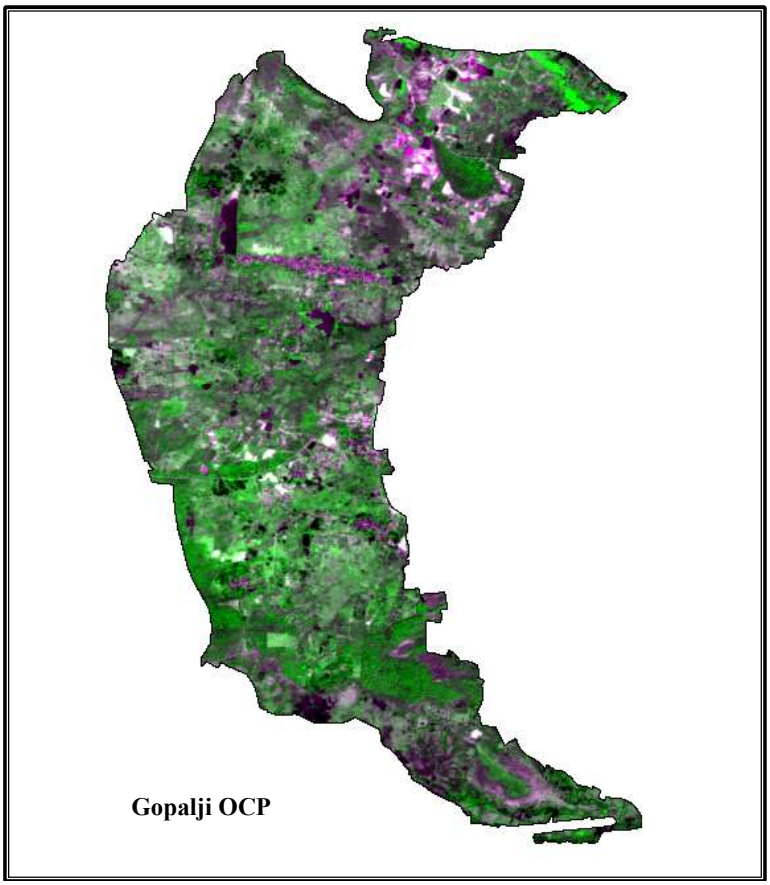
# Land Restoration / Reclamation Monitoring of less than 5 m.cu.m. (Coal+OB) Capacity Open Cast Coal Mine of Mahanadi Coalfields Limited Based on Satellite Data for the Year 2022



Gopalji OCP

*Submitted to*

**Mahanadi Coalfields Limited**

# Land Restoration / Reclamation Monitoring of less than 5 m. cu. m (Coal + OB) capacity Open Cast Coal Mine of Mahanadi Coalfields Limited Based on Satellite Data for the Year 2022

March-2023

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

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# Executive Summary

**1.0 Project**

Land restoration / reclamation monitoring of 1 opencast coal mine 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**

- Mining operation in Gopalji OCP of MCL taken up for this study in the year 2022-23 has not been started as yet. The data like agriculture land, Waste land, Vegetation cover and Surface water body etc related to land Use/Cover within the leasehold boundary of this mine is shown in Table-2.

**TABLE-1**

## LAND RECLAMATION STATUS IN OPENCAST MINE OF MCL BASED ON SATELLITE DATA OF THE YEAR 2022

(PROJECT PRODUCING LESS THAN 5M.C.M (COAL+OB) ANUALLY)

*(Area in Hectare)*

| Sl. No. | Project | Total Leasehold Area | | Technical Reclamation | | Plantation | | | | | | Area under Active Mining | | Total Excavated Area | | Total Area under Plantation (% Green Cover Generated in Leasehold) | | Total Area under Reclamation | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Biological Reclamation | | Other Plantations | | | | | | | | | | | |
| | | | | Area under Backfilling | | Plantation on Excavated / Backfilled Area | | Plantation on External Over Burden Dumps | | Social Forestry, Avanue Plantation Etc. | | | | | | | | | |
| *1* | *2* | *3* | | *4* | | *5* | | *6* | | *7* | | *8* | | *9 (=4+5+8)* | | *10 (=5+6+7)* | | *11(=4+5)* | |
| | | *2019* | *2022* | *2019* | *2022* | *2019* | *2022* | *2019* | *2022* | *2019* | *2022* | *2019* | *2022* | *2019* | *2022* | *2019* | *2022* | *2019* | *2022* |
| 1 | Gopalji | 1141.43 | 1141.43 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | | | 0.00% | 0.00% | 0.00% | 0.00% | | | | | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| | **TOTAL** | **1141.43** | **1141.43** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** |
| | | | | **0.00%** | **0.00%** | **0.00%** | **0.00%** | | | | | **0.00%** | **0.00%** | **0.00%** | **0.00%** | **0.00%** | **0.00%** | **0.00%** | **0.00%** |

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

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

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

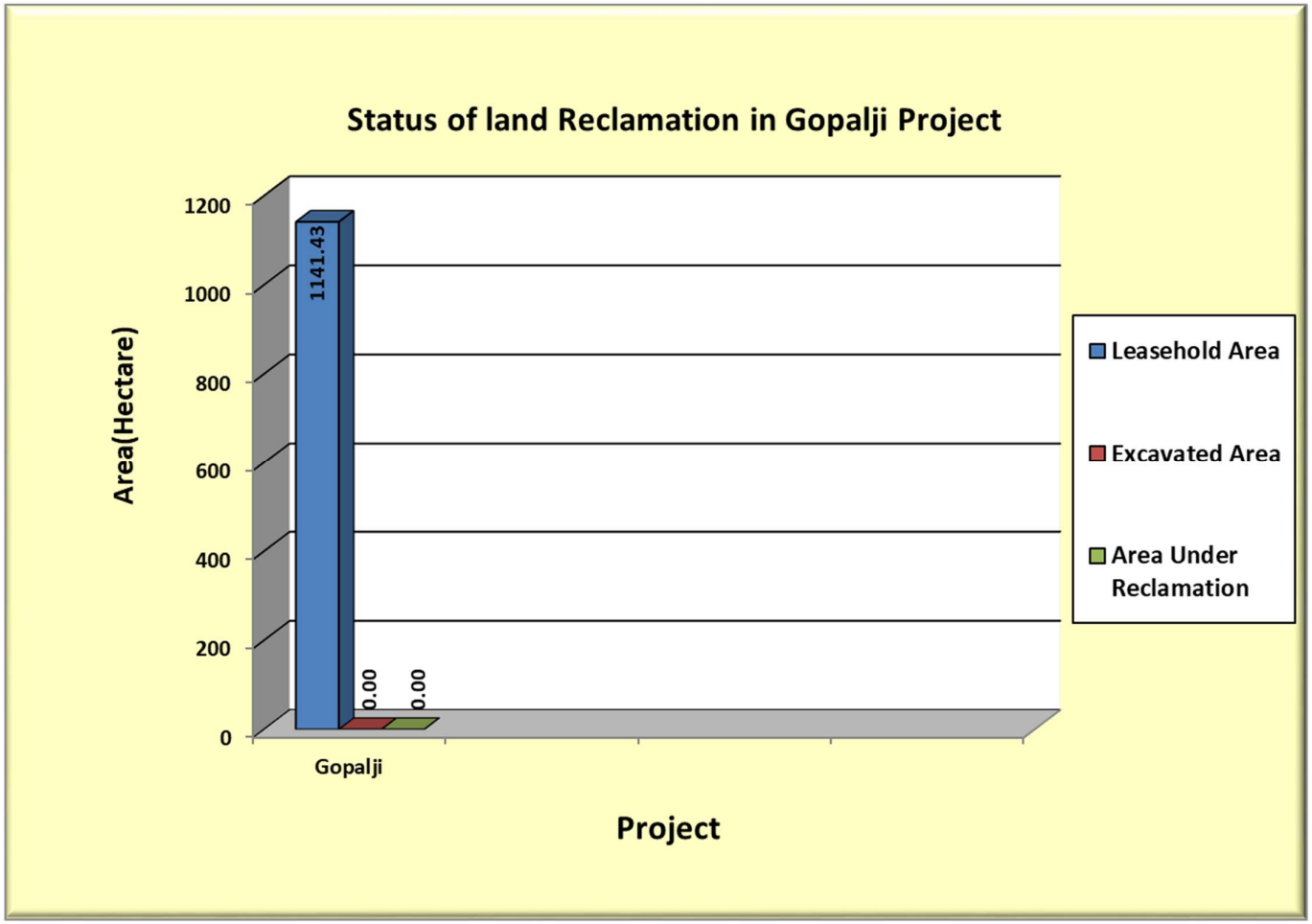



**Fig.1 – Land reclamation status of Gopalji Opencast Project of MCL (2022)**

# 1.0 Background

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

**1.2** Keeping above in view, Coal India Ltd. (CIL) issued a work order vide letter no. CIL/WBP/Env/2009/2428 dated 29.12.2009 to Central Mine Planning & Design Institute (CMPDI), Ranchi, for monitoring land reclamation status of all the opencast coal mines having production of more than 5 million $m^3$ per annum (coal + OB taken together per annum) based on remote sensing satellite data, regularly on annual basis for sustainable development of mining. Further, a revised work order was issued vide letter no. CIL/WBP/Env/2011/4706 dated 12.10.2012 from Coal India Limited for the period 2012-13 to 2016-17 which was subsequently followed by another work order vide letter no. CIL/WBP/Env/2017/DP/8477 dated 21.09.2017 from Coal India Limited for the period 2017-18 to 2021-22 for land reclamation monitoring of opencast projects and vegetation cover monitoring of 19 major coalfields. According to this work order, all mines in CIL with output capacity of 5 million cu. m (coal +OB) shall be monitored every year and all mines below this capacity shall be monitored at an interval of 3 years. All coalfields in CIL shall also be monitored at an interval of 3 years as per a defined plan. Further, a revised work order was issued vide letter no. CIL/ENVT/2022-23/W.O/10899 dated 06.07.2022 from Coal India Limited for the period 2022-23 to 2023-24. According to this work order, 76 OC projects having more than 5 million cu. m (coal +OB) per annum capacity shall be monitored every year and also land reclamation monitoring of

33 OCPs having less than 5 million cu. m (coal +OB) per annum capacity, totaling 109 OC mines and vegetation cover mapping of 06 coalfields for 2022-23 & totaling 123 (76+47) OC mines and vegetation cover mapping of 07 coalfields for 2023-24, covering all the subsidiaries of Coal India Ltd. The result of land reclamation status of all such mines to be put on the website of CIL, (www.coalindia.in), CMPDI (www.cmpdi.co.in) and the concerned coal companies in public domain. Detail report to be submitted to Coal India and respective subsidiaries.

**1.3** Land reclamation monitoring of all open cast projects will have to comply the statutory requirements of Ministry of Environment & Forest (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 2022 carried out for Gopalji OC project 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:

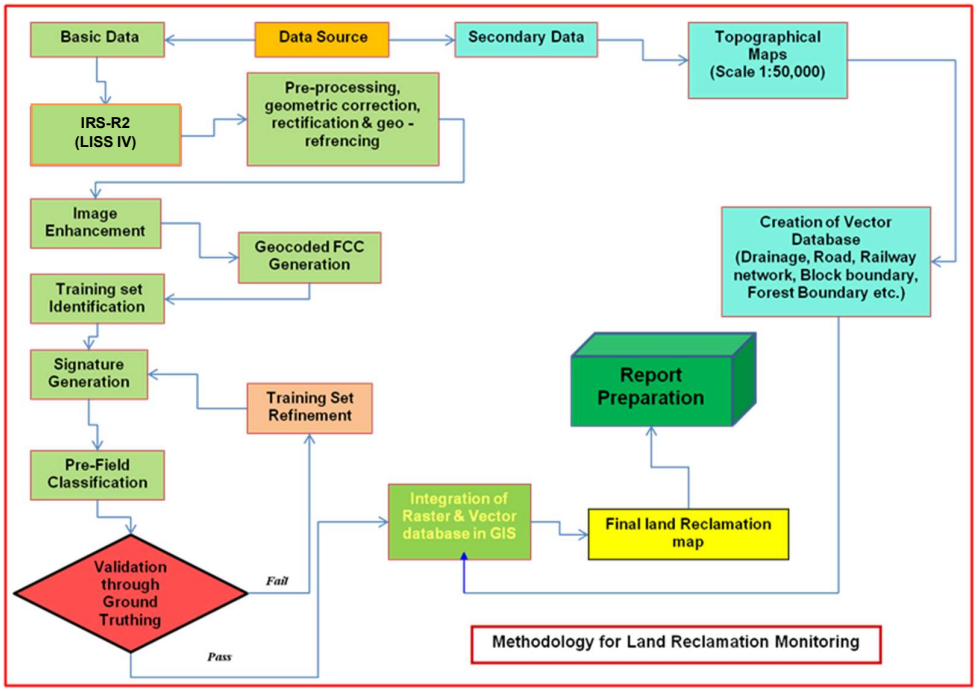



Figure: 2 Methodology for Land Reclamation Monitoring

**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** Gopalji OCP producing less than 5 million $m^3$. (Coal + OB together) of Mahanadi Coalfields Ltd. has been taken up during the year 2022-23 for land reclamation monitoring:

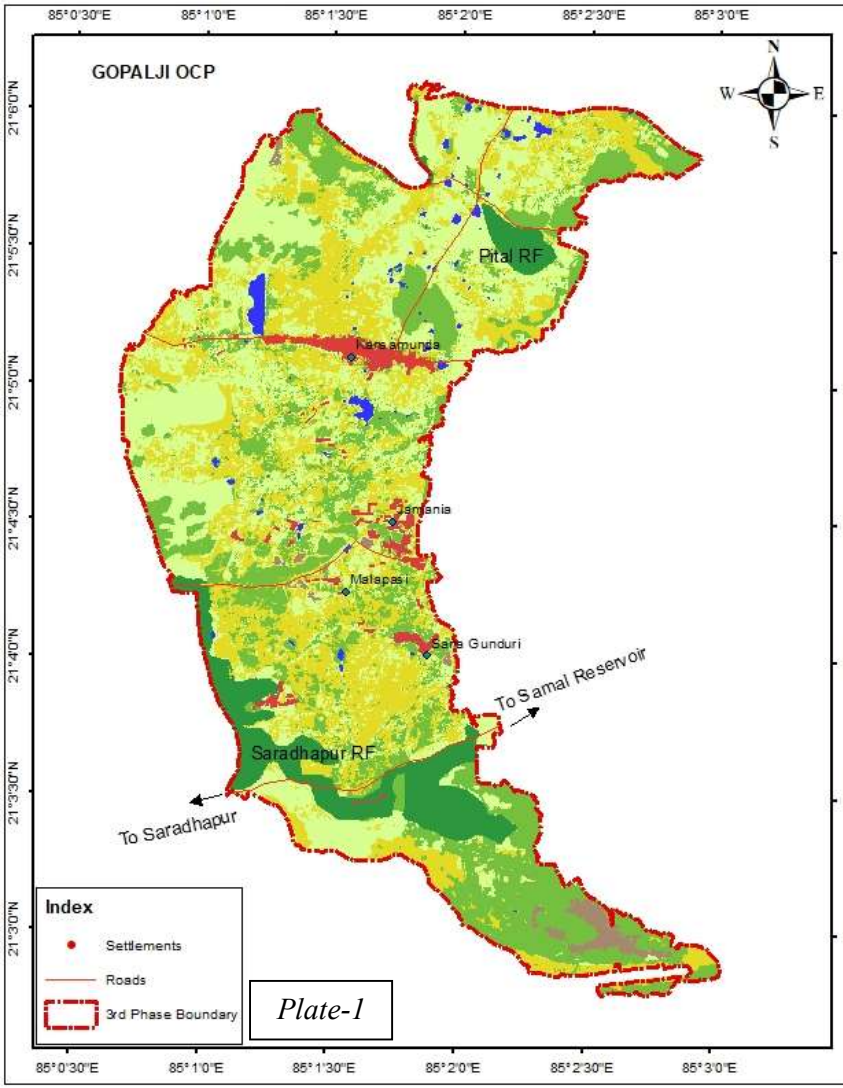
**4.2** Land Reclamation status of above mentioned Gopalji OCP of MCL is given in Table-1 and also shown graphically in Fig-1. Area statistics of different land use class present in the mine leasehold of the above project for the year 2022 is shown in the Table-2. Land use map derived from satellite data is shown in Plate-1 Different land use classes based on satellite data are depicted in Bar Chart in Fig-3.

**4.3** Mining operation of Gopalji OCP of MCL taken up for this study in the year 2022-23 has not been started yet. Study indicates that open forest covers an area of 88.12 ha., scrubs cover 286.36 ha. Waste land covers 14.26 ha., water bodies cover 12.37 ha. Total agricultural land covers an area of 715.49 ha. and settlements cover 24.83 ha. area.

**Table 2: STATUS OF LAND RECLAMATION IN MCL BASED ON SATELLITE DATA OF THE YEAR 2022**

*Area in Hectares*

| | | GOPALJI | | TOTAL | |
|---|---|---|---|---|---|
| | | Area | % | Area | % |
| FORESTS | Dense Forest | 0.00 | 0.00 | 0.00 | 0.00 |
| | Open Forest | 88.12 | 7.72 | 88.12 | 7.72 |
| | **Total Forest** | 88.12 | 7.72 | 88.12 | 7.72 |
| SCRUBS | Scrubs | 286.36 | 25.09 | 286.36 | 25.09 |
| PLANTATION | Social Forestry/Avenue Plantation | 0.00 | 0.00 | 0.00 | 0.00 |
| | Plantation on OB Dump | 0.00 | 0.00 | 0.00 | 0.00 |
| | Plantation on Backfill (Biological Reclamation) | 0.00 | 0.00 | 0.00 | 0.00 |
| | ***Total Plantation*** | 0.00 | 0.00 | 0.00 | 0.00 |
| | **Total Vegetation** | **374.48** | **32.81** | **374.48** | **32.81** |
| | Coal Dump | 0.00 | 0.00 | 0.00 | 0.00 |
| ACTIVE MINING | Coal Quarry | 0.00 | 0.00 | 0.00 | 0.00 |
| | Advance Quarry Site | 0.00 | 0.00 | 0.00 | 0.00 |
| | Quarry Filled With Water | 0.00 | 0.00 | 0.00 | 0.00 |
| | **Total Area under *Active Mining*** | **0.00** | **0.00** | **0.00** | **0.00** |
| | Barren OB Dump | 0.00 | 0.00 | 0.00 | 0.00 |
| RECLAIMED | Area Under Backfilling (Technical Reclamation) | 0.00 | 0.00 | 0.00 | 0.00 |
| | **Total Area under *Technical Reclamation*** | **0.00** | **0.00** | **0.00** | **0.00** |
| | **Total Area under Mine Operation** | **0.00** | **0.00** | **0.00** | **0.00** |
| WASTELAND | Waste Lands | 14.26 | 1.25 | 14.26 | 1.25 |
| | Fly Ash Pond / Sand Body | 0.00 | 0.00 | 0.00 | 0.00 |
| | **Total Wasteland** | **14.26** | **1.25** | **14.26** | **1.25** |
| WATERBODIES | Reservoir, nallah, ponds | 12.37 | 1.08 | 12.37 | 1.08 |
| | **Total Waterbodies** | **12.37** | **1.08** | **12.37** | **1.08** |
| AGRICULTURE | Crop Lands | 325.26 | 28.50 | 325.26 | 28.50 |
| | Fallow Lands | 390.23 | 34.19 | 390.23 | 34.19 |
| | **Total Agriculture** | **715.49** | **62.68** | **715.49** | **62.68** |
| SETTLEMENTS | Urban Settlement | 0.00 | 0.00 | 0.00 | 0.00 |
| | Rural Settlement | 24.83 | 2.18 | 24.83 | 2.18 |
| | Industrial Settlement | 0.00 | 0.00 | 0.00 | 0.00 |
| | **Total Settlement** | **24.83** | **2.18** | **24.83** | **2.18** |
| | **Grand Total** | **1141.43** | **100.00** | **1141.43** | **100.00** |




**Area Statistics - Gopalji OCP (2022)**

| Classes | | Colour | Core Zone | |
|---|---|---|---|---|
| Level-I | Level-II | | Area (Ha) | % of Total |
| Forests | Dense Forest | | 0.00 | 0.00 |
| | Open Forest | | 88.12 | 7.72 |
| | **Total Forest (A)** | | **88.12** | **7.72** |
| | **Scrubs (B)** | | **286.36** | **25.09** |
| Plantation Area | Social Forestry | | 0.00 | 0.00 |
| | Plantation on OB | | 0.00 | 0.00 |
| | Plantation on Backfill | | 0.00 | 0.00 |
| | **Total Plantation (C)** | | **0.00** | **0.00** |
| | **Total Vegetation (A+B+C)** | | **374.48** | **32.81** |
| Agriculture Land | Crop land | | 325.26 | 28.50 |
| | Fallow Land | | 390.23 | 34.19 |
| | **Total Agriculture Land** | | **715.49** | **62.68** |
| Waste Land | Waste Land | | 14.26 | 1.25 |
| | Fly Ash Pond | | 0.00 | 0.00 |
| | **Total Waste Land** | | **14.26** | **1.25** |
| Mining Area | Advance Quarry Area | | 0.00 | 0.00 |
| | Coal Quarry | | 0.00 | 0.00 |
| | Barren OB Dump | | 0.00 | 0.00 |
| | Back Fill | | 0.00 | 0.00 |
| | Coal Dump | | 0.00 | 0.00 |
| | Water Filled Qry | | 0.00 | 0.00 |
| | **Total Mining Area** | | **0.00** | **0.00** |
| Settlements | Urban Settlements | | 0.00 | 0.00 |
| | Rural Settlements | | 24.83 | 2.18 |
| | Industrial Settlements | | 0.00 | 0.00 |
| | **Total Settlement Area** | | **24.83** | **2.18** |
| Water Body | **River/ Ponds** | | **12.37** | **1.08** |
| | **Total Area** | | **1141.43** | **100.00** |

| | | | | | |
|---|---|---|---|---|---|
| Customer | **Mahanadi Coalfields Limited** | | | | |
| Title | **Land Reclamation Monitoring of OC Projects** | | | | Job No. 564922120 |
| Subject Land Reclamation Status of Gopalji OCP based on Satellite Data (IRS R2 L-IV) of the year 2022. | Activity | Name | Designation | Signature | Date |
| | Prepared | A. Parida | Dy. Manager (Geology) | | |
| | Checked | T. Mandal | CM(RSC) | | |
| cmpdi A Mini Ratna Company | Approved | R. Kumar | GM (Geomatics) | | |
| | Scale 0 0.25 0.5 1 Km | | | | Sheet |
| | Drg No. HQ REM 07 A4 22 01 | | | | REV No. |

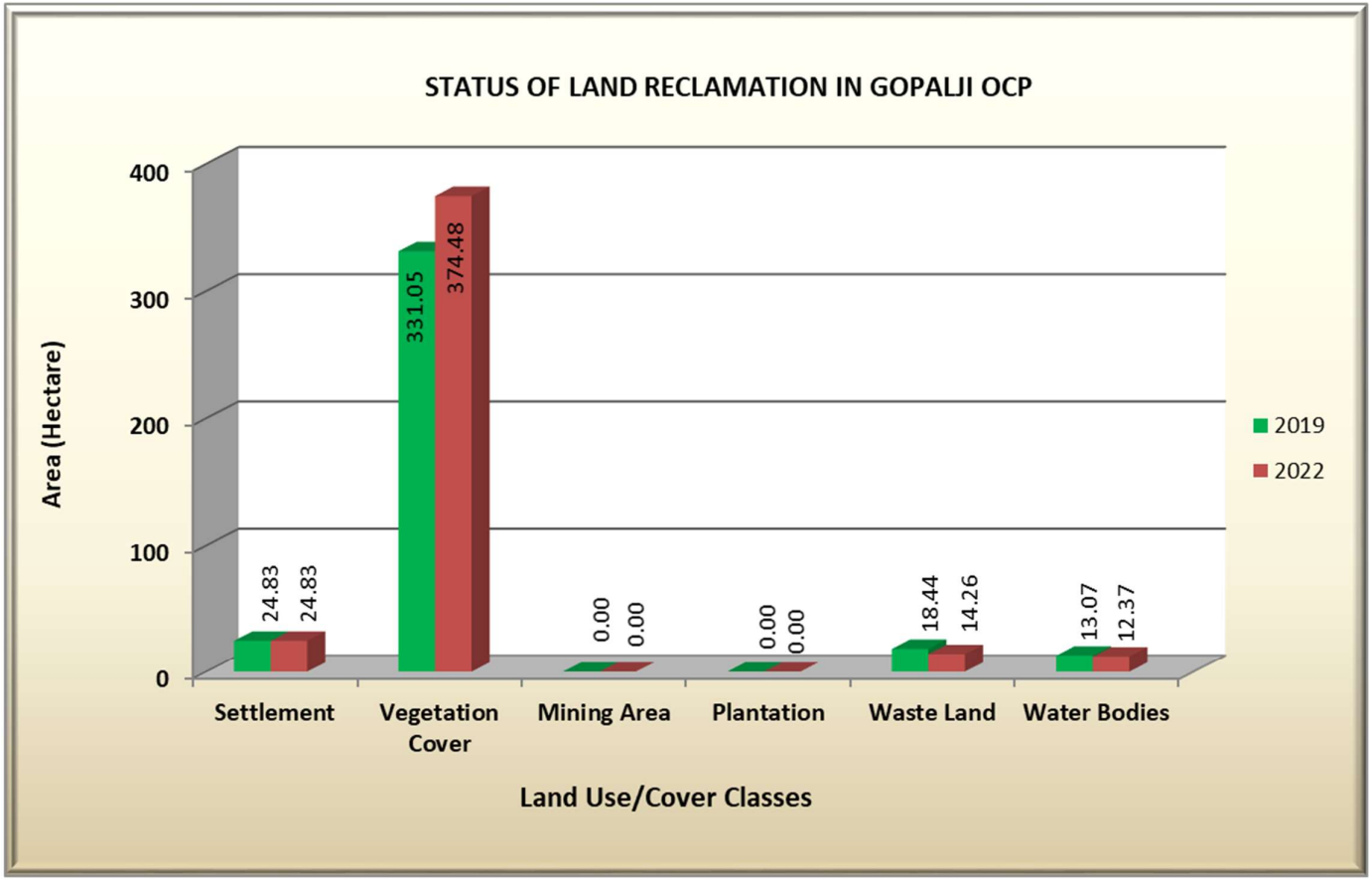

STATUS OF LAND RECLAMATION IN GOPALJI OCP
Area (Hectare)
400
300
200
100
0
24.83
24.83
331.05
374.48
0.00
0.00
0.00
0.00
18.44
14.26
13.07
12.37
Settlement
Vegetation Cover
Mining Area
Plantation
Waste Land
Water Bodies
Land Use/Cover Classes
2019
2022

**Figure:3**

## ABBREVIATIONS

| | |
|---|---|
| SoI | Survey of India |
| MoEF & CC | Ministry of Environment, Forest & Climate Change |
| CIL | Coal India Limited |
| ECL | Eastern Coalfields Limited |
| BCCL | Bharat Coking Coal Limited |
| CCL | Central Coalfields Limited |
| WCL | Western Coalfields Limited |
| SECL | South Eastern Coalfields Limited |
| NCL | Northern Coalfields Limited |
| MCL | Mahanadi Coalfields Limited |
| NEC | North Eastern Coalfields |
| CMPDIL | Central Mine Planning & Design Institute Ltd |
| NRSC | National Remote Sensing Centre |
| R2/ R2A | ResourceSat Satellites |
| LISS - 4 | Linear Imaging and Self Scanning Sensor |
| FCC | False Colour Composite |
| OCP | Opencast Project |
| UGP | Underground Project |
| OB | Over Burden |
| GCP | Ground Control points |
| GIS | Geographic Information System |
| WGS-84 | World Geodetic System |
| UTM | Universal Transverse Mercator |

# GLOSSARY

| Sl. | Term | Definition |
|---|---|---|
| 1. | Land Reclamation | To manage, reclaim and restore mined out/ degraded land as close as possible to its original stage. |
| 2. | Over Burden | The material that lies above the coal seam/ deposit |
| 3. | Monitoring | A process of evaluation to check or keep record for a period of time. |
| 4. | Opencast Coal Mine | Open-pit mining, also known as opencast mining, is a surface mining technique that extracts minerals from an open pit in the ground. |
| 5. | Social Forestry | Social forestry is the management and protection of forests and afforestation of barren and deforested lands with the purpose of helping environmental, social and rural development. Plantation (Social/ Avenue or other) carried out outside mining area. |
| 6. | Biological Reclamation | Plantation on Backfilled areas<br>(Stablised Internal Dumps) |
| 7. | Technical Reclamation | Area under backfilling (Over burden dumped inside the mine voids) in mining area. |
| 8. | Green Cover Generated | Total Plantation carried out in the lease area of Project. This includes Plantation on Backfill, Plantation on OB and Social Forestry. |
| 9. | Leasehold Area | The area, for which lease is granted for the purpose of undertaking mining and allied operations. |
| 10. | Excavated area | Mined out area which includes active mining, area under backfilling and plantation on backfilled areas |
| 11. | Active Mining | Mining areas which include Coal Quarry, Advance Quarry, Quarry Filled with Water etc. |
| 12. | Environmental Protection | It is the practice of protecting the natural environment by individuals, organizations and governments. Its objectives are to conserve natural resources and the existing natural environment and, where possible, to mitigate damage and reverse trends. |
| 13. | Remedial Measure | Any measure or action required or undertaken to investigate, monitor, clean up, remove, treat, prevent, contain or otherwise remediate the presence or release of any hazardous substance or activity. |
| 14. | Systematic Error | Every measurement differing from the true measurement in the same direction, and even by the same amount in some cases. |

| | | |
|---|---|---|
| 15. | Geometric Distortion | It refers to the improper positioning of any image with respect to their true geographic position when viewed in a properly scaled common image display plane. |
| 16. | Land Use/ Cover Class | Land cover is what covers the surface of the earth and land use describes how the land is used. |
| 17. | Accuracy | The closeness of agreement between a measured quantity value and a true quantity value. |
| 18. | Environmental Clearance | Environmental Clearance (EC) for any developmental projects like coal mining projects etc. has been made mandatory by the Ministry of Environment, Forests and Climate Change (MoEF & CC) through its Notification issued on 27.01.1994 under the provisions of Environment (Protection) Act, 1986. |
| 19. | Rectification and Geo-referencing | Geo-referencing is the assigning of absolute location of a data point or data points. Geo-rectification refers to the removal of geometric distortions between sets of data points, most often the removal of terrain, platform, and sensor induced distortions from remote sensing imagery. |
| 20. | Image Enhancement | It is the process of modifying digital images so that the results are more suitable for processing or further image analysis. |
| 21. | Training set selection | It is a portion of a data set used to fit or train a model for prediction or classification of values that are known in the training set, but unknown in other (future) data. |
| 22. | Image Classification | It refers to the task of extracting information classes from a multiband raster image. The resulting raster from image classification can be used to create thematic maps. |
| 23. | Temporal Changes | The 'temporal change' means the change in any entity with a period of time. |
| 24. | Ground Truthing | Collection of primary/ basic information from ground realities for satellite image interpretation and thematic mapping. |
| 25. | Cluster | Group of opencast and/ or underground mines clubbed together for administrative purposes. |
| 26. | Arc GIS | GIS Software used for Map preparation |
| 27. | ERDAS IMAGINE | Satellite Image Data Classification Software |



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