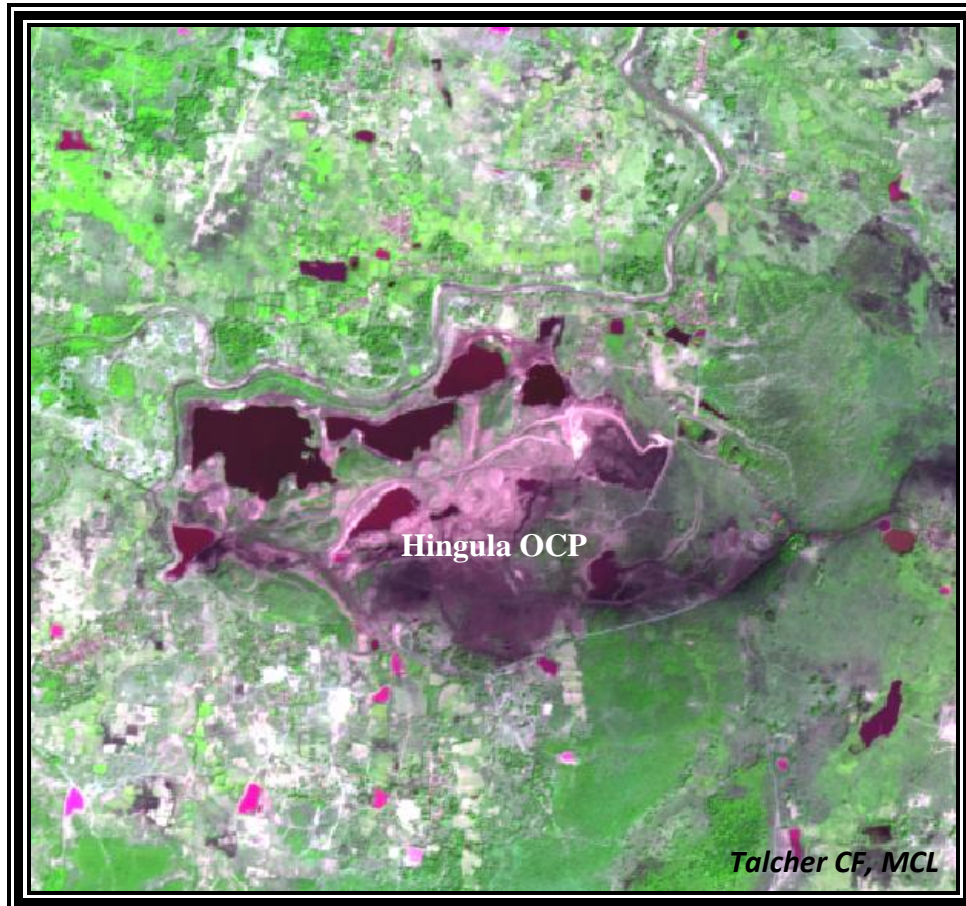


Land Restoration/Reclamation Monitoring of more than 5 million cu.m (Coal+OB) Capacity Opencast Coal Mines of Mahanadi Coalfields Limited based on Satellite Data for the Year 2013



Submitted to
Mahanadi Coalfields Limited



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 for the Year 2013

March 2014



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

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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 2013-14; total excavated area is 44.43 Km² (51.45%), out of which 14.50 Km² area (32.64%) has been planted, 14.34 Km² area (32.27%) is under backfilling and 15.59 Km² area (35.09%) is under active mining. It is evident from the analysis that 64.91% areas of the OC projects is under reclamation (biological and technical) and balance 35.09% 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 2013 with respect to the year 2012 in different projects, it is evident from the analysis that area under land reclamation has increased from 27.04 Km² (Yr. 2012) to 28.84 Km² (Yr.2013). Out of 11 projects of MCL, Bharatpur OC ranks on top for land reclamation (78.99%) followed by Balram OC (75.56%).
 - Area of biological reclamation (plantation) has increased from 14.41 Km² (Yr.2012) to 14.50 Km² (Yr.2013) where as area of technical reclamation (area under backfilling) has increased from 12.63 Km² (Yr. 2012) to 14.34 Km² (Yr.2013) in MCL. This increase of 1.80 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 2013**

Sl. No.	Project		(% Calculated in terms of Total Excavated Area)								Area are in Km ²	
	Name	Leasehold (i)	Plantation/ Vegetation		Under Backfilling		Under Active Mining		Total Excavated Area		Area under Reclamation	
			ii		iii		iv		ii+iii+iv		ii+iii	
			2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
1	Ananta	4.56	1.03	1.04	1.12	1.30	1.44	1.38	3.59	3.72	2.15	2.34
			28.69	27.98	31.20	34.98	40.11	37.04			59.89	62.96
2	Balram	10.21	1.32	1.37	1.77	2.02	1.29	1.10	4.38	4.48	3.09	3.39
			30.14	30.44	40.41	45.13	29.45	24.44			70.55	75.56
3	Lingaraj	7.26	0.87	0.88	1.00	1.27	1.79	1.60	3.66	3.75	1.87	2.15
			23.77	23.43	27.32	33.98	48.91	42.59			51.09	57.41
4	Bharatpur	9.43	2.50	2.54	1.56	1.77	0.90	1.15	4.96	5.46	4.06	4.31
			50.40	46.60	31.45	32.38	18.15	21.01			81.85	78.99
5	Bhubaneswari	7.33	0.47	0.47	0.63	0.91	1.16	1.72	2.26	3.10	1.10	1.38
			20.80	15.18	27.88	29.39	51.33	55.43			48.67	44.57
6	Jagannath	4.99	2.16	2.16	0.77	0.85	1.21	1.17	4.14	4.18	2.93	3.01
			52.17	51.71	18.60	20.35	29.23	27.94			70.77	72.06
7	Hingula	4.83	0.57	0.57	0.83	0.94	1.49	1.54	2.89	3.06	1.40	1.51
			19.72	18.66	28.72	30.82	51.56	50.52			48.44	49.48
8	Belpahar	9.74	2.15	2.15	0.77	0.80	1.41	1.51	4.33	4.47	2.92	2.95
			49.65	48.17	17.78	17.94	32.56	33.89			67.44	66.11
9	Lakhanpur	16.20	1.49	1.49	1.82	1.91	1.73	2.20	5.04	5.60	3.31	3.41
			29.56	26.67	36.11	34.11	34.33	39.22			65.67	60.78
10	Samleswari	7.13	1.30	1.30	1.53	1.67	1.65	1.69	4.48	4.66	2.83	2.97
			29.02	27.83	34.15	35.95	36.83	36.22			63.17	63.78
11	Lajkura	4.68	0.55	0.53	0.83	0.88	0.51	0.55	1.89	1.96	1.38	1.41
			29.10	26.99	43.92	45.12	26.98	27.88			73.02	72.12
TOTAL (MCL)		86.36	14.41	14.50	12.63	14.34	14.58	15.59	41.62	44.43	27.04	28.84
			34.62	32.64	30.35	32.27	35.03	35.09	48.19	51.45	64.97	64.91

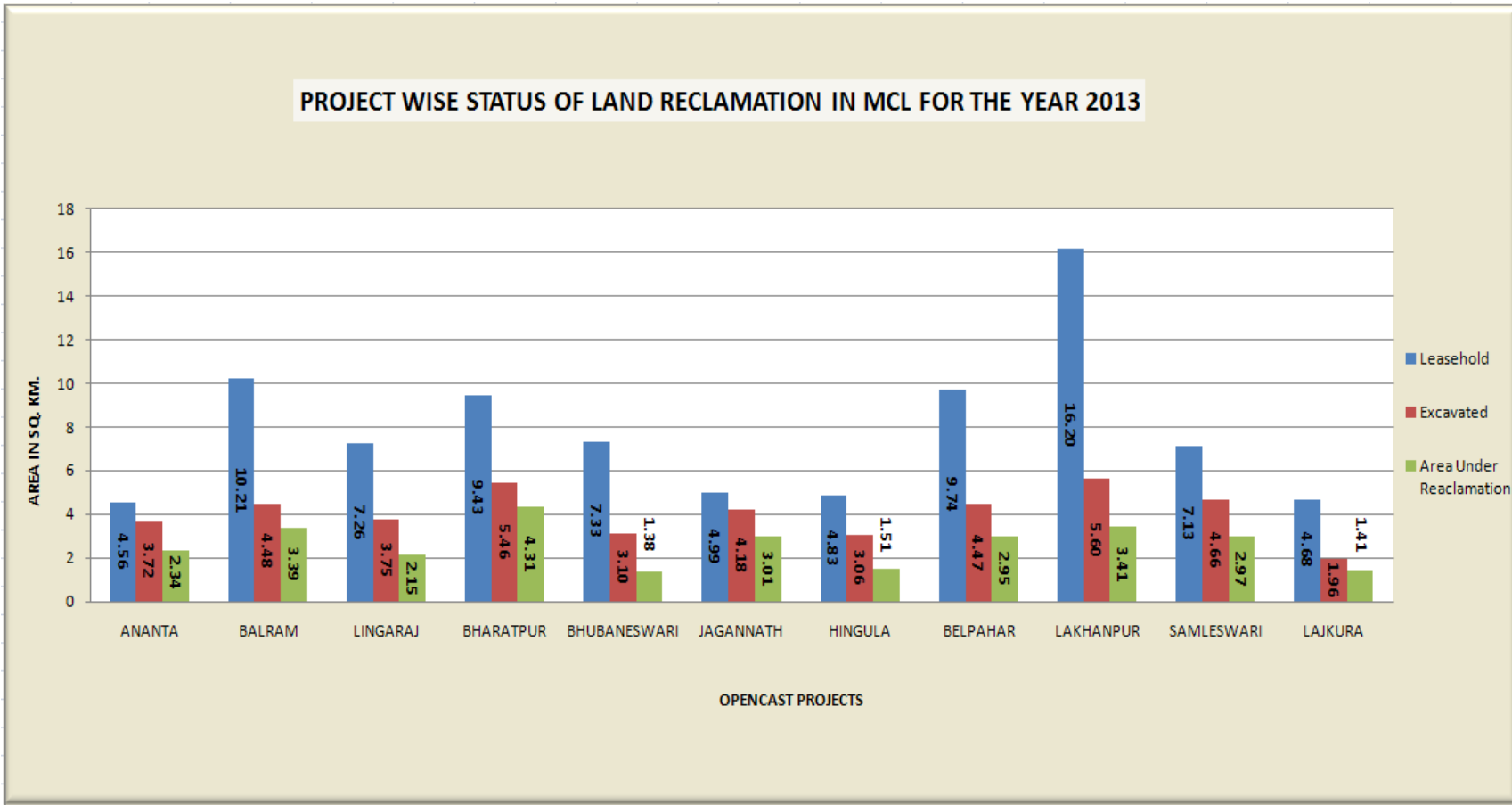


Fig.1: Land reclamation status in OC projects of MCL in the year 2013

1.0 Background

- 1.1** Land is the most important natural resource which embodies soil, water, flora, fauna and total ecosystem. All human activities are based on the land which is the most scarce natural resource in our country. Mining is a site specific industry and it could not be shifted anywhere else from the location where mineral occurs. It is a fact that surface mining activities do effect the land environment due to ground breaking. Therefore, there is an urgent need to reclaim and restore the mined out land for its productive use for sustainable development of mining. This will not only mitigate environmental degradation, but would also help in creating a more congenial environment for land acquisition by coal companies in future.
- 1.2** Keeping above in view, Coal India Ltd. (CIL) issued a work order vide letter no. CIL/WBP/Env/2011/4706 dated 12.10.2012 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 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 (MoEF). Such monitoring would not only facilitate in taking timely mitigation measures against

environmental degradation, but would also enable coal companies to utilize the reclaimed land for larger socio-economic benefits in a planned way.

- 1.4** Present report is embodying the finding of the study based on satellite data of the year 2013 carried out for all the OC projects producing more than 5 mcm (Coal+OB) for Mahanadi Coalfield 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:

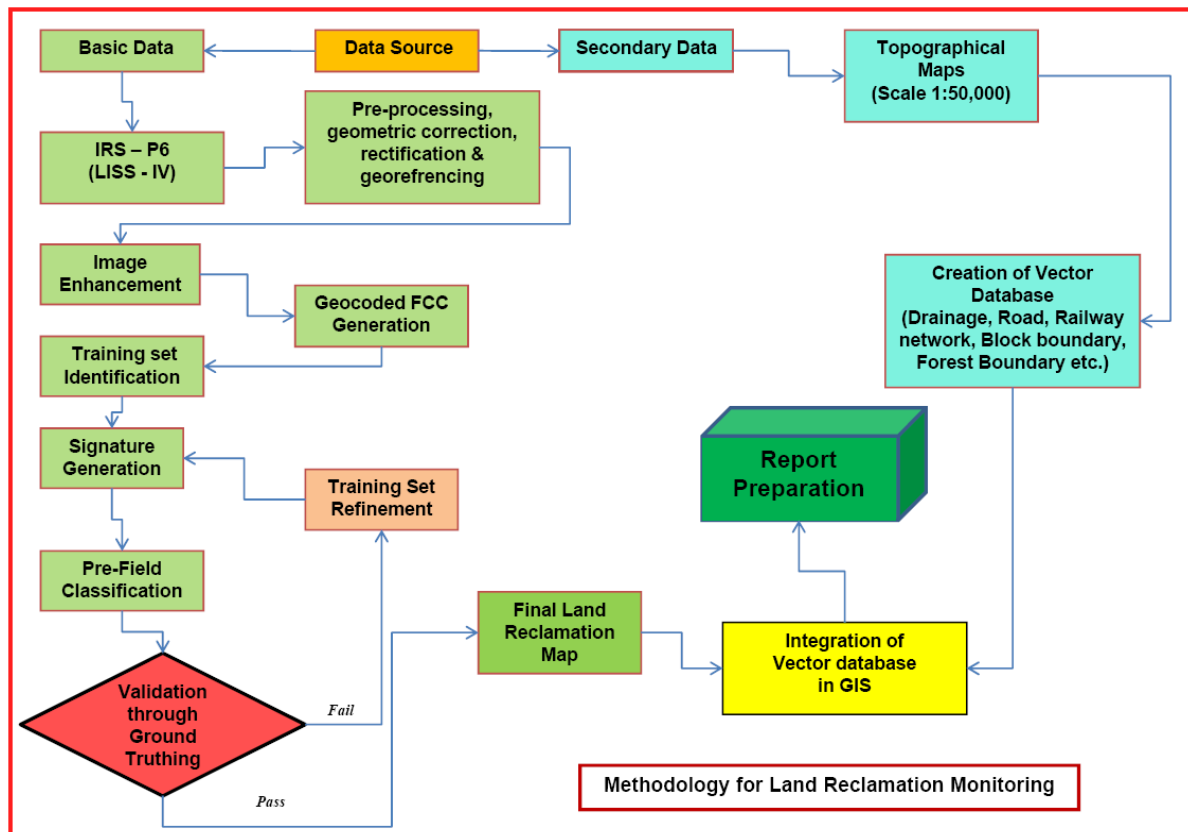


Figure: 2 - **Methodology for Land Reclamation Monitoring**

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 2013 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 2013 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.2013 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 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 2013-14 based on satellite data of the year 2013.

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

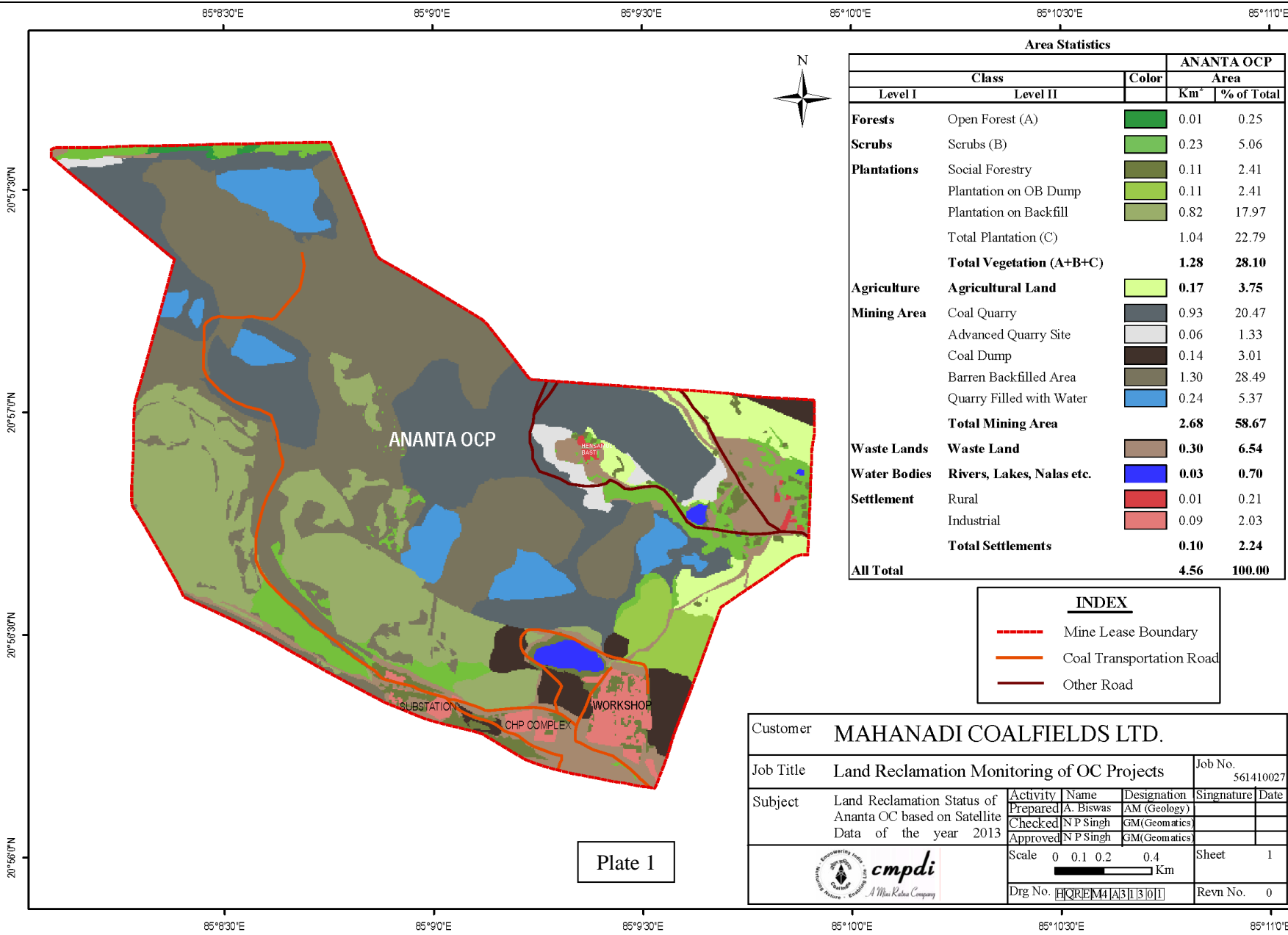
4.2 Area statistics of different land use class present in the mine leasehold of the above projects for the year 2013 are shown in the Table -1. Land use maps derived from satellite data are shown in Plate 1 - 11. Land reclamation status of the above mentioned 11 projects, were also prepared for the year 2013-2014. 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 44.43 Km² excavated area; 28.84 Km² area (64.91%) is under reclamation. Out of which 14.50 Km² (32.64%) area has been re-vegetated and 14.34 Km² (32.27%) area is under backfilling.

4.4 Analysis of satellite data indicates that area of plantation has increased from 14.41 Km² (2012) to 14.50 Km² (2013). This increase of 0.09 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 2013 with respect to the year 2012 in different projects, it is evident from the analysis that area of land reclamation has increased from 27.04 Km² (Yr. 2012) to 28.84 Km² (Yr.2013).
- 4.6** Out of 11 projects of MCL, Bharatpur OC ranks on top for land reclamation (78.99%) followed by Balram OC (75.56%).



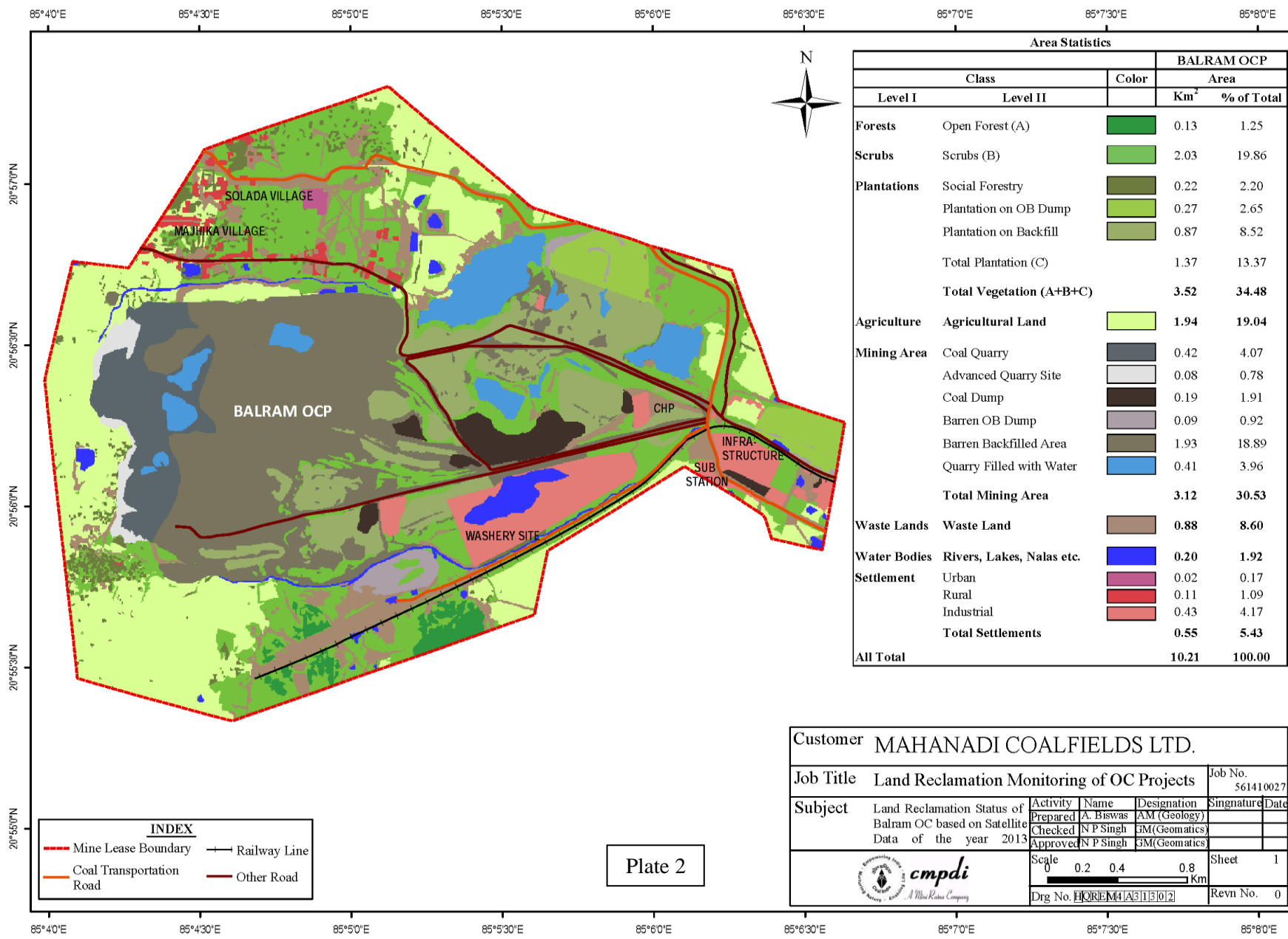
Area Statistics			ANANTA OCP	
Level I	Class	Color	Area	
			Km ²	% of Total
Forests	Open Forest (A)		0.01	0.25
	Scrubs	Scrubs (B)		0.23
Plantations	Social Forestry		0.11	2.41
	Plantation on OB Dump		0.11	2.41
	Plantation on Backfill		0.82	17.97
	Total Plantation (C)		1.04	22.79
	Total Vegetation (A+B+C)		1.28	28.10
Agriculture	Agricultural Land		0.17	3.75
	Mining Area	Coal Quarry		0.93
Advanced Quarry Site			0.06	1.33
Coal Dump			0.14	3.01
Barren Backfilled Area			1.30	28.49
Quarry Filled with Water			0.24	5.37
Total Mining Area			2.68	58.67
Waste Lands	Waste Land		0.30	6.54
Water Bodies	Rivers, Lakes, Nalas etc.		0.03	0.70
Settlement	Rural		0.01	0.21
	Industrial		0.09	2.03
	Total Settlements		0.10	2.24
All Total			4.56	100.00

INDEX	
	Mine Lease Boundary
	Coal Transportation Road
	Other Road

Customer	MAHANADI COALFIELDS LTD.			
Job Title	Land Reclamation Monitoring of OC Projects			Job No. 561410027
Subject	Land Reclamation Status of	Activity	Name	Designation
	Ananta OC based on Satellite	Prepared	A. Biswas	AM (Geology)
	Data of the year 2013	Checked	N P Singh	GM(Geomatics)
		Approved	N P Singh	GM(Geomatics)
		Scale	0 0.1 0.2 0.4	Sheet 1
				Km
		Drg No.	HQREM4/A31/B01	Revn No. 0

Plate 1





INDEX

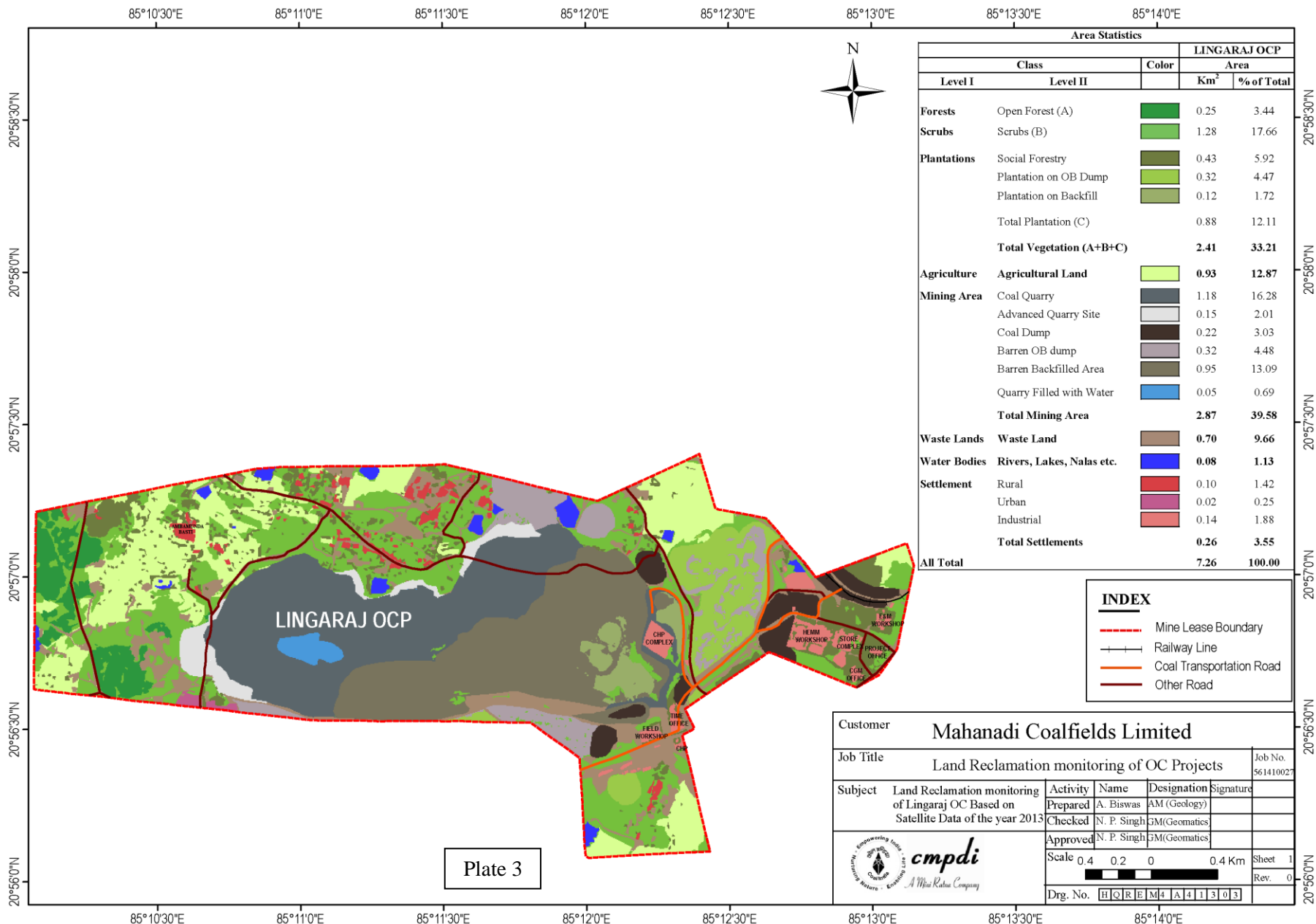
	Mine Lease Boundary		Railway Line
	Coal Transportation Road		Other Road

Plate 2

Customer **MAHANADI COALFIELDS LTD.**

Job Title	Land Reclamation Monitoring of OC Projects	Job No.	561410027
Subject	Land Reclamation Status of Balram OC based on Satellite Data of the year 2013	Activity	Name
		Prepared	A. Biswas
		Checked	N P Singh
		Approved	N P Singh
		Designation	AM (Geology)
			GM (Geomatics)
			GM (Geomatics)
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		Drng No.	HCENM4/A3/11/3/02
		Revn No.	0

cmpdi
A Mahanadi Company



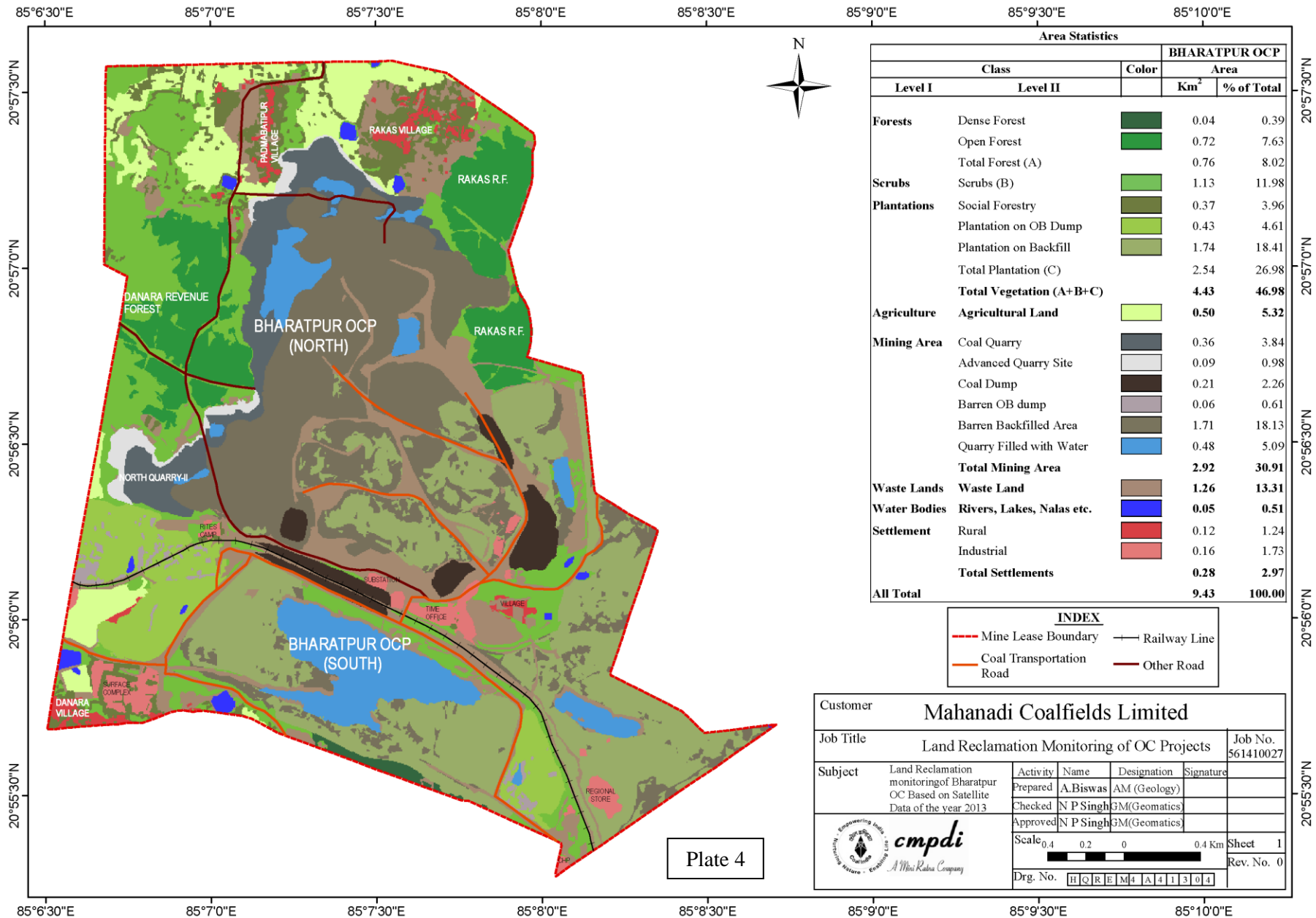
Area Statistics				
Class			LINGARAJ OCP Area	
Level I	Level II	Color	Km ²	% of Total
Forests	Open Forest (A)		0.25	3.44
	Scrubs (B)		1.28	17.66
Plantations	Social Forestry		0.43	5.92
	Plantation on OB Dump		0.32	4.47
	Plantation on Backfill		0.12	1.72
	Total Plantation (C)		0.88	12.11
Total Vegetation (A+B+C)			2.41	33.21
Agriculture	Agricultural Land		0.93	12.87
Mining Area	Coal Quarry		1.18	16.28
	Advanced Quarry Site		0.15	2.01
	Coal Dump		0.22	3.03
	Barren OB dump		0.32	4.48
	Barren Backfilled Area		0.95	13.09
	Quarry Filled with Water		0.05	0.69
Total Mining Area			2.87	39.58
Waste Lands	Waste Land		0.70	9.66
Water Bodies	Rivers, Lakes, Nalas etc.		0.08	1.13
Settlement	Rural		0.10	1.42
	Urban		0.02	0.25
	Industrial		0.14	1.88
Total Settlements			0.26	3.55
All Total			7.26	100.00

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	Mine Lease Boundary
	Railway Line
	Coal Transportation Road
	Other Road

Plate 3

Customer		Mahanadi Coalfields Limited			
Job Title		Land Reclamation monitoring of OC Projects			Job No. 561410027
Subject	Land Reclamation monitoring of Lingaraj OC Based on Satellite Data of the year 2013	Activity	Name	Designation	Signature
Prepared	A. Biswas	AM (Geology)			
Checked	N. P. Singh	GM (Geomatics)			
Approved	N. P. Singh	GM (Geomatics)			
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Drg. No.		HQR/EM4/A4/1/3/03			Rev. 0



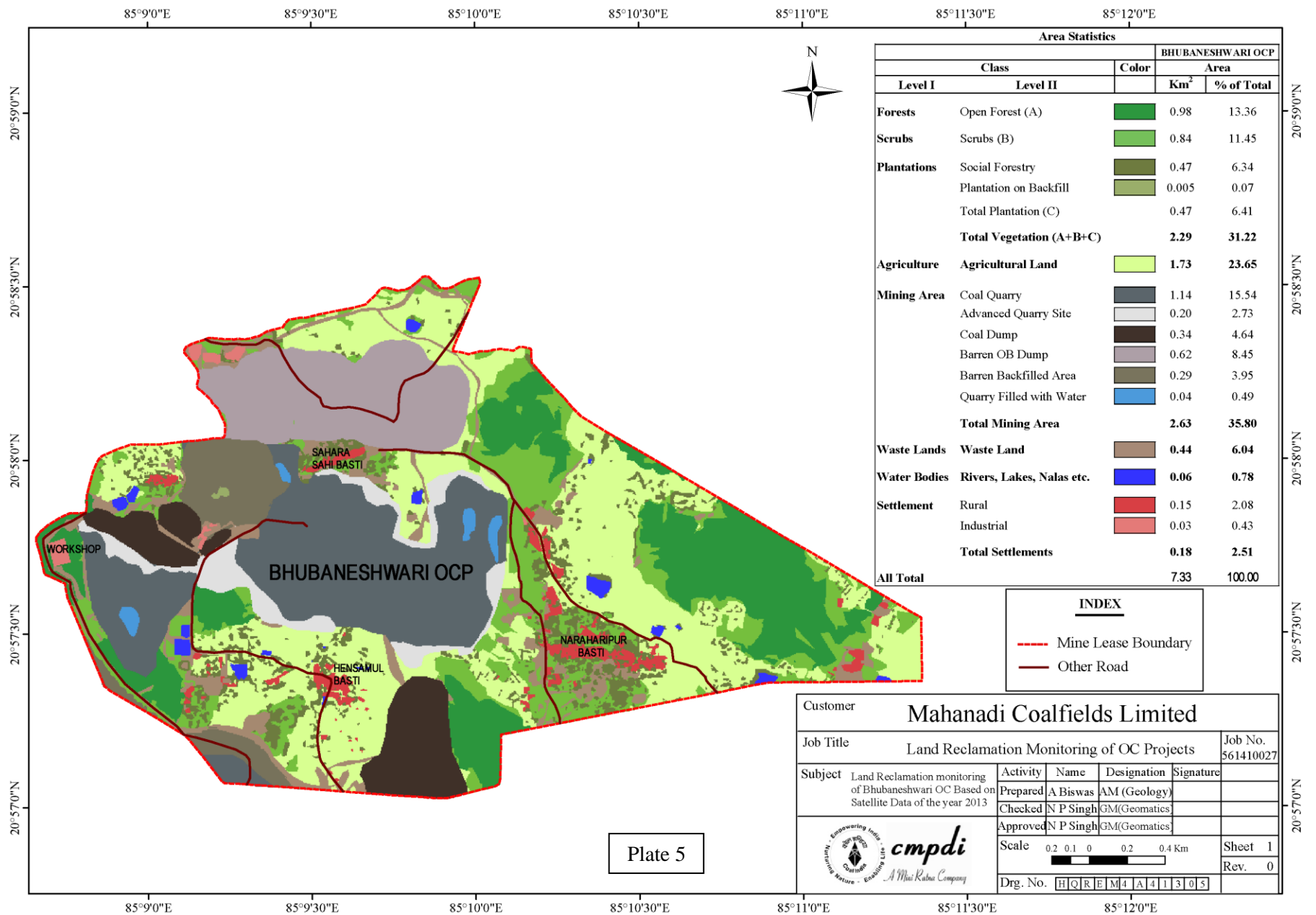


Area Statistics			BHARATPUR OCP	
Class		Color	Area	
Level I	Level II		Km ²	% of Total
Forests	Dense Forest		0.04	0.39
	Open Forest		0.72	7.63
	Total Forest (A)		0.76	8.02
Scrubs	Scrubs (B)		1.13	11.98
Plantations	Social Forestry		0.37	3.96
	Plantation on OB Dump		0.43	4.61
	Plantation on Backfill		1.74	18.41
	Total Plantation (C)		2.54	26.98
Total Vegetation (A+B+C)			4.43	46.98
Agriculture	Agricultural Land		0.50	5.32
Mining Area	Coal Quarry		0.36	3.84
	Advanced Quarry Site		0.09	0.98
	Coal Dump		0.21	2.26
	Barren OB dump		0.06	0.61
	Barren Backfilled Area		1.71	18.13
	Quarry Filled with Water		0.48	5.09
	Total Mining Area		2.92	30.91
Waste Lands	Waste Land		1.26	13.31
Water Bodies	Rivers, Lakes, Nalas etc.		0.05	0.51
Settlement	Rural		0.12	1.24
	Industrial		0.16	1.73
	Total Settlements		0.28	2.97
All Total			9.43	100.00

INDEX	
	Mine Lease Boundary
	Railway Line
	Coal Transportation Road
	Other Road

Customer		Mahanadi Coalfields Limited			
Job Title		Land Reclamation Monitoring of OC Projects		Job No.	561410027
Subject	Land Reclamation monitoring of Bharatpur OC Based on Satellite Data of the year 2013	Activity	Name	Designation	Signature
		Prepared	A. Biswas	AM (Geology)	
		Checked	N P Singh	GM (Geomatics)	
		Approved	N P Singh	GM (Geomatics)	
		Scale	0.4 0.2 0 0.4 Km		Sheet 1
		Drg. No.	HQR/EM4/A413/04		Rev. No. 0

Plate 4



Area Statistics			BHUBANESHWARI OCP	
Class		Color	Area	
Level I	Level II		Km ²	% of Total
Forests	Open Forest (A)		0.98	13.36
	Scrubs (B)		0.84	11.45
Plantations	Social Forestry		0.47	6.34
	Plantation on Backfill		0.005	0.07
	Total Plantation (C)		0.47	6.41
Total Vegetation (A+B+C)			2.29	31.22
Agriculture	Agricultural Land		1.73	23.65
	Total Mining Area		2.63	35.80
Mining Area	Coal Quarry		1.14	15.54
	Advanced Quarry Site		0.20	2.73
	Coal Dump		0.34	4.64
	Barren OB Dump		0.62	8.45
	Barren Backfilled Area		0.29	3.95
	Quarry Filled with Water		0.04	0.49
	Total Mining Area		2.63	35.80
Waste Lands	Waste Land		0.44	6.04
Water Bodies	Rivers, Lakes, Nalas etc.		0.06	0.78
Settlement	Rural		0.15	2.08
	Industrial		0.03	0.43
Total Settlements			0.18	2.51
All Total			7.33	100.00

INDEX	
	Mine Lease Boundary
	Other Road

Customer	Mahanadi Coalfields Limited			
Job Title	Land Reclamation Monitoring of OC Projects			Job No. 561410027
Subject	Land Reclamation monitoring of Bhubaneswari OC Based on Satellite Data of the year 2013	Activity	Name	Designation
		Prepared	A Biswas	AM (Geology)
		Checked	N P Singh	GM(Geomatics)
		Approved	N P Singh	GM(Geomatics)
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				Rev. 0
	Drg. No.	HQRE/M4/A4/13/05		

Plate 5



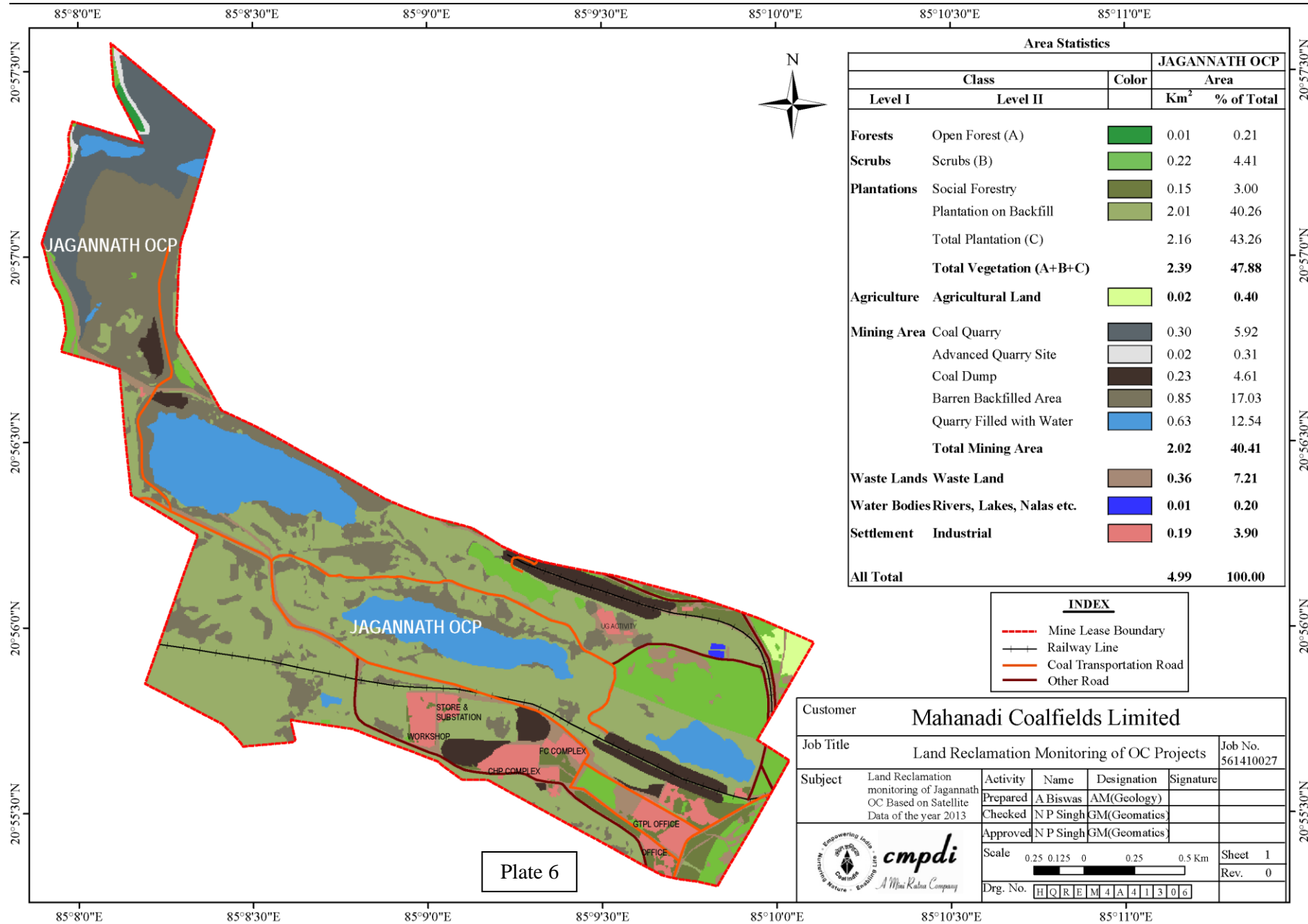
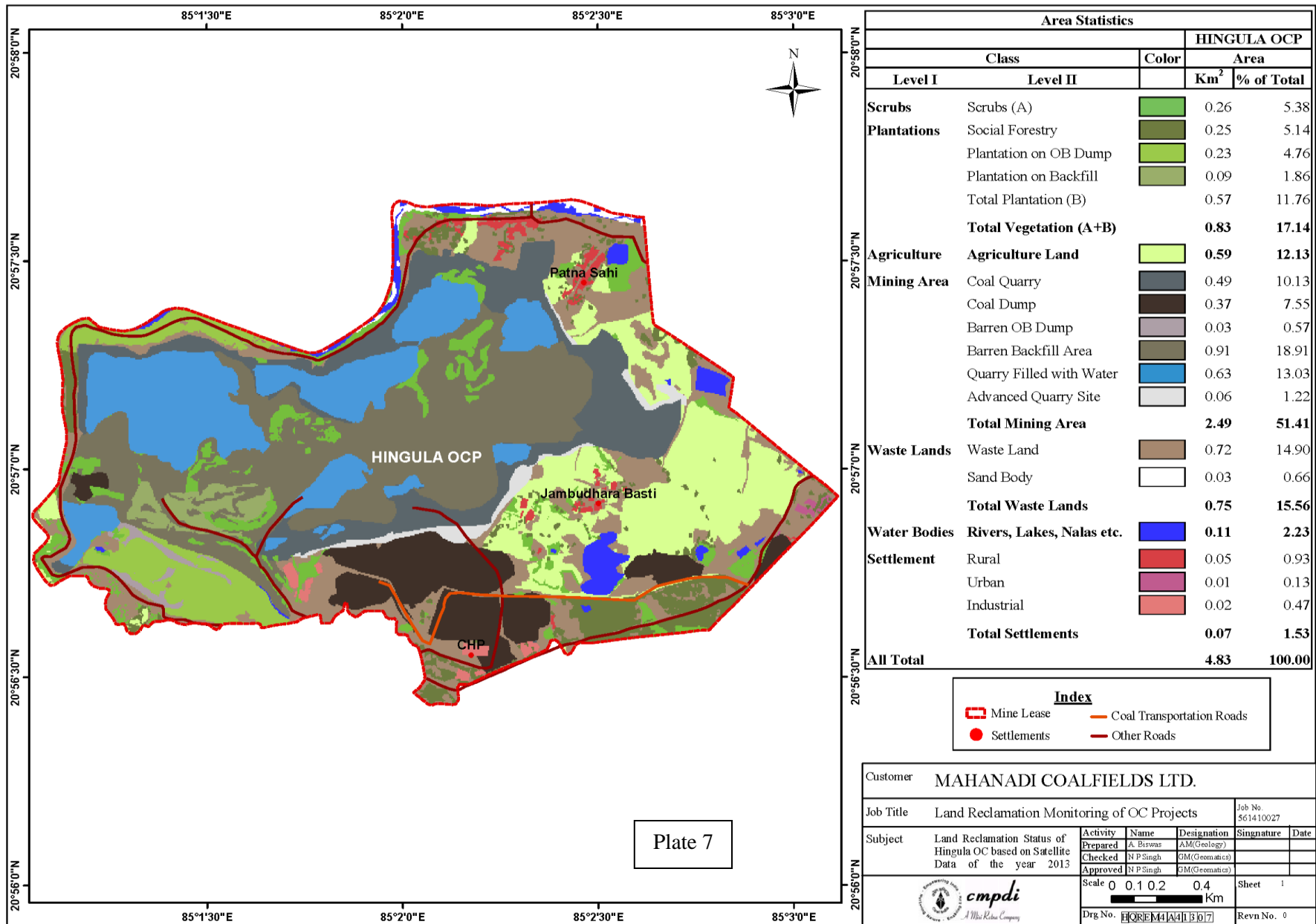


Plate 6

Area Statistics				
			JAGANNATH OCP	
Class		Color	Area	
Level I	Level II		Km ²	% of Total
Forests	Open Forest (A)		0.01	0.21
	Scrubs (B)		0.22	4.41
Plantations	Social Forestry		0.15	3.00
	Plantation on Backfill		2.01	40.26
	Total Plantation (C)		2.16	43.26
Total Vegetation (A+B+C)			2.39	47.88
Agriculture	Agricultural Land		0.02	0.40
Mining Area	Coal Quarry		0.30	5.92
	Advanced Quarry Site		0.02	0.31
	Coal Dump		0.23	4.61
	Barren Backfilled Area		0.85	17.03
	Quarry Filled with Water		0.63	12.54
Total Mining Area			2.02	40.41
Waste Lands	Waste Land		0.36	7.21
Water Bodies	Rivers, Lakes, Nalas etc.		0.01	0.20
Settlement	Industrial		0.19	3.90
All Total			4.99	100.00

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Customer	Mahanadi Coalfields Limited				
Job Title	Land Reclamation Monitoring of OC Projects			Job No. 561410027	
Subject	Land Reclamation monitoring of Jagannath OC Based on Satellite Data of the year 2013	Activity	Name	Designation	Signature
		Prepared	A Biswas	AM(Geology)	
		Checked	N P Singh	GM(Geomatics)	
		Approved	N P Singh	GM(Geomatics)	
 <i>cmpdi</i> <small>A Mini-Ratna Company</small>	Scale	0.25 0.125 0 0.25 0.5 Km	Sheet	1	
	Drg. No.	HQR/EM/44/41/308	Rev.	0	



Area Statistics				
			HINGULA OCP	
Class		Color	Area	
Level I	Level II		Km ²	% of Total
Scrubs	Scrubs (A)		0.26	5.38
	Plantations	Social Forestry		0.25
	Plantation on OB Dump		0.23	4.76
	Plantation on Backfill		0.09	1.86
	Total Plantation (B)		0.57	11.76
	Total Vegetation (A+B)		0.83	17.14
Agriculture	Agriculture Land		0.59	12.13
Mining Area	Coal Quarry		0.49	10.13
	Coal Dump		0.37	7.55
	Barren OB Dump		0.03	0.57
	Barren Backfill Area		0.91	18.91
	Quarry Filled with Water		0.63	13.03
	Advanced Quarry Site		0.06	1.22
	Total Mining Area			2.49
Waste Lands	Waste Land		0.72	14.90
	Sand Body		0.03	0.66
	Total Waste Lands		0.75	15.56
Water Bodies	Rivers, Lakes, Nalas etc.		0.11	2.23
Settlement	Rural		0.05	0.93
	Urban		0.01	0.13
	Industrial		0.02	0.47
	Total Settlements		0.07	1.53
All Total			4.83	100.00

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Customer	MAHANADI COALFIELDS LTD.		
Job Title	Land Reclamation Monitoring of OC Projects		Job No. 561410027
Subject	Activity	Name	Designation
	Prepared	A. Bhowmik	AM(Geology)
	Checked	N.P.Singh	GM(Geomatics)
	Approved	N.P.Singh	GM(Geomatics)
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	Revn No.	0	

Plate 7

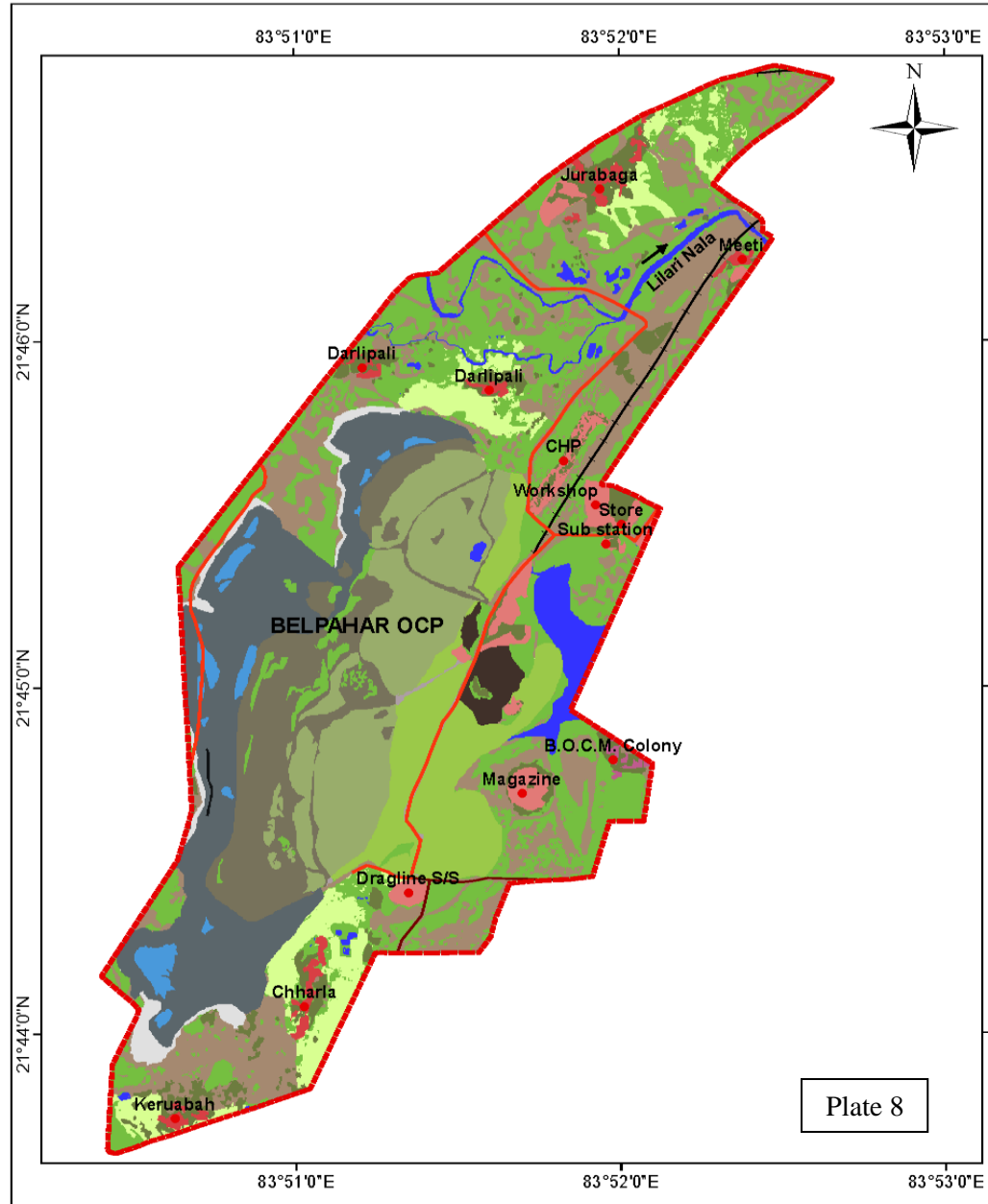


Plate 8

Area Statistics			BELPAHAR OCP	
Class	Color	Area		
Level I	Level II	Km ²	% of Total	
Forest	Open Forest (A)	0.01	0.10	
	Scrubs (B)	2.38	24.43	
Plantations	Social Forestry	0.40	4.13	
	Plantation on OB Dump	0.70	7.18	
	Plantation on Backfill	1.05	10.78	
	Total Plantation (C)	2.15	22.09	
Total Vegetation (A+B+C)		4.54	46.62	
Agriculture	Agriculture Land	0.51	5.24	
Mining Area	Coal Quarry	1.16	11.90	
	Coal Face	0.01	0.10	
	Coal Dump	0.10	1.04	
	Barren OB Dump	0.02	0.22	
	Barren Backfilled Area	0.78	8.01	
	Quarry Filled with Water	0.11	1.13	
	Advanced Quarry Site	0.13	1.38	
	Total Mining Area	2.32	23.78	
Waste Lands	Waste Land	1.73	17.76	
Water Bodies	Rivers, Lakes, Nalas etc.	0.28	2.86	
Settlement	Rural	0.11	1.15	
	Urban	0.01	0.13	
	Industrial	0.24	2.46	
	Total Settlements	0.36	3.74	
All Total		9.74	100.00	

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Customer	MAHANADI COALFIELDS LTD.			
Job Title	Land Reclamation Monitoring of OC Projects			Job No. 561410027
Subject	Land Reclamation Status of Belpahar OC based on Satellite Data of the year 2013	Activity Prepared	Name A. Biswas	Designation AM(Geology)
		Checked	N P Singh	GM(Geomatics)
		Approved	N P Singh	GM(Geomatics)
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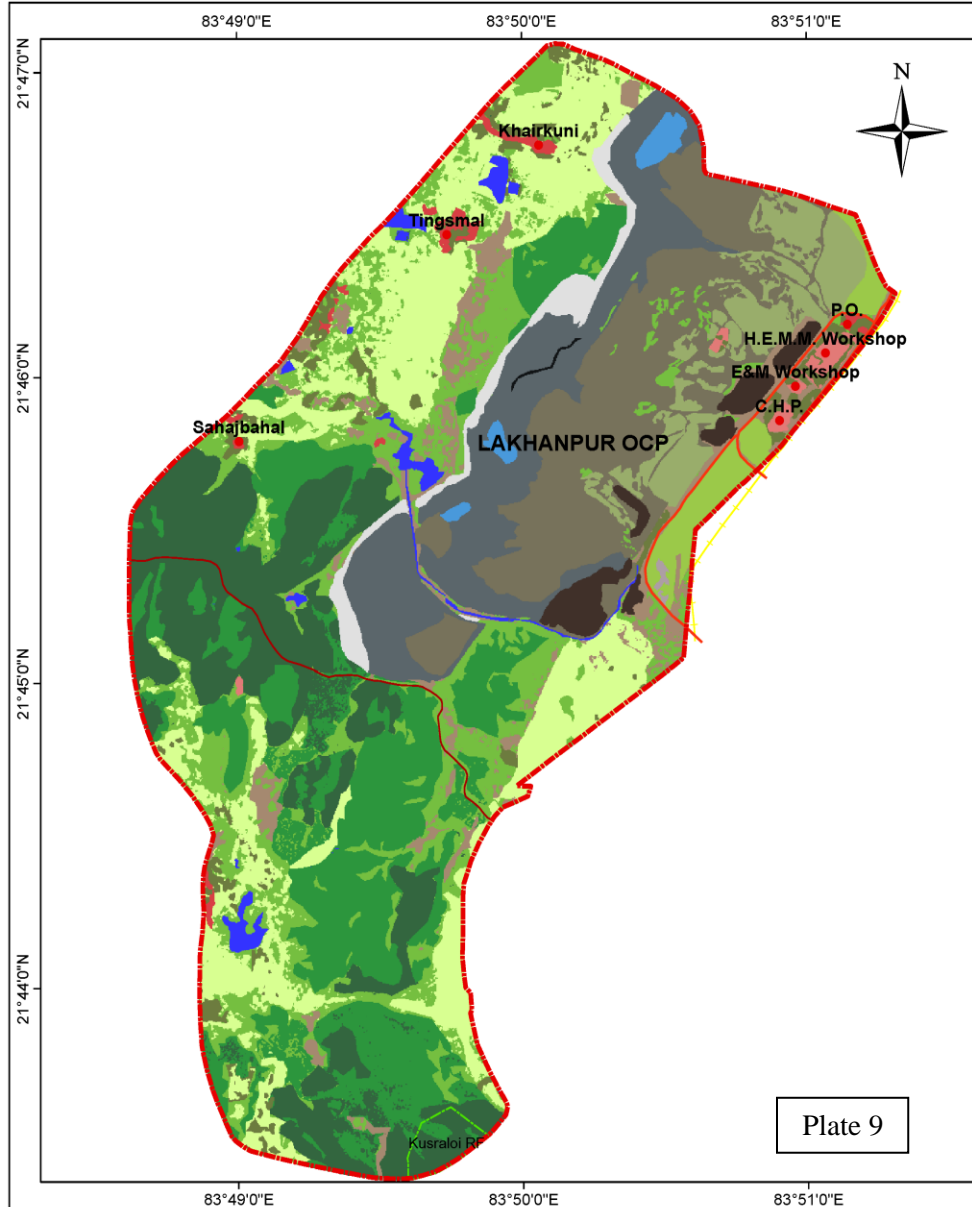
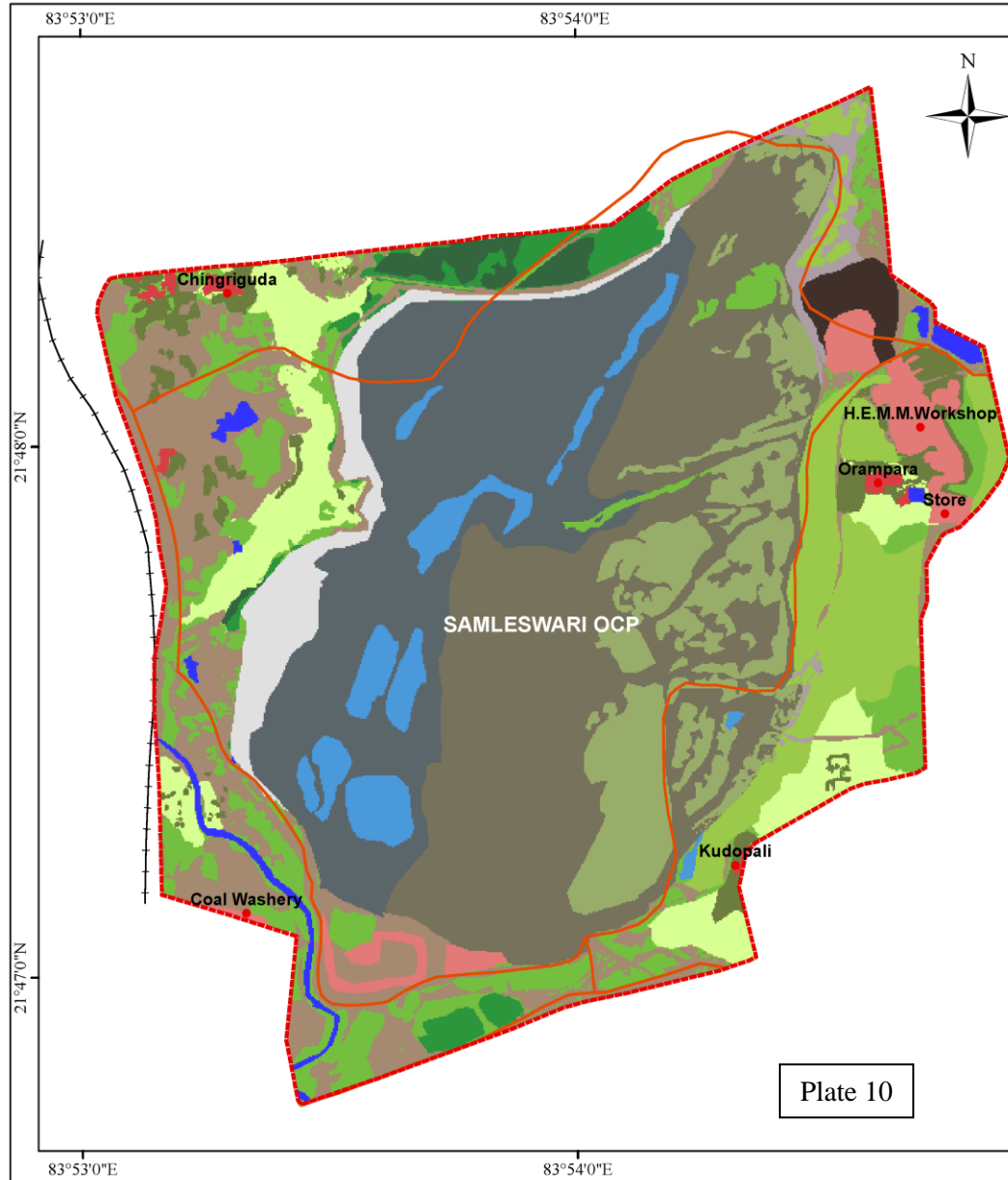


Plate 9

Area Statistics			LAKHANPUR OCP	
Class		Color	Area	
Level I	Level II		Km ²	% of Total
Forests	Dense Forest		1.67	10.31
	Open Forest		2.83	17.47
	Total Forests (A)		4.50	27.78
Scrubs	Scrubs (B)		2.38	14.69
Plantations	Social Forestry		0.43	2.65
	Plantation on OB Dump		0.30	1.88
	Plantation on Backfill		0.76	4.69
	Total Plantation (C)		1.49	9.22
Total Vegetation (A+B+C)			8.37	51.69
Agriculture	Agriculture Land		2.60	16.02
Mining Area	Coal Quarry		1.52	9.38
	Coal Face		0.01	0.06
	Coal Dump		0.27	1.66
	Barren OB Dump		0.01	0.07
	Barren Backfilled Area		1.90	11.73
	Quarry Filled with Water		0.11	0.68
	Advanced Quarry Site		0.29	1.78
	Total Mining Area		4.11	25.36
Waste Lands	Waste Land		0.76	4.70
Water Bodies	Rivers, Lakes, Nalas etc.		0.18	1.12
Settlement	Rural		0.10	0.62
	Industrial		0.08	0.49
Total Settlements			0.18	1.11
All Total			16.20	100.00

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Customer	MAHANADI COALFIELDS LTD.		
Job Title	Land Reclamation Monitoring of OC Projects	Job No.	561410027
Subject	Land Reclamation Status of Lakhapur OC based on Satellite Data of the year 2013	Activity	Signature
		Name	Date
		Designation	
		Prepared	A. Biswas
		Checked	N P Singh
		Approved	N P Singh
			GM(Geomatics)
			GM(Geomatics)
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		Revn No.	0



Area Statistics			SAMLESWARI OCP	
Class		Color	Area	
Level I	Level II		Km ²	% of Total
Forests	Dense Forest		0.08	1.12
	Open Forest		0.13	1.84
	Total Forests(A)		0.21	2.96
Scrubs	Scrubs (B)		0.67	9.39
Plantations	Social Forestry		0.18	2.50
	Plantation on OB Dump		0.48	6.68
	Plantation on Backfill		0.64	9.01
	Total Plantation (C)		1.30	18.19
	Total Vegetation (A+B+C)		2.18	30.54
Agriculture	Agriculture Land		0.41	5.75
Mining Area	Coal Quarry		1.18	16.56
	Coal Dump		0.07	0.95
	Barren OB Dump		0.07	1.05
	Barren Backfill Area		1.60	22.46
	Quarry Filled with Water		0.23	3.20
	Advanced Quarry Site		0.21	2.97
	Total Mining Area		3.36	47.19
Waste Lands	Waste Land		0.91	12.83
Water Bodies	Rivers, Lakes, Nalas etc.		0.06	0.91
Settlement	Rural		0.03	0.39
	Industrial		0.17	2.39
	Total Settlements		0.20	2.78
All Total			7.13	100.00

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Customer	MAHANADI COALFIELDS LTD.			
Job Title	Land Reclamation Monitoring of OC Projects	Job No.	561410027	
Subject	Land Reclamation Status of	Activity	Name	Designation
	Samleswari OC based on	Prepared	A. Biswas	AM(Geology)
	Satellite Data of the year 2013	Checked	N P Singh	GM(Geomatics)
		Approved	N P Singh	GM(Geomatics)
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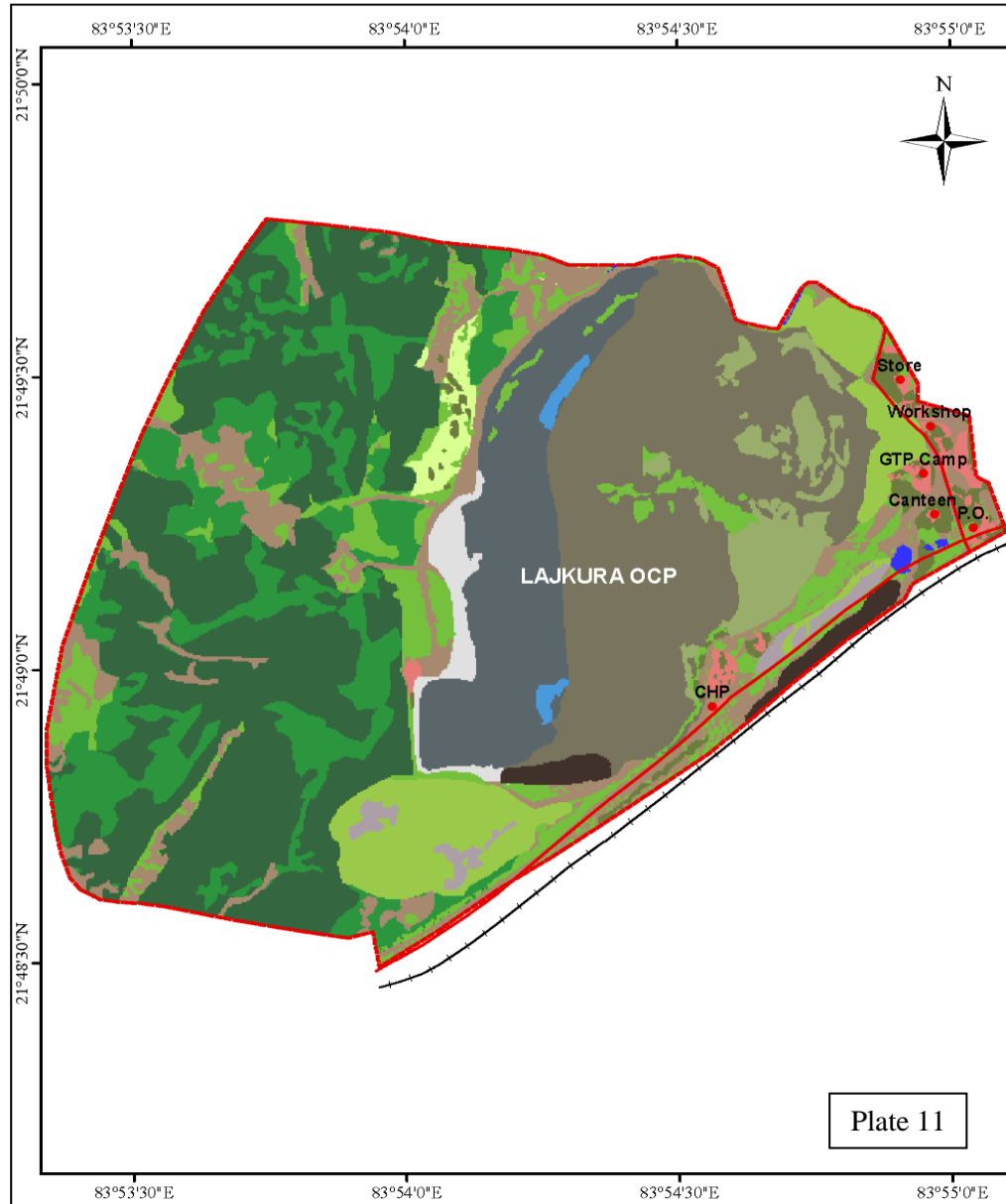


Plate 11

Area Statistics				
			LAJKURA OCP	
Class		Color	Area	
Level I	Level II		Km ²	% of Total
Forests	Dense Forest		1.19	25.40
	Open Forest		0.61	13.01
	Total Forests (A)		1.80	38.41
Scrubs	Scrubs (B)		0.38	8.11
Plantations	Social Forestry		0.06	1.28
	Plantation on OB Dump		0.28	5.94
	Plantation on Backfill		0.19	4.06
	Total Plantation (C)		0.53	11.28
	Total Vegetation (A+B+C)		2.71	57.80
Agriculture	Agriculture Land		0.04	0.91
Mining Area	Coal Quarry		0.41	8.80
	Coal Dump		0.06	1.18
	Barren OB Dump		0.04	0.91
	Barren Backfilled Area		0.84	17.93
	Quarry Filled with Water		0.02	0.37
	Advanced Quarry Site		0.06	1.30
	Total Mining Area		1.43	30.49
Waste Lands	Waste Land		0.45	9.53
Water Bodies	Rivers, Lakes, Nalas etc.		0.01	0.21
Settlements	Industrial		0.05	1.06
All Total			4.68	100.00

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Customer	MAHANADI COALFIELDS LTD.			
Job Title	Land Reclamation Monitoring of OC Projects			Job No. 561410027
Subject	Land Reclamation Status of Lajkura OC based on Satellite Data of the year 2013	Activity	Name	Designation
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		Checked	N. P. Singh	GM (Geomatics)
		Approved	N. P. Singh	GM (Geomatics)
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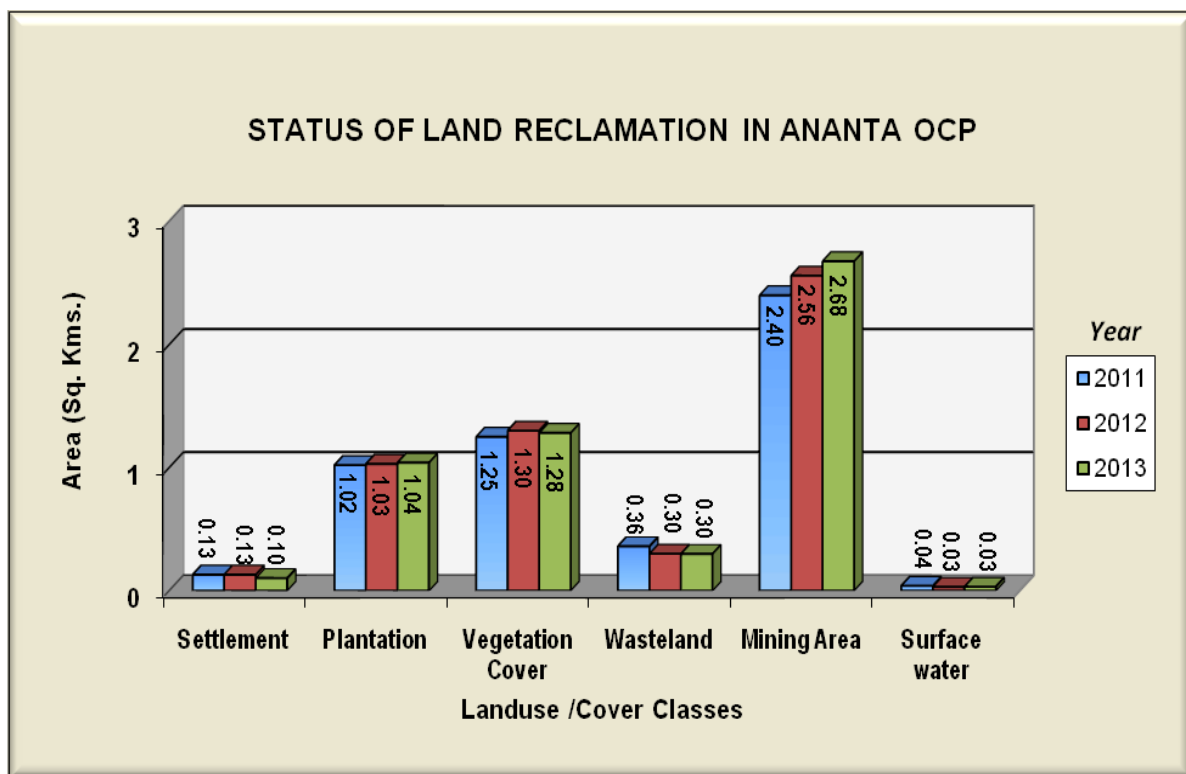


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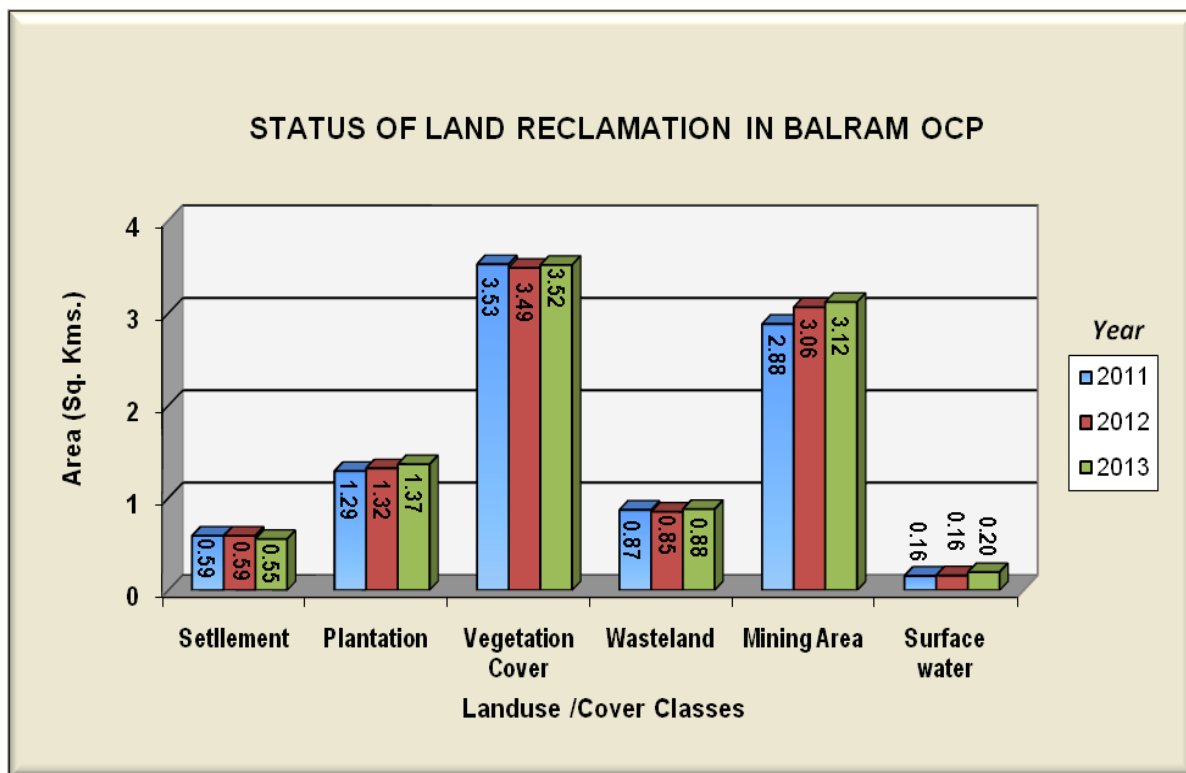


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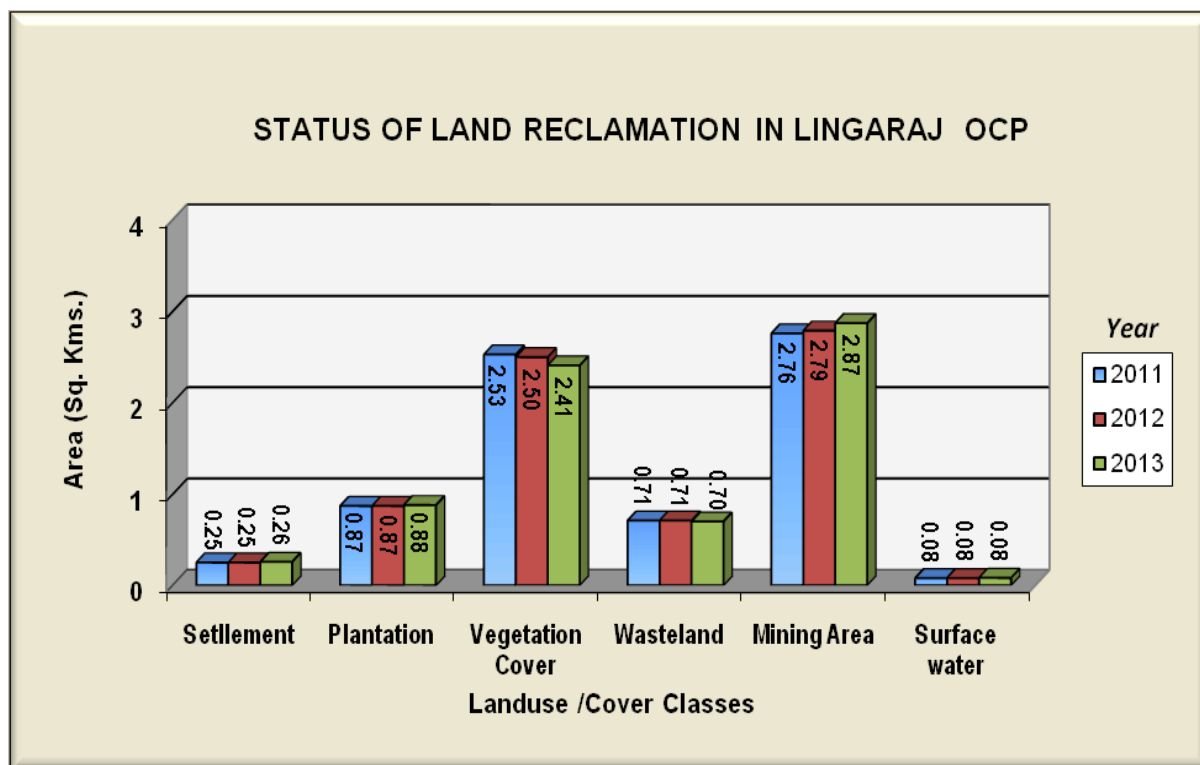


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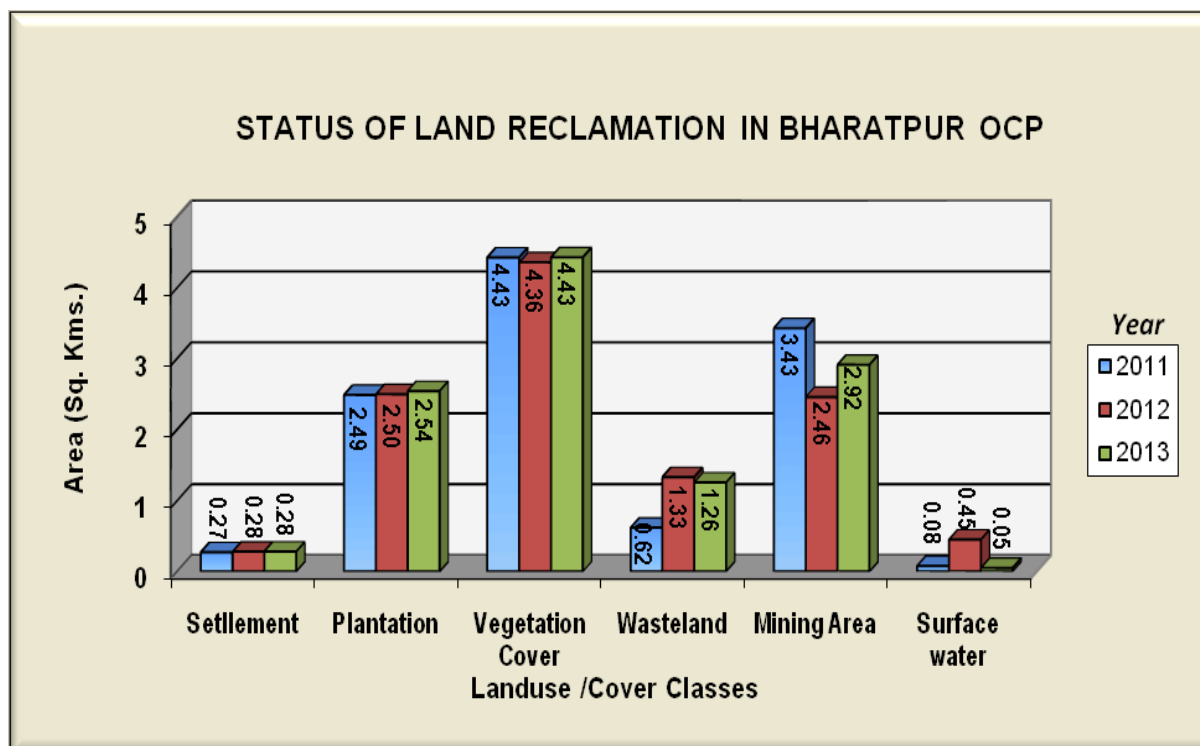


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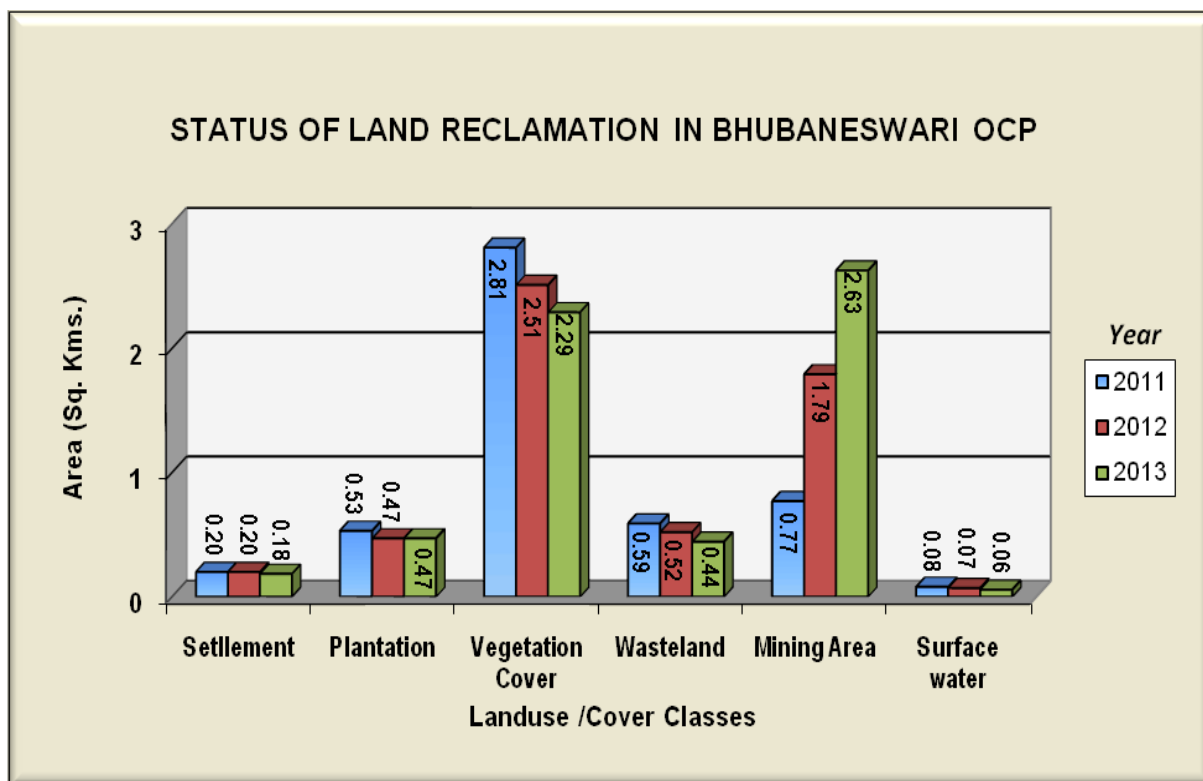


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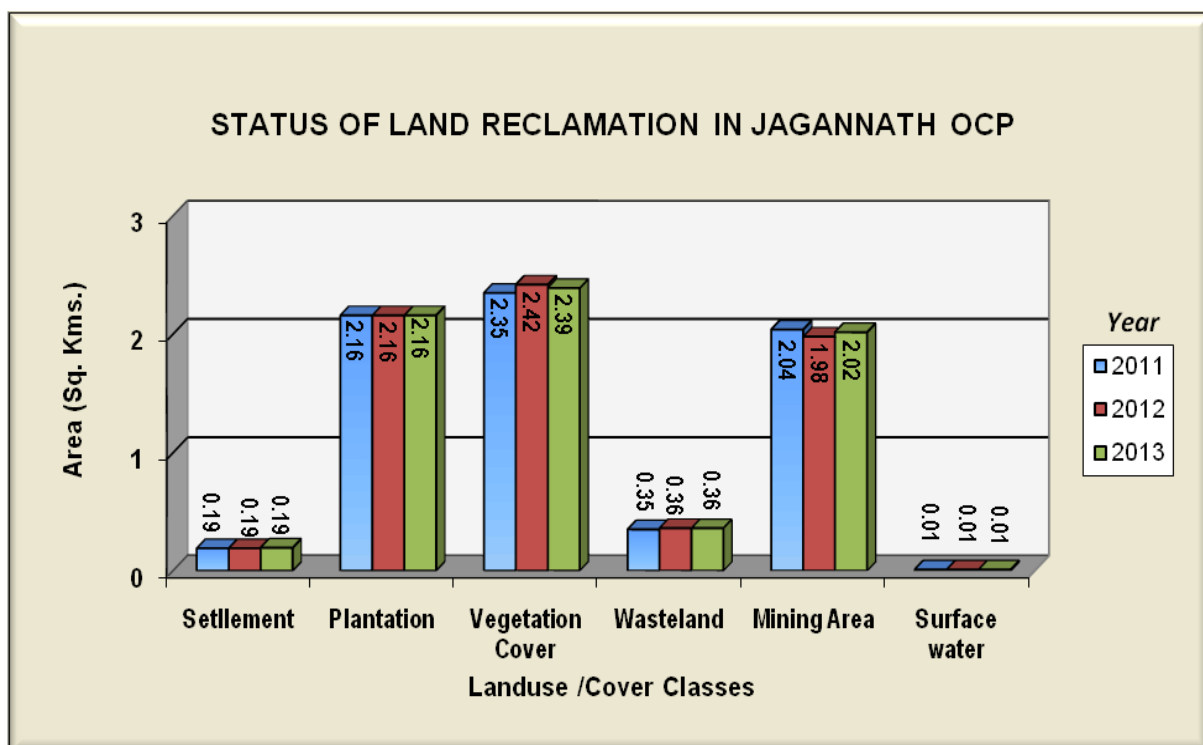


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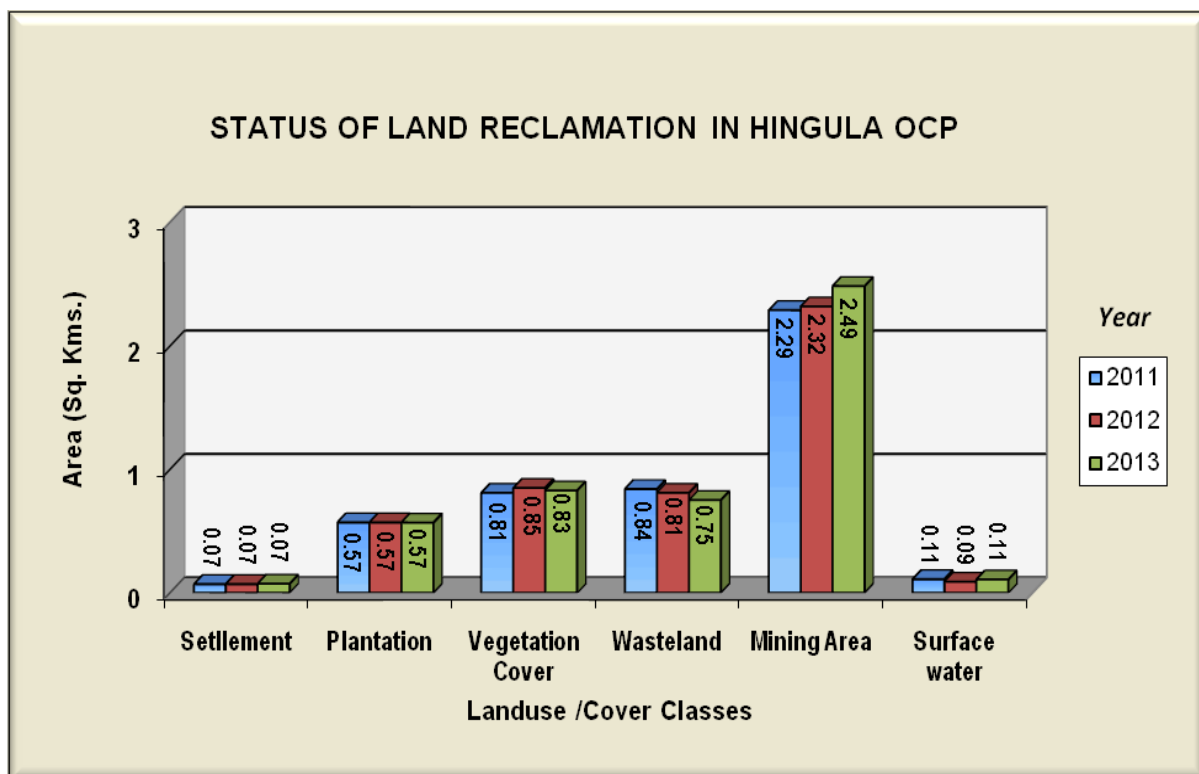


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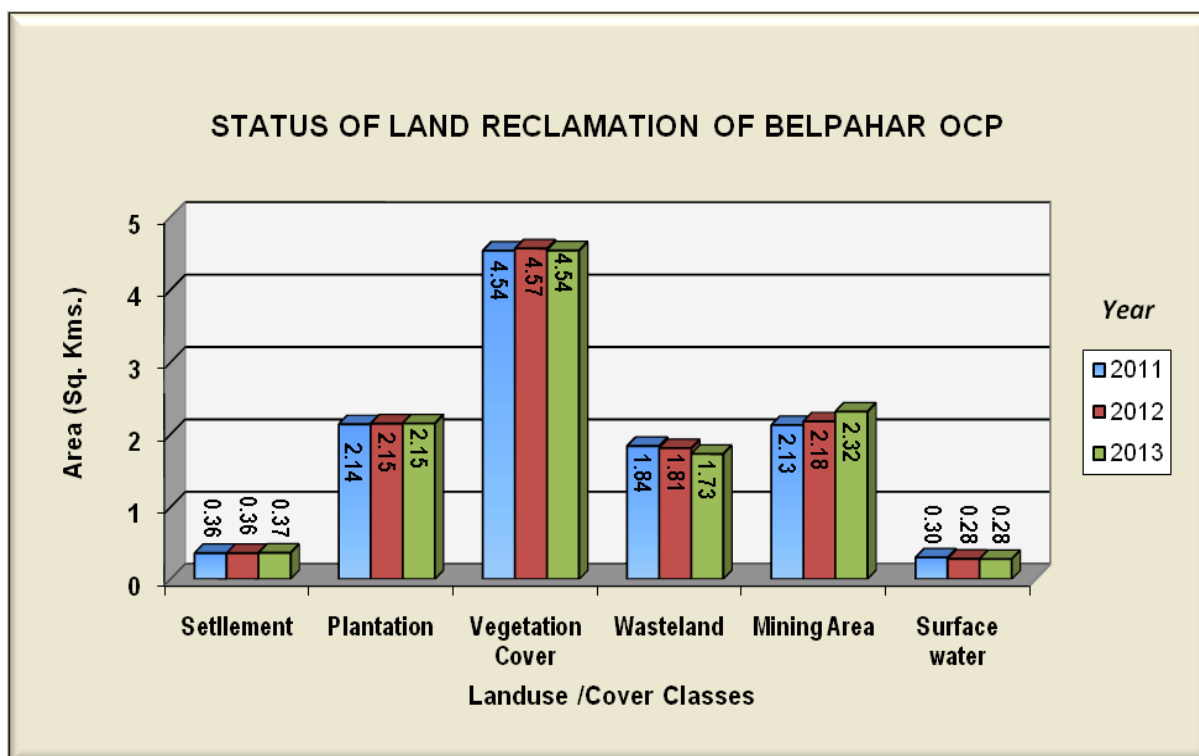


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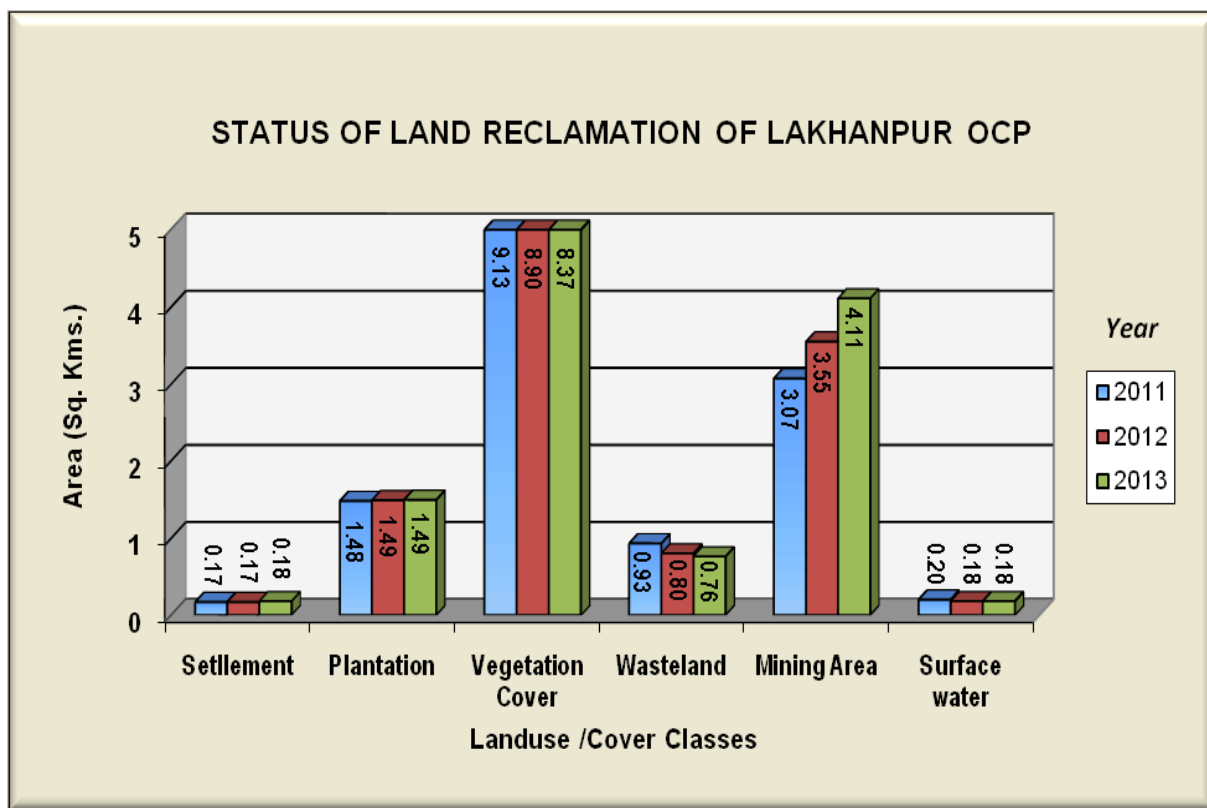


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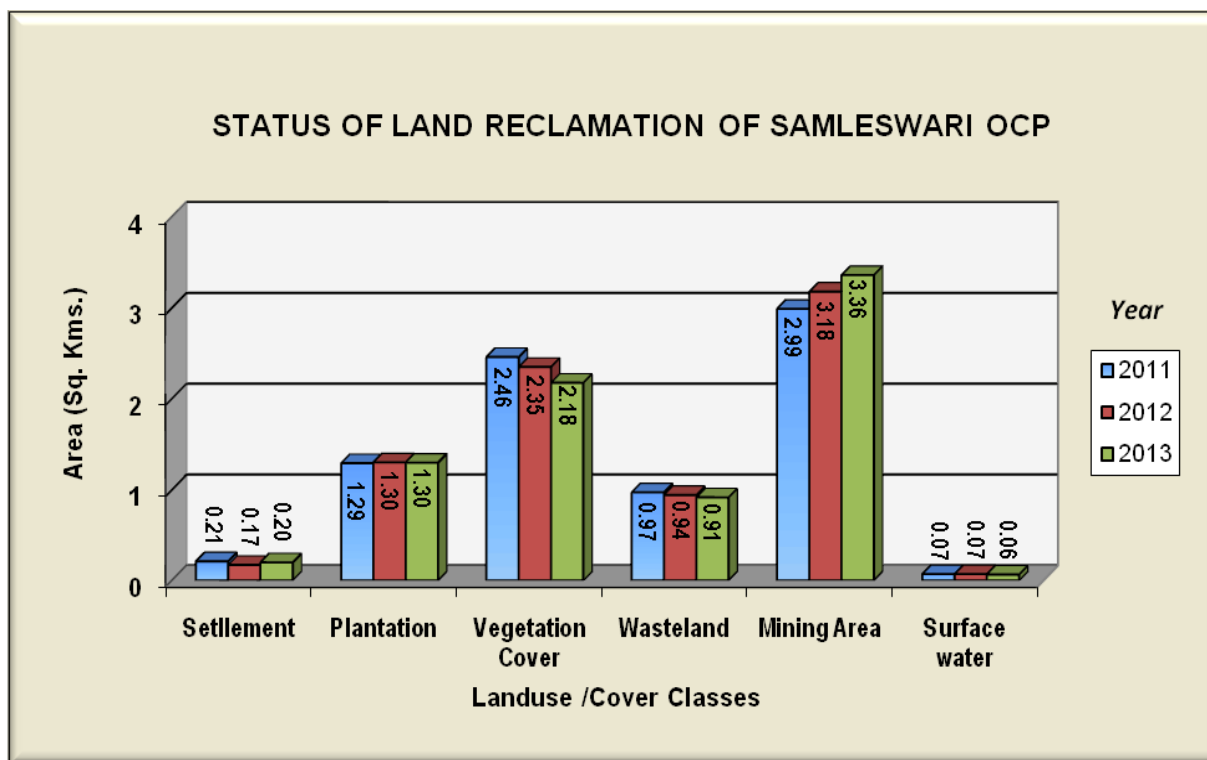


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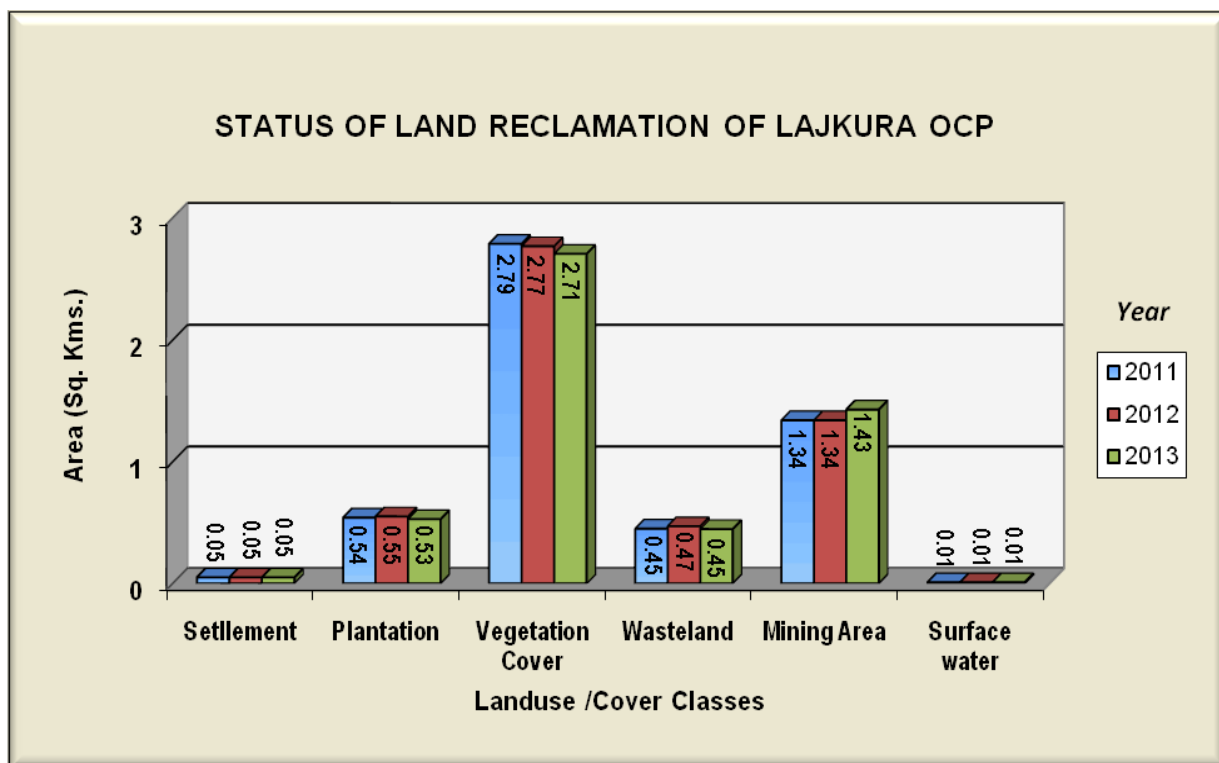


Figure 13



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 Internal OB/Backfill (Bharatpur OC Mine)



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



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



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



Central Mine Planning & Design Institute Ltd.

(A Subsidiary of Coal India Ltd.)

Gondwana Place, Kanke Road, Ranchi 834031, Jharkhand

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

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