



BHARAT COKING COAL LTD.
A Mini Ratna Company
(A Subsidiary of Coal India Ltd.)
REGD. Office: Koyla Bhawan, Koyla Nagar, Dhanbad-826005
CIN No. U10101JH1972GO1000918
OFFICE OF THE GENERAL MANAGER
BARORA AREA

Ref No. GM/AR-1/SURVEY/ /2018

Dated: - 21/11/18

To
The Director
Ministry of Environment, Forest & CC
Regional Office (ECZ), Bungalow No.-2
Shyamali Colony
Ranchi- 834002

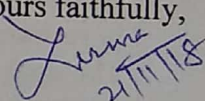
Sub: Six monthly reports on implementation of Environmental measures for the period from April' 2018 to Sept' 2018 in respect of Cluster -XV groups of mines.

Ref:-EC Order No. J-11015/100/2011-IA.II (M)

Dear Sir,

Kindly find enclosed herewith the six monthly report on implementation of Environmental measures for the period from **April' 2018 to Sept' 2018** in respect of Cluster - XV groups of mines.

Hope you will find the same in order.

Yours faithfully,

General Manager
Barora Area

Encl: as above

C.C to

1. The Director, 1A monitoring cell
Paryavaran Bhawan CGO Complex, New Delhi-110003
2. Regional office, JSPCB, Housing colony, Dhanbad
3. Dy. GM (Env.) BCCL Koyla Bhawan, Dhanbad.
4. Nodal Officer (Env.) Barora Area.
5. Nodal Officer (Env.) Govindpur Area.

ENVIRONMENTAL CLEARANCE COMPLIANCE OF CLUSTER-XV

(GRANTED VIDE J-11015/100/2011-IA.II (M) Dated 16.12.2013)

Apr' 2018 to Sept'2018

Action Plan for compliance of EC conditions

SN	A. Specific Conditions by MoEFCC:				Compliance	
i	The maximum production in the cluster shall not exceed beyond that for which environmental clearance has been granted for Cluster –XV as per given below:				The production from the cluster is within the limit for which Environmental clearance has been granted.	
	Sl. No.	Name of Mines	Production capacity (MTY)			Lease area (Ha)
			Normative	Peak		
	1	Kharkharee Coll.	0.092	0.12		584.00
	2	Madhuband coll.	0.113	0.147		393.77
	3	Phularitand coll.	0.120	0.156		340.88
	4	Dharmabandhc oll(Closed for production)	0	0		377.90
	Total	0.325	0.423	1696.55		
ii	The proponent shall prepare a contingency plan for subsidence.				It is being complied as per the guidelines of DGMS.	
iii	Keeping in view the pattern of the subsidence in the area, no depillaring should be carried out until the rehabilitation of the affected families and shifting of infrastructure.				It shall be complied. No depillaring is being carried out at present.	
iv	The channels adjoining the ML area leading to Jamunia river should not be disturbed and be regularly desilted.				It is being complied.	
v	The quality of the Jamunia river water should be continuously monitored and in order to prevent silting, a series of check dams should be constructed using boulders. This will help in recharging the ground water.				It is being complied.	
vi	The coal from the mines will be transported by mechanically covered trucks within two months.				Conversion of existing truck into mechanically covered trucks in a phased manner has been taken up. Presently, transportation is being done by covering vehicle with tarpaulin.	

vii	In underground mining there is presence of organic gases. These gases are volatile in nature. Due to transmission of air, fire takes place. The routine mining engineering will not serve the purpose. Therefore, proper studies are carried out to understand underground seams and how these fire areas could be sealed from further spreading.	All the statutory provisions under mines act 1952 and CMR 1957 along with statutes constituted under Mines act are fully complied to prevent any occurrence of fire. Regular monitoring and inspection is done by DGMS.
viii	Cumulative impact of fire and gases for all the clusters of coal mines in Jharia Coal field is carried out.	It is being complied. Presently Master Plan approved by Govt. of India is under implementation for this purpose. Fire control in Jharia and its periphery is being done with the recommendation received from CIMFR. An international expression of interest had been invited by BCCL and two bidders submitted their proposals, work shall be awarded as per the recommendation of tender committee.
ix	National Remote Sensing Agency (NRSA) should be contacted for thermal imaging techniques which are being utilized for assessing the extent of impact of underground of fire. BCCL should consider for an MOU with NRSA for short and long term studies so as to obtain detailed information on Satellite imagery, thermal imagery, subsidence prediction and surface features of the mining area.	The latest NRSA map is being submitted to RO, Ranchi & enclosed herewith. (Soft copy Enclosed) Action is being taken as specified in EC and as per Jharia Master Plan. Further fire patches are under operation to dig out the fiery coal and combustible materials to save the coal from burning and to stop further spread of the fire.
x	The Project proponent should monitor the water quality of the Jamunia river as per the standards prescribed by the JSPCB/CPCB to maintain the required BOD in the river water.	Work of monitoring ambient environment including water quality of the Jamunia river is being done by CMPDIL, Ranchi. (Soft copy of monitoring report is enclosed)
xi	The nullah as adjacent to the river should not be disturbed.	It is being complied.
xii	The open cast quarries of the abandoned mines should be backfilled to the ground level and restored with native species.	It is being complied.
xiii	All coal from the smaller U/G mines should be transported by high capacity and mechanically covered trucks/tippers.	Regular maintenance of vehicle is being practiced to kept vehicular emission under control. Coal is being transported in tarpaulin covered trucks.
xiv	Green belts shall be developed on both sides of the roads.	Due to absence of permanent roads in the coalfield, avenue plantation couldn't be done but trees were planted near permanent structures to minimize the pollution.
XV	Action plan for quenching of fires and rehabilitation along with the details of master plan be submitted to MOEF for monitoring	It is being complied. The approved master plan is uploaded on BCCL website

	purpose.	(www.bccl.gov.in/PDFs/MPLANBCCL-2008.pdf) and regular monthly progress report is being sent to ministry.
XVI	Presently coal of Munidih washery from other mines of the cluster is taking place through NH. An alternate route for coal transportation may be explored.	Jharia Coalfield is a densely and highly populated region. Alternative route will further add pollution and rehabilitation problems. It may be explored only after the shifting of population, living in coalfield region.
XVII	For understanding the composition of emissions from coal mine fires, BCCL may initiate action as proposed in the visit report of the EAC to Dhanbad.	Source Apportionment Study: Work Order had already been issued to NEERI Nagpur on 12.05.2018. And work has been started in September 2018.
XVIII	The approved mining plan is submitted to the MOEF.	Most of the BCCL mines are taken over mines from the erstwhile private owners who were operating mines without mine plans at the time of nationalization and now are being operated as amalgamated collieries/quarries as per the guide lines of DGMS.
XIX	The measure to identify in the Environmental Plan for Cluster- XV groups of mine and the conditions given in this environmental clearance letter shall be dovetailed to the implementation of the Jharia Action Plan.	It is being complied.
XX	The proponent shall prepare time -series maps of the Jharia Coalfields through NRSA to monitor and prevent fire problems in the Jharia Coalfields by Isothermal mapping /imaging and monitoring temperatures of the coal seams (whether they are close to spontaneous ignition temperatures) and based on which, areas with potential fire problems shall be identified. Measures to prevent ingress of air (Ventilation) in such areas, to prevent restart fresh/spread fires in other areas including in mines of cluster XV shall be undertaken. Expertise available internationally could also be utilized for control of fire in Jharia Coalfields and for their reclamation and to further minimize time for fire and subsidence control. Isothermal mapping using thermal imaging has been got done by NRSA. Measures would be taken prevent ingress of air (Ventilation) in such areas, which may restart fresh fires.	The latest NRSA map is being submitted to RO, Ranchi & enclosed herewith. (Soft copy Enclosed) Action is being taken as specified in EC and as per Jharia Master Plan. Further fire patches are under operation to dig out the fiery coal and combustible materials to save the coal from burning and to stop further spread of the fire.
XXI	The embankment constructed along the river boundary shall be of suitable dimensions and critical patches shall be strengthened by stone pitching on the river front side and stabilized with plantation so as to withstand the peak water flow and prevent mine inundation.	It is being complied.
XXII	No mining shall be undertaken where underground fires continue. Measure shall be taken to prevent/ check such fire including in old OB dump areas where the fire could start due to presence of coal /shale with sufficient	It is being complied. Mining is being carried out as per the guidelines of DGMS in area only Open Cast working is being practiced. However sufficient precaution is being taken to guard against fire.

	carbon content.	
XXIII	Mining shall be carried out as per statuette from the streams/nalas flowing within the lease and maintaining a safe distance from the Nalas flowing along the lease boundary. A safety barrier of a minimum 60m width shall be maintained along the nalas/water bodies.	It is being complied. Mining is being carried out as per the guidelines of DGMS.
XXIV	Total afforestation plan shall be implemented covering an area of 621.28 Ha. (Additional) at the end of mining which will include, Green belt over an area of 229.12 Ha., density of tree plantation 2500/ Ha. Of plants.	Being complied.
XXV	Details of transportation, CSR,R&R and implementation of environmental action plan for the clusters XV should be brought out in a booklet from within a year and regularly updated.	It is being followed. CSR dept has been established at area level. This year BCCL has constructed over 3500 toilets under “SwacchBharat Abhiyan”.(Soft copy enclosed)
XXVI	Specific mitigative measures identified for the Jharia Coalfields in the Environmental Action Plan prepared for Dhanbad as a critically polluted are and relevant for Cluster- XV shall be implemented	Dhanbad Action Plan is being implemented. The salient actions of this area: <ol style="list-style-type: none"> 1. Covered transportation of Coal. 2. Water sprinkling. 3. Plantation. 4. Utilization of surplus mine water
XXVI I	The locations of monitoring stations in the Jharia coalfield should be finalized in consultation with Jharkhand State Pollution Control Board. Committee stated that smoke/dust emission vary from source to source (fuel wood, coal, fly ash from TPPs, silica from natural dust, etc.) and a source Apportionment Study should be got carried out for the entire Jharia Coalfields. Mineralogical composition study should be undertaken on the composition of the suspended particulate matter (PM₁₀ and PM_{2.5}) in Jharia Coalfields and also quantified. These studies would help ascertain source and extent of the air pollution, based on which appropriate mitigative measures could be taken.	Establishment of ambient environment quality monitoring stations has been finalized with the consultation of Jharkhand State Pollution Control Board. The work of monitoring of ambient environment was done by Central Institute of Mining & Fuel Research (CIMFR), Dhanbad which is a CSIR laboratory recognized under the EP Rules. Now the monitoring work has been taken up by CMPDIL, Ranchi. Apportionment Study -Work Order issued to NEERI Nagpur. Copy enclosed
XVIII	The proponent will continue the existing Road-Rail transport network system in view of the implementation of the Master Plan (For 10 years) and another 5 Years gestation period after the completion of Master Plan for consolidation of the backfilled dug out fire areas and unstable areas is required. All mitigation measures (like covered trucks, green belting on either sides of the roads, enhanced water sprinkling, strengthening and maintaining the roads etc.) shall be adopted up to 15 years (phase-I) with the existing	At present we are exploring the technology to cover existing trucks mechanically by local technicians and no OEM is available for covered trucks in Indian market until the coal production is being done by tarpaulin covered trucks.

	Road- Rail transport system. In phase –II, BCCL shall implement conveyor-cum-rail transport to avoid movement of trucks within the cluster for coal transportation in phase-II which shall start after 15 years. Transportation of coal shall be by Rail and Conveyor belt, minimizing the existing road transport system in all the mines of the cluster and shall continue after 15 years. Loading of coal by pay loaders shall be discontinued. Adequate number suitably designed off-take points shall be provided.	
XXIX	1537 nos. of PAFs should be rehabilitated at cost of Rs.140.03 crores as per the approved Jharia Action Plan.	It is being complied as per approved Jharia Action Plan.
XXX	Regular monitoring of subsidence movement on the surface over and around the working area and impact on natural drainage pattern, water bodies, vegetation, structure, roads and surroundings shall be continued till movement ceases completely. In case of observation of any high rate of subsidence movement, appropriate effective corrective measures shall be taken to avoid loss of life and material. Cracks shall be effectively plugged with ballast and clayey soil/suitable material.	It shall be complied .No depillaring is being carried out at present.
XXXI	Coal Extraction shall also be optimized in areas where agricultural production is continuing. Some pillars shall be left below the agricultural land. No depillaring & coal extraction should be carried out below habitation, H.T Lines & beneath road, water bodies.	It is being complied.
XXXI I	Subsidence shall be monitored closely and if subsidence is found exceeding the permitted limits, then the land owners shall be adequately compensated with mutual agreement with the land owners.	No depillaring is being carried out at present.
XXXI II	3-tiers plantation should be developed 2KM stretch of road from the mine using native species.	It is being complied.
XXXI V	Water sprinkling system shall be provided to check fugitive emission from loading operations, conveyor system, haulage roads, transfer points, etc. Major approach roads shall be black topped and properly maintained.	It is being complied.
XXX V	A progressive afforestation plan shall be prepared and implemented over the mine lease area acquired and shall include areas under green belt development, areas along roads infrastructure, along ML boundary and township etc, by planting native species in consultation with the local DFO/Agricultural	It is being complied

	Department.	
XXX VI	Acid water Treatment Plant, volume of water to be treated and disposal of brine should be provided.	Shall be complied.
XXX VII	Mine discharge water outside the ML shall be monitored, particularly for TDS and treated to confirm prescribed levels before discharge into the natural environment.	Mine discharge water is being allowed to settle down in the mine sumps before disposal into storage reservoirs. The monitoring of water quality parameters is being done through CMPDIL, Ranchi and parameters are well within the prescribed limit provided by CPCB. (Soft copy of report is enclosed)
XXX VIII	The Company shall put up artificial groundwater recharge measures for augmentation of ground water resource, incase water table shows a declining trend. The project authorities shall meet water requirement of nearby village(s) in case the village wells go dry due to dewatering of mines.	Presently water is not being discharged outside the ML. Excess mine water is being stored at old quarries and ponds for community use. This will help to recharge the ground water.
XXXI X	Besides carrying out regular periodic health check up of their workers, 10% of the workers identified from workforce engaged in active mining operations shall be subjected to health check up for occupational disease and hearing impairment, if any, through an agency such as NIOH, Ahemdabad within a period of one year and the results reported to this Ministry and to DGMS.	NIOH has conducted health surveillance(Medical checkup) and awareness program program in area.
xI	The mining in the existing mines would be phased out after expiry of the current mining lease and after reclamation of mined over area. The operating mines may be analyzed and monitored for compliance of conditions, having bearing with movement of wild life until such time they are closed/phased out.	Shall be complied.
xIi	Sufficient coal pillars shall be left unextracted around the air shaft (within the subsidence influence area) to protect from any damage from subsidence, if any.	It is being complied.
xIii	High root density tree species shall be selected and planted over likely areas to be affected by subsidence.	It is being complied.
xIiii	Depression due to subsidence resulting in water accumulating within the low lying areas shall be filled up or drained out by cutting drains.	It is being complied.
xIiv	Solid barriers shall be left below the roads falling within the blocks to avoid any damage to the roads.	It is being complied.
xIV	The CSR Action Plan shall consist of need-based CSR Action Plan, CSR Auditing and	It is being complied.

	<p>monitoring mechanism etc. The proponent will spend 5% of the retained earnings of the previous year subject to a minimum of Rs.5/- per tonne of coal production which should be adjusted as per the annual inflation. The progress made there on shall be uploaded on the company website. Monitoring of the impact of the activities under CSR shall be carried out periodically</p>	
xIvi	<p>Third party evaluation shall be got carried out regularly for the proper implementation of activities undertaken in the project area under CSR. Issue raised in the Public Hearing shall also be integrated with activities being taken up under CSR. The details of CSR undertaken along with budgetary provisions for the village-wise various activities and expenditure thereon shall be uploaded on the company website every year. The company must give priority to capacity building both within the company and to the local youth, who are motivated to carry out the work in future. The gap/space available between the entire mine area should be suitably planted with native species. Plantation should also be made in vacant area and along the road side so as to reduce dust pollution.</p>	<p>BCCL is implementing CSR activities. A separate CSR committee has been formed at area level of Barora, who will look after the works being executed under CSR. CSR dept is established at the Headquarter level and area level for Executing the CSR Activities.</p> <p>All welfare/ CSR activities are also uploaded in Company web site.</p> <p>TISS has conducted survey to frame CSR policy for better implementation and monitoring of the CSR activities.</p>
xIvii	<p>Central recreation park with herbal garden should be developed for use of all inhabitants.</p>	<p>It shall be complied.</p>
xIviii	<p>The mine water should be treated properly before supply to the villager.</p>	<p>It is being complied.</p>
xIlix	<p>Mine discharge water shall be treated to meet standards prescribed standards before discharge into natural water courses/agriculture. The quality of water discharge shall be monitored at the outlet and proper records maintained thereof and uploaded regularly on the company website.</p>	<p>A work order has been issued to CMPDIL, Ranchi. Regular monitoring of Water Quality Parameters is being carried out by CMPDIL.</p> <p>(Soft copy of report is enclosed)</p>
I	<p>The void shall be converted into a water reservoir of a maximum depth of 15-20 m and shall be gently sloped and the upper benches of the reservoir shall be stabilized with plantation and the periphery of the reservoir fenced. The abandoned pits and voids should be backfilled with OB and reclaimed with plantation and or may be used for pisciculture.</p>	<p>It shall be complied.</p>

1i	<p>Regular monitoring of groundwater level and quality of the study area shall be carried out by establishing a network of existing wells and construction of new peizometers. The monitoring for quantity shall be dome four times a year in pre-monsoon (May), monsoon (August), post-monsoon (November) and winter (January) seasons and for quality including Arsenic and Fluoride during the month of May. Data thus collected shall be submitted to the Ministry of Environment & Forest and to the Central Pollution Control Board/SPCB quarterly within one month of monitoring. Rainwater harvesting measures shall be undertaken in case monitoring of water table indicates a declining trend.</p>	<p>Groundwater level and quality is being monitored by CMPDIL. The Location and design of Piezometers to be installed have been finalized by CMPDIL .</p> <p>Peizometer installation: Tender was done on 28.04.2017. Only one bidder applied who could not fulfil the eligibility criteria. Hence, that tender was cancelled and retendering in process.</p> <p>3 hydrograph stations (A-24, B-32A and B-61A) are located in the core zone of the mine area. Water level monitoring in these monitoring stations has been done in the months of February, April, August & November‘2017 and the Ground water level data is enclosed in the table below:</p> <table><tr><th rowspan="2">Well No.</th><th rowspan="2">Location</th><th colspan="4">Water level (bgl in meters)</th></tr><tr><th>Feb'17</th><th>Apr'17</th><th>Aug'17</th><th>No</th></tr><tr><td>A-24</td><td>Pipratannr</td><td>10.68</td><td>16.28</td><td>2.33</td><td>4</td></tr><tr><td>B-32A</td><td>Madhuband</td><td>2.35</td><td>6.95</td><td>1.60</td><td>2</td></tr><tr><td>B-61A</td><td>Kesargora</td><td>1.42</td><td>2.57</td><td>0.62</td><td>0</td></tr><tr><td colspan="2"><i>Average GW (bgl)</i></td><td><i>4.82</i></td><td><i>8.60</i></td><td><i>1.52</i></td><td><i>2</i></td></tr></table> <p>Ground Water Level (bgl) varies from 1.42 to 10.68 m during February, 2.57 to 16.28 m during April, 0.62 to 2.33 m during August and 0.82 to 4.18 m during November within the Core Zone of Cluster-XV area.</p>	Well No.	Location	Water level (bgl in meters)				Feb'17	Apr'17	Aug'17	No	A-24	Pipratannr	10.68	16.28	2.33	4	B-32A	Madhuband	2.35	6.95	1.60	2	B-61A	Kesargora	1.42	2.57	0.62	0	<i>Average GW (bgl)</i>		<i>4.82</i>	<i>8.60</i>	<i>1.52</i>	<i>2</i>
Well No.	Location	Water level (bgl in meters)																																		
		Feb'17	Apr'17	Aug'17	No																															
A-24	Pipratannr	10.68	16.28	2.33	4																															
B-32A	Madhuband	2.35	6.95	1.60	2																															
B-61A	Kesargora	1.42	2.57	0.62	0																															
<i>Average GW (bgl)</i>		<i>4.82</i>	<i>8.60</i>	<i>1.52</i>	<i>2</i>																															
1ii	<p>ETP shall also be provided for workshop, and CHP, if any. Effluents shall be treated to confirm to prescribe standards in case discharge into the natural water course.</p>	<p>Construction of ETP/Oil grease Trap will be taken-up</p>																																		
1iii	<p>For monitoring land use pattern and for post mining land use, a time series of land use maps, based on satellite imagery (on a scale of 1: 5000) of the core zone and buffer zone, from the start of the project until end of mine life shall be prepared once in 3 years (for any one particular season which is consistent in the time series), and the report submitted to MOEF and its Regional office at Bhubaneswar.</p>	<p>Presently a time series map of vegetation cover in the Jharia Coal Field is being carried out through CMPDI, Ranchi using satellite imagery for every 3 years & it has been uploaded on the official website of company. Further CMPDI has been requested to prepare “Time series of land use maps based on satellite imagery of the core zone and buffer zone in the scale 1:5000 (Attached as Annexure)</p>																																		

1	A Final Mine Closure Plan along with details of Corpus Fund shall be submitted to the Ministry of Environment & Forests five year before mine closure for approval. Habitat Restoration Plan of the mine area shall be carried out using a mix of native species found in the original ecosystem, which were conserved in-situ and ex-situ in an identified area within the lease for reintroduction in the mine during mine reclamation and at the post mining stage for habitat restoration. The mining plan and post –mining plan, closure plan should be prepared and submitted to the Ministry.	CMPDI has prepare the “Final Mine Closure Plan along with a Plan for Habitat Restoration and with details of Corpus Fund”. BCCL has deposited the amount in a separate ESCROW ACCOUNT for corpus fund as per Mine Closure Guidelines as specified in the mine closure Plan.
1v	A separate management structure for implementing environment policy and socio-economic issues and the capacity building required in this regard.	Complied. A full-fledged Environment cell, with a suitable qualified multidisciplinary team of executives has been established. GM (Environment) at head quarter level, co-ordinates with all the Areas and reports to the Director (Technical) and in turn he reports to the CMD of the company. Socio economic issues and capacity building are being evaluated by Tata Institute of Social Science.
1vi	Corporate Environment Responsibility: a) The Company shall have a well laid down Environment Policy approved by the Board of Directors. b) The Environment Policy shall prescribe for standard operating process/procedures to bring into focus any infringements/deviation/violation of the environmental or forest norms/conditions. c) The hierarchical system or Administrative Order of the company to deal with environmental issues and for ensuring compliance with the environmental clearance conditions shall be furnished d) To have proper checks and balances, the company shall have a well laid down system of reporting of non-compliances/violations of environmental norms to the Board of Directors of the company and/or shareholders or stakeholders at large.	<p>A well defined Corporate Environment Policy has already been laid down and approved by Board of Directors. This is also posted on BCCL website. Complied.</p> <p>A hierarchical system of the company to deal with environmental issues from corporate level already exists.</p> <p>Being complied.</p> <p>Being complied.</p>

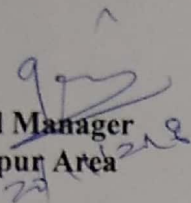
B	General Conditions by MoEFCC:	
i	No change in mining technology and scope of working shall be made without prior approval of the Ministry of Environment and Forests.	Being complied.
ii	No change in the calendar plan of production for quantum of mineral coal shall be made.	Being complied.
iii	Four ambient air quality monitoring stations shall be established in the core zone as well as in the buffer zone for PM₁₀, PM_{2.5}, SO₂ and NO_x monitoring. Location of the stations shall be decided based on the meteorological data, topographical features and environmentally and ecologically sensitive targets in consultation with the State Pollution Control Board. Monitoring of heavy metals such as Hg, As, Ni, Cd, Cr, etc carried out at least once in six months.	The location of monitoring stations in Jharia Coal Field has been finalized in consultation with the Jharkhand State Pollution Control Board. Ambient air quality along with heavy metals such as Hg, As, Ni, Cd, Cr, etc is regularly monitored by CMPDIL. (soft copy attached)
iv	Data on ambient air quality (PM₁₀, PM_{2.5}, SO₂ and NO_x, Hg, As, Ni, Cd, Cr and other monitoring data shall be regularly submitted to the Ministry including its Regional Office at Bhubaneswar and to the State Pollution Control Board and the Central Pollution Control Board once in six months. Random verification of samples through analysis from independent laboratories recognized under the EPA rules, 1986 shall be furnished as part of compliance report.	Data on ambient air and other monitoring data is being regularly submitted to the Ministry along with compliance report. .(soft copy attached)
v	Adequate measures shall be taken for control of noise levels below 85 dBA in the work environment. Workers engaged in blasting and drilling operations, operation of HEMM, etc shall be provided with ear plugs/muffs.	It is being Complied in mines and also the Noise levels are below the Ambient Noise Standard (Day time 75 dB & Night Time (70 dB for Industrial Area). Regular maintenance of vehicles and other machineries are being practiced for control of noise level. Ear plugs/muffs are provided to the persons engaged in blasting and drilling operations, operation of HEMM, etc . (Soft copy of monitoring report is enclosed.)
vi	Industrial wastewater (workshop and wastewater from the mine) shall be properly collected, treated so as to conform to the standards prescribed under GSR 422 (E) dated 19th May 1993 and 31st December 1993 or as amended from time to time before discharge. Oil and grease trap shall be installed before discharge of workshop effluents.	The work of monitoring of ambient environment is being done by CMPDIL, Ranchi. Physico-Chemical characteristics of effluents are well within the prescribed limit. (Soft copy of monitoring report is enclosed.)

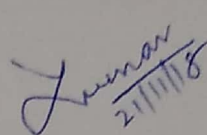
vii	Vehicular emissions shall be kept under control and regularly monitored. Vehicles used for transporting the mineral shall be covered with tarpaulins and optimally loaded.	Being complied. Regular maintenance of vehicle is being practiced to kept vehicular emission under control. Coal is being transported in tarpaulin covered trucks.
viii	Monitoring of environmental quality parameters shall be carried out through establishment of adequate number and type of pollution monitoring and analysis equipment in consultation with the State Pollution Control Board and data got analyzed through a laboratory recognized under EPA Rules, 1986.	Monitoring of Environmental quality parameters have been regularly done by CMPDIL, Ranchi with proper analysis equipment. (REPORT ENCLOSED)
ix	Personnel working in dusty areas shall wear protective respiratory devices and they shall also be provided with adequate training and information on safety and health aspects.	It is being complied. A separate full-fledged Human Resource Development Department is conducting regular training programme on these issues. Apart from this Vocational Training Centers are existing in all the areas of BCCL, which provides periodical training on the safety and occupational health issue to each of the workers working in the mines.
x	Occupational health surveillance programme of the workers shall be undertaken periodically to observe any contractions due to exposure to dust and to take corrective measures, if needed and records maintained thereof. The quality of environment due to outsourcing and the health and safety issues of the outsourced manpower should be addressed by the company while outsourcing.	Initial Medical Examination (IME) and Periodical Medical Examination (PME) of all the personnel is carried out as per the Statutes and Director General of Mines Safety (DGMS) guideline
xi	A separate environmental management cell with suitable qualified personnel shall be set up under the control of a Senior Executive, who will report directly to the Head of the company.	A full-fledged Environment cell, with a suitable qualified multidisciplinary team of executives has been established. GM (Environment) at head quarter level, co-ordinates with all the Areas and reports to the Director (Technical) and in turn he reports to the CMD of the company. Socio economic issues and capacity building are being evaluated by Tata Institute of Social Science
xii	The funds earmarked for environmental protection measures shall be kept in separate account and shall not be diverted for other purpose. Year-wise expenditure shall be reported to this Ministry and its Regional Office at Bhubaneswar.	It is being complied.
xiii	The Project authorities shall advertise at least in two local newspapers widely circulated around the project, one of which shall be in the vernacular language of the locality concerned within seven days of the clearance letter informing that the project has been accorded environmental clearance and a copy of the clearance letter is available with the	complied. Advertisement in local newspaper has been given.

	State Pollution control Board and may also be seen at the website of the ministry of Environment & Forests at http://envfor.nic.in .	
xiv	A copy of the environmental clearance letter shall be marked to concern Panchayat/Zila Parishad, Municipal corporation or Urban local body and local NGO, if any, from whom any suggestion /representation has been received while processing the proposal. A copy of the clearance letter shall also be displayed on company's website.	Complied. Clearance letter has been displayed on Company web site.
xv	A copy of the environmental clearance letter shall also be displayed on the website of the concerned State Pollution Control Board. The EC letter shall also be displayed at the Regional Office, District Industry Sector and Collector's Office/Tehsildar's Office for 30 days	Complied.
xvi	The clearance letter shall be uploaded on the company's website. The compliance status of the stipulated environmental clearance conditions shall also be uploaded by the project authorities on their website and updated at least once every six months so as to bring the same in public domain. The monitoring data of environmental quality parameter (air, water, noise and soil) and critical pollutant such as PM ₁₀ , PM _{2.5} , SO ₂ and NO _x (ambient) and critical sectoral parameters shall also be displayed at the entrance of the project premises and mine office and in corporate office and on company's website.	Complied.
xvii	The project proponent shall submit six monthly compliance reports on status of compliance of the stipulated environmental clearance conditions (both in hard copy and in e-mail) to the respective Regional Office of the Ministry, respective Zonal Office s of CPCB and the SPCB.	Complied/Being complied.
xviii	The Regional Office of this Ministry located at Bhubaneswar shall monitor compliance of the stipulated conditions. The project authorities shall extend full cooperation to the office(s) of the Regional Office by furnishing the requisite data/information/monitoring reports.	Noted. Project authority is ready to extend its full cooperation for any kind of visit and inspection conducted by Regional Office in connection with EC Conditions Compliance.

financial year ending 31 March in Form-V is mandated to be submitted by the project proponent for the concerned State Pollution Control Board as prescribed under the Environment (Protection) Rules, 1986, as amended subsequently, shall also be uploaded on company's website along with the status of compliance of Environment condition and shall be sent to the respective Regional Offices of the MOEF by e-mail.

submitted for mines which is under operation for each financial year to Jharkhand State Pollution Control Board.


General Manager
Govindpur Area


General Manager
Barora Area

STRICTLY RESTRICTED**FOR COMPANY USE ONLY RESTRICTED**

The information given in this report is not to be communicated either directly or indirectly to the press or to any person not holding an official position in the CIL /GOVERNMENT.

ENVIRONMENTAL MONITORING REPORT OF BHARAT COKING COAL LIMITED, CLUSTER – XV

(FOR THE MONTH SEPTEMBER, 2018)

E. C. no. J-11015/100/2011-IA.II (M) dated 16.12.2013-



CMPDI

ISO 9001 Company
Regional Institute-II
Dhanbad, Jharkhand

CONTENTS

SL. NO.	CHAPTER	PARTICULARS	PAGE NO.
1.	CHAPTER - I	EXECUTIVE SUMMARY	3-5
2.	CHAPTER-II	INTRODUCTION	6
3.	CHAPTER-III	RESULTS	7-11
4.	CHAPTER-IV	STANDARDS AND PLANS	12-15

EXECUTIVE SUMMARY

1.0 Introduction

The purpose of environmental monitoring is to assess the quality of various attributes that affects the fauna and flora. In accordance with the quality of these attributes appropriate strategy is to be developed to control the pollution level within the permissible limits. The three major attributes are air, water and noise level.

Bharat Coking Coal Limited (BCCL), a Subsidiary company of Coal India Limited is operating Underground and Opencast Mines in Jharia Coalfield (JCF) is a part of Gondwana Coalfields located in Dhanbad district of Jharkhand, the JCF is bounded by 23°37' N to 23°52' N latitudes and 86°09' E to 86°30' E longitude occupying an area of 450 Sq.km. BCCL has awarded Environmental monitoring work of Jharia Coalfield (JCF) to Central Mine Planning & Design Institute Limited (CMPDIL). The environmental monitoring has been carried out as per the conditions laid down by the MoEF&CC while granting environmental clearance of project, consent letter issued by the respective SPCB, and other statutory requirements.

2.0 Sampling location and rationale

2.1 Ambient air sampling locations

The ambient air quality monitoring stations were selected to represent core, buffer zone area. The rationale has been based on the guidelines stipulated by MoEF&CC, consent letter of SPCB, as well as other statutory requirements.

2.2 Water sampling stations

The Water sampling stations were selected for mine discharge water.

2.3 Noise level monitoring locations

Noise levels vary depending on the various activities in mining areas. The monitoring of noise level in different locations will be helpful to take appropriate mitigating measures. The noise levels were recorded in mining areas, washery areas and in residential areas.

3.0 Methodology of sampling and analysis

3.1 Ambient air quality

Parameters chosen for assessment of ambient air quality were Particulate Matter (PM₁₀), Fine Particulate Matter (PM_{2.5}), Sulphur Di-oxide (SO₂) and Nitrogen Oxides (NO_x). Respirable Dust Samplers (RDS) were used for

sampling of PM₁₀, SO₂, & NO_x and Fine Dust Sampler (PM_{2.5} sampler) were used for sampling of PM_{2.5} at 24 hours interval once in a fortnight and the same for the gaseous pollutants. The samples were analyzed in Environmental Laboratory of CMPDI RI-II, Dhanbad.

3.2 Water quality

Water samples were collected as per standard practice. The Mine effluent samples were collected and analyzed for four parameters on fortnightly basis. Thereafter the samples were preserved and analyzed at the Environmental Laboratory of CMPDI RI- II, Dhanbad.

3.3 Noise level monitoring

Noise level measurements in form of 'L_{EQ}' were taken using Integrated Data Logging Sound Level Meter. Noise levels were measured in Decibels, 'A' weighted average, i.e. dB(A).

4.0 Results and interpretations

4.1 Air quality

It has been seen from the analysis results that the 24 hours average concentration parameters like PM₁₀, PM_{2.5}, SO₂ and NO_x are mostly within the permissible limits in all sampling locations as per MoEF&CC Gazette Notification No. GSR 742(E) dt 25.09.2000 Standards for Coal Mines and National Ambient Air Quality Standard -2009. Sometimes the concentration of PM₁₀& PM_{2.5} exceeds the limits due to heavy public traffic, poor road condition, coke oven plants, burning of coal by surrounding habitants, brick making, municipal waste dumps and industries like Steel Plant, thermal Plants including their fly ash etc.

The following preventive and suppressive mitigative measures can be undertaken to contain the pollution level within prescribed level:-

- Wet drilling and controlled blasting should be practice.
- Explosive used should be optimised to restrict the dust generation.
- Transportation roads should be permanently asphalted free of ruts, potholes etc.
- Water should be sprayed on coal transportation road, service road more frequently and at regular interval.
- Dust from roads should be removed physically or mechanically.
- Greenbelts around industrial sites, service building area besides Avenue plantation along roads should be created.
- Coal dust should be suppressed by using fixed sprinklers.
- Regular maintenance of plant and machinery should be undertaken.

4.2 Water quality

The test results indicate that the major parameters compared with MoEF&CC Gazette Notification No. GSR 742(E) dt 25.09.2000 Standards for Coal Mines, are within permissible limits.

4.3 Noise Level

During the noise level survey it has been observed that the noise level in the sampling locations is within the permissible limits prescribed as per MoEF&CC Gazette Notification No. GSR 742(E) dt 25.09.2000 Standards for Coal Mines for Industrial Area and Noise pollution (Regulation and Control) Rules, 2000.

INTRODUCTION

Any industry and development activities including coal mining is bound to affect environmental attributes. There are positive as well as negative impacts of such operations. For controlling the adverse impacts a regular monitoring is essential. The environmental monitoring is being done as per the guide-lines stipulated by Ministry of Environment, Forest and Climate Change (MoEF&CC), Govt. of India.

The very purpose of environmental monitoring is to assess the quality of various attributes which affects the environment. As per quality of these attributes appropriate strategy is to be developed to control the pollution level within the permissible limits. The three major attributes are air, water and noise level.

Bharat Coking Coal has awarded Environmental Monitoring work of all Projects, Cluster wise, to Central Mine Planning & Design Institute Limited (CMPDIL). The environmental monitoring has been carried out as per conditions laid down by MoEF&CC while granting environmental clearance to different projects. CMPDI has trained manpower and well equipped laboratory to carry out monitoring, analysis and R&D work in the field of environment.

- 1.1 The Cluster-XV is in the Western part of the Jharia coalfield. It includes a group of 4 Mines (viz. Kharkharee, Madhuband, Phularitand&Dharmaband). The Cluster – XV is situated about 25 - 30 kms from Dhanbad Railway Station. The mines of this Cluster – XV are operating since pre nationalization period (prior to 1972-73). It is connected by both Railway and Road. The drainage of the area is governed by Khudia Nala.
- 1.2 The Cluster-XV is designed to produce 0.325 MTPA (normative) and 0.423 MTPA (peak) capacity of coal.

The Project has Environmental Clearance from Ministry of Environment, Forest and Climate Change (MoEF&CC) for a rated capacity 0.325 MTPA (normative) and 0.423 MTPA (peak) capacity of coal production vide letter no. J-11015/100/2011-IA.II (M) dated 16th December, 2013.

Ministry of Environment, Forest and Climate Change while granting environmental clearance has given one of the General conditions that “ Four ambient air quality monitoring stations should be established in the core zone as well as in the buffer zone for PM₁₀, PM_{2.5}, SO₂, NO_x monitoring. Location of the stations should be decided based on the meteorological data, topographical features and environmentally and ecologically sensitive targets in consultation with the State Pollution Control Board.” And other conditions regarding water / effluent and noise level monitoring.

In compliance of these conditions the Environmental Monitoring has been carried out & report prepared for submission to MOEF&CC & SPCB and other statutory authorities.

AMBIENT AIR QUALITY MONITORING

2.1 Location of sampling station and their rationale:

(As per G.S.R. 742 (E) dt. 25th December, 2000)

2.1.1 Ambient Air Quality Sampling Locations

I. CORE ZONE Monitoring Location

i) Kharkharee CISF Office (A21): Industrial Area

The location of the sampling station is 23°46' 29.00" N 86° 14' 37.08"E. The sampler was placed at a height of approx. 1.5m above ground level at Project Office.

ii) Madhuband UGP Office (A33): Industrial Area

The location of the sampling station is 23°45'24.48" N 086°11'59.44"E. The sampler was placed at a height of approx. 1.5m above ground level at Project Office.

II. BUFFER ZONE Monitoring Location

i) Block IV Kooridih OCP (A6): Industrial Area

The location of the sampling station is 23° 47' 54.00" N & 86°16' 20.00" E. The sampler was placed at a height of approx. 1.5m above ground level at Safety Office.

ii) Lohapatti (A20): Industrial Area

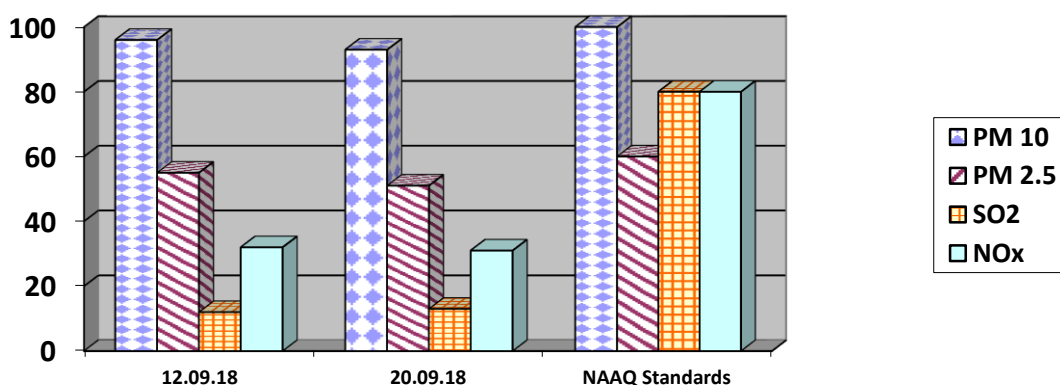
The location of the sampling station is 23°44'29.42" N & 86°16'49.96" E. The sampler was placed at a height of approx. 1.5m above ground level at Safety Office.

AMBIENT AIR QUALITY DATA

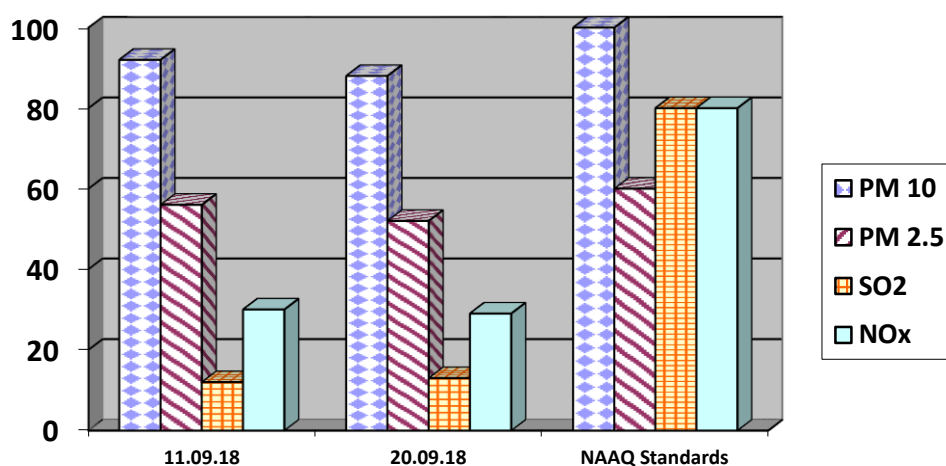
Cluster – XV, Bharat Coking Coal limited Month: SEP 2018

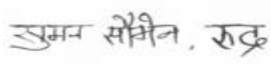
Year : 2018-19.

Station Name: A21 Kharkharee		Zone: Core		Category: Industrial	
Sl. No.	Dates of sampling	PM 10	PM 2.5	SO2	NOx
1	12.09.18	96	55	12	32
2	20.09.18	93	51	13	31
	NAAQ Standards	100	60	80	80

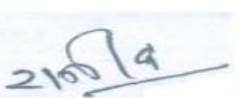


Station Name: A33 Madhuband UGP		Zone: Core		Category: Industrial	
Sl. No.	Dates of sampling	PM 10	PM 2.5	SO2	NOx
1	11.09.18	92	56	12	30
2	20.09.18	88	52	13	29
	NAAQ Standards	100	60	80	80

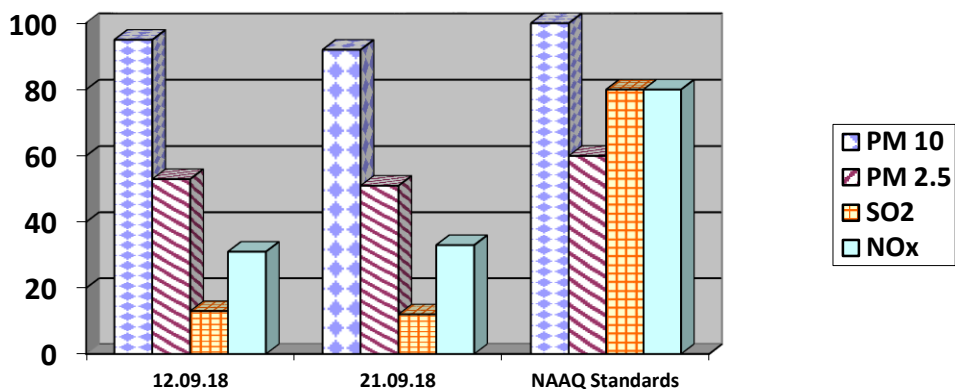



 Analysed By
 JSA/SA/SSA

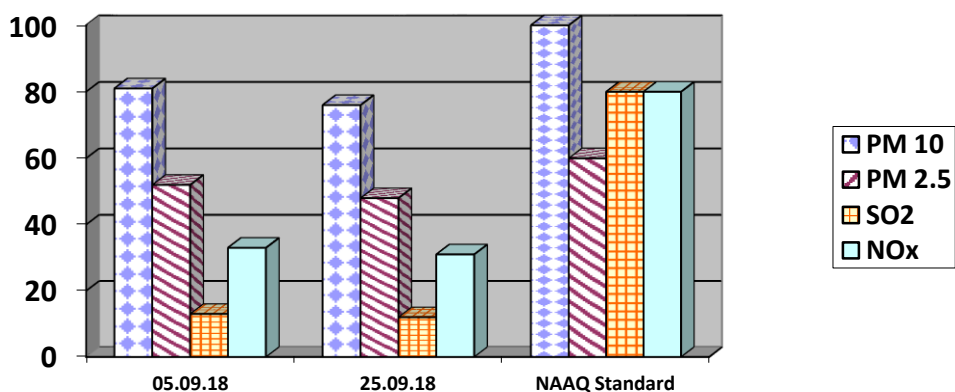

 Checked By
 Lab In Charge
 RI-2, CMPDI, Dhanbad


 Approved By
 HOD(Mining/Environment)
 RI-2, CMPDI, Dhanbad

Station Name: A6 Block IV Kooridih OCP		Zone: Buffer		Category: Industrial	
Sl. No.	Dates of sampling	PM 10	PM 2.5	SO ₂	NO _x
1	12.09.18	95	53	13	31
2	21.09.18	92	51	12	33
	NAAQ Standards	100	60	80	80



Station Name: A20, Lohapatti		Zone: Buffer		Category: Industrial	
Sl. No.	Dates of sampling	PM 10	PM 2.5	SO ₂	NO _x
1	05.09.18	81	52	13	33
2	25.09.18	76	48	12	31
	NAAQ Standard	100	60	80	80



➤ All values are expressed in microgram per cubic meter.

➤ 24 hours duration

सुमन सेठी, रुद्र

Analysed By
JSA/SA/SSA

✓

Checked By
Lab In Charge
RI-2, CMPDI, Dhanbad

21/9/19

Approved By
HOD(Mining/Environment)
RI-2, CMPDI, Dhanbad

WATER QUALITY MONITORING

3.1 Location of sampling sites

(Refer **Plate No. – II**)

i) **Mine Discharge of Kharkharee UGP (MW15)**

A sampling point is fixed to assess the effluent quality of Mine discharge.

3.2 Methodology of sampling and analysis

Water samples were collected as per standard practice. The effluent samples were collected and analysed for four parameters on fortnightly basis at the Environmental Laboratory of CMPDI RI-II, Dhanbad.

3.3 Results & Interpretations

The results are given in tabular form along with the applicable standards. Results are compared with Schedule - VI, effluent prescribed by MoEF&CC. Results show that most of the parameters are within the permissible limits.

WATER QUALITY DATA

(EFFLUENT WATER- FOUR PARAMETERS)

Name of the Cluster: Cluster -XV		Month: SEP, 2018	Name of the Station: Mine Discharge of Kharkharee UGP	
Sl. No.	Parameters	MW15	MW15	As per MOEF General Standards for schedule VI
		First Fortnight 13-09-2018	Second Fortnight 20-09-2018	
1	Total Suspended Solids	48	40	100 (Max)
2	pH	7.94	7.81	5.5 - 9.0
3	Oil & Grease	<2.0	<2.0	10 (Max)
4	COD	48	44	250 (Max)

All values are expressed in mg/lit unless specified.

सुमन सोहन, रुद्र

Analysed By
JSA/SA/SSA

J

Checked By
Lab In Charge
RI-2, CMPDI, Dhanbad

21/9/18

Approved By
HOD(Mining/Environment)
RI-2, CMPDI, Dhanbad

NOISE LEVEL QUALITY MONITORING

4.1 Location of sampling sites

- i) Kharkharee CISF Office (N21)
- ii) Madhuband UGP Office (N33)
- iii) Block IV Kooridih OCP (N6)
- iv) Lohapatti (N20)

4.2 Methodology of sampling and analysis

Noise level measurements in form of 'L_{EQ}' were taken using Integrated Data Logging Sound Level Meter (NL-52 OF RION CO. Ltd. Make) during day time. Noise levels were measured for about one hour time in day time. Noise levels were measured in Decibels, 'A' weighted average, i.e. dB (A).

4.3 Results & Interpretations

Ambient noise levels were recorded during day time and the observed values were compared with standards prescribed by MoEFCC. The results of Noise levels recorded during day time on fortnightly basis are presented in tabular form along with the applicable standard permissible limits. The observed values in terms of L_{EQ} are presented. The observed values at all the monitoring locations are found to be within permissible limits.

NOISE LEVEL DATA

Name of the Project: Cluster -XV			Month: SEPTEMBER, 2018		
Sl. No.	Station Name/Code	Category of area	Date	Noise level dB(A)LEQ	*Permissible Limit of Noise level in dB(A)
1	Kharkharee CISF Office (N21)	Industrial area	12.09.18	62.8	75
2	Kharkharee CISF Office (N21)	Industrial area	20.09.18	49.2	75
3	Madhuband UGP Office (N33)	Industrial area	11.09.18	62.8	75
4	Madhuband UGP Office (N33)	Industrial area	20.09.18	57.9	75
5	Block IV Kooridih OCP (N6)	Industrial area	12.09.18	59.8	75
6	Block IV Kooridih OCP (N6)	Industrial area	21.09.18	59.3	75
7	Lohapatti (N20)	Industrial area	05.09.18	63.2	75
8	Lohapatti (N20)	Industrial area	25.09.18	57.7	75

*Permissible limits of Noise Level as per MOEF Gazette Notification No. GSR 742(E) dt. 25.09.2000 Standards for Coal Mines and Noise Pollution (Regulation and Control) Rules, 2000.

* Day Time: 6.00 AM to 10.00 PM,

अनुमय सैनी, रुद्र
Analysed By
JSA/SA/SSA

Checked By
Lab In Charge
RI-2, CMPDI, Dhanbad

21/9/18
Approved By
HOD(Mining/Environment)
RI-2, CMPDI, Dhanbad

Ambient Air Quality Standards for Jharia Coal Field
As per the Environment (Protection) Amendment Rules, 2000 notified vide
notification G.S.R. 742(E), dated 25.9.2000.

Category	Pollutant	Time weighted average	Concentration in Ambient Air	Method of Measurement
1	2	3	4	5
III Coal mines located in the coal fields of <ul style="list-style-type: none"> • Jharia • Raniganj • Bokaro 	Suspended Particulate Matter (SPM)	Annual Average * 24 hours **	500 $\mu\text{g}/\text{m}^3$ 700 $\mu\text{g}/\text{m}^3$	- High Volume Sampling (Average flow rate not less than 1.1 m^3/min)
	Respirable Particulate Matter (size less than 10 μm) (RPM)	Annual Average * 24 hours **	250 $\mu\text{g}/\text{m}^3$ 300 $\mu\text{g}/\text{m}^3$	Respirable Particulate Matter sampling and analysis
	Sulphur Dioxide (SO_2)	Annual Average * 24 hours **	80 $\mu\text{g}/\text{m}^3$ 120 $\mu\text{g}/\text{m}^3$	1.Improved wet and Gaeke method 2.Ultraviolet fluorescence
	Oxide of Nitrogen as NO_2	Annual Average * 24 hours **	80 $\mu\text{g}/\text{m}^3$ 120 $\mu\text{g}/\text{m}^3$	1. Jacob & Hochheiser Modified (Na-Arsenic) Method 2. Gas phase Chemiluminescence

Note:

* Annual Arithmetic mean for the measurements taken in a year, following the guidelines for frequency of sampling laid down in clause 2.

** 24 hourly/8 hourly values shall be met 92% of the time in a year. However, 8% of the time it may exceed but not on two consecutive days.

NATIONAL AMBIENT AIR QUALITY STANDARDS
New Delhi the 18th FEBRUARY 2009

In exercise of the powers conferred by Sub-section (2) (h) of section 16 of the Air (Prevention and Control of Pollution) Act, 1981 (Act No. 14 of 1981), and in supersession of the notification No(s).S.O.384(E), dated 11th April 1994 and S.O.935(E), dated 14th October 1998, the Central Pollution Control Board hereby notify the National Ambient Air Quality Standards with immediate effect.

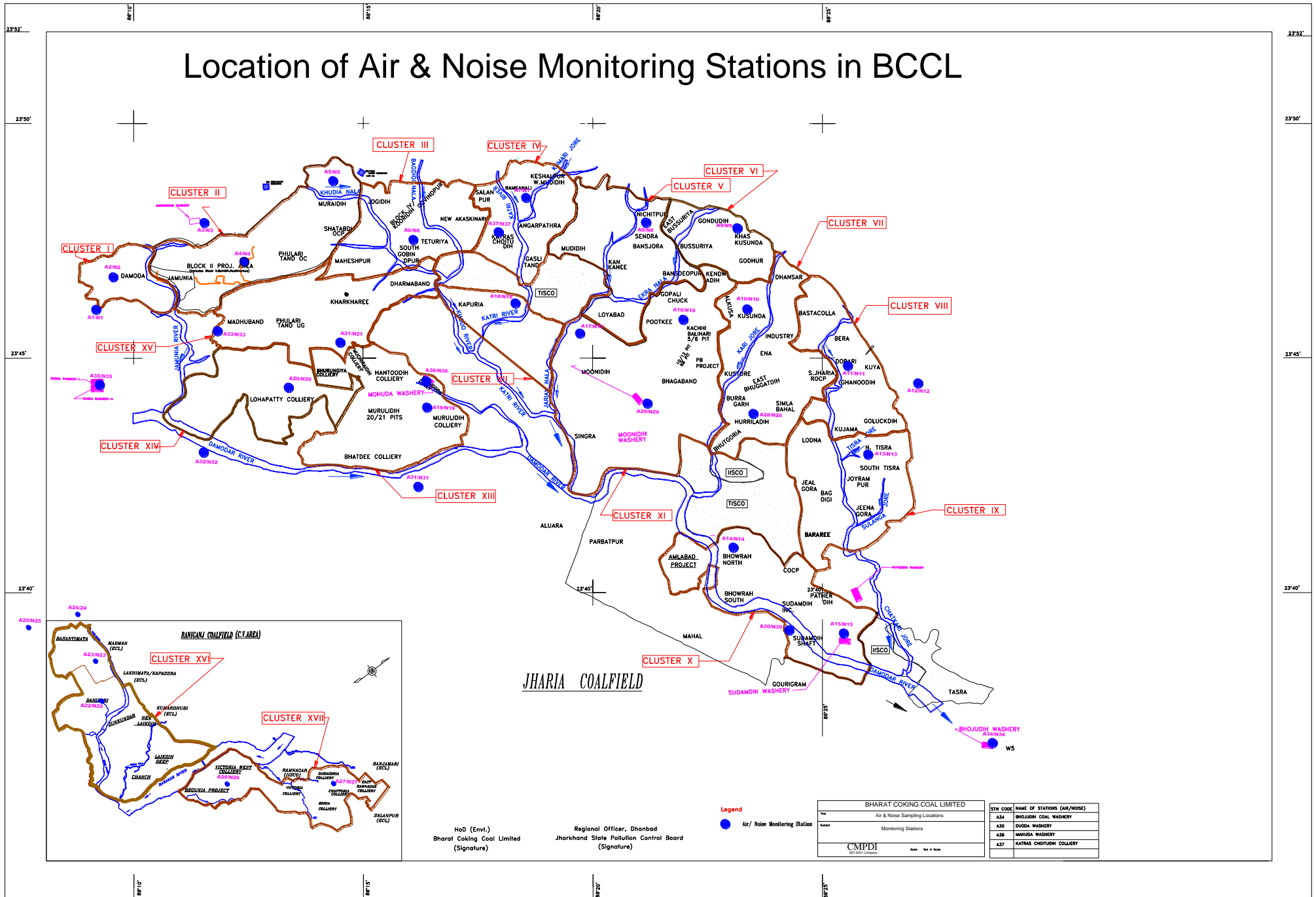
Pollutant	Time Weighted Average	Concentration in Ambient Air		Methods of Measurement
		Industrial, Residential I, Rural and other Areas	Ecologically Sensitive Area (Notified by Central Government)	
Sulphur Dioxide (SO₂), µg/m³	Annual * 24 Hours **	50 80	20 80	-Improved West and Gaeke Method -Ultraviolet Fluorescence
Nitrogen dioxide (NO₂), µg/m³	Annual * 24 Hours **	40 80	30 80	-Jacob & Hochheiser modified (NaOH-NaAsO ₂) Method -Gas Phase Chemiluminescence
Particulate Matter (Size less than 10µm) or PM₁₀, µg/m³	Annual * 24 Hours **	60 100	60 100	-Gravimetric -TEOM -Beta attenuation
Particulate Matter (Size less than 2.5µm) or PM_{2.5}, µg/m³	Annual * 24 Hours **	40 60	40 60	-Gravimetric -TEOM -Beta attenuation
Ozone (O₃) , µg/m³	8 Hours * 1 Hour **	100 180	100 180	-UV Photometric -Chemiluminescence -Chemical Method
Lead (Pb) , µg/m³	Annual * 24 Hours **	0.50 1.0	0.50 1.0	-AAS/ICP Method after sampling on EPM 2000 or equivalent filter paper -ED-XRF using Teflon filter
Carbon Monoxide (CO), mg/m³	8 Hours ** 1 Hour **	02 04	02 04	-Non dispersive Infrared (NDIR) Spectroscopy
Ammonia (NH₃), µg/m³	Annual * 24 Hours **	100 400	100 400	-Chemiluminescence -Indophenol blue method
Benzene (C₆H₆), µg/m³	Annual *	05	05	-Gas Chromatography (GC) based continuous analyzer -Adsorption and desorption followed by GC analysis
Benzo(a)Pyrene (BaP) Particulate phase only, ng/m³	Annual *	01	01	-Solvent extraction followed by HPLC/GC analysis
Arsenic (As), ng/m³	Annual *	06	06	-AAS/ICP Method after sampling on EPM 2000 or equivalent filter paper
Nickel (Ni), ng/m³	Annual *	20	20	-AAS/ICP Method after sampling on EPM 2000 or equivalent filter paper

* Annual Arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals.

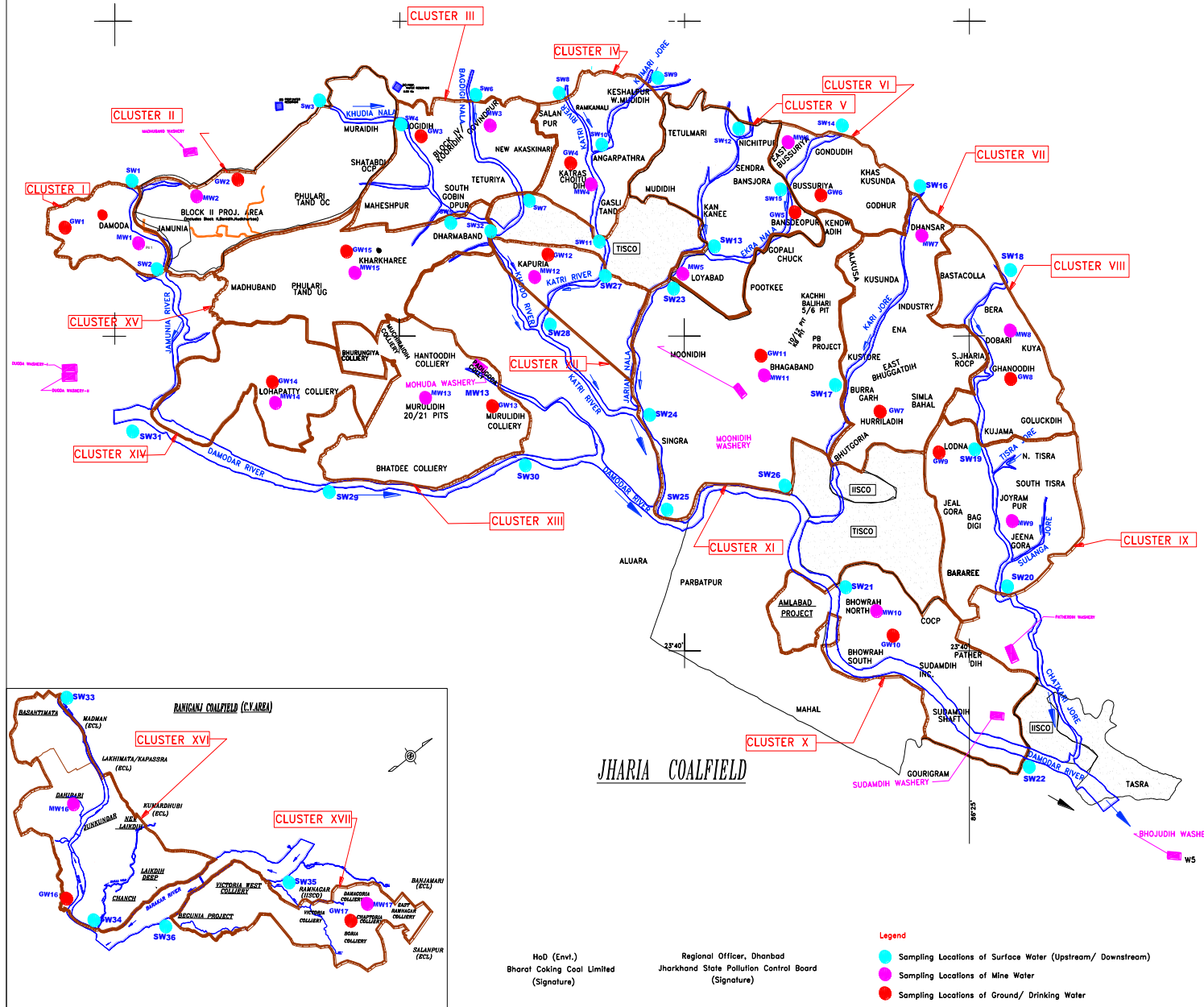
** 24 hourly or 8 hourly or 1 hourly monitored values, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.

NOTE: Whenever and wherever monitoring results on two consecutive days of monitoring exceed the limits specified above for the respective category, it shall be considered adequate reason to institute regular or continuous monitoring and further investigations.

Location of Air & Noise Monitoring Stations in BCCL



Water Sampling Locations in BCCL



INDEX

Cluster	Surface Water (U/S, D/S)	Name of River/ Nala / Jore	Mineral Effluent Water	Sampling Location	Ground Water	Sampling Location
I	SW1, SW2	Jamunia River	MW1	Damoda Area	GW1	Chutway Village
II	SW3, SW4	Khudra Nala	MW2	Block II OCP	GW2	Joyrampur Village
III	SW4, SW5, SW6, SW7	Khudra Nala, Bagdigi Nala	MW3	Govindpur Colliery	GW3	Jogdih Village
IV	SW8, SW11, SW9, SW10	Kan River, Kurnai Jore	MW4	Chotudih	GW4	Kankanees Village
V	SW12, SW13, SW15	Jarian Nala, Ekra Nala	MW5	Mudidih	GW5	Nichitpur
VI	SW14, SW15	Ekra Nala	MW6	East Bassuria UGP	GW6	Banspora Borewell
VII	SW16, SW17	Kan Jore	MW7	Dobari UGP	GW7	Humradih
VIII	SW18, SW19	Kashi Jore	MW8	Dobari UGP	GW8	Gharudih
IX	SW19, SW20	Kashi Jore	MW9	Jeenagora	GW9	Lodra
X	SW21, SW22	Damodar River	MW10	Bhowrah North	GW10	Bhowrah South
XI	SW23, SW24, SW25, SW26	Kan River, Damodar River	MW11	Bhagband UGP	GW11	Bhagbandh
XII	SW27, SW28	Kan River, Damodar River	MW12	Kapuria	GW12	Kapuria
XIII	SW29, SW30	Damodar River	MW13	Muridih (20/21)	GW13	Muridih
XIV	SW31, SW32	Damodar River	MW14	Lohapatti	GW14	Lohapatti
XV	SW5, SW32	Kharkhanees UGP	MW15	Kharkhanees	GW15	Kharkhanees
XVI	SW33, SW34	Khudra River	MW16	Dahabani OCP	GW16	Pallabani Village
XVII	SW35, SW36	Barakar River	MW17	Damagoria Colliery	GW17	Chaptoria

Legend

- Sampling Locations of Surface Water (Upstream/ Downstream)
- Sampling Locations of Mine Water
- Sampling Locations of Ground/ Drinking Water

HoD (Env.)
Bharat Coking Coal Limited
(Signature)

Regional Officer, Dhanbad
Jharkhand State Pollution Control Board
(Signature)

Company	BHARAT COKING COAL LIMITED
Title	WATER SAMPLING LOCATIONS
Subject	MONITORING STATIONS
CMPDI	Scale: Not to Scale

GROUND WATER LEVEL MONITORING REPORT



BHARAT COKING COAL LTD.

(A Subsidiary of Coal India Ltd.)

Prepared by CMPDIL

CONTENT

	<u>Page No.</u>
DETAILS OF THE REPORT	1
1.0 Introduction	2 - 3
1.1 Climate, temperature & rainfall	2
1.2 Geomorphology	2
1.3 Drainage	3
2.0 Groundwater system	4 - 6
2.1 Geology of the area	4
2.2 Hydrogeology of the study area	5
2.3 Aquifer Description	5
2.4 Aquifer parameters	6
3.0 Groundwater level monitoring	7 - 24
3.1 Historical groundwater level	8
3.2 Groundwater level scenario (mining/non-mining)	9
3.3 Quarterly groundwater level, Cluster of mines	10
A Monitoring of Ground Water Levels of Cluster-I	10
B. Monitoring of Ground Water Levels of Cluster-II	11
C. Monitoring of Ground Water Levels of Cluster-III	12
D. Monitoring of Ground Water Levels of Cluster-IV	13
E. Monitoring of Ground Water Levels of Cluster-V	14
F. Monitoring of Ground Water Levels of Cluster-VI	15
G. Monitoring of Ground Water Levels of Cluster-VII	16
H. Monitoring of Ground Water Levels of Cluster-VIII	17
I. Monitoring of Ground Water Levels of Cluster-IX	18
J. Monitoring of Ground Water Levels of Cluster-X	19
K. Monitoring of Ground Water Levels of Cluster-XI	20
L. Monitoring of Ground Water Levels of Cluster-XIII	21
M. Monitoring of Ground Water Levels of Cluster-XIV	22
N. Monitoring of Ground Water Levels of Cluster-XV	23
O. Monitoring of Ground Water Levels of Cluster-XVI	24
4.0 Ground water level scenario	25 – 26
5.0 Stage of Groundwater Development	27 – 28
6.0 conservation measures & future strategy	29 – 30
 Annexure-I: Hydrograph Stations	 31
Annexure-IIA: Hydrograph Stations	32 - 33
Annexure-IIB: Historical water level data	34 - 35
Annexure-III: CGWB well Hydrographs	36 - 37
Annexure-IV: Groundwater sample details	38
 Abbreviations	 39

LIST OF TABLES

<u>Table No</u>	<u>Description</u>	<u>Page No.</u>
Table No – 1	Historical Groundwater Level	8
Table No – 2	Depth to water table	9
Table No – 3	Average hydraulic gradient	9
Table No – 4	GW level data Cluster wise	26
Table No – 5	Block wise Stage of GW Development	27
Table No – 6	Cluster wise GW Development scenario	28

LIST OF FIGURES

<u>Nos.</u>	<u>Description</u>
Figure No - 1	Groundwater monitoring station location map
Figure No - 2	Groundwater Quality sample location map
Figure No – 3	Proposed Piezometers location map

LIST OF ANNEXURES

<u>Nos.</u>	<u>Description</u>	<u>Annexure No</u>
1.	Location details of Monitoring stations	Annexure-I
2.	Details of Hydrograph Stations	Annexure-IIA
3.	Historical Water Level data	Annexure-IIB
4.	Hydrographs of CGWB observation stations	Annexure-III
5.	Groundwater sample details	Annexure-IV

DETAILS OF THE REPORT

SI No.	ITEMS	INFORMATIONS
1	Geographical Area	Jharia Coalfield (JCF): 453 sq. km. Raniganj Coalfield (RCF part): 19.64 sq. km. (Cluster-XVI area only)
2	Major Physiographic Units	Dissected Pediplain with surface Reduced Level (RL) varies from 160 m to 220 m above mean sea level (AMSL) in JCF and 100 m to 140 m AMSL in RCF.
3	Drainage System	Damodar River is the master drainage flowing along western boundary of the JCF. Jamunia River, Khudia River, Katri River, Jarian Nala, Ekra Jore, Kari Jore, Kashi Jore, Chatkari Jore and their tributaries are flowing through the JCF area. Damodar River, Barakar River is the master drainage of the part of RCF area (CV Area).
4	Annual Rainfall	Jharkhand State – 1264 mm Dhanbad District - 1271.6 mm (Source: Rainfall Statistics of India-2016, IMD, Ministry of Earth Sciences)
5	Geological Formations	Gondwana Formation (Talchir Formation, Barakar Formation, Barren Measure & Raniganj Formation)
6	Aquifer System	Top Unconfined/Phreatic Aquifer – average thickness 25 m Semi-confined to confined Aquifer – average thickness 50–200 m
7	Hydrogeological properties	Unconfined Aquifer (Damoda BJ Section & Block-III): Hydraulic Conductivity – upto 0.50 m/day Transmissivity – 10 - 42 m ² /day Semi-confined to confined Aquifer (Sitana & Kumari Block): Hydraulic Conductivity – 0.0006-1.44 & 0.05-0.0027 m/day Transmissivity – 0.06 – 0.573 m ² /day
8	Groundwater Level Monitoring Network	Out of total 254 no of monitoring stations 64 nos located within core mining area and rest comes within Buffers zone. 60 Nos. of Groundwater monitoring well (Dug Wells) network is established by CMPDI to record groundwater level data in and around the Core Zone of JCF and 4 Nos. of Groundwater monitoring well (Dug Wells) in RCF (CV Area).
9	Groundwater Levels Below Ground Level (bgl)	JCF area: Pre-monsoon – 0.67 to 16.28 m (Avg. 5.61 m bgl) in '2017 Post-monsoon – 0.15 to 06.97 m (Avg. 2.41 m bgl) in '2017 RCF area (part): Pre-monsoon – 1.93 to 5.80 m (Avg. 3.25 m bgl) in '2017 Post-monsoon – 1.63 to 3.78 m (Avg. 2.47 m bgl) in '2017
10	Groundwater Quality	Potable
11	Proposed Piezometers	New piezometers (23 nos.) have been proposed to monitor impact of coal mining on groundwater regime within the coalfield area (JCF & part of RCF) for maximum depth upto 290 m to monitor deeper aquifers.
12	Stage of Groundwater Development (CGWB)	Dhanbad District – 77% (GWRE-2013)

1.0 INTRODUCTION

1.1 CLIMATE, TEMPERATURE & RAINFALL

The Jharia Coalfield (JCF) and part of Raniganj Coalfield (RCF) area in Dhanbad District belongs to sub-humid tropical climatic region. The maximum temperature during summer shoots upto 45° C and falls between 10° C to 5° C in winter. The maximum rainfall occurs during the period between June and September.

The annual rainfall in the Dhanbad District is 1271.60 mm (Rainfall Statistics of India-2016, IMD (Ministry of Earth Sciences), has been considered. The non-monsoon rainfall in the District is 93.60 mm (Winter-19.5 mm, Pre-monsoon-48.8 mm and Post-monsoon-25.3 mm) and the monsoon rainfall is 1178.10 mm of total annual rainfall. Monsoon Rainfall is around 92.65% of total annual rainfall in 2016 in Dhanbad District. Rainfall is the primary source of groundwater recharge.

1.2 GEOMORPHOLOGY

Northern part of the JCF area is covered with hills and thin forest. In general the altitude varies from 220 m AMSL in Barora area (Cluster-I) to 160 m above mean sea level (AMSL) in Sudamdih area (Cluster-X). Pediplains are developed over sedimentary rocks or Gondwana formation consisting of Sandstone, Shale, coal, etc. Dissected pediplains are developed over Gondwana formations found in Jharia, Baghmara, Katras areas etc. However, in RCF (part) areas the altitude varies from 100 m to 140 m AMSL (Cluster-XVI). The general slope of the topography is towards south, i.e. Damodar River.

1.3 DRAINAGE

The drainage pattern of the area is dendritic in nature. The drainage system of the area is the part of Damodar sub-basin. All the rivers that originate or flow through the coalfield area have an easterly or south easterly course and ultimately joins Damodar River, the master drainage. The drainage of the JCF is mainly controlled by Jamuniya River (5th order), Khudia nala (3rd order), Katri River (4th) and Chatkari nala (3rd order) flowing from north to south and joins Damodar River. Whereas, Barakar River and Khudia River are controlling the drainage pattern of RCF (part) and joins Damodar River in the south. Damodar River is the main drainage channel and flows from west to east along the southern boundary of JCF and RCF.

The drainage map of the JCF and part of RCF has been prepared on topographic map of scale 1:50000 (**Figure No-1**). The watershed of all tributary rivers (Jamuniya River to Barakar River) falls within the north-western part of Damodar sub-basin which comes under Lower Ganga Basin.

Besides, a large number of ponds/tanks are distributed in and around JCF, out of which one prominent lake is located at Topchanchi in the north-west part. Two reservoirs, Maithon dam in Barakar River and Panchet dam in Damodar River near to Chanch Victoria Area of BCCL (part of RCF) are the main source of water supply to the nearby area. Jharia Water Board, Damodar Water Supply Scheme and Mineral Area Development Authority (MADA) are supplying water to the various coalfield area from Maithon dam, Damodar River, Jamunia River, Topchachi Lake, etc.

2.0 GROUNDWATER SYSTEM

2.1 GEOLOGY OF THE AREA

The Jharia Coalfield covers an area of 453 sq. km. located in Dhanbad District, Jharkhand. The non-coal bearing Talchir Formation is exposed in patches along the northern fringe of the Coalfield. The Barakar Formation which overlies the Talchir is covering the most part of the Jharia Coalfield and having an area of 218 sq. km. This is successively overlain by the non-coal bearing Barren Formation which is mainly exposed in the central part of the Coalfield. This, in turn, is overlain by the Raniganj formation (Coal Bearing horizon) in the south-western part of the Coalfield and covers an area of 54 sq. km.

Chanch-Victoria Area which is located in the western part of Raniganj Coalfield. The Raniganj coalfield represents the eastern most coal basin in the Damodar Valley Region and located in Burdwan District, West Bengal. The Coalfield is almost elliptical in shape and covers an area of about 1530 sq. km. out of which only 35 sq. km. comes under leasehold area of BCCL out of which 19.64 sq. km is the study area (Cluster-XVI only). The coal bearing formations of the area belongs to Barakar Formation of the Lower Gondwana.

2.2 HYDROGEOLOGY OF THE STUDY AREA

The permeable formations mainly composed of sandstone behave as aquifer units. The coal seam and shales developed in the area act as impermeable beds i.e. aquiclude. The aquifer materials of Gondwana Formation are constituted of fine to coarse grained sandstone having primary porosity of intergranular void space. The secondary porosity formed due to presence of faults, fracture, joints, etc. Sandstone of Gondwana formations in JCF and RCF are very hard, compact and cemented sandstone and forming less potential aquifer, particularly the deeper aquifer system. The secondary porosity along with primary porosity forms a conduit system making these formations good aquifers for movement and storage of ground water.

2.3 AQUIFER DISPOSITION

The aquifer system for shallow and deeper aquifer has been established through hydrogeological studies, exploration, surface and subsurface geophysical studies in the JCF and RCF (part) covering all geological formations. The aquifer can be divided into two zones – Un-confined/Phreatic (shallow) and Semi-confined to confined (deeper) aquifer.

PHREATIC/UN-CONFINED AQUIFER

The top aquifer occurred above the top most coal seam/shale bed is called un-confined or water table aquifer and it consists of relatively permeable formation such as weathered sandstone and loose soil. The thickness of the un-confined aquifer is varies from few meters to 50 m. This un-confined aquifer is more potential than deep seated semi-confined to confined aquifer.

SEMI-CONFINED TO CONFINED AQUIFER

The semi-confined to confined aquifer consisting of sandstone bed is sandwiched with coal seams/shale beds and multiple aquifer system developed due to presence of multiple numbers of coal seams/shale beds. With the presence of intercalated shale and carbonaceous shale beds and reduction in permeability with depth, the lower aquifers are poor in potential.

2.4 AQUIFER PARAMETERS

PHREATIC/UN-CONFINED AQUIFER – The wells are tested by CMPDI for determination of aquifer parameters in Damuda (BJ Section) and Block-III area of JCF. The hydraulic conductivity of the un-confined aquifer is 0.50 m/day as computed from pumping tests on the wells. The transmissivity of the unconfined aquifer ranges from 10.68 m²/day to 41.48 m²/day.

SEMI-CONFINED TO CONFINED AQUIFER – Below the un-confined aquifer, the sandstone partings in-between impervious layers of shale and coal seams is designated as semi-confined / confined aquifers. The sandstones in these aquifers are fine to coarse grained, hard and compact with very low porosity. Mostly groundwater occurs in the weak zones formed due to weathering, fracture, faults, which create the secondary porosity. The hydrogeological parameter has been determined by CMPDI in Sitanala Block by conducting aquifer performance test (APT). The hydraulic conductivity (K) of semi-confined aquifer in Barakar Formation ranges from 0.0006 m/day to 1.44 m/day. The hydrogeological parameter has also been determined at Kumari OCP Block in the central JCF by conducting aquifer performance test. The hydraulic conductivity (K) of semi-confined aquifer in Barakar Formation in this area ranges from 0.0027 m/day to 0.05 m/day.

3.0 GROUNDWATER LEVEL MONITORING

To collect the representative groundwater levels in the study area, CMPDI has established a monitoring network of total 254 monitoring stations out of which 64 located within core zone and rest comes within Buffer zone. 60 dug wells within JCF and 04 dug wells within RCF (part) area (Details of the Hydrograph stations & water level are given in **Annexure-I, IIA & IIB**) spread over the entire BCCL leasehold area, **Figure No-1**. Water level monitoring in 254 hydrograph stations has been done in pre-monsoon as well as in post monsoon whereas in 64 stations monitoring done in quarterly (February, May, August and November month of 2017) basis.

Depth to water level of the water table depict the inequalities in the position of water table with respect to ground surface and is useful in delineating recharge / discharge areas, planning of artificial recharge structure and shows the overall status of the groundwater level in the area. Historical groundwater level (GWL) of entire JCF and part of RCF with fluctuation, GWL of Non-mining / Mining areas and GWL of the Cluster of Mines of BCCL are shown in this report to assess the effect of Coal mining activity in the groundwater regime in and around the Coalfield area.

Mining is a dynamic phenomenon. The mining activity creates dis-equilibrium in environmental scenario of the area and disturbs the groundwater conditions/regime in particular. The impact on shallow water regime due to mining activity can be broadly viewed as under:

- Historical GWL with annual fluctuation over the years
- GWL scenario in Non-mining and Mining area (OC/UG mines)
- GWL scenario of Cluster of mines of BCCL

**Construction of piezometers within Jharia Coalfield and part of Raniganj Coalfield to monitor groundwater level of deeper aquifers is already in progress.*

3.1 HISTORICAL GROUNDWATER LEVEL

Historical GWL of JCF and part of RCF are given from 2005 to 2017 of CMPDI monitoring stations (total 64 stations within Coalfield area). Pre-monsoon and Post-monsoon GWL with Fluctuation has been mentioned below in the table.

Table No – 1: Historical Groundwater Level

Period		(Water level in metre below ground level)								
		Pre-Monsoon (April/May)			Post-Monsoon (Nov/Dec)			Fluctuation		
		From	To	Average	From	To	Average	From	To	Average
JCF	2005	0.07	19.08	6.29	0.84	12.13	3.20	0.12	12.45	3.21
	2007	0.40	19.27	5.66	0.35	8.21	2.87	0.02	16.15	2.96
	2008	0.45	18.35	5.42	0.35	14.20	3.62	0.03	9.22	2.45
	2010	0.85	14.47	5.24	0.10	15.88	4.48	0.02	5.55	1.54
	2012	1.27	18.68	5.58	0.15	7.80	2.72	0.08	13.45	2.96
	2013	0.70	19.20	5.65	0.45	8.35	2.77	0.29	15.88	3.17
	2014	0.70	16.28	4.92	0.75	14.98	3.27	0.25	10.15	2.17
	2015	1.38	17.20	6.00	0.45	14.58	3.92	0.28	7.62	2.15
	2016	0.78	16.73	5.64	0.30	12.43	3.19	0.23	6.35	2.88
	2017	0.67	16.28	5.61	0.15	6.97	2.41	0.10	12.10	3.25
RCF (part)	2008	5.02	10.50	7.59	2.85	4.90	3.71	1.82	6.60	3.87
	2010	2.20	8.85	4.74	2.78	9.58	4.63	0.68	1.10	0.89
	2011	3.57	8.02	4.98	2.50	6.21	3.75	0.55	1.90	1.23
	2012	3.10	7.34	4.59	1.55	7.00	3.66	0.05	2.78	0.94
	2013	1.70	9.87	6.54	2.90	8.85	4.71	1.02	5.54	2.84
	2014	3.27	6.48	4.57	2.13	3.03	2.63	0.54	3.45	1.94
	2015	3.38	9.52	5.33	2.68	8.20	5.11	1.06	1.32	1.81
	2016	3.61	10.65	6.24	0.90	6.50	3.18	1.63	4.40	3.06
	2017	1.93	5.80	3.25	1.63	3.78	2.47	1.63	3.78	0.78

3.2 GROUNDWATER LEVEL SCENARIO IN NON-MINING/MINING AREA

Depth to water level (DTW) range in different formations with respect of mining and non-mining areas is summarized in the Table No-2.

Table No – 2: Depth to water table

Formation	Area	DTW (bgl, m) [Year-2017]		Average GWL (m)	
				Pre- monsoon	Post- monsoon
Sedimentary (Gondwana)	Non-mining		1.85-9.80	5.20	2.45
	Mining	OC	0.75-10.45	4.58	2.20
		UG	1.21-16.28	6.96	2.91
Metamorphics	Peripheral part of the Coalfield		0.67-15.15	6.40	3.21

The study revealed that water table is in shallow depth and there is no significant stress in the water table due to coal mining activity. Mining and Non-mining areas shows barely any difference in water table condition in the JCF and RCF (part) area. The average hydraulic gradient of the water table within mining and non-mining areas is given in Table No-3. There is no significant change in hydraulic gradient has been observed. Relatively steep gradient near active opencast mining areas w.r.t., Non-Mining, Underground mines and Metamorphics areas is observed.

Table No – 3: Average hydraulic gradient

Sl. No	Formation	Area		Average hydraulic gradient
1	Sedimentary (Gondwana)	Non-Mining		1.5×10^{-3} to 3.5×10^{-3}
2		Mining	OC	7.75×10^{-3} to 11.82×10^{-3}
3			UG	2×10^{-3} to 5×10^{-3}
4	Metamorphics	Peripheral part of the Coalfield		1.0×10^{-3} to 3.0×10^{-3}

3.3 QUARTERLY GROUNDWATER LEVEL, CLUATER OF MINES (BCCL)

3.3 A Monitoring of Ground Water Levels of Cluster-I

Cluster-I (Damuda Group of Mines) consisting of Damoda (BJ and Gutway section) UG, Damoda (Albion section) OCP, proposed Damoda (B.J.section) OCP and Closed Gutway OCP of Barora Area of BCCL. It is located in the extreme western part of JCF in Bokaro district of Jharkhand.

The present leasehold area of Cluster-I is 575 Ha. The Damoda block area is marked by more or less flat and gently undulating topography. The RL varies from 179 m to 208 m AMSL and the general slope of topography is towards east. Jamuniya River, Kari Jore, Podo Jore and its tributaries are controlling the drainage system of the area. The area comes under the watershed of Jamuniya River.

4 hydrograph stations (**B-15, B-21A, B51 and B-53**) are located in the core zone of the mine area. Water level monitoring in these monitoring stations has been done in the months of February, April and August & November'2017 and the Ground water level data is enclosed in the table below:

Sl No.	Well No.	Location	Water level (bgl in meters)			
			Feb'17	Apr'17	Aug'17	Nov'17
1	B-15	Bera Basti	1.45	1.85	0.83	0.15
2	B-21A	Dugdha	7.65	10.00	2.63	5.65
3	B-51	Taranga	3.30	4.98	2.30	2.55
4	B-53	Karmatanr	2.32	4.02	1.24	1.92
Average WL (bgl)			3.68	5.21	1.75	2.57

Ground Water Level (in bgl) varies from 1.45 to 7.65 m during February, 4.02 to 10.00 m during April, 0.83 to 2.63 m during August and 0.15 to 5.65 m during November within the Core Zone of Cluster-I area.

3.3 B Monitoring of Ground Water Levels of Cluster-II

Cluster-II consists of seven mines namely; Block-II mixed mine (OCP & UGP), Jamunia OCP, Shatabdi OCP, Muraidih mixed mine (OCP & UGP) and Phularitand OCP is under administrative control of Block-II Area and Barora Area of BCCL. It is located in the extreme western part of Jharia Coalfield in Dhanbad district of Jharkhand.

The present leasehold area of Cluster-II is 2025.71 Ha. The Damoda block area is marked by more or less flat and gently undulating topography. The RL varies from 176 m to 235 m AMSL. Jamuniya River, Khudia River and its tributaries are controlling the drainage system of the area. The area comes under the watershed of Jamuniya River and Khudia River.

5 hydrograph stations (**B-1, B-59, B-60, B-61A and B-62A**) are located in the core zone of the mine area. Water level monitoring in these monitoring stations has been done in the months of February, April, August & November'2017 and the Ground water level data is enclosed in the table below:

SI No.	Well No.	Location	Water level (bgl in meters)			
			Feb'17	Apr'17	Aug'17	Nov'17
1	B-1	Muraidih	1.83	2.33	1.43	1.63
2	B-59	Khodovaly	1.26	5.40	0.85	0.60
3	B-60	Bahiyardih	9.23	13.23	3.13	3.18
4	B-61A	Kesargora	1.42	2.57	0.62	0.82
5	B-62A	Sadiyardih	6.15	8.15	2.65	4.35
Average WL (bgl)			3.98	6.34	1.74	2.12

Ground Water Level (in bgl) varies from 1.42 to 9.23 m during February, 2.33 to 13.23 m during April, 0.62 to 3.13 m during August and 0.60 to 4.35 m during November within the Core Zone of Cluster-II area.

3.3 C Monitoring of Ground Water Levels of Cluster-III

Cluster-III consists of nine mines namely, Jogidih UG, Maheshpur UG, South Govindpur UG, Teturiya UG, Govindpur UG, New Akashkinaree mixed mine (OC & UG) and Kooridih/Block-IV mixed mine (OC & UG) under the administrative control of Govindpur Area of BCCL. This Cluster of mines is located in western part of Jharia Coalfield in Dhanbad district of Jharkhand.

The present leasehold area of Cluster-III is 1420.0 Ha. The area is plain with gentle undulation with RL varies from 160 m to 208.80 m AMSL. The general slope of the area is towards south. Khudia River, Baghdihi Jore, Katri River and its tributaries are controlling the drainage system of the area. The area comes under the watershed of Khudia River.

5 hydrograph stations (**A-12, A-25, A-29, B-14 and B-60**) are located in the core zone of the mine area. Water level monitoring in these monitoring stations has been done in the months of February, April, August & November'2017 and the Ground water level data is enclosed in the table below:

Sl No.	Well No.	Location	Water level (bgl in meters)			
			Feb'17	Apr'17	Aug'17	Nov'17
1	A-12	Jamua	1.10	2.55	0.55	0.85
2	A-25	Sinidih	4.88	6.38	1.58	2.88
3	A-29	Dharmaband	3.90	4.40	1.95	1.30
4	B-14	Mathadih	2.64	2.94	0.89	1.84
5	B-60	Sonardih	9.23	13.23	3.13	3.18
Average WL (bgl)			4.35	5.90	1.62	2.01

Ground Water Level (in bgl) varies from 1.10 to 9.23 m during February, 2.55 to 13.23 m during April, 0.55 to 3.13 m during August and 0.85 to 3.18 m during November within the Core Zone of Cluster-III area.

3.3 D Monitoring of Ground Water Levels of Cluster-IV

Cluster-IV consists of six mines namely, Salanpur UG, Katras-Choitudih UG, Amalgamated Keshalpur & West Mudidih OC, Amalgamated Keshalpur & West Mudidih UG, Amalgamated Angarpathra & Ramkanali UG and closed Gaslitand UG of Katras Area of BCCL. It is located in the north-central part of Jharia Coalfield in Dhanbad district of Jharkhand.

The present leasehold area of Cluster-IV is 1123.79 Ha. The area has a general undulating topography, with an overall gentle south-westerly slope. The RL varies from 182 m to 216 m AMSL. Katri River, Kumari Jore and its tributaries are controlling the drainage pattern of the area. The area comes under the watershed of Katri River.

4 hydrograph stations (**A-26, A28A, B-64 and B-65A**) are located in the core zone of the mine area. Water level monitoring in these monitoring stations has been done in the months of February, April, August & November'2017 and the Ground water level data is enclosed in the table below:

Sl No.	Well No.	Location	Water level (bgl in meters)			
			Feb'17	Apr'17	Aug'17	Nov'17
1	A-26	Malkhera	4.28	5.28	2.28	2.53
2	A28A	Lakarka	2.35	4.30	2.15	1.55
3	B-64	Keshalpur	1.35	1.25	0.90	0.85
4	B-65A	Jhinjipahari	3.55	9.05	0.75	1.25
Average WL (bgl)			2.88	4.97	1.52	1.55

Ground Water Level (in bgl) varies from 1.35 to 4.28 m during February, 1.25 to 9.05 m during April, 0.75 to 2.28 m during August and 0.85 to 2.53 m during November within the Core Zone of Cluster-IV area.

3.3 E Monitoring of Ground Water Levels of Cluster-V

Cluster-V consists of twelve mines namely; Tetulmari OC & UG mine, Mudidih OC & UG mine, Nichitpur OC, Sendra Bansjora OC & UG, Bansdeopur OCP (proposed) & UG, Kankanee OC & UG and closed Loyabad UG under the administrative control of Sijua Area of BCCL. This Cluster of mines is located in northern part of Jharia Coalfield in Dhanbad district of Jharkhand.

The present leasehold area of Cluster-V is 1957.08 Ha. The area has a general undulating topography, with an overall gentle south westerly slope. The RL varies from 210 m to 170 m AMSL. Jarian Nala, Nagri Jore, Ekra Jore and its tributaries are controlling the drainage pattern of the area. The area comes under the watershed of Jarian Nala and Ekra Jore.

4 hydrograph stations (**A-3, A-16, A-27 and D-23**) are located in the core zone of the mine area. Water level monitoring in these monitoring stations has been done in the months of February, April, August & November'2017 and the Ground water level data is enclosed in the table below:

SI No.	Well No.	Location	Water level (bgl in meters)			
			Feb'17	Apr'17	Aug'17	Nov'17
1	A-3	Sijua	0.27	0.67	0.57	0.77
2	A-16	Ekra	2.45	3.65	1.50	2.20
3	A-27	Tetulmari	1.95	2.90	0.85	1.25
4	D-23	Jogta	2.40	2.80	2.20	2.98
Average WL (bgl)			1.77	2.51	1.28	1.80

Ground Water Level (in bgl) varies from 0.27 to 2.45 m during February, 0.67 to 3.65 m during April, 0.57 to 2.20 m during August and 0.77 to 2.98 m during November within the Core Zone of Cluster-V area.

3.3 F Monitoring of Ground Water Levels of Cluster-VI

Cluster–VI consists of four coal mines; East Bassuriya OC, Bassuriya UG, Gondudih Khas-Kusunda OC, Godhur Mixed Mines (OC and UG) are under the administrative control of Kusunda Area of BCCL. This Cluster of mines is located in central part of Jharia Coalfield in Dhanbad district of Jharkhand.

The present leasehold area of Cluster-VI is 876.55 Ha. The area has a general undulating topography with general slope towards south. The RL varies from 180 m to 240 m AMSL. Ekra Jore, Kari Jore and their tributaries are controlling the drainage pattern of the area. The area comes under the watershed of Ekra Jore and Kari Jore.

2 hydrograph stations (**D-25 and D-30**) are located in the core zone of the mine area. Water level monitoring in these monitoring stations has been done in the months of February, April, August & November'2017 and the Ground water level data is enclosed in the table below:

Sl No.	Well No.	Location	Water level (bgl in meters)			
			Feb'17	Apr'17	Aug'17	Nov'17
1	D-25	Godhur	0.10	2.40	0.45	1.20
2	D-30	Borkiboa	2.54	4.40	0.40	1.25
Average WL (bgl)			1.32	3.40	0.43	1.23

3.3 G Monitoring of Ground Water Levels of Cluster-VII

Cluster-VII consists of fourteen mines namely; Dhansar mixed mine, Kusunda OCP, Viswakarma OCP, Industry UG (closed), Alkusa UG, Ena OCP, S.Jharia/Rajapur OCP, Burragarh UG, Simlabahal UG, Hurriladih UG, Bhutgoria UG, Kustore UG (closed) and E.Bhuggatdih UG (closed) under the administrative control of Kusunda Area and Kustore Area of BCCL. This Cluster of mines is located in east central part of Jharia Coalfield in Dhanbad district of Jharkhand.

The present leasehold area of Cluster-VII is 2127.70 Ha. The area has a general undulating topography with general slope towards south. The RL varies from 172 m to 221 m above M.S.L. Kari Jore, Chatkari Jore and its tributaries are controlling the drainage pattern of the area. The area comes under the watershed of Kari Jore and Chatkari Jore.

7 hydrograph stations (**D-3, D-4, D-33, D-34, D-47, D-55 and D-80**) are located in the core zone of the mine area. Water level monitoring in these monitoring stations has been done in the months of February, April, August & November'2017 and the Ground water level data is enclosed in the table below:

Sl No.	Well No.	Location	Water level (bgl in meters)			
			Feb'17	Apr'17	Aug'17	Nov'17
1	D-3	Dhansar	1.30	2.15	1.25	2.30
2	D-4	Jharia	1.11	1.21	0.91	1.46
3	D-33	Kustore	0.60	0.75	0.60	0.75
4	D-34	Kusunda	0.35	0.80	0.90	0.55
5	D-47	Parastanr	3.20	3.15	1.92	2.85
6	D-55	Hariladih	4.52	6.42	2.12	2.37
7	D-80	Bastacolla	3.70	8.65	2.15	3.70
Average WL (bgl)			2.11	3.30	1.41	2.00

Ground Water Level (in bgl) varies from 0.35 to 4.52 m during February, 0.75 to 8.65 m during April, 0.60 to 2.15 m during August and 0.55 to 3.70 m during November within the Core Zone of Cluster-VII area.

3.3 H Monitoring of Ground Water Levels of Cluster-VIII

Cluster-VIII consists of ten mines namely; Bastacolla mixed mines (OC & UG), Bera mixed mines (OC & UG), Dobari UG, Kuya mixed (OC & UG), proposed Goluckdih (NC) OC, Ghanoodih OC and Kujama OC under the administrative control of Bastacolla Area of BCCL. This Cluster of mines is located in eastern part of Jharia Coalfield in Dhanbad district of Jharkhand.

The present leasehold area of Cluster-VIII is 1200.41 Ha. The area has a general undulating topography with general slope towards south and south-west. The ground elevation in the area ranges from 175 m to 221 m AMSL. Chatkari Jore, Tisra Jore and its tributaries controlling the drainage pattern of the area. The area comes under the watershed of Chatkari Jore.

4 hydrograph stations (**D-8, D-43, D-49 and D-51**) are located in the core zone of the mine area. Water level monitoring in these monitoring stations has been done in the months of February, April, August & November'2017 and the Ground water level data is enclosed in the table below:

Sl No.	Well No.	Location	Water level (bgl in meters)			
			Feb'17	Apr'17	Aug'17	Nov'17
1	D-8	Alokdiha	4.45	5.15	2.35	1.85
2	D-43	Alagdih	2.85	7.50	2.75	3.60
3	D-49	Galucdih	2.25	2.70	1.48	2.05
4	D-51	Chankuiya	9.05	10.45	5.07	5.43
Average WL (bgl)			4.65	6.45	2.91	3.23

Ground Water Level (in bgl) varies from 2.25 to 9.05 m during February, 2.70 to 10.45 m during April, 1.48 to 5.07 m during August and 1.85 to 5.43 m during November within the Core Zone of Cluster-VIII area.

3.3 I Monitoring of Ground Water Levels of Cluster-IX

Cluster-IX consists of eight mines namely; North Tisra/South Tisra Expansion OCP, Lodna UG, Bagdigi UG, Bararee UG and Joyrampur UG and Jealgora UG (closed) are under the administrative control of Lodna Area of BCCL. This Cluster of mines is located in eastern part of Jharia Coalfield in Dhanbad district of Jharkhand.

The present leasehold area of Cluster-IX is 1942.12 Ha. The topography of the area is undulating with gentle slope towards south. The RL varies from 221 m to 188.44 m AMSL. Chatkari Jore, Tisra Jore, Sulunga Jore and its tributaries controlling the drainage pattern of the area. The area comes under the watershed of Chatkari Jore.

6 hydrograph stations (**D-5, D-7, D-39, D-40A, D-41 and D-74**) are located in the core zone of the mine area. Water level monitoring in these monitoring stations has been done in the months of February, April, August & November'2017 and the Ground water level data is enclosed in the table below:

Sl No.	Well No.	Location	Water level (bgl in meters)			
			Feb'17	Apr'17	Aug'17	Nov'17
1	D-5	Jiyalgora	6.70	7.90	2.28	5.20
2	D-7	Golden Pahari	6.18	7.33	2.31	2.88
3	D-39	Tilaboni	4.30	6.17	1.60	4.75
4	D-40A	Khapa Dhawra	1.75	1.45	0.75	1.35
5	D-41	Joyrampur	1.25	1.40	0.90	1.20
6	D-74	Bhulan Bararee	6.10	9.25	2.65	3.85
Average WL (bgl)			4.38	5.58	1.75	3.21

Ground Water Level (in bgl) varies from 1.25 to 6.70 m during February, 1.40 to 9.25 m during April, 0.75 to 2.65 m during August and 1.20 to 5.20 m during November within the Core Zone of Cluster-IX area.

3.3 J Monitoring of Ground Water Levels of Cluster-X

Cluster-X consists of ten coal mines and one coal Washery namely; Bhowrah North mixed mines (UG & OC), Bhowrah South mixed mines (UG, 3 Pit OCP, Chandan OCP), Patherdih Mixed mines (UG, Chandan OCP), Sudamdih incline UG mine, Sudamdih Shaft UG mine, Amlabad UG (Closed) and Sudamdih Coal Washery under the administrative control of Eastern Jharia Area of BCCL. This cluster of mines is located in the eastern part of Jharia Coalfield in Dhanbad district of Jharkhand.

The present leasehold area of Cluster-X is 2057.47 Ha. The area has an undulating topography with gentle slope towards south and south east. The RL varies from 185 m to 150.0 m AMSL. Gaurkuthi Nala and few seasonal streams are controlling the drainage pattern of the area. The area comes under the watershed of Damodar River.

4 hydrograph stations (**A-19, D-35, D-36 and D-77**) are located in the core zone of the mine area. Water level monitoring in these monitoring stations has been done in the months of February, April, August & November'2017 and the Ground water level data is enclosed in the table below:

Sl No.	Well No.	Location	Water level (bgl in meters)			
			Feb'17	Apr'17	Aug'17	Nov'17
1	A-19	Bhowrah	3.10	6.37	1.50	2.45
2	D-35	Patherdih	7.60	8.80	3.30	3.60
3	D-36	Sudamdih	1.10	1.30	0.40	0.70
4	D-77	Amlabad	3.70	6.50	3.80	4.90
Average WL (bgl)			3.88	5.74	2.25	2.91

Ground Water Level (in bgl) varies from 1.10 to 7.60 m during February, 1.30 to 8.80 m during April, 0.40 to 3.80 m during August and 0.70 to 4.90 m during November within the Core Zone of Cluster-X area.

3.3 K Monitoring of Ground Water Levels of Cluster-XI

Cluster–XI consists of eight coal mines and one coal Washery namely; Gopalichak UG Project, Kachi Balihari 10/12 Pit UG, Pootkee Balihari Project UG, Bhagaband UG, Kendwadih UG (closed), Pootkee UG (closed), Kachi Balihari 5/6 Pit UG (closed) are under the administrative control of Pootkee Balihari Area and Moonidih UG & Moonidih Washery are under the administrative control of Western Jharia Area of BCCL. This Cluster of mines is located in central part of Jharia Coalfield in Dhanbad district of Jharkhand.

The present leasehold area of Cluster-XI is 3527.58 Ha. The area has an undulating topography with gentle slope towards south. The RL varies from 201 m to 166 m AMSL. Katri River, Jarian Nala, Ekra Jore and Kari Jore are controlling the drainage of the area. The area comes under the watershed of Katri River and Kari Jore.

5 hydrograph stations (**A-17, A-18, A-20, A-32 and D-34**) are located in the core zone of the mine area. Water level monitoring in these monitoring stations has been done in the months of February, April, August & November'2017 and the Ground water level data is enclosed in the table below:

Sl No.	Well No.	Location	Water below (bgl in meters)			
			Feb'17	Apr'17	Aug'17	Nov'17
1	A-17	Kachi Balihari	2.24	2.44	1.76	2.24
2	A-18	Baghaband	0.99	1.29	0.55	0.99
3	A-20	Gorbudih	3.17	4.27	2.17	1.77
4	A-32	Baludih	2.68	3.15	0.65	1.55
5	A-34	Bhatdih	8.45	12.45	2.50	4.45
Average GW (bgl)			3.51	4.72	1.53	2.20

Ground Water Level (in bgl) varies from 0.99 to 8.45 m during February, 1.29 to 12.45 m during April, 0.55 to 2.50 m during August and 0.99 to 4.45 m during November within the Core Zone of Cluster-XI area.

3.3 L Monitoring of Ground Water Levels of Cluster-XIII

Cluster-XIII consists of one operating mine i.e. Murulidih 20/21 pits UG mine and six abandoned mines (Bhurungiya Colliery, Muchraidih colliery, Hantoodih colliery, Padugora colliery, Murulidih colliery, Bhatdee colliery) of Western Jharia Area of BCCL. It is located in the south-western part of Jharia Coalfield in Dhanbad district of Jharkhand.

The present leasehold area of Cluster-XIII is 1898.62 Ha. The area has an undulating topography with gentle slope towards south-east. The maximum RL is 224 m AMSL in the north-western part of the area whereas the minimum RL is 179 m AMSL at southern part. The area comes under the watershed area of Jamunia River and Katri River.

5 hydrograph stations (**A-22, A-23, A-33, B-25 and B-48**) are located in the core zone of the mine area. Water level monitoring in these monitoring stations has been done in the months of February, April, August & November'2017 and the Ground water level data is enclosed in the table below:

Sl No.	Well No.	Location	Water level (bgl in meters)			
			Feb'17	Apr'17	Aug'17	Nov'17
1	A-22A	Nagdah Basti	2.00	3.40	0.22	1.35
2	A-23	Machhayara	9.47	11.87	5.17	6.97
3	A-33	Mahuda Washery	3.35	6.45	0.90	1.55
4	B-25	Mahuda More	5.40	6.70	1.93	-
5	B-48	Mahuda	3.65	7.70	1.70	4.15
Average GW (bgl)			4.77	7.22	1.98	3.51

Ground Water Level (in bgl) varies from 2.00 to 9.47 m during February, 6.40 to 11.87 m during April, 0.22 to 5.17 m during August and 1.35 to 6.97 m during November within the Core Zone of Cluster-XIII area.

3.3 M Monitoring of Ground Water Levels of Cluster-XIV

Cluster-XIV consists of two mines namely; Lohapatty UG and Lohapatty Opencast Patch (proposed). These are under the administrative control of Western Jharia of BCCL. This Cluster of mines is located in western part of Jharia Coalfield in Dhanbad district of Jharkhand.

The present leasehold area of Cluster-XIV is 1577.22 Ha. The topography of the area is undulating with slope towards south west. The maximum RL is 224 m in the north-eastern part whereas the minimum RL is 170 m above mean sea level on the south-western part of the area. Jamunia River and its tributaries are controlling the drainage of the area. The area comes under the watershed area of Jamunia River.

3 hydrograph stations (**B-23, B-24 and B-67**) are located in the core zone of the mine area. Water level monitoring in these monitoring stations has been done in the months of February, April, August & November'2017 and the Ground water level data is enclosed in the table below:

Sl No.	Well No.	Location	Water level (bgl in meters)			
			Feb'17	Apr'17	Aug'17	Nov'17
1	B-23	Lohapatti	2.67	7.74	1.04	2.14
2	B-24	Telmuchu	4.58	10.03	1.63	4.03
3	B-67	Simatanr	8.45	10.00	1.70	2.15
Average GW (bgl)			5.23	9.26	1.46	2.77

Ground Water Level (in bgl) varies from 2.67 to 8.45 m during February, 7.74 to 10.03 m during April, 1.04 to 1.70 m during August and 2.14 to 4.03 m during November within the Core Zone of Cluster-XIV area.

3.3 N Monitoring of Ground Water Levels of Cluster-XV

Cluster–XV consists of four coal mines; Kharkharee UG and Dharmaband UG are under the administrative control of Govindpur Area and Madhuband UG & Phularitand UG are under the administrative control of Barora Area of BCCL. This Cluster of mines is located in western part of Jharia Coalfield in Dhanbad district of Jharkhand.

The present leasehold area of Cluster-XV is 1696.55 Ha. The topography of the area is undulating with slope towards south west. The maximum RL is 235 m in the Kharkharee mine area whereas the minimum RL is 165 m AMSL on the eastern & western part of the Cluster. Jamunia River and Khudia River are controlling the drainage of the area. The area comes under the watershed area of both Jamunia River and Khudia River.

3 hydrograph stations (**A-24, B-32A and B-61A**) are located in the core zone of the mine area. Water level monitoring in these monitoring stations has been done in the months of February, April, August & November'2017 and the Ground water level data is enclosed in the table below:

Sl No.	Well No.	Location	Water level (bgl in meters)			
			Feb'17	Apr'17	Aug'17	Nov'17
1	A-24	Pipratnr	10.68	16.28	2.33	4.18
2	B-32A	Madhuband	2.35	6.95	1.60	2.80
3	B-61A	Kesargora	1.42	2.57	0.62	0.82
Average GW (bgl)			4.82	8.60	1.52	2.60

Ground Water Level (bgl) varies from 1.42 to 10.68 m during February, 2.57 to 16.28 m during April, 0.62 to 2.33 m during August and 0.82 to 4.18 m during November within the Core Zone of Cluster-XV area.

3.3 O Monitoring of Ground Water Levels of Cluster-XVI

Cluster-XVI consists of five mines namely, Dahibari-Basantimata OC, Basantimata UG, New Laikidih OC, Laikidih Deep UG and Chunch UG under the administrative control of Chanch-Victoria Area of BCCL. This cluster of mines is located in the western part of Raniganj Coalfield in Dhanbad district of Jharkhand.

The present leasehold area of Cluster-XVI is 1964.21 Ha. The topography of the area is undulating with slope towards south west. The area is plain with gently undulating with elevation varying from 100 m to 140 m AMSL. The general slope of the area is towards southeast. Barakar River and Khudia River are controlling the drainage of the area. The area comes under the watershed area of Barakar River.

4 hydrograph stations (**DB-22, DB-23, DB-24 and DB-25**) are located in the core zone of the mine area. Water level monitoring in these monitoring stations has been done in the months of February, April, August & November'2017 and the Ground water level data is enclosed in the table below:

Sl No.	Well No.	Location	Water level (bgl in meters)			
			Feb'17	Apr'17	Aug'17	Nov'17
1	DB-22	Dahibari, Niche Basti	1.93	1.93	1.48	1.63
2	DB-23	Dahibari OC	1.30	2.05	0.80	1.90
3	DB-24	Dahibari	4.45	5.80	3.04	3.78
4	DB-25	Palasya	2.83	3.23	2.03	2.58
Average GW Level			2.63	3.25	1.84	2.47

Ground Water Level (in bgl) varies from 1.30 to 4.45 m during February, 1.93 to 5.80 m during April, 0.80 to 3.04 m during August and 1.63 to 3.78 m during November within the Core Zone of Cluster-XVI area.

4.0 GROUNDWATER LEVEL SCENARIO

During the month of February'2017 the depth to water level (in bgl) within 15 nos Cluster of mines varies from 0.10 m to 10.68 m with an average varies from of 1.32 m to 5.23 m. During the month of April'2017 the depth to water level varies from 0.67 m to 16.28 m with an average varies from 2.51 m to 9.26 m. During the month of August'2017 the depth to water level varies from 0.20 m to 5.17 m with an average varies from 0.43 m to 2.91 m. During the month of November'2017 the depth to water level varies from 0.15 m to 6.97 m with an average varies from 1.23 m to 3.51 m. The summarized water level data of all clusters are given in **Table No – 4**.

Depth to water level (in bgl) values described that water level goes down to maximum 16.68 m during pre-monsoon'2017 and maximum upto 6.97 m during post-monsoon'2017. Un-confined aquifer is affected around 20 m to 30 m maximum close to active opencast mining areas, showing steep gradient towards mine void. Other than that, there is no mining effect in the water level within JCF area and RCF area (part). Historical water level data and hydrograph of permanent observation stations from CGWB shown in **Annexure–III**.

Monitoring groundwater (quantity & quality) to assess the present condition and resource has been done regularly in the coalfield areas. Well hydrographs (**Annexure–III**) are prepared and studied to identify potentially adverse trends so that appropriate action can be taken to protect groundwater resource. According to the hydrograph trend analysis of CGWB monitoring wells, no significant decline trend of water level is noticed in any particular area for the last 10 years within the coalfield area. Regarding quality monitoring, the water sample location map (**Figure No–2**) with collection points details (dug wells) are given in **Annexure–IV**. Locations of proposed Piezometers to monitor deeper aquifers in and around active coal mining area in JCF and RCF (part) is given in **Figure No–3**.

Table No-4: Groundwater level data Cluster-wise

Sl. No.	Cluster of BCCL	No. of Monitoring Wells	Water level fluctuation Below ground level (Feb, Apr, Aug & Nov'17)	Formation
1	I	4 nos.	0.15 to 10.00 m	Barakar
2	II	5 nos.	0.60 to 13.23 m	Barakar
3	III	5 nos.	0.55 to 6.38 m	Barakar
4	IV	5 nos.	0.75 to 9.05 m	Barakar
5	V	4 nos.	0.27 to 3.65 m	Barakar
6	VI	2 nos.	0.10 to 4.40 m	Barakar
7	VII	6 nos.	0.35 to 8.86 m	Barakar
8	VIII	4 nos.	1.48 to 10.45 m	Barakar
9	IX	6 nos.	0.75 to 9.25 m	Barakar
10	X	4 nos.	0.40 to 8.80 m	Barakar
11	XI	5 nos.	0.55 to 12.45 m	Barakar & Barren Measure
12	XIII	5 nos.	0.20 to 11.87 m	Raniganj
13	XIV	3 nos.	1.04 to 10.03 m	Raniganj
14	XV	4 nos.	0.62 to 16.28 m	Barakar & Barren Measure
15	XVI	4 nos.	0.80 to 5.80 m	Barakar

5.0 STAGE OF GROUNDWATER DEVELOPMENT

The groundwater is mainly utilized for domestic needs and for irrigation purposes. The groundwater abstraction is mainly through dug wells and bore wells. The stage of groundwater development in Dhanbad District is 77%. The highest stage of development is in Jharia Block (127.0%) & Dhanbad Block (107.50%) and lowest stage of development is in Baliapur Block (78.24%). The Gondwana sandstones in general, are known to constitute good aquifers at many places. However, the yield potential of the area adjoining to active mines in the coal belt is poor. The active mines often act as groundwater “sinks”. In contrast, the water logged abandoned mines and pits act as potential sources of groundwater. As per the assessment done by Central Ground Water Board (CGWB), Patna in 2013, the Block wise data of Dhanbad District is given below:

Table No–5: Block-wise Stage of Groundwater development

SI No.	Administrative Unit		Stage of GW Development	Category
	District	Block		
1	Bokaro	Bermo	156.30%	Over- exploited
2	Dhanbad	Baghmara	91.74%	Critical
3	Dhanbad	Baliapur	78.24%	Semi- Critical
4	Dhanbad	Dhanbad	107.50%	Over- exploited
5	Dhanbad	Jharia	127.0%	Over- exploited
6	Dhanbad	Topchachi	98.45%	Critical

- **Dynamic Groundwater Resource Assessment (as on 31st March, 2013), CGWB**

Table No-6: Cluster-wise Groundwater development scenario

Cluster/ Area	Adminis- trative Blocks/Stage Of GW Develo- Pment (SOD)	Total Water demand (cum/day)				Avg. GW level (bgl in m) 2017		GW level declining trend 2005-2017		Remarks
		Mine Discharge	Surface Water Source	Total Use (Domestic +Industrial +Others)	Excess Or other use					
						Pre- monsoon	Post- monsoon	Pre- monsoon	Post- monsoon	
Cluster-I	Bermo (SOD: Over- exploited)	2950	NIL	2123	827	5.21	2.57	NO	NO	-
Cluster-II	Baghmara	8350	Jamunia river	7265	1085	6.34	2.12	NO	NO	-
Cluster-III	(SOD: Critical)	10,960	NIL	7290	3670	5.90	2.01	NO	NO	-
Cluster-IV		5900	MADA (Damodar river)	5900	NIL	4.97	1.55	NO	NO	
Cluster-V		11,025	MADA	9214	1811	2.51	1.80	YES	NO	Excess water stored into abandoned UG
Cluster-VI	Dhanbad	4150	MADA (Damodar river)	4150	NIL	3.40	1.23	YES	YES	Artificial recharge structure needed
Cluster-VII	(SOD: Over- exploited)	14,920	MADA	14,639	281	3.30	2.00	NO	NO	
Cluster-VIII	Jharia	9320	MADA	5474	3846	6.45	3.23	NO	NO	Excess water stored into abandoned UG & FF
Cluster-IX	(SOD: Over- exploited)	12,980	MADA	9714	3266	5.40	3.21	NO	NO	Excess water stored into abandoned UG & FF
Cluster-X		11,825	Damodar river	6525	5300	5.74	2.91	YES	NO	Excess water stored into abandoned UG & OC
Cluster-XI	Dhanbad	31,530	MADA & DVC	18,825	12,705	4.72	2.20	NO	YES	Excess water used F.P
Cluster-XIII	Baghmara	4774	Damodar river	4115	659	7.22	3.51	NO	NO	-
Cluster-XIV	(SOD: Critical)	2600	DVC	1875	725	9.26	2.77	NO	NO	
Cluster-XV		6200	Jamunia river	4147 +1800 (ponds)	253	8.60	2.60	NO	YES	Excess water store in surface waterbodies
Cluster-XVI	Nirsa (SOD:Safe)	3380	DVC (Barakar river)	2450	930	3.25	2.47	NO	NO	

6.0 CONSERVATION MEASURES & FUTURE STRATEGY

- BCCL has installed 25 Pressure Filter Plant of total capacity of 4.16 MGD to meet drinking water requirement nearby the area. At present 63 Water Treatment Plants are operational having capacity of 16.16 MGD within Jharia Coalfield area. Further installation of 28 more Pressure Filter Plants with the capacity of 5.84 MGD are in progress.
- BCCL participated in development of low cost technology for drinking water in a CSIR project along with CIMFR, Dhanbad and a pilot plant of 4000 Liters/hour is functional at PB Project site of BCCL. Similar plant has been proposed at other sites of BCCL.
- A scheme entitled 'Scheme for multi-purpose utilization of surplus mine water of Barora Area, Block II and Govindpur Area of BCCL' was prepared with a view to harness the excess water discharge to take care of the persistence problem of water scarcity in the nearby villages. In the scheme, two water reservoirs of capacity 27 MG and 17 MG have been proposed in the non-coal bearing area for storage of 3250 GPM and 2000 GPM surplus mine water which will be fed through pipe line by mine discharge at mines of Barora, Block-II and Govindpur Area.
- Roof-top rainwater harvesting (RWH) will be taken up in the project area using the administrative buildings. 138 no. of quarters having roof-top area of about 14950 sq. m. is already prepared to harvest rainwater and around 13150 cum/annum of water is going to be recharged the nearby groundwater system through RWH structures. Proposal already made to facilitate this kind of RWH structure at suitable locations i.e. Lodna Area, Kusunda Area (Jawahar Nagar, Matkuria, Coal Board Colony), Sijua Area (Nichitpur and Tetulmari Colony) within Jharia Coalfield to augment groundwater recharge.
- After cessation of mining, with plenty rainfall and abundant ground water recharge, the water levels will recoup and attain normalcy. Thus, the impact of mining on groundwater system may be considered as a temporary

phenomenon. The abandoned mine workings (UG) behave as water pool and improves the resources availability in the coalfield area.

- Utilization of treated mine water discharge by both industry and local people in the mine influence area. The excess mine water can be used to recharge groundwater system through connecting pipeline to abandoned dug wells. Utilization of mine water for irrigation use will also enhance the ground water recharge potential through artificial recharge in the area.
- Increase vegetative cover by plantation in the mine area under land amelioration measures. This will contain the surface run-off and increase the groundwater recharge.
- Creation of awareness among workers and local peoples about Rain water harvesting and artificial recharge will be given priority. This aspect is usually covered during the Environmental Week celebrated every year (5 to 12 June).
- Monitoring of water quality of mine water discharge, local River/nala and domestic water source (dug well/hand pump wells) will be continued under routine monitoring (February, May, August & November).

Annexure – I

Location of Hydrograph Stations (Dug Wells)

Well No	Latitude	Longitude	Well No	Latitude	Longitude
A-3	23°47'53.35" N	86°19'55.14" E	B-63	Abandoned due to OCP	
A-12	23°48'20.31" N	86°16'51.64" E	B-64	23°48'43.14" N	86°18'44.25" E
A-16	23°46'57.00" N	86°21'38.57" E	B-65A	23°48'53.65" N	86°18'11.82" E
A-17	23°45'09.44" N	86°22'16.35" E	B-67	23°43'30.70" N	86°14'01.45" E
A-18	23°44'37.65" N	86°22'58.90" E	D-3	23°46'46.31" N	86°24'49.30" E
A-19	23°41'12.86" N	86°23'55.27" E	D-4	23°44'29.37" N	86°24'42.88" E
A-20	23°44'56.64" N	86°19'55.35" E	D-5	23°42'20.05" N	86°24'86.06" E
A-22	23°43'06.65" N	86°14'48.53" E	D-7	23°43'12.08" N	86°27'11.89" E
A-23	23°45'06.38" N	86°15'12.69" E	D-8	23°44'06.13" N	86°27'20.72" E
A-24	23°45'20.44" N	86°13'45.12" E	D-23	23°47'20.89" N	86°20'09.96" E
A-25	23°47'06.20" N	86°15'27.79" E	D-25	23°47'03.28" N	86°23'29.56" E
A-26	23°46'49.24" N	86°18'12.12" E	D-30	23°48'36.10" N	86°21'50.07" E
A-27	23°48'42.55" N	86°20'21.80" E	D-33	23°45'34.62" N	86°23'18.50" E
A-28A	23°47'34.74" N	86°18'04.18" E	D-34	23°45'36.50" N	86°23'02.45" E
A-29	23°47'08.02" N	86°16'02.72" E	D-35	23°40'46.54" N	86°25'46.33" E
A-32	23°44'15.56" N	86°20'43.80" E	D-36	23°40'19.26" N	86°25'18.98" E
A-33	23°44'32.58" N	86°16'58.28" E	D-39	23°43'28.50" N	86°26'0.10" E
A-34	23°42'58.63" N	86°15'19.31" E	D-40A	23°43'20.18" N	86°25'45.70" E
B-1	23°48'48.06" N	86°14'16.87" E	D-41	23°42'40.00" N	86°26'17.20" E
B-14	23°48'00.81" N	86°16'25.88" E	D-43*	NA	NA
B-15	23°46'06.92" N	86°08'59.30" E	D-47	23°45'20.59" N	86°24'34.86" E
B-21A	23°45'10.50" N	86°09'36.38" E	D-49	23°44'08.96" N	86°26'32.71" E
B-23	23°44'13.05" N	86°11'46.56" E	D-51	23°44'20.86" N	86°27'11.37" E
B-24	23°44'26.80" N	86°13'09.38" E	D-55	23°43'58.37" N	86°24'07.45" E
B-25	23°44'44.98" N	86°13'57.80" E	D-74	23°41'33.66" N	86°25'06.10" E
B-32A	23°45'49.18" N	86°13'03.64" E	D-77	23°41'00.74" N	86°22'25.55" E
B-48	23°43'35.09" N	86°16'38.30" E	D-80	23°46'09.46" N	86°24'33.08" E
B-51	23°47'40.20" N	86°09'11.90" E	DB-22	23°43'38.81" N	86°45'09.00" E
B-53	23°45'55.25" N	86°09'35.44" E	DB-23	23°43'44.24" N	86°45'06.39" E
B-53A	-	-	DB-24	23°43'53.00" N	86°45'03.88" E
B-59	23°47'59.87" N	86°13'37.97" E	DB-25	23°44'10.75" N	86°44'35.84" E
B-60	23°48'7.87" N	86°15'37.12" E			
B-61A	23°45'59.85" N	86°11'40.80" E			
B-62A	23°45'44.15" N	86°11'27.80" E			

Annexure – IIA

Details of Hydrograph Stations (Dug Wells)

Well No	Location	M.P. (agl) in m	Well Dia in m	Well Depth (m bmp)	R.L. (G.L) (m)	Formation	Owner	Utility
A-3	Sijua	0.53	3.00	5.20	203	Barakar	Govt.	Domestic
A-12	Jamua	0.80	1.90	3.30	202	Barakar	Govt.	Domestic
A-16	Ekra, Kalali More	0.45	3.10	6.50	205	Barakar	Govt.	Domestic
A-17	Kachi Balihari	0.56	1.60	5.30	182	Barakar	Govt.	Domestic
A-18	Bhagabandh	0.61	1.45	3.37	182	Barakar	Govt.	Domestic
A-19	Bhaura	0.54	3.15	11.65	162	Barakar	Govt.	Domestic
A-20	Gorbhudi	0.43	3.30	8.30	181	BM	Govt.	Domestic
A-22	Nagdah, Niche tola	0.00	1.40	9.50	171	Raniganj	Govt	Irrigation
A-23	Machhyara	0.43	1.85	12.40	203	Raniganj	Govt	Domestic
A-24	Pipra Tanr	0.22	1.80	19.55	208	Raniganj	Govt	Domestic
A-25	Sinidih	0.22	2.00	11.30	203	Barakar	Govt	Domestic
A-26	Pasitanr (Malkera)	0.32	1.80	9.65	198	Barakar	Govt	Domestic
A-27	Chandor	0.60	2.50	5.50	221	Barakar	Govt	Domestic
A-28A	Lakarka 6 no.	0.65	1.30	5.25	199	Barakar	BCCL	Domestic
A-29	Aambagan (Gobindpur)	0.10	2.60	9.15	186	Barakar	Govt	Domestic
A-32	Baludih	0.55	2.30	6.85	182	BM	Govt	Domestic
A-33	Mahuda	0.75	2.00	10.80	195	BM	BCCL	Domestic
A-34	Bhatdih	0.55	3.50	24.50	162	Raniganj	BCCL	Domestic
B-1	Muraidih	0.47	1.80	5.35	212	Talchir	Govt	Domestic
B-14	Mathadih	0.76	2.15	3.75	201	Barakar	Govt	Domestic
B-15	Bera Basti	0.55	1.60	2.50	221	Talchir	Dhanu Roy	Domestic
B-21A	Dugdha	0.55	2.10	10.35	220	Metamorphics	Govt	Domestic
B-23	Lohapati	0.26	3.60	10.85	204	Raniganj	Govt	Domestic
B-24	Telmuchu	0.67	4.35	10.83	207	Raniganj	Govt	Domestic
B-25	Mahuda More	0.10	2.45	8.45	205	Raniganj	Govt	Domestic
B-32A	Madhuband	0.80	4.30	8.60	205	Barakar	BCCL	Domestic
B-48	Mahuda	0.65	2.10	11.50	181	Raniganj	Mosque	Domestic
B-51	Taranga	0.00	2.50	5.75	215	Metamorphics	Bisun	Irrigation
B-53	Karmatanr	0.58	2.70	13.25	195	Barakar	Govt	Domestic
B-53A	Karmatanr-Damoda OCP							
B-59	Khodovaly	0.60	2.40	9.30	202	Barakar	BCCL	Domestic
B-60	Bahiyadih	0.77	3.00	15.60	196	Barakar	BCCL	Domestic
B-61A	Kesargora	0.48	2.00	11.20	201	Barakar	BCCL	Domestic
B-62A	Sadariyadih	0.15	3.10	9.50	188	Barakar	Govt	Domestic

Annexure – IIA

Details of Hydrograph Stations (Dug Wells)

Well No	Location	M.P. (agl) in m	Well Dia in m	Well Depth (m bmp)	R.L. (G.L) (m)	Formation	Owner	Utility
B-63	West Mudidih	0.60	1.70	3.35	196	Barakar	BCCL	Domestic
B-64	Keshalpur	0.65	1.10	3.40	195	Barakar	BCCL	Domestic
B-65A	Jhinjipahari	0.95	2.20	12.40	196	Barakar	Shiv Temple	Domestic
B-67	Simatanr	0.55	2.20	11.80	198	Raniganj	Govt	Domestic
D-3	Dhansar	0.60	1.70	8.70	217	Barakar	Govt	Domestic
D-4	Jharia	0.59	1.90	5.73	218	Barakar	Govt	Domestic
D-5	Jiyalgora	0.70	2.80	10.55	183	Barakar	Govt	Domestic
D-7	Golden Pahari	0.67	2.85	10.05	201	Barakar	BCCL	Domestic
D-8	Alokdiha	0.35	1.75	7.57	201	Metamorphics	BCCL	Domestic
D-23	Jogta (Sindra)	0.40	3.10	7.25	205	Barakar	BCCL	Domestic
D-25	Godhar More	0.60	2.75	5.60	219	Barakar	Govt	Domestic
D-30	Borkiboa	0.70	2.00	5.60	221	Talchir	H.Kumbhakar	Domestic
D-33	Kustore-4	0.55	1.85	3.45	196	Barakar	BCCL	Domestic
D-34	Kusunda-7	0.60	1.50	3.45	201	Barakar	BCCL	Domestic
D-35	Patherdih	0.40	2.00	11.20	160	Barakar	BCCL	Domestic
D-36	Sudamdih	0.90	2.00	6.20	141	Barakar	BCCL	Domestic
D-39	Tilabani	0.85	2.00	5.90	178	Barakar	BCCL	Domestic
D-40A	Khapra Dhaora	0.55	1.95	3.70	180	Barakar	Panchayat	Domestic
D-41	Joyrampur	0.50	1.80	4.00	180	Barakar	BCCL	Domestic
D-43	Alagdih	0.45	2.20	8.90	200	Metamorphics	Govt	Domestic
D-47	Parastanr	0.45	3.20	23.80	206	Barakar	BCCL	Domestic
D-49	Goluckdih	0.55	1.80	6.15	192	Barakar	BCCL	Domestic
D-51	Chankuiya	0.55	3.70	11.90	197	Barakar	BCCL	Domestic
D-55	Hariladih	0.48	2.80	11.80	184	Barakar	Govt	Domestic
D-74	Bhulan Barari	0.10	1.60	12.80	173	Barakar	Govt	Domestic
D-77	Rohoniatanr	0.40	3.15	6.70	156	Barakar	Govt	Domestic
D-80	Bastacolla	0.70	2.50	24.95	219	Barakar	Govt	Domestic
DB-22	Nichebasti	0.67	2.40	10.65	121	Barakar	Govt	Domestic
DB-23	Dahibari OC	0.70	2.30	8.00	-	Barakar	BCCL	Domestic
DB-24	Dahibari	0.60	3.60	13.70	125	Barakar	BCCL	Domestic
DB-25	Palasya	0.37	1.55	5.25	127	Barakar	Govt	Domestic

MP: Measuring Point**R.L.: Reduced Level****W.L.: Water Level m: Meter****Abn.: Abandoned****b.g.l.: Below Ground Level****a.g.l.: Above Ground Level****G.L.: Ground Level****bmp: Below Measuring Point****BM: Barren Measure**

Annexure – IIB

Historical Water Level data of Hydrograph Stations

Well No	Water level below ground level (bgl) in meters														
	May, 10	Nov, 10	May, 11	May, 12	Nov, 12	May, 13	Nov, 13	May, 14	Nov, 14	May, 15	Nov, 15	May, 16	Nov, 16	May, 17	Nov, 17
A-3	4.71	3.57	4.77	4.25	1.87	4.47	4.45	4.67	2.37	3.70	3.42	4.87	0.47	0.67	0.77
A-12	2.82	1.60	2.80	2.80	1.30	3.00	1.17	2.45	1.4	3.00	2.68	2.50	0.70	2.55	0.85
A-16	4.17	1.90	5.80	3.53	1.60	3.80	3.35	5.5	2.9	5.55	4.17	5.85	3.15	3.65	2.20
A-17	2.39	2.37	2.24	2.52	2.34	2.32	1.54	2.19	1.91	3.79	2.64	2.44	2.69	2.44	2.24
A-18	2.49	0.94	2.49	2.59	0.90	2.87	0.91	1.76	1.19	2.84	1.29	1.14	0.89	1.29	0.99
A19	3.61	2.81		9.61	2.46	7.46	4.46	3.00	2.75	3.05	2.75	7.81	4.11	6.37	2.45
A-20	7.42	1.87	7.87	7.17	1.57	6.47	0.67	3.97	2.55	4.59	2.93	7.49	3.50	4.27	1.77
A22A				1.90	1.05	1.79	1.00	1.50	2.0	3.20	1.96	3.25	1.75	4.27	1.77
A-23	10.67	11.07	11.92	9.87	4.75	10.57	5.82	8.76	6.82	11.3	9.37	11.87	8.13	6.40	1.50
A-24	14.47	15.88	18.28	18.68	5.23	16.01	3.25	16.28	14.98	17.2	14.5	16.62	12.43	11.87	6.97
A-25	7.23	5.10	6.83	10.23	4.43	10.23	2.98	7.03	5.28	7.78	5.85	7.43	4.58	6.38	2.88
A-26	7.77	3.95	9.18	8.76	4.28	7.56	4.28	7.71	4.58	7.73	3.18	8.93	4.48	5.28	2.53
A-27	1.98	1.42	3.00	2.13	1.10	1.62	1.25	1.63	1.55	4.40	3.95	4.85	1.80	2.90	1.25
A28A	3.29	2.73	3.90	2.90	2.45	3.35	2.45	3.29	1.91	4.35	3.60	3.35	1.47	4.30	1.55
A-29	3.80		5.50	9.30	1.42	6.95	1.67	3.3	2.35	4.55	4.60	5.92	6.96	4.40	1.30
A-32	1.95	1.35	2.30	2.19	1.10	2.45	1.95	3.15	2.45	4.41	2.13	4.75	2.10	3.15	1.55
A-33	3.03	1.85	3.07	5.25	1.25	4.13	1.80	4.08	1.57	4.91	1.97	5.75	2.60	6.45	1.55
A-34	2.85	3.77	2.90	6.95	2.90	6.21	2.50	4.45	4.45	8.40	4.81	4.75	4.45	12.45	4.45
B-1	2.43	1.73	1.78	2.08	1.73	1.53	1.83	2.43	1.81	3.28	2.75	3.58	1.93	2.33	0.85
B-14	1.35	1.09	2.49	1.34	1.42	1.74	1.45	3.24	4.44	2.94	2.29	2.44	0.47	2.94	1.84
B-15	1.40	1.38	1.37	1.27	0.45	1.20	0.55	0.95	1.45	1.50	0.45	1.85	0.55	4.85	0.15
B21A	9.15	5.65	7.60	9.00	5.05	8.01	4.95	9.54	3.7	7.37	4.65	5.55	4.50	8.85	5.65
B-23	6.14	3.56	9.14	3.71	1.74	5.27	1.39	6.57	2.74	7.86	4.29	6.81	2.41	7.74	2.14
B-24	9.45	4.95	10.33		3.09	8.88	2.83	9.40	2.21	10.0	5.78	10.63	4.28	10.03	4.03
B-25	5.88	7.00	8.35	8.35	2.60	7.08	2.15	5.82	5.15	6.88	-	7.05	1.70	6.70	1.40
B32A	6.50	4.32	7.80	7.75	3.22	6.25	2.68	8.33	2.05	7.55	3.32	6.95	3.07	6.95	2.80
B-48	4.10		5.75	5.43	3.85	4.69	3.20	6.38	4.35	7.90	5.42	9.35	4.60	7.70	4.15
B-51	3.94	2.38	3.95	3.60	2.05	3.35	2.49	2.09	1.98	4.65	3.40	4.90	3.18	4.98	2.55
B-53	1.77	1.72	1.67	6.97	1.42	4.15	1.12	3.39	-	5.58	2.82	4.70	1.45	4.02	1.92
B-59	6.75	1.00	8.25	6.90	0.60	7.56	0.30	2.65	1.0	4.12	1.60	4.40	0.50	5.40	0.60
B-60	10.56	5.24	11.44	10.18	5.13	11.29	5.23	9.82	4.59	9.21	5.28	10.33	5.03	13.23	3.18
B61A	4.96	3.36	10.72	5.42	2.40	8.17	2.02	6.93	3.57	6.15	4.52	6.58	3.87	2.57	0.82
B62A	8.37	7.90	8.85	7.85	4.90	7.73	4.63	8.83	5.85	9.10	5.21	9.30	4.95	8.15	4.35

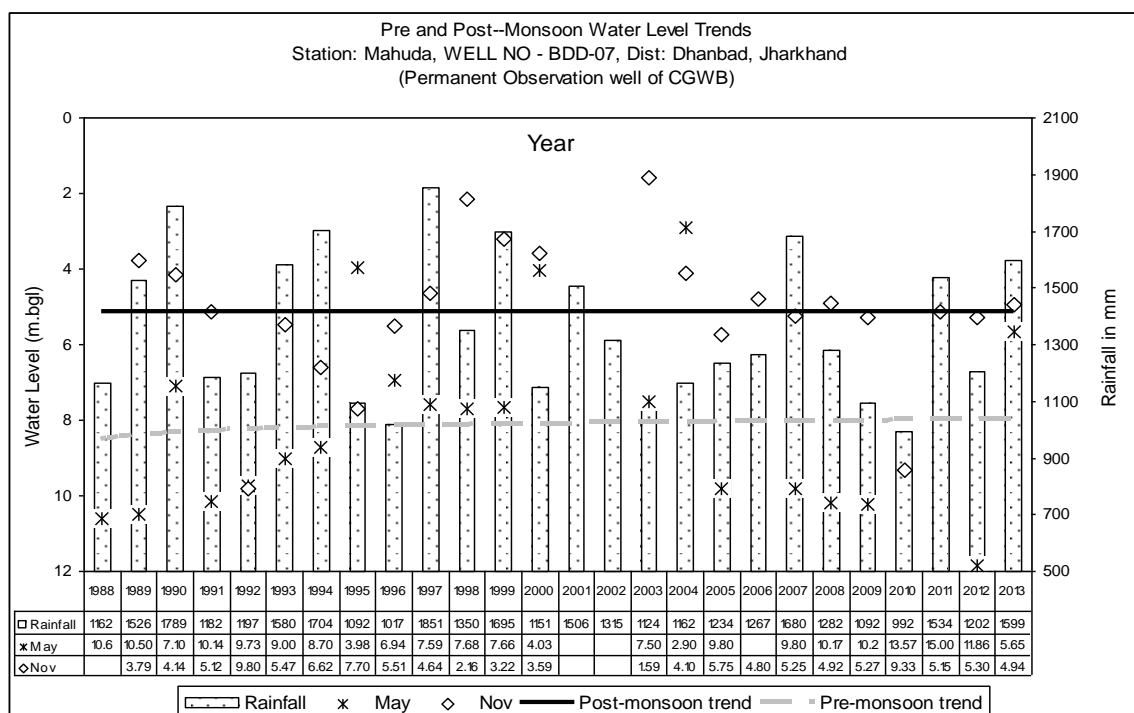
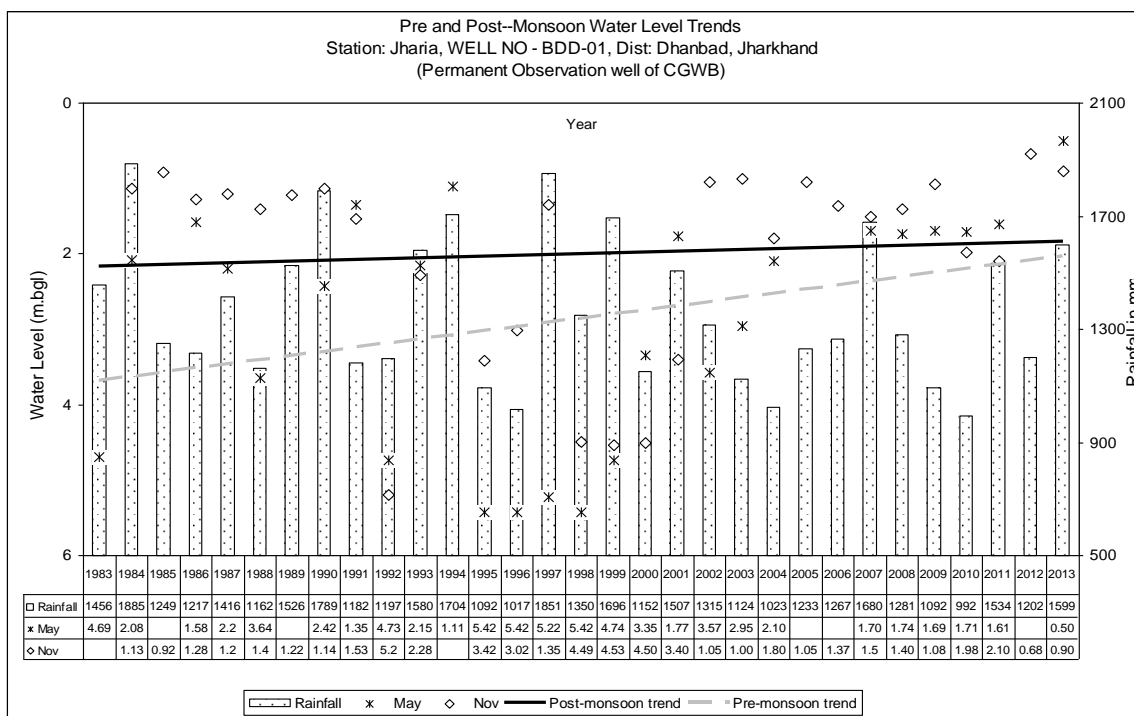
Annexure – IIB

Historical Water Level data of Hydrograph Stations

Well No	Water level below ground level (bgl) in meters														
	May, 10	Nov, 10	May, 11	May, 12	Nov, 12	May, 13	Nov, 13	May, 14	Nov, 14	May, 15	Nov, 15	May, 16	Nov, 16	May, 17	Nov, 17
B-63	1.03	1.00	1.05	1.09		1.32	0.80	1.22	0.92	2.46	1.40	2.44	-	-	-
B-64	0.79	1.05	0.85	1.05	1.00	1.35	0.85	0.7	1.15	1.38	0.95	2.35	0.55	1.25	0.85
B65A	11.45	3.39	9.65	11.45	1.73	10.11	1.82	10.45	2.4	7.82	5.87	7.15	2.68	9.05	1.25
B-67	11.00	10.69	11.25	8.55	6.50	9.73	5.31	9.80	3.72	9.23	5.53	9.53	4.30	10.00	2.15
D-3	3.15	2.55	2.55	2.93	1.80	3.45	1.68	2.54	2.11	4.25	2.25	2.35	1.90	2.15	2.30
D-4	2.61	1.46	1.51	1.94	0.91	2.41	0.98	1.23	0.91	2.41	1.27	1.21	1.36	1.21	1.46
D-5	9.05	6.65	9.05	9.50	6.45	9.32	4.59	9.0	7.8	9.37	8.33	9.40	6.40	7.90	5.20
D-7	9.23		9.33	6.08	5.83	7.19	4.63	5.28	5.53	8.25	5.61	7.53	4.03	7.33	2.88
D-8	6.85	6.73	7.75	6.15	3.75	6.65	2.85	7.73	-	6.24	4.38	8.00	3.43	5.15	1.85
D-23	5.85	4.85	6.80	6.00	3.30	6.60	1.20	6.38	2.4	6.55	3.48	5.70	1.63	2.80	2.98
D-25	5.10	2.30	4.70	5.20	3.65	4.26	3.45	4.42	2.9	4.48	2.45	2.40	1.90	2.40	1.20
D-30	2.90	2.23	5.10	3.88	1.80	4.38	3.08	4.17	3.3	4.55	3.15	4.45	3.20	4.40	1.25
D-33	0.94	0.70	0.95	2.85	0.35	1.80	0.45	1.72	0.35	2.25	1.10	2.50	1.95	0.75	0.75
D-34	2.85	2.65	2.85	2.35	2.50	2.50	2.13	2.80	0.30	2.55	1.45	2.30	0.30	0.80	0.55
D-35	7.30	6.15	8.20	8.05	5.55	7.70	4.10	6.94	6.15	9.80	7.90	9.52	6.45	8.80	3.60
D-36	0.85	0.10	1.95	1.55	0.15	1.28	0.80	1.82	0.75	1.66	1.13	0.78	0.95	1.30	0.70
D-39	4.75	3.40	5.05	5.05	3.65	3.98	2.50	5.03	2.25	5.00	2.61	2.18	2.65	6.17	4.75
D40A	2.50	1.65	1.95	2.45	1.70		2.25	2.35	2.45	3.07	2.45	1.40	0.85	1.45	1.35
D-41	1.60	1.55	1.55	1.50	1.50	1.72	1.35	3.20	1.35	2.65	2.32	1.30	1.52	1.40	1.20
D-43	7.95	4.95	7.65	7.05	4.00	6.23	4.05	6.0	4.75	6.61	5.05	8.20	3.35	7.50	3.60
D-47	2.95	2.75	4.35	1.95	2.12	2.60	2.97	8.0	2.37	9.60	3.60	3.18	2.95	3.15	2.85
D-49	1.40	1.81	1.55	1.60	1.65	1.30	1.45	2.51	1.65	3.55	2.35	2.45	1.72	2.70	2.05
D-51	11.03	8.93	10.85	10.00	7.85	8.94	8.35	9.60	9.05	10.48	9.15	11.15	6.45	10.45	5.43
D-55	4.62	2.44	5.97	1.93	1.82	3.90	1.45	1.95	2.07	6.15	1.57	2.52	3.62	6.42	2.37
D-74	4.04	3.80	4.05	4.95	3.60	4.55	3.41	5.0	4.0	10.05	7.20	7.73	5.00	9.25	3.85
D-77	6.40	6.30	6.30	6.50	4.75	4.79	5.10	6.23	6.0	6.44	5.60	4.60	2.90	6.50	4.90
D-80	19.20	3.05	17.45	14.20	3.35	15.25	3.32	13.3	3.15	10.97	3.35	6.55	4.15	8.65	3.70
RCF (part)		May, 11	Nov, 11	May, 12	Nov, 12	May, 13	Nov, 13	May, 14	Nov, 14	May, 15	Nov, 15	May, 16	Nov, 16	May, 17	Nov, 17
DB22		2.90	2.23	2.43	2.38	8.18	2.64	6.48	3.03	4.59	3.53	5.38	3.33	1.93	1.63
DB23		3.25	2.70	2.90	2.33	5.05	3.10	3.95	2.13	3.38	6.04	5.30	0.90	2.05	1.90
DB24							8.25	-	8.45	9.52	8.20	10.65	6.50	5.80	3.78
DB25		4.03	2.13	3.96	1.18	1.33	2.53	3.27	2.73	3.83	2.68	3.61	1.98	3.23	2.58

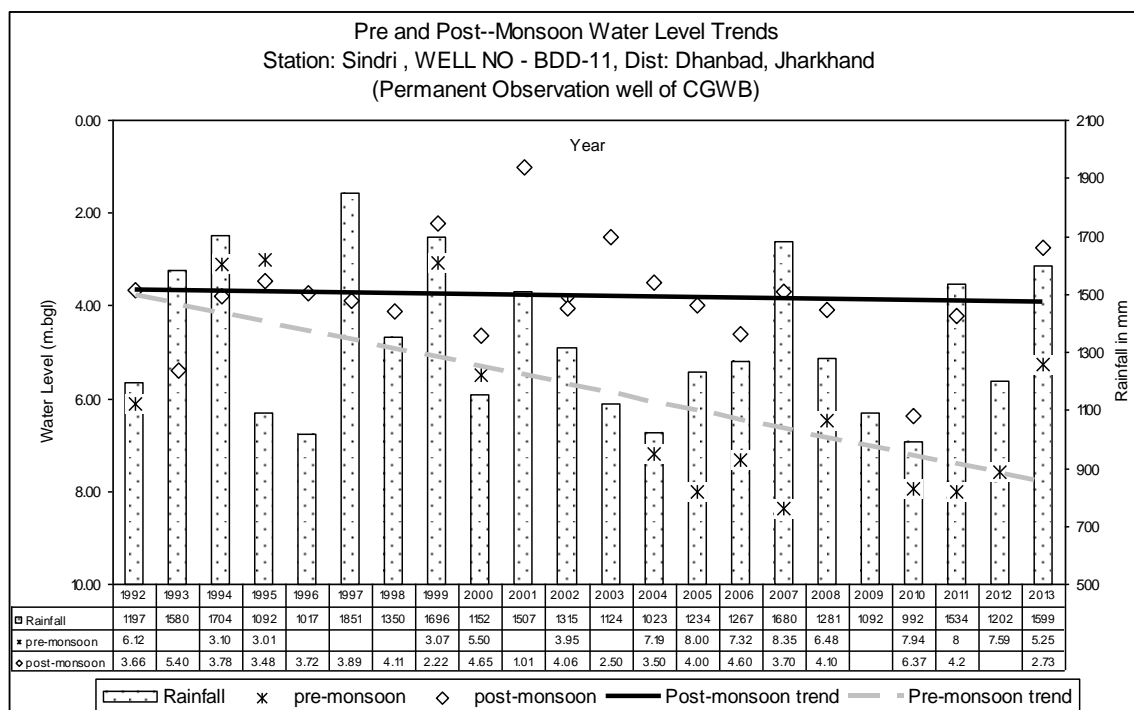
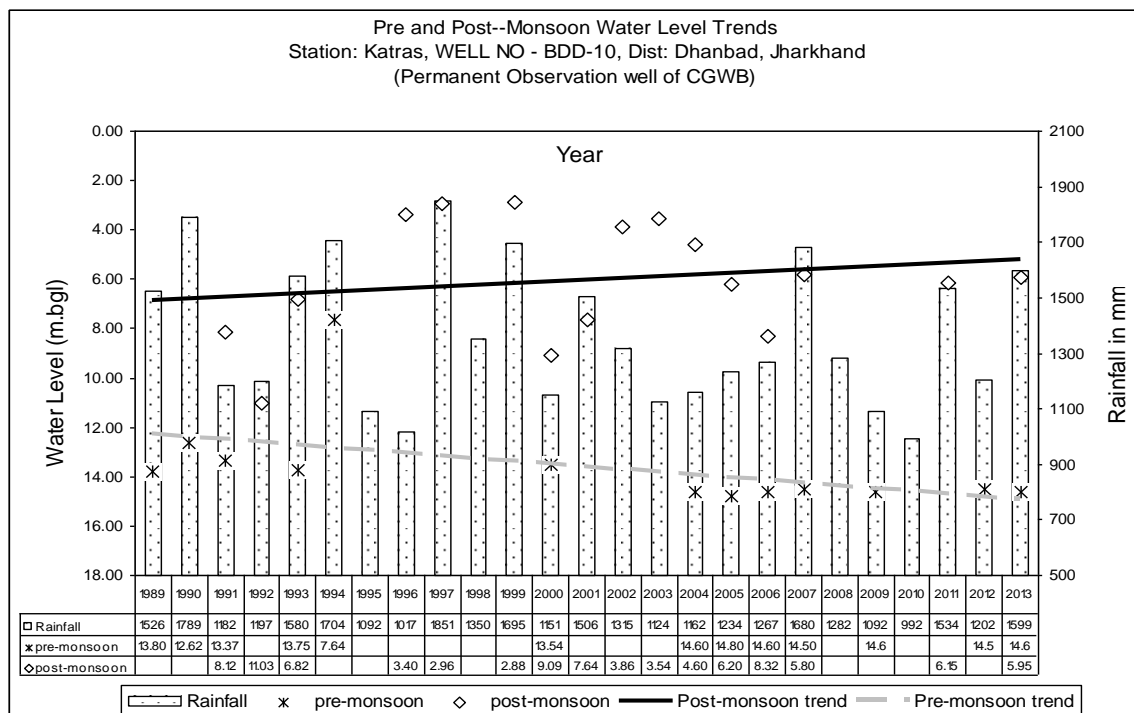
Annexure – III

HYDROGRAPHS OF CGWB PERMANENT OBSERVATION STATIONS



Annexure – III

HYDROGRAPHS OF CGWB PERMANENT OBSERVATION STATIONS



Annexure – IV

GROUNDWATER SAMPLE LOCATION DETAILS

Sampling month: February, June, September & December month of assessment year'2017

SI No	Name of Cluster	Ground Water Sample	Dug well (CMPDI)	Location	Sampling Date			
					Feb'17	June'17	Sep'17	Dec'17
1	CLUSTER-I	GW-1	B-15	BERA VILLAGE	18.02.17	13.06.17	01.09.17	04.12.17
2	CLUSTER-II	GW-2	B-59	KHODOVALY VILLAGE	18.02.17	13.06.17	01.09.17	04.12.17
3	CLUSTER-III	GW-3	A-29	GOVINDPUR,AMBAGAN VILLAGE	18.02.17	13.06.17	01.09.17	04.12.17
4	CLUSTER-IV	GW-4	B-63	KESHALPUR, BATIGHAR	18.02.17	13.06.17	01.09.17	04.12.17
5	CLUSTER-V	GW-5	D-30	BORKIBOA VILLAGE	18.02.17	13.06.17	01.09.17	04.12.17
6	CLUSTER-VI	GW-6	D-25	GODHUR MORE	18.02.17	13.06.17	01.09.17	05.12.17
7	CLUSTER-VII	GW-7	D-80	DHANSAR MINE RESCUE STN.	17.02.17	14.06.17	02.09.17	05.12.17
8	CLUSTER-VIII	GW-8	D-49	NEAR GHANOODIH OC	17.02.17	14.06.17	02.09.17	05.12.17
9	CLUSTER-IX	GW-9	D-5	JEALGORA, NEAR P.O.	17.02.17	14.06.17	02.09.17	05.12.17
10	CLUSTER-X	GW-10	D-35	PATHERDIH RLY. COLONY	17.02.17	14.06.17	02.09.17	05.12.17
11	CLUSTER-XI	GW-11	A-32	MONNIDIH BAZAR	18.02.17	13.06.17	01.09.17	04.12.17
12	CLUSTER-XIII	GW-13	A-23	MACHHAYARA	18.02.17	13.06.17	01.09.17	04.12.17
13	CLUSTER-XIV	GW-14	B-23	LOHAPATTI VILLAGE	18.02.17	13.06.17	01.09.17	04.12.17
14	CLUSTER-XV	GW-15	B-32A	MADHUBAND VILLAGE	18.02.17	13.06.17	01.09.17	04.12.17
15	CLUSTER-XVI	GW-16	D-22	DAHIBARI,NICHE BASTI	17.02.17	14.06.17	02.09.17	05.12.17

Abbreviations

AMSL: Above mean sea level

Avg.: Average

APT: Aquifer Pumping Test

BCCL: Bharat Coking Coal Ltd.

bgl: Below Ground Level

Buffer zone: periphery of the 10 km radius from the project boundary

Core zone: Project / mine / colliery boundary (leasehold area)

CMPDI: Central Mine Plan & Design Institute

DVC: Damodar Valley Corporation

DTW: Depth to water level

GW: Groundwater

IMD: Indian Meteorological Division

JCF: Jharia Coalfield

RCF: Raniganj Coalfield

MADA: Mineral Area Development Authority

MCM: Million Cubic Meter

MGD: Million Gallon per day

NTU: Nephelometric Turbidity unit

OC / UG: Opencast / Underground

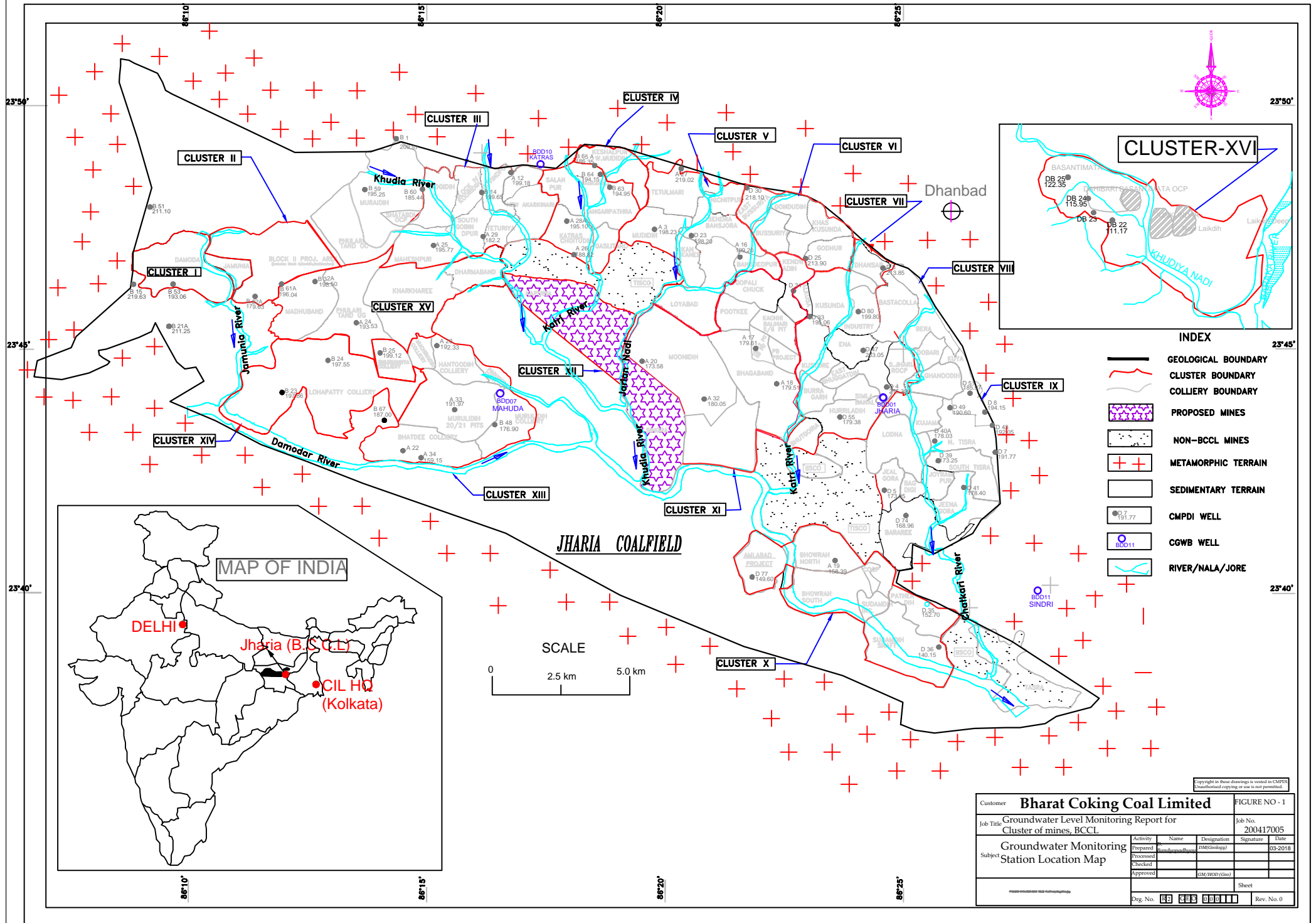
OCP / UGP: Opencast Project / Underground Project

RL: Reduced Level

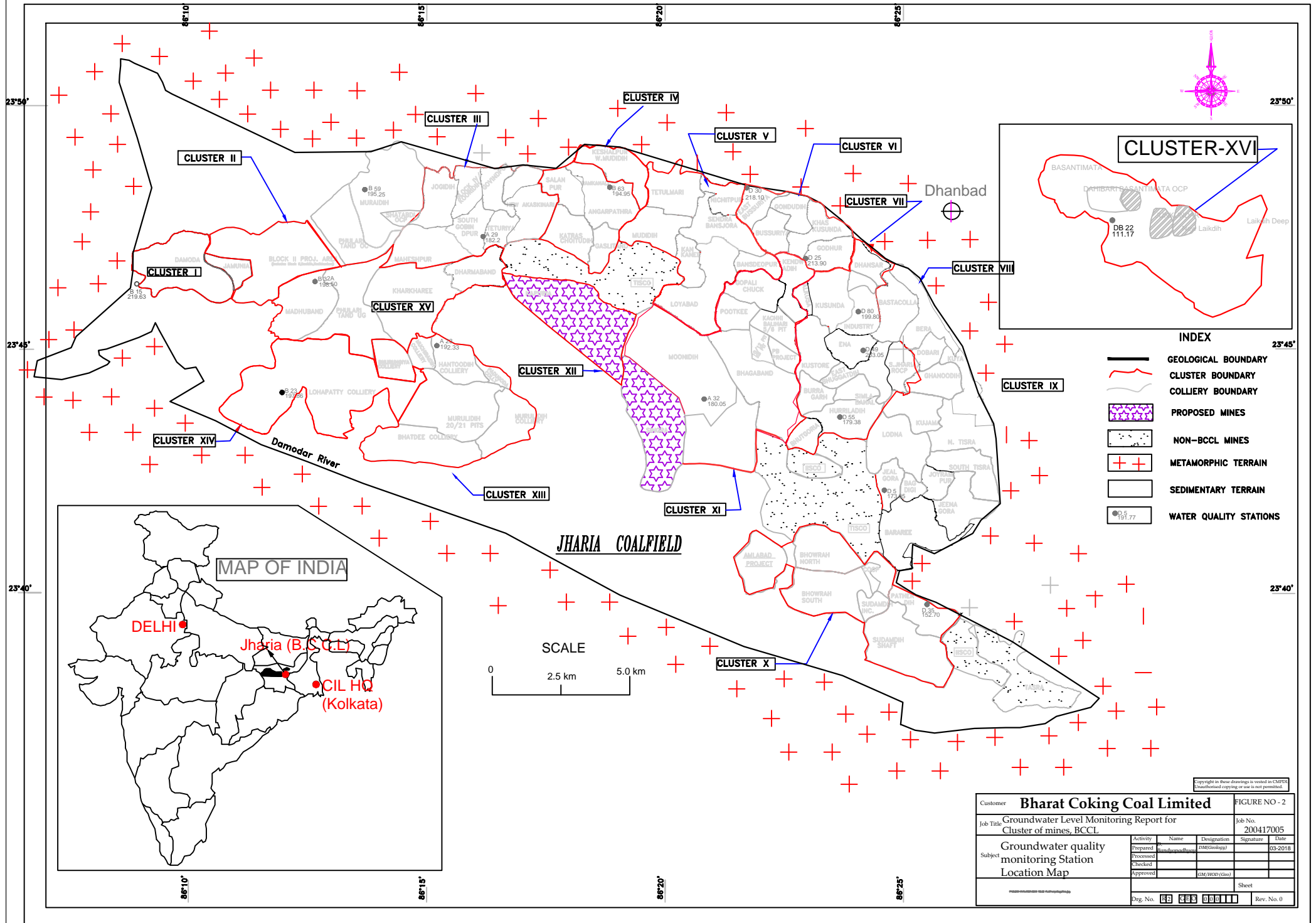
RWH: Rainwater Harvesting

FF: Fire Fighting

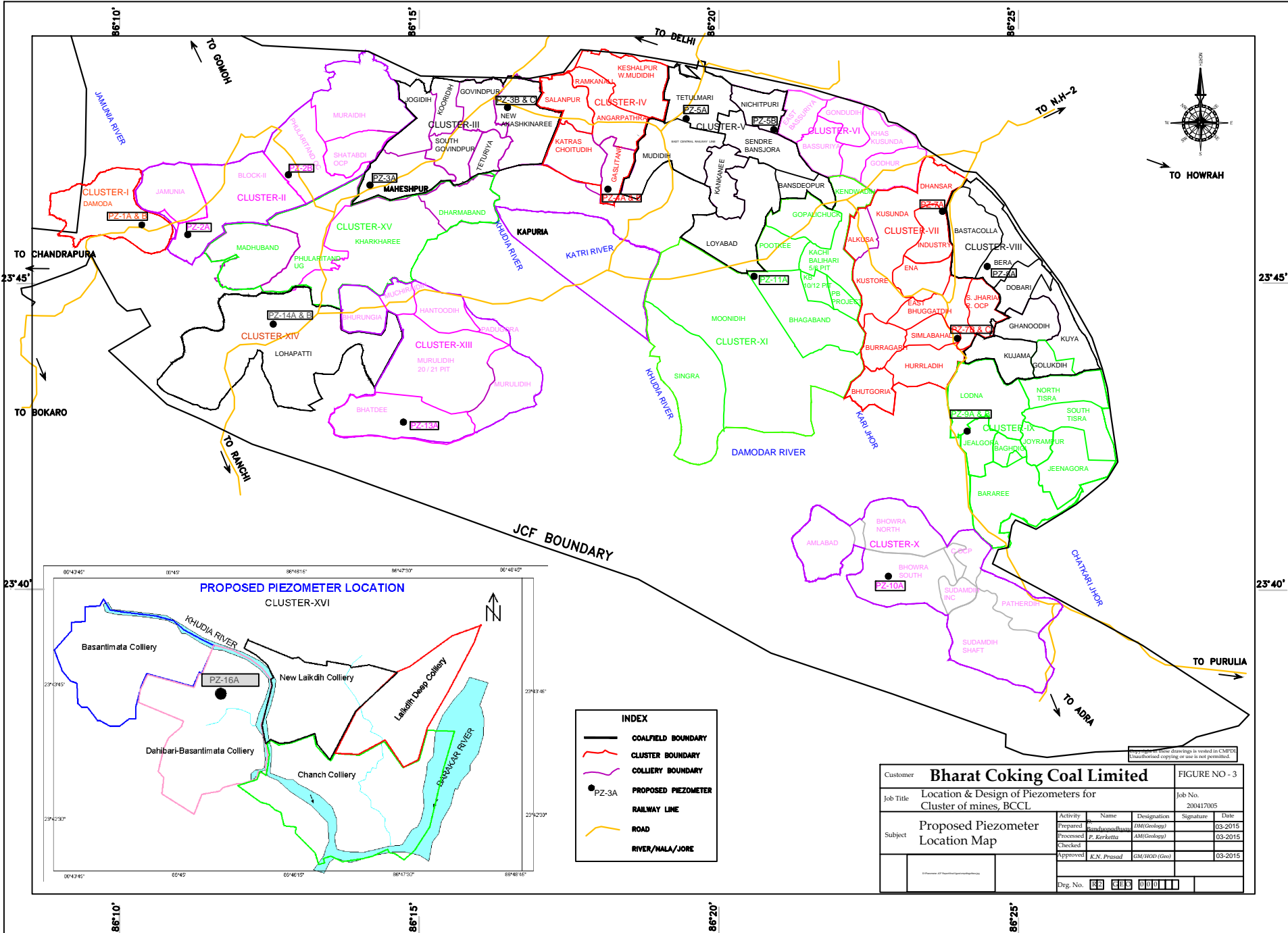
GROUNDWATER MONITORING STATION LOCATION MAP



GROUNDWATER QUALITY MONITORING STATION LOCATION MAP



PROPOSED PIEZOMETER LOCATION MAP, JCF & RCF (part)



Vegetation Cover Mapping of Jharia Coalfield based on Satellite Data of the Year- 2016



Submitted to
Bharat Coking Coal Ltd (BCCL)
Dhanbad

March 2017



Vegetation Cover Mapping of Jharia Coalfield based on Satellite Data of the Year- 2016

March-2017



Remote Sensing Cell
Geomatics Division
CMPDI, Ranchi

Document Control Sheet

(1) Job No.	RSC/561410027
(2) Publication Date	March 2017
(3) Number of Pages	49
(4) Number of Figures	6
(5) Number of Tables	10
(6) Number of Plates	17
(7) Title of Report	Vegetation cover mapping of Jharia Coalfield based on satellite data for the year 2016.
(8) Aim of the Report	To prepare Land use and vegetation cover map of Jharia Coalfield on 1:50000 scale based on satellite data for monitoring the impact of coal mining on land use pattern and vegetation cover & also to prepare cluster wise Land use/ Cover maps falling under Jharia Coalfield.
(9) Executing Unit	Remote Sensing Cell, Geomatics Division Central Mine Planning & Design Institute Limited, Gondwana Place, Kanke Road, Ranchi 834008
(10) User Agency	Coal India Ltd.(CIL) / Bharat Coking Coal Ltd.(BCCL)
(11) Authors	Ms Ayesha Parida, Assistant Manager (Remote Sensing)
(12) Security Restriction	Restricted Circulation
(13) No. of Copies	5
(14) Distribution Statement	Official

Contents

	Page No.
Document Control Sheet	i
List of Figures	iii
List of Tables	iii
List of Plates	iii
1.0 Introduction	1 - 4
1.1 Project Reference	
1.2 Project Background	
1.3 Objectives	
1.4 Location and Accessibility	
1.5 Physiography	
2.0 Remote Sensing Concept & Methodology	5 - 17
2.1 Remote Sensing	
2.2 Electromagnetic Spectrum	
2.3 Scanning System	
2.4 Data Source	
2.5 Characteristics of Satellite/Sensor	
2.6 Data Processing	
2.6.1 Geometric Correction, rectification & geo-referencing	
2.6.2 Image enhancement	
2.6.3 Training set selection	
2.6.4 Signature generation & classification	
2.6.5 Creation / Overlay of vector database in GIS	
2.6.6 Validation of classified image	
3.0 Land use / Vegetation Cover Mapping	18- 28
3.1 Introduction	
3.2 Land use / Vegetation Cover Classification	
3.3 Data Analysis & Change Detection	
3.3.1 Vegetation Cover	
3.3.2 Mining Area	
3.3.3 Agricultural Land	
3.3.4 Wasteland	
3.3.5 Settlements	
3.3.6 Water Bodies	
3.4 Data analysis of clusters under Jharia Coalfield	
4.0 Conclusion and Recommendations	29- 30
4.1 Conclusion	
4.2 Recommendations	

List of Figures	Page No.
2.0 Location Map of Jharia Coal Field.	4
2.1 Remote Sensing Radiation system	5
2.2 Electromagnetic Spectrum.	6
2.3 Expanded diagram of the visible and infrared regions (upper) and microwave regions (lower) showing atmospheric windows.	7
2.4 Methodology for Land use / vegetation cover mapping.	12
2.5 Geoid-Ellipsoid -Projection Relationship.	14

List of Tables

2.1 Electromagnetic spectral regions.	8
2.2 Characteristics of the satellite/sensor used in the present project work.	11
3.1 Vegetation cover / land use classes identified in Jharia Coalfield.	19
3.2 Distribution of Land use / Cover Patten in Jharia Coalfield in the year 2016	21
3.3 Vegetation Cover in Jharia Coalfield	22
3.4 Distribution of Mining area in Jharia Coalfield during the year 2016	24
3.5 Agricultural Land in Jharia Coalfield during the year 2016	25
3.6 Wastelands in Jharia coalfield during the year 2016	26
3.7 Distribution of Settlements in Jharia Coalfield during the year 2016	27
3.8 Cluster wise Land Use/Cover statistics	28

List of Plates

List of maps/plates prepared on a scale of 1:50,000 are given below:

1. Plate No. HQ/REM/ 001: IRS-R2/ L4FMX FCC of Jharia Coalfield	
2. Plate No. HQ/REM/ 002: Land use / Cover Map of Jharia Coalfield based on IRS – R2/ L4FMX data of January 2016.	
3. Land Use/Cover map of Cluster I	31
4. Land Use/Cover map of Cluster II	32
5. Land Use/Cover map of Cluster III	33
6. Land Use/Cover map of Cluster IV	34
7. Land Use/Cover map of Cluster V	35
8. Land Use/Cover map of Cluster VI	36
9. Land Use/Cover map of Cluster VII	37
10. Land Use/Cover map of Cluster VIII	38
11. Land Use/Cover map of Cluster IX	39

List of Plates	Page No.
12. Land Use/Cover map of Cluster X	40
13. Land Use/Cover map of Cluster XI	41
14. Land Use/Cover map of Cluster XII	42
15. Land Use/Cover map of Cluster XIII	43
16. Land Use/Cover map of Cluster XIV	44
17. Land Use/Cover map of Cluster XV	45

Chapter 1

Introduction

1.1 Project Reference

To monitor the regional impact of coal mining on land use pattern and vegetation cover in the 28 major coalfields at regular interval of three years based on remote sensing satellite data, Coal India Ltd. issued a work order to CMPDI vide letter no.CIL/WBP/ENV/2011/4706 dated 12.10.12. As the Impact of coal mining on land environment has to be assessed regularly at interval of three years, Geo-environmental data base for Jharia coalfield based on satellite data was prepared earlier in the year 2010, 2012 under the above project. The present study is based on the satellite data of the year 2016. BCCL vide their letter No BCCL/ DGM(Env)/File-/16/276 dated 25.05.2016 requested that the map of each cluster under Jharia Coalfield shall also be incorporated in the report for EC compliance. Therefore cluster-wise land use/cover maps are also included in this report.

1.2 Objective

The objective of the present study is to prepare a regional land use and vegetation cover map of Jharia coalfield on 1:50,000 scale based on satellite data of the year 2016, using digital image processing technique for monitoring the impact of coal mining and other industrial activities on land use and vegetation cover in the coalfield area in period of last three years.

1.4 Location of the Area & Accessibility

The Jharia Coalfield (JCF) is located in the north east part of the State of Jharkhand, approximately 260 km west of Kolkata. It is linked to Kolkata and Delhi through NH 2, which is the part of Golden Quadrilateral highway network of India. The coalfield contains proven coal reserves of approximately one billion tonnes in a crescent-shaped basin of approximately 400 km². BCCL operates within an area of approximately 258 Sq km. The Jharia coalfield covers an area of about 393 sq km. it is bounded by Lat 23°49'0.63"N and 23°38'36.50"N and Long 86°08'49.91"E and 86°25'54.92E. The major part of coalfield (about 400 sq km) lies in Dhanbad district of Jharkhand. Coalfield is connected by Major Highways road with Ranchi (117 km), Asansol (60 km), Jamshedpur (108 km) and Dhanbad (8 km). The nearest major railway station is Dhanbad, located on Delhi-Howrah Grand Chord line of East Central Railway which passes parallel to northern boundary of the coalfield.

1.5 Physiography and Geology

Jharia coalfield is characterized by gently undulating to a rolling topography with an overall slope towards east-southeast. The coalfield is roughly sickle shaped on plan and occurs as a basin with its axis trending broadly east-west and plunging towards the west. The southern flank is truncated by a major Boundary Fault. The general dip of the formation is 10 to 15 degrees. Flatter dips have also been noted at places. The entire southern part of Jharia coalfield in the vicinity of the Boundary Fault, however shows generally steep dipping beds with amounts increasing even up to 70 degrees.

The drainage pattern in the Jharia coalfield is dendritic in nature. This may be due to more or less homogeneous lithology and structural controls. Damodar river is the main control of drainage system along the Jharia coalfield. It is a fourth order stream to which a number of third to first order streams, viz.

Jamunia, Khudia, Katri, Ekra, Tisra, Chatkari etc. join. Damodar river flows along the southern periphery of the coalfield and is guided by the Main Boundary Fault. The main flow direction is from west to east.

The strike of the formation is generally WSW to ENE in the western part and WNW to ESE in the southern part of the coalfield. This gradually swings to EW in the centre of the coalfield and then to NS further east. In the south-eastern part the strike is generally WNW-ESE. Besides the boundary part the coalfield is traversed by a number of other major and minor faults.

The Barakar formation contains 18 standard coal horizons (numbered I to XVIII). Of the Barakar formations, the coal seams XIII and above are generally thin and of relatively superior quality. Seams XII to IX/X are of medium to superior quality and attain sizable thickness at places. The V, VI, VII, IV, III & II are generally thick seams of inferior quality. The bottom most seam I is of superior medium coking quality in the eastern part of the coalfield.

A map of India showing the location of Jharia Coalfield is given in Fig1.1.

.

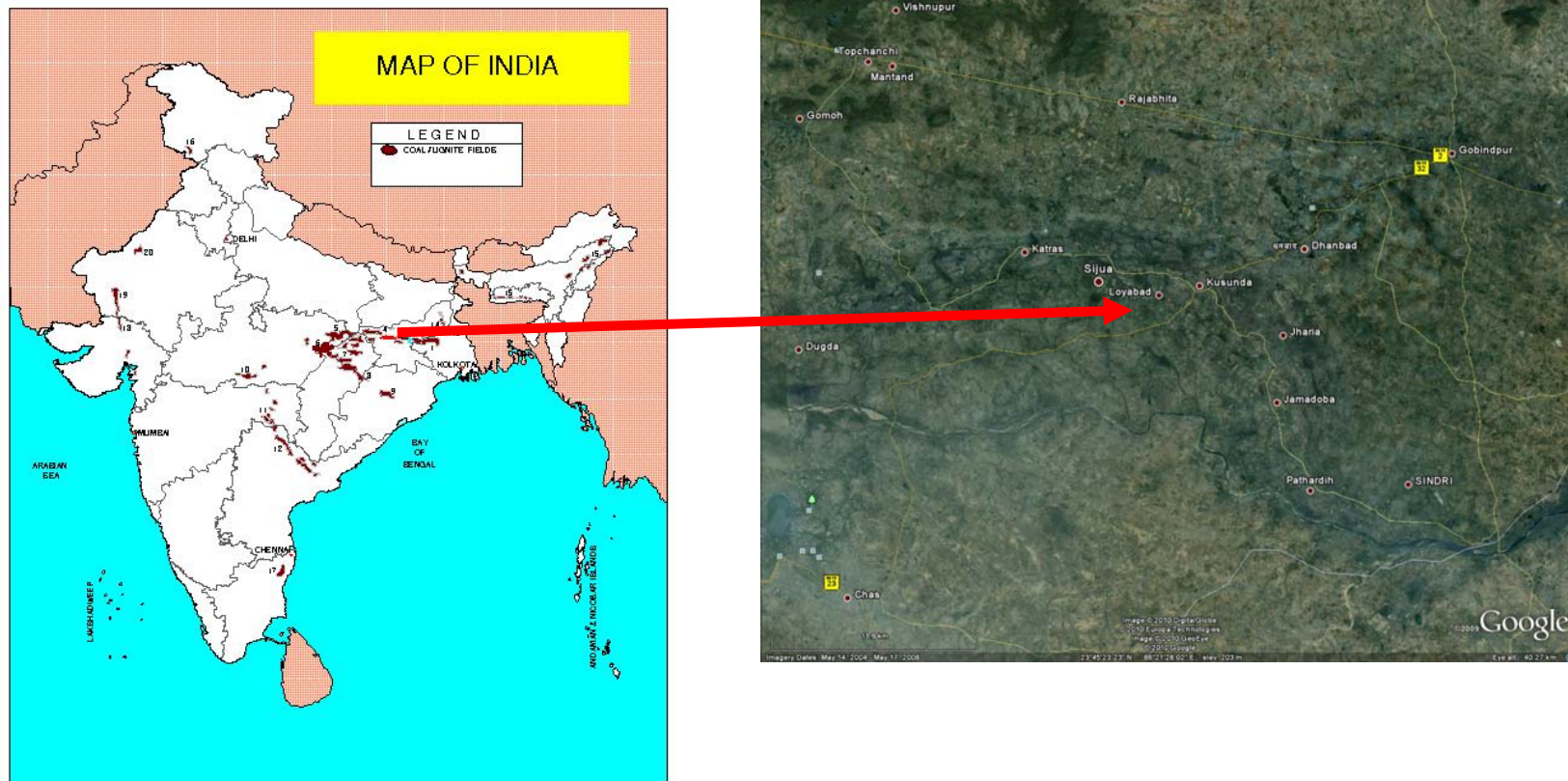


Fig 1.1: Map of India Showing the Location of Jharia Coalfields

Chapter 2

Remote Sensing Concepts and Methodology

2.1 Remote Sensing

Remote sensing is the science and art of obtaining information about an object or area through the analysis of data acquired by a device that is not in physical contact with the object or area under investigation. The term *remote sensing* is commonly restricted to methods that employ electromagnetic energy (such as light, heat and radio waves) as the means of detecting and measuring object characteristics.

All physical objects on the earth surface continuously emit electromagnetic radiation because of the oscillations of their atomic

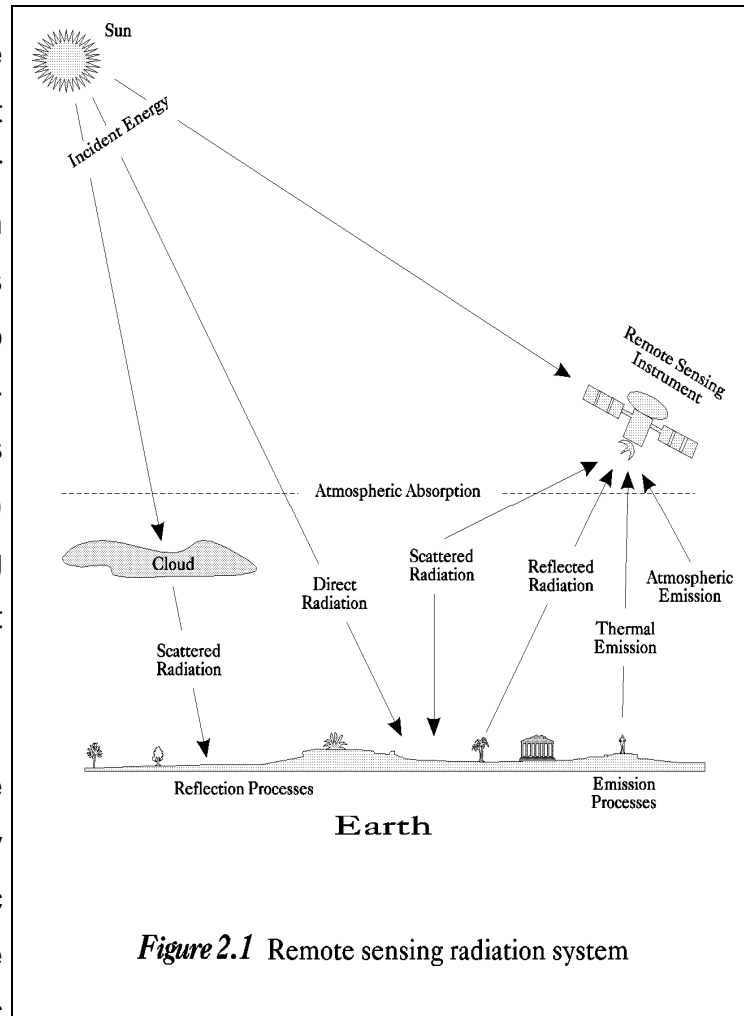


Figure 2.1 Remote sensing radiation system

particles. Remote sensing is largely concerned with the measurement of electromagnetic energy from the *SUN*, which is reflected, scattered or emitted by the objects on the surface of the earth. Figure 2.1 schematically illustrate the generalised processes involved in electromagnetic remote sensing of the earth resources.

2.2 Electromagnetic Spectrum

The electromagnetic (EM) spectrum is the continuum of energy that ranges from meters to nanometres in wavelength and travels at the speed of light. Different objects on the earth surface reflect different amounts of energy in various wavelengths of the EM spectrum.

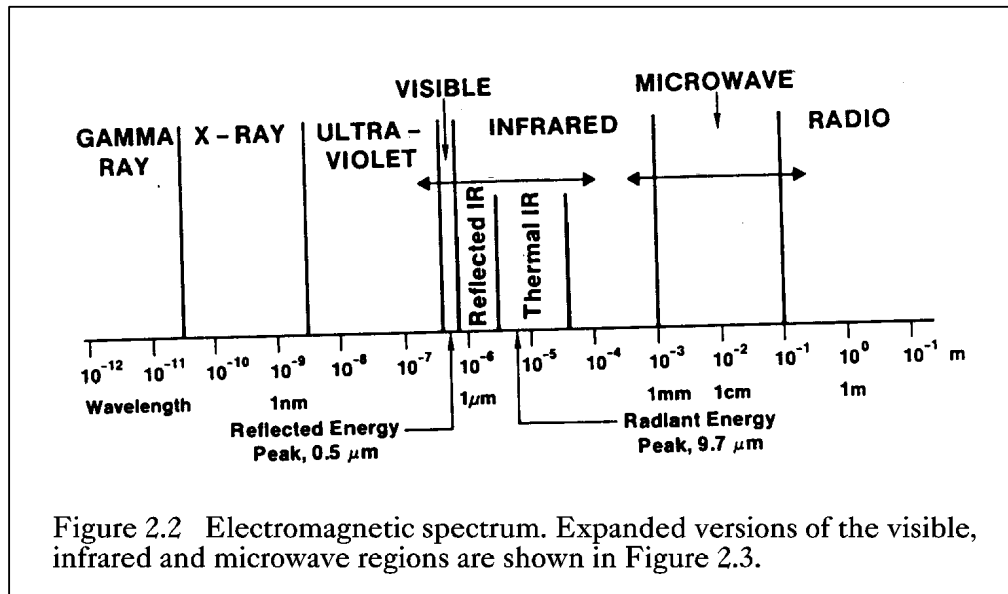


Figure 2.2 shows the electromagnetic spectrum, which is divided on the basis of wavelength into different regions that are described in Table 2.1. The EM spectrum ranges from the very short wavelengths of the gamma-ray region to the long wavelengths of the radio region. The visible region ($0.4\text{-}0.7\mu\text{m}$ wavelengths) occupies only a small portion of the entire EM spectrum.

Energy reflected from the objects on the surface of the earth is recorded as a function of wavelength. During daytime, the maximum amount of energy is reflected at $0.5\mu\text{m}$ wavelengths, which corresponds to the green band of the visible region, and is called the *reflected energy peak* (Figure 2.2). The earth also radiates energy both day and night, with the maximum energy $9.7\mu\text{m}$ wavelength. This *radiant energy peak* occurs in the thermal band of the IR region.

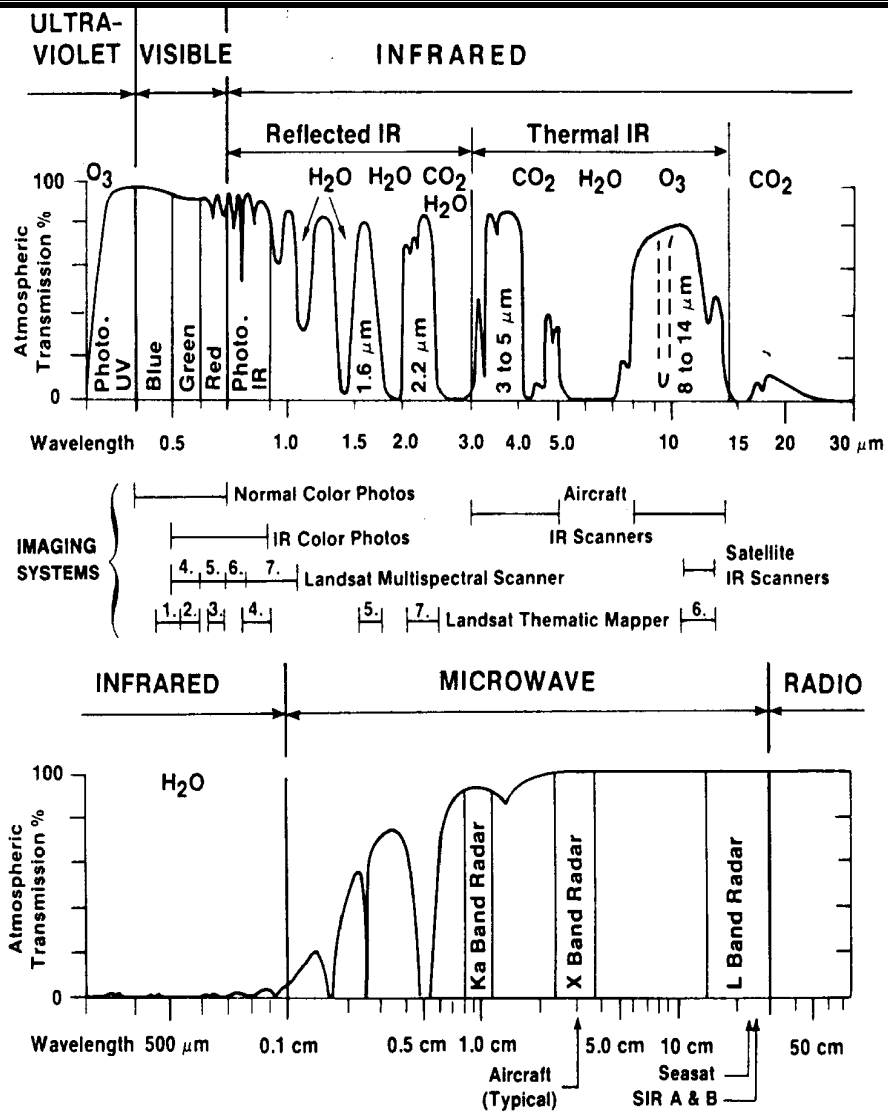


Figure 2.3 Expanded diagrams of the visible and infrared regions (upper) and the microwave regions (lower) showing atmospheric windows. Wavelength bands of commonly used remote sensing systems are indicated. Gases responsible for atmospheric absorption are shown.

Table 2.1 Electromagnetic spectral regions

Region			Wavelength	Remarks
<i>Gamma ray</i>	<		0.03 nm	Incoming radiation is completely absorbed by the upper atmosphere and is not available for remote sensing.
<i>X-ray</i>	0.03	to	3.00 nm	Completely absorbed by atmosphere. Not employed in remote sensing.
<i>Ultraviolet</i>	0.03	to	0.40 μm	Incoming wavelengths less than 0.3mm are completely absorbed by Ozone in the upper atmosphere.
<i>Photographic UV band</i>	0.30	to	0.40 μm	Transmitted through atmosphere. Detectable with film and photo detectors, but atmospheric scattering is severe.
<i>Visible</i>	0.40	to	0.70 μm	Imaged with film and photo detectors. IBCCLudes reflected energy peak of earth at 0.5mm.
<i>Infrared</i>	0.70	to	100.00 μm	Interaction with matter varies with wavelength. Absorption bands separate atmospheric transmission windows.
<i>Reflected IR band</i>	0.70	to	3.00 μm	Reflected solar radiation that contains no information about thermal properties of materials. The band from 0.7-0.9mm is detectable with film and is called the <i>photographic IR band</i> .
<i>Thermal IR band</i>	3.00 8.00	to to	5.00 μm 14.00 μm	Principal atmospheric windows in the thermal region. Images at these wavelengths are acquired by optical-mechanical scanners and special Videocon systems but not by film.
<i>Microwave</i>	0.10	to	30.00 cm	Longer wavelengths can penetrate clouds, fog and rain. Images may be acquired in the active or passive mode.
<i>Radar</i>	0.10	to	30.00 cm	Active form of microwave remote sensing. Radar images are acquired at various wavelength bands.
<i>Radio</i>	>		30.00 cm	Longest wavelength portion of electromagnetic spectrum. Some classified radars with very long wavelength operate in this region.

The earth's atmosphere absorbs energy in the gamma-ray, X-ray and most of the ultraviolet (UV) region; therefore, these regions are not used for remote sensing. Details of these regions are shown in Figure 2.3. The horizontal axes show wavelength on a logarithmic scale; the vertical axes show percent atmospheric transmission of EM energy. Wavelength regions with high transmission are called *atmospheric windows* and are used to acquire remote sensing data. The major remote sensing sensors record energy only in the visible, infrared and micro-wave regions. Detection and measurement of the recorded energy enables identification of surface objects (by their characteristic wavelength patterns or spectral signatures), both from air-borne and space-borne platforms.

2.3 Scanning System

The sensing device in a remotely placed platform (aircraft/satellite) records EM radiation using a *scanning system*. In scanning system, a *sensor*, with a narrow field of view is employed; this sweeps across the terrain to produce an image. The sensor receives electromagnetic energy radiated or reflected from the terrain and converts them into signal that is recorded as numerical data. In a remote sensing satellite, multiple arrays of linear sensors are used, with each array recording simultaneously a separate band of EM energy. The array of sensors employs a spectrometer to disperse the incoming energy into a spectrum. Sensors (or *detectors*) are positioned to record specific wavelength bands of energy. The information received by the sensor is suitably manipulated and transported back to the ground receiving station. The data are reconstructed on ground into digital images. The digital image data on *magnetic/optical media* consist of picture elements arranged in regular rows and columns. The position of any picture element, *pixel*, is determined on a x-y co-ordinate system. Each pixel has a numeric value, called digital number (DN), which records the intensity of electromagnetic energy measured for the ground resolution cell represented by that pixel. The range of digital numbers in an image data is controlled by the radiometric resolution of the satellite's sensor system. The digital image data are further processed to produce master images of the study area. By analysing the digital data/imagery, digitally/visually, it is possible to detect, identify and classify various objects and phenomenon on the earth surface.

Remote sensing technique provides an efficient, speedy and cost-effective method for assessing the changes in vegetation cover certain period of time due to its inherited capabilities of being multi-spectral, repetitive and synoptic aerial coverage.

2.4 Data Source

The following data are used in the present study:

- **Primary Data** –Raw satellite data, obtained from National Remote Sensing Centre (NRSC), Hyderabad, as follows, was used as primary data source for the study.

IRS R2/ L4FMX; Band 2,3,4,5; Path # 106, Row # 055; Date of pass 5.01.2016*.

The detail specification of the data is also given in Table 2.2.

- **Secondary Data**

Secondary (ancillary) and ground data constitute important baseline information in remote sensing, as they improve the interpretation accuracy and reliability of remotely sensed data by enabling verification of the interpreted details and by supplementing it with the information that cannot be obtained directly from the remotely sensed data.

2.5 Characteristics of Satellite/Sensor

The basic properties of a satellite's sensor system can be summarised as:

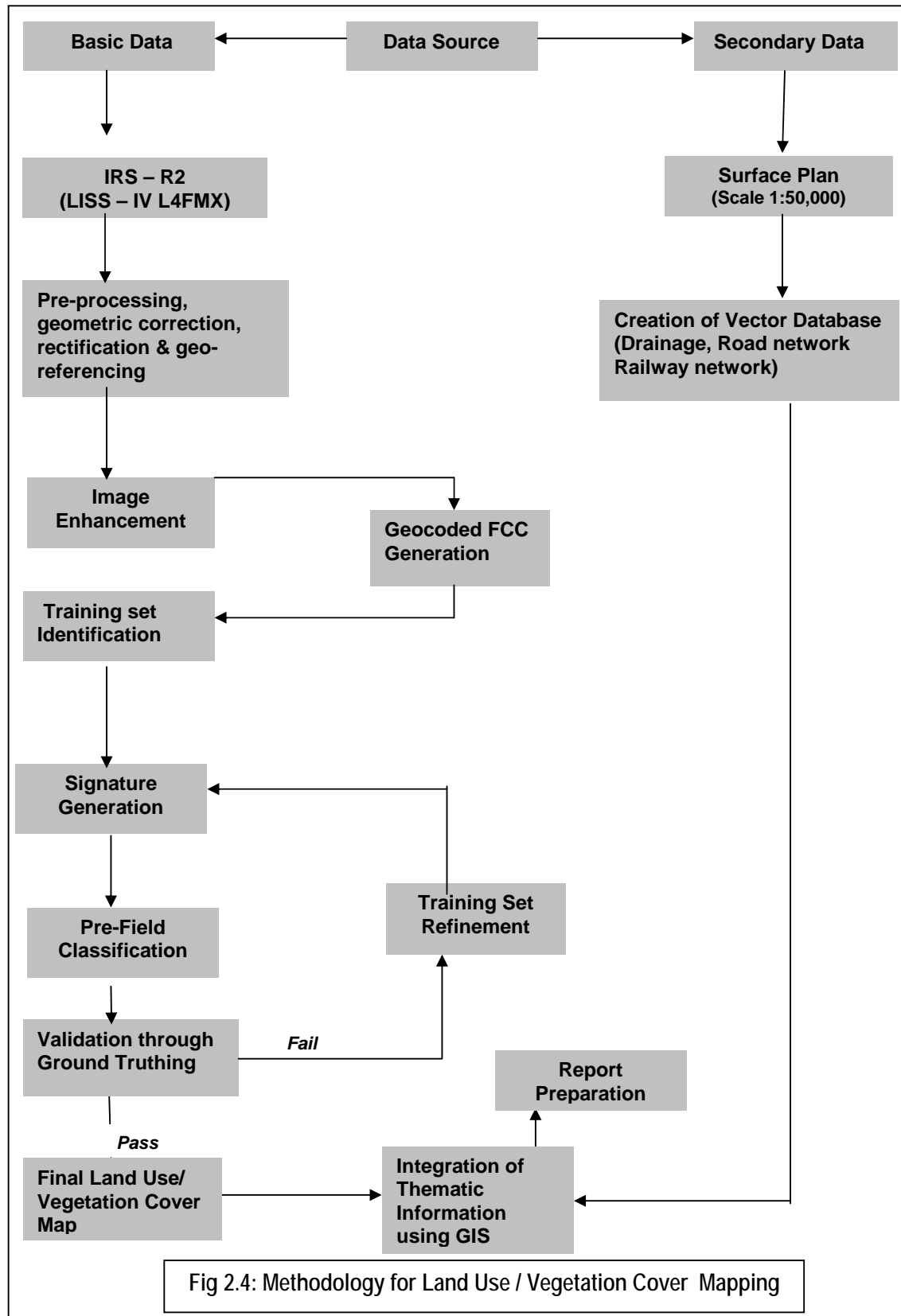
- (a) Spectral coverage/resolution, i.e., band locations/width;
 - (b) spectral dimensionality: number of bands;
 - (c) radiometric resolution: quantisation;
 - (d) spatial resolution/instantaneous field of view or IFOV; and
 - (e) temporal resolution.
- Table 2.2 illustrates the basic properties of IRS-R2 satellite/sensor that is used in the present study.

Table 2.2 Characteristics of the satellite/sensor used in the present project work										
Platform	Sensor	Spectral Bands in μm					Radiometric Resolution	Spatial Resolution	Temporal Resolution	Country
IRS- P-6	LISS-IV	B2	0.52	-	0.59	Green	10 bits (7 bits transmitted with DPCM)	5.8m	24 days	India
		B3	0.62	-	0.68	Red				
		B4	0.77	-	0.86	NIR				
		B5	1.55	-	1.70	MIR				
NIR: Near Infra-Red MIR: Middle Infra-Red										

2.6 Data Processing

The methodology for data processing carried out in the present study is shown in Figure 2.4. The processing involves the following major steps:

- (a) Geometric correction, rectification and geo-referencing;
- (b) Image enhancement;
- (c) Training set selection;
- (d) Signature generation and classification;
- (e) Creation/overlay of vector database;
- (f) Validation of classified image;
- (g) Layer wise theme extraction using GIS
- (g) Final vegetation map preparation.



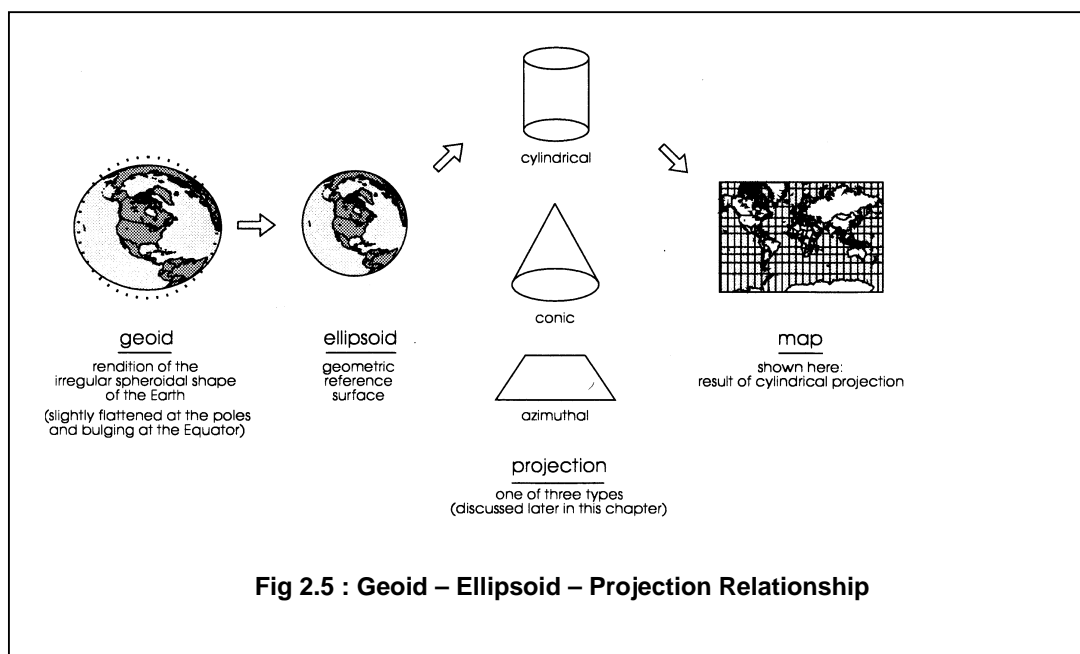
2.6.1 Geometric correction, rectification and georeferencing

Inaccuracies in digital imagery may occur due to 'systematic errors' attributed to earth curvature and rotation as well as 'non-systematic errors' attributed to intermittent sensor malfunctions, etc. Systematic errors are corrected at the satellite receiving station itself while non-systematic errors/ random errors are corrected in pre-processing stage.

In spite of 'System / Bulk correction' carried out at supplier end; some residual errors in respect of attitude attributes still remains even after correction. Therefore, fine tuning is required for correcting the image geometrically using ground control points (GCP).

Raw digital images contain geometric distortions, which make them unusable as maps. A map is defined as a flat representation of part of the earth's spheroidal surface that should conform to an internationally accepted type of cartographic projection, so that any measurements made on the map will be accurate with those made on the ground. Any map has two basic characteristics: (a) scale and (b) projection. While *scale* is the ratio between reduced depiction of geographical features on a map and the geographical features in the real world, *projection* is the method of transforming map information from a sphere (round Earth) to a flat (map) sheet. Therefore, it is essential to transform the digital image data from a generic co-ordinate system (i.e. from line and pixel co-ordinates) to a projected co-ordinate system. In the present study geo-referencing was done with the help of Survey of India (Sol) topo-sheets so that information from various sources can be compared and integrated on a GIS platform, if required.

An understanding of the basics of projection system is required before selecting any transformation model. While maps are flat surfaces, Earth however is an irregular sphere, slightly flattened at the poles and bulging at the Equator. Map projections are systemic methods for “*flattening the orange peel*” in measurable ways. When transferring the Earth and its irregularities onto the plane surface of a map, the following three factors are involved: (a) geoid (b) ellipsoid and (c) projection. Figure 2.5 illustrates the relationship between these three factors. The *geoid* is the rendition of the irregular spheroidal shape of the Earth; here the variations in gravity are taken into account. The observation made on the geoid is then transferred to a regular geometric reference surface, the *ellipsoid*. Finally, the geographical relationships of the ellipsoid (in 3-D form) are transformed into the 2-D plane of a map by a transformation process called map projection. As shown in Figure 2.5, the vast majority of projections are based upon *cones*, *cylinders* and *planes*.



In the present study, **UTM projection** along with **WGS 84 model** was used so as to prepare the map compatible with the Sol topo-sheets. UTM projection is used in Sol topo-sheets as it is best suited for small-scale mapping and larger area as well as for areas with North-South orientation (viz. India). Maps prepared using this projection is a compromise of many properties; it is neither conformal perspective nor equal area. Distances, areas and shapes are true only along central meridian. Distortion increases away from central meridian. Image transformation from generic co-ordinate system to a projected co-ordinate system was carried out using ERDAS Imagine 2014 digital image processing system.

2.6.2 Image enhancement

To improve the interpretability of the raw data, image enhancement is necessary. Most of the digital image enhancement techniques are categorised as either point or local operations. Point operations modify the value of each pixel in the image data independently. However, local operations modify the value of each pixel based on brightness value of neighbouring pixels. Contrast manipulations/stretching technique based on local operation were applied on the image data using ERDAS Imagine 2014 s/w. The enhanced and geocoded FCC (False colour composite) image of Jharia Coalfield is shown in Plate No. 1 for the year 2013.

2.6.3 Training set selection

The image data were 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. Based on the variability of land use/cover condition and terrain characteristics and accessibility, 90 points were selected to generate the training sets.

2.6.4 Signature generation and classification

Image classification was carried out using the minimum distance 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 was 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. The aerial extent of each land use class in the coalfield was determined using ERDAS Imagine 2014 s/w. The classified image for the year 2016 for Jharia Coalfield is shown in Drawing No. HQREMA10002.

2.6.5 Creation /overlay of vector database in GIS

Plan showing leasehold areas of mining projects supplied by BCCL are superimposed on the image as vector layer in the GIS database. Road network, rail network and drainage network are digitised on different vector layers in GIS database. Layer wise theme extraction was carried out using Arc GIS s/w and imported the same on GIS platform for further analysis.

2.6.6 Validation of classified image

Ground truth survey was carried out for validation of the interpreted results from the study area. Based on the validation, classification accuracy matrix was prepared.

The overall classification accuracy was found to be 88.59%.

2.6.7 Interpretation of Data

Interpretation of data for Land Use/vegetation cover was carried out through GIS by analysing the Land Use/ vegetation Cover map of the year 2016. Final Land Use/vegetation cover maps (on 1:50,000 scale) were printed using HP Design jet 4500 Colour Plotter.

Chapter 3

Land Use/ Vegetation Cover Monitoring

3.1 Introduction

Land is one of the most important natural resource on which all human activities are based. Therefore, knowledge on different type of lands as well as its spatial distribution in the form of map and statistical data is vital for its geospatial planning and management for optimal use of the land resources. In mining industry, the need for information on land use/ vegetation cover pattern has gained importance due to the all-round concern on environmental impact of mining. The information on land use/vegetation cover inventory that includes type, spatial distribution, aerial extent, location, rate and pattern of change of each category is of paramount importance for assessing the impact of coal mining on land use/ cover.

Remote sensing data with its various spectral and spatial resolution offers comprehensive and accurate information for mapping and monitoring of land use/cover pattern, dynamics of changing pattern and trends over a period of time.. By analysing the data of different cut-off dates, impact of coal mining on land use and vegetation cover can be determined.

3.2 Land Use / Vegetation Cover Classification

The array of information available on land use/cover requires be arranging or grouping under a suitable framework in order to facilitate the creation of database. Further, to accommodate the changing land use/vegetation cover pattern, it becomes essential to develop a standardised classification system that is not only

flexible in nomenclature and definition, but also capable of incorporating information obtained from the satellite data and other different sources.

The present framework of land use/cover classification has been primarily based on the '**Manual of Nationwide Land Use/ Land Cover Mapping Using Satellite Imagery**' developed by National Remote Sensing Agency, Hyderabad, which has further been modified by CMPDI for coal mining areas. Land use/vegetation cover map was prepared on the basis of image interpretation carried out based on the satellite data for the year 2016. Following land use/cover classes are identified in the Jharia coalfield region (Table 3.1).

Table 3.1 Land use / Vegetation Cover classes identified in Jharia Coalfield		
	LEVEL -I	LEVEL-II
1	Vegetation Cover	3.1 Dense Forest 3.2 Open Forest 3.3 Scrub 3.4 Plantation under Social Forestry 3.5 Plantation on OB Dumps
2	Mining Area	5.1 Coal Quarry 5.2 Barren OB Dump 5.3 Area Under Backfilling 5.4 Coal Dump 5.5 Water Filled Quarry
3	Agricultural Land	2.1 Crop Land 2.2 Fallow Land
4	Wasteland	4.1 Waste upland with/without scrubs 4.2 Slurry Pond 4.3 Sand Body
5	Settlements	1.1 Urban 1.2 Rural 1.3 Industrial
6	Water Bodies	6.1 River/Streams /Reservoir

3.3 Data Analysis of Jharia Coalfield

Satellite data of the year 2016 was processed using ERDAS Imagine v.2014 image processing s/w in order to interpret the various land use and vegetation cover classes present in the Jharia coalfield. The analysis was carried out for entire coalfield covering about 393 sq. km.

The area of each class was calculated and analysed using *ERDAS Digital Image Processing* s/w and *ArcGIS* s/w. Analysis of land use / vegetation cover pattern in Jharia Coalfield in the year 2016 has been done and details are and shown in table 3.2.

TABLE – 3.2: STATUS OF LAND USE/COVER PATTERN IN JHARIA COALFIELD DURING YEAR 2013 & 2016

LAND USE CLASSES	Year 2013		Year 2016		Change		Reasons for change
	Area (Km ²)	%	Area (Km ²)	%	Area (Km ²)	%	
SETTLEMENTS							
Urban Settlement	35.05	8.92	35.05	8.92	0.00	0.00	No change
Rural Settlement	3.17	0.81	3.74	0.95	0.57	0.15	Migration of population to mining areas
Industrial Settlement	3.35	0.85	2.29	0.58	-1.06	-0.27	Dismantling of some industrial structures, eg Lodna Washery
Total Settlements	41.57	10.58	41.08	10.46	-0.49	-0.12	
VEGETATION COVER							
FORESTS							
Dense Forest	0.29	0.07	0.29	0.07	0.00	0.00	No Change
Open Forest	8.51	2.16	6.27	1.60	-2.24	-0.56	Minor decrease due to deforestation
Total Forest (A)	8.8	2.23	6.56	1.67	-2.24	-0.56	
SCRUBS							
Scrubs (B)	122.5	31.2	105.87	26.95	-16.63	-4.25	Conversion of UG mines into OC mines, Land with scrubs were used
PLANTATION							
Social forestry	19.41	4.94	19.52	4.97	0.11	0.03	Increase in plantation along roads, creation of ecological resoration parks
Plantation on OB Dump	11.94	3.04	8.59	2.19	-3.35	-0.85	Decrease due to increase in mining activity & conversion of UG mines into OC mines
Total Plantation (C)	31.35	7.98	28.11	7.16	-3.24	-0.82	
Total Vegetation (A+B+C)	162.65	41.4	140.54	35.77	-22.11	-5.63	
MINING AREA							
Coal Quarry	6.98	1.78	11.36	2.89	4.38	1.11	Increase in mining activity
Coal Dump	1.3	0.33	0.23	0.06	-1.07	-0.27	Places where coal dumps were observed have been shifted
Quarry filled with water	0.25	0.06	0.77	0.20	0.52	0.13	Minor change in places with water filled quarries
Barren OB Dump	19.06	4.85	12.55	3.19	-6.51	-1.66	Some area under small OB dumps coming under new amalgamated projects
Area Under Backfilling	7.36	1.87	15.62	3.98	8.26	2.10	Due to increase in excavation due to opencast mining activities
Total Mining Area	35.22	8.97	40.53	10.32	5.31	1.35	
AGRICULTURE							
Crop Lands	3.94	1	3.71	0.94	-0.23	-0.06	Derease due to crop land being converted into fallow land
Fallow Lands	35.85	9.13	40.68	10.36	4.83	1.23	Conversion of scrub land into fallow land
Total Agriculture	39.79	10.13	44.39	11.30	4.60	1.17	
WASTELANDS							
Wastelands	100.05	25.47	113.97	29.01	13.92	3.54	Scrubland converted to wasteland
Ash pond/Slurry/ Tailing Ponds	0.26	0.07	0	0.00	-0.26	-0.07	
Sand Body	1.53	0.39	4.85	1.23	3.32	0.85	Temporal change over period
Total Wastelands	101.84	25.92	118.82	30.25	16.98	4.32	
WATERBODIES							
River, Lakes, Nallas, ponds, etc	11.78	3	7.48	1.90	-4.30	-1.09	Temporal change over period
TOTAL	392.85	100	392.85	100.00	0.00	0.00	

3.3.1 Vegetation Cover

Vegetation cover in the coalfield area comprises following five classes:

- Dense Forest
- Open Forest
- Scrubs
- Plantation on Over Burden(OB) Dumps / Backfilled area, and
- Social Forestry

There has been significant variation in the land use under the vegetation classes within the area as shown below in Table 3.3.

TABLE – 3.3

Status of change in Vegetation Cover in Jharia Coalfield during the year 2013 & 2016

VEGETATION COVER	Year 2013		Year 2016		Change	
FORESTS	Area (sq Km)	%	Area (sq Km)	%	Area (sq Km)	%
Dense Forest	0.29	0.07	0.29	0.07	0.00	0.00
Open Forest	8.51	2.16	6.27	1.60	-2.24	-0.56
Total Forest (A)	8.80	2.23	6.56	1.67	-2.24	-0.56
SCRUBS						
Scrubs (B)	122.50	31.20	105.87	26.95	-16.63	-4.25
PLANTATION						
Social forestry	19.41	4.94	19.52	4.97	0.11	0.03
Plantation on OB Dump	11.94	3.04	8.59	2.19	-3.35	-0.85
Total Plantation (C)	31.35	7.98	28.11	7.16	-3.24	-0.82
Total Vegetation (A+B+C)	162.65	41.40	140.54	35.78	-22.11	-5.63

Dense forest – Forest having crown density of above 40% comes in this class. Dense forest over the area is same as in year 2013.. A total dense forest is estimated to be 0.29

sq km, i.e. 0.07% of the coalfield area. The area of the dense forest within the coalfield has remained same since 2013.

Open Forest – Forest having crown density between 10% to 40% comes under this class. Open forest cover over Jharia coalfield which was estimated to be 8.51 sq km (2,16%) in 2013 has marginally decreased to 6.27 sq km, i.e. 1.60 % of the coalfield area. Thus the area reduced is 2.24 sq km which is 0.56 % of the total coalfield area. This reduction is due to deforestation by local inhabitants.

Scrubs – Scrubs are vegetation with crown density less than 10%. Scrubs in the coalfield are seen to be scattered signature all over the area mixed with wastelands. There is 105.87 sq km, of scrubs, ie 26.95% of the coalfield area. In year 2013 the scrubs covered 122.50 sq km which were 31.20% of the coalfield area. There is a decrease of 16.63 sq km which is 4.25% of the coalfield area .The decrease is due to increase in mining areas and conversion of underground mine into open cast ones & also increase in agricultural land & waste land.

Social Forestry – Plantation which has been carried out on wastelands, along the roadsides and colonies on green belt come under this category. Analysis of data reveals Social Forestry covers 19.52 sq km, which is 4.97% of the coalfield area. In 2013 the area covered under social forestry was 19.41 sq km (4.94%) . there is an increase of 0.11 sq km (0.03%). This increase is due to creation of some ecological restoration sites.

Plantation over OB Dump and backfilled area – Analysis of the data reveals that BCCL has carried out significant plantation on OB dumps as well as backfilled areas during the period for maintaining the ecological balance of the area. The plantation on the OB dumps and backfilled areas are estimated to be 8.59 sq km, i.e. 2.19% of the coalfield area. In year 2013 the plantation on OB Dumps were estimated to cover an area of 11.94 sq km which was 3.04% of the coalfield area. There is a decrease of 3.35 sq km (0.85%) in plantation over OB dumps. This is due to increase in mining activity & conversion of UG mines into OC mines.

3.3.2 Mining Area

The mining area was primarily been categorized as.

- Coal Quarry
- Barren OB Dump

To make the study more relevant and to give thrust on land reclamation, in the current study some more classes have been added as follows:

- Barren Backfilled Area
- Coal Dumps
- Water filled Quarry

The overall area where mining operations are being carried out has increased significantly by 5.31 sq km which is 1.35% of the total area. In the year 2013 this area was estimated to be 35.22 sq km (8.97%) which has increased to 40.53 sq km (10.32%) in the year 2016. This increase is due to increase in production of coal from Open cast areas. The status of land Use in the mining area over the Jharia Coalfield is shown in the table 3.4 below.

TABLE – 3.4

Status of change in Mining Area in Jharia Coalfield during the year 2013 & 2016

	2013		2016		Change	
	Area (Sq km)	%	Area (Sq km)	%	Area (Sq km)	%
MINING AREA						
Coal Quarry	6.98	1.78	11.36	2.89	4.38	1.11
Coal Dump	1.30	0.33	0.23	0.06	-1.07	-0.27
Quarry filled with water	0.25	0.06	0.77	0.20	0.52	0.14
Barren OB Dump	19.06	4.85	12.55	3.20	-6.51	-1.65
Area Under Backfilling	7.36	1.87	15.62	3.97	8.26	2.10
Total Mining Area	35.22	8.97	40.53	10.32	5.31	1.35

3.3.3 Agricultural Land

Land primarily used for farming and production of food, fibre and other commercial and horticultural crops falls under this category. It includes crop land (irrigated and unirrigated) and fallow land (land used for cultivation, but temporarily allowed to rest)

Total agricultural land is 44.39 sq km in year 2016, which is 11.31 % of the coalfield area.. in year 2013 the total agricultural area was estimated to be 39.79 sq km which was 10.12% of the coalfield area. There is an increase on 4.60 sq km which is 1.19% of the coalfield area. The details are shown below in Table 3.5.

TABLE – 3.5

Status of change in Agricultural land in Jharia Coalfield during the year 2013 & 2016

	2013		2016		Change	
AGRICULTURE	Area (Sq km)	%	Area (Sq km)	%	Area (Sq km)	%
Crop Lands	3.94	1.00	3.71	0.95	-0.23	-0.05
Fallow Lands	35.85	9.12	40.68	10.36	4.83	1.24
Total Agriculture	39.79	10.12	44.39	11.31	4.60	1.19

3.3.4 Wasteland

Wasteland is degraded and unutilised class of land which is deteriorating on account of natural causes or due to lack of appropriate water and soil management. Wasteland can result from inherent/imposed constraints such as location, environment, chemical and physical properties of the soil or financial or management constraints. There are two types of wastelands predominant within the coalfield area, viz waste upland and fly ash pond.

The land use pattern within the area for waste lands is shown below in Table – 3.6. The waste land was estimated to be 101.84 sq km (25.93%) in the year 2013. This has increased by 16.98 sq km (4.32%) to 118.82 sq km (30.24%) over the 3 year period because some scrubland has been converted to wasteland.

TABLE – 3.6

Status of Change in Wastelands in Jharia Coalfield during the year 2013 & 2016

	2013		2016		Change	
WASTELANDS	Area (Sq km)	%	Area (Sq km)	%	Area (Sq km)	%
Wastelands	100.05	25.47	113.97	29.01	13.92	3.54
Ash pond/Slurry/ Tailing Ponds	0.26	0.07	0.00	0.00	-0.26	-0.07
Sand Body	1.53	0.39	4.85	1.23	3.32	0.85
Total Wastelands	101.84	25.93	118.82	30.24	16.98	4.32

3.3.5 Settlements

All the man-made constructions covering the land surface are included under this category. Built-up land has been further divided in to rural, urban and industrial classes. In the present study, industrial settlement indicates only industrial complexes excluding residential facilities. In the year 2013 the total area covered by settlements were estimated to be 41.57 sq km (10.58%). In year 2016 the estimated area under settlements has grown to 41.08 sq km (10.45%). There is a decrease in settlements by 0.49 sq km which is about 0.12% of the total area. This decrease is due to decrease in industrial settlement which may be due to dismantling of some establishments.

The details of the land use under this category are shown in Table 3.7 as follows:

TABLE 3.7

Status of Change in Settlements in Jharia Coalfield during the year 2013 & 2016

	2013		2016		Change	
SETTLEMENTS	Area (Sq km)	%	Area (Sq km)	%	Area (Sq km)	%
Urban Settlement	35.05	8.92	35.05	8.92	0.00	0.00
Rural Settlement	3.17	0.81	3.74	0.95	0.57	0.15
Industrial Settlement	3.35	0.85	2.29	0.58	-1.06	-0.27
Total Settlements	41.57	10.58	41.08	10.45	-0.49	-0.12

3.3.6 Water bodies

It is the area of impounded water includes natural lakes, rivers/streams and man made canal, reservoirs, tanks etc. The water bodies in the study area have found to be 11.78 sq km in year 2013, which is 3.00% of the coalfield area. In 2016 there is a reduction in the area of water bodies 4.30 sq km (1.10%) of the total area.

3.4 Data Analysis of clusters under Jharia Coalfield

Land use and vegetation cover classes present in each cluster (Cluster I to Cluster XV) falling under the Jharia coalfield has also been prepared. The map of each cluster is included in this report under pages 31 to 45. Each map contains the area statistics of Land use/cover classes present in them. The cluster wise Land Use/Cover statistics for cluster I to cluster XV falling under Jharia Coalfield is given under Table 3.8.

Table-3.8

(Area in Hectare)																																		
		CLUSTER I		CLUSTER II		CLUSTER III		CLUSTER IV		CLUSTER V		CLUSTER VI		CLUSTER VII		CLUSTER VIII		CLUSTER IX		CLUSTER X		CLUSTER XI		CLUSTER XII		CLUSTER XIII		CLUSTER XIV		CLUSTER XV		TOTAL		
		Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	
FORESTS	Dense Forest	<div></div>	14.56	2.34	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	14.56	0.06		
	Open Forest	<div></div>	15.11	2.43	0.00	0.00	32.73	2.11	0.00	0.00	0.00	0.00	0.00	0.00	0.38	0.02	0.00	0.00	0.00	0.00	65.50	3.16	0.00	0.00	0.00	0.00	172.73	9.23	0.00	0.00	63.05	3.46	349.50	1.38
Total Forest			29.67	4.77	0.00	0.00	32.73	2.11	0.00	0.00	0.00	0.00	0.00	0.38	0.02	0.00	0.00	0.00	0.00	65.50	3.16	0.00	0.00	0.00	0.00	172.73	9.23	0.00	0.00	63.05	3.46	364.06	1.44	
SCRUBS	Scrubs	<div></div>	182.00	29.24	233.14	10.31	274.77	17.70	87.26	7.04	237.06	13.74	63.71	7.66	301.39	14.59	117.43	8.82	275.34	14.00	482.12	23.25	1470.72	40.79	256.27	29.60	583.41	31.19	494.37	34.86	610.87	33.58	5669.86	22.45
	Social Forestry	<div></div>	16.60	2.67	150.07	6.64	110.03	7.09	82.10	6.62	60.01	3.48	33.83	4.07	99.35	4.81	12.99	0.97	163.31	8.30	136.29	6.57	269.08	7.46	24.30	2.81	125.11	6.69	54.94	3.87	138.17	7.59	1476.18	5.85
PLANTATION	Plantation on OB Dump	<div></div>	47.32	7.60	105.98	4.69	23.17	1.49	38.25	3.08	20.80	1.21	21.03	2.53	20.08	0.97	23.80	1.79	30.68	1.56	92.78	4.47	0.12	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	424.01	1.68	
	Plantation on Backfill	<div></div>	10.65	1.71	81.89	3.62	12.96	0.83	0.01	0.00	30.64	1.78	31.36	3.77	60.62	2.93	33.98	2.55	57.92	2.94	44.31	2.14	1.18	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	365.52	1.45	
	Total Plantation (Biological Reclamation)		74.57	11.98	337.94	14.95	146.16	9.41	120.36	9.70	111.45	6.47	86.22	10.37	180.05	8.71	70.77	5.31	251.91	12.80	273.38	13.18	270.38	7.50	24.30	2.81	125.11	6.69	54.94	3.87	138.17	7.59	2265.71	8.97
Total Vegetation			286.24	45.99	571.08	25.26	453.66	29.22	207.62	16.74	348.51	20.21	149.93	18.03	481.82	23.32	188.20	14.13	527.25	26.80	821.00	39.59	1741.10	48.29	280.57	32.41	881.25	47.11	549.31	38.73	812.09	44.63	8299.63	32.87
ACTIVE MINING	Coal Quarry	<div></div>	11.60	1.86	148.85	6.58	82.36	5.30	178.26	14.37	117.63	6.82	57.63	6.93	86.60	4.19	180.71	13.57	112.86	5.74	31.34	1.51	34.83	0.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1042.67	4.13
	Coal Face	<div></div>	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	0.00	0.00	0.00	
	Coal Dump	<div></div>	0.00	0.00	9.32	0.41	1.94	0.13	0.62	0.05	1.03	0.06	0.65	0.08	2.99	0.14	3.13	0.23	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	19.68	0.08	
	Advance Quarry Site	<div></div>	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	0.00	0.00	0.00	
	Quarry Filled With Water	<div></div>	7.30	1.17	20.45	0.91	13.26	0.85	0.00	0.00	8.62	0.50	1.18	0.14	4.13	0.20	0.70	0.05	4.82	0.25	3.68	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	64.14	0.25	
	Total Area under Active Mining			18.90	3.03	178.62	7.90	97.56	6.28	178.88	14.42	127.28	7.38	59.46	7.15	93.72	4.53	184.54	13.85	117.68	5.99	35.02	1.69	34.83	0.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1126.49
RECLAIMED	Barren OB Dump	<div></div>	16.32	2.62	194.48	8.60	93.67	6.03	181.14	14.61	150.31	8.72	64.88	7.80	81.38	3.94	112.23	8.42	135.88	6.91	94.20	4.54	18.22	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1142.71	4.53
	Area Under Backfilling	<div></div>	28.54	4.58	393.74	17.42	77.77	5.01	66.69	5.38	181.89	10.55	99.13	11.92	312.89	15.15	162.24	12.18	106.51	5.41	107.49	5.18	18.20	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1555.09	6.16
	Total Area under Technical Reclamation			44.86	7.20	588.22	26.02	171.44	11.04	247.83	19.99	332.20	19.27	164.01	19.72	394.27	19.09	274.47	20.60	242.39	12.32	201.69	9.72	36.42	1.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2697.80
Total Area under Mine Operation			63.76	10.23	766.84	33.92	269.00	17.32	426.71	34.41	459.48	26.65	223.47	26.87	487.99	23.62	459.01	34.45	360.07	18.31	236.71	11.41	71.25	1.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3824.29	15.15
WASTELAND	Waste Lands	<div></div>	133.62	21.47	624.95	27.65	503.68	32.44	350.38	28.25	585.22	33.93	318.55	38.29	528.08	25.56	415.58	31.20	683.07	34.72	404.11	19.48	917.12	25.44	275.00	31.76	705.27	37.71	504.15	35.55	640.16	35.19	7588.94	30.05
	Sand Body	<div></div>	10.66	1.71	4.00	0.18	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	100.55	4.85	7.03	0.19	0.00	0.00	22.18	1.18	42.35	2.99	0.00	0.00	186.77	0.74	
	Total Wasteland			144.28	23.18	628.95	27.83	503.68	32.44	350.38	28.25	585.22	33.93	318.55	38.29	528.08	25.56	415.58	31.20	683.07	34.72	504.66	24.33	924.15	25.63	275.00	31.76	727.45	38.89	546.50	38.54	640.16	35.19	7775.71
WATERBODIES	Reservoir, nallah, ponds	<div></div>	14.75	2.37	20.39	0.90	14.71	0.95	8.82	0.71	5.45	0.32	8.97	1.08	13.55	0.66	8.11	0.61	16.01	0.81	126.31	6.09	33.20	0.92	19.37	2.24	25.94	1.39	18.24	1.29	19.94	1.09	353.76	1.40
	Total Waterbodies			14.75	2.37	20.39	0.90	14.71	0.95	8.82	0.71	5.45	0.32	8.97	1.08	13.55	0.66	8.11	0.61	16.01	0.81	126.31	6.09	33.20	0.92	19.37	2.24	25.94	1.39	18.24	1.29	19.94	1.09	353.76
AGRICULTURE	Crop Lands	<div></div>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.88	0.40	0.00	0.00	39.16	1.89	16.12	1.21	0.31	0.02	19.11	0.92	94.10	2.61	2.90	0.33	60.45	3.23	6.88	0.48	6.51	0.36	252.42	1.00
	Fallow Lands	<div></div>	91.85	14.76	77.09	3.41	58.05	3.74	53.69	4.33	40.02	2.32	1.02	0.12	20.38	0.99	65.11	4.89	42.59	2.16	62.64	3.02	323.90	8.98	254.61	29.40	93.18	4.98	224.53	15.83	211.56	11.63	1620.22	6.42
	Total Agriculture			91.85	14.76	77.09	3.41	58.05	3.74	53.69	4.33	46.90	2.72	1.02	0.12	59.54	2.88	81.23	6.10	42.90	2.18	81.75	3.94	418.00	11.59	257.51	29.73	153.63	8.21	231.41	16.31	218.07	11.99	1872.64
SETTLEMENTS	Urban Settlement	<div></div>	0.00	0.00	163.66	7.24	243.23	15.67	192.99	15.56	269.93	15.65	113.08	13.59	475.46	23.02	169.76	12.75	332.56	16.91	243.91	11.76	375.11	10.40	23.83	2.75	26.10	1.40	0.00	0.00	83.80	4.61	2713.42	10.75
	Rural Settlement	<div></div>	20.73	3.33	24.84	1.10	8.33	0.54	0.00	0.00	0.00	0.00	0.00	0.00	1.35	0.07	0.00	0.00	0.00	0.00	41.47	2.00	12.11	0.34	9.64	1.11	54.28	2.90	72.37	5.10	42.38	2.33	287.50	1.14
	Industrial Settlement	<div></div>	0.87	0.14	7.69	0.34	1.87	0.12	0.00	0.00	9.03	0.52	16.81	2.02	17.90	0.87	10.06	0.76	5.36	0.27	18.27	0.88	30.76	0.85	0.00	0.00	1.82	0.10	0.42	0.03	2.86	0.16	123.72	0.49
Total Settlement			21.60	3.47	196.19	8.68	253.43	16.33	192.99	15.56	278.96	16.17	129.89	15.61	494.71	23.96	179.82	13.51	337.92	17.18	303.65	14.64	417.98	11.59	33.47	3.86	82.20	4.40	72.79	5.13	129.04	7.10	3124.64	12.37
Grand Total			622.48	100.00	2260.54	100.00	1552.53	100.00	1724.21	100.00	1724.52	100.00	831.83	100.00	2065.69	100.00	1331.95	100.00	1667.22	100.00	2074.08	100.00	3605.68	100.00	865.92	100.00	1870.47	100.00	1418.25	100.00	1819.30	100.00	25250.67	100.00

Chapter 4

Conclusion & Recommendations

4.1 Conclusion

In the present study, land use/ vegetation cover mapping has been carried out based on IRS-R2/ L4FMX satellite data of January, 2016 in order to monitor the impact of coal mining on land environment which may helps in formulating the mitigation measures required, if any.

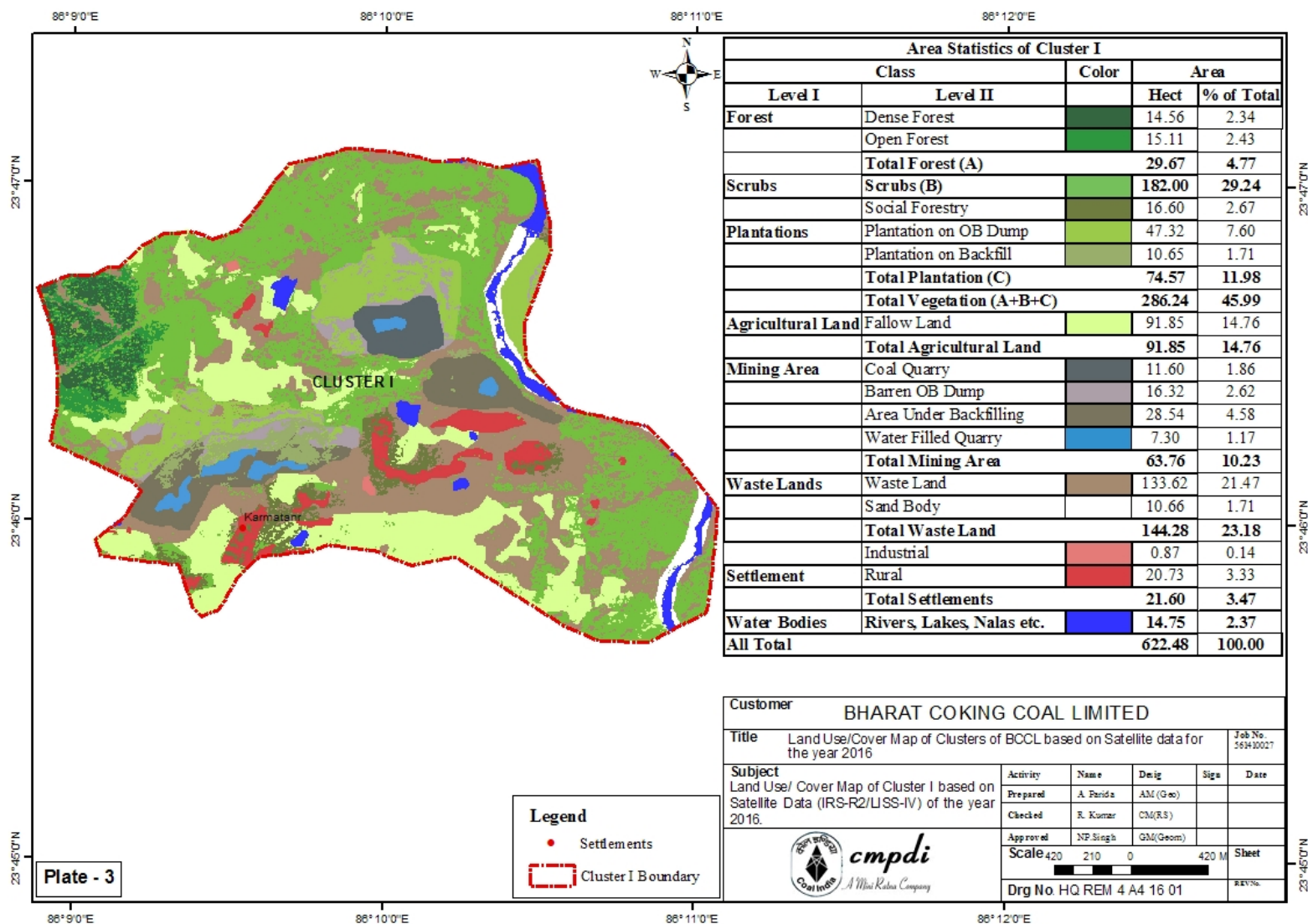
Study reveals that the total area of settlements which includes urban, rural and industrial settlements in the Jharia coalfields covers 41.08 km² (10.45%) area. There is a decrease in settlements by 0.49 sq km over the 2013 study primarily because dismantling of some industrial establishments. Vegetation cover which includes dense forests, open forests, scrubs, avenue plantation & plantation on over-burden dumps, covers an area of 140.54 km² (35.78%). As compared to 2013 study there is a decrease in overall vegetation cover by 22.11 sq km (5.62%) this is mainly because there is a reduction in scrubs areas. Area of scrubs has decreased by 16.63 sq km. because of its use in opencast mines and use of scrub land for agriculture. The analysis further indicates that total agricultural land which includes both crop and fallow land covers an area of 44.39km² (11.31%) has increased 4.60 sq km (1.19%) from that was in 2013. The increase in 4.60 sq km is due to some scrubland getting converted into agricultural land. The mining area which includes coal quarry, advance quarry site, barren OB dump, area under backfilling, covers 40.53 km² (10.32%). There is a significant increase in areas under mining operations because large areas have now been taken up for Open cast mining in BCCL. As compared to 2013 there is an increase of 5.31 sq km (1.35%) in the areas under mining operation. Wasteland covers 118.82 km²

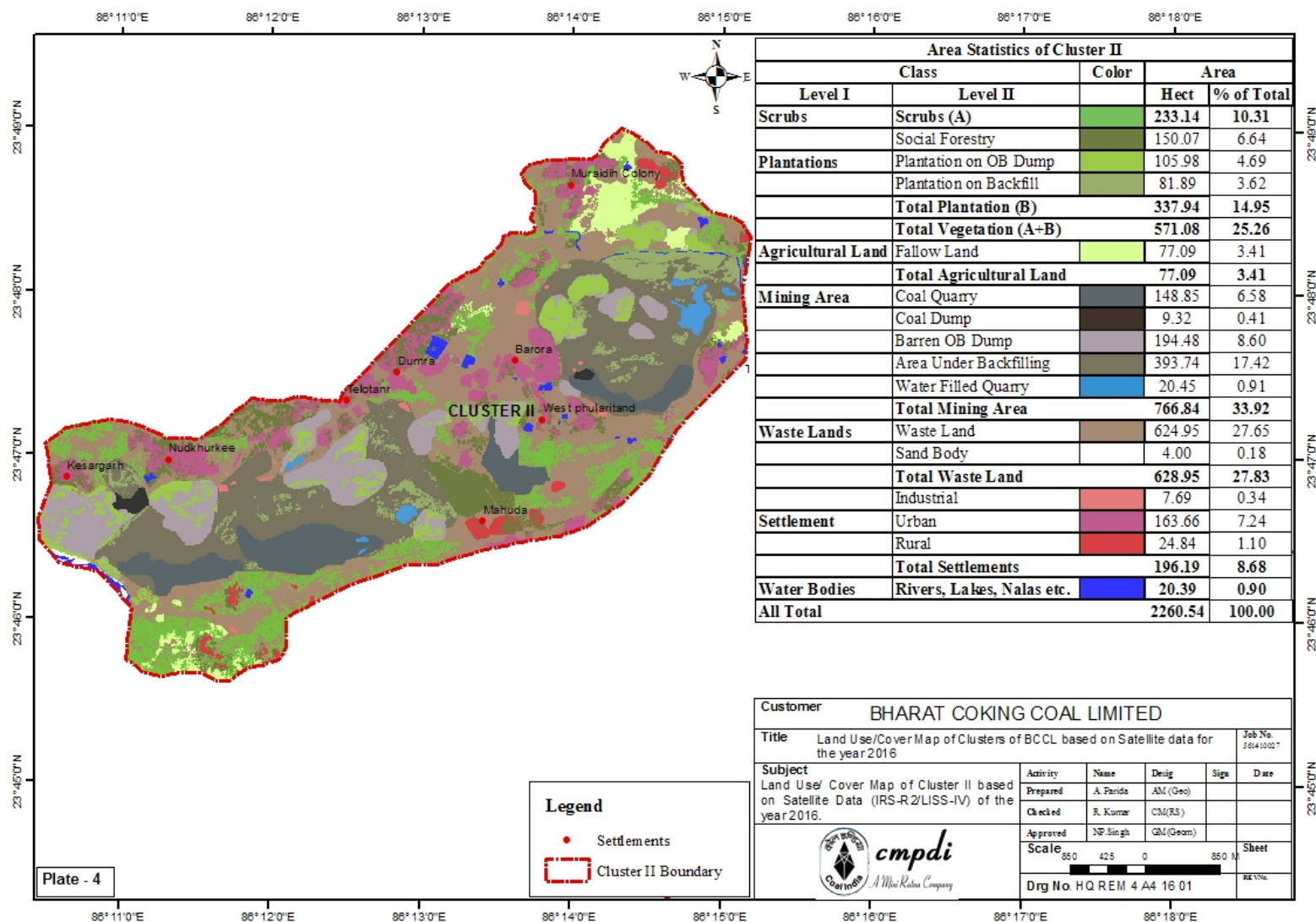
(30.24%). Waste lands have increased because some scrubland has been converted to wasteland. Surface water bodies covered area of 7.48 km² (1.90).

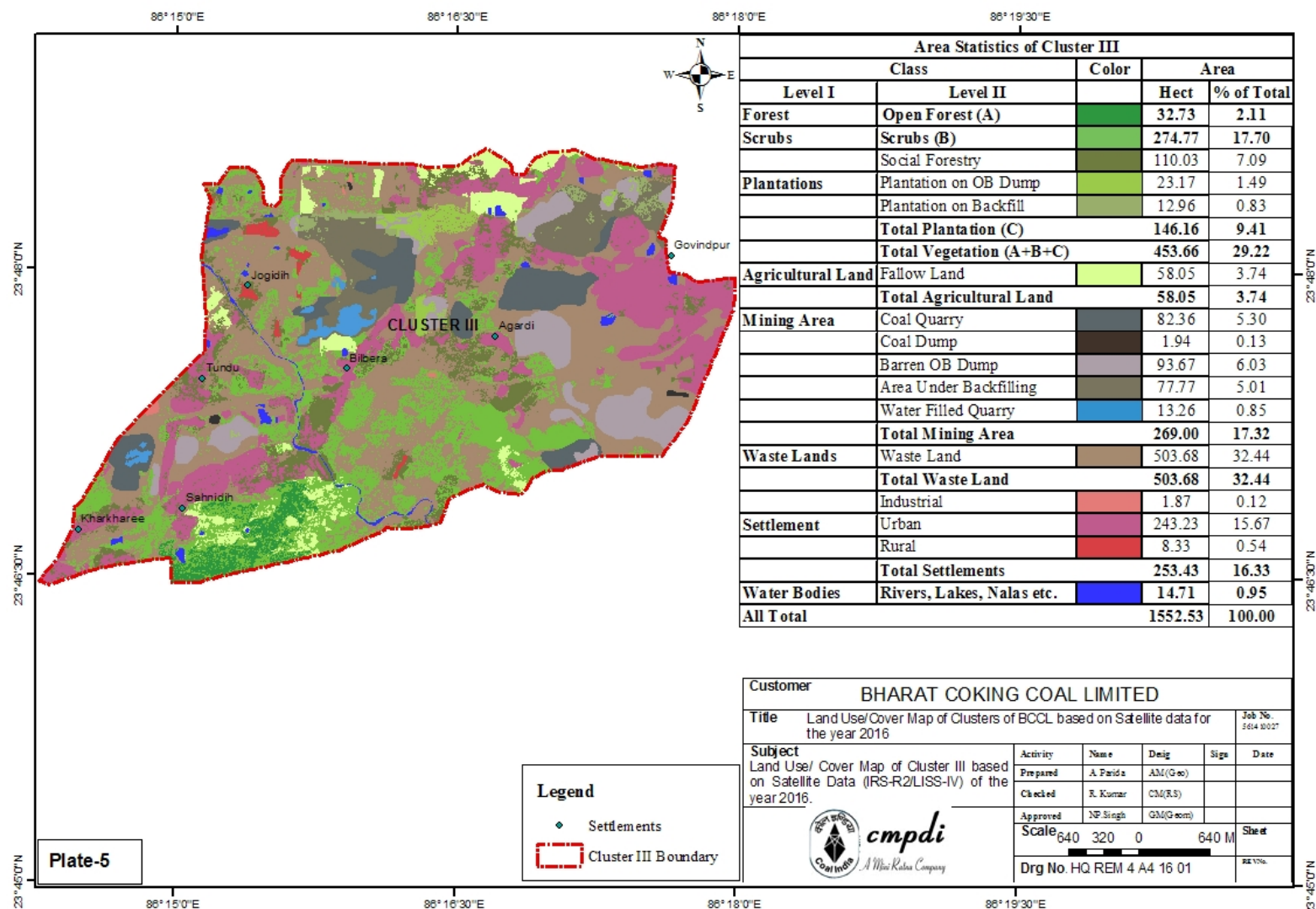
The detail statistical analysis is given under Table-3.2.

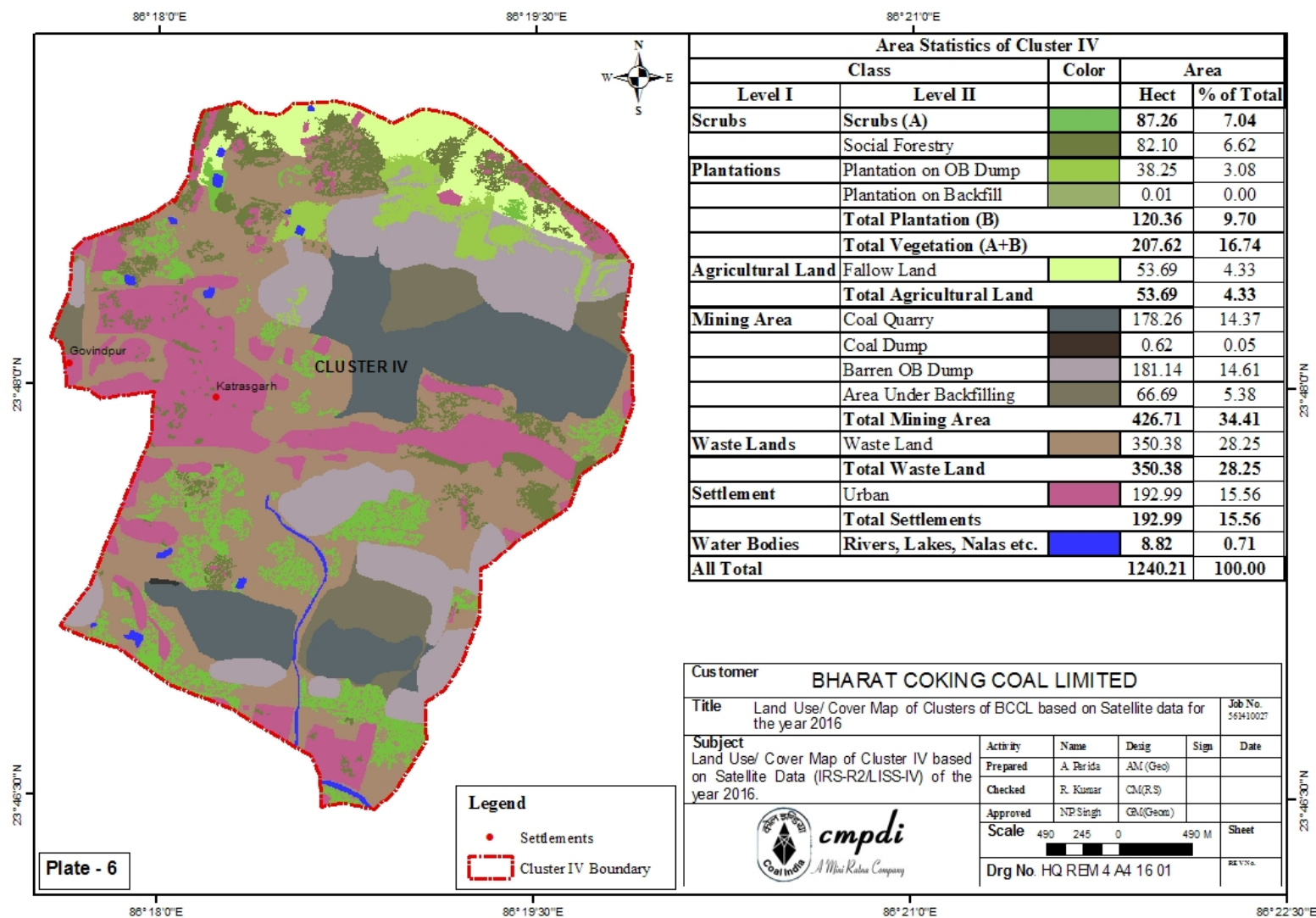
4.2 Recommendations

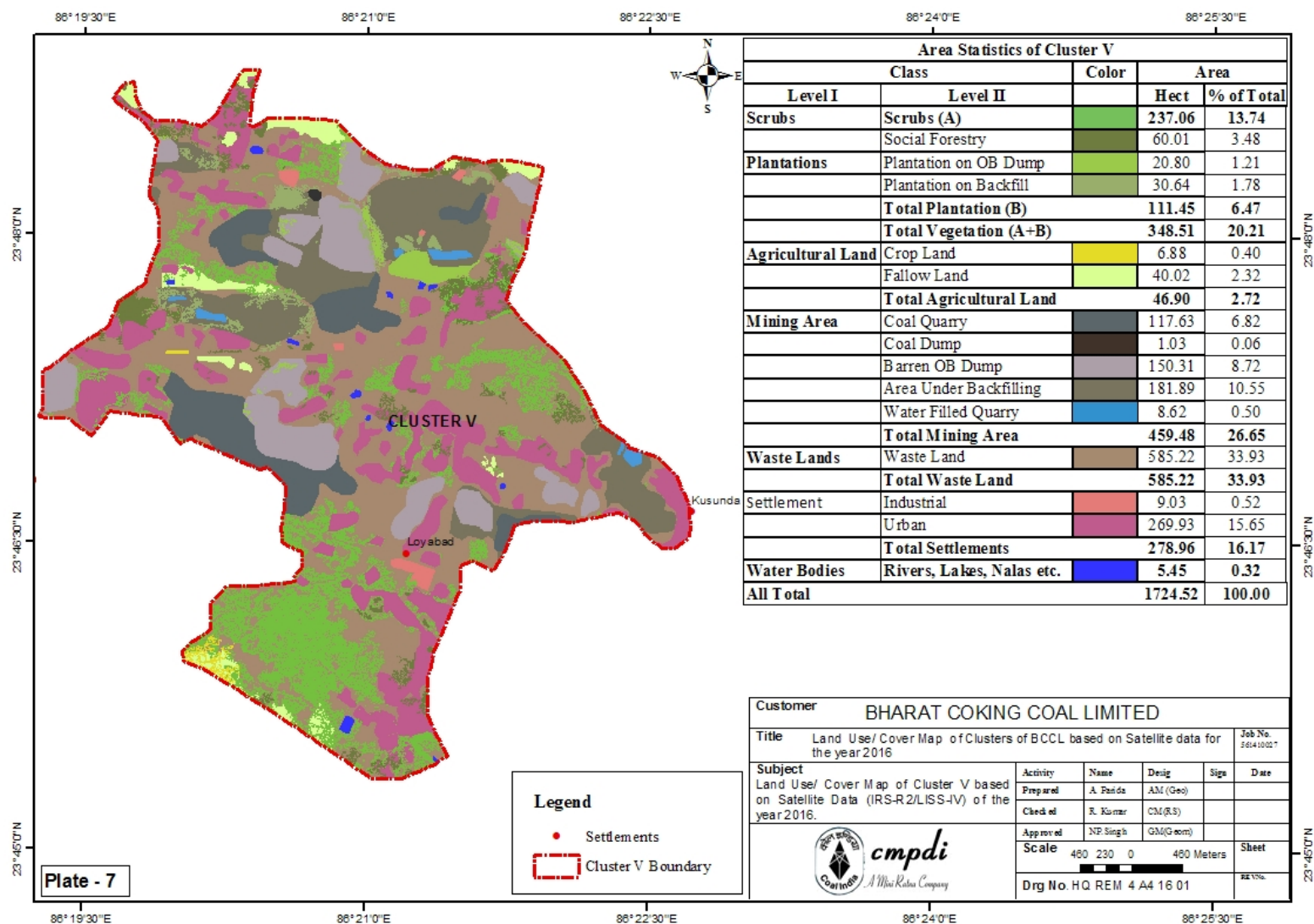
It is essential to maintain the ecological balance for sustainable development of the area together with coal mining in Jharia Coalfield. It is recommended that land reclamation of the mining area should be taken up on top priority by BCCL. Such studies should be carried out regularly to assess the impact of coal mining on land use pattern and vegetation cover in the coalfield to formulate and take remedial measures, if any, required for mitigating the adverse impact of coal mining on land environment. Regional study will also be helpful in assessing the environmental degradation / up gradation carried out by different industries operating in the coalfield area.

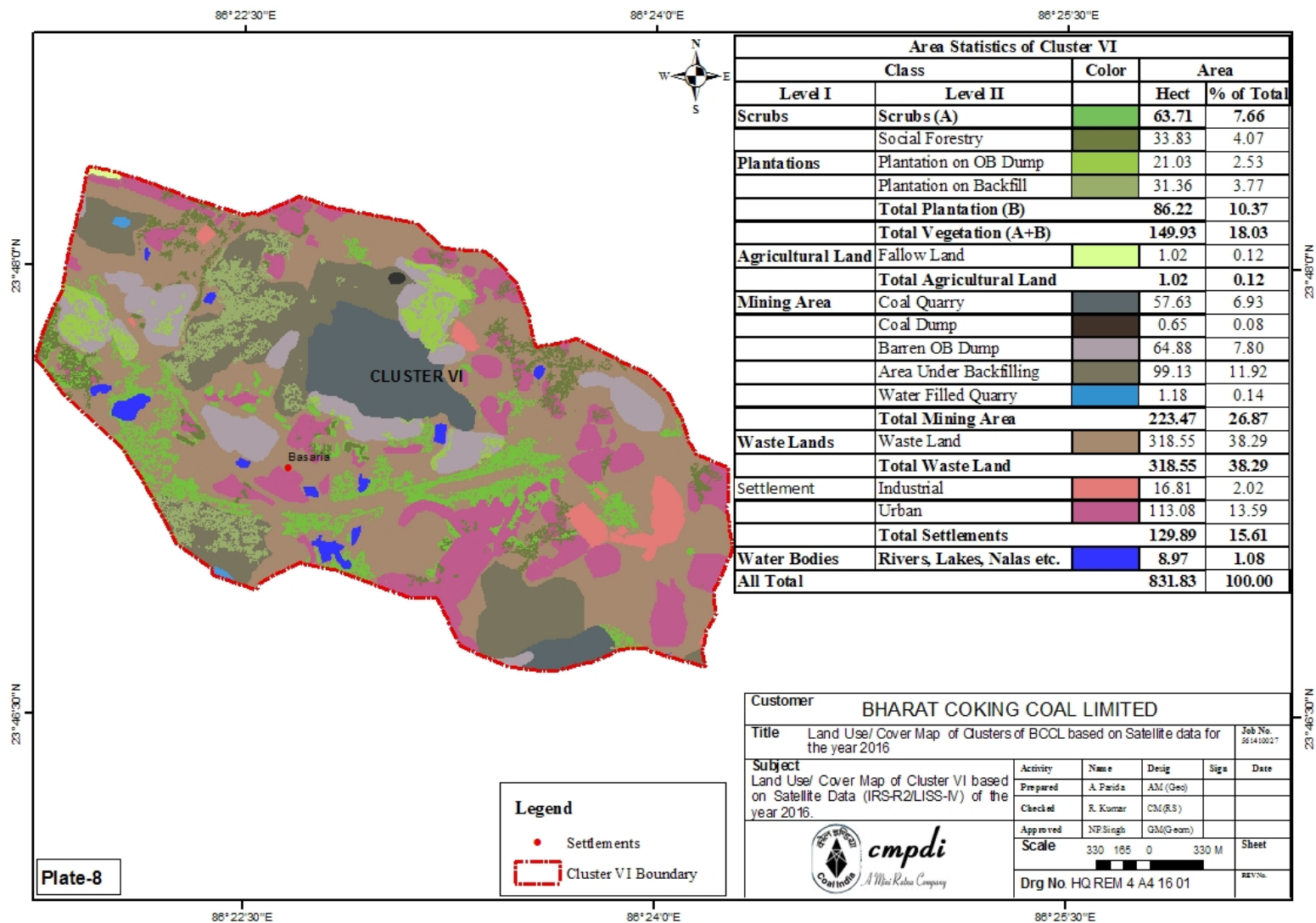


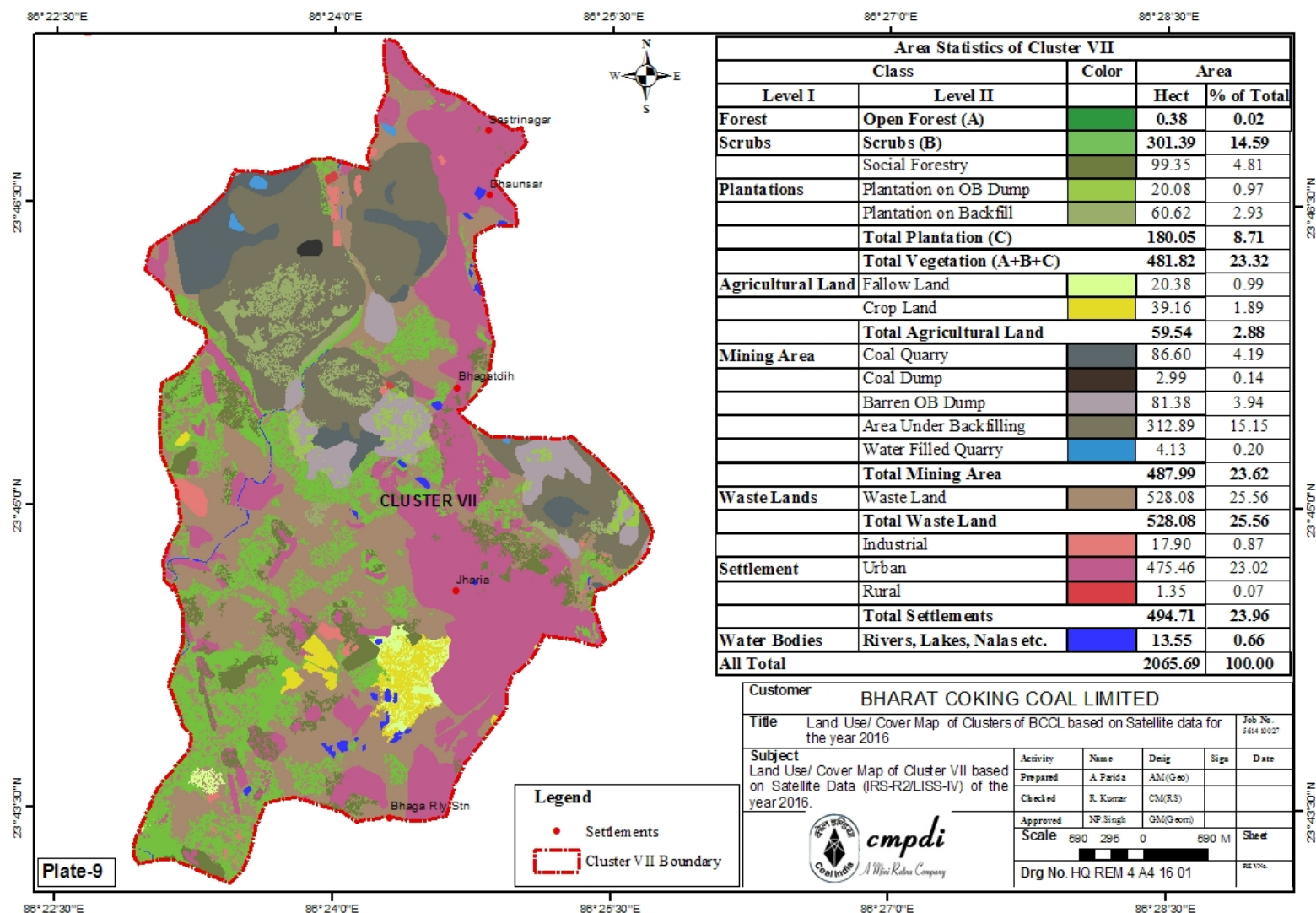


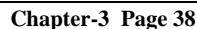


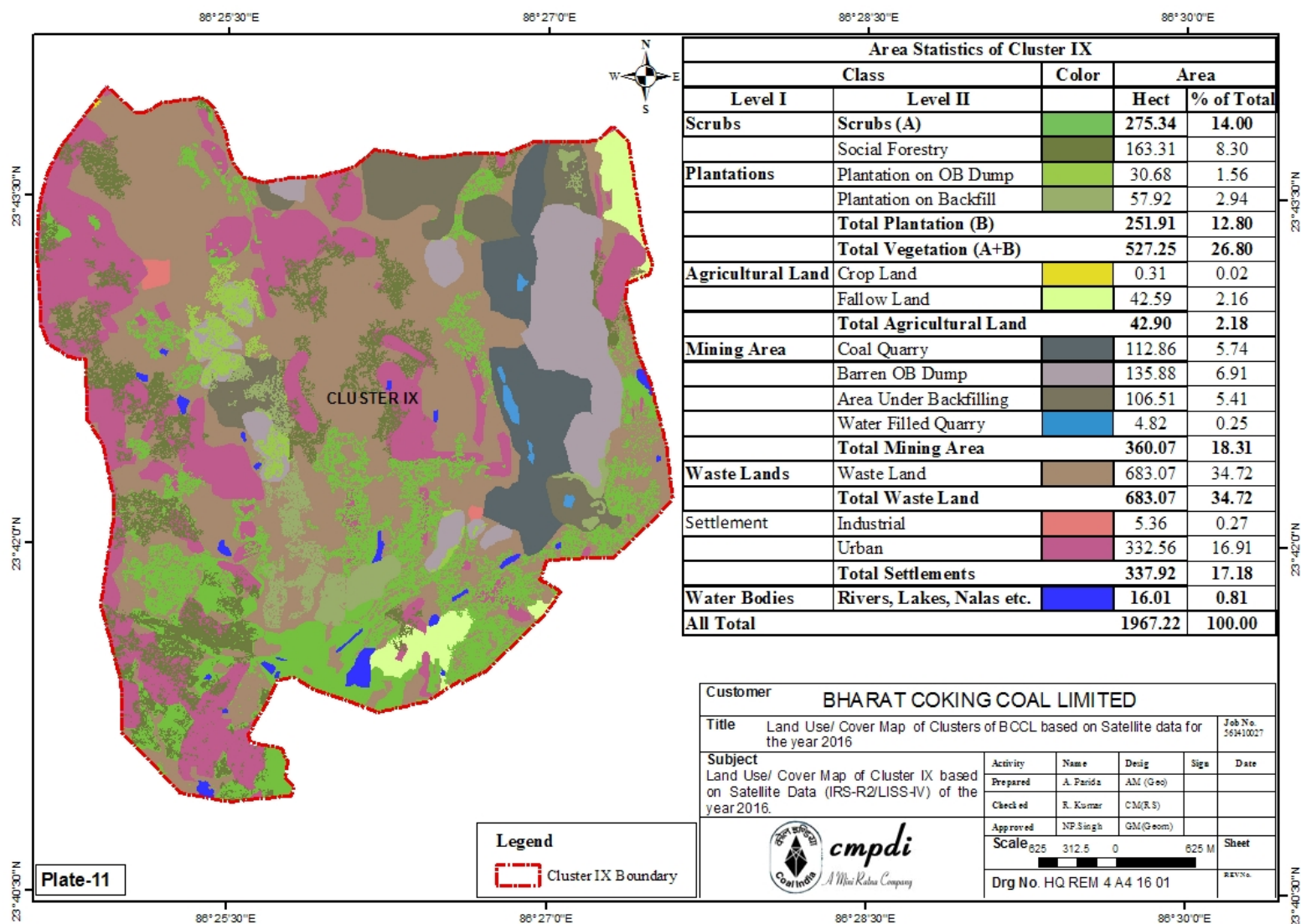


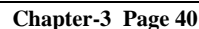


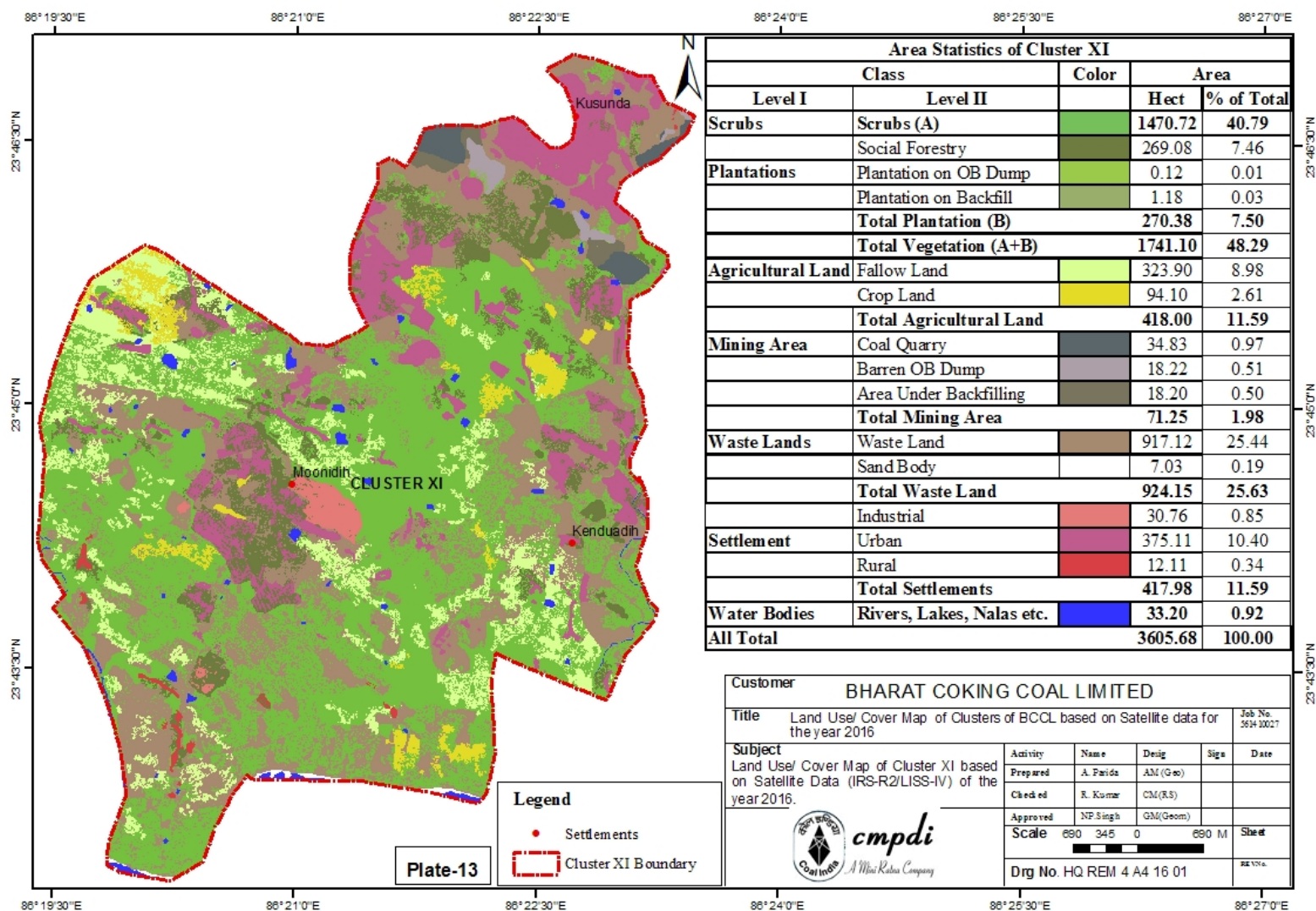


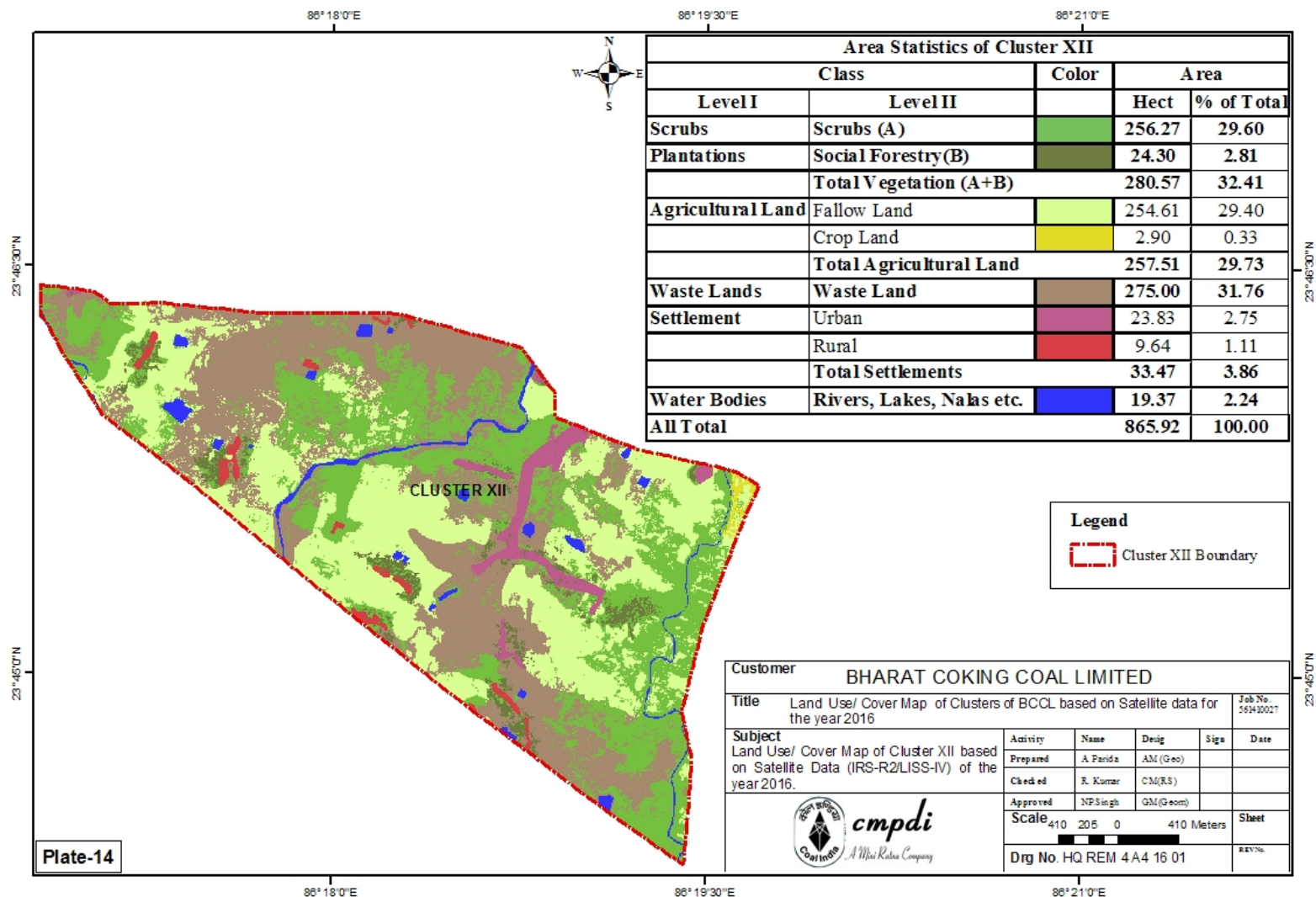


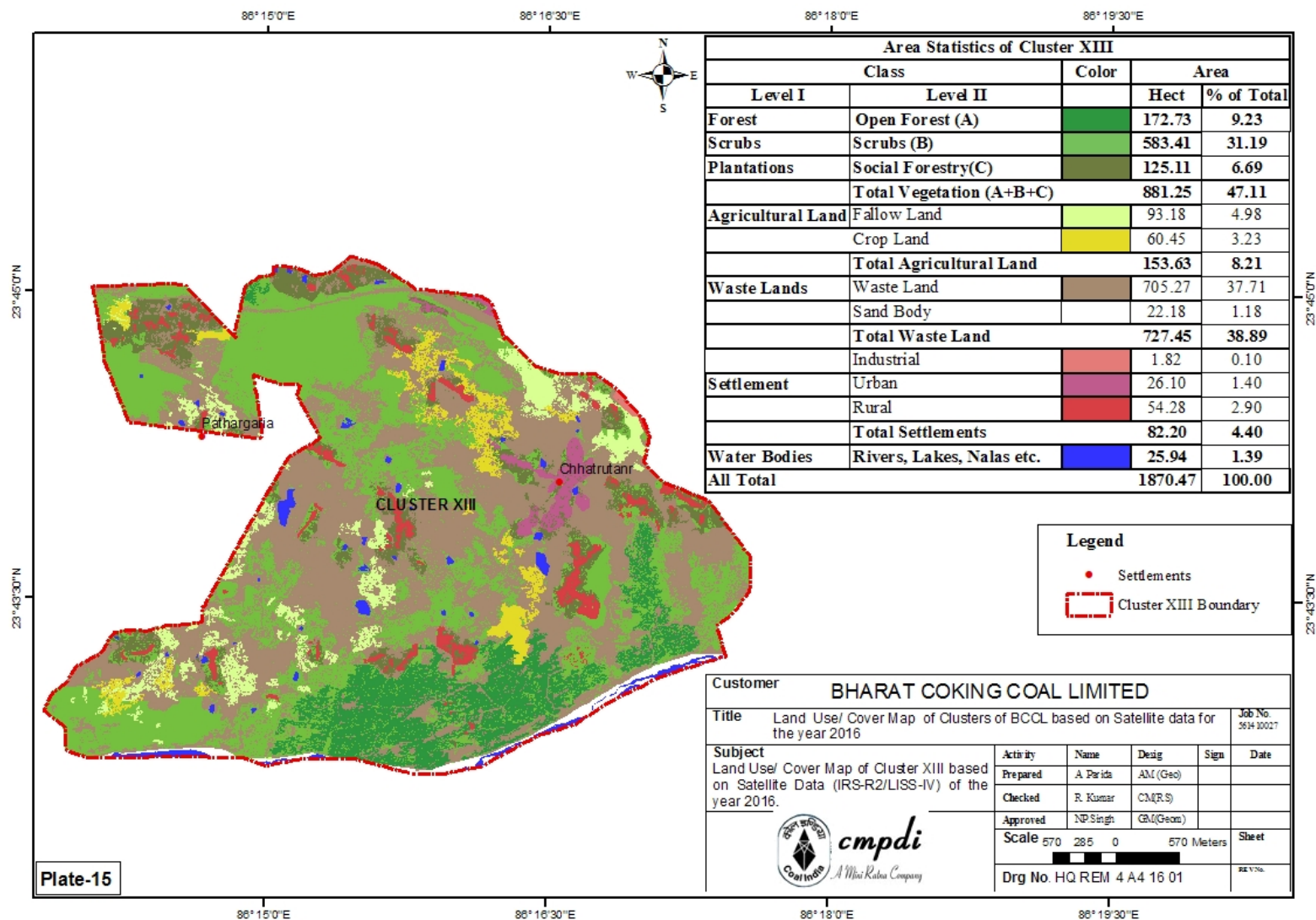


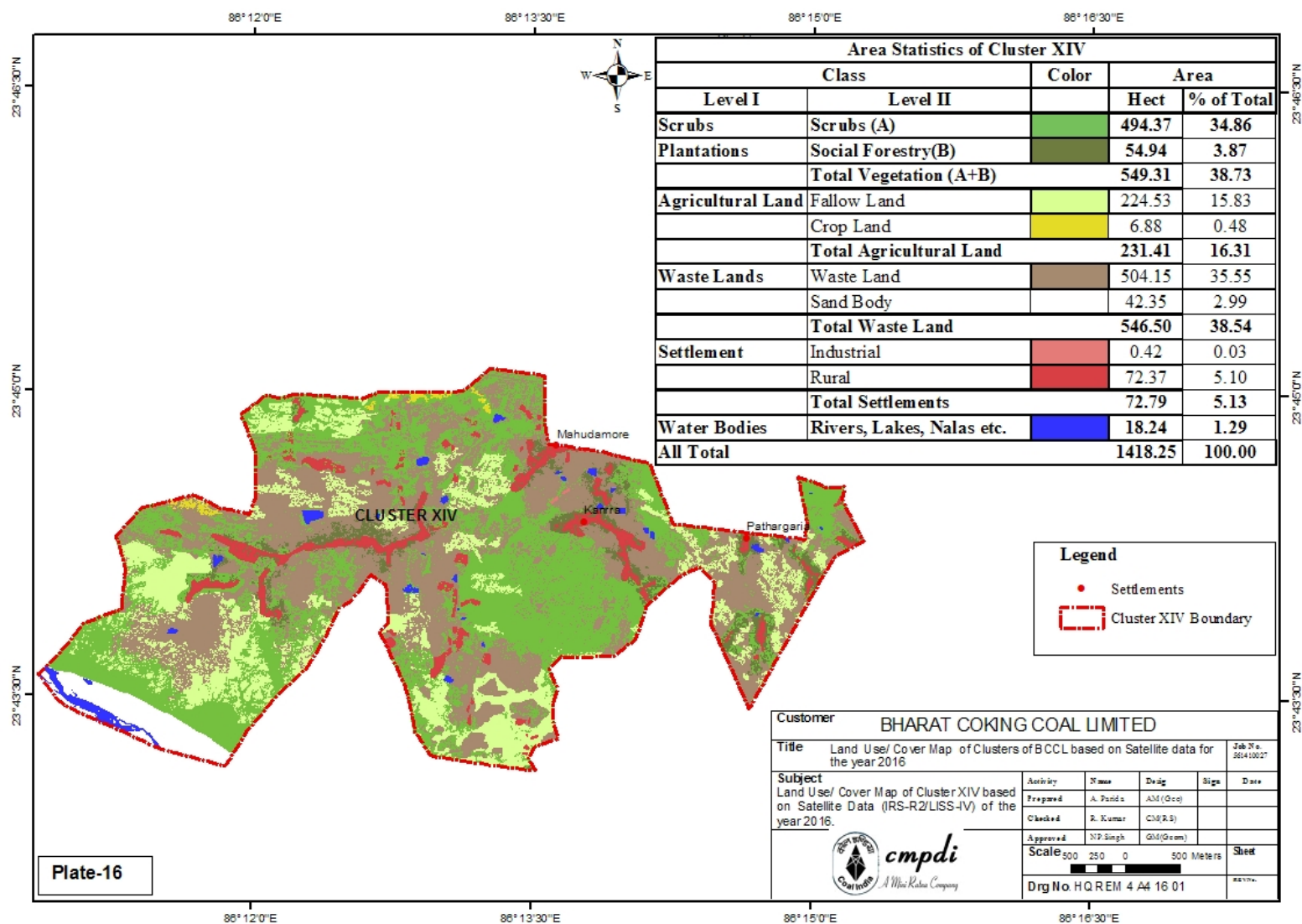


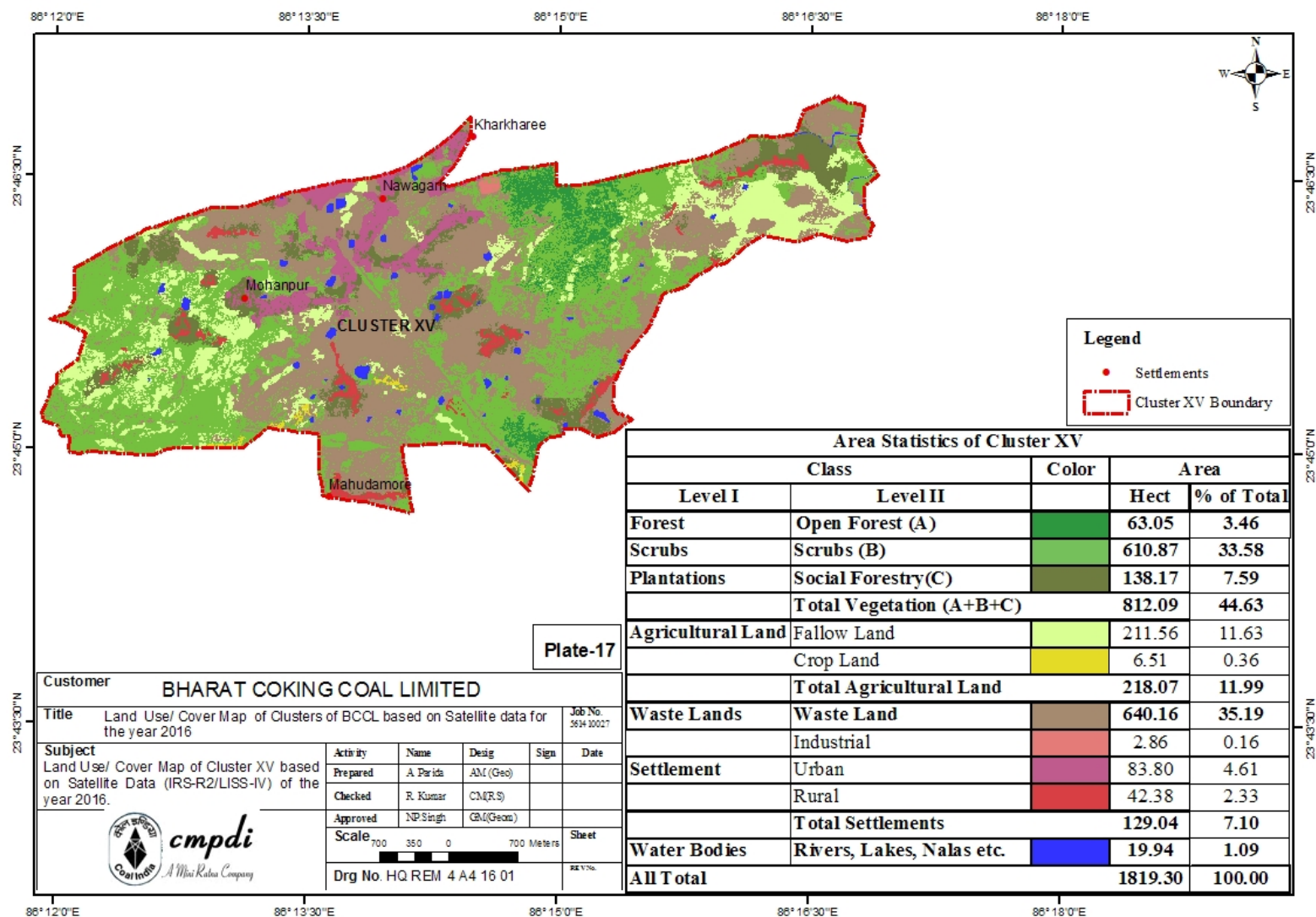














cmpdi
A Mini-Rustna Company

Central Mine Planning & Design Institute Ltd.
(A Subsidiary of Coal India Ltd.)

Gondwana Place, Kanke Road, Ranchi - 834 008, India

Phone : (+91-0651) 2230001, 2230002, 2230483, Fax (91-0651) 2231851, 2231447

Email : cmpdi2@hub.nic.in, cmpdihq@cmpdi.co.in

DELINEATION OF SURFACE COAL FIRE AND LAND SUBSIDENCE IN THE JHARIA COALFIELD, DHANBAD, JHARKHAND FROM REMOTE SENSING DATA

**GEOSCIENCES GROUP
REMOTE SENSING APPLICATIONS AREA
NATIONAL REMOTE SENSING CENTRE
INDIAN SPACE RESEARCH ORGANISATION
DEPT. OF SPACE, GOVT. OF INDIA
HYDERABAD-500 037**



JANUARY, 2018

**DELINEATION OF SURFACE COAL FIRE AND
LAND SUBSIDENCE IN THE JHARIA COALFIELD,
DHANBAD, JHARKHAND FROM REMOTE
SENSING DATA**

Report for

BHARAT COKING COAL LIMITED (BCCL)

(A SUBSIDIARY OF COAL INDIA LTD.)

**ENVIRONMENT DEPARTMENT, KOYLA BHAWAN
KOYLA NAGAR, DHANBAD – 826 005, JHARKHAND**

GEOSCIENCES GROUP

REMOTE SENSING APPLICATIONS AREA

NATIONAL REMOTE SENSING CENTRE

INDIAN SPACE RESEARCH ORGANISATION

DEPT. OF SPACE, GOVT. OF INDIA

HYDERABAD-500 037

JANUARY, 2018



1. **Dr. K VINOD KUMAR**, Group Head, Geosciences Group
Project formulation and coordination
2. **Dr. Tapas R. Martha**, Scientist ‘SF’
Field survey and report preparation
3. **Shri Priyom Roy**, Scientist ‘SD’
Image processing, interpretation, field survey, maps and report preparation

- 1. Dr. K VINOD KUMAR**, Group Head, Geosciences Group
Project formulation and coordination
- 2. Dr. Tapas R. Martha**, Scientist ‘SF’
Field survey and report preparation
- 3. Shri Priyom Roy**, Scientist ‘SD’
Image processing, interpretation, field survey, maps and report preparation

CONTENTS

ACKNOWLEDGEMENTS	i
EXECUTIVE SUMMARY	ii
LIST OF FIGURES AND TABLES	iii
CHAPTER – I INTRODUCTION	1
1.1 BACKGROUND	2
1.2 OBJECTIVES	2
1.3 STUDY AREA	3
CHAPTER – II GENERAL DESCRIPTION OF THE STUDY AREA	4
2.1 LOCATION AND ACCESSIBILITY	4
2.2 PHYSIOGRAPHY, DRAINAGE AND CLIMATE	4
2.3 GENERAL GEOLOGY	4
CHAPTER – III DATA REQUIREMENTS	7
3.1 REMOTE SENSING DATA	7
3.2 ANCILLARY DATA	7
CHAPTER – IV REMOTE SENSING DATA ANALYSIS	8
4.1 METHODOLOGY	8
4.1.1 PROCESSING OF LANDSAT 8 DATA	8
4.1.2 THRESHOLDING OF RADIANT TEMPERATURE IMAGE	9
4.2 METHODOLOGY FOR SUBSIDENCE DETECTION	12
4.2.1 PROCESSING OF ALOS-PALSAR-2 DATA	12
CHAPTER – V FIELDWORK	17
CHAPTER – VI POST FIELD WORK ANALYSIS	19
CHAPTER – VII DISCUSSIONS AND CONCLUSIONS	20
7.1 DISCUSSION	20
7.2 CONCLUSIONS	22
CHAPTER – VIII LIMITATIONS	24
REFERENCES	26
Annexure – I	27
Annexure - II	29
Annexure - III	31
Annexure - IV	34

ACKNOWLEDGEMENTS

The project team is grateful to Dr. Y.V.N. Krishnamurthy, Director, NRSC, for his support at various stages during execution of this project. We are extremely grateful to Dr. P.V.N. Rao, Deputy Director (RSAA), NRSC for his overall guidance and encouragement. We thank Shri D. Gangopadhyay (Director, P&P). BCCL, for this project initiative and for providing Geosciences group, NRSC, the opportunity to carry out the task. We are thankful to Shri A. K. Singh (GM, I/C), BCCL for taking keen interest in the project work and for the support during our fieldwork. We also thank Shri Dipankar Maity, Surveyor (Mining) and Shri Mithilesh Kumar, Sr. Manager (Mining) for their support and fruitful discussion during the fieldwork. The support of all the BCCL officials in the various collieries visited during the course of the ground truth verification is duly acknowledged.

EXECUTIVE SUMMARY

Coal fire is a serious problem in Jharia coal field, where high ranking coals are gradually burnt due to these fires. The combined effect of surface and sub-surface fires and mining related subsidence has endangered the environmental stability of Jharia coal field. Coupled with the ecological changes instigated by open cast mining, the landscape in and around Jharia have changed drastically over the years. In the present study, delineation of coal fire and mining related land subsidence have been addressed. Thermal band of Landsat-8 (100m resolution) have been used to demarcate the coal mine fire areas from non fire areas. For this study, Landsat-8 data of May, 2017 have been used. The band 10 (10.60-11.19 μm) of Landsat-8 data is used to derive the relative radiant temperature. Further ALOS-PALSAR 2, L band microwave data has been used to delineate zone of probable land subsidence (using differential interferometry) due to mining. The study reflects that, compared to 2012, the eastern flanks (Lodna and Tisra) show a larger fire area. The western flank (Nadkhurkee and Shatabdi) and the northern flank (Katrass and Gaslitand) show isolated fire pockets in active mines as well as OB dumps. Among all the colliery areas, Kusunda and Lodna area is most affected by coal mine fire. The current fire area mapped is 3.28 sq.km. Apart from this, five distinctive areas of land subsidence have been identified using interferometric method. These are primarily caused by older or active underground mining. The Moonidih Project is most affected by subsidence. The coal mine fire and subsidence areas are further verified on the ground. The final coal mine fire and subsidence map of Jharia coal field is prepared by using remote sensing data analysis with field validation.

LIST OF FIGURES AND TABLES

- Figure 1 : Study area map of Jharia Coalfield, Jharkhand
- Figure 2 : Geological map of Jharia coal field, Dhanbad, Jharkhand (published by CMPDIL)
- Figure 3 : False colour composite image of Jharia Coalfield (VNIR 3N,2,1) , with subset blocks (in red) to obtain temperature values (from radiant temperature image) within the Barakar formation across the Jharia coalfield.
- Figure 4 : Maximum temperature plotted against mean temperature for various locations; cluster separation observed around 39 °C (marked with arrow)
- Figure 5 : Coal mine fire map (May, 2017) of Jharia coal field, Dhanbad. The fire areas shown in this map have been verified in the field as per field points in figure 13.
- Figure 6 : DInSAR acquisition scheme
- Figure 7 : Work flow diagram for generating land subsidence map using DInSAR technique
- Figure 8 : ALOS-PALSAR - 2 Master-Slave pairs for short and long temporal base line processing
- Figure 9 : Fringe patterns generated from short baseline processing (e.g. Master: Oct, 16, Slave: Feb, 17)
- Figure 10 : Fringe patterns generated from long baseline processing (e.g. Master: Oct, 15, Slave: Feb, 17)
- Figure 11 : Subsidence map of Jharia coal field, Dhanbad
- Figure 12 : Total fire area statistics
- Figure 13 : Field data points for coal fire verification
- Figure 14 : Field data points for subsidence verification

Field Photographs

- Figure 15 : Fume cracks in Lodna-Tisra Area. (point 39 in figure 13 and table 4)
- Figure 16 : Burnt area near OB dump in Lodna area (point 41 in figure 13 and table 4).

- Figure 17 : Coalfries in active seams in Kusunda (point 23 in figure 13 and table 4)
- Figure 18 : Sagged area due to subsidence, south of Block II OCP. (point 1 in figure 14 and table 5).
- Figure 19 : Fire in OB dumps in Kusunda area. (point 24 in figure 13 and table 4).
- Figure 20 : Fume cracks in the Bhulanbarari area.

List of Tables

- Table 1 : Generalised stratigraphy of JCF
- Table 2 : List of satellite data used in the present study
- Table 3 : Threshold temperature for fire area estimation of individual mines.
- Table 4 : Coal Fire observations during fieldwork (see figure 13 for reference)
- Table 5 : Coal Fire observations during fieldwork (see figure 14 for reference)
- Table 6 : Colliery wise break-up of change in fire area from 2012 to 2017

CHAPTER I

INTRODUCTION

Coal fire is a perennial problem in Jharia coal field (JCF) covering 447 sq. km. area in the Dhanbad district of Jharkhand state. Subsurface and surface coal fires are a serious problem in many coal-producing countries. The severity and extent of mine fires in some of the Indian coalfields, particularly Jharia and Raniganj coalfields, are quite alarming. Combustion can occur either within coal or in coal dumps on the surface. Considerable economic loss and environmental problem arises due to the coal fire. Coal fire burns valuable coal and also creates difficulties in mining by increasing the cost of production or making existing operations difficult. Noxious gases like sulphur dioxide, nitrogen oxide, carbon monoxide, carbon dioxides, which are the result of coal burning processes, often affect the immediate surroundings of an active coal fire area (Gangopadhyay, 2003). These greenhouse gases not only affect local atmosphere but also play a crucial role in the damages, found associated with coal fire such as land surface subsidence and surface cracking. Coal fires are caused by oxidation of coal but the reaction involved in oxidation of coal is not understood till date. Broadly, the potential for spontaneous combustion lies in its ability to react with oxygen at ambient temperature. This occurs through the reaction of oxygen at the surface of the coal resulting in an exothermic reaction. As a consequence, the temperature of coal rises and if temperature reaches the threshold temperature, ranging between 80⁰ to 120⁰C, a steady reaction starts, which produces carbon dioxide. Temperature keeps on increasing once CO₂ started to form and at 2300⁰C, the exothermic reaction becomes rapid. It is known that high grade coals (high carbon content) are more fire prone, though the reason behind this is not well understood. Another important parameter, which controls fire, is the size of the particles. Larger the effective area of coal (fire particles), more rapidly the reaction proceeds. Cracks, fissures play a role like positive catalysts to coal oxidation by slowly supplying oxygen / air through their conduits.

Coal mining in Jharia Coal Field (JCF) started way back in 1895. History of fire in Jharia Coal Field date back to 1916 when the first incidence of fire was reported from XIV seam of Bhowrah colliery. JCF was nationalised in 1972 and over the decades, the fire has spread or been contained but never extinguished. The combination of underground fire and subsidence have affected vast areas of JCF.

1.1 Background

Remote sensing technique in thermal band offers a cost-effective and time-saving technology for mapping various geoenvironmental / hazardous features such as coal fires, forest fires, oil well fires, volcanic eruptions etc. NRSC has carried out coal fire mapping projects in the past; conducting an airborne campaign in 1989 and using Landsat-5 TM data in 1995 (Bhattacharya *et. al.*, 1995), over Jharia coalfield, Jharkhand and using Landsat-5 TM data for 2001 over Raniganj coalfield, West Bengal. Further, projects were executed in 2006 and 2012 in which coal fires of the JCF were mapped using Landsat-7 ETM+ and ASTER data, respectively. Additionally, a R&D study was taken up in 2013 to delineate subsidence areas using differential interferometric (DInSAR) technique. In view of the past experiences, based on the letter (Ref. no. NRSC/16/76) from Director (Tech.), Operations, BCCL addressed to Director, NRSC on 01 February 2016. a project was formulated to take up Coal fire and Land Subsidence study of the Jharia Coal Field using space-borne remote sensing technique. The formal Memorandum of Understanding between BCCL and NRSC was signed on 23rd of Dec, 2016.

1.2 Objectives

The following objectives are formulated on the basis of the above mentioned background:

- I. To map Coal fire in the study area based on pixel integrated relative radiant temperature derived from latest available Landsat-8 data of 2016-17 time period.
- II. To compare the change in the coal fire distribution in the Jharia coalfield within the period of 2012 and 2016-17.
- III. To delineate probable subsidence areas in the region using differential interferometry method.

1.3 Study Area

Jharia Coalfield is located in the Dhanbad district of Jharkhand state (Figure 1) and it is named after the main coal mining town of Jharia. It is situated in the Damodar River valley and is about 250 km NW of Kolkata. The coalfield is contained roughly within latitudes $23^{\circ} 42' \text{N}$ and $23^{\circ} 50' \text{N}$ and longitudes $86^{\circ} 09' \text{E}$ and $86^{\circ} 30' \text{E}$.

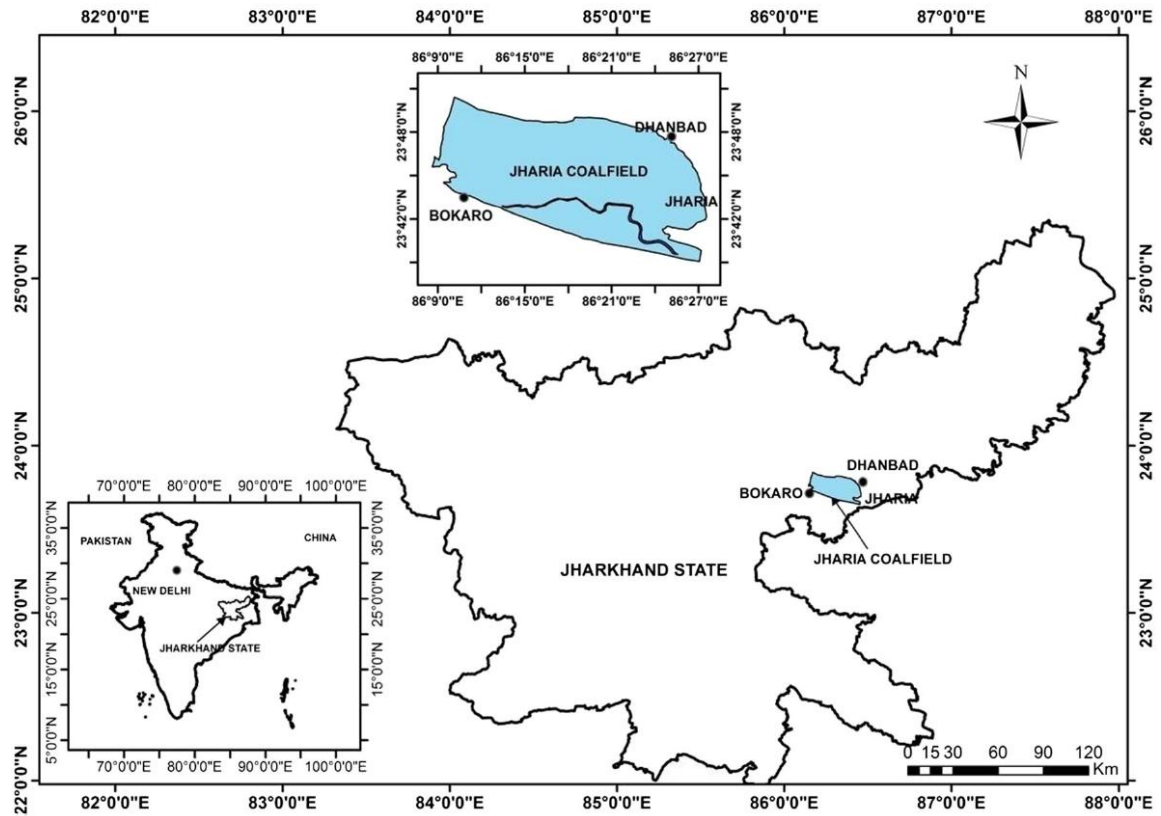


Figure 1: Study area map of Jharia Coalfield, Jharkhand

CHAPTER II

GENERAL DESCRIPTION OF THE STUDY AREA

2.1 Location and Accessibility

Jharia is an old mining town in the Dhanbad district of Jharkhand. This town is famous for its surrounding mines producing high grade coal and supplying mainly to the neighbouring industrial areas. Jharia is approximately 6 km in south western direction from Dhanbad town and connected by metal road. Dhanbad is well connected to Kolkata by road and rail.

2.2 Physiography, Drainage and Climate

Jharia coalfield is characterised by undulatory topography with very low rolling slope towards the eastern part of the area. The average height of the area is around 200 meters above the mean sea level. Damodar is the major river in the study area. The other tributaries to the Damodar River in this area are Jamuniya Nadi, Khudia Nadi, Khatri Nadi, Jarian Nala, Kari Jora and Domohani Nadi. Damodar River flows from west to east in this area. The minimum temperature is $<10^{\circ}$ C in the month of December – January and maximum temperature is $>50^{\circ}$ C in the month of May – June.

2.3 General Geology

Gondwana Super Groups of rocks of Up. Carboniferous to Lr. Cretaceous age (i.e. from 320 MY to 98 MY) are exposed here. Gondwana Super Group rocks unconformably overlie Archaean rocks. In Gondwana Rocks, Raniganj and Barakar Formations of Permian age have more potential as far as the coal production is concerned. Barakar Formation is exposed in north and north eastern part of the basin (Figure 2). Most of the coal mines are confined to the Barakar Formation in JCF. Barakars consists of coarse, medium grey and white sandstones, shales and coal seams. Raniganj consists of grey and greenish soft feldspathic sandstones, shales and coal seams. Faults are prevalent in this portion of basins (Figure 2). NW trending faults are conspicuous north to Jharia. Many lamprophyre and dolerite dykes are also exposed in this area in a criss-cross manner. The Raniganj Formation though coal bearing, has suffered much deformation due to faulting, thus causing difficulty for

mining in the area. The generalised stratigraphy of JCF is mentioned below (after Saraf, et al., 1995).

FORMATION	LITHOLOGY	MAXIMUM THICKNESS
Supra Panchet	Red and Grey sandstones and shales	300m
Panchet	Micaceous Yellow and Grey sandstones, Red and Greenish shales	600m
Raniganj	Grey and Greenish soft feldspathic sandstones, shales and coal seams	1050m
Ironstone Shales	Dark carbonaceous shales with ironstone bands	360m
Barakar	Coarse and medium Grey and white sandstones, shales and coal seams	630m
Talchir Boulder Bed	Coarse sandstones above and Greenish shales below	300m

Table 1: Generalised stratigraphy of JCF.

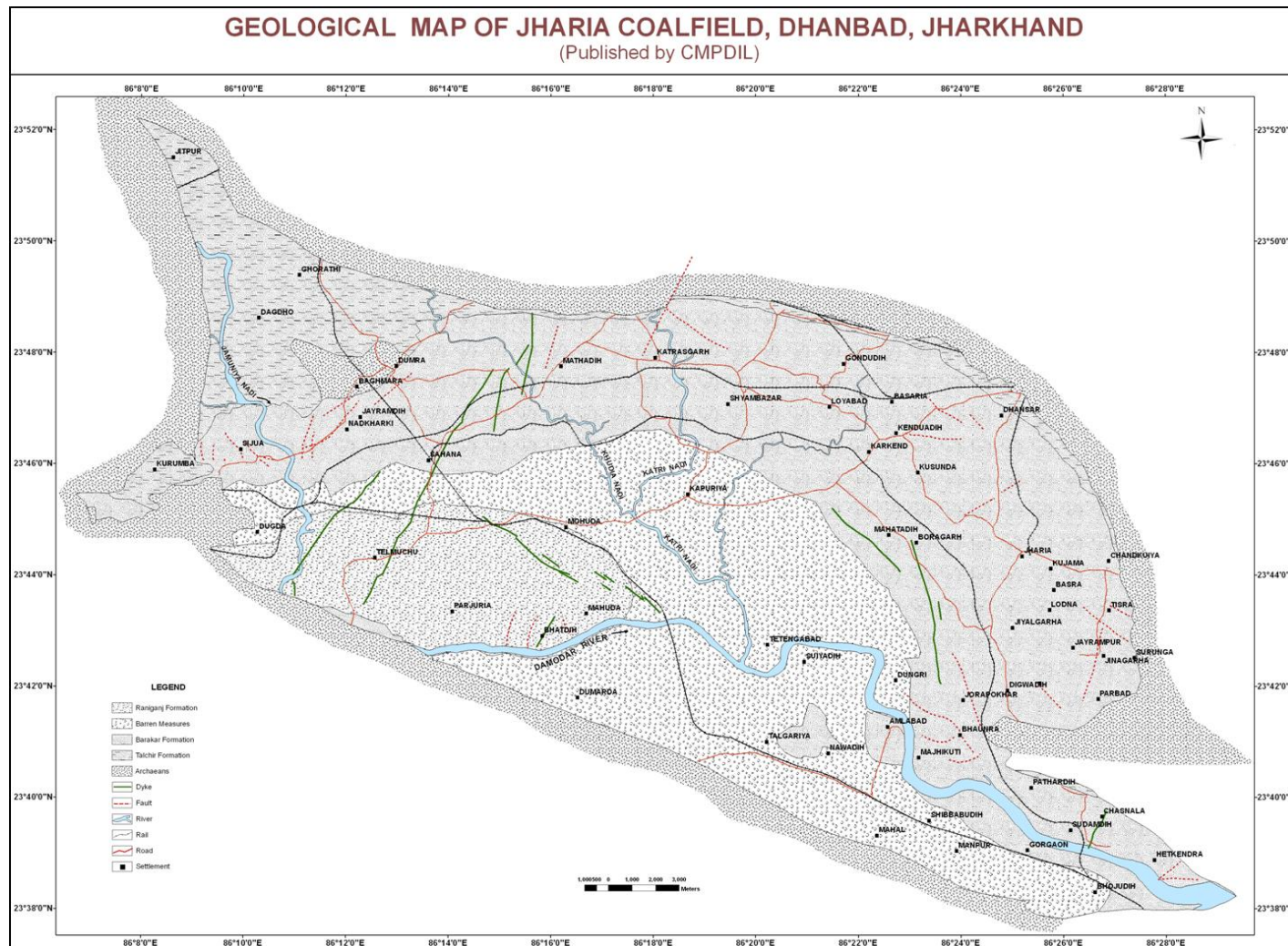


Figure 2 : Geological map of Jharia coal field, Dhanbad, Jharkhand (published by CMPIDL)

CHAPTER III

DATA REQUIREMENTS

3.1 Remote Sensing Data

The most recent available thermal satellite data was used in conjunction with the fieldwork for mapping coal fire in JCF. A coal fire map generated from the same, would serve as a reference for the fieldwork, as the observations can be verified in the field. For this purpose, a coal fire map was created from LANDSAT 8 TIRS data of 14-May 2017 .

Further, the coal fire map of 2012 prepared by NRSC (NRSC, 2012) from ASTER data was used as a reference to identify the changes that has occurred in the extent and disposition of the fires from 2012 to 2017.

For the land subsidence study, L-band microwave data from ALOS-PALSAR satellite (JAXA) were used. Five scenes of "Fine mode" SLC data were taken from PALSAR-2 archives over a period from October, 2014 to February, 2017. This was done to identify long term terrain changes and differentiate the same from short term changes due to mining excavations and overburden dumping.

Table 2: List of satellite data used in the present study.

Sl. No	Satellite	Sensor	Time	Date	Data source
1	LANDSAT-8	TIRS	Daytime	14 May 2017	USGS, USA
2	ALOS-PALSAR-2 (Fine mode)	PALSAR-2	-	4 October. 2014	JAXA, Japan
3				3 October, 2015	
4				20 February. 2016	
5				01 October, 2016	
6				18 February. 2017	

3.2 Ancillary data

1. Geological map of Jharia coal field.
2. Mine surface plans as provided by BCCL.

CHAPTER IV**REMOTE SENSING DATA ANALYSIS****4.1 Methodology****4.1.1 Processing of Landsat 8 Data**

With the launch of the LANDSAT-8 mission in February, 2013; thermal space borne data is available from its thermal infrared sensor (TIRS). This has enabled monitoring of the earth with a spatial resolution of 100 m in the thermal domain with a repeat cycle of 16 days. The LANDSAT-8 has two channels (Band 10 and Band 11) in the thermal infrared region (Table 1) which ranges from 10.4 micrometer to 12.5 micrometer. In present study, band 10 of TIRS sensor (acquired on 14 May, 2017) has been used coal fire mapping (Gangopadhyay et al. 2012). The spectral domain of the band is known for its maximum transmittance (Chatterjee et al. 2007; Martha et al. 2010). The data are freely accessible through USGS portal (Landsat 8 download source: <http://landsatlook.usgs.gov>).

Landsat-8 data are available in GeoTiff format and the data are converted to top of the atmosphere spectral radiance using the radiance rescaling factors provided in the metadata file, using equation 1.

$$L_{\lambda} = M_L Q_{cal} + A_L \dots\dots\dots (1)$$

Where:

L_{λ} = Spectral radiance (Watts/ (m² * srad * μ m)).

M_L = Band-specific multiplicative rescaling factor from the metadata.

A_L = Band-specific additive rescaling factor from the metadata.

Q_{cal} = Quantized and calibrated standard product pixel values (DN).

Once the spectral radiance (L_{λ}) for ASTER Band 13 and Landsat-8 band 10 data is generated, it is possible to calculate radiant (brightness) temperature directly using equation 2. Planck's radiation function (Planck, 1914) forms the basis of radiant temperature derivation from spectral radiances and the theory is discussed in detail in existing literatures (Gupta, 2003).

$$T_R = K_2 / \ln ((K_1 / L_{\lambda}) + 1) \dots\dots\dots (2)$$

T_R = Radiant (brightness) temperature,

K_1 = Calibration constant (1260.56 K),

K_2 = Calibration constant (666.09 watts/ (m² *ster* μ m)),

L_λ = Spectral radiance

4.1.2 Thresholding of radiant temperature image

Once the Landsat-8 data are converted to radiant temperature image, the next step was to segregate fire pixels from the background, which requires the estimation of the cut-off temperature (Roy et al. 2015). This has been attempted by the statistical analysis of sensor derived radiant temperature to delineate clusters (in the scatter-plot) indicative for fire and non-fire pixels. Mean and maximum radiant temperatures are derived from randomly sampled uniform sized pixel blocks distributed in entire spatial extent of Barakar formation (Figure 3) known for fire bearing coal seams. The pixel block sizes are chosen to adequately represent the overall areal extent of the coalfield and homogeneously encompass all the mining blocks (27x27 pixels for Landsat-8, Figure 3). The maximum temperature value recorded in each representative area, derived from each of the datasets, is plotted against the mean temperature. The maximum temperature represents that of fire (wherever present), whereas the mean temperature represents the average background temperature, for normalization. The fire and background populations show considerable variance, separating coal fire and background radiant temperatures. The cut-off temperature derived is the maximum temperature of the background cluster, above which all temperatures represent coal fires. In the case of the Landsat-8 data used in this study, the cut-off temperature was determined around 39°C (Figure 4). Based on this cut-offs, regional coal fire map was prepared (Figure 5).

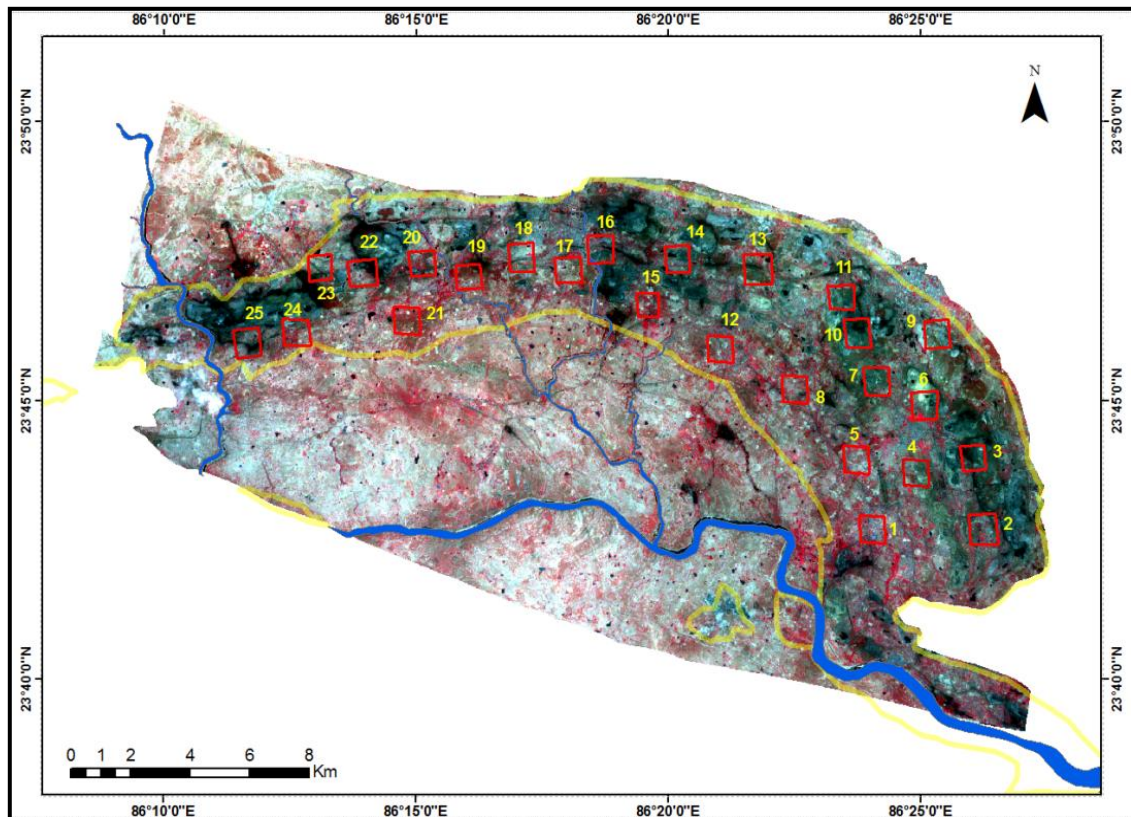


Figure 3. False colour composite image of Jharia Coalfield, with subset blocks (in red boxes) to obtain temperature values (from radiant temperature image) within the Barakar formation across the Jharia coalfield.

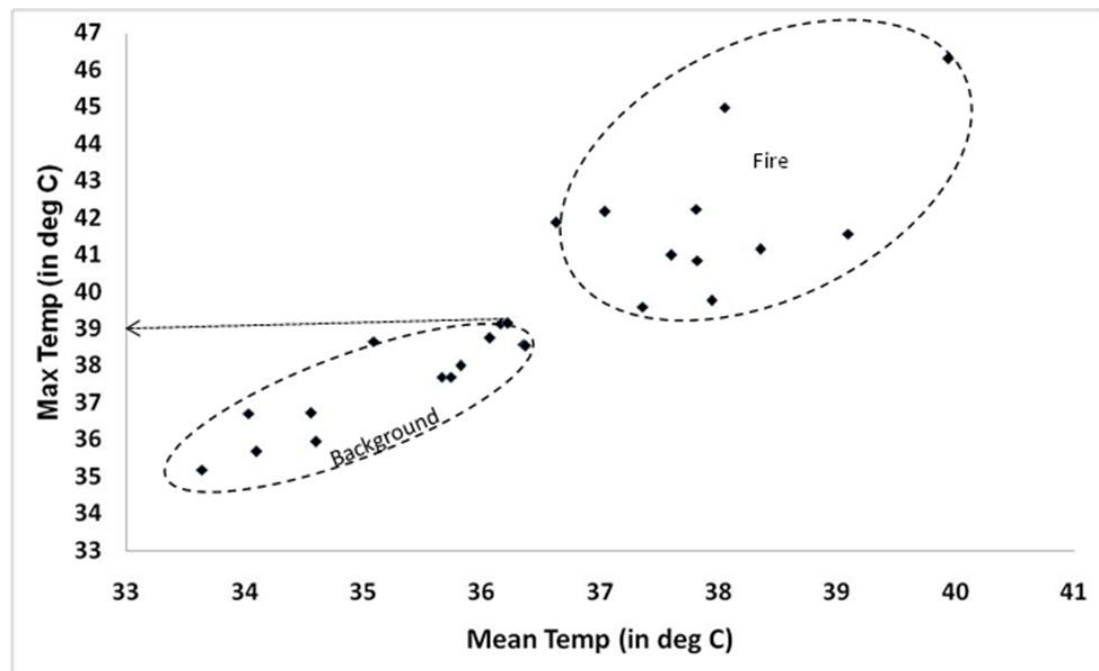


Figure 4. Maximum temperature plotted against mean temperature for various locations; cluster separation observed around 39 °C (marked with arrow)

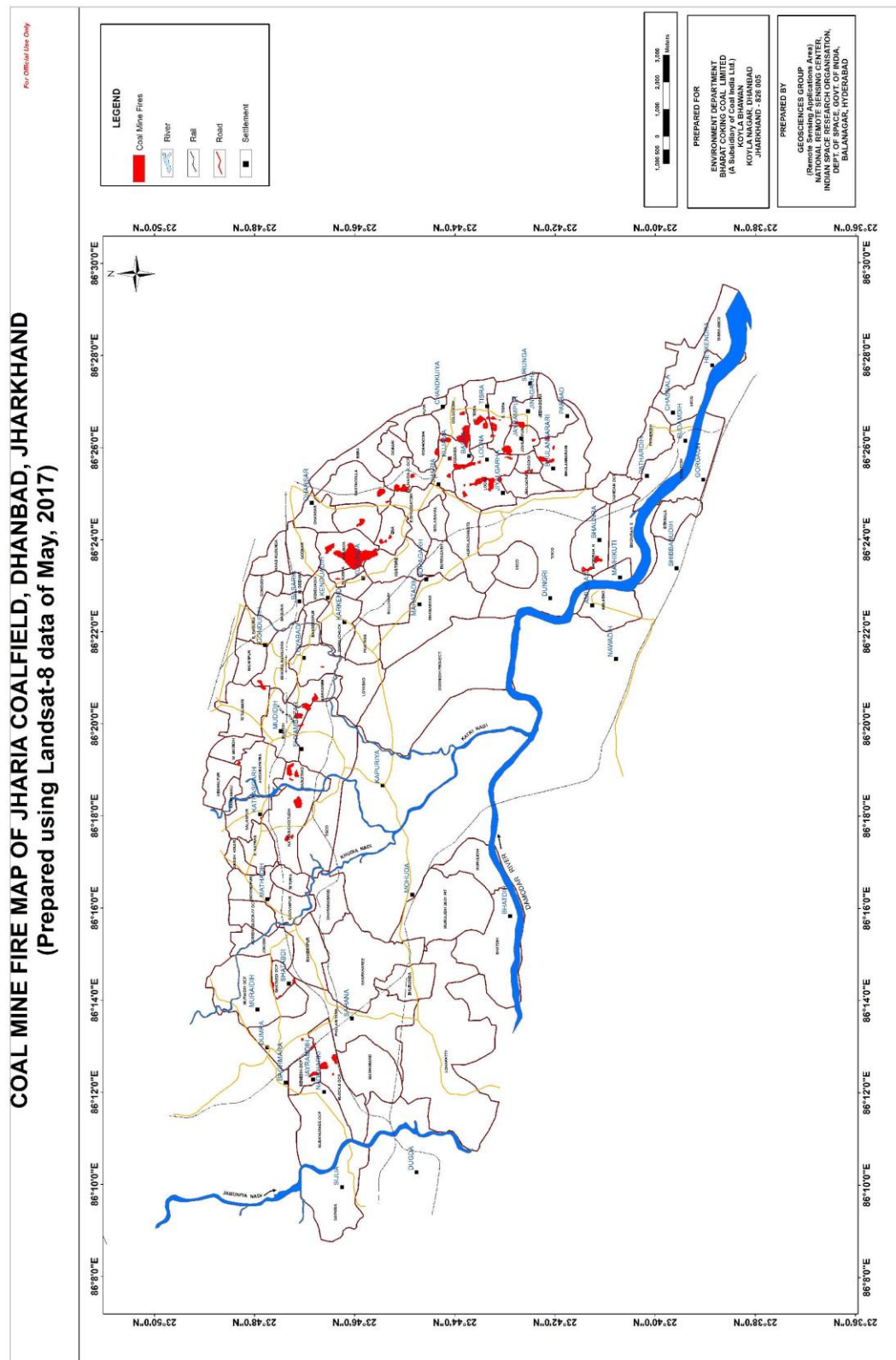


Figure 5: Coal mine fire map (May, 2017) of Jharia coal field, Dhanbad. The fire areas shown in this map have been verified in the field as per field points in figure 13.

4.2 Methodology For Subsidence Detection

4.2.1 Processing of ALOS-PALSAR 2 Data

Differential Interferometric SAR (DInSAR) techniques consist of combination of two SAR images of the same area acquired from slightly different positions (Figure 6).

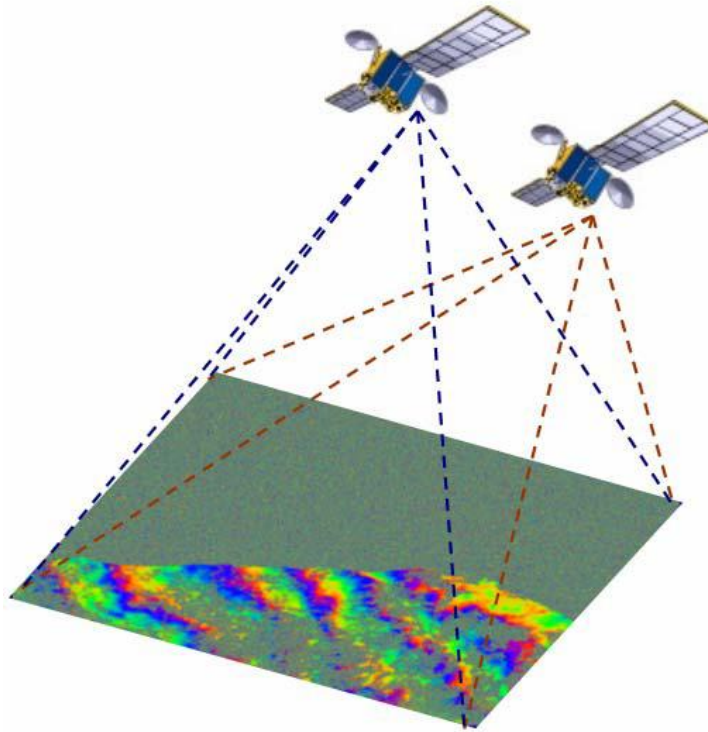


Figure 6. DInSAR acquisition scheme.

The result of this combination provides a new image, known as 'interferogram', whose phase component is formed by the following term:

$$\Delta\Phi_{Int} = \Phi_{Topo} + \Phi_{Mov} + \Phi_{Atm} + \Phi_{Noise} \quad (3)$$

where, Φ_{Topo} denotes the topographic component, Φ_{Mov} denotes the terrain deformation/ displacement component, Φ_{Atm} is the noise component and Φ_{Noise} is the thermal noise.

Topography, atmospheric effects and thermal noise needs to be removed or optimized to obtain precise measurements of terrain movement. When working with classical DInSAR interferograms (combination of two SAR images) the main problem is the presence of atmospheric artefacts, since there is no way to cancel them without a priori information. On the other hand, the term related with topography can be cancelled out using an external Digital Elevation Model (DEM) and the orbital ephemeris from the SAR acquisitions, considering no height errors on the DEM.

$$\Delta\Phi_{dif} = \Phi_{ErrorTopo} + \Phi_{Mov} + \Phi_{Atm} + \Phi_{Noise} \quad (ii)$$

Since the coal mine area is very dynamic in terms of its surfacial changes (open cast mine, abandoned mine, fire affected waste/reclaimed land, over burden dumps) over time, it is proposed to utilize an advanced DInSAR technique. It is a recent remarkable improvements in SAR differential interferometry that has led to an innovative approach based on the use of a large dataset of SAR images over the same area to overcome the intrinsic limitations of conventional DInSAR in terms of temporal and geometrical decorrelation as well as atmospheric disturbances (Ferretti et al 2001; Hooper et al 2004; Kampes, 2006; Lanari et al 2004; Mora et al 2003; Werner et al 2003).

Broad work flow diagram for generating land subsidence map using satellite based DInSAR technique is shown in Figure 7.

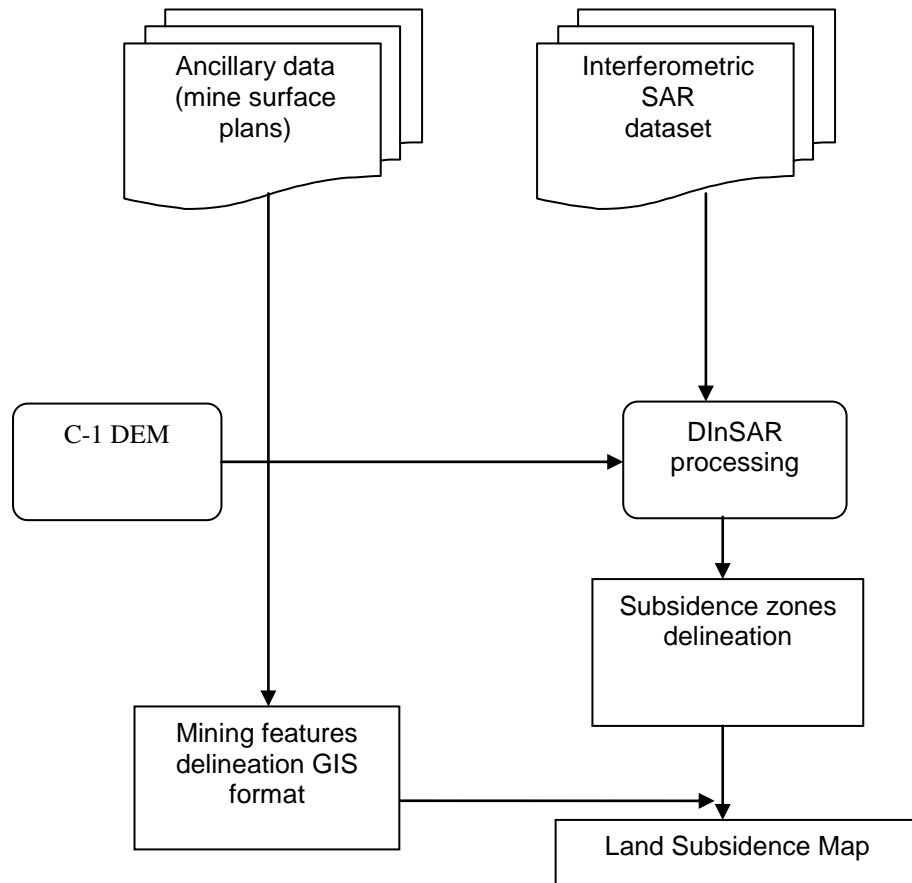


Figure 7. Work flow diagram for generating land subsidence map using DInSAR technique.

In the present study, 5 sets of ALOS-PALSAR L-band microwave data (as mentioned in table 1) were procured. The datasets were paired into master-slave pairs as per short and long temporal baselines. The short temporal baselines include master slave pairs of time difference of six months or less, whereas long temporal baselines include data pairs of time difference of one year or more. This has been illustrated in figure 8.

		SLAVE IMAGE				
		October, 2014	October, 2015	February, 2016	October, 2016	February, 2017
MASTER IMAGE	October, 2014					
	October, 2015					
	February, 2016					
	October, 2016					
	February, 2017					
		Short Temporal Baseline Pair (less than 1 year)				
		Long Temporal Baseline Pair (more than 1 year)				

Figure 8. ALOS-PALSAR - 2 Master-Slave pairs for short and long temporal baseline processing

The interferometric fringes generating from short baseline pairs will generally indicate terrain changes due to mining activity happening over a short period of time. This will include mining excavations and creation of new OB dumps adjacent to the mining area. Any incidences of slow land subsidence will not be demarcated in the results (figure 9).

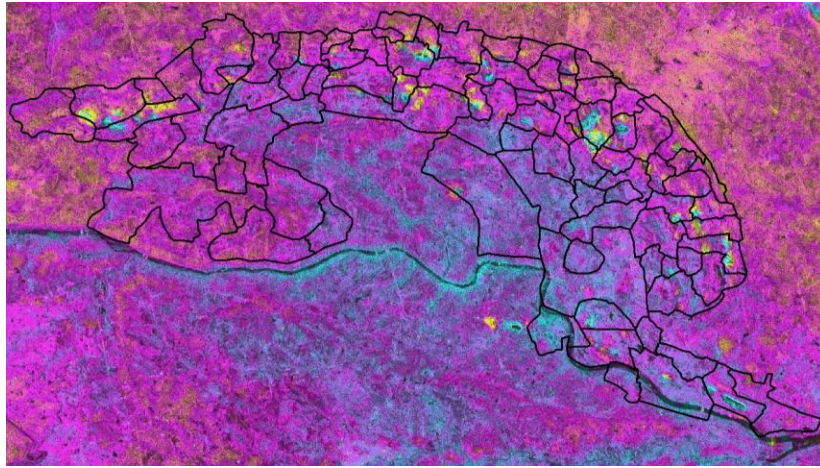


Figure 9. Fringe patterns generated from short baseline processing (e.g. Master: Oct, 16, Slave: Feb, 17).

On the other hand, master-slave pairs of long temporal baseline (one year or more, as shown in figure 8) will incorporate terrain changes due to mining activities as well, as long term ground subsidence from underground mining where ever present (figure 10).

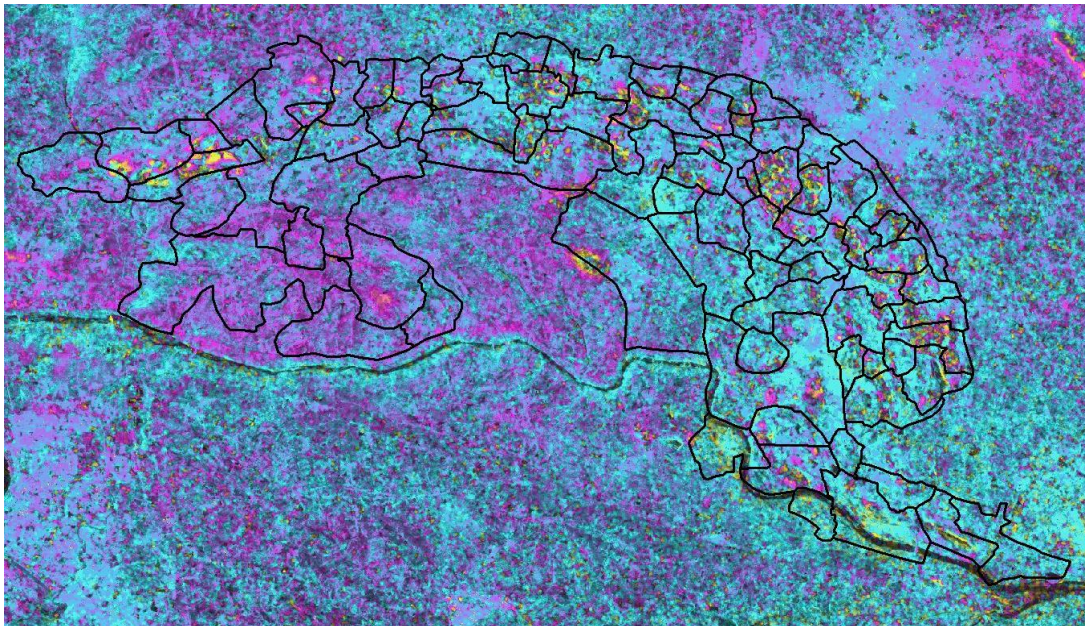


Figure 10. Fringe patterns generated from long baseline processing (e.g. Master: Oct, 15, Slave: Feb, 17).

The results from the long and short baseline processing can be compared and zone where fringes have been developed due to terrain changes due to mining excavation and dumping, can be systematically identified and demarcated. The remaining fringes from the long temporal baseline processing will then indicated towards zones where subsidence has taken place due to underground mining. Using this, a terrain change

map of the Jharia Coalfield was generated demarcating terrain changes due to mining activities and subsidence areas (Figure 11).

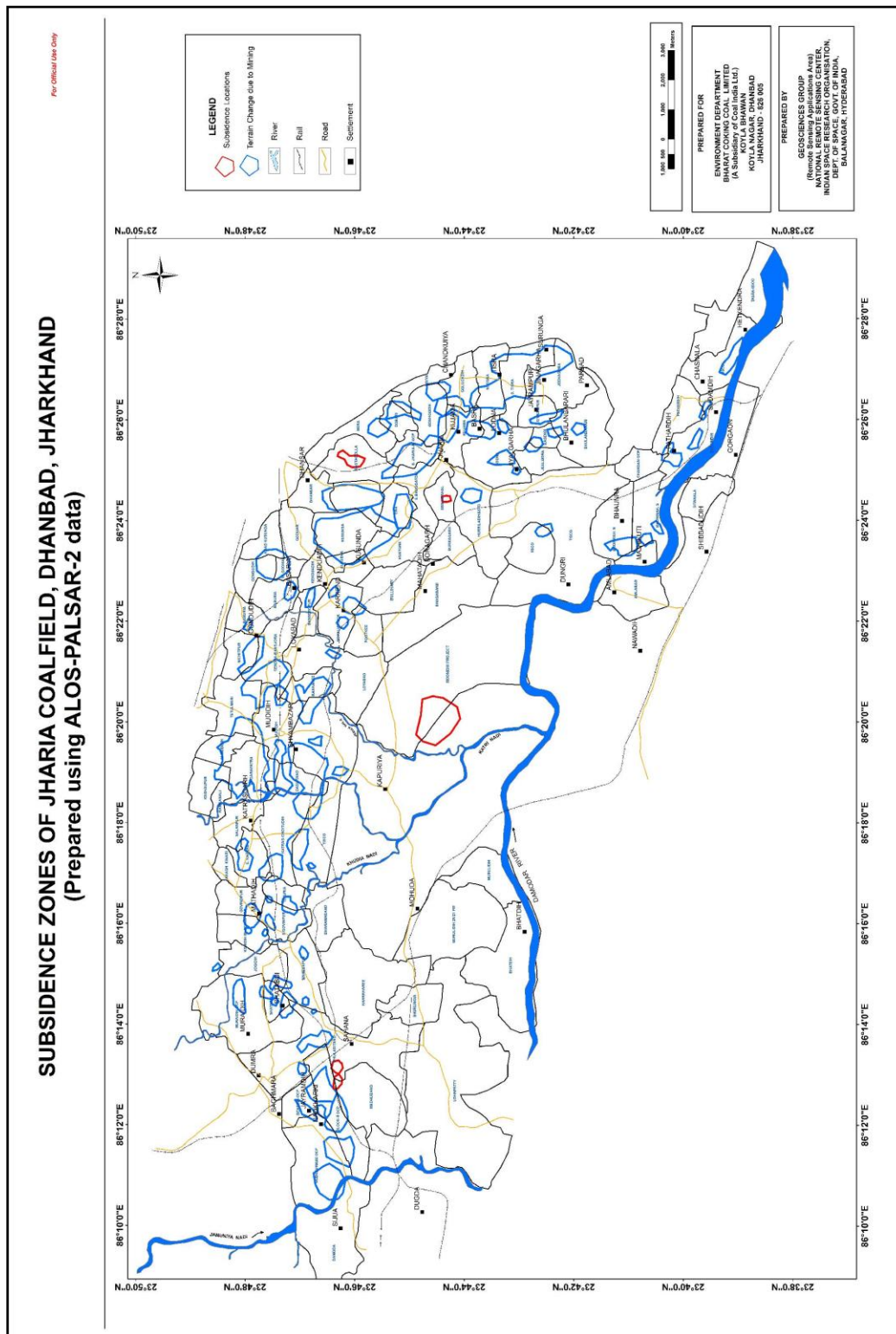


Figure 11: Subsidence map of Jharia coal field, Dhanbad.

CHAPTER V

FIELD WORK

A field work for verification of the coal fire locations and the subsidence zones as identified by the satellite data were taken up in December, 2017. A total of 53 coal fire points and 37 land subsidence locations were identified from the satellite data analysis. The locations of these points along with geographic coordinates were given to BCCL prior to the December, 2017 field work for their feedback on the status of these points. Out of the 53 coal fire locations identified, 52 points were confirmed to be fire bearing as per the present masterplan of the Jharia coalfield created by BCCL. Both the coal fire and the subsidence locations were further independently verified by NRSC during the fieldwork in December, 2017. The locations and the observations are coal fire and subsidence are provided in annexure 1 and annexure 2 of this report respectively.

The salient overview of the field observations are as follows:

Coal-fire observations:

1. The coal fires as observed identified by the Landsat-8 data are mostly accurately delineated. Fires have been identified in the western, northern and eastern flank of the coalfield with considerable accuracy in the spatial locations.
2. In the eastern flank, the main fire affected mines are Kusunda, Lodna and Tisra. Active fires area present in the mines and fumes can be seen from the OB dumps. The Bhowra and Bhulanbarari mines also show presence of fire, however, the extent of the fire area appears to be underestimated in the data. Similarly, the extent of fires in Lodna and Tisra appears to have been overestimated in the data. The largest extent of fire in the single mine block is that in Kusunda.
3. In the northern flank, the main fire bearing mines are Katras, Gaslitand and Mudidih, However, it is seen that in these areas, the fires appears in pockets and are not pervasively present. The spatial extent of the fires on the ground and as estimated in the data can be correlated.

4. In the western flank, the Block II OCP is the primary fire affected region. However, it is seen that the Shatabdi OCP also bears fire pockets along semi-vertical mine walls, This is not identified in the data.

Subsidence location observations:

1. Subsidence locations as identified by the data area difficult to verify in the field, unless there are tell-tale signatures like large cracks or fissures on the ground or damage to anthropogenic constructions like vertical cracks on building cracks etc.
2. Out of the 37 identified subsidence locations from the microwave data, it is seen that 32 are due to terrain changes resulting from mining activities like ongoing excavations or formation of new mining dump. These decrease or increase in elevations has resulted in forming of interferometric fringes in the data thus creating false positives.
3. Five areas were firmly established as subsidence zones. Out of these, the main area where subsidence is occurring in a pervasive scale, is that in the Moonidih Underground Project. The Moonidih Project is an underground long wall mine where excavations are going on for over decades. This may have resulted in pervasive subsidence in the region. The signatures of subsidence such as ground cracks are observed in the area.
4. Two adjacent locations are observed south of the Block II OCP and in Phularitand mining block. This may be resulted due to older underground mining in the area. Signatures such as sagging of ground is seen.
5. Another minor subsidence region was identified around the Simlabahal underground mining project. This is again due to active underground mining in the area. A similar region was also observed in the northern part of the Bastacolla mines where active underground mining is ongoing.

In lieu of the observations in field on the fire and subsidence locations, few post field work correction in the coal fire and subsidence maps was necessitated and has been discussed in the next chapter.

CHAPTER VI**POST FIELDWORK ANALYSIS**

As observed in the fieldwork, there were certain mine areas where the presence of fire was not detected by the satellite data. For example in Shatabdi and Bhulanbarari mine areas, the fire appears in small pockets on mine faces and was possibly not detected by the threshold temperature calculated for the entire mine area. On the other hand, in the Bhowra, Lodna and Tisra mine areas, the spatial extent of fire appears to have been overestimated by the regional threshold temperature use to separate the fire and the background areas.

Therefore, mine specific threshold temperature analysis was carried out for Shatabdi, Bhulanbarari, Bhowra, Lodna and Tisra mine areas to correctly depict the fire areas on the ground. The threshold temperature selected from each of these mine areas are given in Table 3.

Table 3: Threshold temperature for fire area estimation of individual mines.

Name of the Mine Block	Threshold Temperature (in °C)
Bhowra	38.5
Tisra (north and south)	North : 41; South : 40.5
Lodna	41
Bhulanbarari	38.5
Shatabdi	38

Using the threshold temperatures as mentioned in the table 3, the previously undetected fire areas in the Shatabdi and Bhulanbarari mines were detected. Further the spatial extent of the fire areas in Bhowra, Lodna and Tisra mines were changed to adequately represent the actual extent of the fire on the ground. These were incorporated in the coalfire map shown in figure 5.

DISCUSSIONS AND CONCLUSIONS

CHAPTER VII

7.1 Discussions

7.1.1 Coal fire analysis

The present study is aimed to provide the status of coal fire in the Jharia coal field for the period of 2017. Landsat-8 data of May, 2012 was used to prepare the coal mine fire map (Figure 5) for the year 2017. The data have 100 m spatial resolution in the thermal bands and is as on study date, the best thermal satellite data available. The Coal fire maps of 2017 when compared to map of 2012 (NRSC, 2014) depicts the dynamics of coal fire. Coal fire is difficult to mitigate because of its dynamic nature. But the understanding the trend in the shift of coal fire zones and over all distribution of coal fire will help in environmental and risk management related to coal mining activities.

The coal mine fire map for the year 2017 (Figure 5 illustrates the overall fire distribution in the area). The maps reveal that the coal fires are distributed across the Jharia coal field in pockets associated with major open cast mining activities. All most all the coal mine fires are restricted to the Barakar Formation where coal seams are exposed. In the eastern flank of the arcuate shaped mining extent, the collieries in Lodna and Tisra (North and South) is the highest fire affected mining blocks and Bhowra, Bhulanbarari, Kujama and Jharia are also affected by multiple smaller fire pockets. The fire in the areas is mostly manifested by high temperature fume cracks with occasional presence of active flames especially the the Lodna-Tisra area. Further, towards the north east, in Ena and Kusunda active fires are more prevalent and the area is extensively affected. The highest radiant temperatures (in order of ~50°C) are recorded by the satellite sensors in these areas. In the north, a large number of moderate to small fire pockets are seen in the areas around Shyambazar (Figure 5 & 6). These are related to the mining areas of Katras, Gaslitand, Mudidih and Kankanee. Mining activity, over the last few of years has exposed new, isolated and discontinuous fires in these regions.

In the western flank, three distinguishable fire affected zones are seen. Toward the western end of the mining area, the Benedih and Block II OCP are affected by smaller fires from isolated coal seams. These again are surfacially manifested in the

form of fume cracks with smoke emanating from them. The Shatabdi OCP are also affected but fire is manifested in the along vertical mining wall sections.

Comparison of the 2017 coal fire map with that of 2012 (NRSC, 2014) indicated the dynamism in the spatial extent and distribution of the coal fires. The changes are highlighted as follows:

- i. In reference to the map generated in 2012, the 2017 map shows that the emergence/re-emergence of fires in the eastern flank, namely Kujama, Tisra, Lodna and Jharia etc. The entire zone has been affected by multiple fire occurrences. The spatial disposition of fires in Bastacolla, Jharia and Bhulanbarari appear to have a minor increase.
- ii. The areal extent of major fire zone around Kusunda/Kenduadih and Ena appears to remain the same, though here again the spatial location of the anomalies has changed. This is probably due to the mitigation and active mining in this region.
- iii. The fire zones in Benedih/Block II OCP and Shatabdi OCP have also changed/diminished in areal extent with presence of isolated smaller anomalies. There has been a considerable reduction in fire areas in and around the Shatabdi OCP.
- iv. The spatial disposition of fire areas around Katras, Gaslitand and Mudidih show minor change. In 2012, a number of small fire pockets were seen, however presently those fire pockets have given away to a few fire zones of moderate disposition.
- v. It needs to be noted that the 2012 study was carried out using ASTER data whereas the present study is carried out using Landsat-8 data. Therefore, the difference of sensor sensitivities will have a influence on the way the fires are sensed on the ground. Difference of sensor sensitivities will influence the number of fires identified as well as the areal extent of the fires in the data.

In summary, there is a change in the areal disposition of the fires from 2012 to 2017. Observations suggest the emergence/re-emergence of new areas in the eastern flanks in areas around Lodna and Tisra. Concurrently, there is a decrease in extent of fire areas Shatabdi, Nadkhurkee area in the western flank from 2012 to 2017. A quantitative comparison of the 2012 and 2017 data was carried out. As compared

2012, when the total fire affected extent of about 2.18 km²; in 2017 total fire affected extent is about 3.28 km². The colliery wise break-up of change in fire area from 2012 to 2017 is given in Annexure III.

7.1.2 Subsidence analysis

An attempt to identify subsidence zones in the Jharia Coalfield was also carried out using ALOS-PALSAR-2 L band microwave data using differential interferometric technique. 5 scenes of PALSAR-2 data spanning over a period of 2014 to 2017 were used to delineate the subsidence if any in the region and separately identify them from the terrain changes due to mining. Verification of the subsidence zones as seen from data is difficult as it requires visible signatures of subsidence in the form of cracks on the ground and damage to anthropogenic structures. In this study, data analysis and consequent field verification resulted in identification of 5 prominent subsidence areas. Of these, the major area where considerable ground subsidence is occurring is the Moonidih UG project. Long term underground mining has resulted in continuous subsidence in the area. Apart from this, the other four areas are south of Block II OCP, Simlabahal and Bastacolla. No quantitative estimates of the subsidence has been carried out in the study.

7.2 Conclusions

The following conclusions can be made:

1. As of the date of study in the year 2017 and in comparison with the previous study done in 2012, there has been a change in areal extent and disposition of the fire affected areas.
2. Compared to 2012, the eastern flanks (Lodna, Tisra areas) show considerable increase in fire disposition and the western flank (Shatabdi and Block II area) show diminished fire presence.
3. The major new fire areas are observed in the northern flank in the areas around Lodna and Tisra etc. These areas were not mapped as fire in the 2012 study.
4. The mines in Kenduadih and Lodna remain to be the worst affected with maximum presence of active fires.
5. There is an increase in areal extent of the fire (Figure 12) from 2012 to 2017.

Note: Estimations of fire extent (in terms of sq.km.) both in 2012 and in the present 2017 study are pixel based. They do not represent the actual ground area under fire. These estimations are made for comparative purpose only, to indicate the increase or decrease of areal disposition of fire. Hence, they should not be quoted as fire area on the ground.

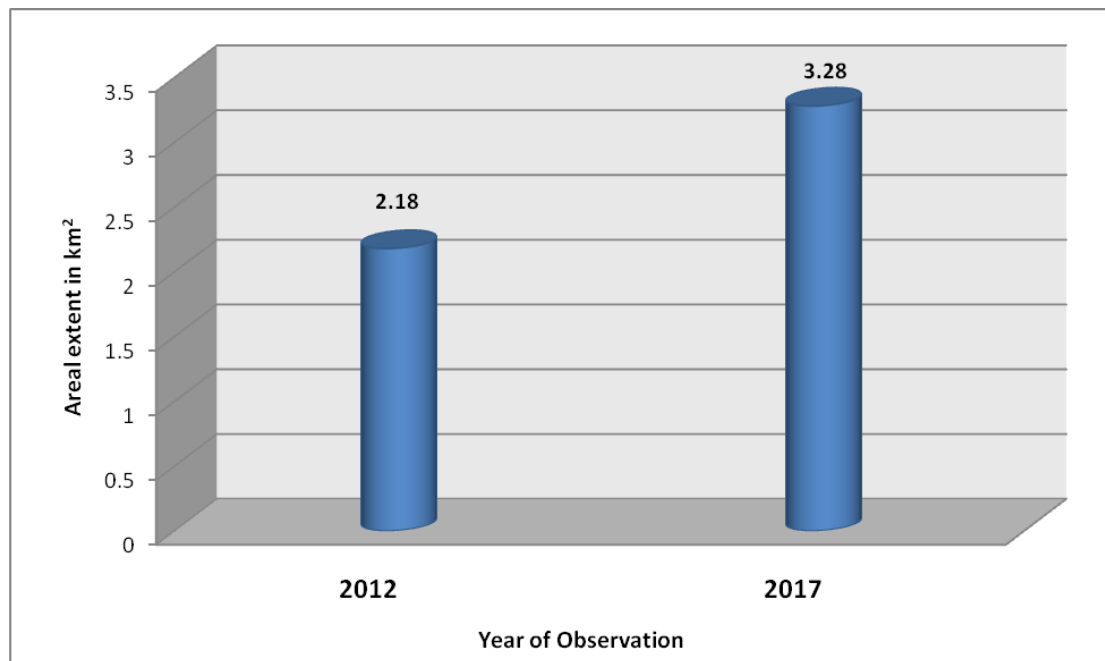


Figure 12: Total fire area statistics

CHAPTER VIII

LIMITATIONS

Delineation and mapping of coal fire from thermal data of remote sensing platforms carries with it some inherent limitations which needs to be understood in order to decipher the results obtained from it. This will assist in deducing the correct information and remove any ambiguity associated with the results. The key limitations of the data and the results obtained are as follows:

- 1) An anomalous pixel from LANDSAT data represents an area of 30m x 30m (resampled from spatial resolution of 100m) on the ground whose temperature is considerably higher than its surroundings. This can be attributed to two circumstances, namely the area has a very high intensity fire located within a smaller pocket or there are a number of low intensity fires spread across it. In both the mentioned cases the actual areal extent of the fire on the surface differs, but appears as a single anomalous pixel in the data. Hence, representation of fire affected ground area by means of pixel area is ambiguous and hence should be considered with caution.
- 2) There are locations as observed during the fieldwork, where coal seams are affected by active fires along vertical/semi-vertical sections of open cast mines (see cover page). In such cases, the actual areal expression of the fire affected area as seen by the sensor changes considerably and the representation from the same is not accurate.
- 3) As discussed in section 4.2.1, thresholding the data to separate the fires from the non fire areas, is a statistical technique. However, this method is dependent on how the temperature of non-fire background area is distinctive from the fire temperature.
- 4) The background temperatures vary with the time of the day when the data is collected, topography, and season of the year when the data is acquired. Night-time data has lower background temperature as compared to day-time. Similarly a data collected in October-November will have a considerably lower background temperature than that collected in May-June due to seasonal temperature variations. Hence, identification of the background temperature range becomes essential in

estimation of threshold temperature and the same varies depending upon the discussed controlling factors.

5) Generally, a constant threshold temperature is estimated over the entire study area, and the same is applied to delineate the fire areas from those of non-fire. However, it is seen that the application of such global thresholding may mask fires which are in turn seen in the field and that the threshold temperature value may vary locally. In the current scenario, it is seen that the fire locations as verified in the fieldwork at Bhulanbarari and Shatabdi were not identified in the data on application of a global threshold of 39°C. However, a subset of the data within the Bulanbarari area only, is analyzed with a lower threshold of 38.5°C, the fire pixels are manifested in the data. Hence, the appropriateness of a singular thresholding temperature value may need to be relooked upon. Future studies can be carried out using colliery wise statistical local thresholding to create a composite coal fire map.

6) Due to the mitigation measures taking place in various mines, it is seen that in a number of places the fire affected seam is excavated and dumped as overburden. However, these overburden dumps retain the excavated burning coals and thus are seen to have active fires occasionally. There lies a possibility that the same will be identified as anomalous pixels and hence, although the fire is not a part of any active coal seam, it will be included as a fire affected area in the final map.

7) Verification of the subsidence zones as detected from the interferometric technique is sometimes difficult due to lack in observable signatures of subsidence such as cracks on the ground and damage to anthropogenic structures.

Therefore, in quantitative estimation of fire affected areas and areas denoted as subsidence, the above mentioned limitations need to be taken into account diligently, as it is inevitable that the area estimate will not define the actual fire/subsidence affected area on the ground. However, the areal extent estimated from the data can be "like to like" compared to earlier estimates of similar studies to understand the change and dynamism of the fire in terms of area affected and spatial disposition.

References

1. Gangopadhyay, P.K., Lahiri-dutt, K., Saha, K. (2005): "Application of remote Sensing to identify coal fires in the Raniganj coal belt, India." *Int. Jour of Applied Earth Observation and Geoinformation*.
2. Gangopadhyay, P.K., Malthuis.B, Van Dink (2005): "Aster Derived emissivity and coal-fire related surface temperature anomaly a case study in Wuda, North China," *Int. Jour. of Remote Sensing*, vol-26, No.-24, pp-5555-5571.
3. Schmugge, T., French, Ritchie, J.C., Rango, A., Pelgrum, H. (2002): "Temperature and emissivity separation from multispectral thermal infrared observation," *Remote Sensing of Environment*, 79, pp-189-198.
4. Saraf A.K., Prakash A., Sengupta, S., Gupta, R.P (1995): "Landsat-TM data for estimating ground temperature and depth of sub-surface coal fire in the Jharia coalfield, India," *Int. Jour. Remote sensing vol-16, no-12*, 2111-2124.
5. Gangopadhyay P.K., (2003): "Coalfire detection and monitoring in Wuda, North China, A multispectral and multi-sensor approach:-Ph.D. Thesis, ITC Netherland.
6. Gupta, R.P. (2003): "Remote Sensing Geology", *Springer-Verlag.Third ed.*pp-183-216.
7. Kealey, P.S and Hook S.J(1993): "Separating temperature and emissivity in thermal infrared Multispectral Scanner Data: Implication for recovering land surface temperatures", *IEE Transaction on Geoscience and Remote Sensing*,vol,31,no-6,pp-1155-1164
8. Zhang, J., Wagner, W., Prakash, A., Mehl,H. and Voigt,S.(2004): "Detecting coal fires using remote sensing techniques," *Int. Jour. Remote sensing*, vol-25, no-6, pp3193-3220.
9. Bhattacharya, A. and Reddy, C.S.S. (1995): Inventory and monitoring of underground and surface coal mine fire in Jharia coalfield, Bihar using thematic mapper thermal IR data: *Geosciences Group, Official report, NRSA*.
10. Coal mine fire delineation and surface features mapping using satellite data in Jharia coal field, Dhanbad, Jharkhand. Geology and Geophysics division. *Official report, NRSA, 2006*
11. Coal mine fire delineation and surface features mapping using satellite data in Jharia coal field, Dhanbad, Jharkhand. Geosciences Group. *Official report, NRSC, 2014*

Annexure –I

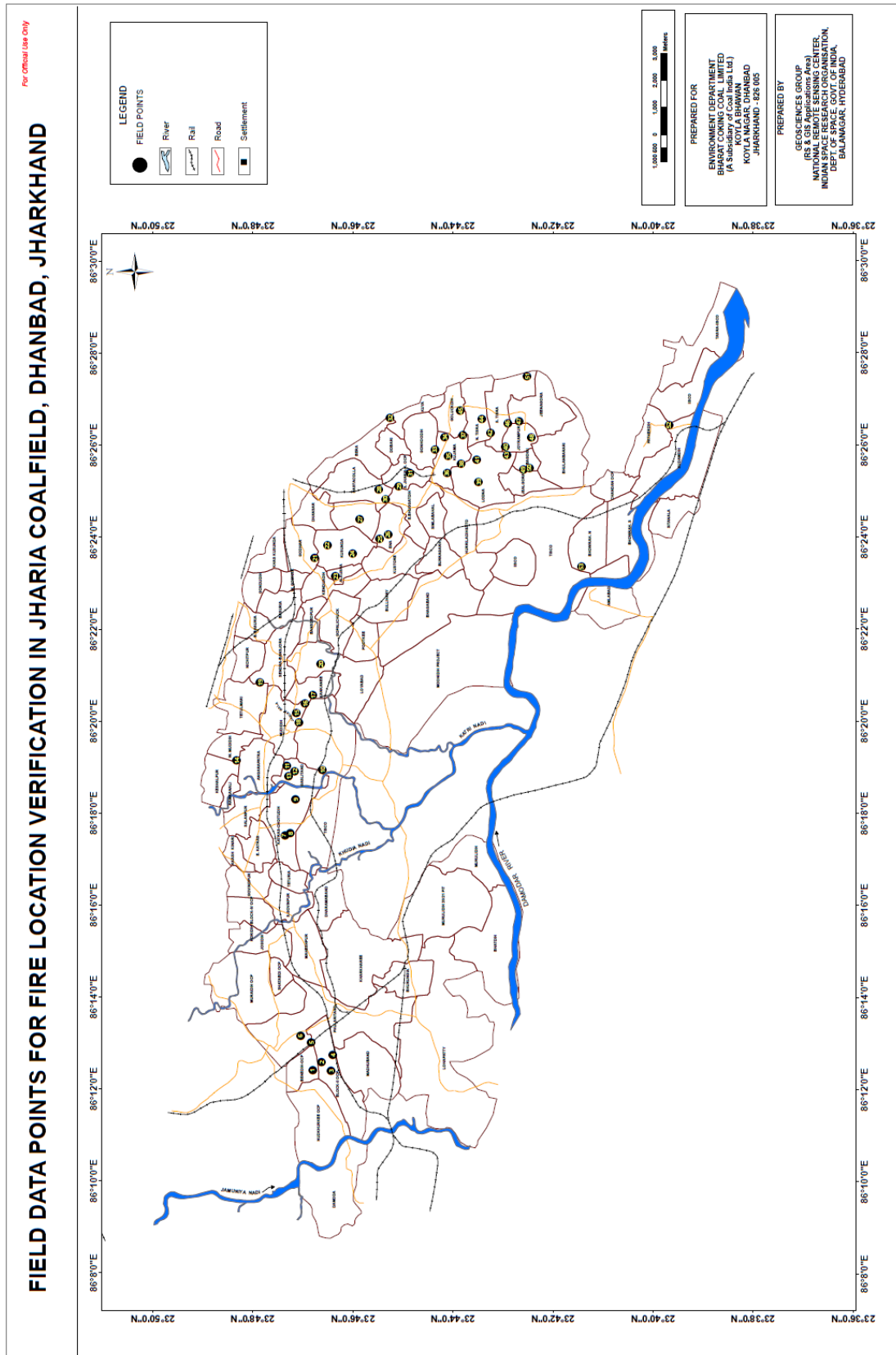


Figure 13. Field data points for coal fire verification

Table – 4: Coal Fire observations during fieldwork (see figure 13 for reference)

SL No.	Point of Observations		Comments		
	Latitude	Longitude	Type of Mining Activity	Presence of Coal Fire	Mine name and Any other Comments
1	23.7801	86.2068	OB Dump	Fire	ABOCP
2	23.7771	86.2097	Active Mine	Fire	ABOCP
3	23.7739	86.2066	Active Mine	Fire	ABOCP
4	23.7733	86.2124	OB Dump	Fire	ABOCP
5	23.7806	86.2168	No Working	Fire	ABOCP
6	23.7841	86.2192	No Working	Fire	Phularitand
7	23.7893	86.2919	No Working	Fire	Katras Chatudih
8	23.7875	86.2926	No Working	Fire	Katras Chatudih
9	23.7857	86.3049	Working	Fire	Gaslitand
10	23.7768	86.3157	Outside Jharia Mines		Tata
11	23.7887	86.3170	OB Dump	Fire	Gaslitand
12	23.7862	86.3151	OB Dump	Fire	Gaslitand
13	23.7880	86.3133	OB Dump	Fire	Gaslitand
14	23.8054	86.3191	Working	Fire	AKWMC
15	23.7855	86.3363	OB Dump	Fire	Mudidih
16	23.7826	86.3397	Working	Fire	Kankanee
17	23.7800	86.3427	Working	Fire	Kankanee
18	23.7848	86.3327	OB Dump	Fire	Mudidih
19	23.7977	86.3473	OB Dump	Fire	Sendra Bansjora
20	23.7775	86.3540	OB Dump	Fire	Loyabad
21	23.7793	86.3924	No Working	No fire	Kusunda (Domestic coal burning)
22	23.7753	86.3970	Working	Fire	Kusunda
23	23.7724	86.3858	Working	Fire	Kusunda
24	23.7669	86.3940	OB Dump	Fire	Kusunda
25	23.7578	86.3993	OB Dump	Fire	Ena
26	23.7550	86.4009	OB Dump	Fire	Ena
27	23.7645	86.4065	Working	Fire	ADIC
28	23.7580	86.4172	Old Quarry	Fire	ROCP
29	23.7515	86.4184	OB Dump	Fire	ROCP
30	23.7559	86.4137	OB Dump	Fire	ROCP
31	23.7476	86.4232	Working	Fire	ROCP
32	23.7543	86.4431	Outside Jharia Mines		Unknown site (Out side of Kuya)
33	23.7394	86.4317	Active Mine	Fire	Ghanoodih
34	23.7360	86.4362	OB dump	Fire	Goluckdih
35	23.7349	86.4293	OB Dump	Fire	Kujama
36	23.7354	86.4232	No Working	Fire	Kujama
37	23.7301	86.4369	Working	Fire	NT-ST
38	23.7305	86.4265	OB dump	Fire	Kujama
39	23.7249	86.4200	No Working	Fire	Lodna
40	23.7159	86.4327	Working	Fire	Joyrampur
41	23.7254	86.4280	No Working	No fire	Lodna
42	23.7209	86.4376	Working	Fire	NT-ST
43	23.7154	86.4296	Working	Fire	Lodna
44	23.7238	86.4427	Working	Fire	NT-ST
45	23.7309	86.4457	OB dump	Fire	NT-ST
46	23.7151	86.4412	Active Mine	Yes	NT-ST
47	23.7114	86.4419	OB Dump	Fire	NT-ST
48	23.7073	86.4360	Active Mine	Fire	Joyrampur
49	23.7097	86.4243	Working	Fire	Bagdigi/Joyrampur
50	23.7079	86.4249	Active Mine	Fire	Bagdigi/Joyrampur
51	23.7086	86.4582	Outside Jharia Mines		Unknown site (Out side of NT-ST)
52	23.6614	86.4404	Outside Jharia Mines		Chasnala
53	23.6906	86.3892	OB dump	Fire	Bhowrah (North)

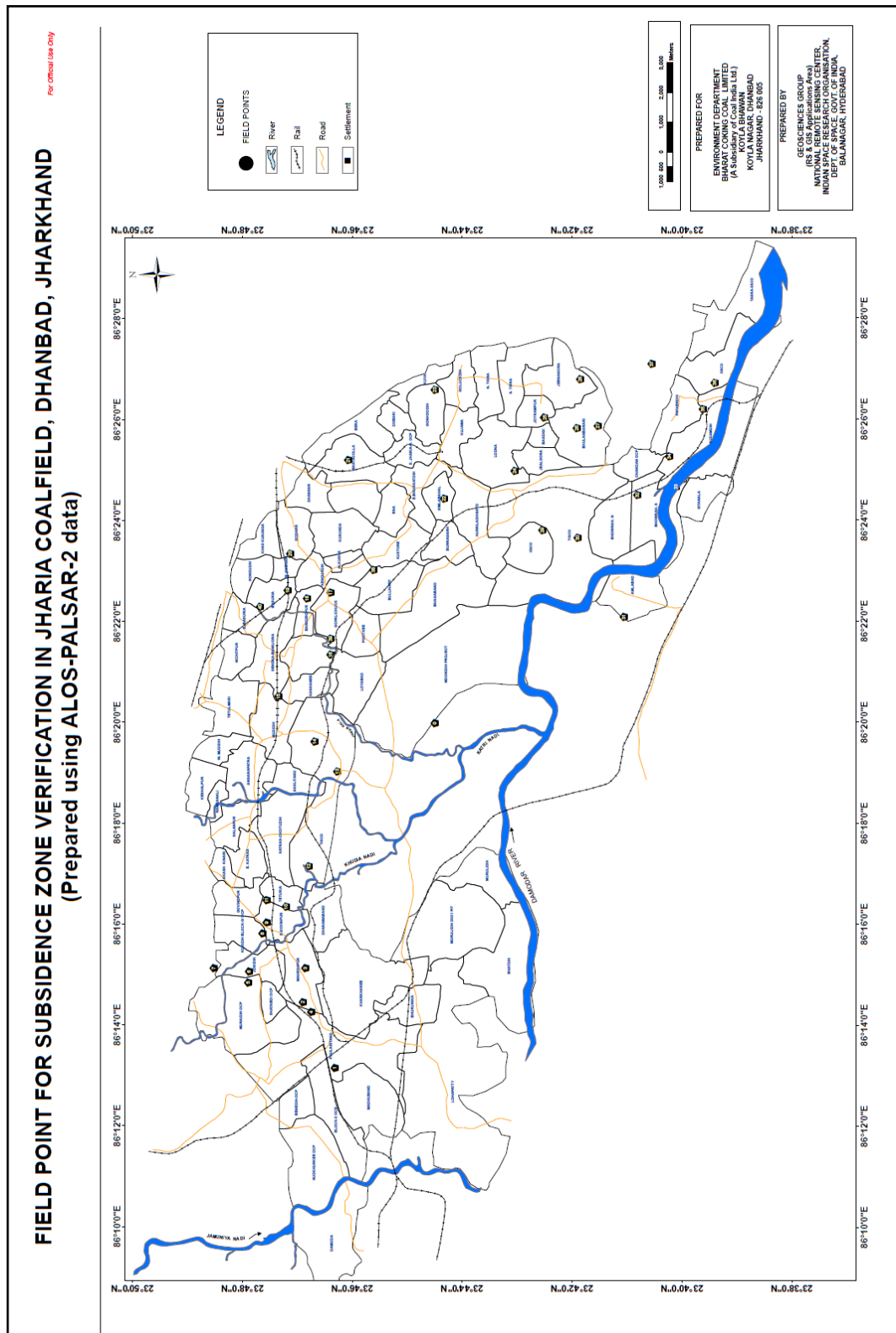


Table – 5: Coal Fire observations during fieldwork (see figure 14 for reference)

Sr. no.	Point of Observations		Comments	
	Latitude	Longitude	Mine name and Any other Comments	Signs of Subsidence (crack on building/ground crack etc.)
0	23.7416	86.3338	Moonidih UG Project	Sagged area, Building damage
1	23.7722	86.2192	South of Block II (2 areas)	Cracks on the ground
2	23.7817	86.2409	Terrain Change due to mining	
3	23.7811	86.2521	Terrain Change due to mining	
4	23.7792	86.2376	Terrain Change due to mining	
5	23.7983	86.2473	Terrain Change due to mining	
6	23.7981	86.2510	Terrain Change due to mining	
7	23.8088	86.2521	Terrain Change due to mining	
8	23.7941	86.2636	Terrain Change due to mining	
9	23.7926	86.2671	Terrain Change due to mining	
10	23.7868	86.2724	Terrain Change due to mining	
11	23.7928	86.2746	Terrain Change due to mining	
12	23.7800	86.2857	Terrain Change due to mining	
13	23.7713	86.3171	Terrain Change due to mining	
14	23.7783	86.3270	Terrain Change due to mining	
15	23.7893	86.3419	Terrain Change due to mining	
16	23.7734	86.3556	Terrain Change due to mining	
17	23.7734	86.3762	Terrain Change due to mining	
18	23.7804	86.3742	Terrain Change due to mining	
19	23.7865	86.3769	Terrain Change due to mining	
20	23.7855	86.3890	Terrain Change due to mining	
21	23.7679	86.4199	Bastacolla	Sagged areas
22	23.7390	86.4071	Simlabahal UG	Sagged areas
23	23.7417	86.4431	Terrain Change due to mining	
24	23.7176	86.4163	Terrain Change due to mining	
25	23.7085	86.4339	Terrain Change due to mining	
26	23.6986	86.4304	Terrain Change due to mining	
27	23.6923	86.4312	Terrain Change due to mining	
28	23.6977	86.4466	Terrain Change due to mining	
29	23.7092	86.3967	Terrain Change due to mining	
30	23.6985	86.3942	Terrain Change due to mining	
31	23.6845	86.3681	Terrain Change due to mining	
32	23.6804	86.4083	Terrain Change due to mining	
33	23.6685	86.4110	Terrain Change due to mining	
34	23.6706	86.4211	Terrain Change due to mining	
35	23.6603	86.4366	Terrain Change due to mining	
36	23.6568	86.4454	Terrain Change due to mining	
37	23.6760	86.4516	Terrain Change due to mining	
38	23.7603	86.3836	Terrain Change due to mining	
39	23.7734	86.3609	Terrain Change due to mining	
40	23.7948	86.3715	Terrain Change due to mining	

Annexure –III

SL. NO.	COLLIERY AREA NAME	FIRE AREA 2012 (SQ. KM.)	FIRE AREA 2017 (SQ. KM.)	AREA CHANGE (SQ. KM.)	Increase/Decrease
1	DAMODA	0.0000	0.0000	0.000	NO FIRE
2	TISCO (west)	0.0000	0.0000	0.000	NO FIRE
3	IISCO	0.0000	0.0000	0.000	NO FIRE
4	TISCO (north)	0.0885	0.0153	-0.073	DECREASE
5	NUDKHURKEE OCP	0.0000	0.0000	0.000	NO FIRE
6	BENEDIH OCP	0.0530	0.0453	-0.008	DECREASE
7	BLOCK-II OCP	0.0530	0.1353	0.082	INCREASE
8	MURAIH OCP	0.1478	0.0022	-0.146	DECREASE
9	SHATABDI OCP	0.0378	0.0361	-0.002	DECREASE
10	TETURIA	0.0000	0.0000	0.000	NO FIRE
11	S.GOVINDPUR	0.0000	0.0000	0.000	NO FIRE
12	KORIDIH BLOCK-IV OCP	0.0000	0.0000	0.000	NO FIRE
13	JOGIDIH	0.0000	0.0000	0.000	NO FIRE
14	DHARAMABAND	0.0000	0.0000	0.000	NO FIRE
15	MAHESHPUR	0.0000	0.0000	0.000	NO FIRE
16	PHULARITAND	0.0133	0.0205	0.007	INCREASE
17	MADHUBAND	0.0000	0.0000	0.000	NO FIRE
18	AKASH KINARI	0.0000	0.0000	0.000	NO FIRE
19	GOVINDPUR	0.0000	0.0000	0.000	NO FIRE
20	E. KATRAS	0.0133	0.0000	-0.013	DECREASE
21	KATRAS-CHOITUDIH	0.1021	0.1368	0.035	INCREASE
22	KESHALPUR	0.0000	0.0013	0.001	INCREASE
23	RAMKANALI	0.0000	0.0000	0.000	NO FIRE
24	NICHITPUR	0.0000	0.0000	0.000	NO FIRE
25	E. BASURIA	0.0000	0.0000	0.000	NO FIRE
26	KHAS KUSUNDA	0.0000	0.0000	0.000	NO FIRE
27	GONDUDIH	0.0000	0.0000	0.000	NO FIRE
28	W. GODHAR	0.0012	0.0000	-0.001	DECREASE
29	BASURIA	0.0000	0.0000	0.000	NO FIRE
30	TETULMARI	0.0223	0.0220	0.000	DECREASE
31	DHANSAR	0.0000	0.0000	0.000	NO FIRE
32	GODHAR	0.1073	0.0000	-0.107	DECREASE
33	INDUSTRY	0.0119	0.0513	0.039	INCREASE
34	KUSUNDA	0.4243	0.7398	0.315	INCREASE
35	SENDRA-BANSJORA	0.0796	0.0275	-0.052	DECREASE
36	BASTACOLLA	0.0663	0.0810	0.015	INCREASE
37	BERA	0.0000	0.0000	0.000	NO FIRE
38	KUYA	0.0000	0.0000	0.000	NO FIRE
39	GOLUCKDIH	0.0301	0.1122	0.082	INCREASE
40	KUJAMA	0.0398	0.2404	0.201	INCREASE

41	S. JHARIA-R. OCP	0.0244	0.1118	0.087	INCREASE
42	DOBARI	0.0000	0.0000	0.000	NO FIRE
43	GONHOODIH	0.0398	0.0322	-0.008	DECREASE
44	SIMLABAHAL	0.0000	0.0000	0.000	NO FIRE
45	HURRILADIH&STD	0.0000	0.0000	0.000	NO FIRE
46	ENA	0.0918	0.0432	-0.049	DECREASE
47	BURRAGARH	0.0000	0.0000	0.000	NO FIRE
48	N. TISRA	0.0098	0.1802	0.170	INCREASE
49	LODNA	0.0000	0.3527	0.353	INCREASE
50	S. TISRA	0.0000	0.1015	0.102	INCREASE
51	BARAREE	0.1037	0.1074	0.004	INCREASE
52	AMLABAD	0.0000	0.0000	0.000	NO FIRE
53	PATHERDIH	0.0000	0.0000	0.000	NO FIRE
54	SUDAMDIH	0.0000	0.0000	0.000	NO FIRE
55	SITANALA	0.0000	0.0000	0.000	NO FIRE
56	MURULIDIH 20/21 PIT	0.0000	0.0000	0.000	NO FIRE
57	MURULIDIH	0.0000	0.0000	0.000	NO FIRE
58	BHATDIH	0.0000	0.0000	0.000	NO FIRE
59	LOHAPATTY	0.0000	0.0000	0.000	NO FIRE
60	IISCO	0.0000	0.0000	0.000	NO FIRE
61	TASRA-IISCO	0.0000	0.0000	0.000	NO FIRE
62	KENDUADIH	0.0610	0.0000	-0.061	DECREASE
63	BULLIHARY	0.0000	0.0000	0.000	NO FIRE
64	GOPALICHUCK	0.0000	0.0000	0.000	NO FIRE
65	POOTKEE	0.0000	0.0000	0.000	NO FIRE
66	BHURUNGIA	0.0000	0.0000	0.000	NO FIRE
67	KHARKHAREE	0.0000	0.0000	0.000	NO FIRE
68	GASLITAND	0.1194	0.1215	0.002	INCREASE
69	KANKANEE	0.0530	0.0525	-0.001	DECREASE
70	MUDIDIH	0.1141	0.1104	-0.004	DECREASE
71	W. MUDIDIH	0.0171	0.0000	-0.017	DECREASE
72	LOYABAD	0.0133	0.0063	-0.007	DECREASE
73	BHAGABAND	0.0000	0.0000	0.000	NO FIRE
74	MOONIDIH PROJECT	0.0000	0.0000	0.000	NO FIRE
75	E.BHUGGATDIH	0.0022	0.0214	0.019	INCREASE
76	ALKUSHA	0.0326	0.0294	-0.003	DECREASE
77	KUSTORE	0.0524	0.0463	-0.006	DECREASE
78	ANGARAPATRA	0.1331	0.0149	-0.118	DECREASE
79	SALANPUR	0.0000	0.0000	0.000	NO FIRE
80	BHOWRAH. N	0.0133	0.0980	0.085	INCREASE
81	BHOWRAH. S	0.0000	0.0000	0.000	NO FIRE
82	BAGDIGI	0.0000	0.0209	0.021	INCREASE
83	JEALGORA	0.0000	0.0067	0.007	INCREASE
84	JEENAGORA	0.0000	0.0470	0.047	NO FIRE

85	JOYRAMPUR	0.0099	0.1042	0.094	INCREASE
86	CHANDAN OCP	0.0000	0.0000	0.000	NO FIRE
87	BANSDEOPUR	0.0000	0.0000	0.000	NO FIRE
TOTAL AREA		2.18	3.28	1.10	INCREASE

Table 6: Colliery wise break-up of change in fire area from 2012 to 2017

Note:

- 1) "**NO FIRE**" implicates that the fire has not been identified satellite data (*either absent or below sensor resolution*)
- 2) "**INCREASE**" implies, increase in fire area OR emergence of fire areas not identified in 2012 study.
- 3) "**DECREASE**" implies, decrease in fire area OR fire areas of 2012, which are not identified in present study (*either absent or below sensor resolution*).
- 4) Estimations of fire extent (in terms of sq.km.) both 2012 and in present 2017 study are pixel based. They do not represent the actual ground area under fire. These estimations are made for comparative purpose only, to indicate the increase or decrease of areal disposition of fire. Hence, they should not be quoted as fire area on the ground.

Annexure –IV



Figure 15: Fume cracks in Lodna-Tisra Area. (point 39 in figure 13 and table 4)



Figure 16: Burnt area near OB dump in Lodna area (point 41 in figure 13 and table 4)



Figure 17: Coalfries in active seams in Kusunda (point 23 in figure 13 and table 4)



Figure 18: Sagged area due to subsidence, south of Block II OCP. (point 1 in figure 14 and table 5)



Figure 19: Fire in OB dumps in Kusunda area. (point 24 in figure 13 and table 4)



Figure 20: Fume cracks in the Bhulanbarari area.



CSR Booklet

Barora Area

Bharat Coking Coal Limited

Contents

1.0 INTRODUCTION	2
2.0 SCOPE	2
3.0 SOURCE OF FUND	2
4.0 ACTION PLAN FOR CORPORATE SOCIAL RESPONSIBILITY	3
5.0 STATUS OF CSR ACTIVITIES	3
5.1 Medical Camps	3
5.2 Health Awareness Programme	3
5.3 CSR Clinics.....	3
5.4 Civil work under CSR.....	5
6.0 COAL TRANSPORTATION PLAN.....	7
7.0 REHABILITATION AND RESETTLEMENT PLAN	8

1.0 INTRODUCTION

Coal India has adopted CSR as a strategic tool for sustainable growth. For Coal India in the present context, CSR means not only investment of funds for Social Activity but also Integration of Business processes with Social processes. Even much before the issue of CSR became global concern; Coal India was aware of its Corporate Social Responsibility and was fulfilling the aspiration of the Society through well-defined “Community Development Policy” within the periphery of 8 Kms. of the Project sites. This has resulted into a harmonious relationship between Coal India and the peripheral Communities. Coal India has identified land outsee, PAP and those staying within the radius of 25 Kms of the Project as primary beneficiaries. Poor and needy section of the society living in different parts of India is second beneficiaries. For carrying out CSR activities, 80% of the budgeted amount are spent within the radius of 25 Km of the Project Site/Mines/Area HQ/Company HQ and 20% of the budget to be spent within the States in which operating.

2.0 SCOPE

As per Schedule VII of New Companies Act 2013 the following should be the Scope of Activities under Corporate Social Activities:

- 1) Eradicating hunger, poverty and malnutrition, promoting healthcare including preventive health care and sanitation and making available safe drinking water.
- 2) Promoting education, including special education and employment enhancing vocation skills especially among children, women, elderly, and differently able and livelihood enhancement projects.
- 3) Promoting gender equality, empowering women, setting up homes and hostels for women and orphans, setting up old age homes, day care centers and such other facilities for senior citizens and measures for reducing inequalities faced by socially and economically backward groups.
- 4) Ensuring environmental sustainability, ecological balance, protection of Flora and Fauna, animal welfare, agro-forestry, conservation of natural resources and maintaining quality of soil, air and water.
- 5) Protection of national heritage, art and culture including restoration of buildings and sites of historical importance and works of art; setting up public libraries, promotion and development of traditional arts and handicrafts.
- 6) Measures for the benefit of armed forces veterans, war widows and their dependents
- 7) Training to promote rural sports, nationally recognized sports, Paralympics sports and Olympic Sports.
- 8) Contribution to the Prime Minister’s National Relief Fund or any other fund set up by the Central Government for socio-economic development and relief and welfare of the Scheduled Castes, the Scheduled Tribes, other backward classes, minorities and women.
- 9) Contributions or funds provided to technology incubators located within academic institutions which are approved by the Central Government.
- 10) Rural development projects.

3.0 SOURCE OF FUND

The fund for the CSR should be allocated based on 2% of the average net profit of the Company for the three immediate preceding financial years or Rs. 2.00 per tonne of Coal Production of previous year whichever is higher.

4.0 ACTION PLAN FOR CORPORATE SOCIAL RESPONSIBILITY

When the EC was granted, it was estimated as per prevailing policy, 5% of the retained earnings of the previous year subject to minimum of Rs. 5 per tonne of coal production of the previous year will be provided for Corporate Social Responsibility (CSR).

5.0 STATUS OF CSR ACTIVITIES

5.1 Medical Camps:

(A) During FY 2014-15:

SN	Month	No. of Medical Camp	Beneficiaries	Amount (in Rs.)
1	April 14	24	538	6074.02
2	May 14	15	555	6265.95
3	June 14	17	423	4775.67
4	July 14	11	300	3387.00
5	August 14	13	422	4764.38
6	September 14	19	630	7112.70
7	October 14	14	415	4685.35
8	November 14	15	350	3951.50
9	December 14	15	413	4662.77
10	January 15	10	257	2921.52
11	February 15	17	517	5836.93
12	March 15	11	324	3657.96
	Total	181	5144	58095.75

(B) During FY 2015-16:

SN	Month	No. of Medical Camp	Beneficiaries	Amount (in Rs.)
1	April 15	12	325	3669.25
2	May 15	12	289	3262.81
3	June 15	13	335	3782.15
4	July 15	14	452	5103.08
5	August 15	12	348	3928.92
6	September 15	9	265	2991.85
7	October 15	9	360	4064.40
8	November 15	9	305	3443.45
9	December 15	6	148	1670.92
10	January 16	12	291	3285.39
11	February 16	11	229	2585.41
12	March 16	2	50	564.50
	Total	121	3397	38352.13

(C) During FY 2016-17:

SN	Month	Beneficiaries	Amount (in Rs.)
1	May 16	243	13463.00
2	Nov 16	352	16857.00
	Total	595	30320.00

(D) During FY 2017-18: NIL**5.2 Health Awareness Programme:****(A) During 2014-15:**

SN	Date	Activities	Amount (in Rs.)
1	25.04.2014	Nasa Mukti Abhiyan	10000.00
2	06.06.2014	Blood Pressure Detection	5000.00
4	30.07.2014	Aids Awareness Programme	5000.00
5	20.11.2014	Eye Checkup camp	25000.00

5.3 CSR Clinics :

SN	Month	Beneficiaries 2014-15	Beneficiaries 2015-16	Beneficiaries 2016-17	Beneficiaries 2017-18
1	April	121	115	307	113
2	May	112	101	70	98
3	June	137	152	164	115
4	July	153	132	260	161
5	August	101	120	149	127
6	September	531	109	139	169
7	October	83	86	139	99
8	November	85	87	241	66
9	December	73	80	207	99
10	January	67	80	99	73
11	February	102	158	55	77
12	March	95	81	65	96
	Total	1660	1301	1895	1293

5.4 Civil work under CSR:**(A) During 2014-15:**

S. N.	Details	Award value (In Lac)	Remarks
1	Construction of PCC road at Gonduadih west under Mohanpur village (from Khalil Mahto home to Primary school).	3.98	25.01.2015 to 24.03.2015 (60 days)
2	Construction of Janaja shed at Ramakunda west under Amtand village	3.15	15.10.2014 to 14.12.2014 (60 days)
3	Construction of 1 no. chhathh ghat at Muraidih colony, Hirak road river side	3.01	15.10.2014 to 14.12.2014 (60 days)
4	Construction of Janaja shed at Muraidih colony near river of Hirak road	0.46	31.03.2014 to 29.04.2014 (30 days)
	PCC Road jhunu Rajwar House to Tarkeswar Gope House at Bakaspura Village Luti Pahari (Jhunu Tarkeshwar) Road Length:-	2.30	This is benefiting to approx. 200 families in this locality by all-weather connectivity.
	Making PCC Path from Manoj Matha House to Sahabuddin Ansari house at Ghunghusa Village (Mahato Shahbhuddin)	1.85	This is benefiting to approx. 300 families in this locality by all-weather connectivity
	Steps for Ghat at sarbandh near hirak chowk under B-II Area	2.67	This will ease in performing rituals by local villages of Dumara ,harina & Bada pandeydih.
	Cutting of earth from pond at Chaudhary bandh at Harina Basti, under B-II Area	19.22	This is benefiting to approx 5000 persons in this locality. This pond is used for multipurpose like irrigation, water for households drinking water for animals etc. it will also maintain the water level in locality.
	Drinking Water pipe line works in hadi basti at Bhamkanali.	0.44	This is benefiting to approx. 150 families in this locality
	Rep/Maint of Hand pump at Bara pandeydih (08 Nos).	0.26	This is benefiting to approx. 500 persons in this locality
	Development work at rehabilitation site at Bhimkanali.	6.45	This is benefiting to approx. 500 persons in this locality
	Construction of community hall at Bara Pandeydih Village Under Block-II Area	11.9	This is benefiting to approx. 1000 persons in this locality
	Surplus mine water supply from Xth seam & Madhuban quarry of B-II Area Khonathi Pond	400	This is a multipurpose project to provide water for irrigation & other agricultural use along with maintaining water availability throughout the year along with developing a tourist destination in long run.

(B) During 2015-16:

S.N.	Details	Award value (In Lac)	Remarks
1	Rep. Of Main road & Drain at Bakashpura rehabilitation site.	9.71	This is benefiting to approx. 1500 persons in this locality
2	Engagement of tankers for drinking water supply in nearby villages of B-II Area	1.9	This is benefiting to approx. 2000 families in Viallages like Benidih Baghmara, Luttipahadi, Harina, Kessurgarh, Rathtand, Nudkhurkee, Pinalgarhia, Mandra.
3	Engagement of departmental tankers for drinking water supply in nearby villages of B-II Area as on need bais.	-	This is benefiting to approx. 2000 families in Viallages like Benidih Baghmara, Luttipahadi Kessurgarh, Madhuban Etc.

(B) During 2016-17:

S.N.	Details	Award value (In Lac)	Remarks
1	Construction and maintenance for 5 years of toilets in Government schools in Gumla District under Swachh Vidyalaya Abhiyan. 125 toilets in 69 schools were constructed.	191.67	This is benefiting to approx. 7500 students
2	Construction and maintenance for 5 years of toilets in Government schools in Bokaro District under Swachh Vidyalaya Abhiyan. 179 toilets in 181 schools were constructed.	1702.98	This is benefiting to approx. 10000 students

6.0 COAL TRANSPORTATION PLAN:

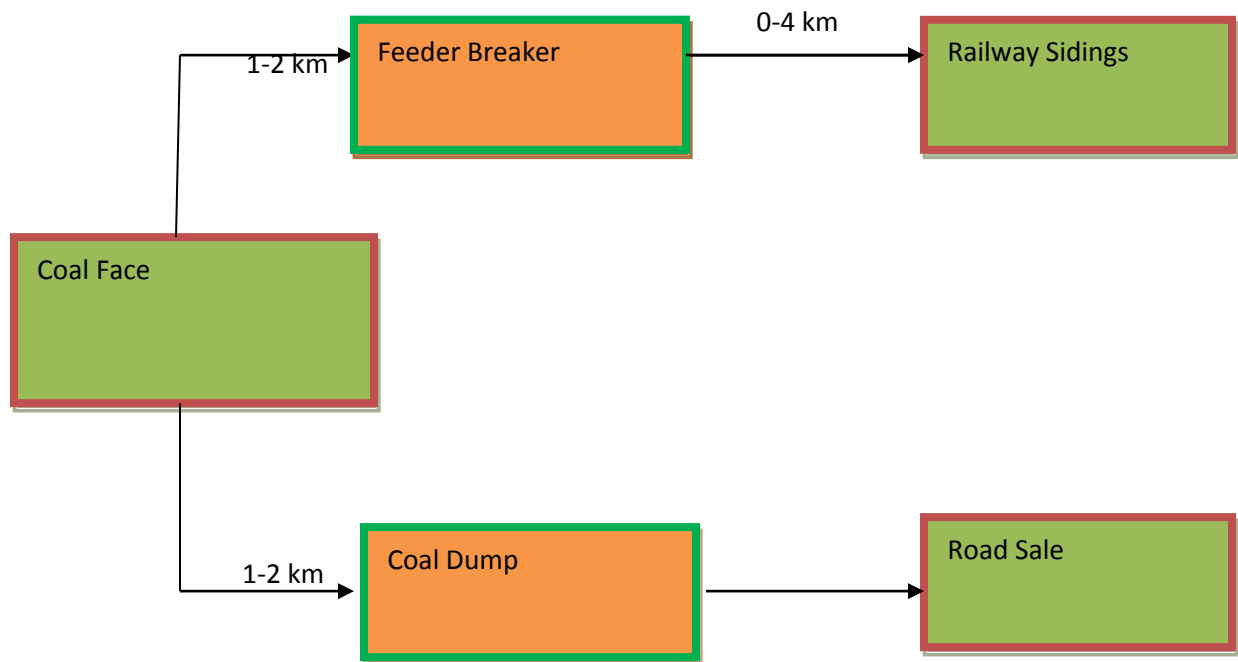


Fig: Coal transportation route

7.0 REHABILITATION AND RESETTLEMENT PLAN:

REHABILITATION AND RESETTLEMENT POLICY OF COAL INDIA LTD 2012.

Preamble

The location and quality of coal reserves, and their distance from major consumers determines to a great extent the selection of mine sites. For reserves that are close to the surface, opencast mining has proven to be the most efficient mining method. Opencast mines require relatively large areas of land. Population growth, particularly in India's eastern region, has made it increasingly difficult for the subsidiary coal companies to acquire the land they need for expanding their operations under the present Resettlement and Rehabilitation policy, 2008 of Coal India.

The resettlement and rehabilitation policies followed by the subsidiary companies have evolved over time and undergone numerous changes in response to changing circumstances. As and when the Central or State Governments enact amendments to the Land Acquisition Act, issue new guidelines for resettlement and rehabilitation, as per its requirement Coal India reviews and modifies its resettlement and rehabilitation policy taking into account the changing conditions in coal producing areas.

In addition to compensation for land coal companies provide Rehabilitation and Resettlement (R&R) package for project affected persons to compensate for loss of livelihood. Apart from compensation for house site, house, trees, cow shed, cost of shifting etc., employment is also provided to land oustees. In addition to this, efforts are made to rehabilitate them by construction of houses, building roads, streets, schools, providing water etc. wherever feasible. However, demand for both more land compensation and better R&R package has been raised by project affected persons and has been highlighted in various Parliamentary Committees. Coal Companies often have to face representations and agitations by these land oustees who obstruct the smooth working of existing mines and come in the way of expansion of new projects.

In the past, subsidiaries found it relatively easy to acquire land, if they were able to offer employment. Partly because of this practice, subsidiaries have built up a largely unskilled labour force beyond their needs. This has contributed to the heavy losses and many mines are incurring and has also affected their efficiency and viability. The subsidiaries may still need to hire people in selected locations and continue to give preference to those whose livelihood will be affected by coal mining operations. However, increasingly subsidiaries will need to develop other ways and means to compensate land owners and others adversely affected by their projects and give them the option to choose which method of compensation best suits their needs. Greater emphasis will also need to be given to community requirements like schools, hospitals etc. Only proper resettlement and rehabilitation will elicit the required cooperation of project affected people, and make it possible for Coal India to acquire the land it needs to fulfill the ever increasing demand of coal for the economic development of the Country.

- 1 -

The purpose of the Resettlement and Rehabilitation Policy 2012 is to revise and provide greater flexibility to the basic principles for the resettlement and rehabilitation of people affected by coal mining projects i.e. Project Affect People (PAPs). It attempts to consolidate the different resettlement and rehabilitation practices that are being followed by subsidiaries as per the different State land Acquisition Acts and various decisions of the Coal India Board and to modify the Policy of 2008 so as to give the Board of the subsidiary Companies greater flexibility to deal more effectively with resettlement and rehabilitation issues and determine the rehabilitation packages best suited to local needs in line with this policy. The provisions of the National Rehabilitation and Resettlement Policy, 2007 and the Land Acquisition, Rehabilitation & Resettlement Bill, 2011 have also been kept in mind while framing the policy.

While Coal India's basic philosophy for compensating land-losers and other project-affected people remains substantially unchanged, the revised policy emphasizes the need to cultivate and maintain good relationships with the people affected by Coal India's projects starting as early as possible; it also underscores that the subsidiaries have a responsibility towards the land oustees whose livelihood is often taken away. On the other hand, subsidiaries need to protect themselves more effectively against unjustified claims, redundant manpower and swelling Wage Bills. To this end, the statement proposes that subsidiaries prepare detailed resettlement and rehabilitation action plans (RAPs) that clearly identify, at an early stage, the entitlements of the people affected by coal projects and enables them to exercise a choice between various options. The concept of Annuity in lieu of compensation/employment is also being introduced to mitigate, if not eliminate the ever dependence of Project Affected Families (PAFs) on CIL for provision of employment.

(1) The revised Resettlement & Rehabilitation Policy, 2012 is based on the deliberations of the inter Ministerial Committee set up vide O.M. 490191/2011-PRIW-I dated 01-07-2011 of Ministry of Coal, deliberations of the CMDs meet held on 05/03/2012 at New Delhi and has been approved by the CIL Board in its 279th meeting held on 12th and 13th March, 2012.

(2) Objectives and general principles of Coal India's Resettlement and Rehabilitation Policy- 2012

- A. To re-visit CIL's existing R&R policy 2008 and evolve a PAP friendly policy by incorporating such provisions of the National Policy and The Draft Land Acquisition, Rehabilitation and Resettlement Bill-2011 as considered suitable in light of the growing difficulties many subsidiaries face in land acquisition.
- B. To accord the highest priority for avoiding or minimizing disturbance of the local population while taking decisions to open new mines or expand existing ones too (exploring alternative sites and project designs) and to ensure that wherever people are likely to be adversely affected by a project, the subsidiaries will prepare resettlement and rehabilitation action plans for the project.
- C. To ensure a humane, participatory, informed consultative and transparent process for land acquisition for coal mining and allied activities with the least disturbance to the owners of the land and other affected families.
- D. To provide just and fair compensation to the affected families whose land has been acquired or proposed to be acquired or are affected by such acquisition and make

adequate provisions for loss of livelihood of such affected persons including their rehabilitation and resettlement.

- E. To ensure that the cumulative outcome of compulsory acquisition should be that the affected persons become partners in development leading to an improvement in their post acquisition social and economic status and matters connected therewith or incidental thereto.
- F. Through the preparation of resettlement and rehabilitation action plans, subsidiaries will safeguard that project-affected people improve or at least regain their former standard of living and earning capacity after a reasonable transition period. The transition period is to be kept to a minimum. However, the involvement of subsidiaries in resettlement and rehabilitation activities may continue until all the actions specified in the rehabilitation plan have been completed.
- G. Involuntary resettlement is conceived and executed as a development programme with project-affected people being provided sufficient resources and opportunities to share in a project's benefits. The efforts of subsidiaries are complementary to the Government's schemes in rural development and the concurrence, approvals and support from concerned Government authorities will be sought.
- H. In parallel, subsidiaries will work closely with non-governmental organizations of proven repute which are legally constituted and recognized and also have the confidence of the project-affected people, in the preparation and implementation of rehabilitation plans.
- I. Corporate Social Responsibility (CSR) : Activities shall be intensified in and around the villages where land is being acquired in accordance with the CSR Policy of Coal India.
- J. Actual implementation of R&R package must follow a detailed survey of the project-affected villages to formulate the list of persons/families affected by the project, nature of the affect, the likely loss of income, etc. For this purpose, if necessary, the services of a reputed NGO with an impressive record of integrity and performance may be engaged.

3. SCOPE:

This Policy may be called "Rehabilitation and Resettlement Policy of Coal India Limited-2012". It extends to the Coal India Limited and its subsidiary companies in India. It shall come into force from the date of its approval by the CIL Board and is applicable to all cases in which land is taken after the date of approval by the CIL Board. While implementing the policy it is to be ensured that the provisions of the concerned Acts applicable and Rules mentioned there under shall not be violated .

4. Definitions

(a) "affected family" means:

- (i) a family whose primary place of residence or other property or source of livelihood is adversely affected by the acquisition of land (including direct negotiation) for a project or involuntary displacement for any other reason; or

- (ii) any tenure holder, tenant, lessee or owner of other property, who on account of acquisition of land (including plot in the *abadi* or other property) in the affected area or other wise, has been involuntarily displaced from such land or other property; or
- (iii) any agricultural or non-agricultural labourer, landless person (not having homestead land, agricultural land, or either homestead or agricultural land), rural artisan, small trader or self-employed person, who has been residing or engaged in any trade, business, occupation or vocation continuously for a period of not less than three years preceding the date of declaration of the affected area, and who has been deprived of earning his livelihood or alienated wholly or substantially from the main source of his trade, business, occupation or vocation because of the acquisition of land in the affected area or being involuntarily displaced for any other reason.

(b) "**family**" includes a person, his/her spouse, son including minor sons, dependant daughters, minor brothers, unmarried sisters, father, mother residing with him or her and dependent on him/her for their livelihood; and includes "**nuclear family**" consisting of a person, his/her spouse and minor children. Provided that where there are no male dependants, the benefit due to a land loser may devolve on dependent daughter nominated by the land loser.

(c) "**land owner**" includes any person—

- (i) whose name is recorded as the owner of the land or part thereof, in the records of the concerned authority; or
- (ii) who is entitled to be granted Patta rights on the land under any law of the State including assigned lands; or
- (iii) who has been declared as such by an order of the court or District Collector;

(d) **Displaced person** - means and includes any person who is deprived of his homestead on account of acquisition. Provided that the person/family who does not ordinarily reside in the homestead land acquired for the project can be termed "Displaced" but he will be eligible for compensation only for homestead and not for livelihood.

(e) **Ordinarily resides**" shall mean residing in the homestead / acquired land for a period more than 6 months every year for at least the preceding 5 years.

5. Socio-economic Survey and preparation of RAP.

A baseline socioeconomic survey will be carried out to identify the PAPs who are enlisted to receive benefits in line with Coal India's Resettlement and Rehabilitation Policy. This survey will be conducted within two months of notification under the relevant land acquisition Acts by the subsidiaries with the help of reputed independent institutional agencies, who are well versed with the social matrix of the area.

The basic objective of the socio-economic study will be to generate baseline data on the social and economic status of the population who are likely to lose their means of livelihood or homestead due to the acquisition of the land for the project. The data base will be used to formulate a viable and practical Rehabilitation Action Plan (RAP) for the affected persons in line with their entitlements. Digital Satellite Maps would also be prepared of the project Area freezing the dwelling units and habitations existing at the time of negotiation for Land Acquisition wherever feasible. The RAP will also address the following-

(A) Implementation, Monitoring and Evaluation, Dispute Mechanism

The rehabilitation action plan will address the following:

- i) The project design, including an analysis of alternative designs aimed at avoiding or minimizing resettlement;
- ii) Socio-economic survey and activities to ensure restoration of incomes of PAPs in line with Coal India's Resettlement and Rehabilitation Policy;
- iii) Description of the institutional and other mechanisms for provision of entitlements;
- iv) Time table for the acquisition and preparation of the resettlement site(s);
- v) The cost and budgets for the resettlement and rehabilitation of PAFs;
- vi) Project-specific arrangements to deal with grievances of PAFs; and
- vii) Time tables, benchmarks and arrangements for monitoring the resettlement and rehabilitation effort.

The RAP will be formulated in consultation with PAPs and State government.

(B). Environment Impact Assessment (EIA) will be conducted as per any law, rule and regulation of the locality in which the land has been acquired.

6. Eligibility Criteria -

(A) Eligibility Criteria for Economic Rehabilitation Benefits

This benefit shall accrue only to Entitled Project Affected Person. Entitled Project Affected Person shall be one from the following categories.

- (i) Persons from whom land is acquired including tribals cultivating land under traditional rights.
- (ii) Persons whose homestead is acquired.
- (iii) Sharecroppers, land lessees, tenants & day labourers.
- (iv) Tribal dependent on forest produce as certified by the District Forest Officer/Revenue Authorities.

(B) Eligibility Criteria for Resettlement Benefits

1. Only a 'Displaced' family / person shall be eligible for resettlement benefits.
2. A family/person shall be termed 'displaced' and hence eligible for resettlement benefits if such family/person has been a permanent resident and ordinarily residing in the project area on the date of publication of notification U/S 9 of CBA(A&D) 1957 / U/S 11 of LA Act, 1894/ Or both/ on the date of the land vested with the State/ Central government as the case may be.
and
(a) on account of acquisition of his/her homestead land / structure is displaced from such areas
or
(b) He/she is a homesteadless or landless family/person who has been/is required to be displaced.

7. Census & Identification of displaced families:

1. Within two months of publication of notice U/S 4(1) of the Land Acquisition Act or U/S 7(1) of CBA (A.D) Act 1957 for acquisition of land for the project a census would be undertaken in the manner to be decided by the Collector / project authority for identification of displaced families and for preparing their socio-economic profile and list of eligible persons for the purpose of receiving Rehabilitation & Resettlement Benefits.

2. A photo identity card to each Entitled Project Affected Person shall be issued under the signature of the Collector / project authority concerned indicating the following particulars:

- (a) Name of the village/GP/PS :
- (b) Name, Father's name and address of the head of the family :
- (c) Category of entitlement :
- (d) Whether S.C./S.T./O.B.C./General :
- (e) Age, Sex, educational qualification of the members of the family :

8. Types of Compensation and Rehabilitation Entitlement

Option to the land losers regarding Rehabilitation & Resettlement Benefit - The land losers shall have the option for Rehabilitation and Resettlement benefits in accordance with the awards for each affected family in terms of the entitlements passed by the Concerned Collector of the State or as per this Policy with the consent of the concerned Collector.

8.1 Eligibility and Compensation

The table below shows the compensation and rehabilitation benefits will be offered by the subsidiaries for each Project Affected Person or family, affected by one of their projects. Evidence to the effect that a person is a legitimate PAP will need to be provided in the form of a written legal document, or reference to a record, such as a revenue officer certificate, electoral roll, ration card or school record.

Category of Persons affected by the Project	Compensation and Rehabilitation entitlement option
	Provisions
(i) Persons (including tribals cultivating land under traditional rights) from whom land is acquired.	All land owners with titles will receive monetary compensation for the land acquired from them. The value of the land is determined on the basis of prevailing legal norms. <i>In respect of tribals cultivating land under traditional rights, authentication of land held under traditional rights by state authorities will be necessary.</i> In addition to above the following shall apply.

Category of Persons affected by the Project	Compensation and Rehabilitation entitlement option
	Provisions
	<p>A). Land Compensation - Land compensation shall be paid as per the provisions of the concerned Act or State Govt. notification. Where no notification of the State Govt. is available the concerned subsidiary Board may decide on the rate of compensation keeping in view the compensation provided by the neighboring states. Authentication of land held under traditional rights by state authorities will be necessary.</p> <p>In addition to above Solatium will be paid as per provisions of the concerned Act / as imposed by the Concerned State Govt.</p> <p>Escalation of land compensation – Escalation will be paid as per provisions of the concerned Act / as imposed by the Concerned State Govt. or Escalation at the rate of 12% per annum for a maximum period of three years.</p> <p>(B): Employment provision: Apart from payment of the land compensation, employment may be given in the following manner –</p> <ol style="list-style-type: none"> 1) The maximum total number of employments that may be provided to the land losers would be limited to the total no. of acres of land acquired divided by two. However employments will be released in proportion to the land possessed . 2) For every two acres of land one employment can be considered; 3) Subsidiaries of CIL may give an option to the Land losers having less than two acres of land to club together their land to the extent of two acres and nominate one of the land losers among the groups or their dependent for employment under package deal or employment under Descending order system by preparing the list of eligible land oustees in the descending order of land lost subject to the cut off equivalent to the total number of permissible employments or any other method with the approval of the respective Board of the subsidiary. 4) The land loser must be a domiciled resident/Mool Niwasi and the certificate to this effect shall be issued by the concerned State Authority 5) The modalities for offering employment shall be such as may be approved by the Board of the Subsidiary companies as per the unique conditions of the subsidiary provided that - <ol style="list-style-type: none"> a) The initial employment shall be given with pay of Category-I pay scale of NCWA, with training period of 6 months. b) In the seniority list, the seniority of the appointee should be reflected in appropriate manner in order to keep the senior most as senior. c) The land loser trainees shall be posted as per requirement, including underground duties.

Category of Persons affected by the Project	Compensation and Rehabilitation entitlement option
	Provisions
	<p>(C): Lumpsum Monetary Compensation –</p> <p>1. All the land losers who are not eligible for employment as above shall be entitled to receive monetary compensation in lieu of employment at the rate of Rs.5,00,000/- (Five Lakhs) for each acre of land on pro-rata basis .</p> <p>2. Land losers who are offered employment as per principle specified in point No (8.(i)B) above will have the option either to opt for employment or to forego employment and opt for monetary compensation at the rate of Rs.5,00,000/- (Five lakhs) for each acre of land on pro-rata basis with minimum of Rs. 50,000 (Fifty thousands) provided that the employment thus surrendered shall not be available for offer to any other person and will stand lapsed from the total sanctioned number of employments as specified in point No.(8.(i)B1).</p> <p>3. The Land losers who have clubbed their land in Package Deal can claim employment for only one land loser of the clubbed two acres of land and remaining land losers of the package cannot claim either employment or lump sum monetary compensation in lieu of the land contributed by them.</p> <p>4. Annuity – All land losers who are entitled to get lump sum monetary compensation may opt for payment of compensation amount in the form of annuity made payable to the land losers monthly, annually or at such intervals (not less than one year) as may be opted for by him. The annuity be paid for a maximum period extending to 60 years of age or the life of the project for which the land has been acquired, whichever is earlier.</p> <p>Note: A person receiving a job forgoes all claims to above compensation and a person receiving above compensation forgoes all claims to employment.</p>
(ii) Person whose homestead is acquired	<p>I. Compensation for homestead shall be paid as per the standard valuation method of the L.A Act. of the concerned State Govt.</p> <p>II. One time lump sum payment of Rs.3,00,000/- (three lakhs),shall be paid in lieu of alternate House site, Assistance in designing Shifting Allowance,compensation for construction of cattle shed , Monetary compensation for construction of work shed etc.The compensation shall be paid to displaced persons only after vacation and demolition of the homestead/ work shed etc.</p> <p>III. Subsistence allowance :Each affected displaced family will get subsistence allowance at the rate of 25 days (Minimum Agricultural Wage) per month for one year.</p>

<i>Category of Persons affected by the Project</i>	<i>Compensation and Rehabilitation entitlement option</i>
	Provisions
(iii) Sharecroppers, land lessees, tenants and day labourers	<p>The subsidiary will assist PAP to take-up non farm self employment through petty contracts or formation of cooperatives. If such co-operatives will not be entitled for awarding work as per Manual for lack of experience, the said co-operative will be facilitated by awarding small jobs to acquire experience after relaxation of the provisions of the Manual pertaining to experience with approval of the Subsidiary Boards. Subsequent jobs may be awarded after getting report of the timely completion / quality / of the awarded jobs from the concerned Department or contractors.</p> <p>Contractors will also be persuaded to give job to eligible PAPs on a preferential basis, where feasible as per terms of contract.</p>
(iv) Landless tribals, Tribal dependent on forest produce	<p>The subsidiary will assist PAP to establish non farm self employment through the provision of infrastructure, petty contracts or formation of cooperatives and encourage provisions of Jobs with contractors. Contractors will be persuaded to give jobs to eligible PAPs on preferential basis, where feasible.</p> <ul style="list-style-type: none"> - In addition, the subsidiaries will shift the tribal community as a unit and provide facilities to meet the specific needs of the tribal community that will allow them to maintain their unique cultural identity. - Tribal affected family will be given one time financial assistance of 500 days of MAW for loss of customary right or usages of forest produce. Loss of customary rights needs to be authenticated by the district authority. - Tribal affected families resettled out of the district shall be given 25% higher rehabilitation and resettlement benefit.

9. Resettlement & Rehabilitation Committee - A Committee will be constituted at project Level under the chairmanship of the Collector to be called the Rehabilitation and Resettlement Committee with the following objectives to monitor and review the progress of implementation of the Rehabilitation and Resettlement scheme and to carry out post-implementation social audits in consultation with the village panchayat in rural areas and municipality in urban areas in the manner will be decided by the concerned State Govt.

- I. To approve the list of land losers and other PAPs;
- II. To approve the list of persons eligible to be offered employment as per R&R Policy;
- III. To approve the detailed Rehabilitation Plan for the project in consultation with the displaced persons and Gram Sabhas;
- IV. To expedite issue of domicile certificates and other necessary documentation required for State Authorities;
- V. To monitor and review the progress of the Rehabilitation Scheme, grant of benefits and handing over of possession of land in a smooth manner;
- VI. To facilitate the land acquisition process in any other manner as may be required including resolution of disputes;
- VII. To carry out post implementation social audit in consultation with the authorities.

10. Community facilities - The subsidiary will provide at the resettlement site a school, road with street light, pucca drain, pond, dugwell and/or tubewell for drinking water supply, community center, place of worship, dispensary, grazing land for cattle and play ground. Similar infrastructural facility, if necessary, will be extended to the host locality. The community facilities and services would be available to all residents of the area, including PAPs and the host population.

The approach for operation of community facilities would be flexible and all efforts will be made to involve the State and local self Government / Panchayat for operating the facilities. To achieve this, subsidiaries will pursue with these agencies to ensure the same. The planning of the community facilities and their construction should be undertaken in consultation with the affected community.

11. Corporate Social Responsibilities - This should be as per Company's Corporate Social Responsibility (CSR) Policy.

12. Monitoring and Evaluation Mechanism.

The RAP will be monitored and evaluated periodically after the completion of the land acquisition process.

- I. The resettlement and rehabilitation activities are the responsibility of a separate group, both at the projects and corporate level, which will be constituted for planning, implementation, monitoring and evaluation of the Rehabilitation Action Plan. At the corporate level the group will be headed by a senior manager, whereas at the project, an executive of the rank of manager will head the group. The project group should have at least one member with social science qualification / experience and skills.

- II. The project group will closely interact with the state authorities during the implementation of the RAP. Although the subsidiaries will develop the plots and infrastructural facilities in the resettlement colony and actively implement the RAP, assistance of State authorities will be taken for administrative services such as allotment of land. Implementation will be planned, monitored and corrective measures will be incorporated in the RAP, if needed. In addition to the State Government, the PAPs, the village leaders including the Pradhans and NGOs will be consulted and associated with the implementation of the RAP.
- III. The Resettlement and Rehabilitation Cell at the corporate level will evaluate the implementation of the RAP after its completion.

13. Flexibility to the Subsidiary Companies – The Subsidiary Companies Boards have been authorised to approve necessary modifications in the R&R Policy with reference to unique conditions prevailing at the concerned Subsidiaries as the policy is not exhaustive.

(The above list is only indicative and not exhaustive)