#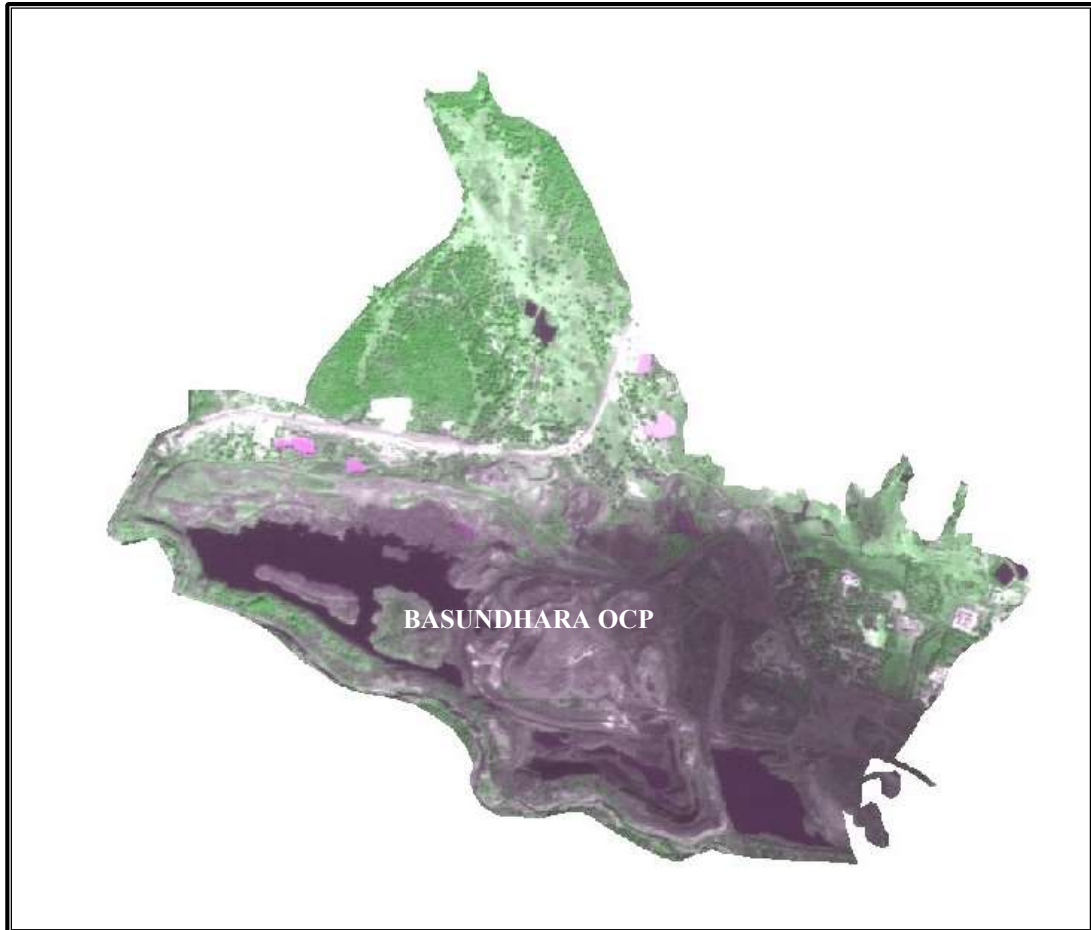 Land Restoration / Reclamation Monitoring of less than 5 m.cu.m. (Coal+OB) Capacity Open Cast Coal Mines of Mahanadi Coalfields Limited Based on Satellite Data for the Year 2018

BASUNDHARA OCP

Submitted to

Mahanadi Coalfields Limited

cmpdi

A Mini Ratna Company

Land Restoration / Reclamation Monitoring of less than 5 m. cu. m (Coal + OB) capacity Open Cast Coal Mines of Mahanadi Coalfields Limited Based on Satellite Data for the Year 2018

March-2019

Remote Sensing Cell
Geomatics Division
CMPDI, Ranchi

CONTENTS

Executive Summary

1.0	**Project**	Land restoration / reclamation monitoring of 3 opencast coal mines of Mahanadi Coalfields Ltd. (MCL) producing less than 5 million cu. m. (Coal + OB) per year based on satellite data, on every three year 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 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 2035.83 hectares of the 3 OC projects Viz. Basundhara, Garjanbahal and Kaniha considered for monitoring during year 2018; total excavated area is only 361.48 ha , out of which 1.13 ha area (0.31%) has been planted, 164.06 ha area (45.39%) is under backfilling and 196.29 ha area (54.30%) is under active mining. It is evident from the analysis that 45.70% area of the OC projects have already been under reclamation and balance 54.30% 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 2018 with respect to the year 2015 in different projects, it is evident from the analysis that area under land reclamation has increased from 84.87Ha. (Yr. 2015) to 165.19Ha. (Yr.2018). Out of 3 projects of MCL, Basundhara OC ranks on top for land reclamation (61.41%) followed by Kaniha OC (14.82%).

- Out of the above mentioned three projects taken up for monitoring, Garjanbahal is an upcoming project and the current status can be used as base data for any future analysis on reclamation monitoring.

- It is important to note that a new table format has been designed by Coal India Ltd. with new parameters of biological and technical reclamation. For comparative purposes the basic dataset for the year 2015-16 has been fed into the new format so that it can be compared with the results of 2018-19.

TABLE-1

Project wise Land Reclamation Status in OC projects of Mahanadi Coalfields Ltd
# Based on Satellite data of the Year 2015 and 2018

(Area in Hectare)

Sl. No.	Project	Total Leasehold Area	Technical Reclamation — Area under Backfilling		Biological Reclamation — Plantation on Excavated / Backfilled Area		Other Plantations — Plantation on External Over Burden Dumps		Social Forestry, Avanue Plantation Etc.		Area under Active Mining		Total Excavated Area		Total Area under Plantation (% Green Cover Generated in Leasehold)		Total Area under Reclamation	
1	2	3	4		5		6		7		8		9 (=4+5+8)		10 (=5+6+7)		11(=4+5)	
			2015	2018	2015	2018	2015	2018	2015	2018	2015	2018	2015	2018	2015	2018	2015	2018
1	Basundhara	705.00	81.84	146.00	1.13	1.13	14.30	14.30	15.38	15.38	138.72	92.45	221.69	239.58	30.81	30.81	82.97	147.13
			36.92%	60.94%	0.51%	0.47%					62.57%	38.59%			4.37%	4.37%	37.43%	61.41%
2	Garjanbahal	653.83	0.00	0.00	0.00	0.00	0.00	0.00	1.95	1.95	0.00	0.00	0.00	0.00	1.95	1.95	0.00	0.00
			0.00%	0.00%	0.00%	0.00%					0.00%	0.00%			0.30%	0.30%	0.00%	0.00%
3	Kaniha	677.00	1.90	18.06	0.00	0.00	0.00	0.00	10.53	10.53	53.88	103.84	55.78	121.90	10.53	10.53	1.90	18.06
			3.41%	14.82%	0.00%	0.00%					96.59%	85.18%			1.56%	1.56%	3.41%	14.82%
	TOTAL	**2035.83**	**83.74**	**164.06**	**1.13**	**1.13**	**14.30**	**14.30**	**27.86**	**27.86**	**192.60**	**196.29**	**277.47**	**361.48**	**43.29**	**43.29**	**84.87**	**165.19**
			30.18%	**45.39%**	**0.41%**	**0.31%**					**69.41%**	**54.30%**			**2.13%**	**2.13%**	**30.59%**	**45.70%**

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

Note: In reference of the above Table, different parameters are classified as follows:
1. Area under Biological Reclamation includes Areas under Plantation done on Backfilled Area Only.
2. Area under Technical Reclamation includes Area under Barren Backfilling only
3. Area under Active Mining Includes Coal Quarry, Advance Quarry Site, Quarry filled with water etc., if any.
4. Social Forestry and Plantation on External OB Dumps are not included in Biological Reclamation and are put under separate categories as shown in the Table above..
5. (%) calculated in the above Table is in respect to Total Excavated Area except for ""Total Area under Plantation"' where % is in terms of "Leasehold Area"'.

Fig 1: Project Wise Land Reclamation Status In Year 2018
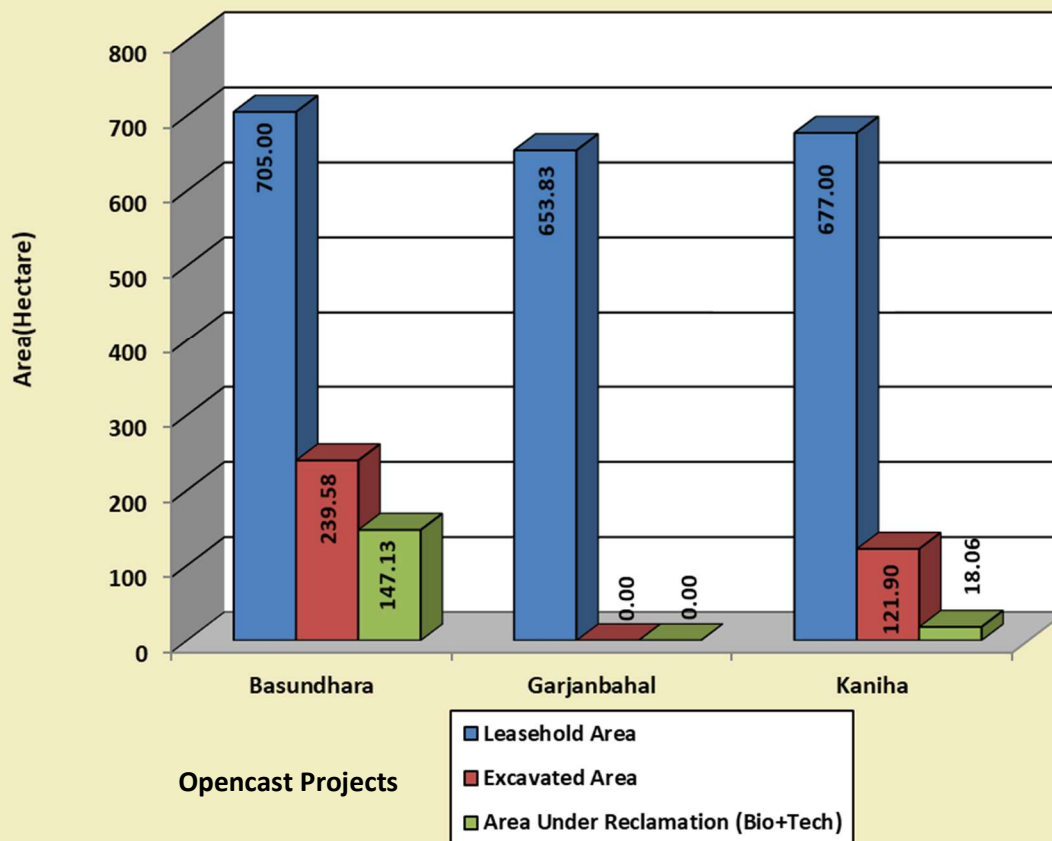
1.0 Background

1.1 Land is the most important natural resource which embodies soil, water, flora, fauna and total ecosystem. All human activities are based on the land which is the scarcest natural resource in our country. Mining is a site specific industry and it could not be shifted anywhere else from the location where mineral occurs. It is a fact that surface mining activities do effect the land environment due to ground breaking. Therefore, there is an urgent need to reclaim and restore the mined out land for its productive use for sustainable development of mining. This will not only mitigate environmental degradation, but would also help in creating a more congenial environment for land acquisition by coal companies in future.

1.2 Keeping above in view, M/s. Coal India Ltd. (CIL) issued a work order vide letter no. CIL/WBP/ENV./2017/DP/8477 dated 21/09/17 for monitoring of opencast mines of less than 5 million m^3 per annum capacity (Coal +OB) for the period 2017-18 to 2021-22 at intervals of three years. The result of land reclamation status of all such mines is to be published on the website of **CIL**, (www.coalindia.in), **CMPDI** (www.cmpdi.co.in) and the concerned coal companies in public domain. Detailed reports are to be submitted to Coal India and respective subsidiaries.

1.3 Land reclamation monitoring of all open cast projects will have to comply the statutory requirements of Ministry of Environment & Forest (MoEF). Such monitoring will not only facilitate in taking remedial measures against environmental degradation, but also enable Coal companies to utilize the reclaimed land for further socio-economic benefits in a planned way.

1.4 Present report is embodying the finding of the study based on satellite data of the year 2018 carried out for 3 no. of OC projects of capacity less than 5 mcm (coal +OB) for Mahanadi Coalfields Ltd.

2.0   Objective

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

3.0   Methodology

There are number of steps involved between raw satellite data procurement and preparation of final map. National Remote Sensing Centre (NRSC) Hyderabad, being the nodal agency for satellite data supply in India, provides only raw digital satellite data, which needs further digital image processing for extracting the information and map preparation before uploading the same in the website. Methodology for land reclamation monitoring is given in fig 2. Following steps are involved in land reclamation /restoration monitoring:
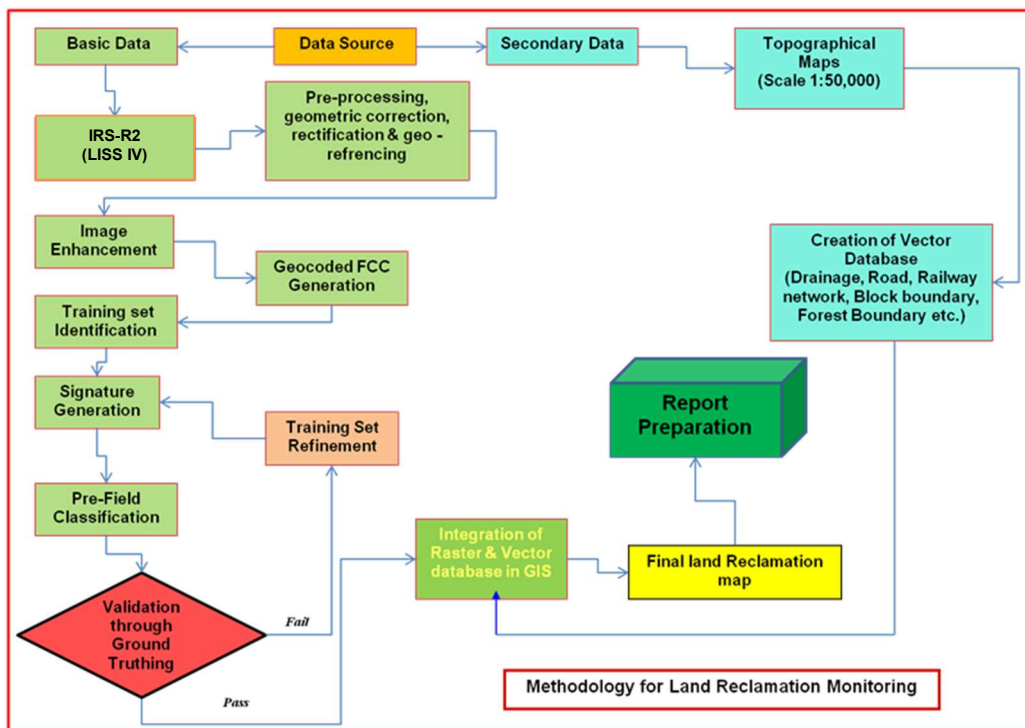

Figure: 2 Methodology for Land Reclamation Monitoring

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

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

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

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

- **Training set selection**

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

- **Classification and Accuracy assessment**

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

- **Area calculation**

  The area of each land use class in the leasehold is determined using ERDAS IMAGINE v. 2014 software and given in table 2.

- **Overlay of Vector data base**

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

- **Pre-field map preparation**

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

3.3 Ground Truthing:

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

3.4 Land reclamation database on GIS:

Land reclamation database is created on GIS platform to identify the temporal changes identified from satellite data of different cut-off dates.
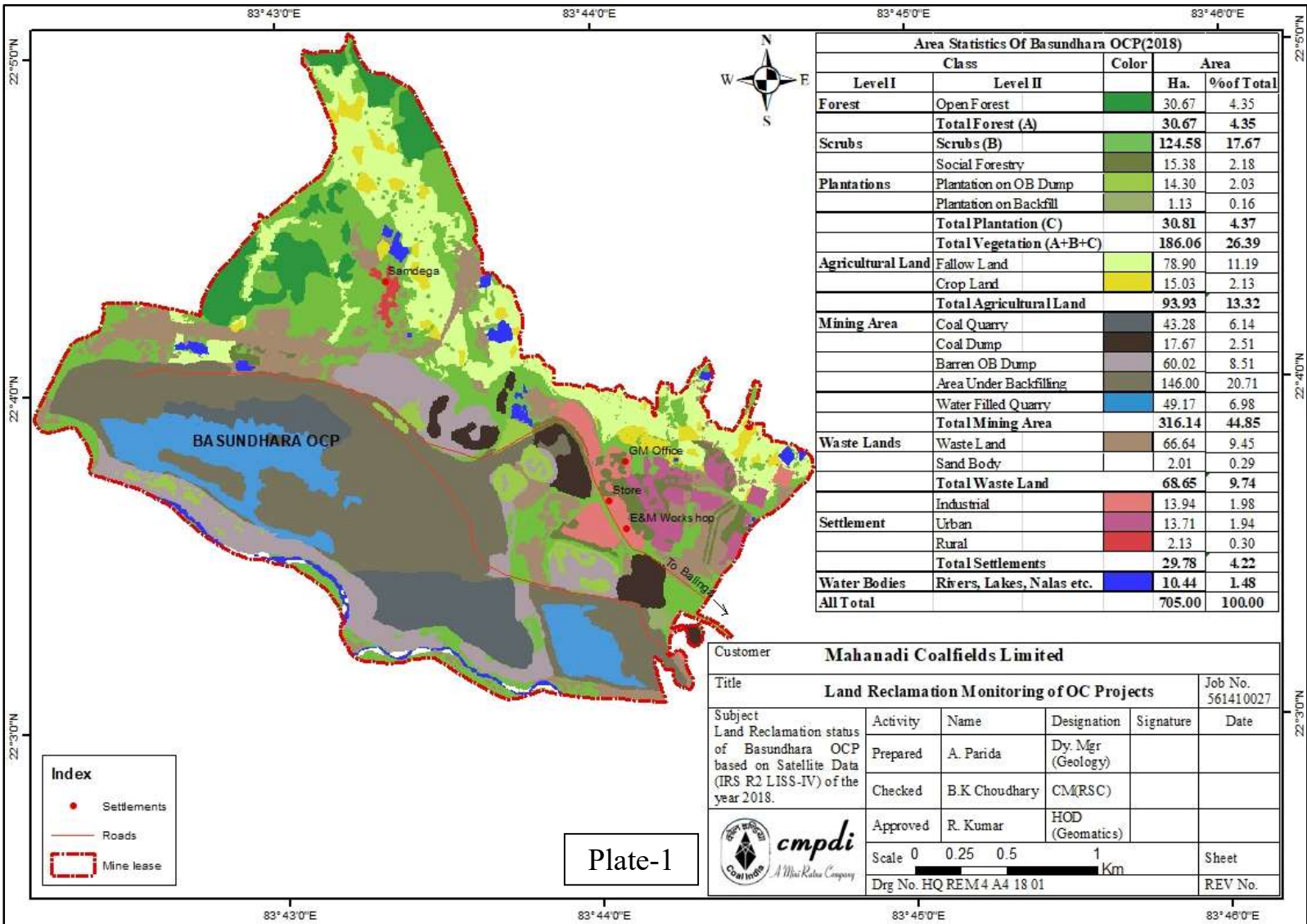
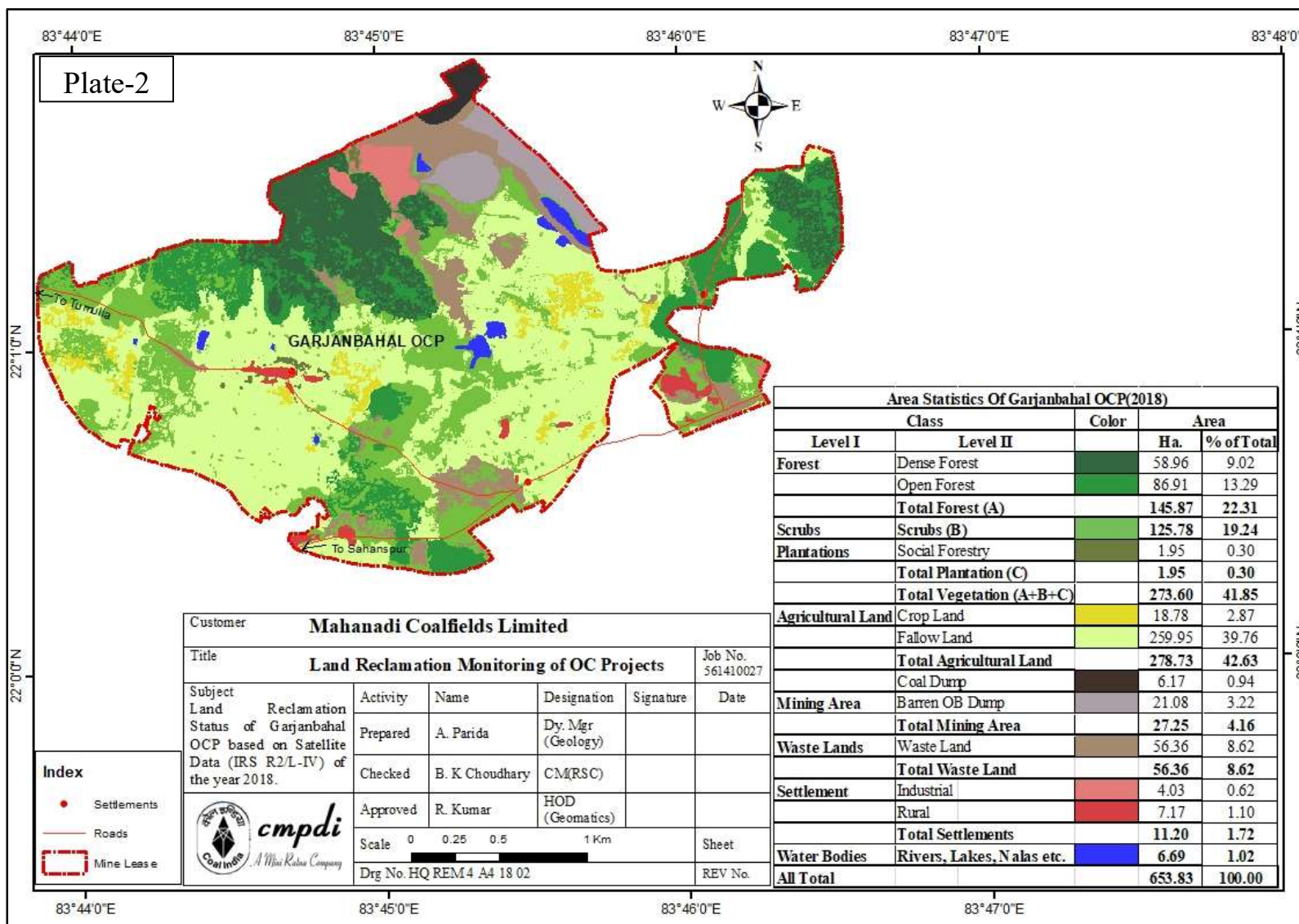## 4.0 Land Reclamation Status in Mahanadi Coalfields Ltd.

4.1   Following 3 OC projects producing less than 5 million m³. (Coal + OB together) of Mahanadi Coalfields Ltd. have been taken up during the year 2018 for land reclamation monitoring:

- Basundhara

- Garjanbahal

- Kaniha

4.2   Area statistics of different land use classes present in OC projects in the year 2018 is given in Table 2. Land use maps derived from the satellite data is given in Plate no.1 to 3. Land use statuses are shown in Fig. 3 – 5 and field photographs showing plantation on OB and backfilled areas, social forestry plantations in Basundhara & Kaniha projects are shown in photo 1 - 4. Land reclamation status of the above mentioned opencast projects were also prepared for the year 2015.

4.3   Study reveals that out of the total mine leasehold area of 2035.83 hectares of the 3 OC projects of MCL mentioned above taken for this study in 2018-19; total excavated area is 361.48 ha out of which 1.13 ha area (0.31%) has been planted on backfill *(Biologically Reclaimed)*, 164.06 ha area (45.39%) is under backfilling *(Technically Reclaimed)* and balance 196.29 ha area (54.30%) is under active mining.

4.4   Analysis of satellite data indicates that area of plantation in the leasehold of the above projects is same at 43.29Ha. in 2015 and 2018. This indicate that MCL is committed for reclamation of mine land for maintaining the ecological balance in the region.

4.5   On comparing the status of land reclamation for the year 2018 with respect to the year 2015 in different projects, it is evident from the analysis that area under land reclamation has increased from 84.87Ha. (Yr. 2015) to 165.19Ha. (Yr.2018).
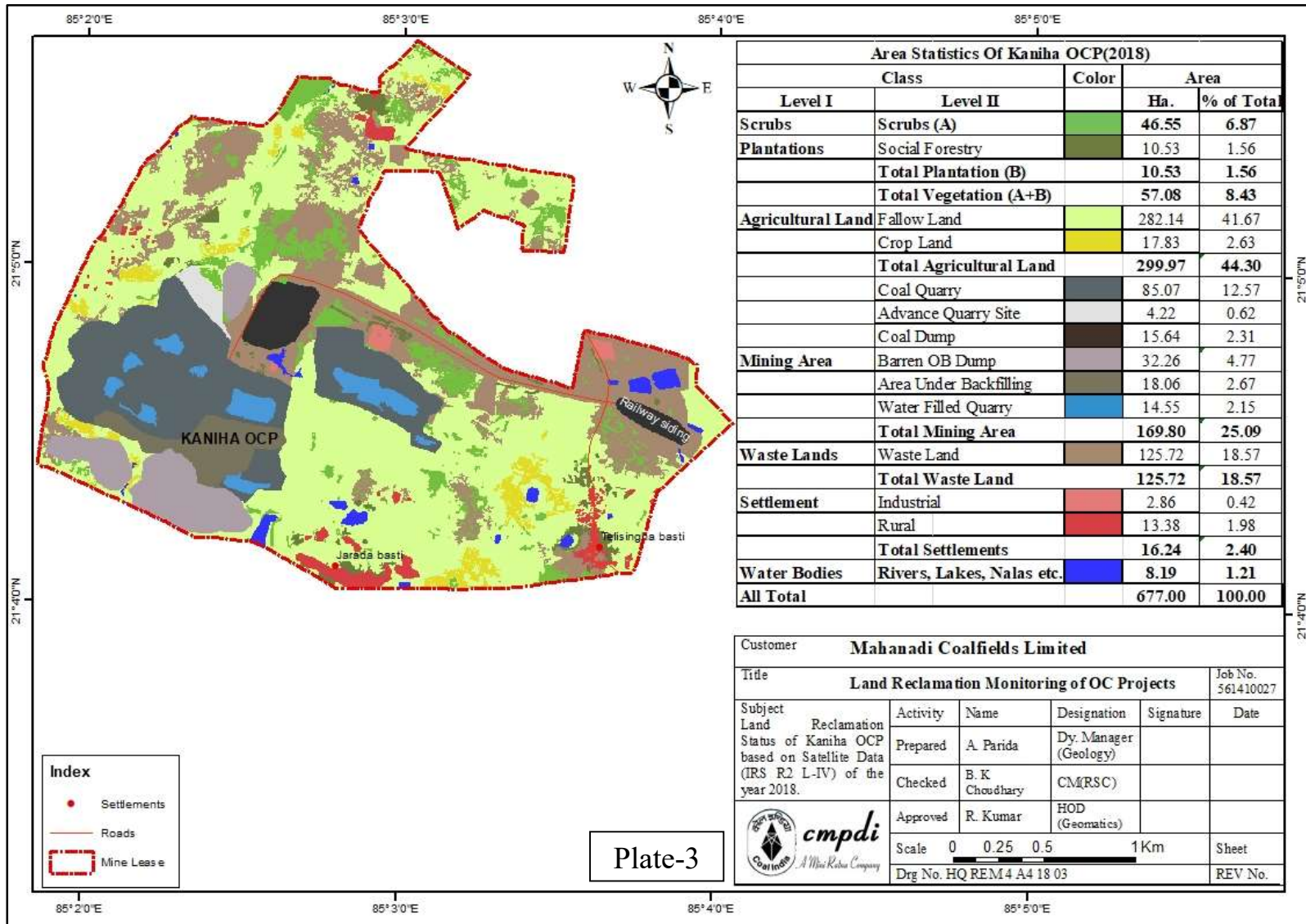
4.6 There has been increase in area under technical reclamation (backfilling) in all projects of MCL except for Garjanbahal OCP where there is no biological (plantation on backfill) and technical reclamation (backfilling) as this project is not in operation.

4.7 Out of 3 projects of MCL, Basundhara OCP has carried out maximum land reclamation with (61.41%).

Table 2: STATUS OF LAND RECLAMATION IN MCL BASED ON SATELLITE DATA OF THE YEAR 2018

(Area in Hectare)

			BASUNDHARA		GARJANBAHAL		KANIHA		TOTAL	
			Area	%	Area	%	Area	%	Area	%
FORESTS	Dense Forest		0.00	0.00	58.96	9.02	0.00	0.00	58.96	2.90
	Open Forest		30.67	4.35	86.91	13.29	0.00	0.00	117.58	5.78
	Total Forest		30.67	4.35	145.87	22.31	0.00	0.00	176.54	8.67
SCRUBS	Scrubs		124.58	17.67	125.78	19.24	46.55	6.87	296.91	14.58
PLANTATION	Social Forestry		15.38	2.18	1.95	0.30	10.53	1.56	27.86	1.37
	Plantation on OB Dump		14.30	2.03	0.00	0.00	0.00	0.00	14.30	0.70
	Plantation on Backfill (Biological Reclamation)		1.13	0.16	0.00	0.00	0.00	0.00	1.13	0.06
	Total Plantation		30.81	4.37	1.95	0.30	10.53	1.56	43.29	2.13
	Total Vegetation		186.06	26.39	273.60	41.85	57.08	8.43	516.74	25.38
ACTIVE MINING	Coal Dump		17.67	2.51	6.17	0.94	15.64	2.31	39.48	1.94
	Coal Quarry		43.28	6.14	0.00	0.00	85.07	12.57	128.35	6.30
	Advance Quarry Site		0.00	0.00	0.00	0.00	4.22	0.62	4.22	0.21
	Quarry Filled With Water		49.17	6.98	0.00	0.00	14.55	2.15	63.72	3.13
	Total Area under *Active Mining*		92.45	13.12	0.00	0.00	103.84	15.34	196.29	9.64
RECLAIMED	Barren OB Dump		60.02	8.51	21.08	3.22	32.26	4.77	113.36	5.57
	Area Under Backfilling (Technical Reclamation)		146.00	20.71	0.00	0.00	18.06	2.67	164.06	8.06
	Total Area under *Technical Reclamation*		146.00	20.71	0.00	0.00	18.06	2.67	164.06	8.06
	Total Area under Mine Operation		316.14	44.85	27.25	4.16	169.80	25.09	513.19	25.21
WASTELAND	Waste Lands		66.64	9.45	56.36	8.62	125.72	18.57	248.72	12.22
	Fly Ash Pond / Sand Body		2.01	0.29	0.00	0.00	0.00	0.00	2.01	0.10
	Total Wasteland		68.65	9.74	56.36	8.62	125.72	18.57	250.73	12.32
WATERBODIES	Reservoir, nallah, ponds		10.44	1.48	6.69	1.02	8.19	1.21	25.32	1.24
	Total Waterbodies		10.44	1.48	6.69	1.02	8.19	1.21	25.32	1.24
AGRICULTURE	Crop Lands		15.03	2.13	18.78	2.87	17.83	2.63	51.64	2.54
	Fallow Lands		78.90	11.19	259.95	39.76	282.14	41.67	620.99	30.50
	Total Agriculture		93.93	13.32	278.73	42.63	299.97	44.30	672.63	33.04
SETTLEMENTS	Urban Settlement		13.71	1.94	0.00	0.00	0.00	0.00	13.71	0.67
	Rural Settlement		2.13	0.30	7.17	1.10	13.38	1.98	22.68	1.11
	Industrial Settlement		13.94	1.98	4.03	0.62	2.86	0.42	20.83	1.02
	Total Settlement		29.78	4.22	11.20	1.72	16.24	2.40	57.22	2.81
	Grand Total		705.00	100.00	653.83	100.00	677.00	100.00	2035.83	100.00

Plate-1

Plate-2

To Tumlia

22°1'0"N

GARJANBAHAL OCP

To Sahanspur

22°0'0"N

83°44'0"E 83°45'0"E 83°46'0"E 83°47'0"E 83°48'0"E

Customer	**Mahanadi Coalfields Limited**					
Title	**Land Reclamation Monitoring of OC Projects**				Job No. 561410027	
Subject Land Reclamation Status of Garjanbahal OCP based on Satellite Data (IRS R2/L-IV) of the year 2018.	Activity	Name	Designation	Signature	Date	
	Prepared	A. Parida	Dy. Mgr (Geology)			
	Checked	B. K Choudhary	CM(RSC)			
	Approved	R. Kumar	HOD (Geomatics)			
	Scale	0 0.25 0.5 1 Km			Sheet	
	Drg No. HQ REM 4 A4 18 02				REV No.	

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Area Statistics Of Garjanbahal OCP(2018)				
Class		Color	Area	
Level I	Level II		Ha.	% of Total
Forest	Dense Forest		58.96	9.02
	Open Forest		86.91	13.29
	Total Forest (A)		**145.87**	**22.31**
Scrubs	Scrubs (B)		125.78	19.24
Plantations	Social Forestry		1.95	0.30
	Total Plantation (C)		**1.95**	**0.30**
	Total Vegetation (A+B+C)		**273.60**	**41.85**
Agricultural Land	Crop Land		18.78	2.87
	Fallow Land		259.95	39.76
	Total Agricultural Land		**278.73**	**42.63**
Mining Area	Coal Dump		6.17	0.94
	Barren OB Dump		21.08	3.22
	Total Mining Area		**27.25**	**4.16**
Waste Lands	Waste Land		56.36	8.62
	Total Waste Land		**56.36**	**8.62**
Settlement	Industrial		4.03	0.62
	Rural		7.17	1.10
	Total Settlements		**11.20**	**1.72**
Water Bodies	Rivers, Lakes, Nalas etc.		**6.69**	**1.02**
All Total			**653.83**	**100.00**

Area Statistics Of Kaniha OCP(2018)				
Class		Color	Area	
Level I	Level II		Ha.	% of Total
Scrubs	Scrubs (A)		46.55	6.87
Plantations	Social Forestry		10.53	1.56
	Total Plantation (B)		10.53	1.56
	Total Vegetation (A+B)		57.08	8.43
Agricultural Land	Fallow Land		282.14	41.67
	Crop Land		17.83	2.63
	Total Agricultural Land		299.97	44.30
	Coal Quarry		85.07	12.57
	Advance Quarry Site		4.22	0.62
	Coal Dump		15.64	2.31
Mining Area	Barren OB Dump		32.26	4.77
	Area Under Backfilling		18.06	2.67
	Water Filled Quarry		14.55	2.15
	Total Mining Area		169.80	25.09
Waste Lands	Waste Land		125.72	18.57
	Total Waste Land		125.72	18.57
Settlement	Industrial		2.86	0.42
	Rural		13.38	1.98
	Total Settlements		16.24	2.40
Water Bodies	Rivers, Lakes, Nalas etc.		8.19	1.21
All Total			677.00	100.00

Customer	Mahanadi Coalfields Limited				
Title	Land Reclamation Monitoring of OC Projects				Job No. 561410027
Subject Land Reclamation Status of Kaniha OCP based on Satellite Data (IRS R2 L-IV) of the year 2018.	Activity	Name	Designation	Signature	Date
	Prepared	A. Parida	Dy. Manager (Geology)		
	Checked	B. K Choudhary	CM(RSC)		
	Approved	R. Kumar	HOD (Geomatics)		
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	Drg No. HQ REM 4 A4 18 03				REV No.

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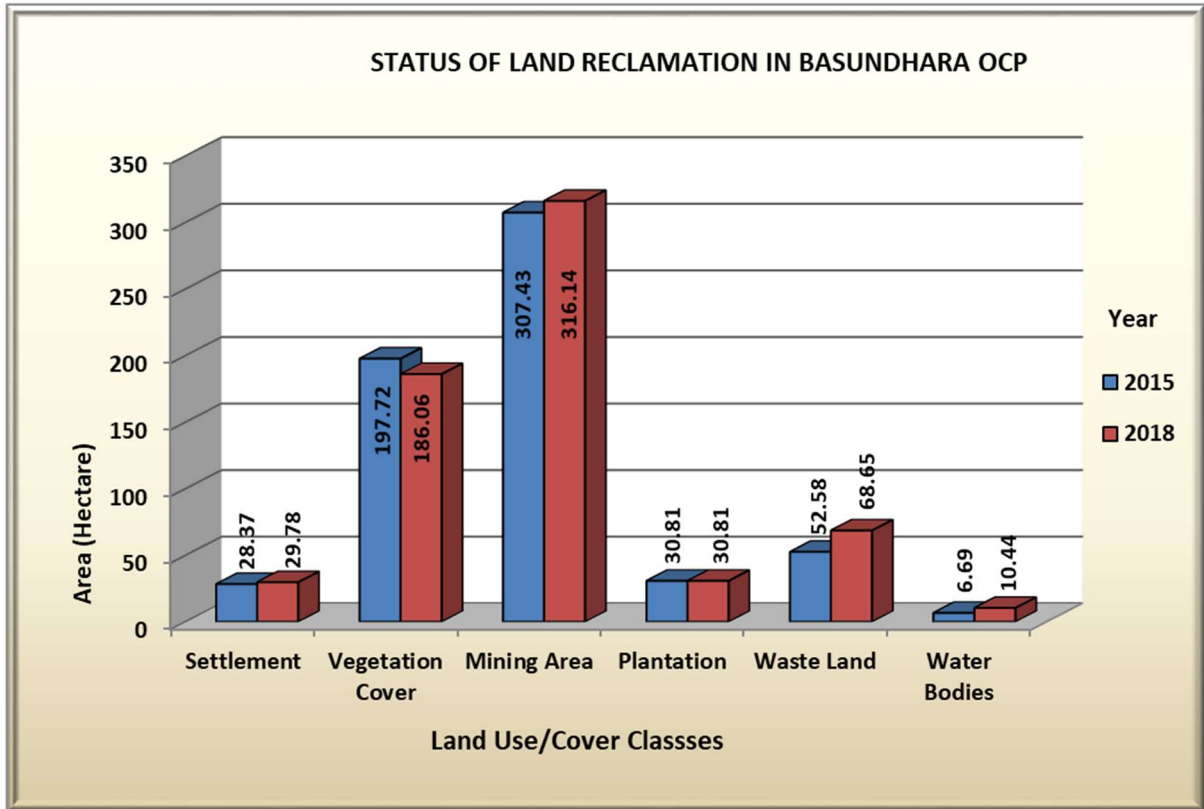- Roads
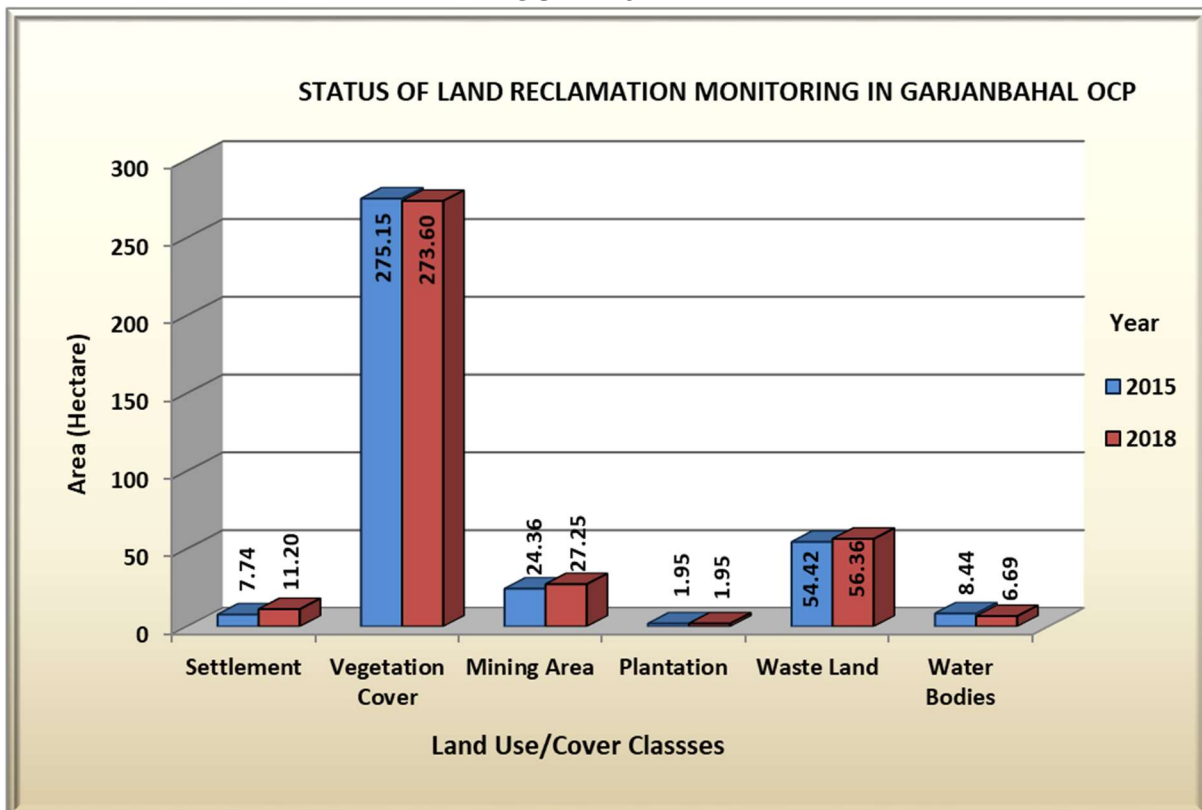- Mine Lease

Plate-3

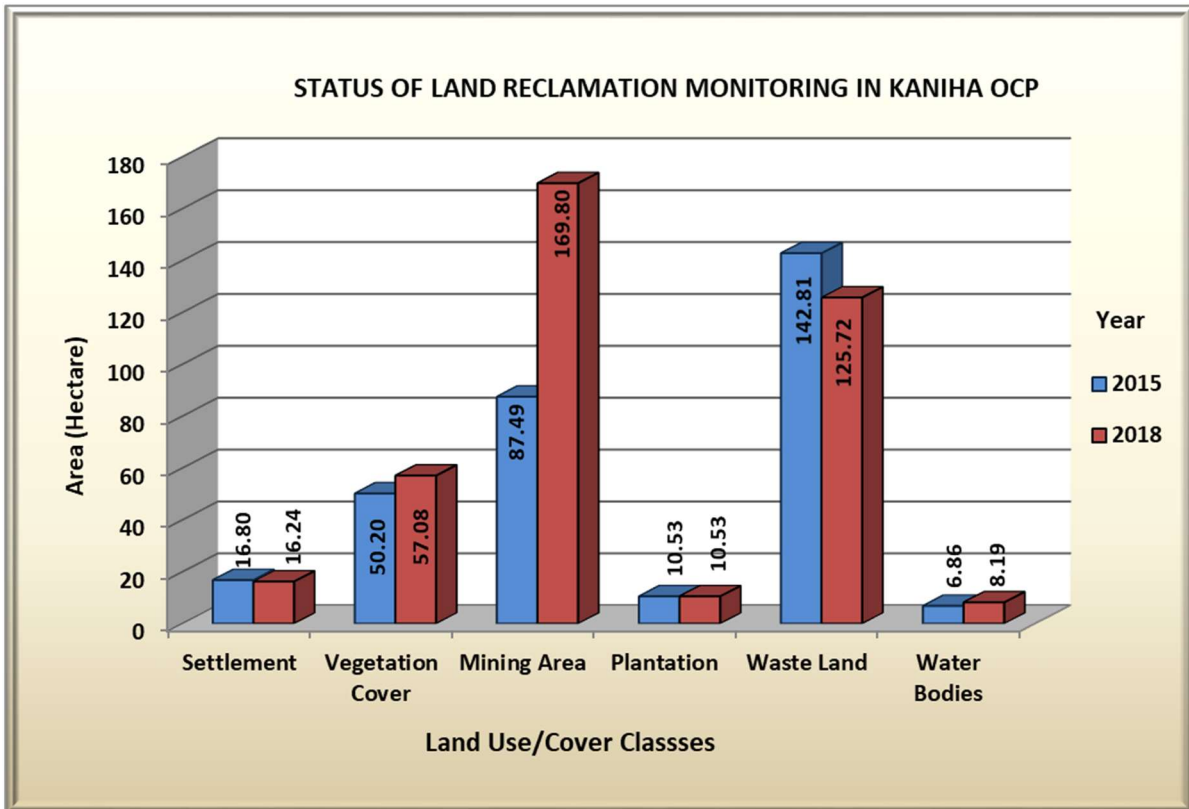**FIGURE - 3**

FIGURE - 4

FIGURE – 5

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

Photo 2: Plantation on Backfill (Basundhara OCP)

Photo 3: Social forestry Plantation (Kaniha OCP)

Photo 4: Social forestry Plantation (Kaniha OCP)