Annexure – XV

2021

DRAFT REPORT

FOR

Ecosystem Services Study

OF

Dhirauli Coal Block

In
Singrauli Coal Field
District: Singrauli, Madhya Pradesh

Vardan EnviroNet
Certificate No. – NABET/EIA/1922/RA0166

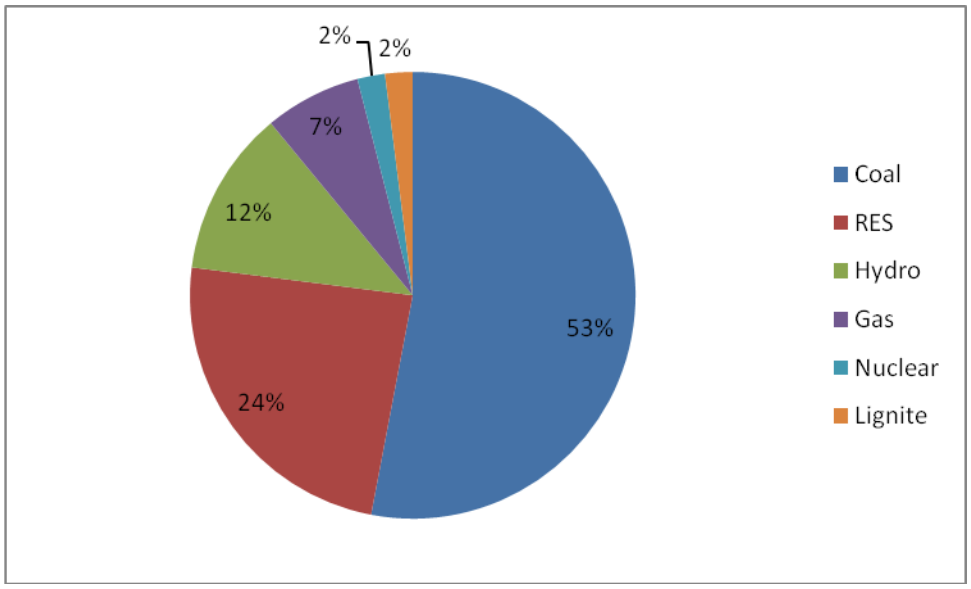
CONTENTS

CHAPTER-1-ECOSYSTEM SERVICES

1. INTRODUCTION

A. COAL MINING

Coal plays a crucial role in the production of electricity in India. As per the CEA data with regard to installed capacity in India (as of Oct'20), coal based installed capacity is about 53%, followed by Renewable Energy Sources (RES) at 24%, while hydro power (12%), gas (7%), nuclear (2%) and lignite (2%) round up the rest. The graph representing the fuel wise contribution to the country's installed power generation capacity is shown in the figure 1.1 below.



Source: https://powermin.nic.in/en/content/power-sector-glance-all-india

Figure 1.1: Fuel-wise contribution in India installed power generation capacity

Mining is one of the major contributors towards the growth and sustenance of human civilization. In this context, coal mining has played a special role since ancient times, as coal is a major source of energy for the development of a society. However, coal mining has its own downside i.e. coal mines lead to degradation of land and especially for an opencast mine, where large tracts of land are used. During production of coal from mines and subsequent transportation of coal, significant pollution is generated. The pollution includes land degradation, air pollution, and water pollution, noise pollution, besides having impact on socio-economic status of the area and flora & fauna.

It is of utmost importance that areas in and around coal mines are subjected to different mitigation measures, so as to make life of the communities living around these areas livable and easy and so that it can also ameliorate the whole adjoining ecosystem. Decommissioning of mines also involves removal of environmental, health and safety hazards.

Coal has been one of the key sources of primary energy for the world, contributing to roughly half of the total primary energy consumption. However, the significance of coal varies across the world with Asia leading the consumption, both in absolute terms and as a proportion of total primary energy consumption. The total coal production in India in 2019-20 surpassed 730 MT and is likely to increase to about 1000 MT by 2022-23. Power generation remains the key consumer of coal in India.

B. ECOSYSTEM SERVICES

The idea that human society benefits from the environment or nature in various ways, both directly and indirectly, is certainly not a new one, and can be traced back several millennia. But the modern-day concept emerged in the 1970s as 'environmental services', was re-named 'ecosystem services' in the mid-1980s, and really gained momentum from 1997 onwards. The most popular current definition of ecosystem services (ES) is **'The functions and products of ecosystems that benefit humans, or yield welfare to society'** (MA 2005).

Ecosystem Services study has been mandated vide condition no. 15.3.4 (iv) of the Terms of References reproduced below-

"Ecosystem services study of the area shall be carried over by project proponent considering the project being in Singrauli, having ~1400 ha of forest land and presence of other coal mining activity and industries."

Ecological services are the benefits arising out of from the ecological functions of the ecosystems. Such services benefit all living organisms in the niche, including animals, plants, and human beings.

The eco-system services include provisioning services such as food and water; regulating services such as regulation of floods, drought, land degradation, and disease; supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious and other non-material benefits.

The Economics of Ecosystem & Biodiversity (TEEB)

The different categories of ecosystem services that ecosystems provide are:

- Provisioning services
- Regulating services
- Habitat or supporting services
- Cultural services

1.1. Provisioning Services

These are ecosystem services that describe the material or energy outputs from ecosystems. They include food, water and other resources.

a) ***Food:*** Ecosystems provide the conditions for growing food. Food comes principally from managed agro-ecosystems but marine and freshwater systems or forests also provide food for human consumption. Wild foods from forests are often underestimated.

b) ***Raw materials:*** Ecosystems provide a great diversity of materials for construction and fuel including wood, biofuels and plant oils that are directly derived from wild and cultivated plant species.

c) ***Fresh water:*** Ecosystems play a vital role in the global hydrological cycle, as they regulate the flow and purification of water. Vegetation and forests influence the quantity of water available locally.

d) ***Medicinal resources:*** Ecosystems and biodiversity provide many plants used as traditional medicines as well as providing the raw materials for the pharmaceutical industry. All ecosystems are a potential source of medicinal resources.

1.2. Regulating Services

These are the services that ecosystems provide by acting as regulators *e.g.* regulating the quality of air and soil or by providing flood and disease control.

a) ***Local climate and air quality:*** Trees provide shade whilst forests influence rainfall and water availability both locally and regionally. Trees or other plants also play an important role in regulating air quality by removing pollutants from the atmosphere.

b) ***Carbon sequestration and storage:*** Ecosystems regulate the global climate by storing and sequestering greenhouse gases. As trees and plants grow, they remove carbon dioxide from the atmosphere and effectively lock it away in their tissues. In this way forest ecosystems are carbon stores. Biodiversity also plays an important role by improving the capacity of ecosystems to adapt to the effects of climate change.

c) ***Moderation of extreme events:*** Extreme weather events or natural hazards include floods, storms, tsunamis, avalanches and landslides. Ecosystems and living organisms create buffers against natural disasters, thereby preventing possible damage. For example, wetlands can soak up flood water whilst trees can stabilize slopes. Coral reefs and mangroves help protect coastlines from storm damage.

d) ***Waste-water treatment:*** Ecosystems such as wetlands filter both human and animal waste and act as a natural buffer to the surrounding environment. Through the biological activity of microorganisms in the soil, most waste is broken down. Thereby pathogens

(disease causing microbes) are eliminated, and the level of nutrients and pollution is reduced.

1.3. Habitat or Supporting Services

These include the following:

a) ***Habitats for species*****:** Habitats provide everything that an individual plant or animal needs to survive: food; water; and shelter. Each ecosystem provides different habitats that can be essential for a species' lifecycle. Migratory species including birds, fish, mammals and insects all depend upon different ecosystems during their movements.

b) ***Maintenance of genetic diversity*****:** Genetic diversity is the variety of genes between and within species populations. Genetic diversity distinguishes different breeds or races from each other thus providing the basis for locally well-adapted cultivars and a gene pool for further developing commercial crops and livestock. Some habitats have an exceptionally high number of species which makes them more genetically diverse than others and are known as 'biodiversity hotspots'.

1.4. Cultural Services

This includes the following:

a) ***Recreation and mental and physical health:*** Walking and playing sports in green space is not only a good form of physical exercise but also lets people relax. The role that green space plays in maintaining mental and physical health is increasingly being recognized, despite difficulties of measurement.

b) ***Tourism:*** Ecosystems and biodiversity play an important role for many kinds of tourism which in turn provides considerable economic benefits and is a vital source of income for many countries. In 2008 global earnings from tourism summed up to US$ 944 billion. Cultural and eco-tourism can also educate people about the importance of biological diversity.

c) ***Aesthetic appreciation and inspiration for culture, art and design:*** Language, knowledge and the natural environment have been intimately related throughout human history. Biodiversity, ecosystems and natural landscapes have been the source of inspiration for much of our art, culture and increasingly for science.

d) ***Spiritual experience and sense of place:*** In many parts of the world natural features such as specific forests, caves or mountains are considered sacred or have a religious meaning. Nature is a common element of all major religions and traditional knowledge, and associated customs are important for creating a sense of belonging.

The concept of **ecosystem services** was given increased public recognition through the Millennium Ecosystem Assessment (MEA) launched in 2001 by the UN Secretary General and completed in 2005. A conceptual framework was developed to highlight the real impacts of the ecosystem services on human health, security, social relations and physical wellbeing to explain the integrated aspects organized into four categories (Fig. 1).

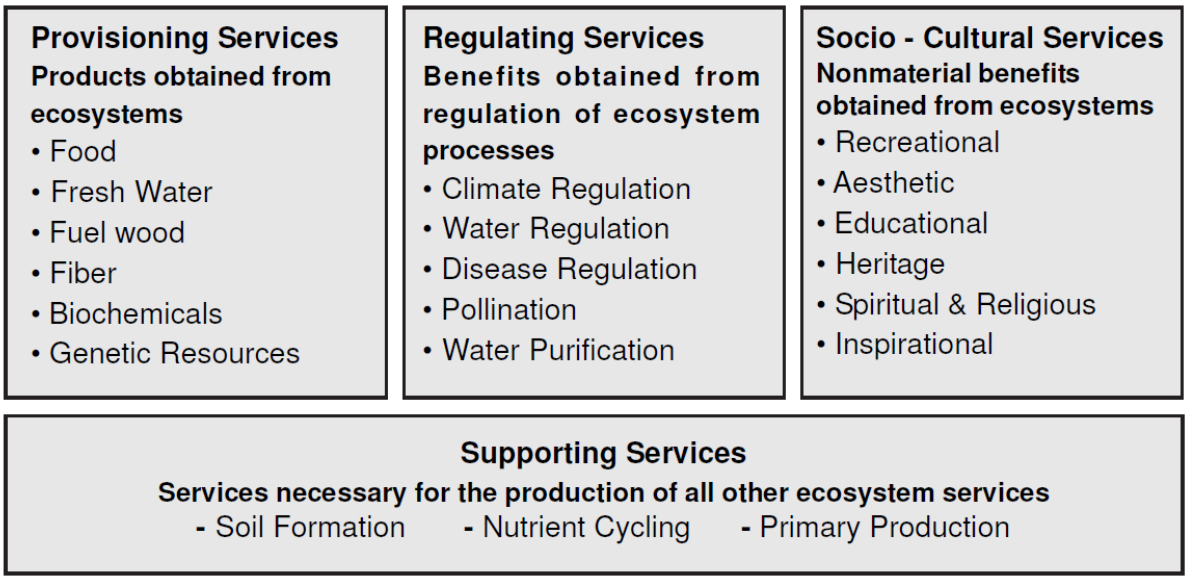


Figure-1.2: Classification of ecosystem services developed by the Millennium Ecosystem Assessment. *Source: MEA (2005)*

M/s. Vardan EnviroNet (QCI-NABET) has been assigned with Ecosystem Services Study for Dirauli Coal Block in line with Terms of References submitted to MoEF&CC. the report entitled impact on ecosystem services available in the mining area of Dhirauli coal Mining Project of Open cast cum Underground of 6.5 MTPA (5 MTPA Open Cast & 1.5 MTPA Underground) in Mine Lease Area of 2672 ha by M/s Stratatech Mineral Resources Private Limited (SMRPL) located at villages Dhirauli, Phatpani, Sirswah, Amdand, Jhalari, Amraikhoh, Bansibridha, and Belwar, Teshil Sarai, District Singrauli, (Madhya Pradesh). This report draws upon the baseline information and analysis conducted in the relevant parts of the Environment Impact Assessment and Environment Management Plan (EIA & EMP). The findings of the assessment in this report have been used to inform the impact assessment and mitigation processes in each relevant technical service.

2. STUDY AREA

The Dhirauli Coal Block in Singrauli Coalfield, in the State of Madhya Pradesh has been allocated to M/s Stratatech Mineral Resource Private Limited (SMRPL) vide Letter No. NA-104/7/2020-NA dated 03.03.2021 by MoC, GoI.

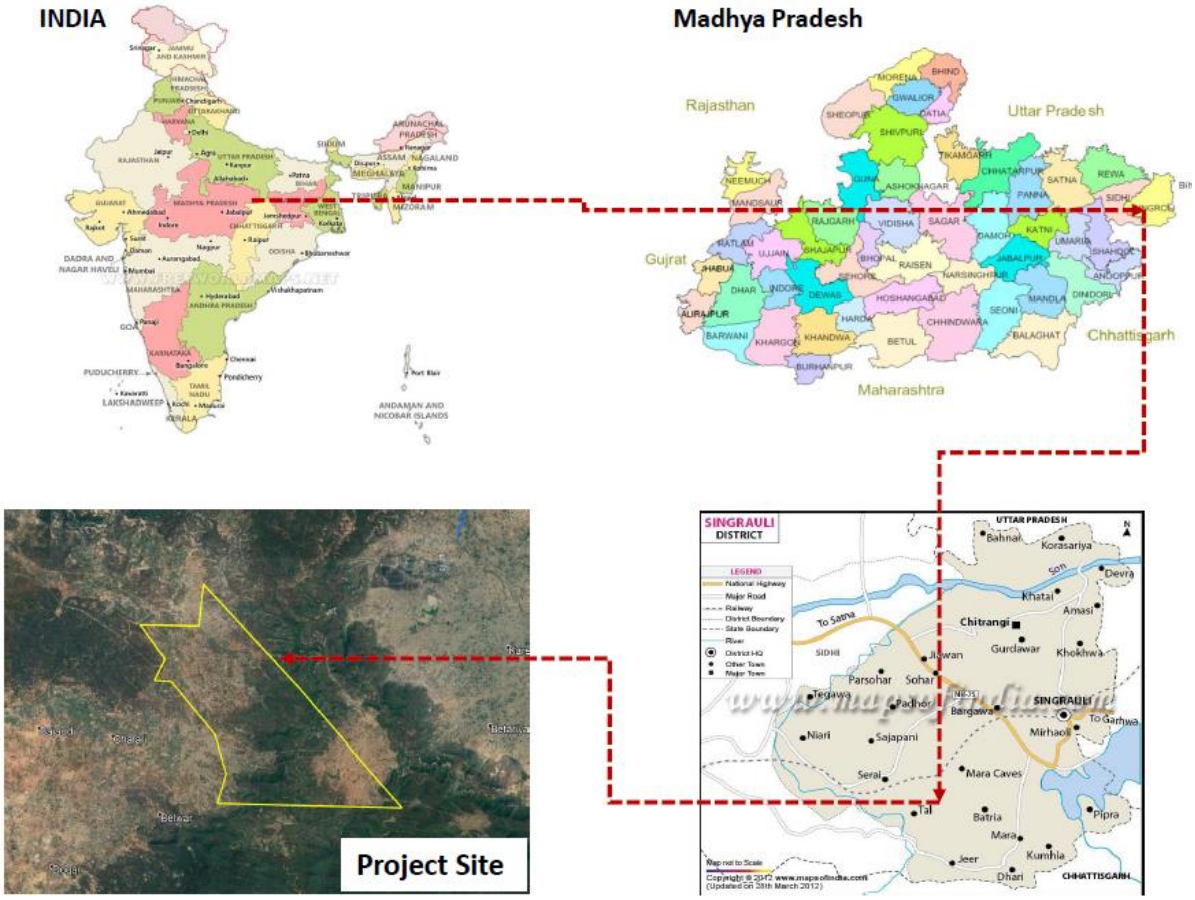


Figure 1.3: Location Map of the proposed Dhirauli Coal Block

The Singrauli Coalfield which forms the northern most part of Son- Mahanadi Master basin occupies a prominent position on power map of India due to its vast Quarriable coal resources. Singrauli Coalfield covering an area of about 2200 sq km is located mainly in Singrauli district of Madhya Pradesh with a small portion falling in Sonbhadra District of Uttar Pradesh. Singrauli coalfield is structurally composed of two techno-sedimentary domain viz. the Moher sub basin in north east and the Main Basin in the west. The large part of the coalfield known as Main Basin covering nearly 1900 sq km has been partly explored while the Moher sub basin having an area of around 300 sq km has been extensively explored in detail. These two basins of Singrauli Coalfield are separated by a concealed basement high. The Dhirauli Coal block spread over a total 26.72 sq.km area is located at about 70 km south-west of Singrauli township, whereas, it is around 50 km south-west of Waidhan township, the District Headquarter of Singrauli District. This area is a part of Survey of India Topo sheet No.64 I/05 (on R.F.1:50000).

Block is traversed by number of fair weathered and forest roads. The important villages in and around the block are Suliyari & Dhirauli villages located within the block, while village Jhalri & Majhalipath are located outside, west of the block.

Western part of Dhirauli block is characterized by almost plain topography, while, north-eastern and south-central part are highly undulating and have rugged topography as evident from the topographical plan. The north-eastern and south central part of the block have forest cover and is occupied by hillocks of elevation up to a maximum of 638 m above MSL. In general elevation of ground varies from 459.23m to 603.45 m in the south-western and south-eastern corner of the block respectively.

Drainage of the block is mainly controlled by westerly flowing Hardul Nala which traverses the block and passes almost through central part of the block. Many small seasonal nallas originating from elevated topography of north eastern and south-central part of the block drain its water into Hardul Nala. The minor nallas and tributaries present in the block shows dendritic to sub-dendritic drainage pattern.

2.1. Important Surface Features within the Project Area and Major Diversion or Shifting Involved:

Human habitation: Eight villages (Aamdand, Amraikhoh, Basi-Berdah, Phatani, Belwar, Dhirauli, Jahalari, Sirswah) are located in / immediate periphery of the block.

Road: There are 4 roads passing from block having total length of approx. ~18 km which needs to be diverted along southern, western and northern boundary of the block.

1.	Khanua-Dongri-Phatpani Road
2.	Suliyari-Baheritola Road
3.	Pondi-Gurwani Road
4.	Jhalari-basiberdha Road

Ponds: Few Small ponds and dug wells in the area. These are utilized for irrigation and drinking water purpose.

Pond along with the Transmission Lines

Nala/River: The ground is deeply incised by a prominent Hardul nala and its tributaries flowing from almost East to west in the central part. Few small nala is also following out from Northern and southern side of block.

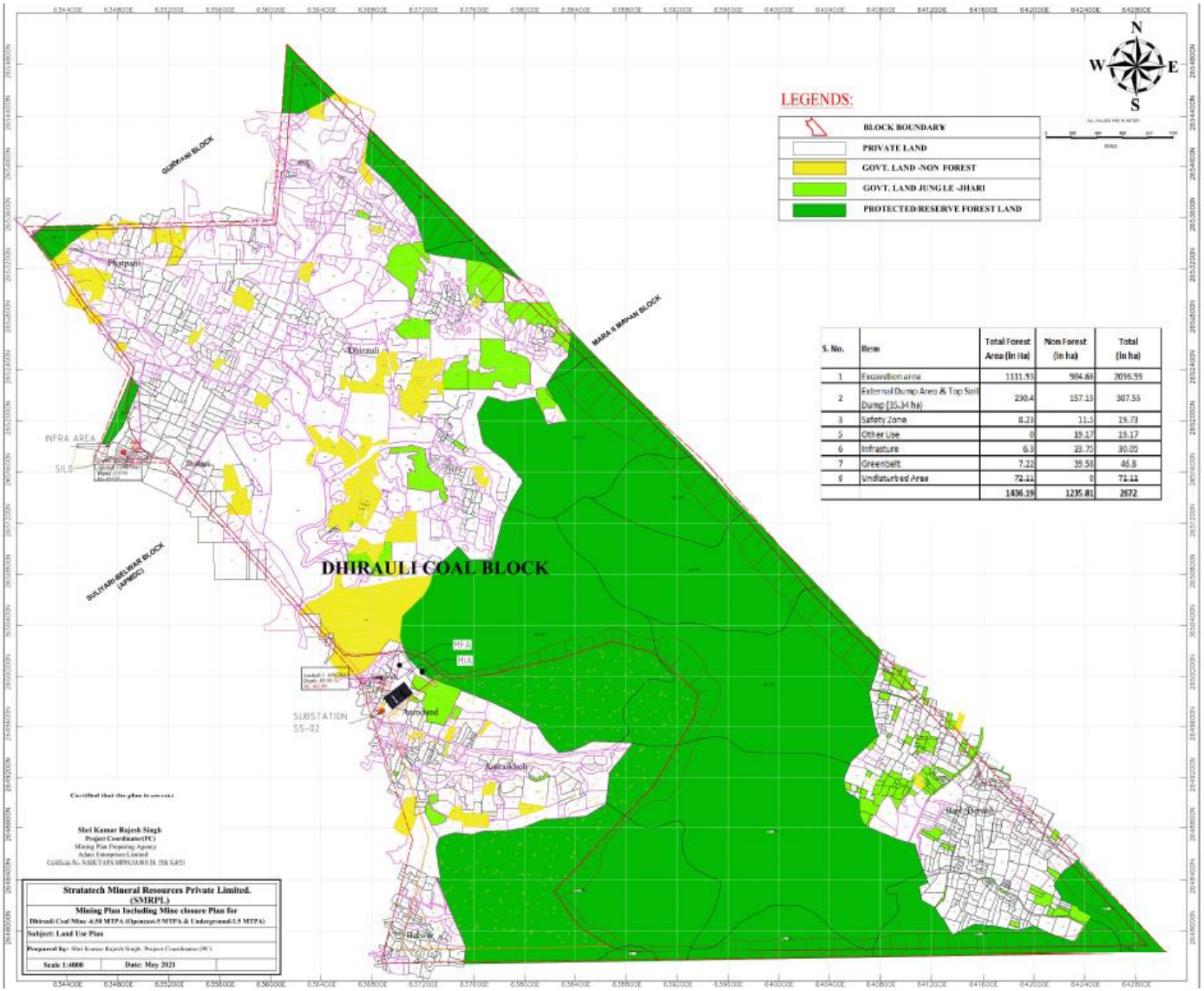
Hardul Nala within the Coal Block

Transmission line: Total 5 transmission lines (132kv- one line and 765kv – 4 lines) are passing from the block which is proposed to divert from outside of Dhirauli coal block.

The administrative jurisdiction of this Coal mine is coming under Waidhan Forest Division. Out of the lease hold area of 2672.00 ha, only 548.841 ha is tenancy land.

Table-1.1: Pre-Mining Lease Hold Area

Ownership	Type of Land Use	Area (Ha)
Tenancy Land	Agricultural	530.841
	Township	
	Grazing	
	Barren	
	Water Bodies	6.000
	Road	12.000
	Community	
Sub Total		**548.841**
Govt. Non-Forest Land	Agricultural	684.431
	Township	
	Grazing	
	Barren (Road)	
	Other	
Sub Total		**684.431**
Forest Land	Protected Forest Land	1337.144
	Reserve Forest	101.585
Sub Total		**1438.729**
Grand Total		**2672.00**



S. No.	Item	Total Forest Area (In Ha)	Non Forest (in ha)	Total (In ha)
1	Excavation area	1111.93	984.66	2096.59
2	External Dump Area & Top Soil Dump (35.34 ha)	290.4	157.15	387.55
3	Safety Zone	8.23	11.5	19.73
5	Other Use	0	19.17	19.17
6	Infrasture	6.3	23.75	30.05
7	Greenbelt	7.22	39.58	46.8
8	Vindlaturbed Area	72.11	0	72.11
		1436.19	1235.81	2672

Figure 1.4: Dhirauli Coal Block

CHAPTER-2-ENVIRONMENTAL SETTING

The environmental setting deal with the baseline data collected and its relevant results in respect of following environmental setting:

- Air
- Noise
- Water
- Soil
- Land-use
- Socioeconomic
- Biodiversity

2.1. STUDY PERIOD

The baseline environmental study has been done for the period of March, 2021 to May 2021**.**

2.2. OBJECTIVES

I. Assessment of floral and faunal diversity of study area by ground survey and secondary documents.
II. Categorization of diversity of study area as per IUCN and Wildlife Protection Act, 1972.
III. To assess the ecosystem availability and mapping of ecosystem services in the project study area.
IV. To assess the dependency (Direct and Indirect), impact and management measures for the management of ecosystem services.
V. To identify the dependency (Direct or Indirect) on the Biodiversity and Ecosystem Services (B&ES) with all alternatives like no alternative, short term alternative and many alternatives.
VI. To identify the components not dependent on Biodiversity and Ecosystem Services for any project operation.

2.3. RESULT & DISCUSSION

2.3.1. AIR

The meteorological data helps for appropriate interpretation of the baseline status of the study area as well as for input into prediction models to evaluate air quality dispersion. Chronological data on meteorological parameters also plays an important role in identifying

the general meteorological regime of the region. The year may broadly be divided into three seasons i.e. Pre-Monsoon Season, Monsoon Season and Post-Monsoon Season.

Methodology Adopted

The methodology adopted for monitoring surface observations is as per the standard norms laid down by Bureau of Indian Standards (IS:8829) and India Meteorological Department (IMD). On-site monitoring was undertaken for various meteorological variables in order to generate the site-specific data. Data was collected every hour continuously from 1st March 2021 to 31st May 2021 representing pre-monsoon seasons.

Selection of Sampling Locations for Air

The sources of air pollution in the region are mining activity emissions, vehicular traffic, dust arising from unpaved roads and domestic fuel burning.

Due consideration during the selection of sampling locations has been given to the likely affected zones during mining activity. The location of human habitation and other sensitive areas within the study area were also considered in selection of ambient air quality monitoring locations. 10 numbers of monitoring stations are set up to assess the existing air quality of the study area. Two stations are located inside the proposed project site (core zone) and the eight others locations are outside (buffer zone) the proposed project site.

The locations of the monitoring stations are also based on the meteorological conditions of the study area like likeliness of pollution dispersion in areas located towards predominant wind directions. Locations are also based on sensitive receptors in the study area like densely populated areas, forest area, river bodies, etc. Logistic considerations as ready accessibility, security, availability of reliable power supply, etc were examined while finalizing the monitoring locations. The Ambient Air Quality Monitoring locations have been presented in Figure 2.1.

Table 2.1: Ambient Air Quality Monitoring Stations

Stations	Name	Distance/Direction	Selection Criteria
A1	Mine Area (Dhirauli South)	M. L. Area	Proposed Mine Site
A2	Mine Area (Dhirauli North)	M. L. Area	Proposed Mine Site
A3	Bhaiyatola	2.0 km in NNW	Rural/Residential
A4	Budheri	3.9 km in North	Rural/Residential
A5	Khairahi	4.5 km in NE	Rural/Residential
A6	Churwani	4.6 km in E	Rural/Residential
A7	Berdaha	0.5 km in ESE	Rural/Residential
A8	Bansi	0.8 km in South	Rural/Residential
A9	Majholipath	0.8 km in SW	Rural/Residential
A10	Bijauri	2.6 km in W	Rural/Residential

Source: Primary On-site Data

Sampling and Analytical Techniques

The air samples were analyzed as per standard methods specified by Central Pollution Control Board (CPCB), IS:5182 and American Public Health Organization (APHA).

Particulate Matter (PM10)

Respirable dust samplers APM-460 BL attached with APM-151 instruments have been used for sampling of respirable dust (<10 microns) and gaseous pollutants like SO2 and NO2.

PM10 (<10□) present in ambient air is drawn through the cyclone. Coarse and non-respirable dust (>10□) is separated from the air stream by centrifugal forces acting on the solid particles. These separated particulates fall through the cyclone's conical hopper and collect in the sampling cup placed at the bottom of the cyclone. The fine dust (<10 microns) forming the respirable fraction passes through the cyclone and is retained by the filter paper.

A tapping is provided on the suction side of the blower to provide suction for sampling air through a set of impingers. Samples of gases are drawn at a flow rate of 0.2 liters per minute (lpm). The air samples were analyzed as per standard methods specified in IS: 5182.

Particulate Matter (PM2.5)

APM 550 Fine Particulate Sampler (PM2.5) attached with impactor have been used for sampling of fine particulate (<2.5 microns).

An electrically powered air sampler draws ambient air at a constant volumetric flow rate (16.7 lpm) maintained by a mass flow / volumetric flow controller coupled to a microprocessor into specially designed inertial particle-size separator (i.e. cyclones or impactors) where the suspended particulate matter in the PM2.5 size ranges is separated for collection on a 47 mm Poly Tetra Fluoro Ethylene (PTFE) filter over a specified sampling period. Each filter is weighed before and after sample collection to determine the net gain due to the particulate matter.

Dust samplers of Pollutech instruments were used for monitoring PM10 (<10 microns), PM2.5 and gaseous pollutants like SO2 and NO2. Glass tubes were deployed for collection of grab samples of carbon monoxide. Gas chromatography techniques have been used for the estimation of CO.

The results of air quality monitoring are discussed below and compared with **National Ambient Air Quality Standards.**

Table 2.2 (a): Ambient Air Quality

Station Code	Location	PM_{10} (µg/m^3)				$PM_{2.5}$ (µg/m^3)				SO_2 (µg/m^3)				NO_X (µg/m^3)			
		Min	Max	Avg.	98 %le	Min	Max	Avg.	98 %le	Min	Max	Avg.	98 %le	Min	Max	Avg.	98 %le
AAQ1	Mine Area (Dhirauli South)	34.8	79.5	43.2	49.3	17.1	29.2	22.6	28.7	13.2	16.3	14.7	16.2	17.4	23.6	19.7	23.3
AAQ2	Mine Area (Dhirauli North)	35.9	52.3	43.7	51.8	17.6	30.3	23.3	29.9	13.5	17.1	15.0	17.0	17.9	23.9	19.8	23.2
AAQ3	Bhaiyatola	35.1	49.3	43.0	49.3	16.9	27.9	21.4	26.1	12.8	15.9	14.2	15.6	16.5	25.4	21.2	25.3
AAQ4	Budheri	33.8	48.9	41.5	48.9	16.6	26.7	21.7	26.6	13.9	21.6	17.2	21.5	18.0	25.5	21.6	25.3
AAQ5	Khairahi	38.9	58.6	46.9	58.5	21.8	33.6	27.1	33.1	17.8	25.1	21.0	24.7	22.6	34.2	26.2	33.9
AAQ6	Churwani	39.7	61.3	47.8	59.3	23.1	40.2	29.7	40.0	17.3	23.8	20.4	23.7	21.0	32.2	25.6	31.7
AAQ7	Berdaha	37.5	51.3	43.4	51.1	22.9	39.2	29.2	39.0	15.6	22.8	18.8	22.5	20.6	30.9	27.5	30.8
AAQ8	Bansi	26.5	44.6	36.8	44.4	15.8	28.2	21.6	28.0	13.1	20.7	16.3	20.1	20.5	29.1	26.0	28.9
AAQ9	Majholipath	35.0	51.8	42.5	51.2	17.9	32.5	24.3	31.2	14.2	23.4	18.1	22.9	21.3	31.5	26.0	31.3
AAQ10	Bijauri	28.9	48.9	39.3	48.9	16.8	27.8	21.8	27.8	12.5	15.8	14.2	15.6	16.4	24.9	20.6	24.8
Study Area Range		**26.5 – 61.3**				**15.8 – 40.2**				**12.5 – 25.1**				**16.4 – 34.2**			
CPCB Standards		**100**				**60**				**80**				**80**			

Table 2.2 (b): Ambient Air Quality

Station Code	Location	CO (µg/m^3)				O_3 (µg/m^3)				NH_3 (µg/m^3)	C_6H_6 (µg/m^3)	BaP (µg/m^3)	As (µg/m^3)	Ni (µg/m^3)	Pb (µg/m^3)
		Min	Max	Avg.	98 %le	Min	Max	Avg.	98 %le						
AAQ1	Mine Area (Dhirauli South)	316	418	382	417	4.3	8.3	6.1	8.2	<20.0	<1.0	<0.1	<1.0	<1.0	<0.1
AAQ2	Mine Area (Dhirauli North)	314	419	381	415	4.8	8.9	6.7	8.4	<20.0	<1.0	<0.1	<1.0	<1.0	<0.1
AAQ3	Bhalyatola	350	439	384	431	4.2	7.9	5.6	7.4	<20.0	<1.0	<0.1	<1.0	<1.0	<0.1
AAQ4	Budheri	317	378	333	358	4.4	8.6	6.1	8.0	<20.0	<1.0	<0.1	<1.0	<1.0	<0.1
AAQ5	Khairahi	381	487	406	473	4.9	9.6	7.1	9.0	<20.0	<1.0	<0.1	<1.0	<1.0	<0.1
AAQ6	Churwani	373	472	406	473	4.8	9.8	7.1	9.7	<20.0	<1.0	<0.1	<1.0	<1.0	<0.1
AAQ7	Berdaha	325	415	354	391	4.1	9.4	6.1	9.1	<20.0	<1.0	<0.1	<1.0	<1.0	<0.1
AAQ8	Bansi	305	335	319	327	3.7	7.9	5.5	7.6	<20.0	<1.0	<0.1	<1.0	<1.0	<0.1
AAQ9	Majholipath	353	437	366	399	4.3	8.9	6.5	8.6	<20.0	<1.0	<0.1	<1.0	<1.0	<0.1
AAQ10	Bijauri	312	342	319	327	4.0	8.2	5.8	7.9	<20.0	<1.0	<0.1	<1.0	<1.0	<0.1
Study Area Range		**305 - 487**				**3.7 – 9.8**				**<20.0**	**<1.0**	**<0.1**	**<1.0**	**<1.0**	**<0.1**
CPCB Standards		**2000**				**100**				**400**	**5**	**1**	**-**	**-**	**-**

- **Particulate Matter (PM_{10}):** The minimum and maximum concentrations for PM_{10} were recorded as 26.5 µg/m3 and 61.3 **µ**g/m3 and respectively. The minimum concentration was recorded at Bansi Village (AAQ8) maximum concentration was recorded at Churwani Village (AAQ6).
- **Particulate Matter ($PM_{2.5}$):** The minimum and maximum concentrations for PM2.5 were recorded as 15.8 µg/m3 and 40.2 µg/m3 and respectively. The minimum concentration was recorded at Bansi Village (AAQ8) maximum concentration was recorded at Churwani Village (AAQ6).
- **Sulphur Dioxide (SO_2):** The minimum and maximum SO2 concentrations were recorded as 12.5 µg/m3 and 25.1 µg/m3. The minimum concentration was recorded at Bijauri Village (AAQ10) and the maximum concentration was recorded at Khairahi Village (AAQ5).
- **Oxides of Nitrogen (NO_X):** The minimum of 16.4 µg/m3 observed at Bijauri Village (AAQ10) and maximum concentration of 34.2 µg/m3 recorded at Khairahi Village (AAQ5).
- **CO:** The minimum and maximum carbon monoxide concentrations 305 µg/m3 and 487 µg/m3. The minimum concentration was recorded at Bansi Village (AAQ8) and the maximum concentration was recorded at Khairahi Village (AAQ6).
- **Ozone (O_3):** The minimum and maximum Ozone concentrations were recorded as 3.7 □g/m3 and 9.8 □g/m3. The minimum concentration was recorded at Bansi Village (AAQ8) and the maximum concentration was recorded at Churwani Village (AAQ6)

In summary, the ambient air quality of Dhirauli Coal Block mine area and its buffer zone showed that the concentrations of all monitored parameters were within the stipulated standards of CPCB.

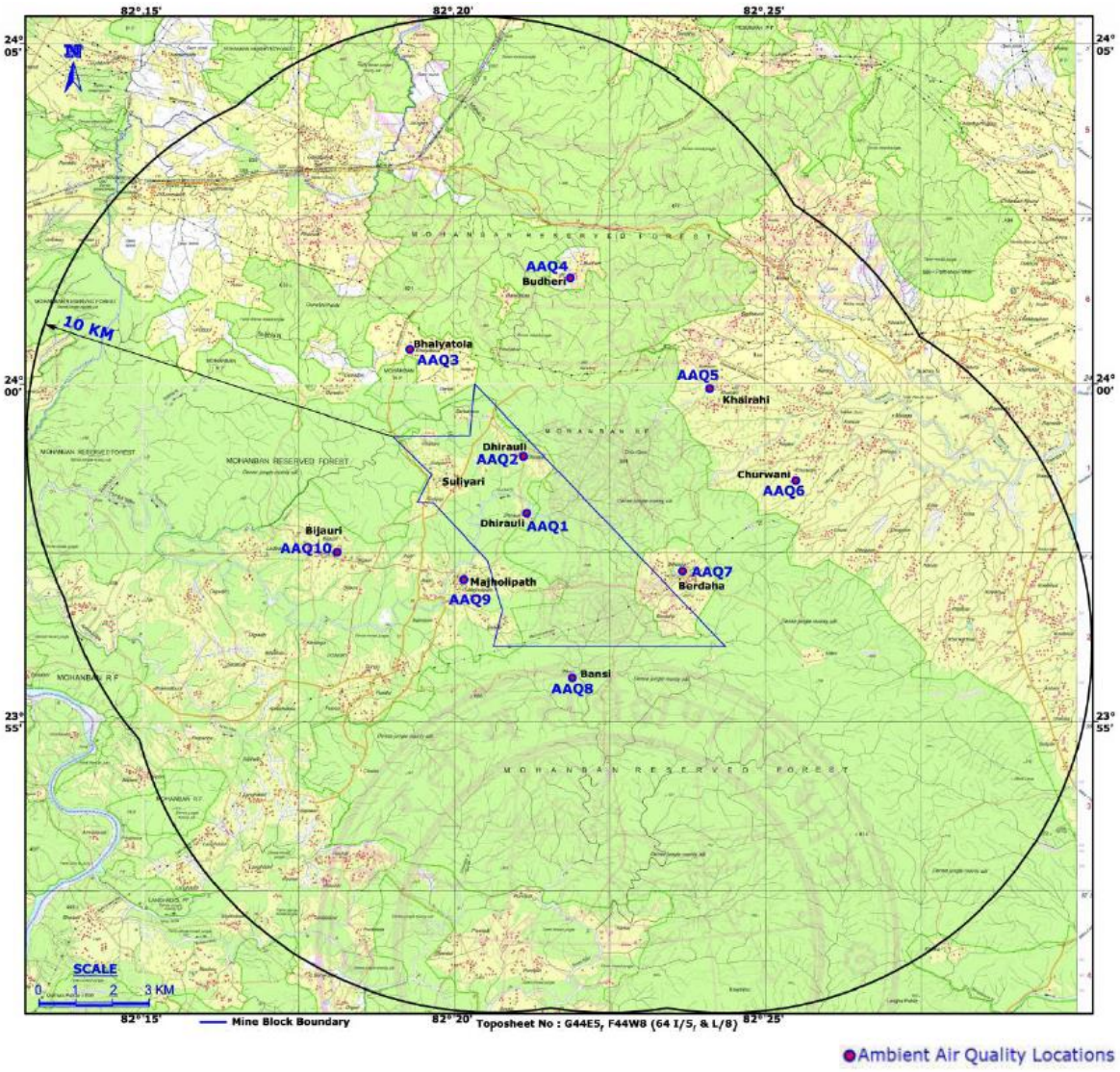


Figure 2.1: Ambient Air Quality Monitoring Sampling Locations

2.3.2. WATER

Selected water quality parameters for surface and ground water resources along with biological indicators within 10 km of the study area have been used for describing the water environment and assessing the impact on it by the proposed expansion of mine operations. Studies on water environment aspects of ecosystem plays an important role in the assessment of Ecosystem services utilized by proposed project and to identify sensitive issues and take appropriate action by maintaining ecological homeostasis in the early stages of development of the project.

The purpose of this study is to:

- Assess the water quality characteristics for critical parameters;

- Evaluate the impacts on agricultural productivity, habitat conditions, recreational resources and aesthetics in the vicinity; and
- Predict impact on water quality by this project and related activities.

Methodology

Eight Ground water samples consisting of bore wells and dug wells and Five surface water sources covering 10 km radial distance from the mine lease boundary were examined for physio-chemical, heavy metals and bacteriological parameters in order to assess the effect of operations from mine and other activities on surface and ground water quality. The samples were analyzed as per the procedures specified in 'Standard Methods for the Examination of Water and Wastewater' published by American Public Health Association (APHA).

Table 2.3: Water Sampling Locations

Code	Location Name	Distance (km)	Direction from Mine Site
SURFACE WATER			
SW1	Hurdul Nala near Majholipath (U/S)	0.7	SW
SW2	Hurdul Nala near Digwah (D/S)	6.9	W
SW3	Rampa River near Badhaura (U/S)	7.4	NE
SW4	Rampa River near Rampa (D/S)	9.6	E
SW5	Biniao Nala near Kamai (U/S)	7.5	S
GROUND WATER			
GW1	M.L. Area Dhirauli South	M.L. Area	
GW2	Bhalyatola	2.0	NNW
GW3	Khairahi	4.5	NE
GW4	M.L. Area Berdaha	M.L. Area	
GW5	Majholipath	0.8	SW
GW6	M.L Area near Suliyari	M.L. Area	
GW7	Bijauri	2.6	W
GW8	Dongri	2.9	SW

The results of the parameters analysed for the 8 ground water and 5 surface water samples are compared with the standards for drinking water as per IS: 10500-2012 “Specifications for Drinking Water (Ground water)” and as well as with the IS: 2296-1986 to compare the result of surface water.

A. Ground Water

The analysis results indicate that the pH ranges in between 6.61 to 7.54 which are well within the specified standard of 6.5 to 8.5. The maximum value was observed at Mine Lease area - Suliyari (GW6) and the minimum value observed at Bhaiyatola Village (GW2) whereas the prescribed limit of is 6.5 to 8.5.

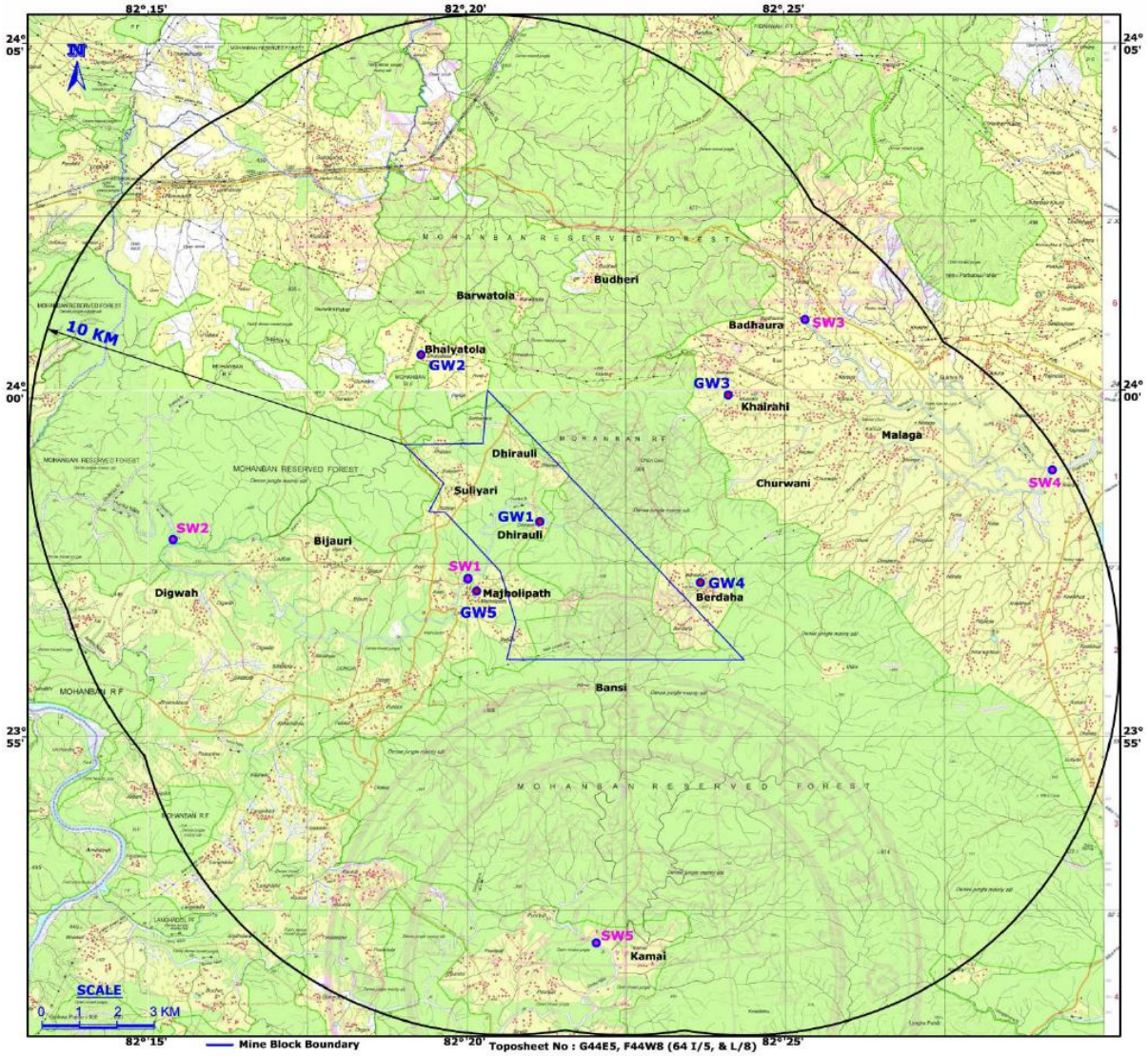


Figure 2.2: Ground/Surface Monitoring Sampling Locations

Table 2.4 (a): Ground Water Quality

S. No.	Parameters	GW1	GW2	GW3	GW4	Limits of IS:10500-2012	
						Desirable limit (Max.)	Permissible limit in the Absence of Alternate Source (Max.)
1	pH	6.86	6.61	7.49	7.12	6.5 to 8.5	No Relaxation
2	Colour (Hazen)	1	1	1	1	5	15
3	Taste	Agreeable				Agreeable	Agreeable
4	Odour	Agreeable				Agreeable	Agreeable
5	Conductivity (µS/cm)	305	260	717	435	-	-
6	Turbidity (NTU)	2	2	3	3	5	10
7	TDS (mg/l)	178	162	389	267	500	2000
8	Total Hardness (mg/l)	90.9	77.9	263.4	147.6	200	600

9	Alkalinity ($CaCO_3$) (mg/l)	95	65	265	125	200	600
10	Calcium as Ca (mg/l)	17.6	15.7	61.4	32.2	75	200
11	Magnesium as Mg (mg/l)	11.4	9.4	26.7	16.3	30	100
12	Residual Chlorine (mg/l)	<0.1	<0.1	<0.1	<0.1	0.2	-
13	Boron as B (mg/l)	0.06	0.05	0.11	0.09	1.0	-
14	Chlorides as Cl (mg/l)	27.4	32.8	46.9	52.2	250	1000
15	Sulphates as SO_4 (mg/l)	9.6	10.3	14.8	8.7	200	400
16	Fluorides as F (mg/l)	0.2	0.3	0.2	0.4	1.0	1.5
17	Nitrates as NO_3 (mg/l)	7.8	9.2	14.5	11.8	45	No Relaxation
18	Sodium as Na (mg/l)	26.7	23.5	41.7	29.6	-	-
19	Potassium as K (mg/l)	1.5	1.0	2.3	5.2	-	-
20	Phenolic Compound (mg/l)	<0.001	<0.001	<0.001	<0.001	0.001	0.002
21	Cyanides as CN (mg/l)	<0.02	<0.02	<0.02	<0.02	0.05	No Relaxation
22	Anionic detergent (mg/l)	<0.1	<0.1	<0.1	<0.1	0.2	1.0
23	Mineral Oil (mg/l)	<0.01	<0.01	<0.01	<0.01	0.01`	0.03
24	Cadmium as Cd (mg/l)	<0.003	<0.003	<0.003	<0.003	0.01	No Relaxation
25	Arsenic as As (mg/l)	<0.01	<0.01	<0.01	<0.01	0.01	No Relaxation
26	Copper as Cu (mg/l)	<0.01	<0.01	<0.01	<0.01	0.05	1.5
27	Lead as Pb (mg/l)	<0.01	<0.01	<0.01	<0.01	0.05	No Relaxation
28	Manganese as Mn (mg/l)	0.02	0.01	0.03	0.02	0.1	0.3
29	Iron as Fe (mg/l)	0.11	0.09	0.12	0.14	0.3	1.0
30	Chromium as Cr (mg/l)	<0.01	<0.01	<0.01	<0.01	0.05	No Relaxation
31	Selenium as Se (mg/l)	<0.01	<0.01	<0.01	<0.01	0.01	No Relaxation
32	Zinc as Zn (mg/l)	0.08	0.05	0.07	0.09	5.0	15
33	Aluminium as Al (mg/l)	0.03	0.02	0.04	0.02	0.03	0.2
34	Mercury as Hg (mg/l)	<0.001	<0.001	<0.001	<0.001	0.001	No Relaxation
35	Pesticides (mg/l)	Absent				-	-
36	E. Coli	Absent				-	-
37	Total Coliforms (MPN/100 ml)	Absent				10	-

Table 2.4 (b): Ground Water Quality

S. No.	Parameters	GW1	GW2	GW3	GW4	Limits of IS:10500-2012	
						Desirable limit (Max.)	Permissible limit in the Absence of Alternate Source (Max.)
1	pH	7.10	7.54	6.89	6.78	6.5 to 8.5	No Relaxation
2	Colour (Hazen)	1	1	1	1	5	15
3	Taste	Agreeable				Agreeable	Agreeable

4	Odour	Agreeable				Agreeable	Agreeable
5	Conductivity (µS/cm)	392	600	336	367	-	-
6	Turbidity (NTU)	3	4	2	2	5	10
7	TDS (mg/l)	239	360	210	225	500	2000
8	Total Hardness (mg/l)	118.0	173.6	95.2	102.3	200	600
9	Alkalinity ($CaCO_3$) (mg/l)	110	165	74	95	200	600
10	Calcium as Ca (mg/l)	23.5	41.8	19.4	22.4	75	200
11	Magnesium as Mg (mg/l)	14.4	16.8	9.5	11.2	30	100
12	Residual Chlorine (mg/l)	<0.1	<0.1	<0.1	<0.1	0.2	-
13	Boron as B (mg/l)	0.12	0.09	0.14	0.11	1.0	-
14	Chlorides as Cl (mg/l)	44.5	66.4	28.2	32.5	250	1000
15	Sulphates as SO_4 (mg/l)	11.5	32.6	12.9	10.2	200	400
16	Fluorides as F (mg/l)	0.3	0.5	0.2	0.3	1.0	1.5
17	Nitrates as NO_3 (mg/l)	13.6	10.5	9.7	12.5	45	No Relaxation
18	Sodium as Na (mg/l)	32.4	57.5	25.2	28.3	-	-
19	Potassium as K (mg/l)	6.4	3.7	2.4	4.8	-	-
20	Phenolic Compound (mg/l)	<0.001	<0.001	<0.001	<0.001	0.001	0.002
21	Cyanides as CN (mg/l)	<0.02	<0.02	<0.02	<0.02	0.05	No Relaxation
22	Anionic detergent (mg/l)	<0.1	<0.1	<0.1	<0.1	0.2	1.0
23	Mineral Oil (mg/l)	<0.01	<0.01	<0.01	<0.01	0.01`	0.03
24	Cadmium as Cd (mg/l)	<0.003	<0.003	<0.003	<0.003	0.01	No Relaxation
25	Arsenic as As (mg/l)	<0.01	<0.01	<0.01	<0.01	0.01	No Relaxation
26	Copper as Cu (mg/l)	<0.01	<0.01	<0.01	<0.01	0.05	1.5
27	Lead as Pb (mg/l)	<0.01	<0.01	<0.01	<0.01	0.05	No Relaxation
28	Manganese as Mn (mg/l)	0.01	0.02	0.01	0.01	0.1	0.3
29	Iron as Fe (mg/l)	0.09	0.12	0.07	0.05	0.3	1.0
30	Chromium as Cr (mg/l)	<0.01	<0.01	<0.01	<0.01	0.05	No Relaxation
31	Selenium as Se (mg/l)	<0.01	<0.01	<0.01	<0.01	0.01	No Relaxation
32	Zinc as Zn (mg/l)	0.07	0.05	0.09	0.04	5.0	15
33	Aluminium as Al (mg/l)	0.02	0.04	0.01	0.03	0.03	0.2
34	Mercury as Hg (mg/l)	<0.001	<0.001	<0.001	<0.001	0.001	No Relaxation
35	Pesticides (mg/l)	Absent				-	-
36	E. Coli	Absent				-	-
37	Total Coliforms (MPN/100 ml)	Absent				10	-

- Colours of the samples are 1 Hazen whereas the prescribed limit is 5 to 15 Hazen.
- Turbidity of the samples ranged from 2 - 4 NTU whereas the prescribed limit is 1 to 5 NTU.

- Electrical conductivity of the samples ranged from 260 - 717 µS/cm.
- The Total Dissolved Solids of the samples ranged from 162 - 389 mg/l. The maximum value was observed at Khairahi Village (GW3) and the minimum value observed at Bhaiyatola Village (GW2) whereas the prescribed limit of 500 - 2000 mg/l.
- Calcium concentrations ranged from 15.7 – 61.4 mg/l respectively whereas the prescribed limit of 75 - 200 mg/l.
- Magnesium concentrations ranged from 9.4 – 26.7 mg/l respectively whereas the prescribed limit of 30 - 100mg/l.
- The Total Hardness of the samples ranged from 77.9 – 263.4 mg/l. The minimum TDS was observed at Bhaiyatola Village (GW2) and whereas the maximum value observed at Khairahi (GW3). The Total Hardness values are well within the prescribed limit of 300 – 600 mg/l.
- Ranges of Chlorides concentrations at all the locations 27.4 – 66.4 mg/l whereas the prescribed limit is 250 - 1000 mg/l.
- Range of Sulphates concentrations at all the locations as 8.7 – 32.6 mg/l whereas the prescribed limit is 200 - 400 mg/l.
- Similarly, Nitrates are also found to be ranging between 7.8 – 14.5 mg/l whereas the prescribed limit is 45 mg/l.
- Fluoride concentrations are ranging in between 0.2 - 0.5 mg/l and are found to be within the permissible limits 1.0 - 1.5 mg/l.
- Iron concentrations in ground waters varied from 0.09 - 0.14 mg/l whereas the prescribed limit is 0.3 mg/l.
- All other metal concentrations are observed to be below detectable limits.

Based on the above results it is evident that all of the parameters in ground water fairly meet the desirable standard limits of IS: 10500.

B. Surface Water

The analysis results indicate that the pH ranges in between 7.26 to 8.05 which are well within the specified standard of 6.5 to 8.5. The maximum pH of 8.05 was observed at Pond near Raturiyadand (SW7) and the minimum pH of 7.26 was observed at Hurdul Nala (Up-Stream) (SW1).

Table 2.5: Surface Water Quality

S. No.	Parameters	SW1	SW2	SW3	SW4	SW5
1	pH	7.34	7.43	7.355	7.67	7.49
2	Colour (Hazen)	3	4	3	4	4
3	Conductivity (µS/cm)	188	160	235	192	260
4	TDS (mg/l)	120	97	141	110	152
5	TSS	11	12	16	19	14
6	Turbidity (NTU)	5	7	4	6	5
7	DO	5.2	5.4	5.7	5.3	5.1
8	BOD	<3	<3	<3	<3	<3
9	COD	<5	<5	<5	<5	<5
10	Total Hardness (mg/l)	58.8	48.1	59.3	77.7	93.1
11	Alkalinity ($CaCO_3$) (mg/l)	60	56	80	76	84
12	Calcium as Ca (mg/l)	12.5	10.7	11.2	17.1	18.3
13	Magnesium as Mg (mg/l)	6.7	5.2	7.6	8.5	11.5
14	Chlorides as Cl (mg/l)	14.1	13.6	19.8	7.8	23.1
15	Residual Free Chlorine (mg/l)	<0.1	<0.1	<0.1	<0.1	<0.1
16	Phosphate as PO_4 (mg/l)	0.07	0.05	0.08	0.06	0.09
17	Sulphates as SO_4 (mg/l)	6.7	3.4	5.3	5.7	9.8
18	Fluorides as F (mg/l)	0.4	0.3	0.2	0.3	0.4
19	Nitrates as NO_3 (mg/l)	6.8	2.9	4.8	5.2	3.1
20	Sodium as Na (mg/l)	13.4	14.0	22.3	7.83	15.2
21	Potassium as K (mg/l)	4.2	2.52	7.9	2.45	3.4
22	Boron as B (mg/l)	0.09	0.21	0.08	0.14	0.12
23	Phenolic Compound (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001
24	Cyanides as CN (mg/l)	<0.02	<0.02	<0.02	<0.02	<0.02
25	Oil & grease (mg/l)	<1.0	<1.0	<1.0	<1.0	<1.0
26	Cadmium as Cd (mg/l)	<0.003	<0.003	<0.003	<0.003	<0.003
27	Arsenic as As (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01
28	Copper as Cu (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01
29	Lead as Pb (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01
30	Iron as Fe (mg/l)	0.09	0.12	0.07	0.05	0.3
31	Chromium as Cr (mg/l)	<0.05	<0.05	<0.05	<0.05	<0.05
32	Selenium as Se (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01
33	Zinc as Zn (mg/l)	0.09	0.0	0.08	0.06	0.05
34	Aluminium as Al (mg/l)	0.03	0.04	0.02	0.03	0.02
35	Mercury as Hg (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001
36	SAR	0.76	0.88	1.26	0.39	0.69

37	Pesticides (mg/l)	Absent				
38	Anionic detergents as MBAS (mg/l)	<0.02	<0.02	<0.02	<0.02	<0.02
39	Total Coliforms (MPN/100 ml)	1120	1030	1180	1340	1160

Note: Due to Pre-monsoon season, there was no flow/trace of water at the river near Baloder (SW3)

- The analysis results of surface water samples indicate that the pH value was observed to be 7.34 – 7.67.
- Electrical conductivity of surface water samples was observed to be 160 – 260 µS/cm.
- The total dissolved solids were observed about 97 - 152 mg/l.
- Total hardness was observed in the range of 48.1 – 93.1 mg/l.
- Sulphates were found to be in the range of 3.4 – 9.8 mg/l and Nitrates were found to be in the range of 2.9 – 6.8 mg/l which are within the prescribed limits only.
- Fluoride concentration was found to be 0.2 - 0.4 mg/l at all the locations.

The baseline results of ground and surface water were compared with the data for Singrauli district provided by CGWA and was found to be in course with the same.

The area in which project site is falling i.e. Dhirauli coal block at Singrauli Coal Field, District- Singrauli coming under **'Safe'** category (CGWB) indicating no deficit in groundwater resources of the area and availability of groundwater resources for future utilization and development. However, rainwater-harvesting measures will be practiced for betterment and augmentation of groundwater resources in long run. The combined project has proposal for ground water recharge in and around the study area. Therefore, there will be no impact in the ground water quality as well as ground water level due to coal mining.

2.3.3. NOISE ENVIRONMENT

The noise monitoring has been conducted for determination of noise levels at eight locations in the study area. The noise levels at each of the locations were recorded for 24 hours during April 2021.

Table 2.6: Ambient Noise Sampling Locations

Code	Location Name	Distance (km)	Direction from Mine Site	Environmental Setting
N1	Mine Site (Dhirauli)	0.0	Mine Site	**Industrial**
N2	Bhalyatola	2.0	NNW	**Rural/Residential**
N3	Budheri	3.9	N	**Rural/Residential**
N4	Khairahi	4.5	NE	**Rural/Residential**

N5	Churwani	4.6	E	**Rural/Residential**
N6	Berdaha	0.5	ESE	**Rural/Residential**
N7	Bansi	0.8	S	**Rural/Residential**
N8	Jhalri	1.5	W	**Rural/Residential**

As all the villages are thinly populated with limited industries around and without much vehicular traffic, the results from noise monitoring locations were observed below the prescribed value. The noise level at all of the sampling locations ranged from 42.2 and 65.2 dB (A), with the maximum 65.2 dB(A) was recorded at Khairahi Village (N4) and the minimum 42.2 dB(A) was recorded at Bansi Village (N7).

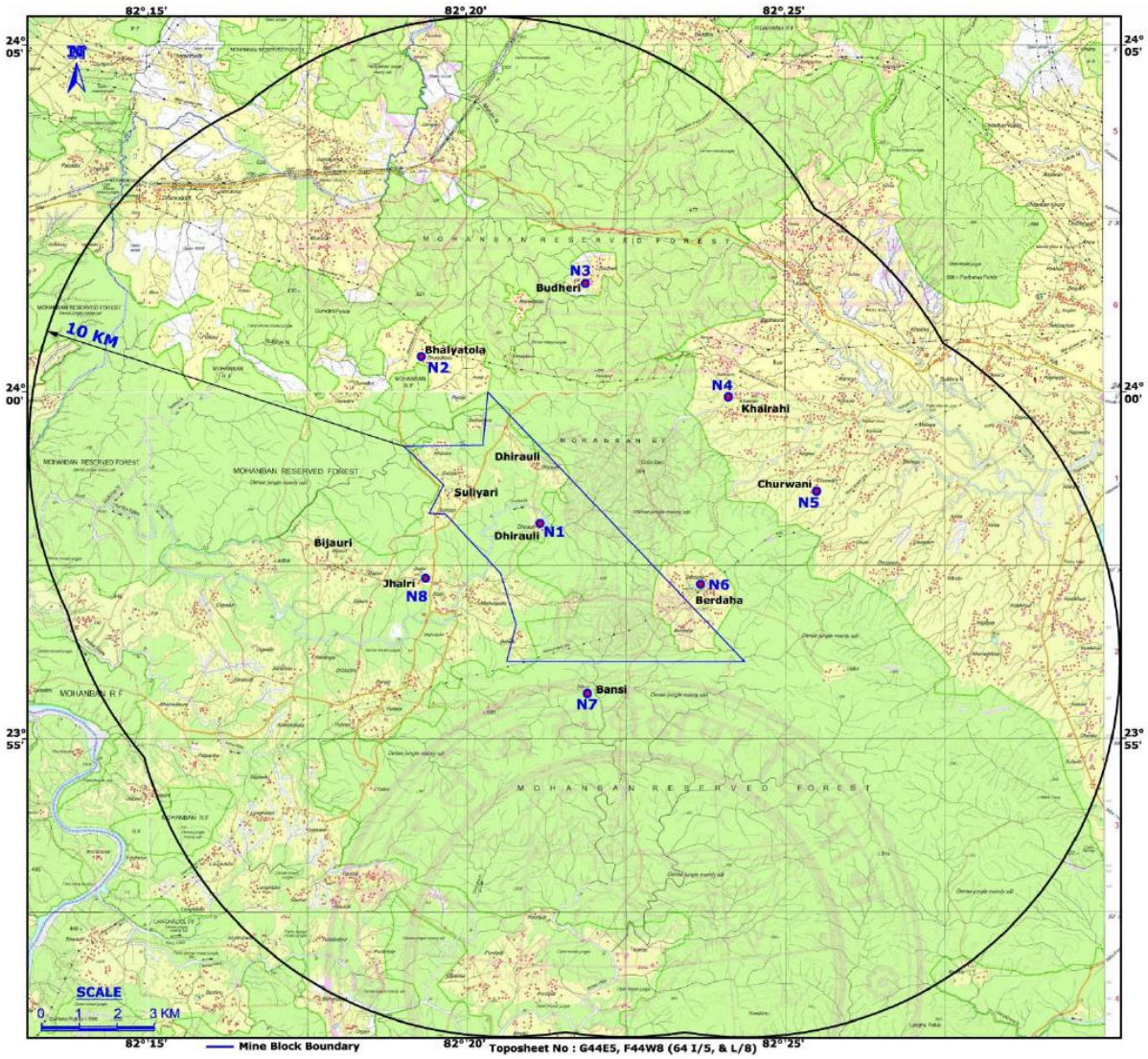


Figure 2.3: Ambient Noise Monitoring Sampling Locations

Table 2.7: Ambient Noise Levels

Code	Location Name	Average Noise Levels in dB(A)			
		L_{eq}	L_{day}	L_{night}	L_{dn}
N1	Mine Site (Dhirauli)	47.8	48.4	45.2	52.2
N2	Bhalyatola	44.9	45.8	42.2	49.3
N3	Budheri	46.9	47.5	44.5	51.5
N4	Khairahi	64.6	65.2	62.1	69.1
N5	Churwani	60.9	61.4	58.2	65.2
N6	Berdaha	42.8	43.9	40.0	47.2
N7	Bansi	41.7	42.2	39.3	46.3
N8	Jhalri	49.6	50.1	47.0	54.0

Table 2.8: Ambient Noise Standards

Area Code	Category of Area	Noise levels dB (A) Leq (Limits)	
		Day Time	Night Time
A	Industrial Area	75	70
B	Commercial Area	65	55
C	Residential Area	55	45
D	Silence Zone	50	40

The Noise levels reported from all the noise monitoring stations were below the prescribed value. The noise level at all of the sampling locations ranged from 39.3 – 62.1 dB(A), with the maximum 62.1 dB(A) was recorded at Khairahi Village (N4) and the minimum 39.3 dB(A) was recorded at Bansi Village (N7).

However, with suitable control measures and EMP, the noise levels will be reduced and the impacts can be minimized.

Any industrial/mining complex in general consists of several sources of noise in clusters or single. This clusters/single source may be housed in buildings of different dimensions made of different materials or installed in open or under sheds. The material of construction of boundary implies different attenuation co-efficient. The main noise generating sources in the mines are Shovel, Dumper, Drill, dozer, blasting, truck and cranes etc. All these sources will generate noises in stopgap way. The equipment shall be maintained to comply with the stipulated limit of 90 dB (A).

2.3.4. SOIL ENVIRONMENT

Locations in and around the mine lease area were selected for soil sampling. At each location, soil samples were collected from 0 to 30 cm, below the surface and are homogenized. This is in line with IS: 2720 and Methods of Soil Analysis, Part-1, 2nd edition, 1986 of (American Society for Agronomy and Soil Science Society of America). The homogenized samples were analyzed for physical and chemical characteristics. The soil samples were collected during pre-monsoon season.

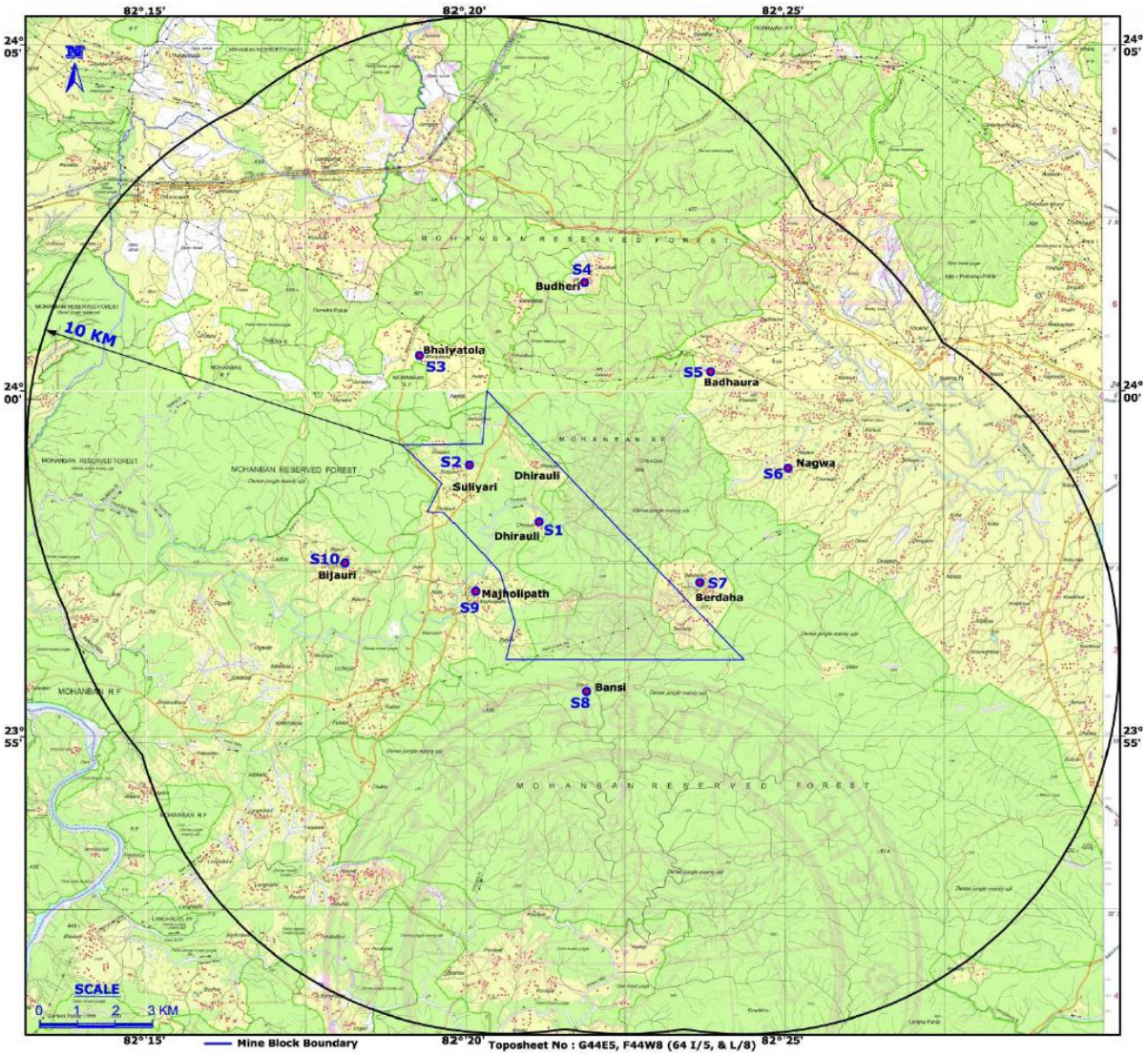


Figure 2.4: Soil Sampling Locations

Table 2.9: Details of Soil Sampling Locations

Code	Location Name	Distance (km)	Direction from Mine Site	Environmental Setting
S1	Mine Area (Dhirauli)	M.L. Area		Industrial
S2	Mine Area (Suliyari)	M.L. Area		Industrial

S3	Bhaiyatola	2.0	NNW	Rural/Residential
S4	Budheri	3.9	N	Rural/Residential
S5	Badhaura	4.7	NE	Rural/Residential
S6	Churwani	4.6	E	Rural/Residential
S7	Berdaha	0.5	ESE	Rural/Residential
S8	Bansi	0.8	S	Rural/Residential
S9	Majholipath	0.8	SW	Rural/Residential
S10	Bijauri	2.6	W	Rural/Residential

Based on the results obtained from the different soil samples, it is evident that the soil samples are predominantly sandy type. It has been observed that the pH of the soil in the study area ranged from 4.89 to 7.06. The maximum pH value of 7.06 was observed at S6 and whereas the minimum value of 4.89 was observed at S1.

The electrical conductivity was observed to be in the range of 51 to 161 µmhos/cm, with the maximum observed at S5 and the minimum observed in S4.

The nitrogen values range between 53.9 to 155.3 kg/ha. The nitrogen content in the study area is low to better content.

The phosphorus values range between 63.7 to 109.1 kg/ha, indicating that the phosphorus content in the study area falls in average sufficient to more than sufficient category.

The potassium values range between 120.3 to 378.1 kg/ha. The potassium content in the study area falls in less to more than sufficient category.

The chlorides were found to be in the range of 85.0 to 170.0 mg/kg of soil.

Table 2.10: Soil Analysis Result

Sr. No.	Parameters	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
1.	Texture	Sandy clay		Clay			Sandy clay	Clay	Sandy clay		
A	Sand %	49	51	23	21	22	48	24	53	49	46
B	Silt %	15	10	25	15	20	13	14	11	12	16
C	Clay %	36	39	52	64	58	39	62	36	39	38
2	Texture class	Sandy clay		Clay			Sandy clay	Clay	Sandy clay		
3	Bulk Density g/cc	1.3	1.2	1.2	1.1	1.2	1.3	1.2	1.2	1.3	1.2
4	pH	4.89	5.98	5.67	5.56	5.94	7.06	5.44	5.35	6.40	5.49
5	Conductivity (µS/cm)	63	74.5	66.9	51	161	106.9	103.6	83.10	98.30	130.90
6	Calcium as Ca (mg/kg)	1918.9	1476.3	1096.3	1138.3	2871.1	2440.6	1559.8	1033.8	2028.6	1869.1
7	Magnesium as Mg (mg/kg)	449.3	424.2	508.6	303.3	721.7	735.3	595.3	748.8	604.1	531.5
8	Sodium as Na (mg/kg)	17.0	12.7	14.7	13.3	31.1	13.9	16.5	18.9	11.7	12.4
9	Sodium Absorption Ratio (SAR)	0.02	0.01	0.02	0.02	0.03	0.01	0.03	0.04	0.01	0.02
10	Nitrogen as N (kg/ha)	53.9	84.2	136.0	112.6	155.3	104.9	140.8	103.7	90.1	97.2
11	Phosphorus as P (kg/ha)	79.7	63.7	103.8	85.1	109.1	68.2	107.2	71.5	68.9	75.0
12	Potassium as K (kg/ha)	120.3	248.9	143.1	240.1	378.1	360.0	296.9	364.2	355.8	265.9
13	Organic Carbon %	0.25	0.42	0.68	0.61	0.77	0.48	0.70	0.52	0.42	0.49
14	Organic Matter %	0.43	0.72	1.17	1.06	1.34	0.83	1.21	0.89	0.72	0.84
15	Water Soluble Chlorides (mg/kg)	134.5	99.2	120.4	113.0	85.0	148.9	127.5	92.1	170.0	148.8
16	Water Soluble Sulphates (mg/kg)	36.2	32.2	43.6	50.9	37.0	29.1	38.8	35.6	27.2	31.8
17	Aluminium %	0.98	1.11	1.93	1.01	1.38	0.47	0.72	1.16	0.51	0.65
18	Iron %	0.54	0.49	0.66	0.55	1.82	0.60	1.04	0.68	1.09	0.71
19	Manganese (mg/kg)	216.3	487.2	214.2	183.2	444.3	250.6	385.8	159.3	356.5	196.4

20	Boron (mg/kg)	96.5	100.2	93.0	88.3	76.4	55.8	49.3	60.7	52.7	49.2
21	Zinc (mg/kg)	14.0	35.1	33.8	31.2	38.1	19.8	16.1	20.2	27.1	12.0
22	Chromium as Cr (mg/kg)	46.5	19.0	16.2	25.4	74.5	30.2	43.9	10.6	35.6	45.5
23	Lead as Pb (mg/kg)	13.1	6.6	18.3	9.4	10.3	3.1	11.6	15.7	6.7	12.0
24	Nickel as Ni (mg/kg)	8.8	20.7	24.7	16.4	29.2	11.2	10.3	14.5	8.2	6.6
25	Arsenic as As (mg/kg)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
26	Mercury as Hg (mg/kg)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
27	Cadmium as Cd (mg/kg)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
28	Exchangeable Calcium (meq/100g)	9.59	7.38	5.48	5.69	14.36	12.20	7.80	5.17	10.14	9.35
29	Exchangeable Magnesium (meq/100g)	3.74	3.53	4.24	2.53	6.01	6.13	4.96	6.24	5.03	4.43
30	Exchangeable Sodium (meq/100g)	0.07	0.06	0.06	0.06	0.14	0.06	0.07	0.08	0.05	0.05
31	Exchangeable Potassium (meq/100g)	0.03	0.07	0.04	0.07	0.11	0.09	0.08	0.10	0.09	0.07
32	Cation Exchange Capacity (meq/100g)	13.44	11.04	9.82	8.35	20.61	18.48	12.91	11.59	15.32	13.90

Physical Characters

The physical characters include bulk density, grain size distribution (textural analysis).

Grain Size Distribution: Texture indicates relative proportion of various sizes of primary soil particles such as sand, silt and clay present in the soil. Based on their quantities present in the soil sample and using the textural classification diagram. The textural classes of ten soil samples are sandy clay and clay

Bulk Density: In case of bulk density total soil space (space occupied by solid and pore spaces combined) are taken in to consideration. Thus, bulk density is defined as the mass (weight) of a unit volume of a dry soil. This volume would, of course include both solids and pores. Soil texture, soil structure and organic matter content are the factors influencing the bulk density of a soil. Bulk Density, besides being an interesting and significant physical characteristic, is very important as a basis for certain computations. The Bulk density of the Ten soil sample under consideration are inferred from texture data is 1.10 to 1.30 is low as per texture of the samples.

Chemical Characters

The parameters considered for chemical analysis are: Soil reaction (pH), Electrical conductivity (EC), Cation Exchange Capacity (CEC)) Cations, like Calcium, Magnesium, Sodium and Potassium, water soluble sulphates, and chlorides, sodium Adsorption Ratio (SAR)., Macro nutrients like Available Nitrogen, total Organic carbon, organic matter Available phosphorus, available potassium Micro nutrients like Iron, Zinc, manganese and boron. Heavy metals like Chromium, Lead, Nickel, Arsenic, Mercury and cadmium.

Soil Reaction (pH):

The nutritional importance of pH is illustrated, thus hydrogen ion concentration has influence not only on, solubility of nutrients, but also upon facility with which these nutrients are absorbed by plants, even already in soil solution for e.g. Fe, Mn and Zn become less available as pH rises from 4.5 to 7 to 8. At pH 6.5 to 7.0 utilization of nitrate and ammonia nitrogen becomes more available. In case of phosphorus it becomes less available to plant as pH increases above 8.5, due to its fixation in exchange complex of soil. For the Eight soil sample under consideration the pH ranges between 4.89 to 7.06 indicating soils are very strongly acidic to neutral.

Electrical Conductivity (EC):

The salt content of the soils is estimated by EC measurements, and is useful to designate soils as normal or sodic (saline). Electrical conductivity is expressed as µmhos/cm at 25°C, µsmhos/cm or mmhos /cm or sm/cm. The EC of Eight soil samples is between 51 to 161

µs/cm and are below the limits to be called as saline and hence the soils are normal for crop growth.

Organic Carbon/Organic Matter (%):

Although accounting for only a small part of the total soil mass in mineral soils, organic matter influences physical, chemical, and biological activities in the soil. Organic matter in the soil is plant and animal residue which serves as a reserve for many essential nutrients, especially nitrogen. Determination of organic matter helps to estimate the nitrogen which will be released by bacterial activity for the next season depending on the conditions, soil aeration, pH, type of organic material, and other factors. The Ten soil samples under consideration contain 0.25 to 0.77 % organic carbon and 0.43 to 1.21% organic matter, OM is calculated from organic carbon estimation. As per crop requirements the soils are less to on an average sufficient in organic carbon content.

Available Nitrogen (N):

Nitrogen is a part of all living cells and is a necessary part of all proteins, enzymes and metabolic processes involved in the synthesis and transfer of energy. Nitrogen is a part of chlorophyll, the green pigment of the plant that is responsible for photosynthesis. Helps plants with rapid growth, increasing seed and fruit production and improving the quality of leaf and forage crops. The available nitrogen in the Ten samples in question, as per analysis ranges between 53.9 to 155.3 kg/ha showing less to better nitrogen content for crop growth.

Available Phosphorus (P):

Like nitrogen, phosphorus (P) is an essential part of the process of photosynthesis, involved in the formation of all oils, sugars, starches, etc. Helps with the transformation of solar energy into chemical energy; proper plant maturation; withstanding stress, effects rapid growth, Encourages blooming and root growth. The phosphorus content of soil of Ten samples ranges between 63.7 to 109.1 kg/ha and falls under medium to more than sufficient category for crop growth

Available Potassium (K):

Potassium is absorbed by plants in larger amounts than any other mineral element except nitrogen and, in some cases, calcium. Helps in the building of protein, photosynthesis, fruit quality and reduction of diseases. The Potassium content of Ten soil samples ranges between 120.3 to 378.1 kg/ha and is low to more than sufficient for crop growth.

Cation Exchange Capacity (CEC):

The total amount of exchangeable cations that a soil can retain is designated as cation exchange capacity (CEC) and usually expressed as meq/100gm of soil. Determination of

amount of cations present in soil is useful, because CEC influences the availability of adsorbed cations to both higher plants and soil microorganisms. Thus, CEC is directly related to fertility of soils. The CEC of the Ten samples range between 8.35 to 20.61 me/100gm soil.

Exchangeable Calcium (Ca++):

Calcium, an essential part of plant cell wall structure, provides for normal transport and retention of other elements as well as strength in the plant. It is also thought to counteract the effect of alkali salts and organic acids within a plant and soil acidity. The exchangeable calcium content of Ten soil samples ranges between 5.17 to 14.36 me/100gm soil.

Exchangeable Magnesium (Mg++):

Magnesium is part of the chlorophyll in all green plants and essential for photosynthesis. It also helps activate many plant enzymes needed for growth. The magnesium content of the Ten soil samples ranges between 6.54 to 24.56 me/100gm soil.

Exchangeable Sodium (Na+):

Though sodium is not an essential plant nutrient, but it has some role in potassium nutrition. Sodium also has a role in affecting the pH of soils; Sodium present above a certain limit makes soil alkaline which affect soil physical condition, and fixing of available phosphorus. In the Ten samples sodium ranges between 0.05 to 0.14 me/100gm soil.

Exchangeable Potassium (K+):

Potassium is absorbed by plants in larger amounts than any other mineral element except nitrogen and, in some cases, potassium Helps in the building of protein, photosynthesis, fruit quality and reduction of diseases. The Potassium content of Ten soil sample is 0.03 to 0.11 me/100 gm

Sodium Adsorption Ratio (SAR):

Sodium adsorption ratio is ratio of Na+ to under root of Ca++ Mg++ by 2. SAR values of soil solution along with EC and pH helps in diagnosing soils as normal, saline, saline-alkali or alkali. The Ten soil samples show SAR values between 0.01 to 0.04.

Iron (Fe):

Iron is essential for crop and other plants for chlorophyll formation Iron deficiency likely occurs in soils with high pH, poor aeration, excessive phosphorus, or low organic matter. It may be produced also by an imbalance of Mo, Cu, and Mn. In plants, the deficiency shows up as a pale green leaf color (chlorosis) with sharp distinction between green veins and yellow inter-venial tissues. The iron content of Ten samples ranges between 0.49 to 1.82%

Aluminum (Al):

Exchangeable Aluminum (Al) is not present in a plant available form in soils with a pH above 5.5 and therefore tests for extractable aluminum need only be done on distinctly acid soils. In soils with a pH range of 4.5 - 5.5 are those most likely to be affected by aluminum toxicity. In the Ten samples the total Aluminum ranges between 0.47 to 1.93%.

Manganese (Mn):

Is an important plant micro nutrient and is required by plants in second greater quantity compared to iron, like any other element, it can have limiting factor on plant growth, if it is deficient or toxic in plant tissue.

Manganese is used in plants as major contribution to various biological systems, including photo synthesis, respiration and nitrogen assimilation. Mn content in the Ten samples ranges between 159.3 to 487.2 mg/kg.

Zinc (Zn):

Zn deficiency most often is present in sandy soils with neutral or alkaline pH, or with low organic matter. Total zinc may be high but the availability depends on other factors. In the present 10 samples Zinc content ranges between 12.0 to 38.1 mg/kg.

2.3.5. LAND-USE ENVIRONMENT

Studies on land use aspects of eco-system play important roles for identifying sensitive issues, if any, and taking appropriate actions for maintaining the ecological balance in the development of the region. As per the interpretation of satellite data and field observations during the ground truth in the project area, the Land use Land cover categories observed are mainly forest cover, Land with or Without Scrub and Agriculture lands.

IRS-RS2 Geo-Coded FCC on LISS-IV FX satellite imagery was acquired for 07th March, 2021 and was used for the mapping and interpretation. Besides, other collateral data as available in the form of maps, charts, census records, other reports and especially topographical survey of India maps are used. In addition to this, ground truth survey was also conducted to verify and confirm the ground features.

The False Colour Composite (FCC) of IRS Resourcesat-2 L4FMX satellite data used for pre-field interpretation work. Taking the help of topo-sheets, geology and geomorphology and by using the image elements the features are identified and delineated the boundaries roughly. Each feature is identified on image by their image elements like tone, texture, colour, shape, size, pattern and association. A tentative legend in terms of land cover and land use,

physiography and erosion were formulated. The sample areas for field check are selected covering all the physiographic, land use/land cover feature cum image characteristics.

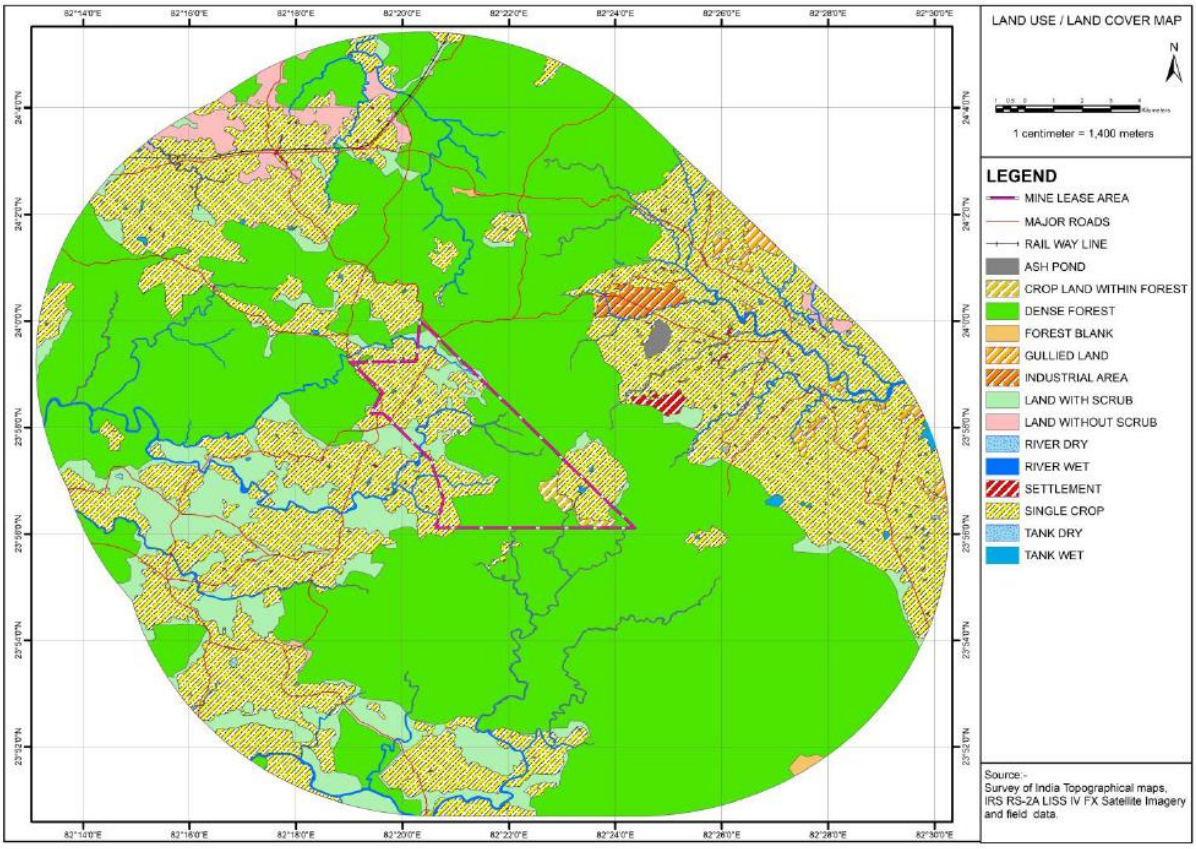


Figure 2.5: Land-Use of the Study Area

The final output would be the land use/land cover map and numerals were given different color code for each category as shown in map. Area estimation of all features of Land use/Land cover categories was noted. The thematic map, toposheet of study area and landuse map are shown in **Figure-2.5** and **Figure-2.6.** The details of the land use in 10 km radial study area are given in **Table-2.11.**

Table 2.11: Land Use Pattern in the Study Area

Sr. No.	Land Use	Area (Sq. Km)	%
1	**BUILD-UP LAND**		
	A. Settlement	14.256	2.4
	B. Industrial area	6.534	1.1
2	**WATER BODIES**		
	A. Tank/River etc.	37.422	6.3
3	**FOREST**		
	A. Dense Forest	265.518	44.7
4	**CROP LAND**		
	A. Single Crop	202.554	34.1
	B. Crop Land within Forest	7.128	1.2
5	**WASTELANDS**		
	A. Land with Scrub	31.482	5.3

	B. Land without Scrub	12.474	2.1
	C. Forest Blank	6.534	1.1
	D. Gullied Land	7.722	1.3
	E. Ash Pond	2.376	0.4
Total		**594**	**100**

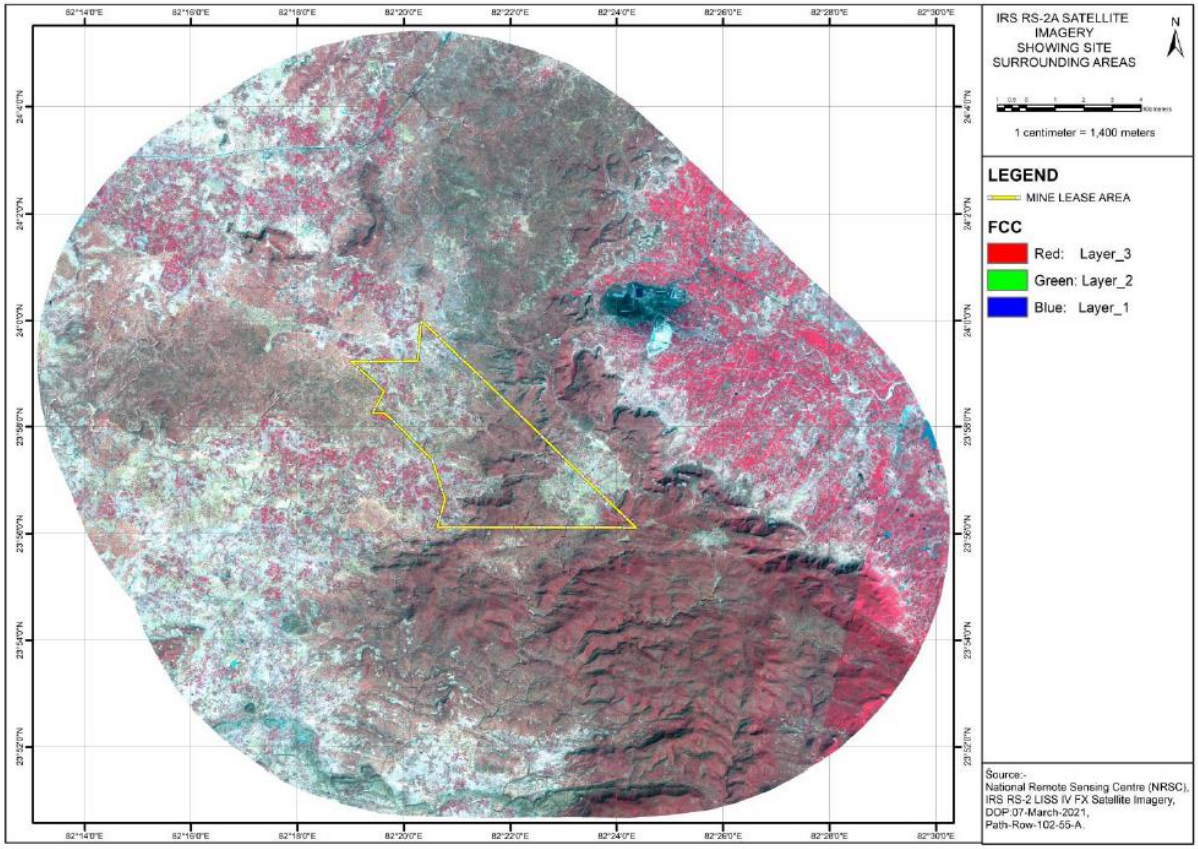


Figure 2.6: Thematic Map of Study Area (IRS-RS2:LISS4)

2.3.6. SOCIO ECONOMIC ENVIRONMENT

- Majority of the respondents were illiterates or just up to primary level or up to secondary level.
- Major populations in the study area are wage-laborers engaged in agriculture activity.
- Major population were landless. Most of the farmers belonged to the marginal farmer category.
- This small land holding was responsible for their dependency for their livelihoods on mining and related ancillary activities.
- Major population in the region is tribal and mostly is dependent of forest products for their livelihood.
- Majority of the respondents accepted the negative impact of mining on adjoining forest and agriculture. They reported that forest/tree cover has been decreased.

- Skill development programs for the local populace should be organized, so that they can earn their livelihoods. It may be implemented through trainings for making local products, Sericulture, Medicinal Plant Cultivation, harvesting of NWFP like Tendu Leaves and Mahua (Mahua Flowers, Fruits and Seed), Bamboo Cultivation, Sewing etc. and implementing these Socio-economic activities will lead give further Value Additions in the region.
- The introduction of mining in the study area had not only enhanced the source of revenue for Government but had also increased the source of livelihood for local communities, both directly and indirectly. It has also attracted lots of outsiders into its periphery to work either as permanent or temporary mine workers.
- It can be summarized from the data collected that the project authority is working towards the welfare of the community in surrounding villages of the project site.
- Major conclusion can be drawn from the study that the mining activity in the region has helped in the economic development in the region.

2.3.7. BIOLOGICAL ENVIRONMENT

The qualitative analysis of flora and fauna found in the region was prepared by conducting field survey and by discussions with concerned Forest Department personnel using the list available in the Working Plan as a base.

The Core and Buffer Zone is located in Singrauli Coal Field, Tehsil Sarai, Madhya Pradesh which comprises of hilly to plan terrain studded with forests, sparsely populated and spanned with intermittent agricultural areas. The biotic environment can be described under following heads:

A. Core Zone:

i. Barren/Waste Land
ii. Forest/Natural Vegetation
iii. Agricultural Land
iv. Wildlife and Avi Fauna

B. Buffer Zone:

i. Agricultural Land
ii. Plantation around Human Settlement
iii. Waste Land
iv. Forest Area
v. Wildlife and Avifauna

All the water bodies (Lentic & Lotic) have strong self-purification system which controls the entire functioning of the ecosystem. All kinds of aquatic biota, their composition and their distribution depend upon the geo-morphological and physico-chemical characteristics of the water bodies. Aquatic biodiversity of any water body reflects its potential to carry the external pollution load from the nearby catchment area. During the present study, physico-chemical and biological characteristics of all water bodies situated in the study area of Dhirauli Coal Block indicates that, it's healthy and productive nature. Surface water at all the sampling sites located nearby the proposed project is suitable for drinking, aquaculture practices, irrigation and other usage of domestic purpose. Some anthropogenic activities and direct mixing of domestic waste water has been observed which may affect the natural conditions of Hurdul Nala and Jhana Nala within the mine lease area and Mahan Nala, Chhiraha Nala, Sulkhia Nala, Biniao Nala, Sukar Nala, Sukhra Nala, Nimji Nala, Hariya Nala Ramnpa & Gopal River within the 10 km radius of the proposed coal block.

Core Zone Floral Diversity

The core zone, Dhirauli Coal Block, have been allotted to M/s Stratatech Mineral Resource Private Limited (SMRPL) vide Letter No. NA-104/7/2020-NA dated 03.03.2021 by MoC, GoI.

The Dhirauli coal mine Project covers an area of 2672 Ha and located in eight villages Dhirauli, Phatpani, Sirswah, Amdand, Jhalari, Amraikhoh, Bansibridha, and Belwar.

The Dhirauli coal block boundary coordinates in WGS84 datum as per CMDPA is as follows:

Point	Latitude	Longitude
1.	23°56'07"	82°19'04"
2	23°56'07"	82°24'21"
3	23°03'04"	82°24'21"
4	23°03'04"	82°19'04"

A change in the composition of biotic communities is reflected by a change in the distribution pattern of natural species of flora and fauna existing in the ecosystem. The sensitivity of animal and plant species to the changes occurring in their existing ecosystem can, therefore, be used for monitoring of Impact Assessment studies of any project.

Biological communities are the indicator environmental condition and resource of its distribution and survival. Biotic component comprises of both plants (Flora) and animal

(Fauna) communities, which interact not only within and between them but also with the Abiotic components, viz. physical and chemical components of the environment. The changes in biotic community are studied in the pattern of distribution, abundance and diversity.

Table 2.12: Floral Diversity within Core Zone

Family name	Botanical name	Local/Trade name
(a) Upper layer – Trees		
Anacardiaceae	*Semecarpus anacardium*	Bibba
Annonaceae	*Annona squamosa*	Sitaphal
Bignoniaceae	*Stereospermum xylocarpum*	Katori
Caesalpinaceae	*Bahunia racemosa*	Apta
	Cassia fistula	Bahawa
	Delonix regia	
	Hardwickia binata	Anjan
	Parkinsonia aculeate	Vedi-babul
	Tamarindus indica	Chunch
Simaroubaceae	*Ailanthus excels*	Maharukh
Combretaceae	*Anogiessus latifolia*	Dhawda
	Terminalia alata	Ain
	T. arjuna	Arjun/Kahu
	T. chebula	Hirda
Depterocarpaceae	*Shorea robusta*	Sal
Ebenaceae	*Diospyros melanoxylon*	Tendu
Euphorbiaceae	*Phyllanthus emblica*	Awla
Fabaceae	*Butea monosperma*	Palas
	Dalbergia paniculata	Dhobin
	D. sissoo	Sisam
	Erythrina variegate	Kasai
	Pongamia pinnata	Karanj
	Pterocorpus marsupium	Bija
Poaceae	*Bambusa arundinaceae*	Katang bamboo
Leeaceae	*Leea crispa*	Kuram
Lythraceae	*Lagerstroemia parviflora*	Lendia/lenda
Meliaceae	*Azadirachta indica*	Neem
	Melia azedarach	Bakneem
Mimosaceae	*Acacia arculiformis*	Babul
	A. catechu	Khair
	A.nilotica	Babul
	Albizzia lebbeck	Sirish
	A.odoratissima	Shinchuva
	A. procera	Pandra
	Cassia siamea	Kashid
	Leucaena leucocephala	Subabul

Family name	Botanical name	Local/Trade name
	Xylia xylocarpa	Suria
Moraceae	*Ficus benghalensis*	Vad
	F.racemosa	Umber
	F.religiosa	Pipal
	Ficus hispida	Katgular
Moringaceae	*Moringa citrifolia*	Aal
Myrtaceae	*Syzygium cumini*	Jamun
Palmae	*Borassus flabellifer*	Sindhi
Rhamnaceae	*Zizyphus mauritiana*	Ber
Rubiaceae	*Adina cordifolia*	
	Mitragyna parviflora	Mundi
Rutaceae	*Chloroxylon swietenia*	Behura
	Aegle marmelos	Bel
Sapindaceae	*Schleichera oleosa*	Kusumb
	Sapindus laurifolium	Ritha
Sterculiaceae	*Sterculia urnes*	Karaj
Tiliaceae	*Grewia tiliaefolia*	Dhaman
	Grewia disperma	Chaturli
Verbenaceae	*Tectona grandis*	Sagwan
	Gemelina arborea	Gamari
(b) Middle layer – Trees, Shrubs & Climbers		
Asclepidaceae	*Daemia extensa*	Utaranvel
Celastraceae	*Maytenus emarginata*	Bharati
Combretaceae	*Calycopteris floribunda*	Gilibuli
	Combretum ovilifolium	Piwarvel
Convolvulaceae	*Argyrea nervosa*	Rakath vel
Cuscutaceae	*Cuscuta reflexa*	Amar vel
	Ipomoea quiomeelit	Ganesh vel
	I. eriocarpa	Boota
	I.palmata	Ghiabato
	I.absucura	Dopateluta
Discoreaceae	*Dioscorea bulbifera*	Akas vel
Euphorbiaceae	*Kirganelia reticulate*	Pitundi
	Securenga virosa	Dhani
Fabaceae	*Abrus precartorious*	Gunj
	Butea superb	Palas vel
Flocourtiaceae	*Flacourtia indica*	Kakai
Minispermaceae	*Cocculus hirsutus*	Vasan vel
Nyctaginaceae	*Nyctanthus arbortristis*	Kharasi
Ascclepiadaceae	*Cryptolepis buchanani*	Dhdhi
Rhamnaceae	*Ventilago denticulate*	Lokhandi
	Zizypus juzuba	Bhor
	Z.oenoplia	Eroni
Tiliaceae	*Grewia hirsute*	Gaturli
Verbenaceae	*Lantana camara*	Raimunia
	Vitex negundo	Nirgundi

Family name	Botanical name	Local/Trade name
(c) Climbers		
Caesalpiniaceae	*Bauhinia vahlii*	Mahul
	Caesalpinia decapetala	Chilati
Combretaceae	*Calycopteris floribunda*	Gilibuli
Cuscutaceae	*Cuscuta reflexa*	Amar vel
Convolvulaceae	*Ipomoea qumoclit*	Ganesh vel
Dioscoreaceae	*Dioscorea bulbifera*	Gathalu
	Dioscorea pentaphylla	Musalkand
Cucurbitaceae	*Momordica charantia*	Karela
Mimosaceae	*Acacia caesia*	Gurar
	Acacia pinnata	Raoni
Asclepiadaceae	*Cryptolepis buchanani*	Dudhi
(d) Ground layer – Shrubs & Herbs		
Acanthaceae	*Andropogon pumilus*	Diwartan
Amaranthaceae	*Achyranthus aspera*	Chirchitta
	Amaranrhus spinosus	Kate chawli
Caesalpinaceae	*Cassia tora*	Kan kuti
Asteraceae	*Tridax procumbens*	Kamarmodi
	Parthenium hysterophorus	Gajar gawat
	Spilanthus acmella	Na
Convolvulaceae	*Evolvulus alsinoides*	Na
	E.nummularis	Na
	Merremia emarginata	Undir khani
Euphorbiaceae	*Euphorbia hirta*	Dhudhi
	E.rosea	Na
Fabaceae	*Alyscicarpus monilifer*	Na
	Indigofera linifolia	Na
	I.cordifolia	Na
	Tephrosia hamiltonii	Divali
	Tephrosia purpuea	
Laminaceae	*Hyptis suaveolens*	Na
	Ocimum sanctum	Tulsi
	Ocimum bassilicum	Rantulsi
	Leucas biflora	Na
Liliaceae	*Gloriosa superb*	Khadyanag
Malvaceae	*Hibiscus lobatus*	Na
	Sida veronicaefolia	Na
	Sida acuta	Na
Pedaliaceae	*Martynia annua*	Waghnakhi
Mimosaceae	*Mimosa pudica*	Lajavanti
Nyctaginaceae	*Boerhavia diffusa*	Na
Oxalidaceae	*Oxalis corniculata*	Tipani
Rananculaceae	*Cleome viscose*	Pivili tilwan
Rubiaceae	*Borreria articularis*	Na
Solanaceae	*Datura metal*	Kala dhotra
	Physalis minima	Na
Zygophylaceae	*Tribulus terrestris*	Goakru

Family name	Botanical name	Local/Trade name
(e) List of Grasses and Sedges of Buffer Zone		
Cyperaceae	*Kylliga tenufolia*	Na
	Scleria annularis	Na
Poaceae	*Apluda mutica*	Phulkia
	Aristida hystrix	Na
	Chloris barbata	Na
	Cymbapogon martini	Tikhadi
	Dactyloctenum aegyptium	Na
	Digitaria ternate	Na
	Eleusine indica	Na
	Eragrostiella bifaria	Na
	Eragrostis ciliaris	Na

Faunal Diversity within the Core Zone

The Fauna of a particular region indicates environmental conditions and the well being of the population residing in the region. Faunal studies help to understand the well being of the natural systems and indicate functioning of ecosystem. It helps to monitor pollution levels, biological richness or heritage quality, habitat change quantifying threatened species. The faunal components such as Arthropods, Molluscs, Pisces, Birds and Mammals are very sensitive to any change in the ecosystem, therefore are very good indicators of the health of an ecosystem. The details of faunal diversity of Dhirauli coal block (Core Zone) is given along with the buffer zone in Table-2.14.

Floral Diversity within Buffer Zone

The study area best represents as moist region. The vegetation is fairly dense and occurs on crystalline rocks and yellow loam soils. Soil and topography vary together. It can be helpful to differentiate three subtypes of topography; hilltops and plateaus, lower hill slopes and valley bottom. There is light shrub and weed growth under the forest canopy. The vegetation mainly consists of tall tress of *Shorea robusta, Tectona grandis, Terminalia tomentosa, Madhuca indica.* The vegetation can be described as moist peninsular Sal forest.

The total species of plants are indicating the floristic richness of the area. However, these species are not uniform in their distribution. The most dominant genera were *Shorea, Tectona, Bahuinia, Cassia, Ficus, Euphorbia* followed by *Acacia, Anogessus, Lagerstromia, Bamboo, Jatropha* and *Madhuca.* The most dominant family was Fabaceae, followed by Poaceae (22 species), Euphorbiaceae (17 species), Mimosaceae (11 species), Caesalpinaceae (13 species), Asteraceae (15 species) and Amaranthaceae (10 species).

There is predominance of herbs and trees followed by shrubs, climbers, epiphytes, grasses and sedges. The common climbers are *Butea superba, Combretum decandrum,* and *Bauhinia vahli.* Only two Gymnosperms were noticed which are cultivated in gardens. The Pteridophytes represented reasonably good number (7) along with 6 Bryophytes. They are very much sensitive to humidity and moisture. List of plant species as reported according to the Working Plans of **Suliyari Forest Division** has been studied out of which the main associates of Sal as observed in the field are furnished below in **Table No. 2.13.**

Table-2.13: Floral Diversity within buffer zone of Proposed coal mine

Sr. No.	Common Name	Scientific Name	Family
		Trees	
1.	Khair	*Acacia catechu*	Fabaceae
2.	Hiwar	*Acacia leucophlea*	Fabaceae
3.	Haldu	*Adina cordifolia*	Rubiaceae
4.	Bel	*Aegle marmelos*	Rutaceae
5.	Mahaneem	*Aelanthus excelsa*	Simarubiaceae
6.	Kala siris	*Albizzia lebbek*	Fabaceae
7.	Chichwa	*Albizzia odoratissima*	Fabaceae
8.	Safed siris	*Albizzia procera*	Fabaceae
9.	Pasi	*Anogeissus acuminata*	Combretaceae
10.	Neem	*Azadirachta indica*	Meliaceae
11.	Keolar	*Bauhinia purpurea*	Fabaceae
12.	Kachnar	*Bauhinia variegata*	Fabaceae
13.	Semal	*Bombax ceiba*	Malvaceae
14.	Kasai	*Bridelia retusa*	Euphorbiaceae
15.	Chironji	*Buchnania lanzan*	Anacardiaceae
16.	Palash	*Butea monosperma*	Fabaceae
17.	Bhui	*Karea arborea*	Mayrtaceae
18.	Tondri	*Casearia tomentosa*	Samydaceae
19.	Amaltas	*Cassia fistula*	Fabaceae
20.	Bhirra	*Choloroxylon swietenia*	Meliaceae
21.	Sisham	*Dalbergia latifolia*	Fabaceae
22.	Dhobin	*Dalbergia paniculata*	Leguminoceae
23.	Tendu	*Diospyrosmelanoxylon*	Ebenaceae
24.	Aonla	*Emblica officinalis*	Euphorbiaceae
25.	Pangra	*Erythrina indica*	Leguminoceae
26.	Bargad	*Ficus bengalensis*	Moraceae
27.	Gular	*Ficus glomerata*	Moraceae
28.	Pipal	*Ficus religiosa*	Moraceae
29.	Kekad	*Garuga pinnata*	Burseraceae
30.	Dhaman	*Grewia tiliaefolia*	Tilliaceae
31.	Chirol	*Holoptelia integrifolia*	Urticaceae
32.	Baranga	*Kydia calycina*	Malvaceae
33.	Lrndia	*Lagerstroemia parviflora*	Lythraceae
34.	Jhingan	*Lannea coromandelica*	Anacardiaceae
35.	Gunja	*Lannea grandis*	Anacardiaceae

Sr. No.	Common Name	Scientific Name	Family
36.	Mahua	*Madhuca indica*	Sapotaceae
37.	Aam	*Mangifera indica*	Anacardiaceae
38.	Mundi	*Mitragyna parviflora*	Rubiaceae
39.	Aal	*Morinda tinctoria*	Rubiaceae
40.	Tinsa	*Ougeinia oojeinensis*	Fbaceae
41.	Bija	*Pterocarpus marsupium*	Fabaceae
42.	Khajur	*Phoenix sylvestris*	Palmae
43.	Karanj	*Pongamia pinnata*	Fabaceae
44.	Kusum	*Schleichera oleosa*	Sapindaceae
45.	Bhelva	*Semecarpus anacardium*	Anacanrdiaceae
46.	Sal	*Sorea robusta*	Dipterocarpaceae
47.	Badapadar	*Stereospermum suaveolens*	Bignoniaceae
48.	Rohina	*Soymida febrifuga*	Meliaceae
49.	Jamun	*Syzygium cuminii*	Myrtaceae
50.	Imli	*Tamarindus indica*	Fabaceae
51.	Sagaun	*Tactona grandis*	Verbenaceae
52.	Saja	*Terminalia tomentosa*	Combretaceae
53.	Arjun	*Terminalia arjuna*	Combretaceae
54.	Baheda	*Terminalia belerica*	Combretaceae
55.	Harra	*Terminalia chebula*	Combretaceae
56.	Morphal	*Vitex negundo*	Verbenaceae
57.	Ber	*Zizyphus mauritiana*	Rhamnaceae
		Herbs and Shrubs	
58.	Chirchira	*Achyranthes aspera*	Amaranthaceae
59.	Bhui Neem	*Andrographis paniculata*	Acanthceae
60.	Shomoshi	*Asparagus racemosus*	Liliaceae
61.	Bankapas	*Azanza lampas*	Malvaceae
62.	Aak	*Calotropis-gigantea*	Asclepiadaceae
63.	Karonda	*Carissa opaca, Stapf*	Apocynanceae
64.	Panwar	*Cassia tora*	Fabaceae
65.	Bandar	*Colebrookea oppositifolia*	Labiatae
66.	Hardi	*Curcuma longa*	Seitamineae
67.	Kharata	*Dodonaea viscosa*	Sapindaceae
68.	Baibirang	*Embelia robusta*	Myrsinaceae
69.	Bantulsi	*Eranthemum pulchellum*	Acanthaceae
70.	Ban Rahar	*Flemingia semialata*	Fabaceae
71.	Dikamali	*Gardenia gummigera*	Rubiaceae
72.	Marorphali	*Helicteres isora*	Sterculiaceae
73.	Dhudh	*Holarrhena antidysentrica*	Apocynaceae
74.	Girol	*Indigofera pulchella*	Fabaceae
75.	Ban Mirchi	*Murraya exotica*	Rutacae
76.	Harsigar	*Nyctanthes arbor-tristis*	Oleaceae
77.	Chhind	*Phoenix acaulis*	Palmae
78.	Nirgundi	*Vitex negundo*	Verbenaceae
79.	Dhawai	*Woodfordia fruticosa*	Lytharceae
		Climbers	
80.	Gun	*Abrus precatorlus*	Fabaceae

Sr. No.	Common Name	Scientific Name	Family
81.	Stawar	*Asparagus racemosus*	Fabaceae
82.	Mahul	*Bauhunia vahlii*	Fabaceae
83.	Palasbel	*Butea superba*	Fabaceae
84.	Bet	*Calamus viminalis*	Palmae
85.	Piperbel	*Combretum decandrum*	Combretaceae
86.	Baichandi	*Dioscorea hispida*	Discoreaceae
87.	Agrilaha	*Millettea auriculata*	Fabaceae
88.	Kenwanch	*Mucuna prurita*	Fabaceae
89.	Giloh	*Tinospera cordifolia*	Menispermaceae
90.	Rhmnaceae	*Zizyphus oenoplia*	Makor
		Bamboo	
91.	Salia Bans	*Dendorcalamus strictus*	Poaceae
92.	Kanta bans	*Bambusa arundinacea*	Poaceae
93.	Panoli Bans	*Cephalostachyum pergracile*	Poaceae
94.	Yellow Bans	*Bambusa vulgaris*	Poaceae
		Epiphytes	
95.	Vanda	*Vanda roxburghii*	Loranthceae
		Parasites	
96.	Amarbel	*Cuscuta reflexa*	Convelvulaceae
97.	Banda	*Loranthus longifloris*	Loranthaceae
98.	Viscum	*Viscum articulatum*	Loranthaceae
		Grasses	
99.	Dalphulia	*Andropogon bumilus*	Poaceae
100.	Bargi Ronda	*Aristida setacea*	Poaceae
101.	Sidi	*Arudinella setosa*	Poaceae
102.	Rosa Ghans	*Cymbopogon martini*	Poaceae
103.	Doob	*Cynodon dactylon*	Poaceae
104.	Chhir	*Imperata cylindrica*	Poaceae
105.	Gumar	*Themeda inderbis*	Poaceae
106.	Khas	*Vetiveria zizanoides*	Poaceae

Faunal Diversity within the Buffer Zone

A linear transect of 1.0 km each has been chosen for sampling at each site. Each transect was trekked for 1.5 hr for the sampling of faunal diversity through following methods for different categories. For the sampling of butterflies, the standard '**Pollard Walk**' method was employed and all the species recorded.

For bird's sampling, '**Point Sampling**' along the fixed transect (Foot trails) was carried out. All the species of birds were observed and identified with the help of field guide book and photographs.

For the sampling of mammals, direct count on open width (20m) transect were used. In addition, information on recent sightings/records of mammals by the villagers/locals were

also be collected. For carnivores, indirect sampling was carried out and the mammals were identified by foot marks, faeces and other marks/sign created by them. In case of reptiles mainly lizards were sampled by direct count on open width transects.

The study of fauna takes substantial amount of time to understand the specific faunal characteristic of area. The assessments of fauna were done by extensive field survey of the area. During survey, the presence of wildlife has been confirmed by direct field survey and by the oral information by local inhabitants and data procured from the concerned forest department has been made and given in below (**Table-2.14**).

Table 2.14: Faunal Diversity from Study Area

S. No.	Scientific Name	English Name	WPA-72 Schedule
Mammals			
1	*Axis axis*	Chital	Schedule-III
2	*Bendicota bengalensis*	Field Rat	Schedule-IV
3	*Boselaphus tragocamelus*	Nilgai	Schedule-III
4	*Canis aureus*	Jackal	Schedule-II
5	*Elephas maximus indicus*	Elephant	Schedule-I
6	*Felis chaus*	Jungle Cat	Schedule-I
7	*Funambulus pennanii*	Five Striped Palm Squirrel	Schedule-IV
8	*Herpestes edwerdsii*	Common Mangoose	Schedule-II
9	*Hystrix indica*	Indian Porcupine	Schedule-II
10	*Lepus nigricollis*	Indian Hare	Schedule-IV
11	*Maccaca mulata*	Monkey	Schedule-II
12	*Melursus ursinus*	Sloth bear	Schedule-I
13	*Muntiacus muntjak*	Barking Deer	Schedule-III
14	*Mus booduga*	Indian field mouse	Schedule-V
15	*Presbytis entellus*	Hanuman Langoor	Schedule-II
16	*Rattus rattus*	Black Rat	Schedule-V
17	*Rousettus leschenaultia*	Bat	Schedule-V
18	*Suncus murinus*	Chachundar	Schedule-IV
19	*Sus scrofa*	Wild Boar	Schedule-III
20	*Viverricula indica*	Indian Civet	Schedule-II
21	*Vulpus bengalensis*	Fox	Schedule-II
22	*Manis crassicaudata*	Pangolin	Schedule-I
23	*Hyaena hyaena*	Hyaena	Schedule-III
24	*Panthera pardus*	Leopard	Schedule-I
25	*Munticacus munrjak*	Barking deer	Schedule-III
26	*Canis lupas pallipes*	Indian Wolf	Schedule-I
27	*Varanus bengalensis*	Bengal Monitor Lizard	Schedule-I
28	*Axix axis*	Chital	Schedule-III
Herpatofauna			
1	*Bufo stomaticus*	Marble Toad	NA
2	*Bungarus caeruleus*	Common Indian Krait	Schedule-IV
3	*Calotes versicolor*	Common garden lizard	NA

S. No.	Scientific Name	English Name	WPA-72 Schedule
4	*Daboia siamensis*	Russel Viper	Schedule-II
5	*Duttaphrynus melanostictus*	Common Indian Toad	NA
6	*Euphlyctis cyanophlyctis*	Indian Skipper Frog	Schedule-IV
8	*Hemidactylus flavivridis*	House gecko	NA
9	*Hyla arborea*	Tree Frog	NA
10	*Mabuya carinata*	Brahminy skink	NA
11	*Naja naja*	Indian Cobra	Schedule-II
12	*Natrix piscator*	Common Water Snake	Schedule-IV
13	*Ptyas mucosus*	Common rat snake	Schedule-II
14	*Python molurus*	Python	Schedule-I
15	*Rana hexadactyla*	Indian pond frog	Schedule-IV
16	*Varanus sp.*	Monitor lizard	Schedule-III
17	*Chameleon zeylanicus*	Indian chameleon	Schedule-II
Aves			
1	*Accipiter badius*	Shikra	Schedule-IV
2	*Acridotheres ginginianus*	Bank Myna	Schedule-IV
3	*Acridotheres tristis*	Common Myna	Schedule-IV
4	*Amaurornis phoenicurus*	White breasted water hen	Schedule-IV
5	*Ardeola grayii*	Pond heron	Schedule-IV
6	*Athene brama*	Spotted Owlet	Schedule-IV
7	*Bubulcus ibis*	Cattle Egret	Schedule-IV
8	*Centropus sinensis*	Greater Coucal	Schedule-IV
9	*Ceryle rudis*	Pied Kingfisher	Schedule-IV
10	*Columba livia*	Rock Pigeon	NA
11	*Coracias benshalensis*	Indian roller	Schedule-IV
12	*Coracina macei*	Large Cuckoo-shrike	Schedule-IV
13	*Corvus corax*	Raven	Schedule-IV
14	*Corvus splendens*	House Crow	Schedule-V
15	*Dendrocitta vagabunda*	Tree Pie	Schedule-IV
16	*Dendrocitta vagabunda*	Rufous Treepie	Schedule-IV
17	*Dicrirus macrocercus*	Black Drongo	Schedule-IV
18	*Egretta garzetta*	Little Egret	Schedule-IV
19	*Eudynamys scolopacea*	Asian Koel	Schedule-IV
20	*Francolinus pondicerianus*	Gery francolin	NA
21	*Gallinula chloropus*	Common moorhen	Schedule-IV
22	*Gallus sallus*	Red Jungle Fowl	Schedule-IV
23	*Halcyon smyrnensis*	White Breasted Kingfisher	Schedule-IV
24	*Himantopus himantopus*	Stilt	NA
25	*Merops orientalis*	Little Green Bee-eater	Schedule-IV
26	*Microcarbo niger*	Little cormorant	Schedule-IV
27	*Orthotomus sutorius*	Common Tailorbird	Schedule-IV
28	*Passer domesticus*	House Sparrow	Schedule-IV
29	*Pavo cristatus*	Indian Peafowl	Schedule-I
30	*Psittacula krameri*	Rose-ringed Parakeet	Schedule-IV
31	*Pycnonotus cafer*	Red Vented Bulbul	Schedule-IV
32	*Saxicola caprata*	Pied Bush Chat	Schedule-IV

S. No.	Scientific Name	English Name	WPA-72 Schedule
33	*Saxicoloides fulicata*	Indian Robin	Schedule-IV
34	*Srniculus lugubris*	Drongo Cuckoo	Schedule-IV
35	*Turdoides caudatus*	Common Babbler	Schedule-IV
36	*Turdoides striatus*	Jungle Babbler	Schedule-IV
37	*Upupa epops*	Eurasian Hoopoe	Schedule-IV
Pisces			
1	*Aspidoparia morar*	Chelluah	NA
2	*Barilius barna*	Barna Baril	NA
3	*Catla catla*	Katla	NA
4	*Chagunius chagunio*	Chaguni	NA
5	*Channa maruliuss*	Great Snakehead	NA
6	*Cirrhinus reba*	Reba Carp	NA
7	*Clarias batrachus*	Singi	NA
8	*Cyprinus carpio*	Common Carp	NA
9	*Labeo calbasu*	Calbasu	NA
10	*Labeo dyocheilus*	Kali, Boalla	NA
11	*Labeo rohita*	Rohu	NA
12	*Mystus cavasius*	Cat fish	NA
13	*Notopterus notopterus*	Bronze Feather Back	NA
14	*Puntius chola*	Swamp Barb	NA
15	*Tenualosa ilisha*	Hilsa	NA
Butterflies			
1	*Catopsilia pomona*	Common Emigrant	NA
2	*Cyrestis thyodamas*	Common map	NA
3	*Danaus genutia*	Stripped Tiger	NA
4	*Danaus chrysippus*	Plain Tiger	NA
5	*Danaus genutia*	Stripped Tiger	NA
6	*Euploea core*	Common crow	NA
7	*Eurema hecabe*	Common Grass Yellow	NA
8	*Heliophorus* sp.	western blue sapphir	NA
9	*Hypolimanas misippus*	Danaid Egg Fly	NA
10	*Ixias marianne*	White orange tip	NA
11	*Junonia orithya*	Blue pancy	NA
12	*Melanitis leda*	Common evening Brown	NA
13	*Mycalesis perseus*	Common Bush Brown	NA
14	*Papilio demoleus*	Lime butterfly	NA

(Source: Primary Survey Data)

Cropping Pattern Adopted by Villagers

Two seasonal crops mainly Kharif (summer crop) and Rabi (winter crop) are well developed in this region. The crops grown are Wheat, Paddy, Jawar, Maize and Kodo. Besides pulses like Arhar, Mung, Mustard and Til are also grown. The main Rabi crop is also paddy which is cultivated with a short rotation and this type of crop is grown only where irrigation facilities

are available during winter. In addition Alsi, Mustard, etc. are also grown during Rabi. A very significant matter is use of fertilizers and pesticides in this region are very much limited as most of the agricultural practitioners are traditional and support use of green manure.

Extent of Biotic Pressure of the villagers on the study area:

At present agriculture is not imposing any biotic pressure on the natural ecosystem particularly of this region. The population growth is a common phenomenon all over which is not restricted to only the study area. The population growth has its impact on the natural ecosystem, common to everywhere. The energy consumption by the villagers for cooking food items entirely depends on adjoining forest areas i.e. collection of fuel wood.

Number of Families depending upon the NTFP Collection:

A majority of families in the impact area belong to SC and ST, who are involved in collection of NTFP. The main NTFP (non-timber forest produce) product is *mouha* (*Madhuca indica*) flower. *A*apart from mouha they also collect Amla (*Emblica officinalis*), Baheda (*Terminalia bellirica*), Harra (*Terminalia chebula*) and Aam (*Mangifera indica*) fruits. Honey and *Jhuna (raal)* (resin from Sal tree) collection is infrequent in the study area. Tendu leaf collection is also practised here. However, during our survey we did not found any family entirely dependent on NTFP collection. The left over family members of the main work force (old age people, women and children) are mostly engaged in NTFP collection. All family members' joins for collection of NTFP during the lean period when no other engagement for earning their lively hood is available. Apart from NTFP, fire wood (locally called *Jhati)* collection from forest is a traditional and common practice in the study area. Villagers cut the tree for small timber and firewood for their own consumption. They collect their fencing materials and materials required for agricultural tools from the surrounding forests. On an average per standard family (Father+ mother+ one child) consumes 10 kg of firewood per day.

Method of NTFP Collection:

Handpicking from the ground is the main system of collection of mohua. For collecting from the ground villagers clean the forest floor by igniting fire, which destroy the ground vegetation, as well as restrict the regeneration of tree species. Repeated use of this method adversely impact herbivore population. Due to the impact of this cleaning process of underground forest growth, the ground becomes completely barren at places to check the rainwater flow, resulting in to soil erosion.

- The sign-evidence most suited for the identification of the ground dwelling animals is limited to pugmarks, hoofmarks, foot−prints and dung identification etc. However, in our visits several animals like monkeys, squirrel, birds, butterflies etc. were seen.

However, within the constraint of time limit and with limited resources the faunal data is prepared from the various secondary sources supported by field studies carried on sample basis.

- Almost all the problems described in this section are associated with human inhabitations in and near the study area. Human presence in the villages is due to the presence of villages in and around the study area and villages in the study area and located near the forests. The population in the village also exerts a considerable influence on the forests and wildlife in the study area.
- Just as people affect the forest and wildlife they are also affected due to proximity to the forest. Wild animals raid the crops of villages that are in close proximity to the forest. Wild boars are especially responsible for damaging corps.
- Animal husbandry is common. The most common livestock animals are cows, and goats. Milk is used mostly for personal consumption. Commercial sale of milk is low since the cows are not very productive. Goats are reared in some villages. They are kept for meat but often for sale. Poultry & duck farming are practiced on a small scale by most households, mostly for personal use and sale.
- Households without agricultural land get employment for a few days as agricultural labourers. Others find employment with the Forest Department for tree cutting and bamboo cutting and tree plantation work. Sometimes labour is available with the other government departments such as PWD.
- Habitat fragmentation takes place due to clearing of forests to make way for human inhabitations. This creates discontinuity in the forest. Fragmentation of the landscape hampers the natural movement of animals.

CHAPTER-3-PRELIMINARY SCREENING ECOSYSTEM SERVICES

The preliminary screening exercise for ecosystem assessment tabulated in **Table 3.1**. This has been used to define a preliminary list of ecosystem services to include in the impact assessment. At the screening stages predicted impact on ecosystem services grouped into three categories.

- Moderate or higher
- Minor
- Not significant

The results of the preliminary screening exercise incorporating this list in the table. The Ecosystem which are potential impact are expected to be moderate are carried out from screening exercise into baseline and impact assessment report.

Ecosystem Services Screened Out of the Impact Assessment, including the rational for screening them out of the assessment. Services with ***minor*** impacts include:

- Wild plants and honey (provisioning service);
- Natural oils (provisioning service);
- Ornamental resources (provisioning service); and
- Climate regulation: regional and local climate (regulating service).

Services with ***no significant*** impacts expected or that are excluded to avoid double-counting include:

- Food: aquaculture (provisioning service);
- Air quality regulation by vegetated areas (regulating service);
- Water purification (regulating service);
- Pest regulation (regulating service);
- Pollination (regulating service);
- Climate regulation: global (regulating service);
- Soil formation (supporting service);
- Primary production (supporting service);
- Nutrient cycling (supporting service); and
- Landscape disturbance regime (supporting service).

Table 3.1: Preliminary screening Assessment

Category of Service	Service	Examples	Drivers of Change Associated with the Mine	Include in Impact Assessment
Provisioning	Food: crop cultivation	Agriculture is the primary livelihood activity practiced 61.3% working populations are engaged in agriculture activity.	• Occupation of land • Impacts on surface water • quality and quantity • Demographic and economic change	Y
Provisioning	Food: Livestock cultivation	Poultry (35%), cattle (43%), goats (21%) and Sheep (1%).	• Occupation of land • Impacts on surface water quality and quantity • Demographic and economic change	Y
Provisioning	Food: fish	Inland fishing in rivers and village pond.	• Impacts on surface water quality and quantity • Disturbance to habitats and species • Demographic and economic change	Y
Provisioning	Water Supply: domestic, agricultural, construction use	Domestic water use for consumption, bathing, irrigation and other activity.	• Impacts on surface water quality and quantity • Demographic and economic change	Y
Cultural	Aesthetic value	Cultural value placed on landscapes and landmarks in the area.	• Acquisition of land • Disturbance to habitats and species	Y
Regulating	Surface water and ground water regulation	Role played by the watershed in ground water recharge and estimation of the Ground water and surface water flows.	• Acquisition of land • Impacts on surface water quality and quantity	Y
Regulating	Disease regulation	The role habitats play in providing breeding grounds for mosquitoes and other sources of vector borne disease; and of providing natural protection against the spread of disease	• Acquisition of land • Demographic and economic change	Y

3.1. BASELINE METHODOLOGY

The baseline provides an analysis of two aspects of ecosystem services in the mine study area. These include:

a) Importance of the service to beneficiaries and
b) Replace ability by spatial alternatives.

These are explained below and shown in Table 3.2.

a. Importance of ecosystem services to beneficiaries, is assessed according to the following criteria and assigned a rating from low - essential:

i. Intensity of use – e.g. daily, weekly or seasonal use of a provisioning service; number of downstream villages reliant on erosion or flood control services;
ii. Scope of use – e.g. household level v/s village level; subsistence use, trade, or both;
iii. Geographic proximity (where possible); and
iv. Degree of dependence: e.g. contribution of fish or meat to total protein in the diet.

b. Replace ability of ecosystem services is assessed according to the following criteria and assigned a rating from low – high:

i. The existence of spatial alternatives (other sites where the same ecosystem service is also provided and that are close enough to be utilized by affected communities); and
ii. The sustainability of spatial alternatives given the potential for increased resource use, including a consideration of other users and the existing status and threats to the resource.

PROVISIONING SERVICES IN THE MINE AREA OF INFLUENCE:

The provision of services in the mine area of influence has been depicted in **Table 3.2**.

Table 3.2: Provisioning Services in the Mine Area of Influence

Service	Description	Additional Information (including status, threats and availability of alternatives to the service)	Relevant Habitats	Importance to Beneficiaries	Replace ability
Food: crop cultivation	Agriculture is the primary livelihood activity practiced by households in the mine area. Rice is the primary crop grown by most households in local villages followed by wheat, and Mustard. Women also cultivate small vegetable gardens. Farming is primarily a subsistence activity, providing food for household consumption and limited surplus sold for small income. It is not practiced on a commercial scale in the mine area. Maximum population in the study area is engaged as Cultivators' i.e. depended on agriculture. The cultivator population within the rural area is 6699 (58.90%). It can be concluded from the data the populations in the villages are mainly engaged in agriculture activity. Persons working on land owned by others for wages or share in the yield have been treated as agricultural laborers. Out of the total main worker category in the study area, agricultural laborers population in rural area is about 5263 (78.56%).	Many households farm plots of land nearby or within the village, indicating that cultivatable land within this is accessible. A good amount of cultivatable land is believed to be available in and around the mine area. However, the availability and viability of unoccupied land as replacement farmland needs to be confirmed through further stakeholder consultation. In addition, available land may be of lower quality than existing farmland and would require additional inputs to reach equivalent productivity. Replace ability of cultivated land is therefore considered to be moderate on average for the mine area. Generally speaking, yields in the mine study area are relatively low for a variety of reasons and could potentially be increased through support programmes.	Land woodland	High	Moderate

Service	Description	Additional Information (including status, threats and availability of alternatives to the service)	Relevant Habitats	Importance to Beneficiaries	Replace ability
Food: Livestock Cultivation	Traditional livestock farming practiced in villages, including small ruminants (goats and sheep), poultry (chicken) and some cattle. Some cattle grazing also takes place in grazing land classified in land record CFZ. People breed and raise livestock within different land use categories. Pastures are seasonal, taking advantage of fallow lands or occupying areas of grassland. Due to the nature of livestock activities, however, it is difficult to estimate actual areas occupied by pastures. Passing of livestock herding (cattle) also takes place in the mine area of influence. In addition, traditional herders are beginning to settle in the area for extended periods. There are several hamlets between villages many cattle paths and tracks converge towards these areas. Livestock rearing is a secondary source of income for most households near the mine area.	In general there is sufficient good quality land available for grazing in the area and, feeding cattle is not a factor limiting growth. Replace ability is therefore rated Moderate for the mine study area as a whole, but may vary at the village level. Illegal grazing is identified as an ongoing problem, particularly in the mine area, which are explicitly prohibited. Information on value and replace ability will be gathered at the village level as and where needed through stakeholder engagement and data collection as part of the development and implementation of Social Management Plans.	Grassland wooded grassland	High	**Moderate**

Service	Description	Additional Information (including status, threats and availability of alternatives to the service)	Relevant Habitats	Importance to Beneficiaries	Replace ability
Food: freshwater fish	Pond fishing is an important subsistence activity for villagers although it is marginal in terms of income–generation in most parts of the mine area. There are no professional fishermen in and around the mine area. Fish are consumed fresh. Fishing is generally an activity carried out by villagers and mostly during rainy season after the harvest is finished.	The primary fish species utilized by local communities are known to be fairly resilient and are not currently threatened. The availability and health of fish is also closely linked to surface water quality and quantity in the study area. At the time of writing, freshwater fish did not appear to be declining as a result of water quality in pond and rivers and springs in the area were in good condition other than directly downstream of villages. It has not been confirmed whether the freshwater fishery is being overexploited but fishing is believed to be sustainable at this time. Due to uncertainty around fish populations and level of fishing pressure, replace ability is rated moderate for the area as a whole. More information will be gathered on fishing through stakeholder engagement and data collection as part of the development of Social Management Plans	surface water agricultural land (rice fields)	**Moderate**	**Moderate**

Service	Description	Additional Information (including status, threats and availability of alternatives to the service)	Relevant Habitats	Importance to Beneficiaries	Replace ability
Water Supply:	**Domestic water use:** Villages in and around the mine area use ground water for drinking and for other domestic purposes like laundry washing, hygiene, cooking.	Studies indicate that the volumes of water abstracted for household use are small relative to total daily flow in local rivers. As described in Chapter 3:, the baseline surface water quality is generally good, with occasional highly elevated Total Suspended Solids (TSS) and turbidity levels due to high rainfall intensities, relatively erodible soils and steep terrain. Iron and trace element concentrations were below the prescribed limits for streams sampled in the mine area.	Ground water	**Essential**	**Moderate**
	Agricultural water use: Agriculture mainly relies on rainwater. However, lowland rivers running along the boundary of mine may be are used for irrigation, mainly for rice fields and more locally, gardens. River water is also abstracted for livestock watering. Access to sufficient water for agricultural use is an important issue for human health and wellbeing; agriculture is the primary livelihood in the mine study area. Small ponds, Nala and dug wells are common in the area. These are utilized for irrigation and drinking water purpose.	Nevertheless, rainwater remains the most common source of water for agriculture in all villages. There are no known or identified industrial scale water abstractions within the immediate vicinity of the mine site (i.e. large scale water users that would compete for resources). However, village levels replace ability ratings are applied where appropriate in the assessment that follows. To mitigate the negative impacts, Garland drains have been planned on sides of quarries and external	Surface water	**Essential**	**Moderate**

Service	Description	Additional Information (including status, threats and availability of alternatives to the service)	Relevant Habitats	Importance to Beneficiaries	Replace ability
	Hurdul Nala is the main drainage of the core zone that drains into Sulkhia nala which drains into river Gopad. The proposed project shall have certain impacts on surface water quality. Most important impact is the sediment load.	dumps/backfilled surface (depending on contours).			
Non-use value: existence value of biodiversity	This service refers to the value people globally place on protecting species and habitats as otherwise conservation value. The beneficiaries tend to only the non-use value people place on the continued existence of a species. The study area supports a number of species classed as endangered or vulnerable; However, biodiversity is treated as its own equally important component of the impact assessment and is examined at length in Chapter 3 of EIA Report.	A full list of Floral & Faunal Diversity within the core zone & Buffer Zone is included in chapter-2 of this report. By definition, all species on this list are threatened, primarily due to habitat loss and hunting. The concept of replace ability does not apply well to non−use values. Instead, the topic of biodiversity offsetting is discussed in detail in Chapter 3 of EIA Report.	Critical habitats as defined in the biodiversity chapter of EIA Report.	Moderate	N/A

Service	Description	Additional Information (including status, threats and availability of alternatives to the service)	Relevant Habitats	Importance to Beneficiaries	Replace ability
Traditional Practices	Cultural value is placed on traditional practices such as fishing, crafts and use of natural resources. A practice that links a congregation's religious practice to its local surroundings.	A wide range of traditional practices rely on natural resources in the various environmental settings around the area of the mine. In some cases the relationship of the resource to the practice may be integral and in others the relationship be incidental. Not all relationships are well defined yet. Ongoing stakeholder engagement will refine the Project's understanding of the importance of particular products and resources to beneficiaries.	Greenbelt Surface/ ground water grassland	Practice Specific	Not Replaceable
Erosion Control	Vegetation cover binds soils and prevents soil loss. Measurements of total suspended solids (TSS) in disturbed and undisturbed catchments suggest lower erosion rates on undisturbed land, suggesting that vegetation plays an important role in reducing erosion.	Other than the proposed mine, no existing threats have been identified for riparian vegetation or grassland in the area. Areas of similar and complementary vegetation are present on plain land and in catchments across the study area.	forest, grassland	High	Moderate
Surface and ground water regulation	The mine area constitutes a prominent groundwater discharge zone in the study area, with groundwater discharge occurring locally in to local nala as groundwater runoff into streams. Flow derived from groundwater discharge can be as high available during non-monsoon as 90% of the total stream flow volume.	Other than the proposed mine, no existing threats have been identified for surface and groundwater regulation in the study area. Pumped out mine water from the quarry sump(s) will be discharged to series of sedimentation ponds for settling of suspended solids. It is useful to use coagulants viz. alum etc. to accelerate the process.	surface and ground water	High	Low

Service	Description	Additional Information (including status, threats and availability of alternatives to the service)	Relevant Habitats	Importance to Beneficiaries	Replace ability
Natural hazard regulation	Exposed coal act as natural due to spontaneous heating in the coal heaps and coal seam. Director general mine safety, govt. of India, issue directives from time to time for effective safety measures. Seasonal flooding is a part of the natural landscape in the area of the mine, and is essential to maintaining lowland agriculture and water resources in the flood plains fed by back flow waters from local Rivers and nala. However, there is also some risk of uncontrolled flooding during the rainy season. This risk is likely to be mitigated by well-established areas of crop/vegetation along micro watershed of river basins.	For complying with Reg. No 4 of CMR 2017, exercise shall be done to identify, assess and record the hazards of health and safety of the persons employed in the mine after consulting the Safety Committee and Internal Safety Organization (ISO). Based on the above, Safety Management Plan (SMP) shall be formulated for overall management for developing and implementing the safety policy of the company. SMP shall contain, inter alia, plan to implement the policy, principal hazard management, standard operating procedure (SOP), monitor, evaluate and review the plan.	Forest/villagers	Moderate	Moderate
Disease Regulation	The spread of malaria is influenced by a number of environmental factors and characteristics of natural habitats. Health impact of coal mining penetrates from the mine to workers working in the mine to communities living in the region. For those working in mines are classified as occupational diseases where as those in the community suffer from ailments due to burning of coal, coal dust, fugitive emissions, pollution of water resources air land.	Health status of the respondents are studied in the project area. Large numbers of respondents are affected by seasonal diseases like cold, cough, fever, weakness, joint pains, minor injuries etc. Some of them are also suffering from vector borne diseases like Malaria, Typhoid, Skin diseases, Scabies and Jaundice. Seasonal diseases like cold, cough, viral fevers etc. are recorded more predominantly in the children	Within the Mine Lease area and villages of buffer zone	High	Moderate

Service	Description	Additional Information (including status, threats and availability of alternatives to the service)	Relevant Habitats	Importance to Beneficiaries	Replace ability
		followed by females. However, the incidences of Vector borne diseases are similar among all irrespective of the age and sex. The incidence of Goitre was noticeably seen in men than females. Majority of the female respondents are affected by Anemia. The major reason of mortality in the study area in last ten years as reported by the respondents are due to Malaria, Tuberculosis, Jaundice child birth and old age. Tuberculosis is wide spread and main cause of deaths in the study area. The project will have its own hospital. The Hospital will have a dedicated Occupational Health Centre (OHC). This OHC will have the necessary equipment / instruments in order to undertake necessary medical examination. The Centre will also have a pathological laboratory. The records will be computerized. The centre will be manned by Chief Medical Officer (CMO), Medical Officers (MOs).			

3.2. MINE DEPENDENCIES ON ECOSYSTEM SERVICES

This section provides a brief description and prioritization of ecosystem services depended on by the mine during construction, operation and closure. To a large extent, design measures have been put in place to avoid reliance by the mine or its employees on local natural resources such as cultivated crops and other provisioning services in order to avoid placing additional pressure on resources in the area of the mine. As a result, the only ecosystem services for which mine project dependencies have been identified include:

- Fresh water (provisioning service);
- Erosion control (regulating service);
- Disease control (regulating service).

These are discussed in more detail in **Table 3.3** below

Table 3.3 Ecosystem Service Dependencies of the Mine Project

Service	Description	Additional Information (Including status, threats and availability of alternatives)	Relevant Habitats	Importance to Project	Replace ability
Freshwater (provisioning)	The mine will require fresh water resources for a number of activities, including: plant water supply, haul road dust suppression, construction water, and potable water for the work force. In addition to operational needs, water supplies will also be needed to recharge the backfilled pit voids with ground water as mining progresses. The total water required for the project is estimated 1540 KLD of industrial water including 50 KLD potable water. Source of water will be groundwater for initial 2-3 years and later mine quarry water will be used.	The area of the mine receives high levels of rainfall and surface and ground water availability is generally good. Availability will be lower during the dry season. Drainage of the block is mainly controlled by westerly flowing Hurdul Nala which traverses the block and passes almost through central part of the block. Many small seasonal nallas originating from elevated topography of north eastern and south-central part of the block drain its water into Hurdul Nala. The minor nallas and tributaries present in the block shows dendritic to sub-dendritic drainage pattern.	Surface water Ground water	Critical	Moderate
Erosion control (regulating)	The mine relies on sources of natural erosion control, such as vegetation cover, to protect roads, camps and infrastructure leading to the mine.	Other than the proposed mine, no existing threats to riparian cultivator and farm labour. The existing OB dump of mine has the potential to increase erosion in the mine area of influence. The proposed overburden will be in pit dump as backfilled area.	Plain land	Moderate	Moderate

Disease control (regulating)	The mine workforce is at risk of being infected by Asthma.	Asthma and tuberculosis is endemic in the region. The area around the mine has relatively low forest resources. The agriculture crop is also depended on rain	Lowland agriculture	High	Moderate

The most significant ecosystem service dependency of the mine, particularly during operation, is the need to use freshwater resources. Ground water in general occurs under unconfined to semi-confined conditions. The regional hydrogeological setting defined above holds good locally for the Dhirauli Coal Block. Singrauli Coal Blocks are categorized as Safe by Central ground Water Board, Govt. of India depending upon water table behavior and stage of ground water development.

The Drainage of the block is mainly controlled by westerly flowing Hurdul Nala which traverses the block and passes almost through central part of the block. Many small seasonal nallas originating from elevated topography of north eastern and south central part of the block drain its water into Hurdul Nala. The minor nallas and tributaries present in the block shows dendritic to sub-dendritic drainage pattern. Small ponds and dug wells are common in the area. These are utilized for irrigation and drinking water purpose.

There are basically few major coal mines within 10 km buffer zone which uses water including project/mining activities, dust suppression and green belt development, domestic purposes shall be met from surface reservoir/mined out reservoirs of existing mines apart from minor groundwater withdrawal for drinking purpose only. Therefore, total groundwater withdrawal for industrial use may be considered as nil.

3.3. ECOSYSTEM SERVICES PRIORITISATION (Dependencies)

Tables 3.4 summarizes the importance and replace ability ratings assigned to ecosystem services depended on by the mine. In keeping with the prioritization process carried out for potentially impacted ecosystem services, services with a high - critical value rating are considered priority services for the mine.

Table 3.4: Prioritization of Ecosystem Service Dependencies

Ecosystem Service	Importance to Mine	Replace ability	Value Rating
Provisioning			
Freshwater Provision	Essential	Moderate	Medium
Regulating			
Erosion Control	Moderate	Moderate	Medium
Disease Regulation	Moderate	Moderate	Medium

3.4. ASSESSMENT OF IMPACTS

Overview

Over the lifetime of the mine, it is expected that there will be a range of impacts on ecosystem services in the mine area of influence, with implications for the livelihoods, health, culture and wellbeing of communities within this area.

Where an ecosystem service is an intermediary service i.e. the full value of that service is captured by an 'end-use' service, the impact on beneficiaries is evaluated for the end-use ecosystem service only. For example, the end-use for freshwater used for crop irrigation is the production of cultivated crops; this component is therefore assessed under impacts on agricultural production. Freshwater used for household use and consumption, in contrast, is assessed under freshwater resources.

The assessment of impacts on ecosystem services is broken into direct impacts from land occupation and activities associated with the mine and indirect impacts from in-migration. The magnitude of impact during different phases of the mine is assessed as a subcomponent of these over arching categories where relevant. This structure provides a relatively straight forward structure for capturing the many different components to be synthesized in the ecosystem services analysis.

3.4.1. Impacts on Cultivated Crops

Persons working on land owned by others for wages or share in the yield have been treated as agricultural laborers. Out of the total main worker category in the study area, agricultural laborers population in rural area is about 7209 (49.97%). About 90% of the working population is depended on agriculture, in which 6001 (41.60) % of working population is of cultivated and about 48.40% of the regions are agriculture laborer. Crop cultivation is of essential importance and is considered to have moderate replace ability in the study area.

Only ~19.87% (530.841 ha) of the project area (2672 ha) is privately owned and used for agriculture of growing paddy in Kharif (summer season/rainy season).The main crops cultivated in this area are wheat, Paddy, Maize, Kodokutki, Arhar, Sawa, Wheat, Barley, Potato, Grams, Mustard etc. However, with rising costs of cultivation, farm families are utilizing some part of the income from other sources e.g. service, wage labour, self-employment, small business, service etc. to invest in agriculture so as to obtain at least rice from own land. Even then, agricultural remained as backward as it was.

Potential impacts on agriculture from mine activities include direct impacts from occupation of land, changes in water availability, soil quality and dust deposition, and indirect impacts from in-migration.

3.4.2. Direct Impacts from Occupation of Land

Direct impacts from temporary and permanent occupation of land during construction and operation are expected to affect cultivated land in the vicinity of the mine. The Agricultural land covers the minimum land area of the project which is about 530.841 Ha (Tenancy land), 19.87% of the total land area. Due to the availability of agriculture land within the mine lease area some significant direct impacts will take place during the mine operational phase. During operation, there may be additional isolated impacts on agricultural land within the surrounding buffer zone of mine lease area although these will primarily be temporary in nature.

Overall assessment of the agricultural situation leads to the conclusion that the project is not going to cause significant damage to the agricultural situation of the area instead it to benefit the farming community by way of supplementary income through non-farm sources. Consequently, investment in agriculture will increase leading to higher crop production which will be used to meet their own demand. Hence, the impact of the project on agriculture situation of the study area is expected to be good.

In summary, the magnitude of impact from occupation of land on local populations is predicted to be negligible during construction and operation. During and after mine closure, agriculture land will be developed on cleaned up sites and unused land (24 months). The impact on cultivated crops is therefore expected to be negligible.

3.4.3. Direct Impacts from Changes in Water Availability, Dust and Soil Quality

Impacts on cultivated land within the buffer zone of mine will result from changes in water flow in rivers utilized for irrigation as well as potential impacts from dust due to construction and operation activities and potential ‘sterilization’ of soil resources in the mine area.

The proposed project shall have certain impacts on surface water quality. Most important impact is the sediment load. Erosion activity of overburden dumps, spoils and loosened soil by blasting activity increases the sediment load in streams.

In a dry year, farmers utilizing rivers in the buffer zone of mine area for their irrigation and domestic purpose. As a result, irrigated land is considered particularly sensitive to changes or fluctuations in water flow.

Hurdul Nala is the main drainage of the core zone that drains into Sulkhia nala which drains into river Gopad. It originates within the mining lease and westerly flowing. Small ponds and dug wells are common in the area. These are utilized for irrigation and drinking water purpose.

For all catchments, the magnitude of impact on irrigation of crops and rice crops in particular will to a large extent be moderated by the fact that farmers are using flood flows to irrigate. The resulting magnitude of Ecosystem Services has indirect impacts due to changes in water flows will be small or medium in most areas.

Impacts on crops and other vegetation from dust deposition are assessed Air Quality. Dust from mine operation work areas and movement of traffic on un-surfaced roads has the potential to result in nuisance at nearby settlements and to affect crops and natural vegetation through dust deposition. Experience from construction sites around the world suggests that dust deposition levels can be sufficient to adversely affect people and vegetation at distances up to a few hundred meters from construction activity.

As shown through air modeling results in Air Quality, elevated levels of dust deposition will anticipated during operation, particularly around the mine pits and waste emplacements but these will cause no significant impacts from dust nuisance in nearby settlements. Dust emissions from these sources will cause an increase in dust deposition sufficient to cause minor impacts on vegetation in the prevailing wind direction up to a few kilometers away but the areas affected are not of importance for natural vegetation or crops.

The plain topography of the mine area combined with high rainfall intensities and erodible soils means that there is also a low potential for the affected area to be extended by erosion in surrounding land where soils are disturbed. During construction, the mine has the potential to cause erosion and degradation of soil quality as a result of compaction, creation of hard standing areas, and erosion of exposed sub soils in excavated areas, and mixing tap soils and sub soils with better quality soils. The impact will generally be to reduce the agricultural potential of affected area although it is also possible that changes may increase land capability. During operation, the soil resources impacted by the mine will generally be of low or negligible value for agriculture and are therefore excluded from the ecosystems assessment.

3.4.4. Impacts on Livestock

Potential impacts on livestock farming will stem from occupation of pasture land, impacts on water availability and potential restrictions of access to herding routes as well as indirect impacts from in-migration and induced access.

Livestock herding is typically a secondary livelihood activity for sedentary villages in the area. However, nomadic herders also utilize the area. Nomadic rising of livestock takes place mostly in the central part, North, South Western and South Eastern part of the mine project area. They are increasingly becoming sedentary given the high quality of the grazing land in the mine study area. The livestock herding is assessed to be of high importance to beneficiaries and a moderate amount of replacement pasture land is believed to be available; the resulting value rating for this service is high.

3.4.5. Direct Impacts from Occupation of Land

Short- and long-term land occupation by the mine is expected to impact some areas of pasture land and longer distance herding routes. Due to the low intensity of livestock farming in the area and relative availability of pasture land, direct impacts on sedentary farmers are also anticipated to be small. As a result of the high value of the service, impacts on sedentary livestock farming are assessed as moderate during construction and operation.

During decommissioning and mine closure, the mine pits and waste emplacements will remain unsuitable for future beneficial use but much of the remaining land will be rehabilitated and become available for use. The resulting impacts on livestock farming are not significant.

3.4.6. Direct Impacts from Changes in Water Quantity

It is envisaged that to meet the requirement of water for construction, drinking and sanitation as well as mine operation, at the initial stage of 2-3 years, will be met from ground water. After that mine quarry will collect sufficient water which will meet the industrial demand. However, the potable, water demand at mine, mine facilities will be met through ground water by bore wells.

Pumped out mine water from the quarry sump(s) will be discharged to series of sedimentation ponds for settling of suspended solids. It is useful to use coagulants viz. alum etc. to accelerate the process.

A part of this water is channelized for use for HEMM washing, workshop floor, and at designated points for filling water sprinklers for dust suppression of haul roads and green

belt/forestation. The remaining quantity shall be tested for solids and acid /alkalis and if within safe limits, allowed to flow over to the diversion channels for agricultural use.

Baseline surveys found that use of surface water for livestock is widespread, but the quantity needed is very small relative to the overall flow of the surface water. As a result, mine impacts on water flow will be not significant for livestock farming in the mine area.

3.4.7. Impacts on Firewood and Charcoal

Potential impacts on firewood and charcoal services include direct impacts from temporary or permanent land occupation and indirect impacts from in-migration. However at the site due to availability of coal the villagers in the surrounding areas are using coal as fuel. In due course of time necessary provision of LPG cylinders of are proposed for replacing coal as source of fuel. Hence, the impact on firewood and Charcoal which in generally not in used presently shall be insignificant or marginal.

3.4.8. Impacts on Non-Timber Forest Products

Potential impacts on non-timber forest products from mine activities include direct impacts from occupation of land and indirect impacts due to in-migration of workers, job seekers and opportunistic migrants. Since there is 99% forest land in the project area and its buffer zone significant impact are anticipated on NTFP.

3.4.9. Impacts on Fresh Water Supply

Mine activities may have direct impacts on fresh water supply due to changes in patterns of surface water drainage and flow, consumption of water resources by the mine and changes in water quality in catchments downstream of mining activities. Indirect impacts from in-migration will arise as a result of settlement growth and an increase in demand for freshwater. Freshwater supply is one of the most important resources for people living in the vicinity of the mine. Freshwater is used by local communities for domestic purposes, for construction and in agriculture. Impacts on the latter are assessed as an end-use service. As described in the baseline, some villages have a number of wells as well as access to a stream, while others depend solely on natural water streams like Gopad River and Hurdul nalla.

Most of the villages that may be impacted by changes in base flow have access to at least one alternative river or groundwater resource. Overall, freshwater is considered essential to beneficiaries and replace ability is moderate. The value of the service is therefore high for the mine area of influence as a whole. However, replace ability will vary at the village level; the value of potentially impacted water sources therefore varies likewise at the local level.

Dhirauli coal block falls under sub watershed of Hurdul nala. The area forms a part of Son river basin. The area is mainly drained by Gopad River and their tributaries, the Gopad river flows from south to north on western side of the ML and eventually joins the Son River. As described earlier, the mine lease area is drained by the Hurdul Nala which is a tributary to the Gopad River.

3.4.10. Indirect Impacts from In-Migration

Indirect impacts on fresh water supply may occur as the population in the area increases due to in-migration. The growth of settlements, anticipated changes in lifestyle due to increased availability of cash and potential improvements to water delivery infrastructure will all lead to additional water consumption. This impact will continue through all mine phases and post closure. The magnitude of this impact is medium in more remote areas and large near the villages expected to grow most significantly. Indirect impacts from in-migration are therefore expected to have a major to moderate impact on freshwater services during all phases.

3.4.11. Impacts on Spiritual and Religious Sites (Living Cultural Heritage)

Direct impacts on spiritual and religious sites may result from occupation of land, restriction of access, changes in ambience as a result of noise and light during construction and operation and changes to regulating services such as fire regulation or flood control that result in impacts on a particular site.

Disruption of site access may occur if Project activities or structures hinder users from accessing a site. Increased traffic along the road during both construction and operation could make accessing the site more difficult or dangerous. Disruption of site access is not a predicted impact for any known sites in the vicinity of the mine area. Changes in the ambience and character of cultural heritage sites in the mine area are likewise not expected at any known sites in the mine area. However, impacts relating to disruption of access and site ambience are more difficult to predict than physical impacts and these kinds of impacts may arise as the Project moves forward. For this reason, the Community Team will be engaging in community consultation with site users on topics of site use, access and significance to identify potential impacts and decide on appropriate mitigation measures if impacts do arise.

3.4.12. Impacts on Traditional Practices

Local communities in the mine study area have depended on certain provisioning services, such as freshwater fish, meat and natural medicines for many generations. Where mine activities have the potential to impact the availability of or access to, these services, there is

an associated cultural impact, as local communities face a loss or decline of traditional practices. Traditional practices that depend on ecosystem services potentially impacted by the project include:

- crop cultivation
- livestock herding
- production of traditional crafts
- use of natural medicines
- fishing

Prior to mitigation, it is predicted that impacts on traditionally utilized provisioning services will range from moderate (freshwater fisheries) to critical (e.g. crop cultivation, firewood). The cultural value associated with traditional practices is not replaceable. The value of this service to the individuals and communities who would lose one or more traditional practices is difficult to estimate in advance of targeted stakeholder consultation; the value placed on traditional cultural practices may also vary considerably across individuals and groups. As a result, value is conservatively estimated to be high and the resulting impacts on traditional practices are assessed as critical overall for construction and operation and moderate during decommissioning and closure.

3.4.13. Impacts on Regulation of Surface Water Flows

Natural regulation of surface water flows is an intermediate service that supports the provision of freshwater for natural habitats and human use. “End-use” ecosystem services for freshwater include irrigation of cultivated, household water use and freshwater fishing. Impacts on these services as a result of changes in water availability are therefore assessed.

In addition to impacts on water availability and quality for community use, the mine has the potential to disrupt local drainage patterns and cause upstream flooding through the construction of nala diversion infrastructure. Taking these measures into account, the significance of impacts on drainage patterns is assessed as moderate prior to mitigation during construction and operation of the mine.

3.4.14. Impacts on Erosion Regulation

This section discusses potential impacts on erosion regulation services provided by natural vegetation. As an intermediate service that contributes to freshwater quality, erosion related impacts on TSS and water quality in catchments utilized by local communities are assessed. Other impacts not captured in the freshwater quality analysis may include decreases in slope stability and soil quality in the mine area. Erosion regulation does not have natural replacements but restoration of plantation can return the service to its original function.

Plantation in the area will generally fast growing and resilient to change. Replace ability of the service will therefore considered medium and the service will considered of high value overall.

Prior to mitigation, impacts on erosion regulation are assessed as major during construction and operation of the mine. As described no significant impacts are anticipated during deregulation and closure.

3.5. IMPACTS ON NON-PRIORITY ECOSYSTEM SERVICES

This section summarizes impacts and mitigation measures to non priority ecosystem services in the mine area. Non priority services are those rated of medium value or lower in the prioritization exercise as well as services that are not considered sustainable. In the case of no priority ecosystem services, mitigation measures do not necessarily maintain the value and functionality of the service, but do still strive to avoid and minimize impacts in line with the wider approach taken by the EIA/EMP. Non priority ecosystem services potentially impacted by mine activities include freshwater fisheries, timber, existence value, aesthetic value and natural hazard regulation. The assessment of impacts on non priority services is summarized at a slightly higher level than for the priority ecosystem services assessed above.

3.5.1. Freshwater Fisheries

Potential impacts on wild caught fish from mine activities include impacts from changes in patterns of surface water drainage and flow at the mine, degradation of water quality and indirect impacts from in-migration. Inland fishing in rivers and pond is a moderately important subsistence activity and provides a secondary source of protein and income for a number of households in the mine study area (Core/Buffer Zone). The freshwater species targeted by people in the study area are relatively abundant and adaptable to changes in water quality and quantity. The resulting value rating for freshwater fisheries is medium for the study area. Additional information on the importance and sustainability of fish catch at the village level will be collected through ongoing stakeholder engagement activities as part of Social Management Plan processes.

Impacts on freshwater fisheries may occur as a result of impacts from the mine on water quantity and quality during construction and operation. The most significant potential impacts in the mine study area will occur due to changes in surface water drainage and flow caused by the dewatering of the mine. Changes in water quality due to ground disturbance, dewatering discharge, have the potential to impact fish abundance and health. Indirect

impacts on wild caught fish may occur as result of in-migration of workers and opportunity seekers to the area. Fish species targeted by local communities are not currently believed to be overexploited, but with additional pressure on agriculture there may be a corresponding increase in fish consumption as a cheap, relatively accessible source of protein. Secondary impacts due to in-migration are expected to have a medium magnitude impact on fish. Taking into account the medium value of the resource the significance of combined impacts on freshwater fisheries prior to mitigation is assessed as minor during construction and operation and negligible following closure of the mine.

3.5.2. Existence Value of Biodiversity

The value that peoples around the world place on the knowledge that species and habitats exist, typically rare, beautiful or otherwise distinctive ones, is known as 'existence value.' This value is expressed internationally through support for conservation organizations and in organized causes to protect particular species or areas from human use, among other examples.

Since existence value is not a tangible or easily quantified concept, the EIA/EMP does not attempt to assign a rating to impacts on this service. Instead, the biodiversity assessment considers impacts on habitats and species that have been identified as high value through the determination of critical habitat.

Forest covers major portion of the project area. The forest land consists mostly of Protected Forest or Reserved Forest. Some open mixed jungles are also situated in the study area. The study area is covered by forests namely Mohanban Reserved Forest. The total forest area cover is about 1438.729 Ha which is 53.84% of the total mine area.

The proposed mine lease area consisting 20.54% (548.841 ha) of Tenancy land, 25.62% (684.431 ha) of Govt. Non-Forest Land, and 53.84 % (1438.729 Ha) of Forest land.

3.5.3. Natural Hazard Regulation

As described in the baseline, natural vegetation plays multiple roles in terms of regulating the occurrence and severity of natural hazards.

Direct impacts on fire regulation services in the mine study area include spontaneous coal burning at coal stock and in-situ coal seam. This may have some implications for fire prevention around the mine area. Given the fact that the mine will not directly impact the community around villages in part as a form of firebreak, the magnitude of the impact is estimated to be medium during construction and operation.

CHAPTER-4: MITIGATION MEASURES AND REDIDUAL IMPACTS

4.1. MITIGATION MEASURE AND RESIDUAL IMPACTS

4.1.1. Overview

As standard good practice, the mine will strive to avoid and then to minimize all impacts through design before undertaking mitigation. Design measures aimed at achieving this goal are summarized in the description of relevant Project design measures provided earlier in the chapter. The following section provides a description of mitigation measures and predicted residual impacts on ecosystem services in the mine study area, including:

- Mitigation of impacts on cultivated crops;
- Mitigation of impacts on livestock;
- Mitigation of impacts on firewood and charcoal;
- mitigation of impacts on non-timber forest products;
- Mitigation of impacts on freshwater;
- Mitigation of impacts on spiritual and religious sites (Living Cultural Heritage);
- Mitigation of impacts on traditional practices;
- Mitigation of impacts on regulation of surface and groundwater flows;
- Mitigation of impacts on erosion regulation;
- Mitigation of impacts on disease regulation; and
- Mitigation of impacts on non-priority ecosystem services.

The ecosystem services identified in the study area, the measures implemented by the Project have the additional goal of maintaining the value and functionality of these services for beneficiaries over the short and long term. Due to the cross cutting nature of the subject area, mitigation of impacts on ecosystem services will be captured under a range of programmes under both the Environmental Management Plan (EMP) and Social Management Plan (SMP) to be implemented by the Project Proponent. In some cases, mitigation measures are common across several impact topics, for instance, provision of support for natural resource management efforts by authorities and local communities is important for nearly all impacts on provisioning services in the area. A brief discussion of some of the management plans and programmes that will be relevant across a number of different ecosystem services is provided.

4.1.2. Agriculture and Food Security

The Agriculture and Food Security programme under the Employment Creation and Livelihoods theme can be divided into three categories:

- Agriculture, fishing, and livestock support, which focus on local communities' primary land-based livelihoods;
- Natural resources management, which supports sustainable natural resources management and conservation; and
- Food security, which aims to ensure, in partnership with government authorities, that foodstuffs remain in adequate and accessible supply to local communities.

4.1.3. Agriculture, Fishing, and Livestock Support

The Project has already proposed to develop and support a number of focused agricultural development and intensification activities near the mine, as noted Socio-Economic and Community Baseline. The Project will apply lessons learned and, where possible and practicable, continue to utilize partnerships established to date, to enhance and expand these activities or develop new activities suitable for identified community needs. With regards to agriculture, fishing, and livestock-breeding, the Project will:

- Develop sustainable agricultural, fishing, and livestock-breeding programmes, as identified through needs-based assessments and community consultation, that aim to diversify and increase production in the Project area through best practice techniques. Needs based assessments and community consultation with take into account production activities by men, women, and youth;
- Provide training to farmers, fishermen, herders, and other key producers as appropriate in targeted locations to improve their technical capabilities and support the marketing and sale of produced goods;
- Support access to equipment and other inputs (including through microfinance);
- Help establish market linkages between producers and potential customers, including the Project (e.g. support for cooperatives, local market infrastructure, procurement contracts);
- Agricultural, fishing, and livestock breeding programmes with applicable conservation-based outcomes to support sustainable production; and
- In the event of injury or mortality of livestock due to construction or operations, the Project will notify nearby communities and provide appropriate compensation as determined by Govt. department.

Stratatech Mineral Resources Private Limited (SMRPL), a private company wholly owned by the Adani Enterprises Limited (AEL). It has been planned to conduct mining operations through open cast mining with capacity of 5 MTPA and 1.5 MTPA through underground

mining at Singrauli Coalfield, Singrauli District, Madhya Pradesh. The Block is auctioned under commercial coal block. There shall be no restriction to carry on mining operations for own consumption, sale or for any other purpose.

For the proposed Dhirauli coal mine, the total requirement of land is estimated as 2672 Ha, which includes 1436.19 ha of forest land and 1235.81 of non-forest land.

4.1.4. Environmental Management Framework

The Environmental Management Framework (EMF) provides a structure for the detailed design and implementation of the Project's environmental mitigation measures, which will be captured in a series of Environmental Management Plans and Procedures. A full discussion of the EMF is provided along with the Social and Environmental Management Plan.

The EMF group's environmental mitigation measures into a number of programmes fewer than five themes: Land Use Stewardship, Biodiversity, Water, Mineral Waste, Other Emissions and Non-Mineral Waste.

4.2. MITIGATION OF IMPACTS ON CULTIVATED CROPS

4.2.1. Mitigation of Direct Impacts from Land Occupation

All projects infrastructure will, as far as possible, are sited to avoid, or otherwise maximize distance from, highly productive agricultural land such as rice fields and land used for other livelihood activities. Where the mine directly affects livelihood activities through temporary or permanent losses of cropland due to land occupation and operation of mine, the Project will follow procedures outlined in the Plan EIA/EMP. Proposed entitlements for lost agricultural land are separated into village and/or general community land, host community land, lineage land and individual or family land.

In the case of individual or family land, replacement land of similar size and potential will be allocated through the traditional lineage land allocation mechanisms within the boundaries of the village territory. Cash compensation will be provided for any improvements on the land, including clearing, irrigation systems and ploughing. Should there be a lack of suitable replacement land and unless otherwise agreed with the community and affected people, the Project will provide cash compensation for land and improvements on land at replacement value and/or livelihood restoration assistance (such as preference in employment, skill building support).

4.2.2. Mitigation of Direct Impacts from Changes in Water Availability, Dust and Soil Quality

As discussed mitigation of impacts on the surface water flow regime from dewatering will be achieved through the Mine Water Management System (MWMS). This system will collect groundwater from dewatering and storm water runoff from the pit area and distribute to supplement flows in streams affected by dewatering. Catchments where a moderate to critical impact is predicted will receive environmental flow compensation that will allow base flows to recover to at least 95% of their natural levels. This is not considered likely, but if such effects are found then the allocation of dewatering discharges within the system will be reassessed and provision made for agricultural water users accordingly.

4.2.3. Mitigation of Impacts on Firewood and Charcoal

Identification of important community resources under the EIA/EMP process will include consultation with stakeholders to identify the location of important firewood collection areas in order to fully define potential impacts from the mine. Mitigation for short to medium term losses of access to fuel wood through coal supply collection areas will include providing access to alternative sources of fuel wood. The Project will also explore alternative off-grid power provision (e.g., solar energy) for employee housing and, where practicable, surrounding communities.

4.2.4. Proposed Mitigation Measures for Hurdul Nala Diversion

The need for Hurdul Nala diversion for external surface runoff water from northern boundary of mine is required for conservation of nonrenewable coal resources. The nala diversion will also require avoiding mine inundation from peak flood runoff.

The total length of proposed diversion along boundary is 6900 m. The starting & ending RL are 555 m RL & 484 m RL respectively. The general slope will be 1:100 m. It is proposed to carry out surface excavation up to ground level along boundary side of 45 m width.

For Abating Water Pollution

a) Effluent from mine

To prevent surface water contamination, following control measures are proposed in Environmental Management Plan:

- Mine water should be pumped to settling tank for settling and then the clean water will be pumped out and discharged.

- Leak proof containers should be used for storage and transportation of oil/grease.
- To avoid oil/grease spillage in the store, the container containing oil/grease should be kept in empty open containers of higher volume than these containers.
- The area over which oil/grease is handled should be kept effectively impervious.
- Any wash off from the oil/grease handling area or workshop should be drained through impervious drains, collected in specially constructed pit and treated appropriately.
- The sewage waste will be discharged to appropriately designed septic tanks and soak pits to prevent any pollution of surface or ground water.
- All the effluent tested regularly before discharging into the natural drains should meet the applicable standards and need regular monitoring.
- The surface and ground water in and around the mine, loading plant and infrastructure should be tested as per the monitoring schedule and appropriate control measures should be adopted, if required.
- All stacking and loading areas should be provided with proper garland drains equipped with baffles to prevent wash offs from reaching the downstream natural channels.

b) Storm water

Control measures to be adopted are briefly discussed below:

- Check dams should be provided to prevent solids from wash off and screen, if any, from the mine related activities.
- Peripheral bunds should be erected on the outer edge of the abandoned benches before reclamation so that the soil is not carried away by storm water.
- A water gradient of about 1 in 100 will be kept at every bench towards inside of the bench to prevent formation of gullies in the bench slopes causing serious erosion.
- Chutes should be constructed by using local stone masonry to guide the water in areas with loose soil to prevent suspended solid load in run-off and uncontrolled descent of water wherever necessary.
- Construction of garland drains around freshly excavated and dumped areas so that flow of water with loose material is prevented.
- The mine water should be passed through specially constructed catch pits to arrest any loose material being carried away with water.
- Any areas with loose debris within the leasehold should be planted.

- Garland drains should be constructed surrounding the waste dumps and should be connected to the surface water reservoir to avoid the run-off mixing directly to natural water channels before settling.
- Run-off water from mine pit should be directed to the settling pond.

c) Riverine Ecology Management

The planktonic population of the stream is inherently poor due to constant change in water flow as (Hurdul Nala is seasonal in mine lease area), habitat structure and thus has a less role to play in ecological niche. The aquatic species of Jharia/ Jhana Nala is similar to Hurdul nala.

During the post impoundment period following measures shall be followed:

- Periodic monitoring of the changes taking place in the geomorphology and aquatic ecology and suggesting appropriate improvement measures for enrichment of fisheries and aquatic ecology as whole.
- Habitat / Eco-region-based improvement & management
- The diverted Nala route shall be vegetated to improve the habitat / landscape and to overcome soil erosion.
- Regular monitoring of water quality of Diverted Nala in upstream & downstream shall be undertaken.

CHAPTER-5-MANAGEMENT MEASURE FOR MINE DEPENDENCIES ON ECOSYSTEM SERVICES

5.1. OVERVIEW

This section discusses the priority ecosystem services depended on by the mine in the study area. No dependency or impact 'ratings' are given as this section is not part of the formal impact assessment process. Instead, a description is provided of any measures required for the mine to maintain the availability and function of a service for Project use or to establish access to substitutes where needed. The management measures described below are not considered mitigation measures and are not included in the EIA/EMP.

5.1.1. Management Measures for Freshwater Resources

As discussed, the Project envisages that freshwater supplies will be drawn from dewatering sump. The total water requirement is 1590 KLD for the proposed mine including mining activities, & potable water. The demand of water for the project has been estimated as per industrial norms. It is envisaged that to meet the requirement of water for construction, drinking and sanitation as well as mine operation, at the initial stage of 2- 3 years, will be met from ground water. After that mine quarry will collect sufficient water which will meet the industrial demand. However, the potable water demand at mine, mine facilities will be met through ground water by bore wells.

Domestic and industrial effluent will be disposed of after suitable treatment in the effluent treatment plants (STP/ ETP).

Table 5.1: Water Requirement for Mining

Sl. No.	Industrial water	KLD
1	Water requirement for sprinkling at mine haul roads	100
2	Service water requirement for CHP & dust suppression system	1000
3	Water requirement for Base Work Shop & other miscellaneous purposes	100
4	Water requirement for green belt development and biological reclamation	190
5	Evaporation loss	50
6	Potable Water (Drinking and sanitation water requirement in Mine)	50
Total		**1490**

5.1.2. Management Measures for Disease Regulation

As described earlier Community Health, Safety and Security, the mine workforce is at risk of contracting Asthma in the study area. The presence of plantation has been shown to reduce infection rates, whereas the presence of water sprinkler increases the dust suppression in the area.

In addition, the mine site has already put in place a number of mitigation measures to reduce the risk of workers contracting Asthma/other disease. Existing and planned mitigation measures include:

- measures to reduce the potential for dust human interactions in worker accommodation, office space and other buildings; and
- Implementation of regular (annual) information and education campaigns around dust born disease with the workforce throughout the life of the mine.

These programmes should be monitored and reviewed regularly to determine effectiveness.

Stratatech Mineral Resources Private Limited (SMRPL) engages in the mining, processing, acquisition, exploration, and development of various coal properties, including Suliyari Coal Mine and Dhirauli Coal Mine, in Singrauli coal field of District Singrauli, Madhya Pradesh.

The major reason of mortality in the study area in last ten years as reported by the respondents are due to Malaria, Tuberculosis, Jaundice child birth and old age. Tuberculosis is wide spread and main cause of deaths in the study area.

The project will have its own hospital. The Hospital will have a dedicated Occupational Health Centre (OHC). This OHC will have the necessary equipment / instruments in order to undertake necessary medical examination. The Centre will also have a pathological laboratory. The records will be computerized. The centre will be manned by Chief Medical Officer (CMO), Medical Officers (MOs).

5.1.3. Summary of Findings

This section summarizes the findings of the assessment of impacts on ecosystem services during all phases of the Mine. Through the implementation of a wide range of project design and mitigation measures, the Project aims to avoid, minimize and where necessary mitigate impacts on ecosystem services in the area of the mine. For all priority ecosystem services identified in the study area, the measures implemented by the Project proponent have the additional goal of maintaining the value and functionality of these services for beneficiaries over the short and long term. A summary of predicted and residual impacts on ecosystem services is provided in **Table 5.1**.

5.1.4. Provisioning Services

Development of the mine is expected to result in impacts of ***moderate*** or higher significance on all provisioning services in the mine study area. These include priority ecosystem services crop cultivation, livestock herding, non timber forest products, firewood and freshwater supply. There are some non priority services.

In the case of most provisioning services, wherever avoidance of direct impacts on a service through occupation of land is not possible, a series of mitigation measures will be applied under the EMP. Framework to ensure that livelihoods are restored through replacement of land and assets. In the case of impacts on freshwater, the Mine Water Management System (MWMS) will be implemented to avoid or minimize negative impacts on availability of freshwater to communities through dewatering discharges. Where this is not sufficient, provision of access to alternative water resources will be provided through the Social Management Framework. These measures bring direct impacts on all priority services to a residual level of ***minor*** or lower for all phases of the mine.

In the case of nearly all provisioning services in the mine area, indirect impacts from in migration are more difficult to predict and may fall outside of the Project's management control. Mitigation measures for impacts from in migration include implementation of an In-Migration Management Plan, coordination with local communities to manage settlement expansion and implementation of natural resource management and monitoring measures under the Agriculture and Food Security Programme. In addition, the Project has designed agricultural, infrastructure and economic improvement programmes as part of a wider effort to minimize impacts on the livelihoods and wellbeing of communities in the mine area. Despite these measures, the fact that a number of impacts stemming from in migration lie outside of Project control results in a ***moderate*** residual impacts rating for a number of provisioning services (including crop cultivation, firewood and charcoal, fisheries, timber and some non timber forest products).

5.1.5. Cultural Services

Spiritual and religious sites and traditional practices are considered priority ecosystem services in the mine study area. Existence value and aesthetic value are included in the assessment as non priority services. For all cultural impacts, the Project will be undertaking extensive consultation to understand stakeholder concerns and additional mitigation options beyond the ones recommended in the EIA/EMP report.

5.1.6. Regulating Services

Development of the mine is expected to result in impacts of ***moderate*** or higher significance on four regulating services in the mine study area. Two of these services - regulation of surface water flows and erosion regulation are considered priority ecosystem services in the study area. As an intermediate service, impacts and mitigation relating to changes in regulation of surface water flows are captured in the analysis of freshwater availability for household and agricultural use. Impacts on erosion regulation in the mine area are addressed through a number of avoidance and minimization measures such as minimizing works in areas where there is the potential for slope instability, particularly during the rainy season and rehabilitating all disturbed land as soon as practical after completion of works. Implementation of these measures is expected to result in impacts of ***minor*** significance during construction and operation and ***no significant*** impacts following closure. Residual impacts on water quality as a result of changes in erosion regulation are also ***minor*** and are incorporated into the freshwater analysis.

Ecosystems are not believed to play a significant role in regulation of other major diseases in the area. Additional mitigation measures are expected to produce a more favorable residual impact on people (beneficiaries of the service). In this case, mitigation measures including education and prevention programmes are expected to produce an overall ***moderate*** benefit for the health of communities and workers in the mine area.

5.1.7. Summary of Findings: Residual Impacts Table

The assessment of impacts presented in **Table 5.1** where there were variations across the different phases of the mine, the table includes only the highest impact rating assigned (for example, direct impacts on livestock are estimated to be ***moderate*** during construction and operation and ***not significant*** during decommissioning and closure; the ***moderate*** rating is included in the table below):

Table 5.1 Summary of Mine Impacts on Ecosystem Services

Description of Impact	Significance before Mitigation	Key Mitigation Measures	Residual Impact
Provisioning Services			
Cultivated Crops • Direct impacts from occupation of	***Critical***	• Livelihood restoration, monitoring and compensation for lost assets under the Govt. Rule. • Dust suppression techniques such as mist water sprays will be used where excessive dust levels are predicted or reported. • Implementation of measures to protect soils under the Land Use Management Plan. For example, topsoil (and subsoil were deemed necessary) will be salvaged for re-use (additional measures detailed in EIA/EMP. • Implementation of the In-Migration Plan and related measures. • Development of agricultural support programmes under the community development Programme.	***Minor***
• Direct impacts from changes in water availability, soil quality and dust deposition	***Critical*** or below (depending on catchment)		***Minor***
• Indirect impacts from in-migration	***Critical***		***Moderate***
Livestock • Direct impacts from occupation of land	***Moderate*** (sedentary) ***Major*** (nomadic herders)	• Livelihood restoration, monitoring and compensation for lost assets under the Govt. Rule. • Design and implement an information and awareness programme regarding sustainable harvesting, grazing, and conservation of natural resources in partnership with relevant organizations where available and appropriate. • Develop livestock farming programmes under the community development Programme.	***Minor***
• Direct impacts from changes in water availability	***Not Significant***		***Not Significant***
• Indirect impacts from in-migration	***Major***		***Minor***
Firewood and Charcoal • Direct impacts from occupation of	***Moderate***	• Compensation for lost community resources through the Govt. Rule. • Explicitly include consideration of biodiversity and natural resource impacts of in-migration, and integration of appropriate responses into the overall In-Migration Plan. • Mitigation for short- to medium-term losses of access to collection areas will include providing access to alternative sources of fuel wood. • Through Project and participatory environmental monitoring, monitor pressure on natural resources used by the	***Minor***
• Indirect impacts from in-migration	***Critical***		***Moderate***

Description of Impact	Significance before Mitigation	Key Mitigation Measures	Residual Impact
		community. • Cooperation with local authorities to design and implement context-specific natural resource management measures to help communities to manage fuel wood resources over the longer term.	
Non-timber Forest Products • Direct impacts from occupation of land	***Moderate***	• Explicitly include consideration of biodiversity and natural resource impacts of in-migration, and integration of appropriate responses into the overall In-Migration Plan. • Implementation of natural resource management measures through the local village Programme.	***Not Significant*** (most NTFPs) ***Minor*** (raffia palm)
• Indirect impacts from in- migration	***Moderate*** (most NTFPs) ***NTFP – Non-Timber Forest Products.*** ***Major*** (Raffia palm)		***Minor*** (most NTFPs) ***Moderate*** (Raffia Palm)

Fresh Water Supply	***Critical*** or below (depending on catchment)	**Inter glow water security plan is prepared for mitigation of water security.**
		• Design, construct, regularly review and update a Mine Water Management System (MWMS) in order to:
		  • ensure that existing water requirements of high value ecological and / or community receptors are met before operational requirements;
		  • mitigate impacts on existing water users, including communities and ecosystems;
		  • comply with standards for all discharges to the environment; and
		  • Minimize large fluctuations in dewatering rates.
		• Implementation of the In-Migration Plan and related measures.
		• During detailed design a water use audit will be conducted at each supply point to determine more precisely the value of the surface water supply to each community. Values will be assigned based upon current (and where appropriate projected future) use, the availability of alternative supplies,
			Minor or below (depending on catchment) during operation &

• impacts from water supply conflicts	***Moderate***		***Minor***
• Impacts on water quality	***Major***		***Moderate***
• Indirect impacts from in- migration	***Major*** to ***Critical*** depending upon the level of in-migration in a given area		***Minor***

Description of Impact	Significance before Mitigation	Key Mitigation Measures	Residual Impact
		and the assigned value may vary on a seasonal basis; and • MWMS designed and operated such that: • natural base flow conditions in all medium and high ecological value catchments will be maintained; • Sufficient flows are available at community surface water supply points to meet current (and where appropriate projected future) use; and to fill village local pond. • in the event of a flow 'deficit', whereby compensation flows and project water supply requirements cannot be met, then minimum compensation flow thresholds for low or negligible value • Carry out hydrological / yield assessments, integrating concept of environmental flows for alternate supplies. • The Project will work with the project affected communities to support them in securing safe and sustainable water supplies. • Finalize design of water quality standards, control measures, • compliance points and monitoring programmes as described in EIA/EMP. • Implementation of erosion control measures included in the Land Use Management Plan. • Staff training and implementation of Emergency Prevention, Preparedness and Response Plan.	
Cultural Services			
Spiritual and Religious Sites and occupation of land	***Moderate to Major*** depending on the site	• Avoidance, or if not possible and if acceptable to stakeholders, mitigation strategies developed through good faith negotiations with local stakeholders. • Consultations with local communities to identify additional unknown sites, understand site boundaries, identify use and access issues. • Implementation of measures to maintain natural fire regulation services	Residual impact cannot be determined at this stage but aim will be to avoid significant impacts where possible and mitigate remaining impacts so that they are no more than ***Minor*** or ***moderate***.

Description of Impact	Significance before Mitigation	Key Mitigation Measures	Residual Impact
• Direct impacts due to a reduction in natural fire regulation	***Major***		***Minor***
Traditional Practices • Direct impact from mine activities and occupation of land	***Critical**** **Conservative rating covering traditional practices as a whole.* *Values and impacts will vary significantly at the village level and will be assessed in more detail through stakeholder engagement under the CHMP.*	• Mitigation measures directed at maintaining the function of provisioning services that tend to be utilized in traditional activities. • Ongoing consultation with stakeholders to better understand potential impacts, establish a full understanding of and respect for cultural norms, and design appropriate responses to impacts on cultural services over the course of mine activities. • Explicitly include consideration of biodiversity and natural resource impacts of in-migration, and integration of appropriate responses into the overall In-Migration Plan.	***Minor*** to ***Moderate*** depending upon the traditional practice in question.
Regulating Services			
Regulation of Surface water flows	***Moderate***	• Drainage systems for operational areas will be designed to take account of any potential for increased flood peaks downstream by installing flood retention or other peak flow balancing / control measures if required. • There will be regular clearance and maintenance of nala diversion drainage structures to maintain capacity. • In-stream construction works will be carefully planned to minimize any potential disruption to existing drainage patterns.	***Minor***
Erosion Regulation	***Major***	Implementation of a Land Use Management Plan, including measures such as: • avoiding unnecessary disturbance of stable surfaces; • protection of soils outside work areas from damage by prohibiting the movement of construction vehicles and equipment outside designated areas; • locating temporary construction areas to avoid ground at risk	***Minor***

Description of Impact	Significance before Mitigation	Key Mitigation Measures	Residual Impact
		from erosion wherever possible; • minimizing works in areas where there is the potential for slope instability; • scheduling works with high erosion potential during the dry season wherever possible; and • Rehabilitating all disturbed land as soon as practical after completion of works.	
Disease Regulation • Direct impacts leading to increased breeding habitat and	***Critical***	• Measures to reduce the presence of standing water onsite and offsite through strict environmental controls and run-off management. • Monitoring the incidence of malaria / dengue using available data most notably the number of workforce cases that occur. • Measures to reduce the potential for mosquito-human interactions at worker camps and office buildings.	***Not Significant***** ** Residual impacts on beneficiaries are expected to be moderately positive following implementation of mosquito related disease awareness and prevention programmes.
• Indirect impacts from in- migration	***Major***		
Freshwater Fisheries • Direct impacts from the mine	***Major***	• Explicitly include consideration of biodiversity and natural resource impacts, and integration of appropriate responses into the overall management. • Implementation of natural resource management measures as described in the EIA/EMP. • Implementation of the Mine Water Management System (MWMS). • The local population should be consulted on the mitigation measures acceptable to them to mitigate, and if necessary, compensate for, the adverse landscape and visual impact. • Provision of regular and appropriate information to people about progress and future plans for regional development. • During design and construction, the Project will aim to minimize visual intrusion by sensitive deign of structures and implement measures to manage lighting, waste, vegetation clearance and tidiness.	***Major***
Aesthetic Value • Direct Impacts on the aesthetic value provided by natural landscapes	***Moderate***		***Moderate***

Description of Impact	Significance before Mitigation	Key Mitigation Measures	Residual Impact
		During the operational phase, measures will include: • temporary work areas are successfully rehabilitated; • landscape planting continues to provide screening where required; and • Working areas and operational facilities are kept tidy and clear of clutter.	
Natural Hazard Regulation • Direct impacts on natural fire breaks	***Moderate***	• Unauthorized open fires will be prohibited. • Fire breaks will be developed around Project sites. • Adequate water supplies for use in the case of a fire will be established in critical locations. • Trained fire crews will be available in each region and personnel will be trained in communication of fire related hazards and first response. • Work with local communities on management of brush fires. Facilitate emergency response, containment and clean-up in the case of a fire, spill or other emergency.	***Minor***
• Indirect impacts from in- migration	***Major***		***Moderate***

Table 5.2: Ecosystem Service Matrix of Proposed Project

Ecosystem Services	ECOSYSTEM											
	Forest Area			Drainage System			Plantation on OB			Agriculture		
	Dep.	Imp.	Manag.	Dep.	Imp.	Manag.	Dep.	Imp.	Manag.	Dep.	Imp.	Manag.
Aesthetic Information	ND	HI	WM									
Air Quality	HD	HI	WM				HD	HI	WM			WM
Carbon Storage & Sequestration	ND	HI	WM				HD	HI	WM			WM
Dust Control	HD	HI	WM				HD	HI	WM	HD	HI	WM
Energy & Raw Material	ND	HI	WM									
Food & Fodder	MD	HI	WM									
Flood Control	HD	HI	WM	HD	HI	WM						
Habitat and Nursery	ND	HI	WM									
Noise Control	HD	HI	WM				HD	HI	WM			
NTFPs	MD	HI	WM									
Pollination	MD	HI	WM							HD	HI	WM
Recreation	ND	HI	WM									
Soil Formation	MD	HI	WM				HD	HI	WM	HD	HI	WM
Soil Retention	MD	HI	WM				HD	HI	WM	HD	HI	WM
Water Regulation	MD	HI	WM	HD	HI	WM	HD	HI	WM	HD	HI	WM
Water Supply	HD	HI	WM	HD	HI	WM				HD	HI	WM

Dependencies Category (Dep)	
High Dependency	HD
Medium Dependency	MD
Low Dependency	LD
No Dependency	ND

Impacts Category (Imp)	
High Impact	HI
Medium Impact	MI
Low Impact	LI
No Impact	LI

Management Level (Manag)	
Not Managed	NM
Partially Managed	PM
Fully Managed	FM
Alternative Identified & under Use	AM
Will Be managed	WM

Agricultural Services Within the Buffer Zone

Water Bodies within the Study Area

Bamboosetum along with *Shorea robusta* within the buffer zone

Daniad Eggfly within the core zone