32	2.17	43.56	0.57	11.77	2.16	22.22	1.51	9.31	1.32	18.53	0.52	11.18	14.60	16.91
Total Vegetation (A+B+C)	1.24	27.24	3.57	35.00	2.07	28.52	4.04	42.87	1.81	24.76	2.41	48.38	0.80	16.54	4.32	44.39	8.00	49.41	2.10	29.47	2.66	56.79	33.05	38.27	
ACTIVE MINING	Coal Quarry	0.63	13.72	0.57	5.55	1.37	18.87	0.63	6.68	1.71	23.29	0.13	2.69	0.63	13.05	1.44	14.75	1.31	8.09	1.12	15.75	0.35	7.50	9.88	11.46
	Coal Dump	0.13	2.85	0.18	1.75	0.22	2.99	0.15	1.61	0.23	3.20	0.21	4.30	0.33	6.88	0.09	0.94	0.22	1.34	0.07	0.95	0.06	1.18	1.89	2.19
	Advance Quarry Site	0.01	0.28	0.04	0.44	0.16	2.21	0.10	1.08	0.22	3.02	0.02	0.31	0.07	1.38	0.17	1.72	0.23	1.40	0.15	2.16	0.04	0.77	1.21	1.40
	Quarry Filled with Water	0.20	4.47	0.43	4.20	0.18	2.41	0.55	5.87	0.08	1.08	0.71	14.23	0.67	13.87	0.13	1.34	0.03	0.22	0.09	1.21	0.02	0.35	3.09	3.58
	Total Area under Active Mining	0.97	21.32	1.22	11.94	1.92	26.48	1.44	15.24	2.24	30.59	1.07	21.53	1.70	35.18	1.83	18.75	1.79	11.05	1.43	20.07	0.46	9.80	16.07	18.63
RECLAIMED	Barren OB dump	0.00	0.00	0.09	0.91	0.48	6.68	0.06	0.60	0.78	10.69	0.00	0.00	0.02	0.46	0.03	0.31	0.004	0.02	0.07	0.95	0.04	0.93	1.59	1.84
	Area Under Backfilling	1.81	39.68	2.05	20.05	1.12	15.43	2.05	21.80	0.54	7.34	0.91	18.31	1.01	20.93	1.05	10.78	2.89	17.84	2.09	29.30	1.02	21.67	16.54	19.15
	Total Area under Technical Reclamation	1.81	39.68	2.14	20.96	1.60	22.11	2.11	22.40	1.32	18.03	0.91	18.31	1.03	21.39	1.08	11.09	2.89	17.86	2.16	30.25	1.06	22.60	18.12	20.99
Total Area under Mine Operation	2.78	61.01	3.36	32.90	3.53	48.59	3.55	37.64	3.56	48.62	1.99	39.85	2.73	56.57	2.91	29.84	4.68	28.91	3.59	50.31	1.52	32.40	34.19	39.62	
WASTELANDS	Waste Lands	0.29	6.36	0.87	8.56	0.62	8.58	1.01	10.72	0.38	5.14	0.36	7.19	0.65	13.47	1.51	15.50	0.65	4.00	0.82	11.50	0.41	8.75	7.57	8.77
	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	0.03	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.03	
	Total Wastelands	0.29	6.36	0.87	8.56	0.62	8.58	1.01	10.72	0.38	5.14	0.36	7.19	0.68	14.04	1.51	15.50	0.65	4.00	0.82	11.50	0.41	8.75	7.60	8.8
WATER	Reservoir, nallah, ponds etc.	0.03	0.58	0.20	1.93	0.05	0.71	0.06	0.65	0.06	0.88	0.004	0.09	0.13	2.62	0.26	2.64	0.16	0.98	0.06	0.89	0.01	0.17	1.02	1.18
	Total Waterbodies	0.03	0.58	0.20	1.93	0.05	0.71	0.06	0.65	0.06	0.88	0.004	0.09	0.13	2.62	0.26	2.64	0.16	0.98	0.06	0.89	0.01	0.17	1.02	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	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Fallow Lands	0.12	2.63	1.65	16.16	0.72	9.96	0.46	4.84	1.34	18.26	0.03	0.62	0.42	8.70	0.40	4.11	2.51	15.51	0.35	4.96	0.04	0.91	8.05	9.32
	Total Agriculture	0.12	2.63	1.65	16.16	0.72	9.96	0.46	4.84	1.34	18.26	0.03	0.62	0.42	8.70	0.40	4.11	2.51	15.51	0.35	4.96	0.04	0.91	8.05	9.32
SETTLEMENTS	Urban Settlement	0.00	0.00	0.02	0.17	0.02	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.13	0.01	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.06
	Rural Settlement	0.005	0.10	0.11	1.06	0.10	1.37	0.12	1.22	0.14	1.96	0.00	0.00	0.05	0.93	0.11	1.08	0.09	0.59	0.03	0.39	0.00	0.00	0.74	0.86
	Industrial Settlement	0.09	2.08	0.43	4.21	0.15	2.00	0.19	2.05	0.03	0.38	0.19	3.88	0.02	0.46	0.23	2.32	0.10	0.60	0.18	2.48	0.05	0.98	1.65	1.91
	Total Settlements	0.10	2.18	0.56	5.44	0.26	3.63	0.31	3.27	0.17	2.33	0.19	3.88	0.07	1.52	0.34	3.54	0.19	1.19	0.21	2.88	0.05	0.98	2.45	2.83
GRAND TOTAL	4.56	100.00	10.21	100.00	7.26	100.00	9.43	100.00	7.33	100.00	4.99	100.00	4.83	99.99	9.74	100.00	16.20	100.00	7.13	100.00	4.68	100.00	86.36	100.00	

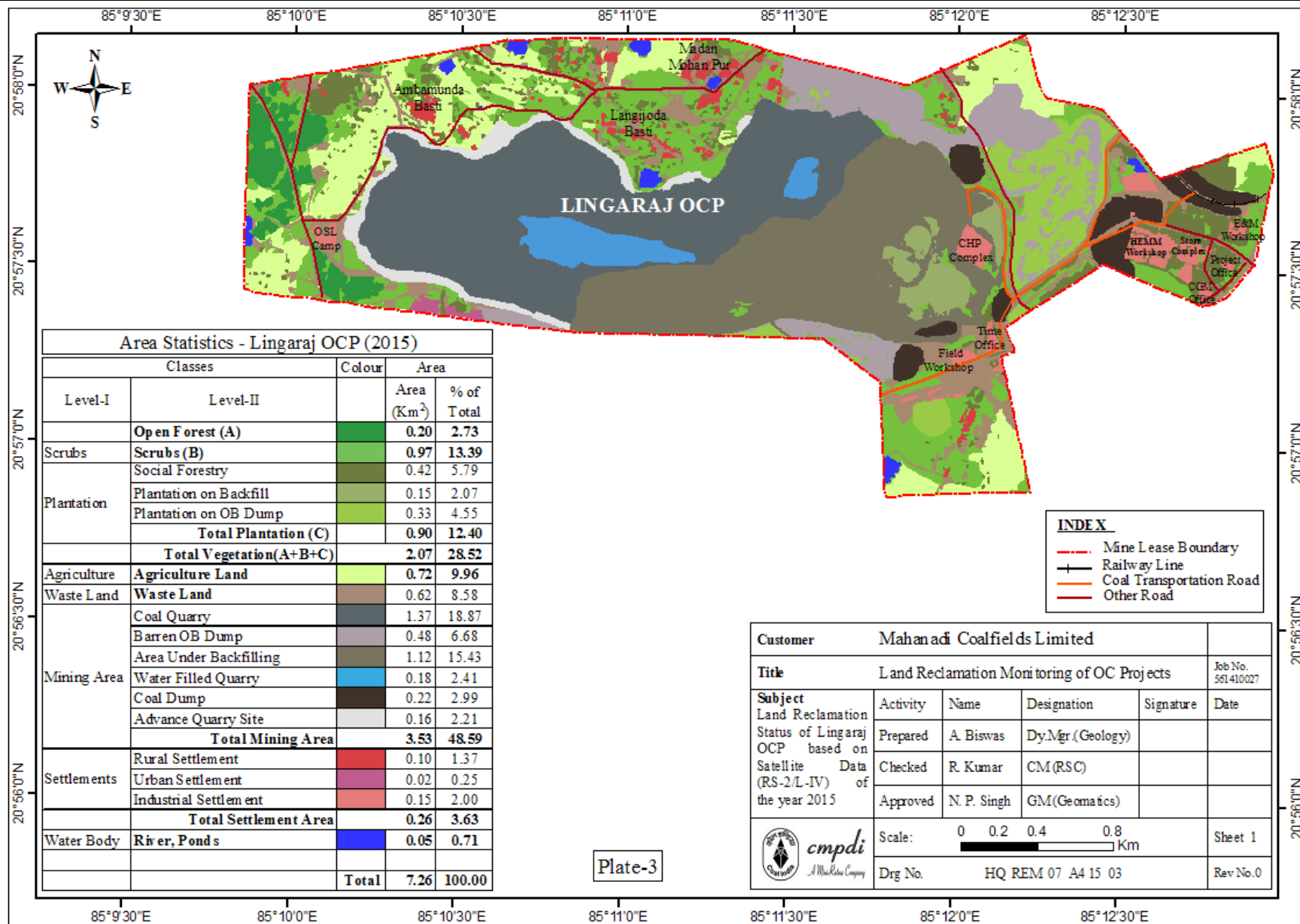




Area Statistics - Balram OCP (2015)				
Classes		Colour	Area	
Level-I	Level-II		Area (Km ²)	% of Total
	Open Forest (A)		0.13	1.25
Scrub	Scrub (B)		2.02	19.76
	Social Forestry		0.21	2.06
Plantation	Plantation on Backfill		0.95	9.31
	Plantation on OB Dump		0.27	2.63
	Total Plantation (C)		1.43	13.99
	Total Vegetation(A+B+C)		3.57	35.00
Agriculture	Agriculture Land		1.65	16.16
Waste Land	Waste Land		0.87	8.56
Mining Area	Coal Quarry		0.57	5.55
	Barren OB Dump		0.09	0.91
	Area Under Backfilling		2.05	20.05
	Water Filled Quarry		0.43	4.20
	Coal Dump		0.18	1.75
	Advance Quarry Site		0.04	0.44
		Total Mining Area		3.36
Settlements	Rural Settlement		0.11	1.06
	Urban Settlement		0.02	0.17
	Industrial Settlement		0.43	4.21
	Total Settlement Area		0.56	5.44
Water Body	River, Ponds		0.20	1.93
	Total		10.21	100.00

Customer		Mahanadi Coalfields Limited			
Title		Land Reclamation Monitoring of OC Projects			Job No. 561410027
Subject Land Reclamation Status of Balram OCP based on Satellite Data (RS-2/L-IV) of the year 2015	Activity	Name	Designation	Signature	Date
	Prepared	A. Biswas	Dy.Mgr.(Geology)		
	Checked	R. Kumar	CM(RSC)		
Approved	N. P. Singh	GM(Geomatics)			
Scale:		0 0.25 0.5 1 Km			Sheet 1
Drg No.		HQ REM 07 A4 15 02			Rev.No.0

Plate-2

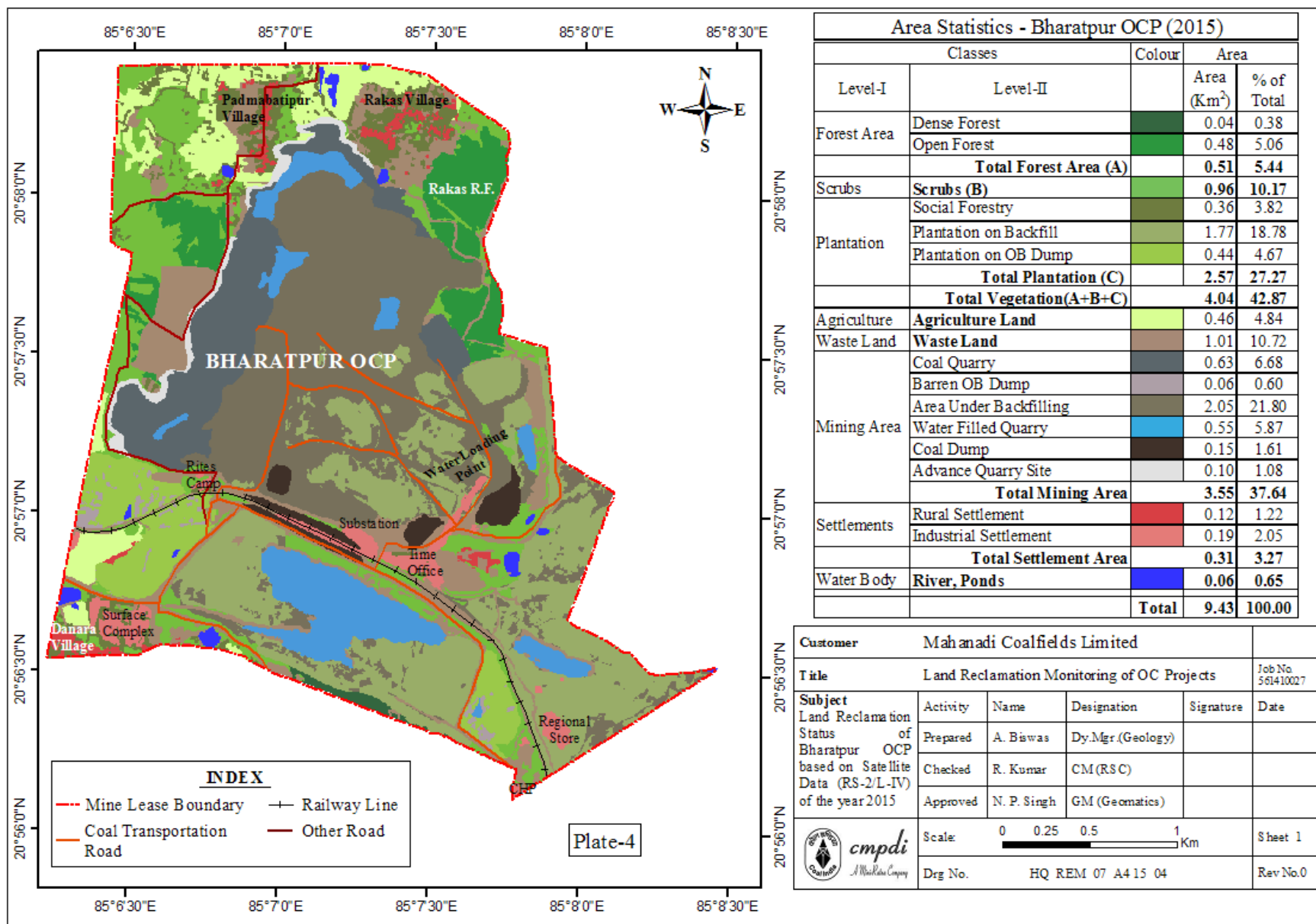


Area Statistics - Lingaraj OCP (2015)				
Classes		Colour	Area	
Level-I	Level-II		Area (Km ²)	% of Total
	Open Forest (A)		0.20	2.73
Scrubs	Scrubs (B)		0.97	13.39
	Social Forestry		0.42	5.79
Plantation	Plantation on Backfill		0.15	2.07
	Plantation on OB Dump		0.33	4.55
	Total Plantation (C)		0.90	12.40
	Total Vegetation(A+B+C)		2.07	28.52
Agriculture	Agriculture Land		0.72	9.96
Waste Land	Waste Land		0.62	8.58
Mining Area	Coal Quarry		1.37	18.87
	Barren OB Dump		0.48	6.68
	Area Under Backfilling		1.12	15.43
	Water Filled Quarry		0.18	2.41
	Coal Dump		0.22	2.99
	Advance Quarry Site		0.16	2.21
	Total Mining Area		3.53	48.59
Settlements	Rural Settlement		0.10	1.37
	Urban Settlement		0.02	0.25
	Industrial Settlement		0.15	2.00
	Total Settlement Area		0.26	3.63
Water Body	River, Ponds		0.05	0.71
	Total		7.26	100.00

INDEX	
	Mine Lease Boundary
	Railway Line
	Coal Transportation Road
	Other Road

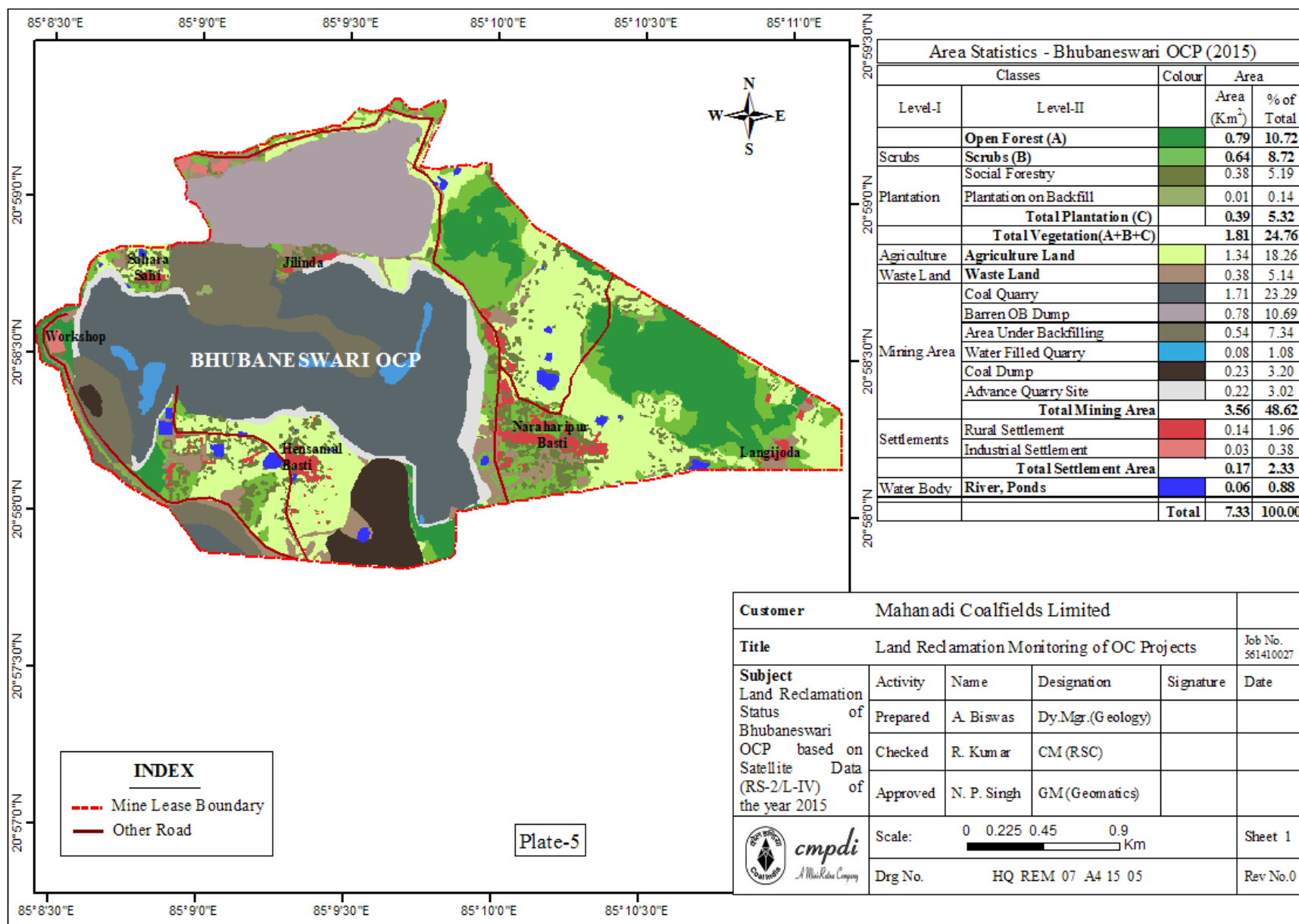
Customer	Mahanadi Coalfields Limited				
Title	Land Reclamation Monitoring of OC Projects				Job No. 561410027
Subject Land Reclamation Status of Lingaraj OCP based on Satellite Data (RS-2/L-IV) of the year 2015	Activity	Name	Designation	Signature	Date
	Prepared	A. Biswas	Dy.Mgr (Geology)		
	Checked	R. Kumar	CM(RSC)		
Approved	N. P. Singh	GM(Geomatics)			
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Drg No.	HQ REM 07 A4 15 03				Rev No. 0

Plate-3

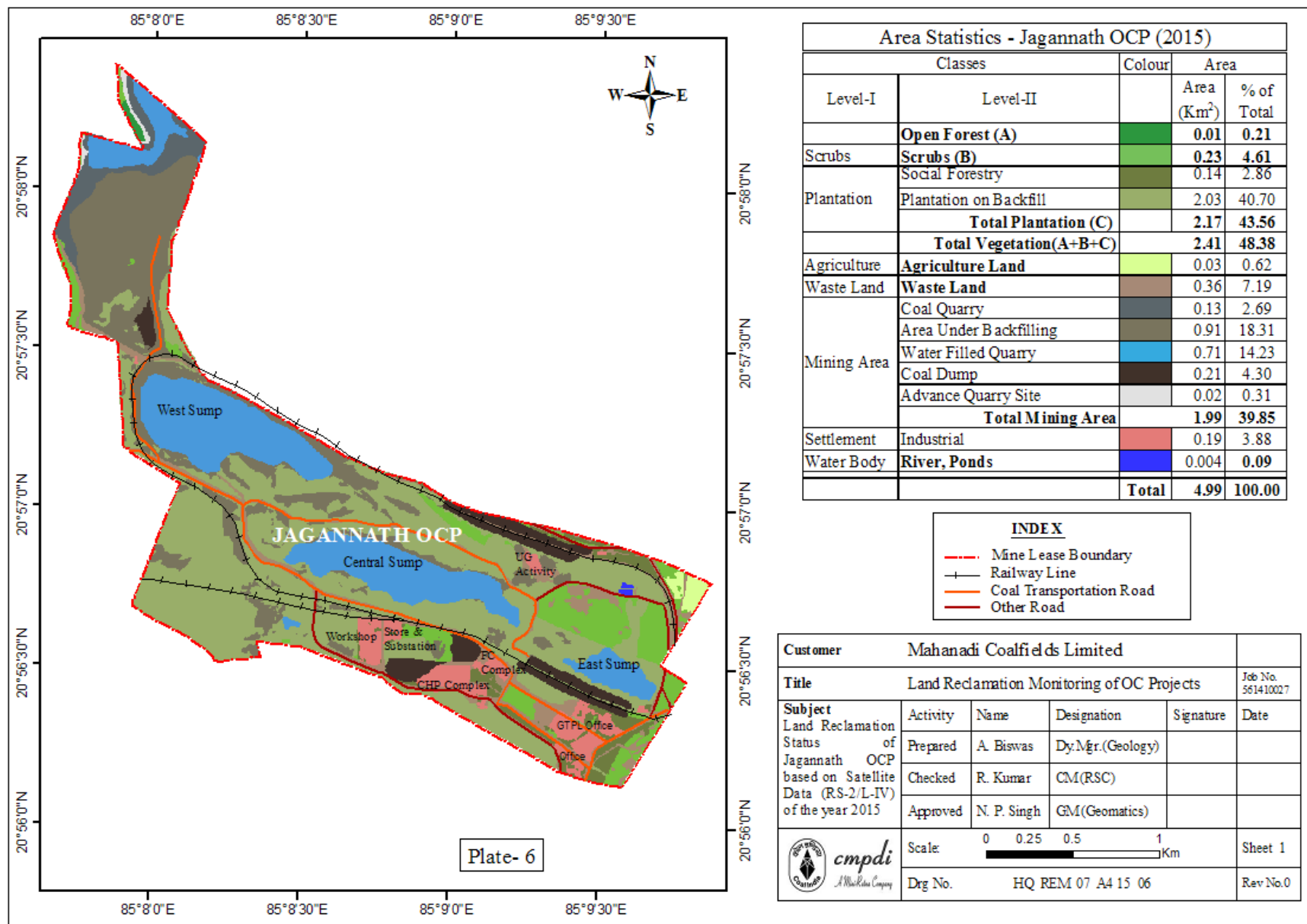


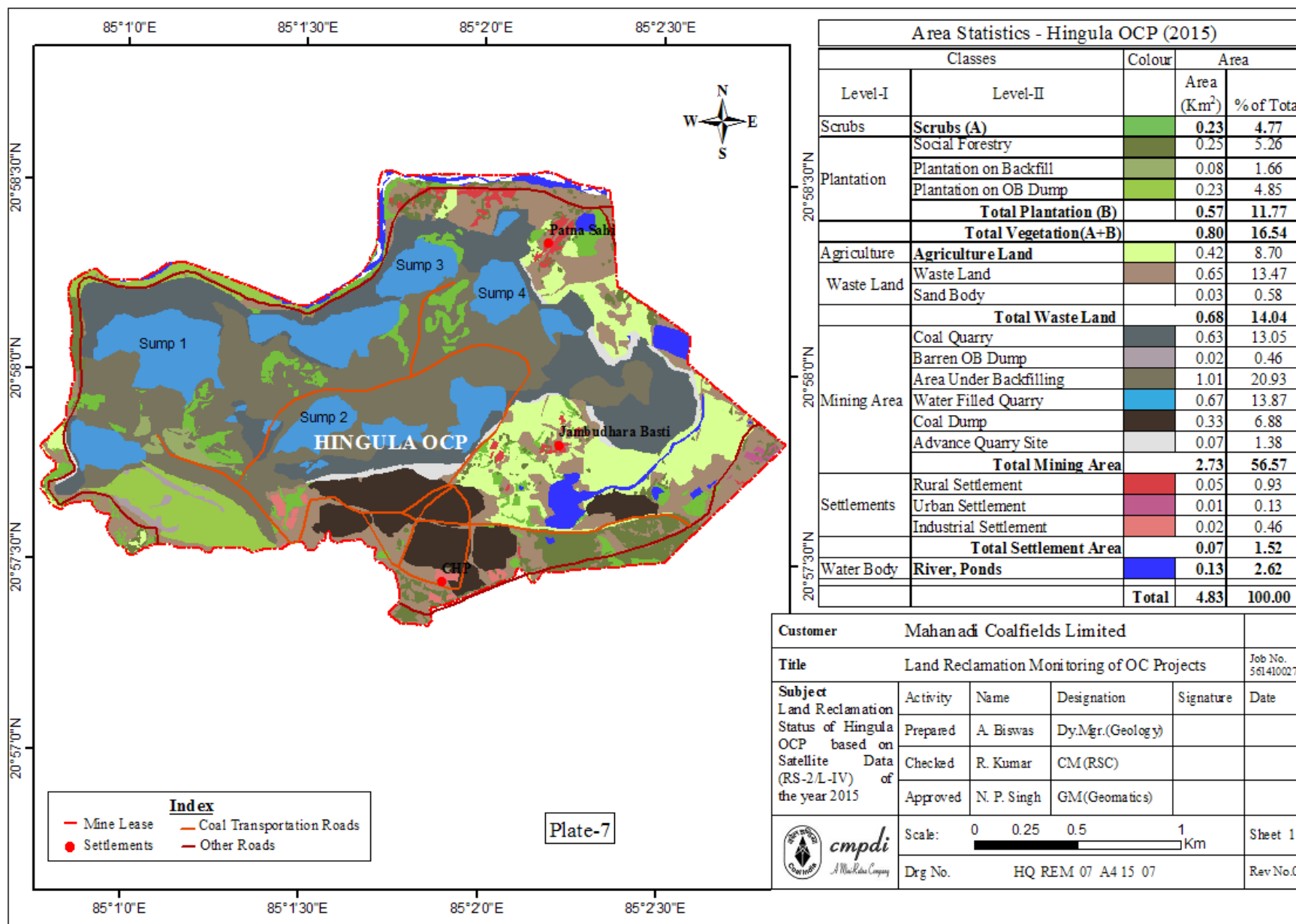
Classes		Colour	Area	
Level-I	Level-II		Area (Km ²)	% of Total
Forest Area	Dense Forest		0.04	0.38
	Open Forest		0.48	5.06
Total Forest Area (A)			0.51	5.44
Scrub	Scrub (B)		0.96	10.17
Plantation	Social Forestry		0.36	3.82
	Plantation on Backfill		1.77	18.78
	Plantation on OB Dump		0.44	4.67
Total Plantation (C)			2.57	27.27
Total Vegetation(A+B+C)			4.04	42.87
Agriculture	Agriculture Land		0.46	4.84
Waste Land	Waste Land		1.01	10.72
Mining Area	Coal Quarry		0.63	6.68
	Barren OB Dump		0.06	0.60
	Area Under Backfilling		2.05	21.80
	Water Filled Quarry		0.55	5.87
	Coal Dump		0.15	1.61
	Advance Quarry Site		0.10	1.08
Total Mining Area			3.55	37.64
Settlements	Rural Settlement		0.12	1.22
	Industrial Settlement		0.19	2.05
Total Settlement Area			0.31	3.27
Water Body	River, Ponds		0.06	0.65
Total			9.43	100.00

Customer		Mahanadi Coalfields Limited			
Title		Land Reclamation Monitoring of OC Projects			Job No. 561410027
Subject Land Reclamation Status of Bharatpur OCP based on Satellite Data (RS-2/L-IV) of the year 2015	Activity	Name	Designation	Signature	Date
	Prepared	A. Biswas	Dy.Mgr.(Geology)		
	Checked	R. Kumar	CM(RSC)		
Approved	N. P. Singh	GM(Geomatics)			
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Drg No.		HQ REM 07 A4 15 04			Rev No.0




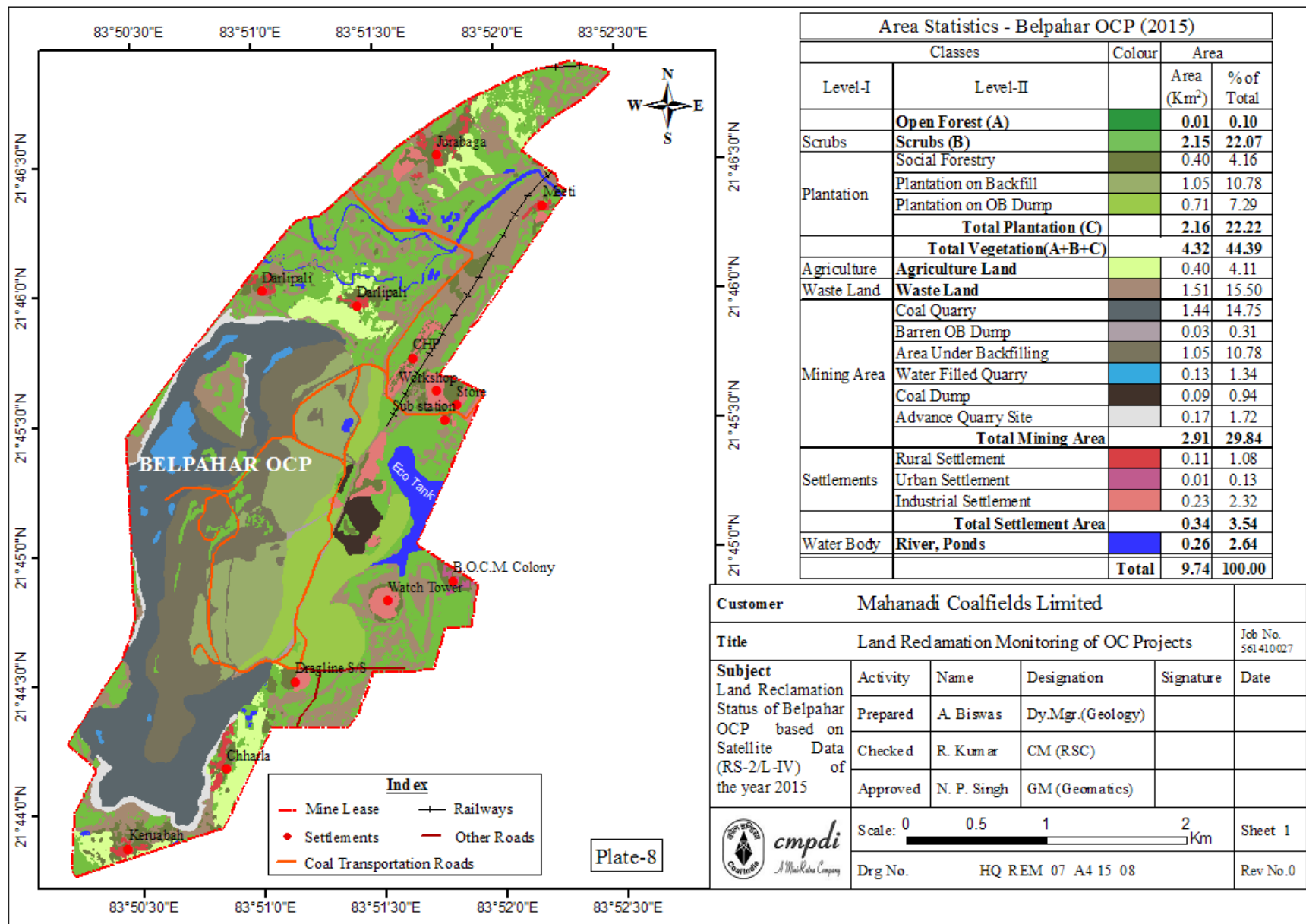
Customer		Mahanadi Coalfields Limited			
Title		Land Reclamation Monitoring of OC Projects			Job No. 561410027
Subject Land Reclamation Status of Bhubaneswari OCP based on Satellite Data (RS-2/L-IV) of the year 2015	Activity	Name	Designation	Signature	Date
	Prepared	A. Biswas	Dy.Mgr.(Geology)		
	Checked	R. Kumar	CM (RSC)		
Approved	N. P. Singh	GM (Geomatics)			
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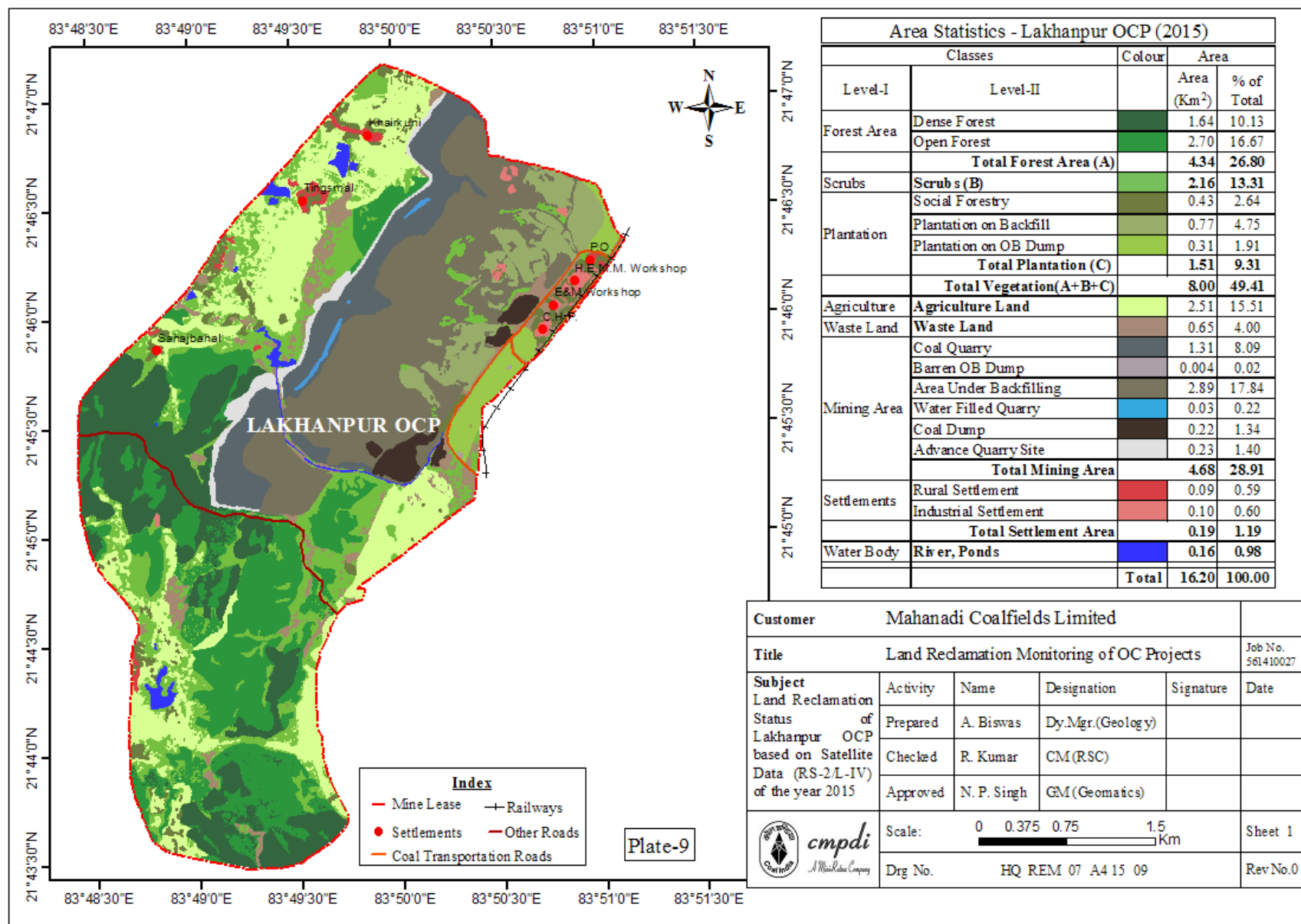


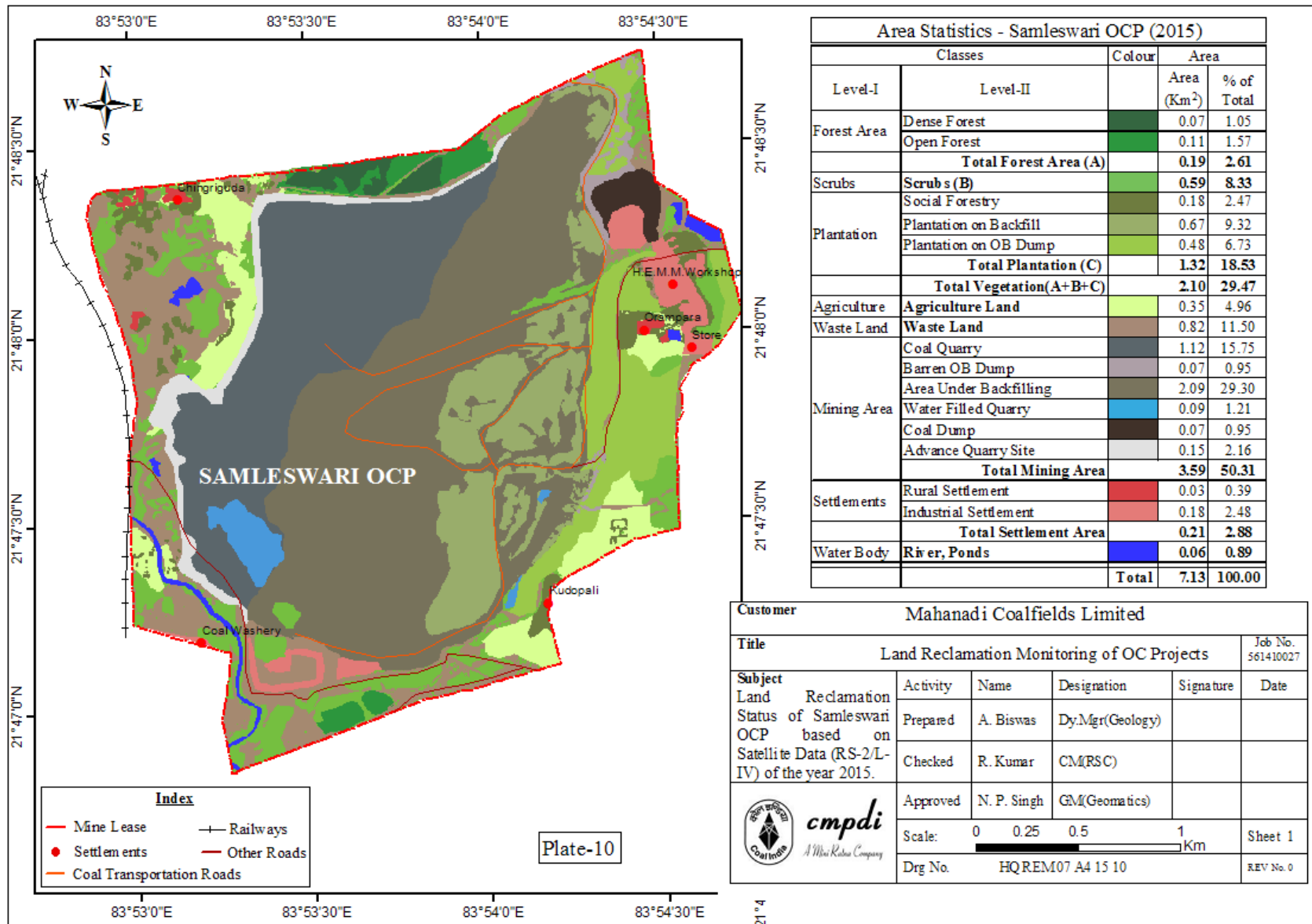


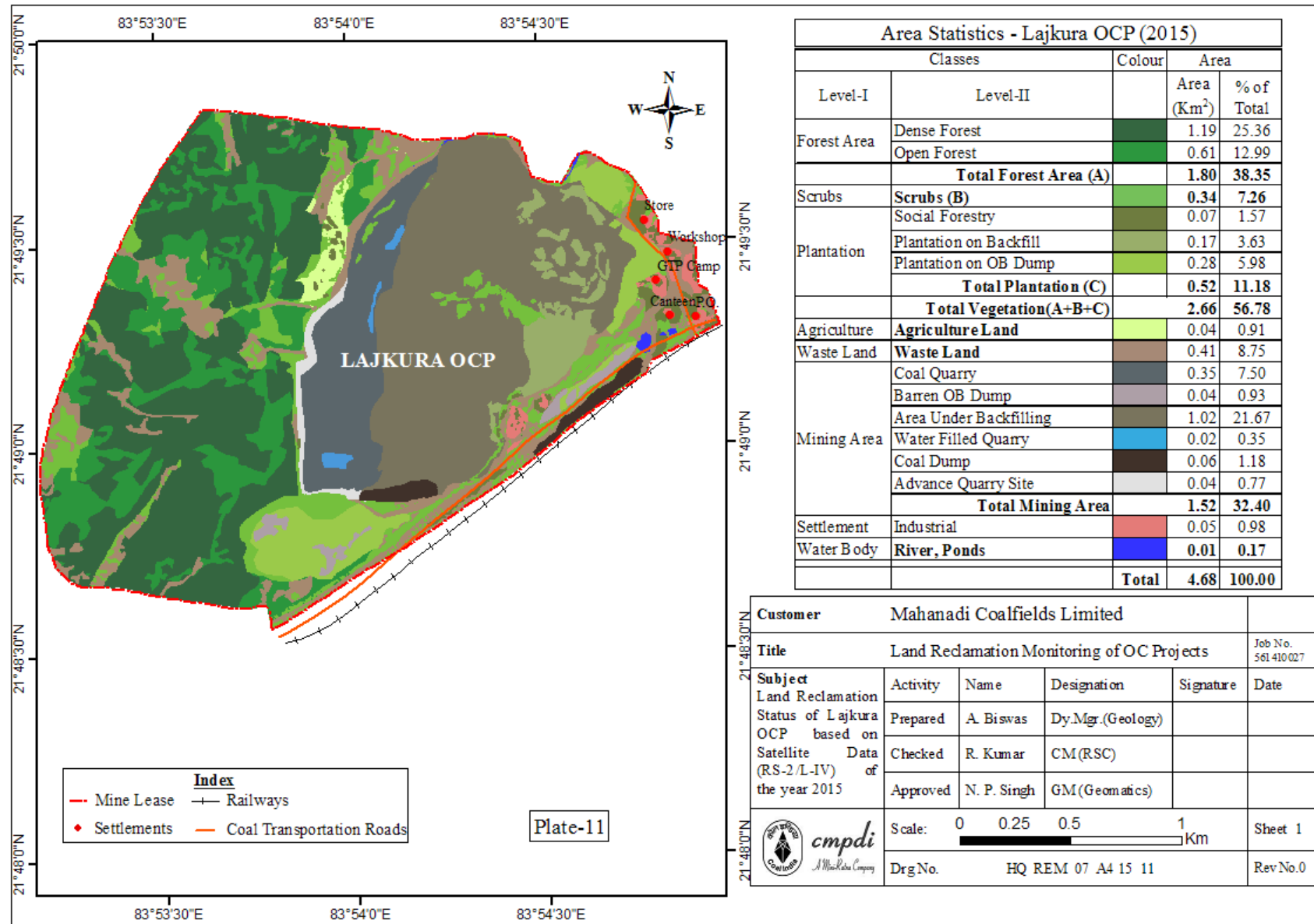
Classes		Colour	Area	
Level-I	Level-II		Area (Km ²)	% of Total
Scrubs	Scrubs (A)		0.23	4.77
	Social Forestry		0.25	5.26
Plantation	Plantation on Backfill		0.08	1.66
	Plantation on OB Dump		0.23	4.85
	Total Plantation (B)		0.57	11.77
Total Vegetation(A+B)			0.80	16.54
Agriculture	Agriculture Land		0.42	8.70
Waste Land	Waste Land		0.65	13.47
	Sand Body		0.03	0.58
	Total Waste Land		0.68	14.04
Mining Area	Coal Quarry		0.63	13.05
	Barren OB Dump		0.02	0.46
	Area Under Backfilling		1.01	20.93
	Water Filled Quarry		0.67	13.87
	Coal Dump		0.33	6.88
	Advance Quarry Site		0.07	1.38
	Total Mining Area		2.73	56.57
Settlements	Rural Settlement		0.05	0.93
	Urban Settlement		0.01	0.13
	Industrial Settlement		0.02	0.46
Total Settlement Area			0.07	1.52
Water Body	River, Ponds		0.13	2.62
Total			4.83	100.00

Customer		Mahanadi Coalfields Limited			
Title		Land Reclamation Monitoring of OC Projects			Job No. 561410027
Subject Land Reclamation Status of Hingula OCP based on Satellite Data (RS-2/L-IV) of the year 2015	Activity	Name	Designation	Signature	Date
	Prepared	A. Biswas	Dy.Mgr.(Geology)		
	Checked	R. Kumar	CM(RSC)		
Approved	N. P. Singh	GM(Geomatics)			
 cmpdi A Mahanadi Company		Scale:	0 0.25 0.5 1 Km		Sheet 1
		Drg No.	HQ REM 07 A4 15 07		Rev No.0









Classes		Colour	Area	
Level-I	Level-II		Area (Km ²)	% of Total
Forest Area	Dense Forest		1.19	25.36
	Open Forest		0.61	12.99
Total Forest Area (A)			1.80	38.35
Scrubs	Scrubs (B)		0.34	7.26
	Social Forestry		0.07	1.57
Plantation	Plantation on Backfill		0.17	3.63
	Plantation on OB Dump		0.28	5.98
	Total Plantation (C)		0.52	11.18
Total Vegetation (A+B+C)			2.66	56.78
Agriculture	Agriculture Land		0.04	0.91
Waste Land	Waste Land		0.41	8.75
	Coal Quarry		0.35	7.50
Mining Area	Barren OB Dump		0.04	0.93
	Area Under Backfilling		1.02	21.67
	Water Filled Quarry		0.02	0.35
	Coal Dump		0.06	1.18
	Advance Quarry Site		0.04	0.77
Total Mining Area			1.52	32.40
Settlement	Industrial		0.05	0.98
Water Body	River, Ponds		0.01	0.17
Total			4.68	100.00

Customer		Mahanadi Coalfields Limited			
Title		Land Reclamation Monitoring of OC Projects			Job No. 561410027
Subject Land Reclamation Status of Lajkura OCP based on Satellite Data (RS-2/L-IV) of the year 2015	Activity	Name	Designation	Signature	Date
	Prepared	A. Biswas	Dy.Mgr.(Geology)		
	Checked	R. Kumar	CM(RSC)		
Approved	N. P. Singh	GM(Geomatics)			
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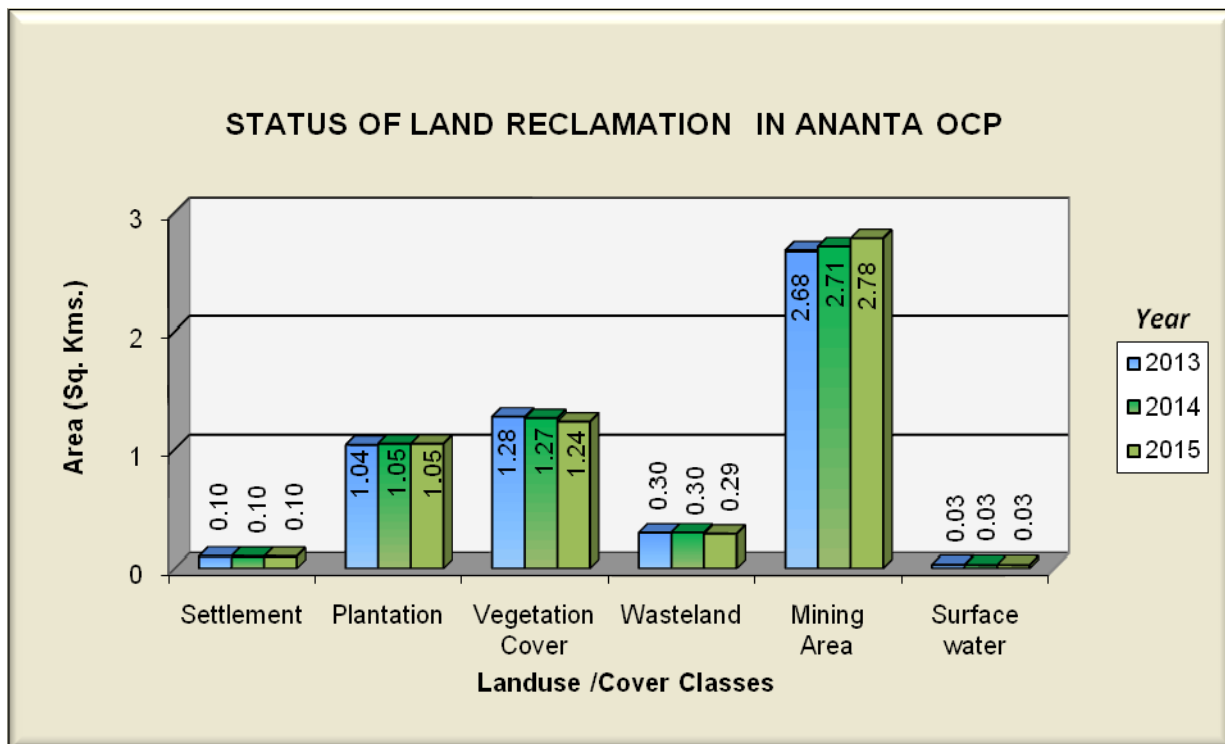


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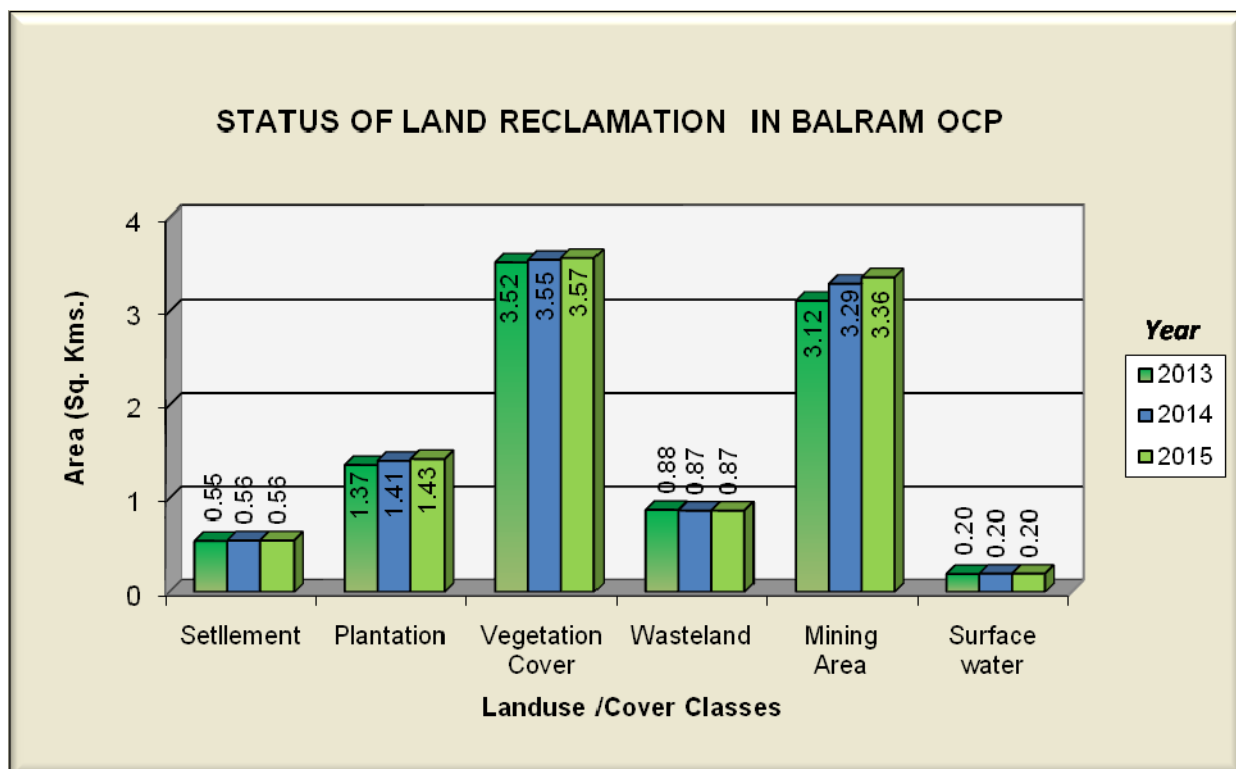


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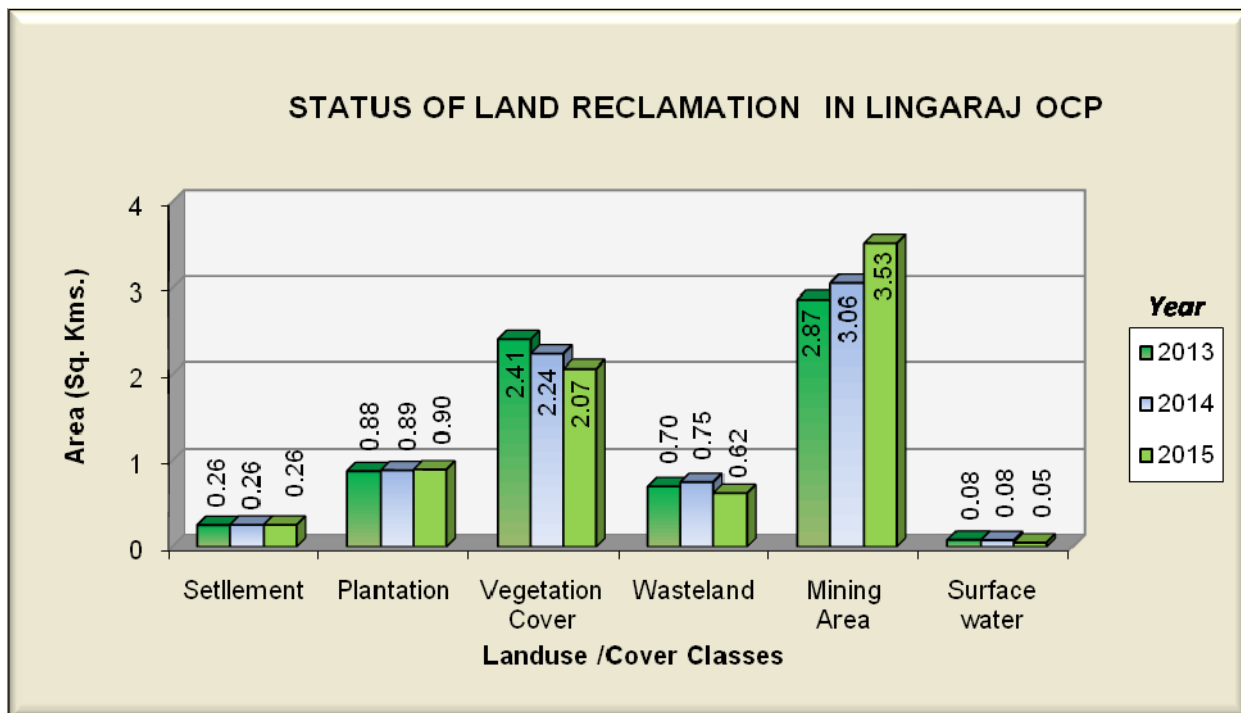


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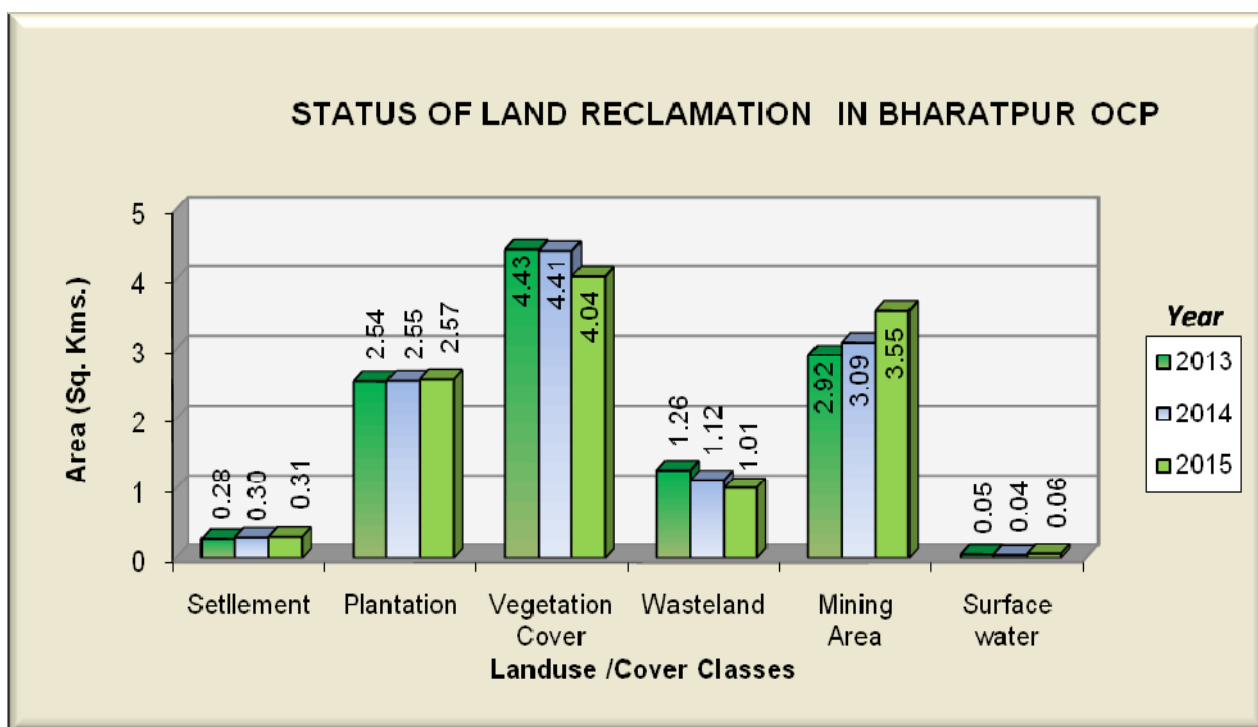


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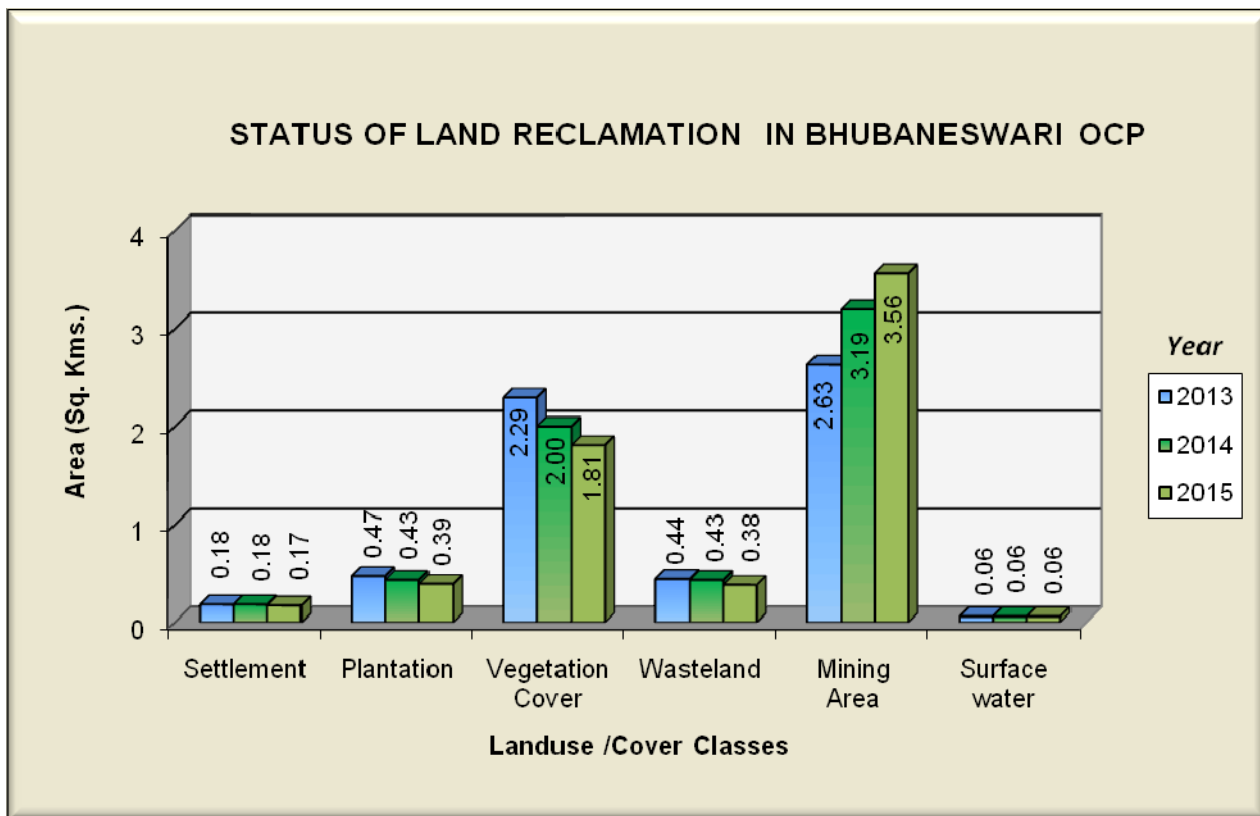


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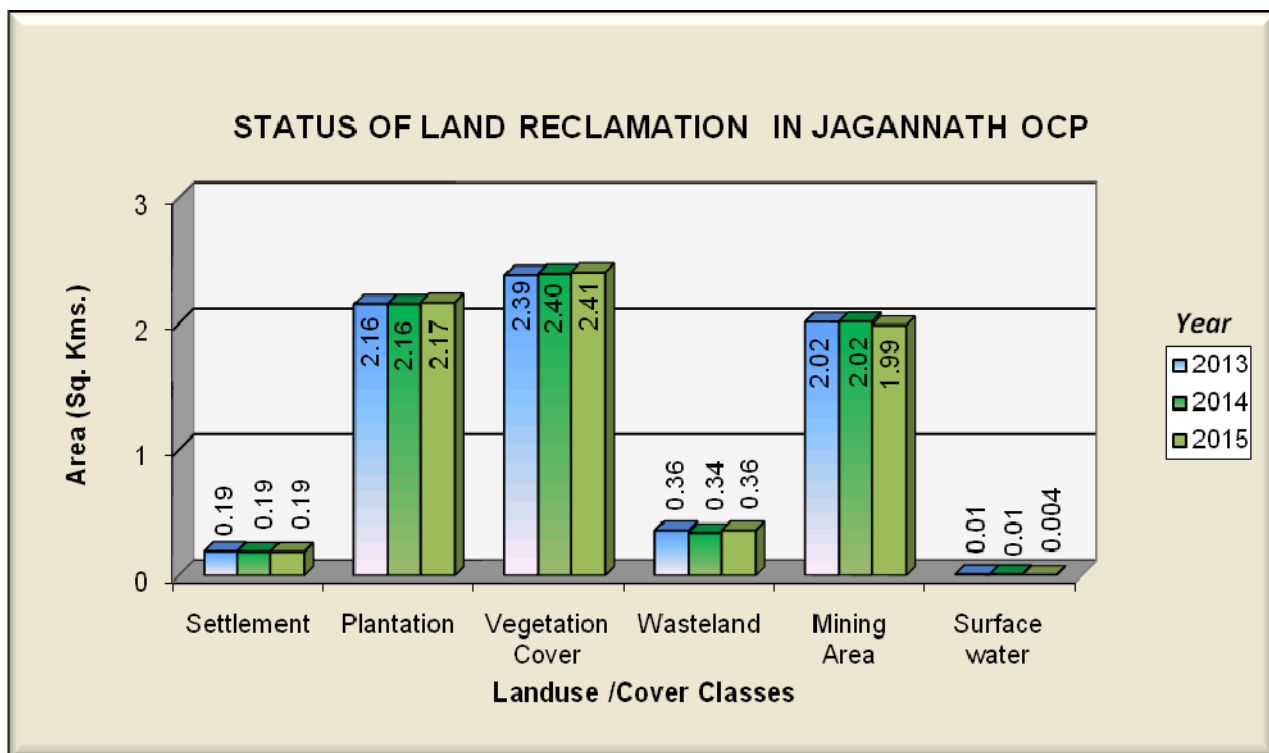


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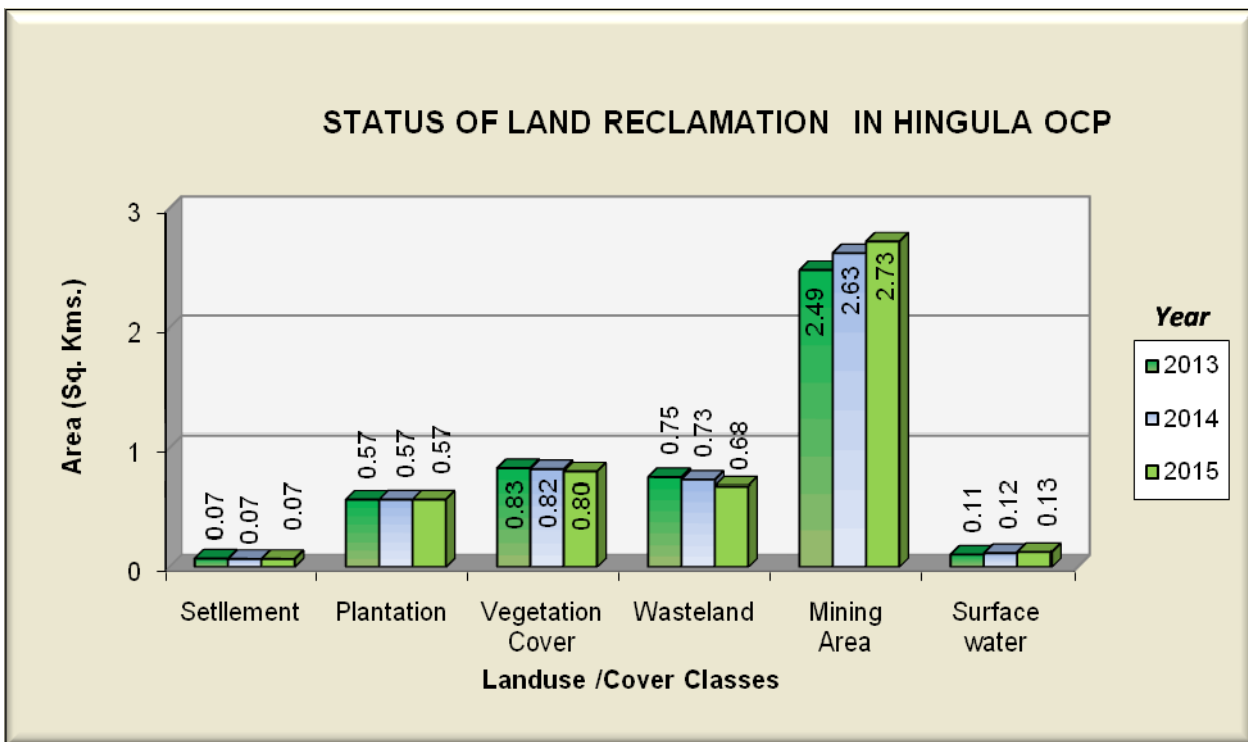


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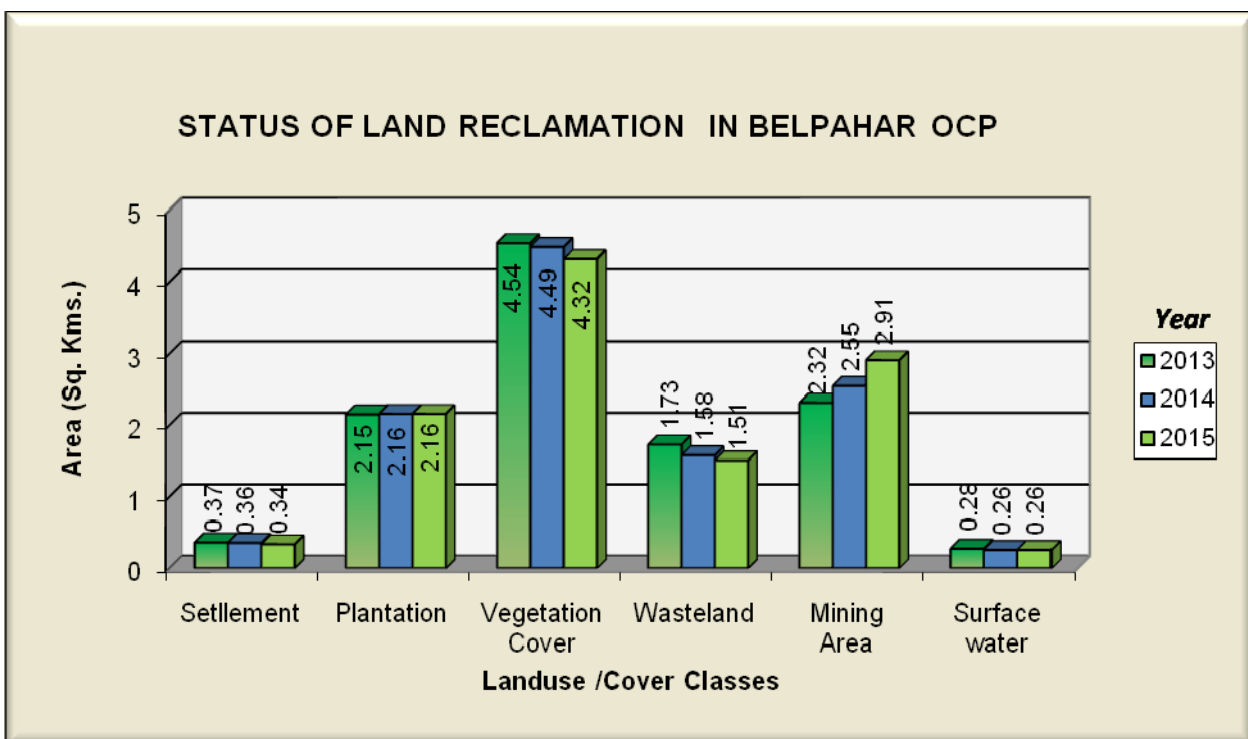


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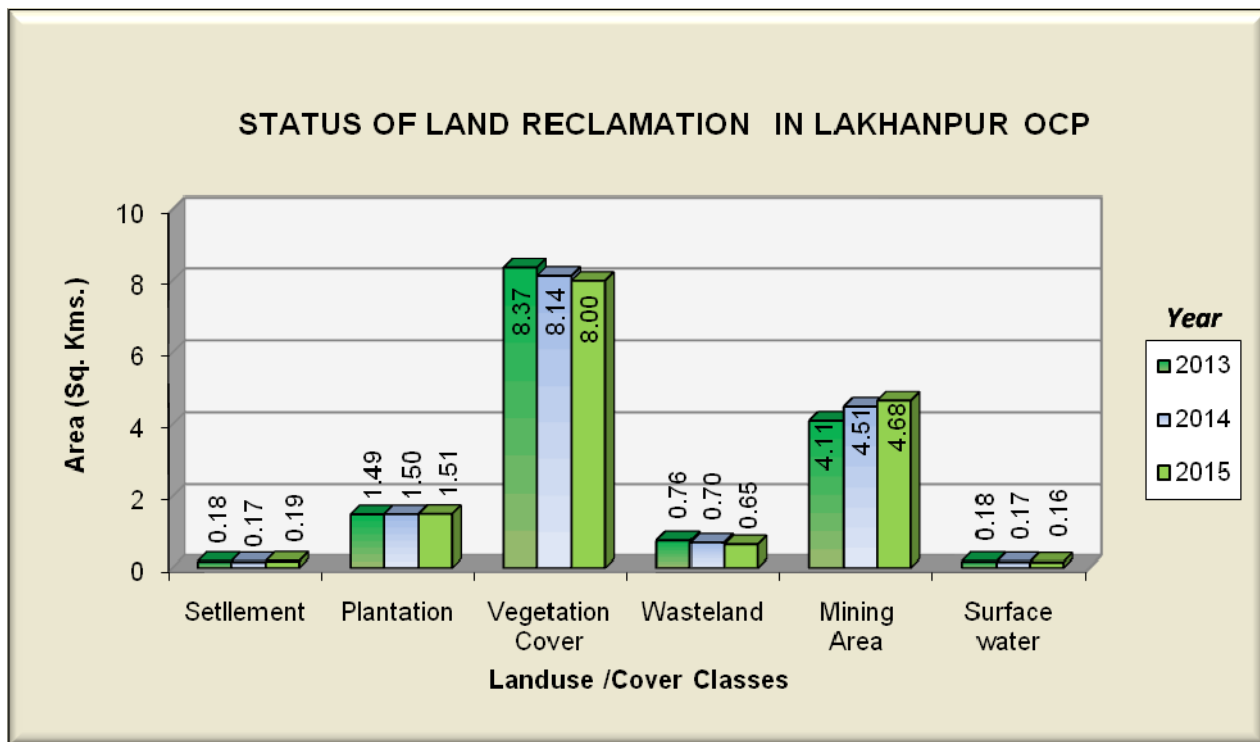


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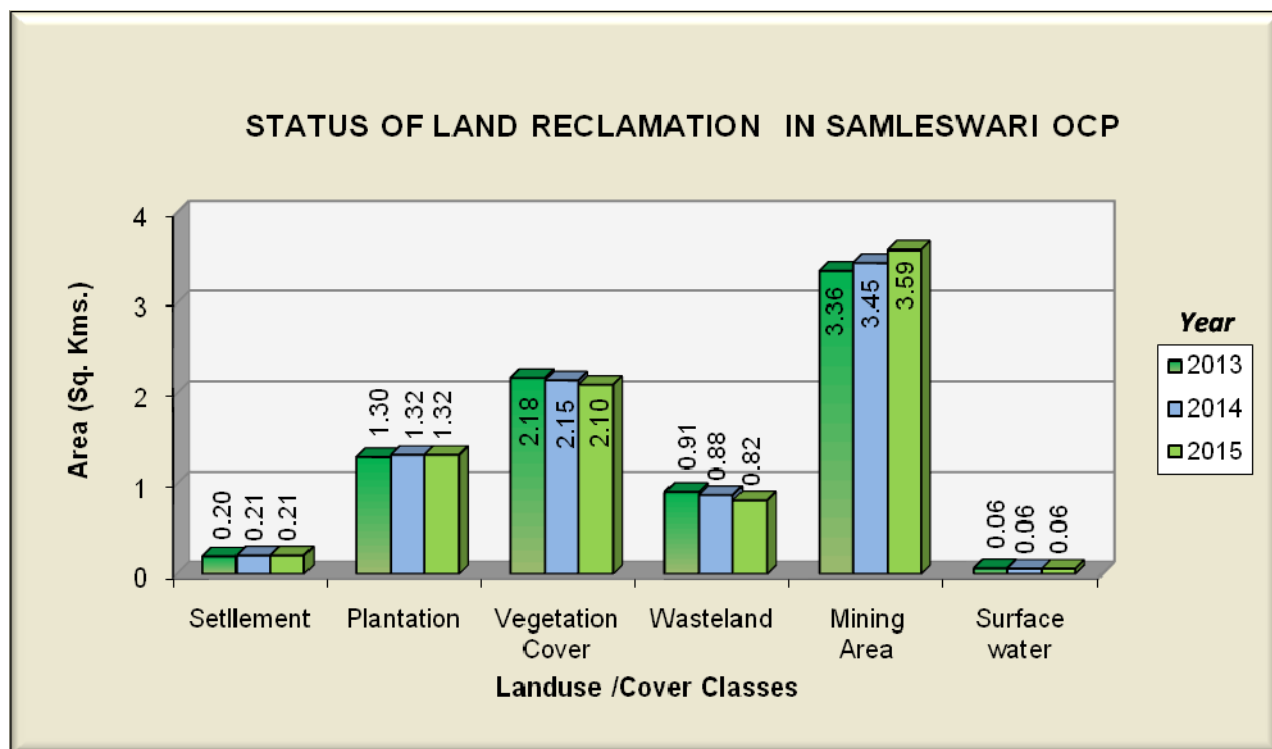


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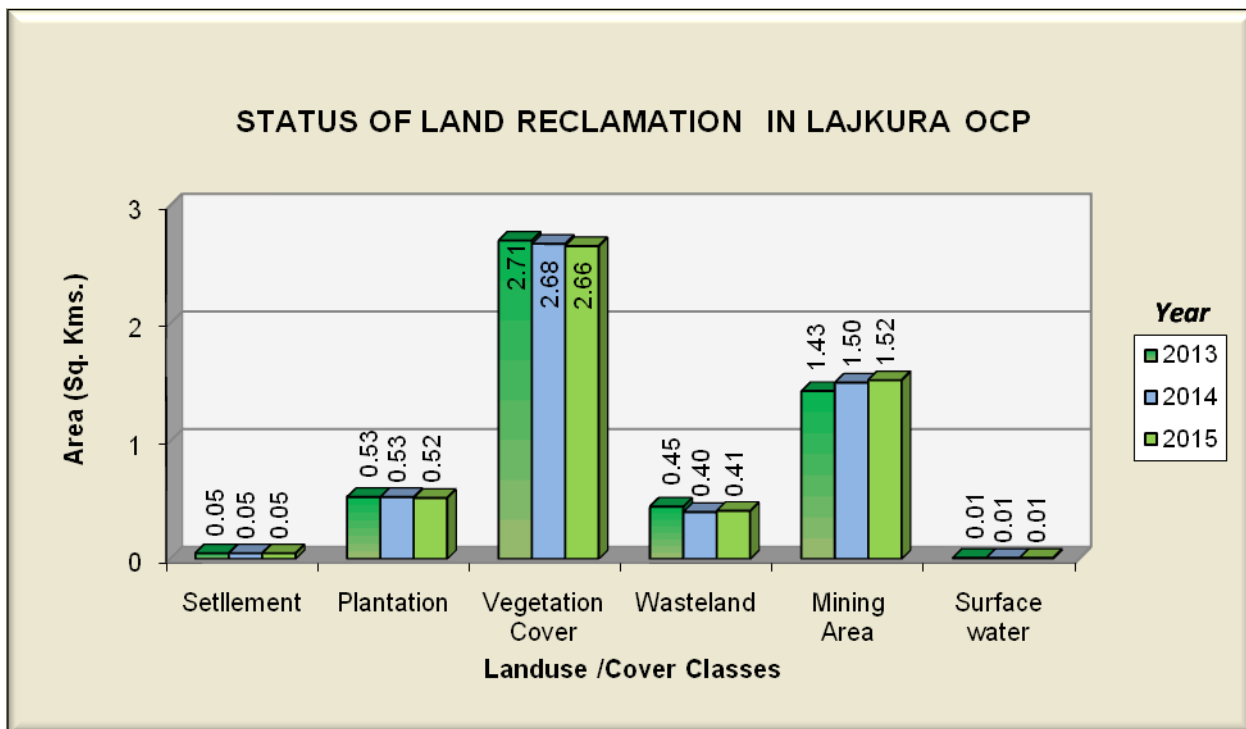


Figure 13



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



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



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



Photograph-4: Plantation on External OB (Bharatpur OC Mine)



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



Photograph-6: Plantation on Internal OB/Backfill (Hingula OC Mine)



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



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



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



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



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