Land Restoration / Reclamation Monitoring of 50 Opencast Coal Mines Projects of CIL producing more than 5 mcm (Coal+OB) based on Satellite Data for the Year 2016-17

cmpdi
A Mini-Ratna Company

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Remote Sensing Cell
Geomatics Division
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Executive Summary

1.0 Project

Land restoration / reclamation monitoring of 50 opencast coal mines in different subsidiaries of Coal India Ltd. (CIL) producing 5 million cu.m. and more (Coal+OB) per year based on satellite data on annual basis.

2.0 Objective

Objective of the land restoration / reclamation monitoring is to assess the area under backfilling, plantation, social forestry, active mining area, water bodies, distribution of wasteland, agricultural land and forest in the leasehold area of the project. This will help in assessing the progressive status of mined land reclamation and to take up remedial measures, if any, required for environmental protection.

3.0 Salient Findings

- Out of the total mine leasehold area of 617.08 Km^2 of the 50 OC projects considered for monitoring during 2016-17; total excavated area is 379.18 Km^2; out of which 161.56 Km^2 area (42.61%) has been planted (Biologically Reclaimed), 132.63 Km^2 area (34.98%) is under backfilling (Technical Reclamation) and 84.99 Km^2 area (22.41%) is under active mining. It is evident from the analysis that 294.19 Km^2 (77.59%) area out of the total excavated area of the 50 OC projects is already under reclamation and balance 84.99 Km^2 (22.41%) area is under active mining. Company wise details are given in Table - 1 & Fig-1.

- On comparing the status of land reclamation carried out in year 2016-17 with respect to years 2015-16 in the 50 Opencast projects of different coal companies, it is evident from the analysis that area under land reclamation has increased from 289.38 Km^2 (Yr. 2015-16) to 294.19 Km^2 (Yr. 2016-17) which includes both plantation (Biological Reclamation) and areas under backfilling (Technical Reclamation). This increase of 4.81 Km^2 area of land reclamation in last one year is the result of the efforts made by CIL's subsidiary companies towards reclamation. Year wise comparison in land reclamation in different subsidiaries is given in Fig.2.

- It has been observed that in NCL, WCL & CCL area of biological reclamation has reduced in the leasehold areas of the opencast projects selected for this study primarily because of OB dumping on vegetated OB Dump/ Backfilled /Other areas due to constrain of dumping space.

Table-1

Company wise Land Reclamation Status in OC projects (5 million cu.m. and more Coal +OB) based on Satellite Data of year 2016-17

Sl. No.	Coal Company (No. of OC Projects)	Area in Sq. Kms. (% calculated in respect of total excavated area)											
		Leasehold / All Right Boundary	Biological Reclamation		Technical Reclamation		Area under Active Mining		Total Excavated Area		Total Area under Reclamation	
			Area under Plantation		Area under Backfilling / OB							
			2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
		(i)		(ii)		(iii)		(iv)	(ii+iii+iv)		(ii+iii)	
1	WCL (10)	95.01	28.48	27.92	26.28	27.82	10.90	11.50	65.66	67.24	54.76	55.74
			43.37	41.52	40.02	41.37	16.60	17.10			83.40	82.90
2	SECL (10)	157.20	43.02	44.49	29.08	29.12	19.06	17.83	91.16	91.44	72.10	73.61
			47.19	48.65	31.90	31.85	20.91	19.50			79.09	80.50
3	NCL (10)	174.28	57.52	54.96	31.03	32.61	26.50	29.40	115.05	116.97	88.55	87.57
			50.00	46.99	26.97	27.88	23.03	25.13			76.97	74.87
4	MCL (11)	86.36	14.59	14.61	18.12	19.24	16.07	16.53	48.77	50.38	32.70	33.85
			29.91	29.00	37.15	38.19	32.95	32.81			67.05	67.19
5	CCL (05)	48.47	15.07	14.24	7.00	8.10	4.76	4.48	26.83	26.82	22.07	22.34
			56.17	53.09	26.09	30.20	17.74	16.70			82.26	83.30
6	BCCL (02)	16.32	1.55	1.60	5.53	5.73	1.12	0.99	8.20	8.32	7.08	7.33
			18.90	19.23	67.44	68.87	13.66	11.90			86.34	88.10
7	ECL (02)	39.44	3.70	3.74	8.42	10.01	3.26	4.26	15.38	18.01	12.12	13.75
			24.06	20.77	54.75	55.58	21.20	23.65			78.80	76.35
TOTAL CIL (50)		**617.08**	**163.93**	**161.56**	**125.46**	**132.63**	**81.67**	**84.99**	**371.05**	**379.18**	**289.38**	**294.19**
(More than 5 MCM)			44.18	42.61	33.81	34.98	22.01	22.41			77.99	77.59

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

1. *Area under **Biological Reclamation** includes Areas under Plantation done on Backfill & External OB Dumps.*
2. *Area under **Technical Reclamation** includes Area under Backfilling & OB Dumps.*
3. *Area under **Active Mining** Includes Coal Quarry, Advance Quarry Site, Quarry filled with water, if any.*

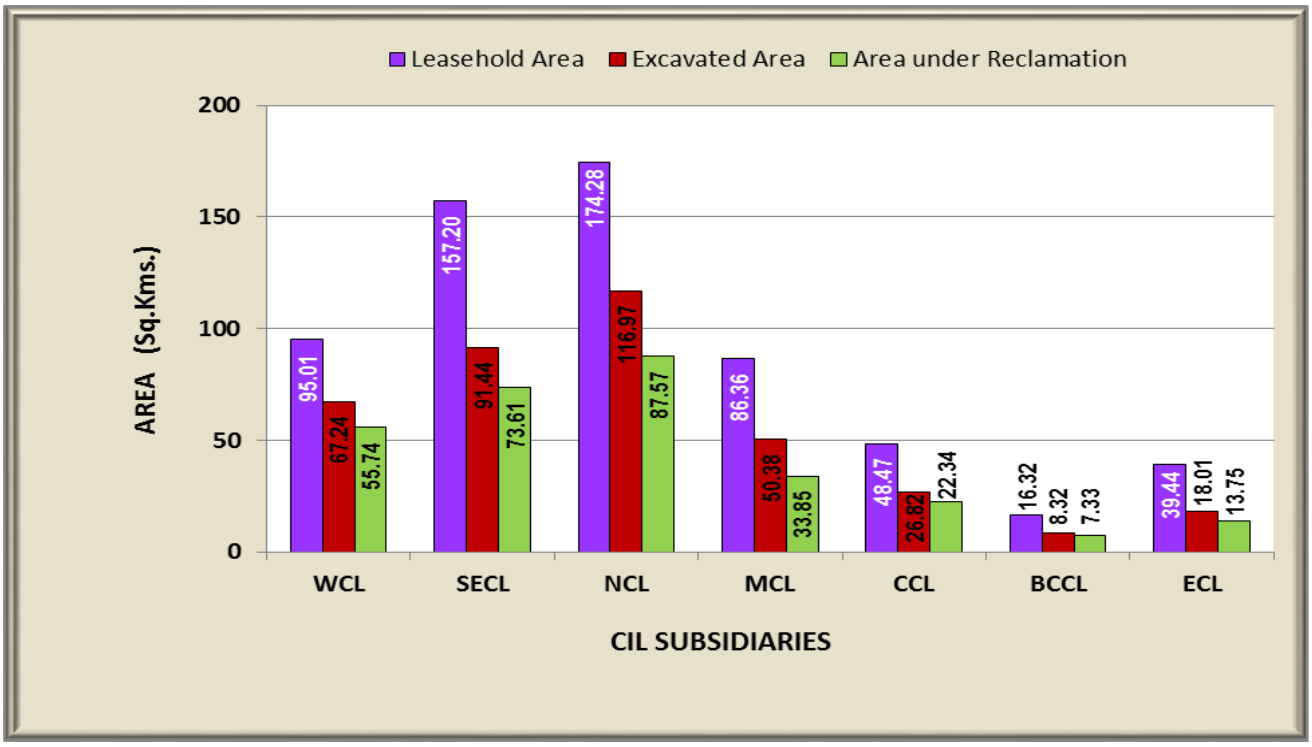


Fig. 1 : **Company wise Land Reclamation Status in the Year 2016**

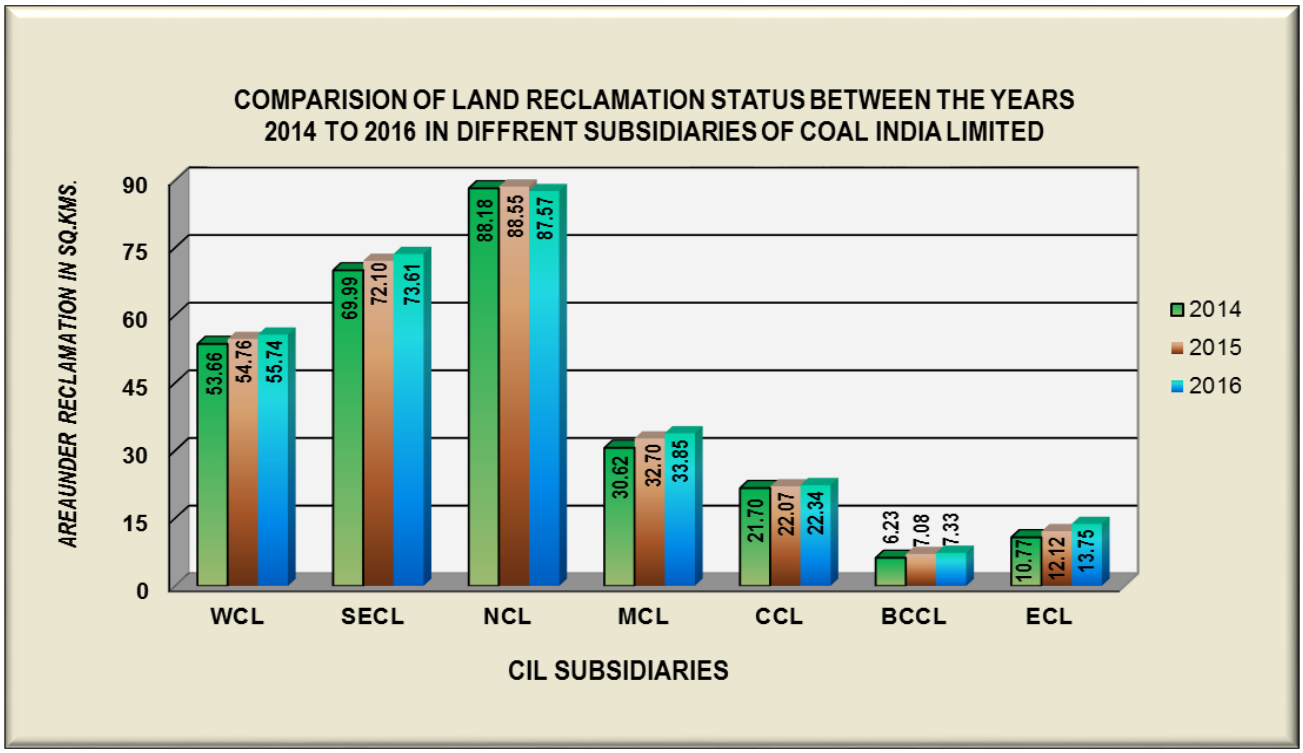


Fig.2 : **Yearwise comparision of Land Reclamation in CIL Subsidiaries**

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 m^3 per annum (coal + OB taken together per annum) based on remote sensing satellite data, regularly on annual basis for sustainable development of mining. Another work order vide letter no. CIL/WBP/ENV./2011dated23/08/11was issued by CIL for monitoring of less than 5 million m^3 per annum capacity (Coal +OB) projects from the year 2011 at interval of three years. 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. 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 yrs. All coalfields in CIL shall also be monitored at an interval of 3 years as per a defined plan. 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 CMPDI undertook the above study and the present report is embodying the findings in nutshell carrying out for the 50 opencast projects of different subsidiaries producing 5 million cubic m. coal +OB or more in the year 2016-17. This study is being carried out in since year 2008 on annual basis and progressive changes in the status of land reclamation have been assessed.

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 3. Following steps are involved in land reclamation /restoration monitoring:

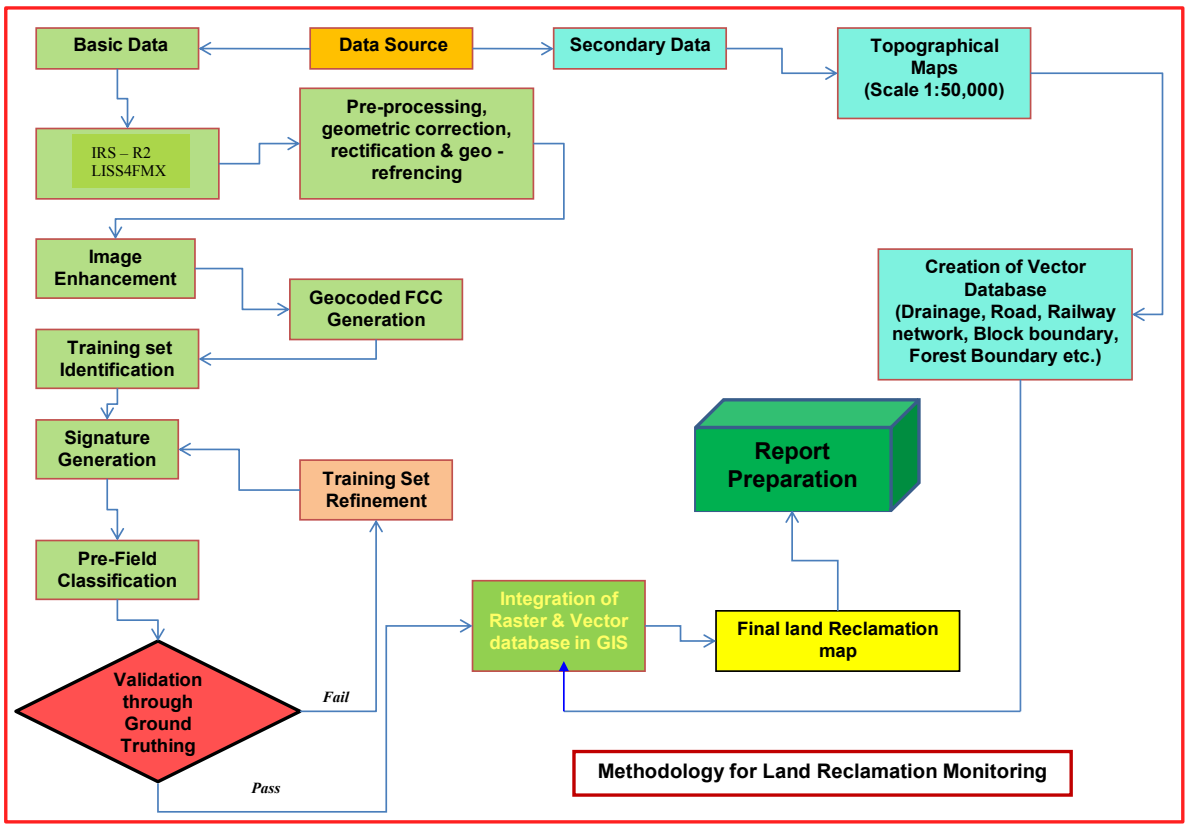


Fig.3 : Methodology for Land Reclamation Monitoring

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 Professional v2014 s/w / PCI Geomatica digital image processing s/w. Methodology involves the following major steps:

- **Rectification & Geo-referencing:** 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, geo-referencing 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 Professional v2014 s/w / PCI Geomatica digital image processing s/w and enhance the image quality for proper 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 Professional v2014/ PCI Geomatica digital image processing s/w.

- **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 Work Plan

4.1 Total 50 opencast projects producing 5 million cubic m. and more (Coal + OB together) during the year 2016-17 were taken up for the study. Based on the *RESOURCESAT-2* satellite data, land reclamation / mine closure monitoring was carried out using ERDAS IMAGINE digital image processing s/w and Arc-Info GIS. Baseline data on reclamation of these OC projects of CIL's subsidiaries have been generated and the same has been annually updated since year 2008.

4.2 Besides project wise land reclamation monitoring, coalfield wise vegetation cover monitoring on regional scale has also been planned for the major 28 coalfields of India at regular interval of three years using remote sensing satellite data to assess the regional impact of coal mining and associated industrialization on the land use and vegetation cover in the coalfield. Geo-environmental baseline data for Raniganj, Jharia , East Bokaro, West Bokaro, Karanpura, Singrauli (Moher Sub-basin), Korba, Bisrampur, Shoagpur, Mand-Raigarh, Talcher, Ib Valley , Wardha Valley, Bander , Kamptee, Umrer, Pench Kanhan and Makum coalfields based on the satellite data have been generated and will be monitored regularly at three years interval.

4.3 The list of subsidiary wise 50 opencast projects taken up for Land Reclamation Monitoring based on satellite data of year 2016-17 is given in table below :

Subsidiary *(No. of Projects)*	**Opencast Projects** *(5 million Cu.m. Coal +OB or more per annum)*
WCL (10)	Sasti, Padmapur, Durgapur, Mugoli, Umrer, Ukni, Niljai, New Majri, Pimpalgaon & Ghugus
SECL (10)	Dipka, Gevra, Kusmunda, Manikpur, Bishrampur, Dugga, Jamuna, Rajnagar, Dhanpuri & Chirimiri
NCL (10)	Amlohri, Nigahi, Jayant, Dudhichua, Khadia, Krishnashila, Bina, Kakri, Jhingurdah, Block-B
MCL (11)	Ananta, Balram, Lingraj, Bharatpur, Bhubaneswari, Jagannath, Hingula, Belpahar, Lakhanpur, Samleswari, & Lajkura
CCL (05)	Ashoka, Piparwar, K.D. Hesalong, Parej & Rajrappa
BCCL (02)	Block-II, Muraidih
ECL (02)	Sonpur-Bazari, Rajmahal
TOTAL (50)	

4.4 Subsidiary wise land reclamation status of the above mentioned 50 OC projects derived from satellite data for the year 2016 are given in the following pages:

CENTRAL COALFIELDS LIMITED

9.0 Land Reclamation Status in Central Coalfields Ltd.

9.1 Following 5 OC projects producing more than 5 million m^3. (Coal + OB together) of Central Coalfields Ltd. have been taken up during the year 2016-17 for land reclamation monitoring:

- Ashok
- Piparwar
- KD Hesalong
- Parej East
- Rajrappa

9.2 Projectwise Land Reclamation status in CCL in the year 2016 is given in Table 9.1 and also shown graphically in Fig 9.1. Area statistics of different land use classes present in OC projects in the year 2016 is given in Table 9.2. Land use maps derived from the satellite data is given in Plate no. 9.1 to 9.5. Changes in land use status are shown in Fig. 9.2 – 9.6 and field photographs showing plantation and backfilled area in mining projects in photo 9.1-9.5.

9.3 Study reveals that 83.30% of excavated mining area has already been reclaimed by CCL in the above 5 OC projects, out of which 53.09% area has been re-vegetated and 30.20 % area is under backfilling.

9.4 After analyzing the satellite data of year 2016, it is seen that the plantation carried out on backfilled area, OB dumps as well as under social forestry in all the 5 mines of CCL has reached 14.24 Km^2 till the year 2016.

9.5 It may be seen from the Table.9.1 that area of total reclamation has reached 83.30% of the total excavated area till the year 2016-17.

TABLE – 9.1

Project wise Land Reclamation Status in OC projects of Central Coalfields Ltd Based on Satellite data of the Year 2016

% Calculated in terms of Total Excavated Area *(Area in Km^2)*

Sl. No.	Project			Biological Reclamation (Plantation)		Technical Reclamation (Under Backfilling)		Area Under Active Mining		Total Excavated Area		Total Area under Reclamation	
	Name	Leasehold		ii		iii		iv		ii+iii+iv		ii+iii	
		2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
1	*ASHOK*	6.75	6.75	1.30	1.30	1.23	1.39	1.06	1.09	3.59	3.78	2.53	2.69
				36.21	*34.39*	*34.26*	*36.77*	*29.53*	*28.84*			*70.47*	*71.16*
2	*PIPARWAR*	11.20	11.20	4.71	4.00	1.22	1.72	1.76	1.60	7.69	7.32	5.93	5.72
				61.25	*54.64*	*15.86*	*23.50*	*22.89*	*21.86*			*77.11*	*78.14*
3	*KDH*	4.50	4.50	1.47	1.50	1.49	1.57	0.51	0.47	3.47	3.54	2.96	3.07
				42.36	*42.37*	*42.94*	*44.35*	*14.70*	*13.28*			*85.30*	*86.72*
4	*PAREJ EAST*	6.20	6.20	0.70	0.73	0.89	0.96	0.33	0.28	1.92	1.97	1.59	1.69
				36.46	*37.06*	*46.35*	*48.73*	*17.19*	*14.21*			*82.81*	*85.79*
5	*RAJRAPPA*	19.82	19.82	6.89	6.71	2.17	2.46	1.10	1.04	10.16	10.21	9.06	9.17
				67.81	*65.72*	*21.36*	*24.09*	*10.83*	*10.19*			*89.17*	*89.81*
	TOTAL (CCL)	**48.47**	**48.47**	**15.07**	**14.24**	**7.00**	**8.10**	**4.76**	**4.48**	**26.83**	**26.82**	**22.07**	**22.34**
				56.17	*53.09*	*26.09*	*30.20*	*17.74*	*16.70*	*55.35*	*55.33*	*82.26*	*83.30*

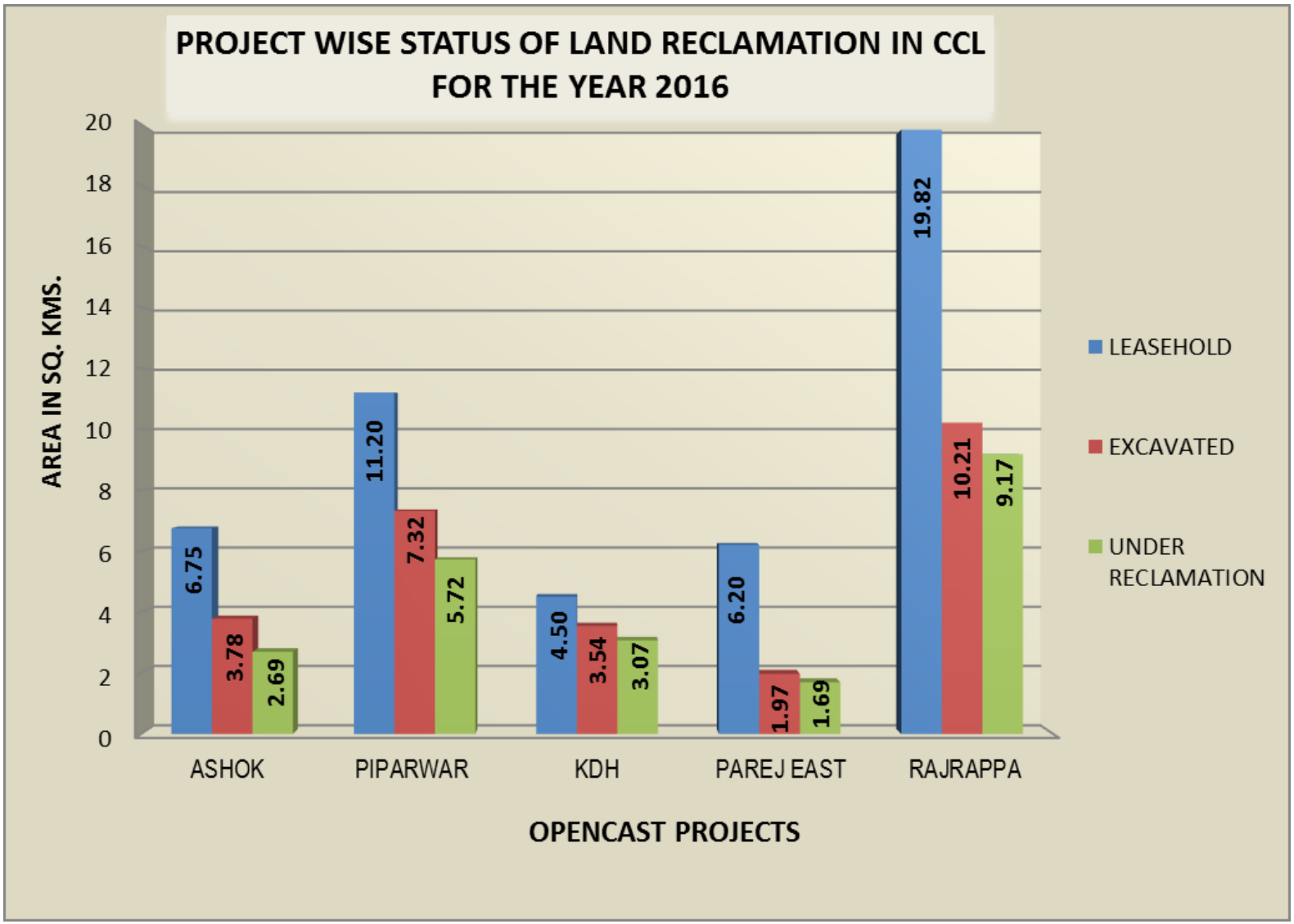
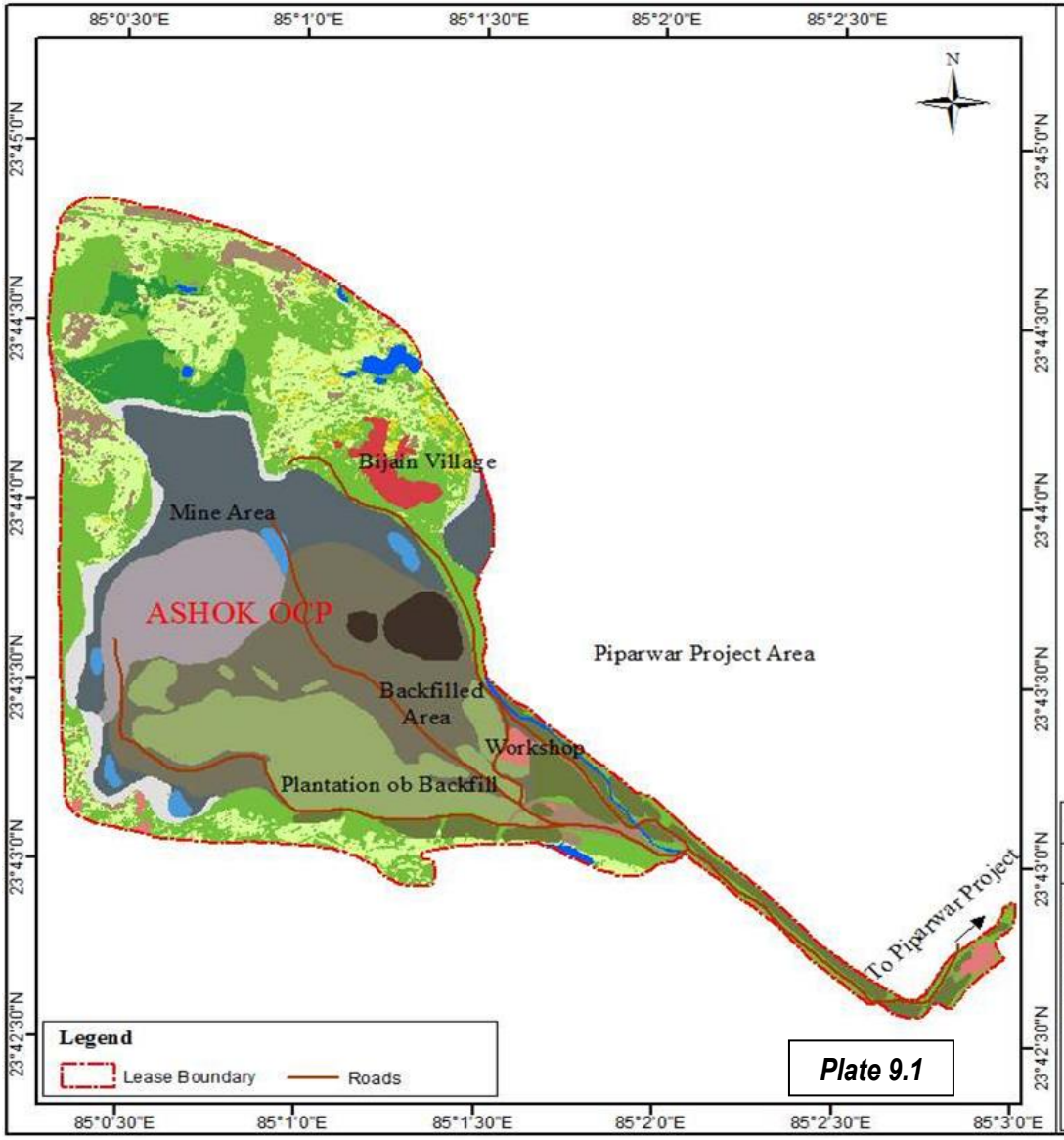


Fig. 9.1 : **Project wise Land Reclamation Status in Year 2016**

Table 9.2: STATUS OF LAND RECLAMTION IN CENTRAL COALFIELDS LIMITED BASED ON THE SATELLITE DATA OF THE YEAR 2016-17

(Area in Sq. Km)

		ASHOK		PIPARWAR		KDH		RAJRAPPA		PAREJ EAST		TOTAL	
		Area	%	Area	%	Area	%	Area	%	Area	%	Area	%
FORESTS	Dense Forest	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Open Forest	0.23	3.41	0.16	1.43	0.00	0.00	1.50	7.57	1.31	21.13	3.20	6.60
	Total Forest	**0.23**	**3.41**	**0.16**	**1.43**	**0.00**	**0.00**	**1.50**	**7.57**	**1.31**	**21.13**	**3.20**	**6.60**
SCRUBS	Scrubs	**1.33**	**19.70**	**1.07**	**9.55**	**0.48**	**10.67**	**4.86**	**24.52**	**1.87**	**30.16**	**9.61**	**19.83**
PLANTATION	Social Forestry	0.34	5.04	1.65	14.73	0.12	2.67	1.88	9.49	0.09	1.45	4.08	8.42
	Plantation on OB Dump	0.00	0.00	0.80	7.14	0.05	1.11	3.56	17.96	0.04	0.65	4.45	9.18
	Plantation on Backfill	0.96	14.22	1.55	13.84	1.33	29.56	1.27	6.41	0.60	9.68	5.71	11.78
	Total Plantation *(Biological Reclamation)*	**1.30**	**19.26**	**4.00**	**35.71**	**1.50**	**33.33**	**6.71**	**33.85**	**0.73**	**11.77**	**14.24**	**29.38**
	Total Vegetation	**2.86**	**42.37**	**5.23**	**46.70**	**1.98**	**44.00**	**13.07**	**65.94**	**3.91**	**63.06**	**27.05**	**55.81**
ACTIVE MINING	Coal Quarry	0.73	10.81	0.95	8.48	0.22	4.89	0.45	2.27	0.09	1.45	2.44	5.03
	Coal Dump	0.12	1.78	0.16	1.43	0.11	2.44	0.23	1.16	0.11	1.77	0.73	1.51
	Advance Quarry Site	0.18	2.67	0.17	1.52	0.00	0.00	0.16	0.81	0.02	0.32	0.53	1.09
	Quarry Filled With Water	0.06	0.89	0.32	2.86	0.14	3.11	0.20	1.01	0.06	0.97	0.78	1.61
	Total Area under *Active Mining*	**1.09**	**16.15**	**1.60**	**14.29**	**0.47**	**10.44**	**1.04**	**5.25**	**0.28**	**4.51**	**4.48**	**9.24**
RECLAIMED	Barren OB Dump	0.43	6.37	0.00	0.00	0.50	11.11	1.76	8.88	0.52	8.39	3.21	6.62
	Area Under Backfilling	0.96	14.22	1.72	15.36	1.07	23.78	0.70	3.53	0.44	7.10	4.89	10.09
	Total Area under *Technical Reclamation*	**1.39**	**20.59**	**1.72**	**15.36**	**1.57**	**34.89**	**2.46**	**12.41**	**0.96**	**15.49**	**8.10**	**16.71**
	Total Area under *Mine Operation*	**2.48**	**36.74**	**3.32**	**29.65**	**2.04**	**45.33**	**3.50**	**17.66**	**1.24**	**20.00**	**12.58**	**25.95**
WASTELAND	Waste Lands	0.28	4.15	0.45	4.02	0.15	3.33	0.85	4.29	0.17	2.74	1.90	3.92
	Fly Ash Pond / Sand Body	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.32	0.02	0.04
	Total Wasteland	**0.28**	**4.15**	**0.45**	**4.02**	**0.15**	**3.33**	**0.85**	**4.29**	**0.19**	**3.06**	**1.92**	**3.96**
WATERBODY	Reservoir, Nallah, Ponds	0.06	0.89	0.23	2.05	0.12	2.67	0.02	0.10	0.06	0.97	0.49	1.01
	Total Waterbodies	**0.06**	**0.89**	**0.23**	**2.05**	**0.12**	**2.67**	**0.02**	**0.10**	**0.06**	**0.97**	**0.49**	**1.01**
AGRICULTURE	Crop Lands	0.07	1.04	0.12	1.07	0.00	0.00	0.08	0.40	0.04	0.65	0.31	0.64
	Fallow Lands	0.87	12.88	1.12	9.99	0.01	0.23	1.20	6.06	0.39	6.29	3.59	7.41
	Total Agriculture	**0.94**	**13.92**	**1.24**	**11.06**	**0.01**	**0.23**	**1.28**	**6.46**	**0.43**	**6.94**	**3.90**	**8.05**
SETTLEMENTS	Urban Settlement	0.00	0.00	0.07	0.63	0.01	0.22	0.47	2.37	0.16	2.58	0.71	1.46
	Rural Settlement	0.08	1.19	0.16	1.43	0.00	0.00	0.27	1.36	0.17	2.74	0.68	1.40
	Industrial Settlement	0.05	0.74	0.50	4.46	0.19	4.22	0.36	1.82	0.04	0.65	1.14	2.35
	Total Settlement	**0.13**	**1.93**	**0.73**	**6.52**	**0.20**	**4.44**	**1.10**	**5.55**	**0.37**	**5.97**	**2.53**	**5.22**
	Grand Total	**6.75**	**100.00**	**11.20**	**100.00**	**4.50**	**100.00**	**19.82**	**100.00**	**6.20**	**100.00**	**48.47**	**100.00**



Area Statistics - Ashok OCP (2016)

Classes		Colour	Area	
Level-I	Level-II		Area (Km^2)	% of Total
Forest Area	Dense Forest		0.00	0.00
	Open Forest		0.23	3.41
	Total Forest Area		**0.23**	**3.41**
Scrubs	**Scrubs**		**1.33**	**19.70**
Plantation	Social Forestry		0.34	5.04
	Plantation on Backfill		0.96	14.22
	Plantation on OB Dump		0.00	0.00
	Total Plantation		**1.30**	**19.26**
	Total Vegetation Area		**2.86**	**42.37**
Agriculture	Crop Land		0.07	1.04
	Fallow Land		0.87	12.89
	Total Agriculture Area		**0.94**	**13.93**
Waste Land	Waste Land		0.28	4.15
	Sand Body		0.00	0.00
	Total Waste Land		**0.28**	**4.15**
Mining Area	Coal Quarry		0.73	10.81
	Barren OB Dump		0.43	6.37
	Area Under Backfilling		0.96	14.22
	Water Filled Quarry		0.06	0.89
	Coal Dump		0.12	1.78
	Advance Quarry Site		0.18	2.67
	Total Mining Area		**2.48**	**36.74**
Settlements	Rural Settlement		0.08	1.19
	Urban Settlement		0.00	0.00
	Industrial Settlement		0.05	0.74
	Total Settlement Area		**0.13**	**1.93**
Water Body	**River, Ponds**		**0.06**	**0.89**
		Total	**6.75**	**100.00**

Customer	Central Coalfields Limited				
Title	Land Reclamation Monitoring of OC Projects				Job No. 561410027
Subject Land Reclamation Status of Ashok OCP based on Satellite Data (RS-2/L-IV) of the year 2016	Activity	Name	Designation	Signature	Date
	Prepared	Hariharalal B	Sr. Mgr(Sys)		
	Checked	R. Kumar	Ch. Mgr(RSC)		
	Approved	N. P. Singh	GM(Geomatics)		
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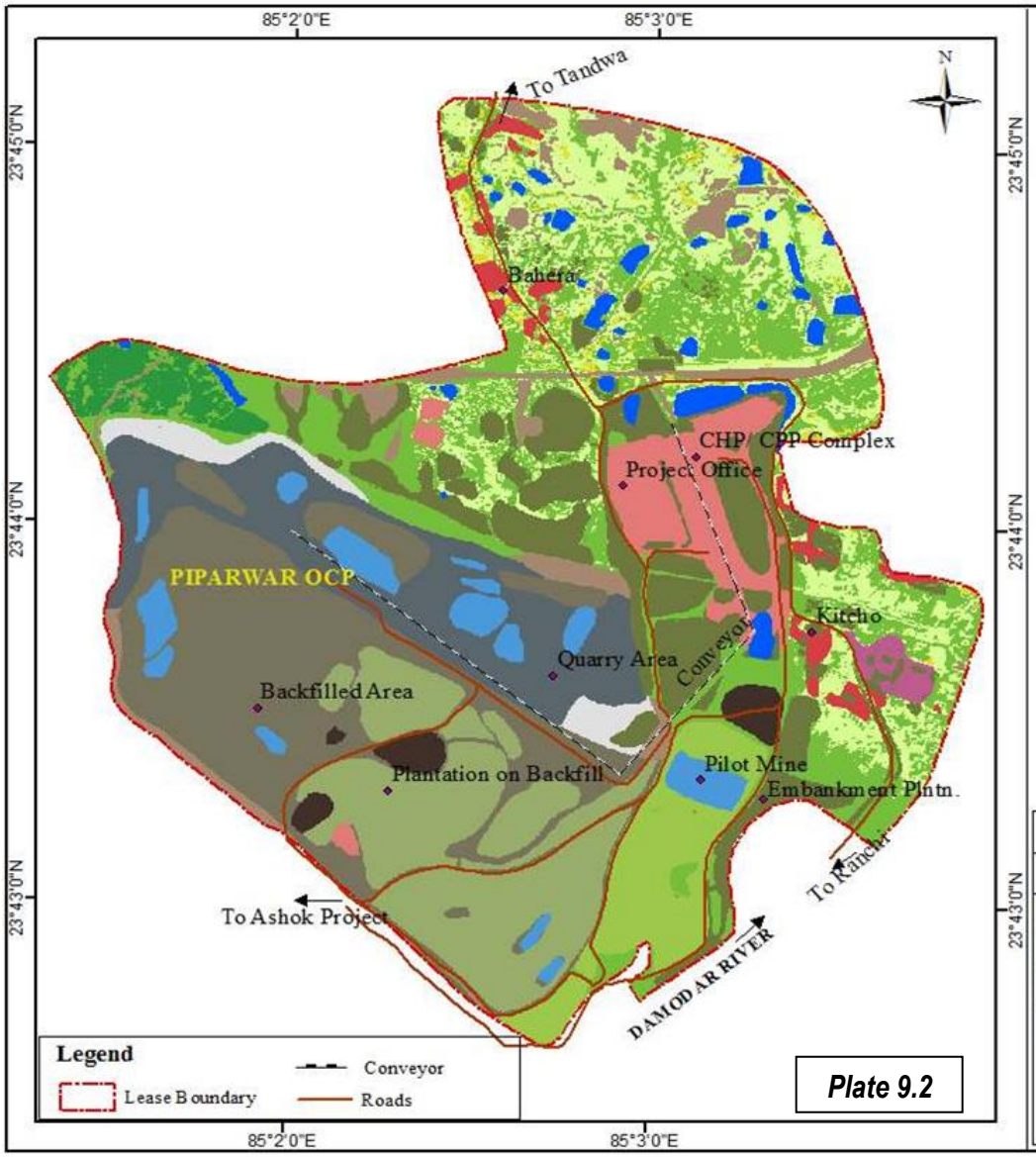
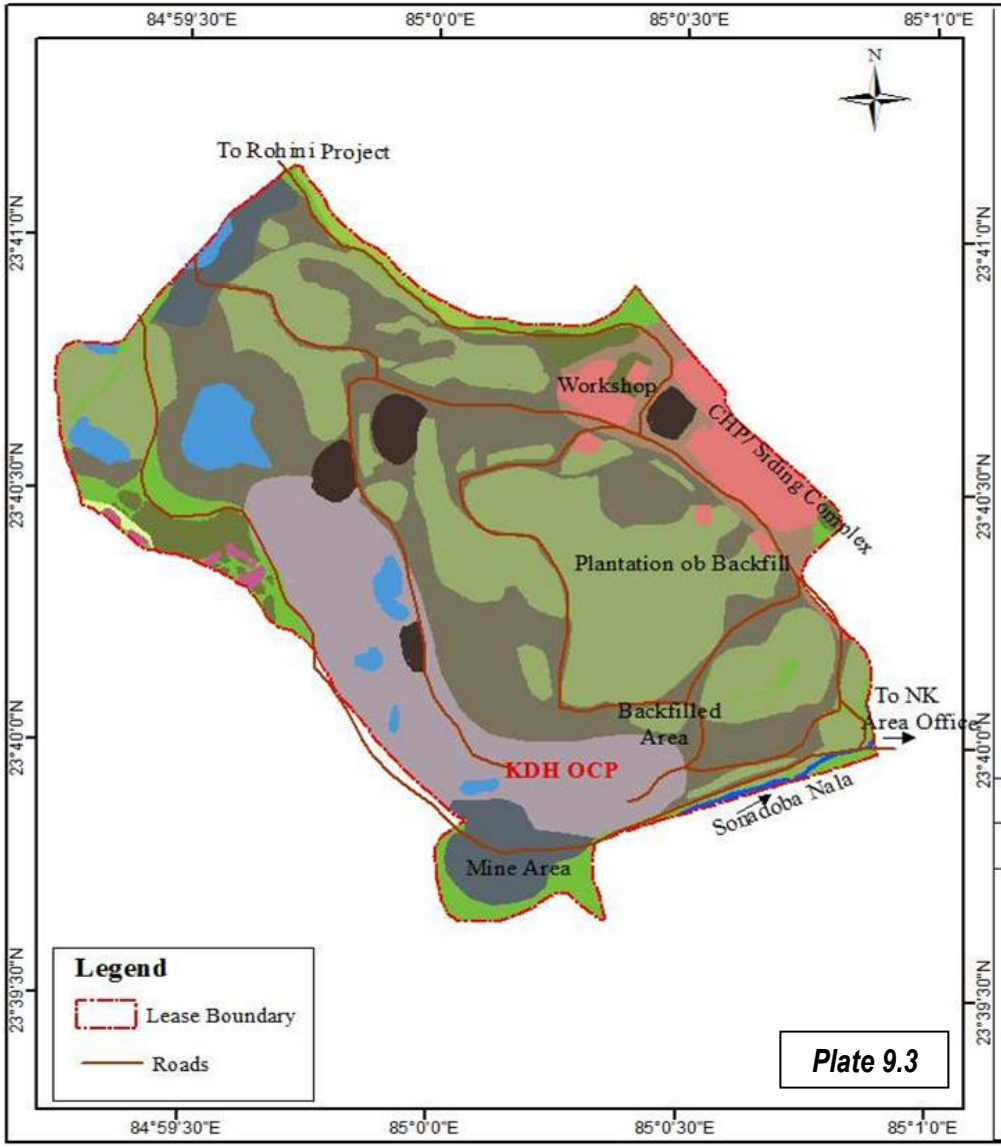
	Drg No. HQ REM 16 3 A4 05				Rev No.0



Area Statistics - Piparwar OCP (2016)

Classes		Colour	Area	
Level-I	Level-II		Area (Km^2)	% of Total
Forest Area	Dense Forest		0.00	0.00
	Open Forest		0.16	1.43
	Total Forest Area		**0.16**	**1.43**
Scrubs	**Scrubs**		**1.07**	**9.55**
Plantation	Social Forestry		1.65	14.73
	Plantation on Backfill		1.55	13.84
	Plantation on OB Dump		0.80	7.14
	Total Plantation		**4.00**	**35.71**
	Total Vegetation Area		**5.23**	**46.70**
Agriculture	Crop Land		0.12	1.07
	Fallow Land		1.12	10.00
	Total Agriculture Area		**1.24**	**11.07**
Waste Land	Waste Land		0.45	4.02
	Sand Body		0.00	0.00
	Total Waste Land		**0.45**	**4.02**
Mining Area	Coal Quarry		0.95	8.48
	Barren OB Dump		0.00	0.00
	Area Under Backfilling		1.72	15.36
	Water Filled Quarry		0.32	2.86
	Coal Dump		0.16	1.43
	Advance Quarry Site		0.17	1.52
	Total Mining Area		**3.32**	**29.64**
Settlements	Rural Settlement		0.16	1.43
	Urban Settlement		0.07	0.63
	Industrial Settlement		0.50	4.46
	Total Settlement Area		**0.73**	**6.52**
Water Body	**River, Ponds**		**0.23**	**2.05**
		Total	**11.20**	**100.00**

Customer	Central Coalfields Limited				
Title	Land Reclamation Monitoring of OC Projects				Job No. 561410027
Subject Land Reclamation Status of Piparwar OCP based on Satellite Data (RS-2/L-IV) of the year 2016	Activity	Name	Designation	Signature	Date
	Prepared	Hariharalal B	Sr. Mgr(Sys)		
	Checked	R. Kumar	Ch. Mgr(RSC)		
	Approved	N. P. Singh	GM(Geomatics)		
cmpdi	Scale: 0 0.25 0.5 1 km				Sheet 1
	Drg No. HQ REM 16 3 A4 06				Rev No.0



Area Statistics - KDH OCP (2016)

Classes		Colour	Area	
Level-I	Level-II		Area (Km^2)	% of Total
Forest Area	Dense Forest		0.00	0.00
	Open Forest		0.00	0.00
	Total Forest Area		**0.00**	**0.00**
Scrubs	**Scrubs**		**0.48**	**10.67**
Plantation	Social Forestry		0.12	2.67
	Plantation on Backfill		1.33	29.56
	Plantation on OB Dump		0.05	1.11
	Total Plantation		**1.50**	**33.33**
	Total Vegetation Area		**1.98**	**44.00**
Agriculture	Crop Land		0.00	0.00
	Fallow Land		0.01	0.22
	Total Agriculture Area		**0.01**	**0.22**
Waste Land	Waste Land		0.15	3.33
	Sand Body		0.00	0.00
	Total Waste Land		**0.15**	**3.33**
Mining Area	Coal Quarry		0.22	4.89
	Barren OB Dump		0.50	11.11
	Area Under Backfilling		1.07	23.78
	Water Filled Quarry		0.14	3.11
	Coal Dump		0.11	2.44
	Advance Quarry Site		0.00	0.00
	Coal Face		0.00	0.00
	Total Mining Area		**2.04**	**45.33**
Settlements	Rural Settlement		0.00	0.00
	Urban Settlement		0.01	0.22
	Industrial Settlement		0.19	4.22
	Total Settlement Area		**0.20**	**4.44**
Water Body	**River, Ponds**		**0.12**	**2.67**
		Total	**4.50**	**100.00**

Customer	Central Coalfields Limited				
Title	Land Reclamation Monitoring of OC Projects				Job No. 561410027
Subject Land Reclamation Status of KDH OCP based on Satellite Data (RS-2/L-IV) of the year 2016	Activity	Name	Designation	Signature	Date
	Prepared	Hariharalal B	Sr. Mgr(Sys)		
	Checked	R. Kumar	Ch. Mgr(RSC)		
	Approved	N. P. Singh	GM(Geomatics)		
	Scale: 0 0.25 0.5 1 km				Sheet 1
	Drg No. HQ REM 16 3 A4 07				Rev No.0

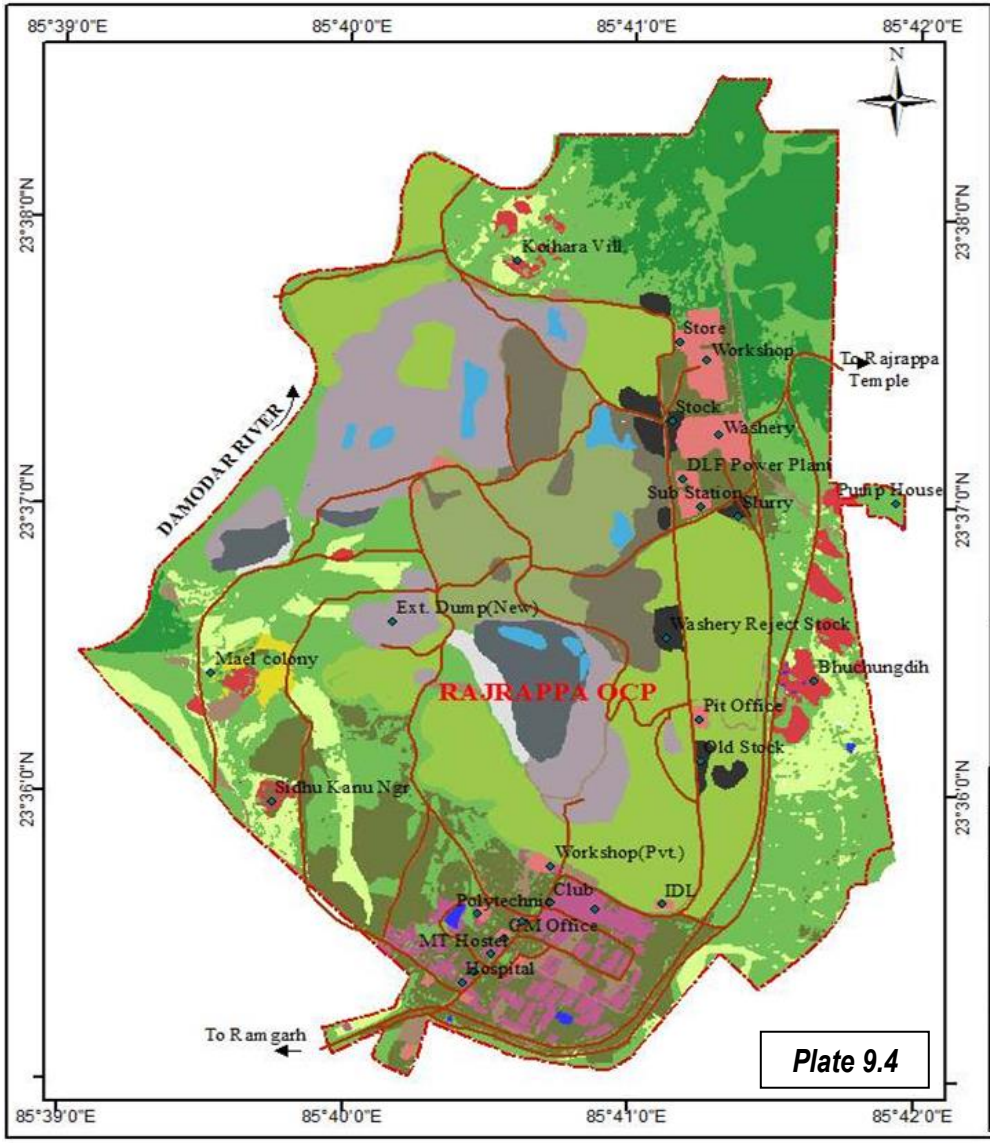


Plate 9.4

Legend

- Lease Boundary
- Roads

Area Statistics - Rajrappa OCP (2016)

Classes		Colour	Area	
Level-I	Level-II		Area (Km^2)	% of Total
Forest Area	Dense Forest		0.00	0.00
	Open Forest		1.50	7.57
	Total Forest Area		**1.50**	**7.57**
Scrubs	**Scrubs**		**4.86**	**24.52**
Plantation	Social Forestry		1.88	9.49
	Plantation on Backfill		1.27	6.41
	Plantation on OB Dump		3.56	17.96
	Total Plantation		**6.71**	**33.85**
	Total Vegetation Area		**13.07**	**65.94**
Agriculture	Crop Land		0.08	0.40
	Fallow Land		1.20	6.05
	Total Agriculture Area		**1.28**	**6.46**
Waste Land	Waste Land		**0.85**	**4.29**
	Sand Body		0.00	0.00
	Total Waste Land		**0.85**	**4.29**
Mining Area	Coal Quarry		0.45	2.27
	Barren OB Dump		1.76	8.88
	Area Under Backfilling		0.70	3.53
	Water Filled Quarry		0.20	1.01
	Coal Dump		0.23	1.16
	Advance Quarry Site		0.16	0.81
	Total Mining Area		**3.50**	**17.66**
Settlements	Rural Settlement		0.27	1.36
	Urban Settlement		0.47	2.37
	Industrial Settlement		0.36	1.82
	Total Settlement Area		**1.10**	**5.55**
Water Body	**River, Ponds**		**0.02**	**0.10**
		Total	**19.82**	**100.00**

Customer	Central Coalfields Limited				
Title	Land Reclamation Monitoring of OC Projects				Job No. 561410027
Subject Land Reclamation Status of Rajrappa OCP based on Satellite Data (RS-2/L-IV) of the year 2016	Activity	Name	Designation	Signature	Date
	Prepared	Hariharalal B	Sr. Mgr(Sys)		
	Checked	R. Kumar	Ch. Mgr(RSC)		
	Approved	N. P. Singh	GM(Geomatics)		
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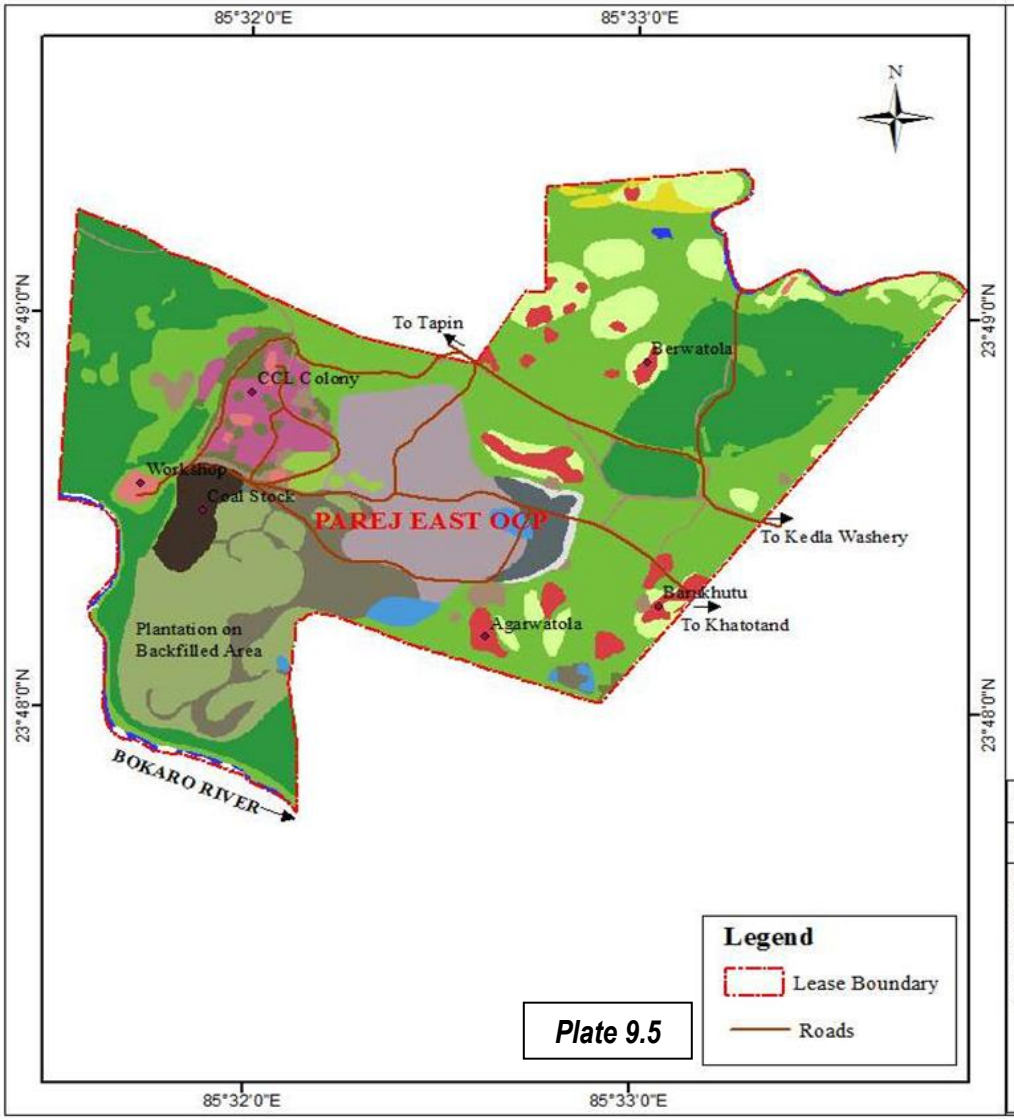
	Drg No. HQ REM 16 3 A4 08				Rev No.0

cmpdi — A Miniratna Company



Area Statistics - Parej East OCP (2016)				
Classes		Colour	Area	
Level-I	Level-II		Area (Km^2)	% of Total
Forest Area	Dense Forest		0.00	0.00
	Open Forest		1.31	21.13
	Total Forest Area		**1.31**	**21.13**
Scrubs	**Scrubs**		**1.87**	**30.16**
Plantation	Social Forestry		0.09	1.45
	Plantation on Backfill		0.60	9.68
	Plantation on OB Dump		0.04	0.65
	Total Plantation		**0.73**	**11.77**
	Total Vegetation Area		**3.91**	**63.06**
Agriculture	Crop Land		0.04	0.65
	Fallow Land		0.39	6.29
	Total Agriculture Area		**0.43**	**6.94**
Waste Land	Waste Land		0.17	2.74
	Sand Body		0.02	0.32
	Total Waste Land		**0.19**	**3.06**
Mining Area	Coal Quarry		0.09	1.45
	Barren OB Dump		0.52	8.39
	Area Under Backfilling		0.44	7.10
	Water Filled Quarry		0.06	0.97
	Coal Dump		0.11	1.77
	Advance Quarry Site		0.02	0.32
	Total Mining Area		**1.24**	**20.00**
Settlements	Rural Settlement		0.17	2.74
	Urban Settlement		0.16	2.58
	Industrial Settlement		0.04	0.65
	Total Settlement Area		**0.37**	**5.97**
Water Body	**River, Ponds**		**0.06**	**0.97**
		Total	**6.20**	**100.00**

Customer	Central Coalfields Limited				
Title	Land Reclamation Monitoring of OC Projects				Job No. 561410027
Subject Land Reclamation Status of Parej East OCP based on Satellite Data (RS-2/L-IV) of the year 2016	Activity	Name	Designation	Signature	Date
	Prepared	Hariharalal B	Sr. Mgr(Sys)		
	Checked	R. Kumar	Ch. Mgr(RSC)		
	Approved	N. P. Singh	GM(Geomatics)		
cmpdi A Miniratna Company	Scale: 0 0.25 0.5 1 km				Sheet 1
	Drg No. HQ REM 16 3 A4 09				Rev No.0

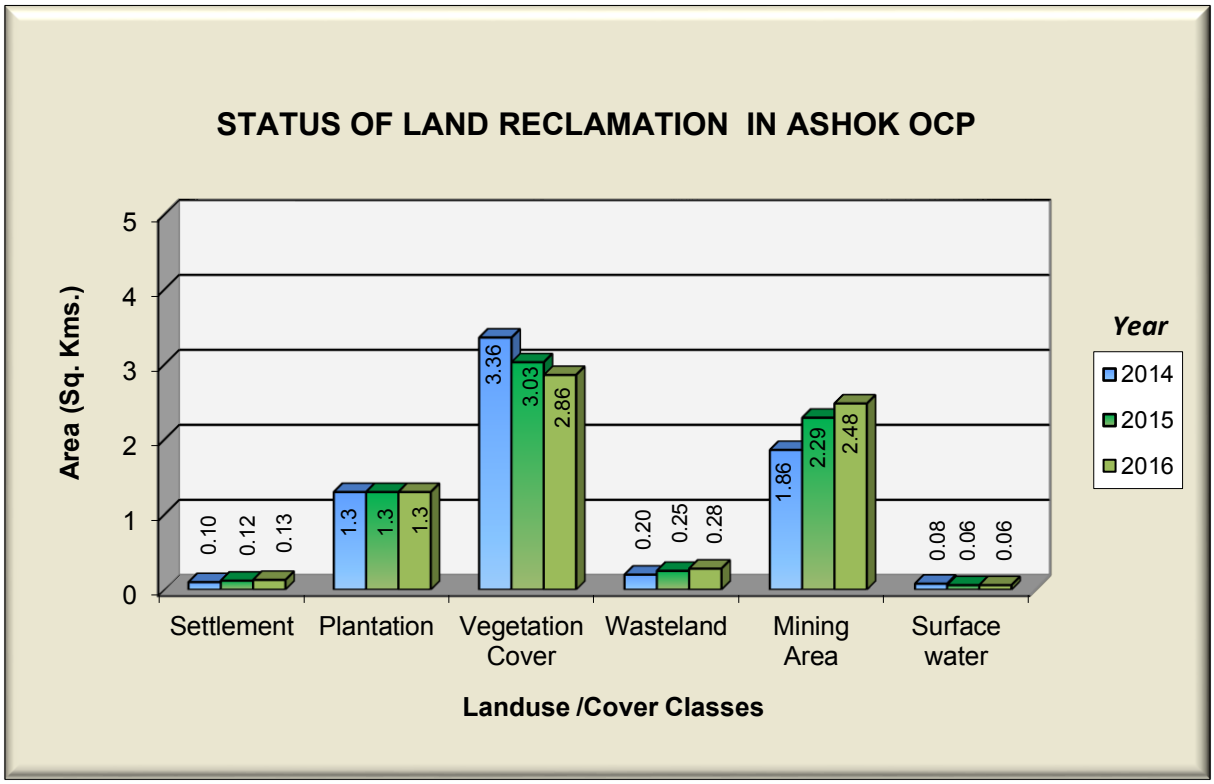


Figure 9.2

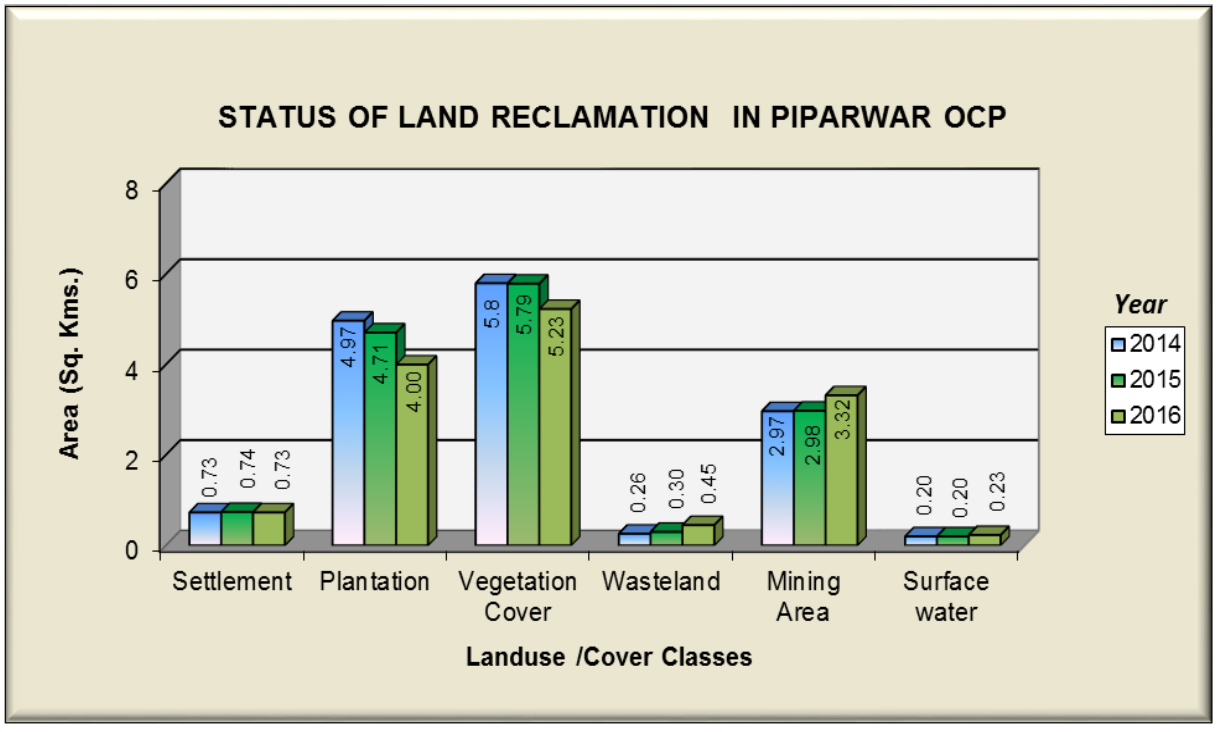


Figure 9.3

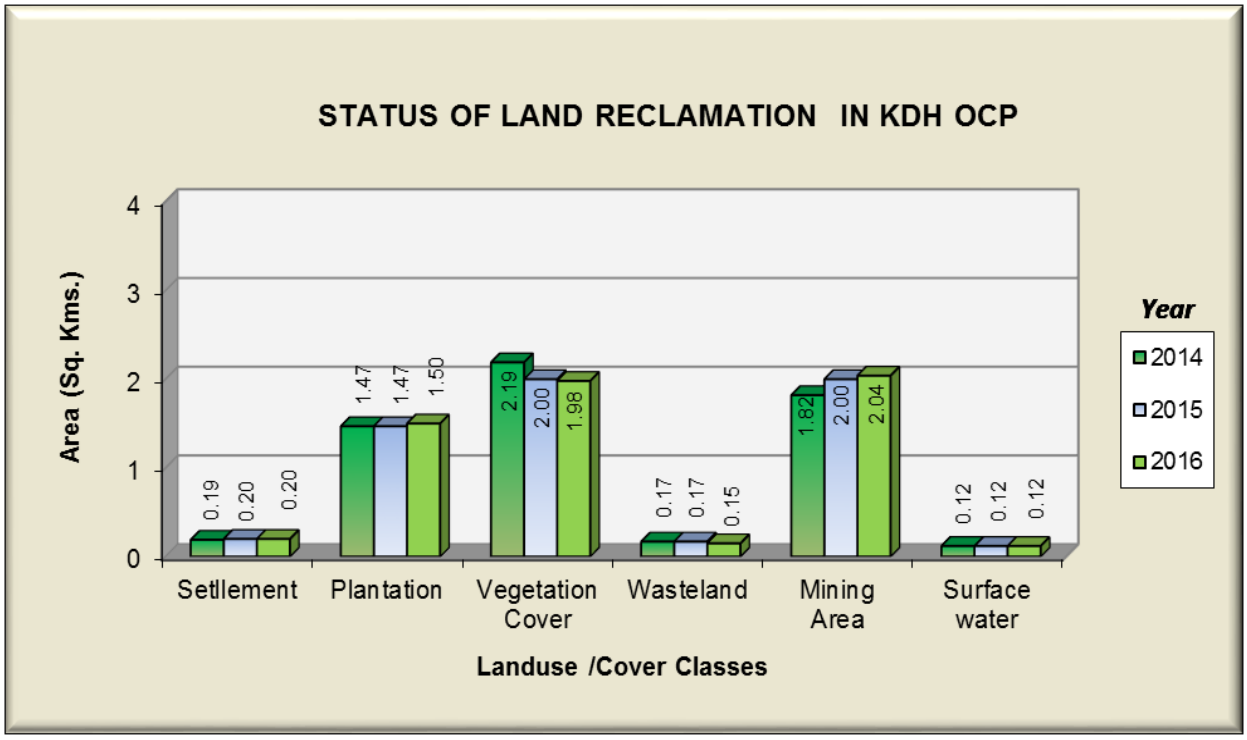


Figure 9.4

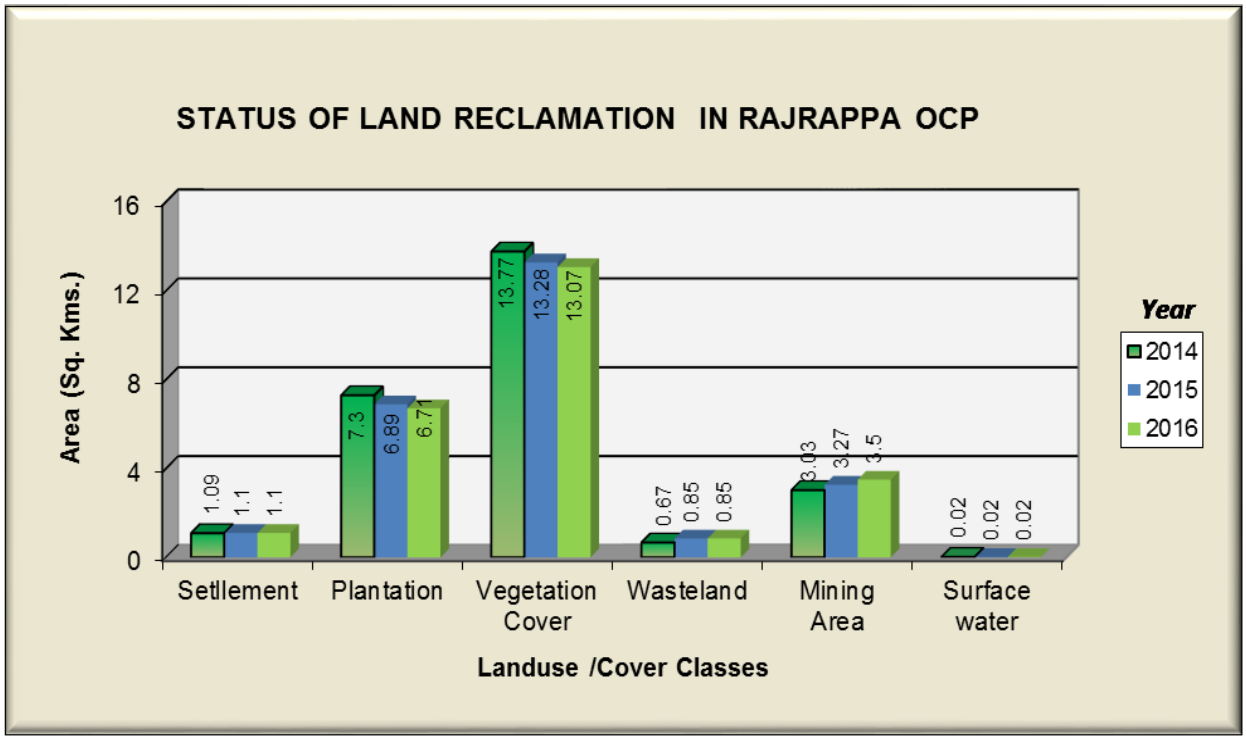


Figure 9.5

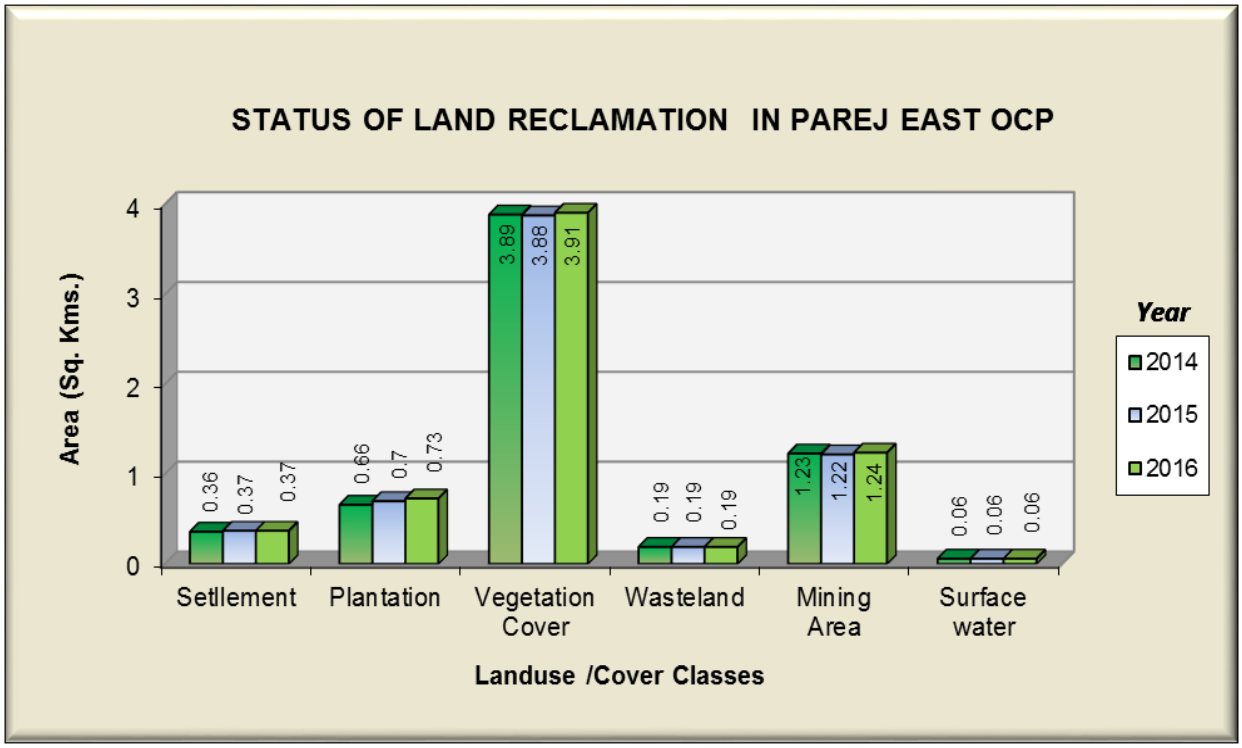

STATUS OF LAND RECLAMATION IN PAREJ EAST OCP
Area (Sq. Kms.)
4
3
2
1
0
0.36
0.37
0.37
0.66
0.7
0.73
3.89
3.88
3.91
0.19
0.19
0.19
1.23
1.22
1.24
0.06
0.06
0.06
Setllement
Plantation
Vegetation Cover
Wasteland
Mining Area
Surface water
Landuse /Cover Classes
Year
2014
2015
2016

Figure 9.6

Photograph 9.1:**Plantation on Backfilled Area -Ashok OCP**

Photograph 9.2 : **Eco Park developed on Reclaimed Area - Piparwar OCP**

Photograph 9.3 : **Plantation- KDH OCP**

Photograph 9.4 : **Plantation in Parej East OCP**

Photograph 9.5 : **Plantation on OB- Rajrappa OCP**