

CHAPTER 3

STUDY AREA

3.1 General statement

The area of our study lies in Singrauli district of Madhya Pradesh and the adjoining Sonbhadra district of Uttar Pradesh state. These two are together termed as Singrauli. The area is mainly dominated by the presence of opencast coal mines, thermal power plants, chemical industries, etc (Bhardwaj et al 2020). Though the mining area mainly occupies the Singrauli district of M.P. state yet a small portion of it falls in the adjoining Sonbhadra district of U.P.(Shirin et al 2019). Due to the presence of a plethora of mineral resources and coal the region is popularly known as “Urjanchal” or ‘Energy Capital’ of India (Kumar et al 2019). As per the census of 2011, the total population of the district is 11,78132 constituting about 1.62% of the total state population. This district has a population density of 208 inhabitants per km² with a population growth rate of 28.03% for the decade 2001-2011. The district has a sex ratio of 916 females for every 1000 males with a literacy rate of 62.36% (“District census 2011”). The Singrauli district is the 50th district of Madhya Pradesh which was striated from Sidhi district with its headquarters at Waidhan out of the total 51 districts of the state. The distance between the state capitals of Madhya Pradesh i.e. Bhopal & Singrauli district is about 663.5 km via MP SH14. The district is well connected by road & rail network however, the nearest airport lying to it is Babatpur Airport falling in Varanasi district for connectivity through aerial route. The district is a landlocked district bounded by Rewa in the north, Sidhi in the East, Sarguja in South and in the west it is bounded by Shahdol district. The whole district covers an area of approximately 5672 km². The whole district is divided into five tehsils i.e. Chitrangi, Deosar, Mada, Sarai and Singrauli with 3 development blocks Deosar, Chitrangi and Waidhan. A total of 746 villages and towns are present in the district. The district stretches between 24.19°N latitude and 82.66°E longitude (latitudelongitude.org/in/singrauli). Shaktinagar is the railway station which lies nearest

to the Singrauli coalfield. The area is considered as an 'Energy Capital of India' due to the fact that majority of the energy based industries are operating in & around the Singrauli district. Apart from coal based industries such as NCL and NTPC many other chemical based industries are also present in the vicinity of the area. Industries which are present in the Singrauli district are as follows:-

- NCL (Northern Coalfield Limited).
- NTPC (National Thermal Power Corporation Limited).
- UPPCL (Uttar Pradesh Power Corporation Limited).
- Season Power Limited.
- Jaypee Power Venture Limited.
- Essar Power Limited.
- Hindalco Industries Limited.
- Lanco Power Limited.
- Chitringi Power Limited.
- Mahan Aluminium Limited.

Since, the state owes a valuable amount of coal reserves of the country (Singh et al 2014) therefore the area has seen a rapid growth in industrialization not only due to presence of NCL, a subsidiary unit of CIL for carrying out excavation of coal in the area but also due to presence of other industries such as cement, chemical and power based industries which are dependent on NCL for fulfilling their coal requirements for proper functioning of the industries. Fig 3.1 shows location map of study area while Fig 3.2 shows the False Colour Composite of the study area.

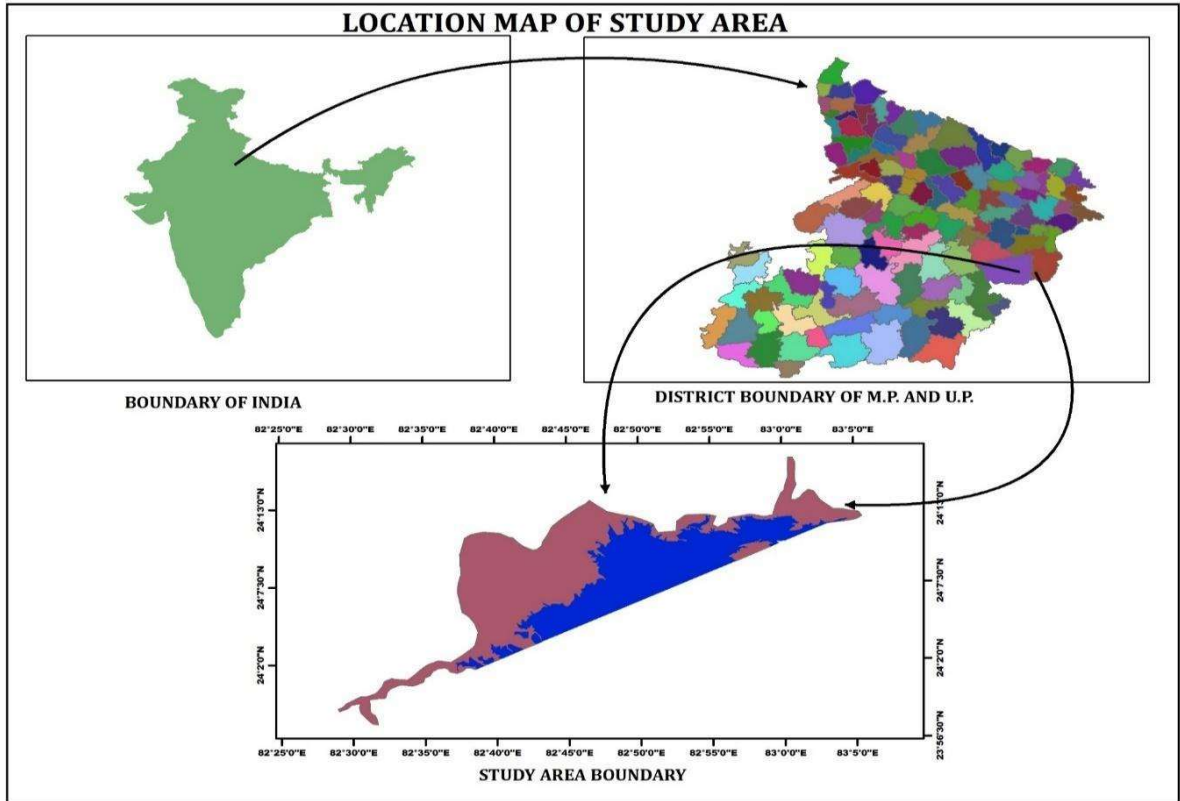


Fig. 3.1 Location map of study area

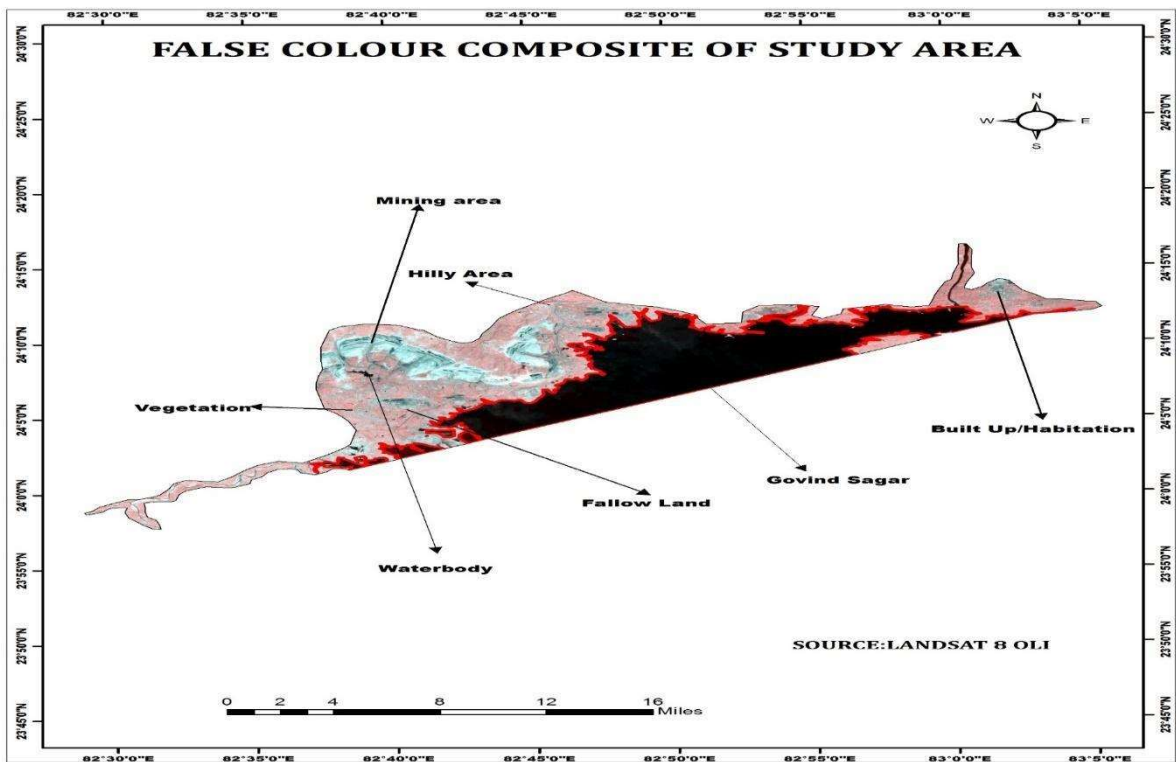


Fig 3.2 False Colour Composite (FCC) of study area

3.2 Administration

The Singrauli district has its headquarters at Waidhan with 746 villages & towns in the district. The study area lies between $24^{\circ}00'$, $24^{\circ}20'N$ latitude and $82^{\circ}30'$ to $83^{\circ}00'E$ longitude. The area under the study is situated on the border of Madhya Pradesh & Uttar Pradesh & falls under 8 survey of India topographical sheets i.e. 63L/11, 63L/12, 63L/15, 63L/16 64I/09, 64I/13, 64P/03 and 64P/04. According to the census of 2011, the total population of the district is 11,78132 covering an area of about 5672km^2 approximately. However, the study area falls in Singrauli Tehsil with a population of around 220257 covering an approx. 728.40km^2 . The district exhibits a literacy rate of about 62.36% as compared to the 74.04% of National literacy rate of India. The district has a sex ratio of 916:1000 ratio of females:males in India. [Census 2011.co.in].Figure 3.3 shows the toposheet of the study area.



Fig 3.3 Toposheet of study area

3.3 Climate

The study area experiences tropical monsoon climate with the Koppen-Geiger climate classification of Cwa. The average annual temperature of the district is 24.7⁰C with a maximum temperature of the district is 40.8⁰C during the month of May and minimum temperature of 8.8⁰C during the month of December.

3.4 Rainfall

As per the data acquired from India Meteorological Department (IMD) Pune, it shows that the average annual rainfall received during the time period of 1967-2018 i.e. 52 years is 1167.53 mm. However, the maximum and minimum rainfall was 2197.40 mm & 507.50 mm during 1978 and 2015 respectively (table 3.1). As shown by the data approximately 80% of the rainfall is received during monsoon season (June-September), 11% approximately during summers and 9% during winter season. Though, the rainfall data shows a declining trend but still few of the years showed higher annual rainfall than the average rainfall experienced by the area. Fig 3.4 shows the variation in annual average rainfall.

Since, the area receives rainfall through southwest monsoon, therefore a high amount of precipitation can be seen in the area. Here, the maximum relative humidity varies between 55 to 88% during July to September while 33 to 55% during winter season (October to February). In summer (March to June) relative humidity is only 14% (CGWB 2013).

The precipitation in the area varies between 4 mm to 315 mm between the driest month i.e. November and the wettest month in August respectively. However, the average precipitation was 84.5 mm during the whole year. (en.climate-data.org/asia/india/madhya-pradesh/singrauli-59731/).

S. No.	Year	Rainfall (mm)
1)	1967	1256.40
2)	1968	1018.90
3)	1969	1009.20
4)	1970	971.80
5)	1971	1642.50
6)	1972	793.60
7)	1973	799.70
8)	1974	761.80
9)	1975	1382.10
10)	1976	1022.00
11)	1977	1871.00
12)	1978	2197.40
13)	1979	1048.30
14)	1980	1457.10
15)	1981	873.70
16)	1982	999.40
17)	1983	969.90
18)	1984	1334.30

19)	1985	1278.70
20)	1986	876.70
21)	1987	1472.10
22)	1988	1140.40
23)	1989	1128.80
24)	1990	994.90
25)	1991	1796.20
26)	1992	1025.30
27)	1993	1109.10
28)	1994	1711.20
29)	1995	1112.30
30)	1996	1149.60
31)	1997	1239.50
32)	1998	1288.40
33)	1999	1741.50
34)	2000	1051.70
35)	2001	1322.20
36)	2002	1082.00
37)	2003	1478.90

38)	2004	1154.70
39)	2005	1163.10
40)	2006	1115.50
41)	2007	867.40
42)	2008	1084.20
43)	2009	877.30
44)	2010	1044.90
45)	2011	1518.50
46)	2012	951.40
47)	2013	1226.30
48)	2014	1071.30
49)	2015	507.50
50)	2016	1103.70
51)	2017	1040.00
52)	2018	577.00

Table 3.1 Average Annual Rainfall (1967-2018) in Singrauli region

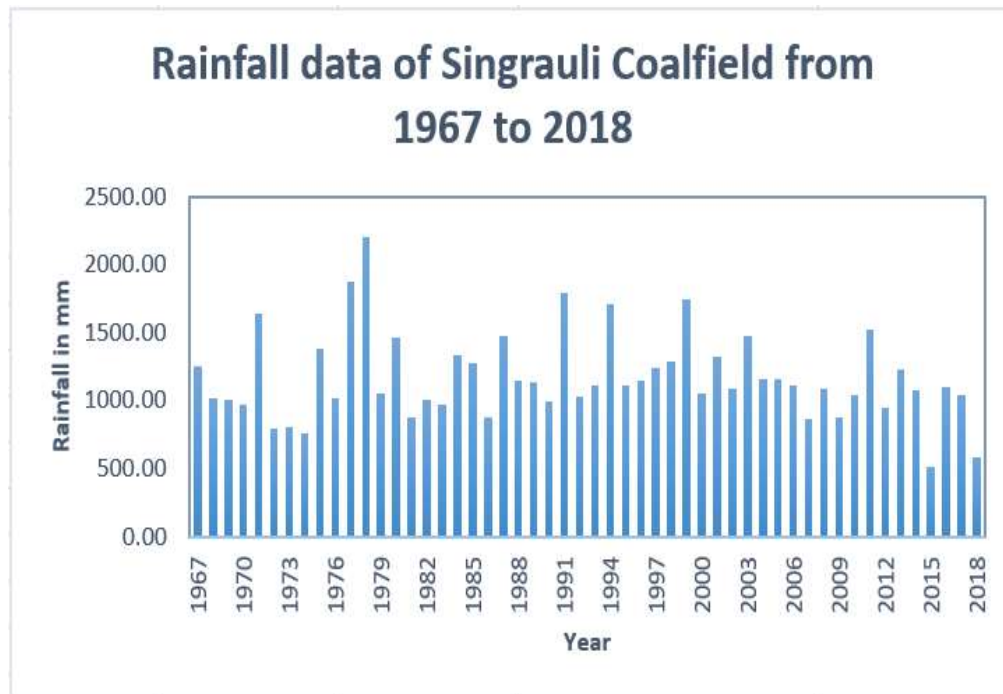


Fig 3.4 Graph representing annual average rainfall

3.5 Geography of the area/ Physiography

The Singrauli region is constituted by the presence of a congregation of numerous low hills & plateau on an undulant surface of prolific plains on the Govind Ballabh Pant Reservoir's upstream end. However, the Singrauli coalfield is mounted as a high raised plateau over the adjacent plains on the Talchir sediments (Christopher et al 2002, Mohan 2007). The Singrauli plateau is at a height of over 500m above the mean sea level (MSL) from the southern plain with a general level of 275m above the mean seal level.

On the Northern front, the Gondwana sediments border it while limited by rocks of Precambrian era with regards to Southern, Eastern & Western direction the area is surrounded with Barakar Sediments over the Talchir outcrops as Scrap faces (CMPDI 2005) . Thus, the Singrauli Coalfield can be considered as a representative of erosional landscape with clusters of plains & plateaus. The Moher plateau where the excavation of coal is in progress currently is dominated by the presence of step like scarp faces towards

the south. Towards the South west of the area, prominent high peaks such as Papari (508m) & Burma (564m) are present. Govind Ballabh Pant Reservoir is the main source of water for industrial, domestic or agricultural purposes located in the southeast of the area taken into study with a full reservoir level of 268m and a catchment area of 13,333km² spreading over an area of 130 km². The reservoir has a capacity of about 10.6 billion cubic metres.

3.6 Soil Characteristics

The study area is usually occupied with Alluvial soil, Black soil, Red Sandy soil, Yellow loamy Sandy soil, laterite soil and red loam soil (cgwb.gov.in/District_Profile/MP/Singrauli.pdf). Here, the alluvial soil is mainly found on the banks of major rivers. However, the most dominant type of soil present in the area is the black soil in the Southern part of the region (Khan et al 2012). Red & Yellow soil mainly occurs in the northern part of the study area while in the northeast part of the area Red Sandy soil is the predominant type of the soil.

3.7 Drainage Pattern

Along the drainage area of Son and Rihand rivers the study area is situated. Many important perennial streams traverse through Singrauli which mostly flow to their full capacity during the rainy season (Anshumali et al 2014). The main perennial streams include Kachan, Mayar, Matwani, Balia nala, Bijul, Deohar nala & Chatka nala. In the Moher scrap, the north flowing streams join the Bijul river, a tributary of Son River while the south flowing streams join the Kachan & Mayar, which are the tributaries of Rihand river (Kumar Vijay 1998). These rivers meet near Tusa & terminate into Govind Ballabh Pant Reservoir. However, few streams drain directly into the reservoir or join the perennial stream of Balia nala as Motwani & Balia nala which finally drains into the

Govind Ballabh Pant Reservoir (Khan Imran 2012). The overall drainage pattern of the study area is towards the south which in turn is connected by the Amjhar nala in the east & feeder nala in the west. (Rabindranath) The Amjhar nala is connected with the Kanchan River which finally drains into Govind Ballabh Pant Reservoir located in the southeast of the study area. However, the general drainage pattern of the area is dendritic in nature depending on the structure & lithology of the study area. One of the major assets of the area is the presence of G.B. Pant Reservoir. The reservoir is one of Asia's largest man made reservoirs formed by Rihand dam which is a gravity dam. The construction of the reservoir was started in early 1950s and completed in 1966 with a total cost of Rs. 375 million. The storage capacity of the reservoir is 10.6 billion m³ (Rai and Tripathi 2009) with a catchment area of 13,333.26 km² irrigating about 2.5 lakh hectares of agricultural land. However, the area of submergence is about 466 km² at a FRL of 268m. The Rihand dam has an installed capacity of 300 MW for hydro power generation with a total turbines of 6X50MW. Fig. 3.5 shows the Drainage map of the study area.

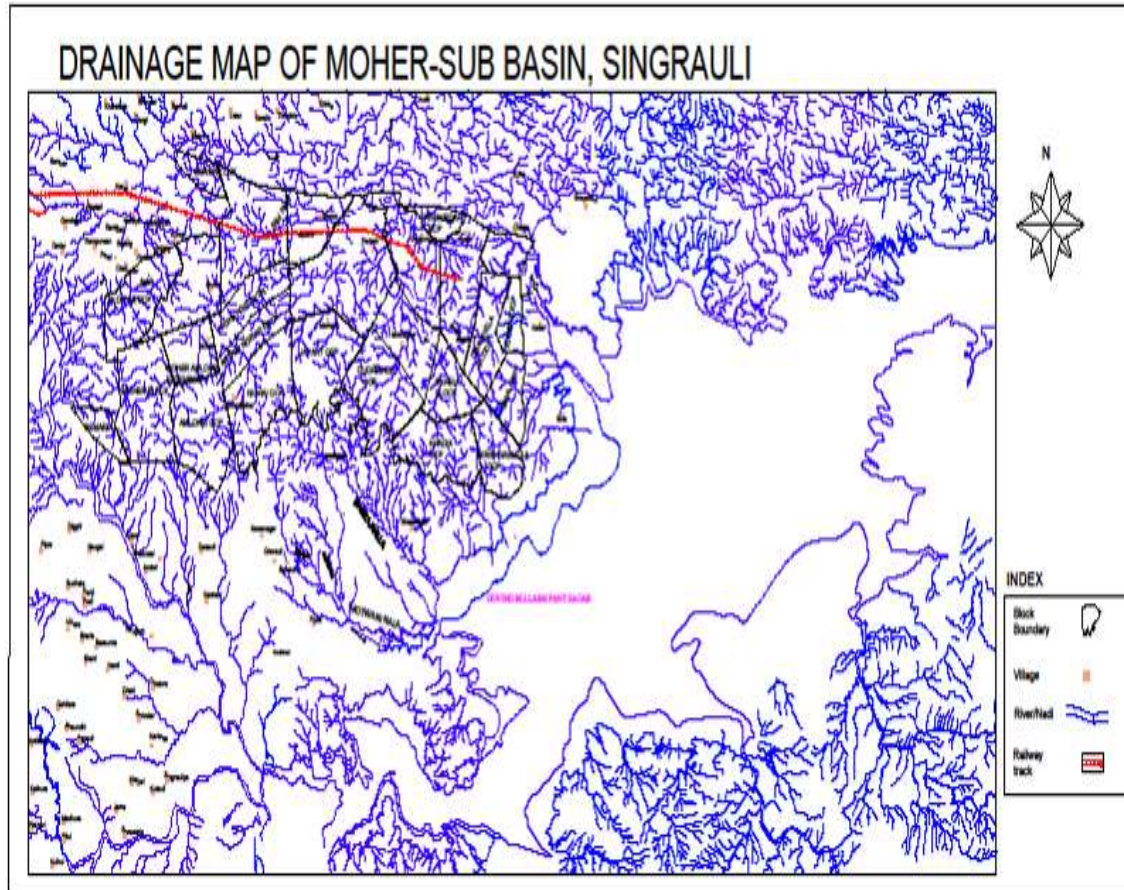


Fig 3.5 Drainage map of the study area

3.8 Flora and Fauna

The major type of forest found in the area is Dry deciduous forest with relatively thicker vegetation cover in the valleys & sparsely distributed on the hillocks. The typical floral species found in the area include Sal, Salai, Shisham, Tendu, Mahua, Bamboo, Amaltas, Palas, Bhira, Saja, Dhaora, Dhawa, Asan, Nirqudi, etc. (CMPDI 2005). The main types of forest found in the area are Sal Forest and Mixed forest where Sal forests are found in the moisture ridden areas and Mixed forest are found in relatively drier regions. Taking into account the agriculture of the area, the main crops grown in the area include Wheat, Jowar, Barley, Paddy, Maize, Urad, Moong, Sugarcane, Vegetables, etc. Here, agriculture

is mainly confined on the banks of Govind Ballabh Pant reservoir in the south and son river in the North (Khan Imran 2012).

The faunal diversity of the area includes animals like Elephants, Tigers, Beers, Bisons, etc since the area is rich in wildlife. Due to increase in mining activities and poaching of animals the density of the animal population in the area is decreasing day by day.

3.9 General Geology

The Geology of the Singrauli coalfield & its adjoining area shows that the region lies at the northern extremity of the Son-Mahanadi basin of the Gondwana supergroup. This stretches from the east coast to the heart of peninsular India. The coalfield occupies a junctional region which lies between the east-west trending Damodar-Keol-Tatapani graben & the northwest-southeast trending rift zone of the Son-Mahanadi Valley. Thus, the tectonic & stratigraphic framework of the Singrauli basin shows character of both Damodar valley & the Son valley Gondwana basins as per the report of Geological Survey of India (GSI) (Raja Rao 1983). Therefore, it can be conferred that the stratigraphic sequence of the area under study shows a wide congruence with the adjoining Gondwana basins of Tatapani, Hutar & Karanpura. The prevalence of a sandstone dominated cycle of the Son valley basin is being shown by the structuring of the lithic piles of the study area. However, the Gondwana sediments in Singrauli were deposited by a north western draining fluvial network which is a characteristic feature of the son valley basin. Thus, the locational aspect of the junction in the rift depends on the peculiarities of the geological formation of the basin. The lower Gondwana formations of the area are distinguished from the main stretch of the coal deposit of Sohagpur-Sonhat master basin by presence of a huge tract covered with supra Barakar sediment. Fig 3.6 represents the opencast coal mine of Northern Coalfield Limited, Singrauli.

The northern limit of the Singrauli coalfield is determined by the presence of east-west trending boundary fault, an offshoot of the Son-Narmada lineament. However, the eastern part of the coalfield is dominated by the Talchir sediments which rests unconformably on the Precambrian rocks. Though in the northern part, the younger lower Gondwana sediments adjoins against the Precambrian basement on the east west trending fault (Hota et al 2012) On the Western side, the Upper Gondwana sediments are collocated against the Bijawar Group of Proterozoic period. The six series of formations found in the area in ascending order are as follows: Talchir, Barakar, Barren Measures, Raniganj, Panchet & Mahadev in which Raniganj & Barakar are the coal bearing formations present in the area (Usham 2018, Kumar and Ahmad 2007, Singh and Srivastava 2011). Fig 3.7 shows the Geological map of the study area and Fig 3.8 represents Google Earth View of study area while the generalized stratigraphic sequence of the study area is shown by Fig 3.9.



Fig 3.6 Opencast coal mine of Northern Coalfield Limited, Singrauli

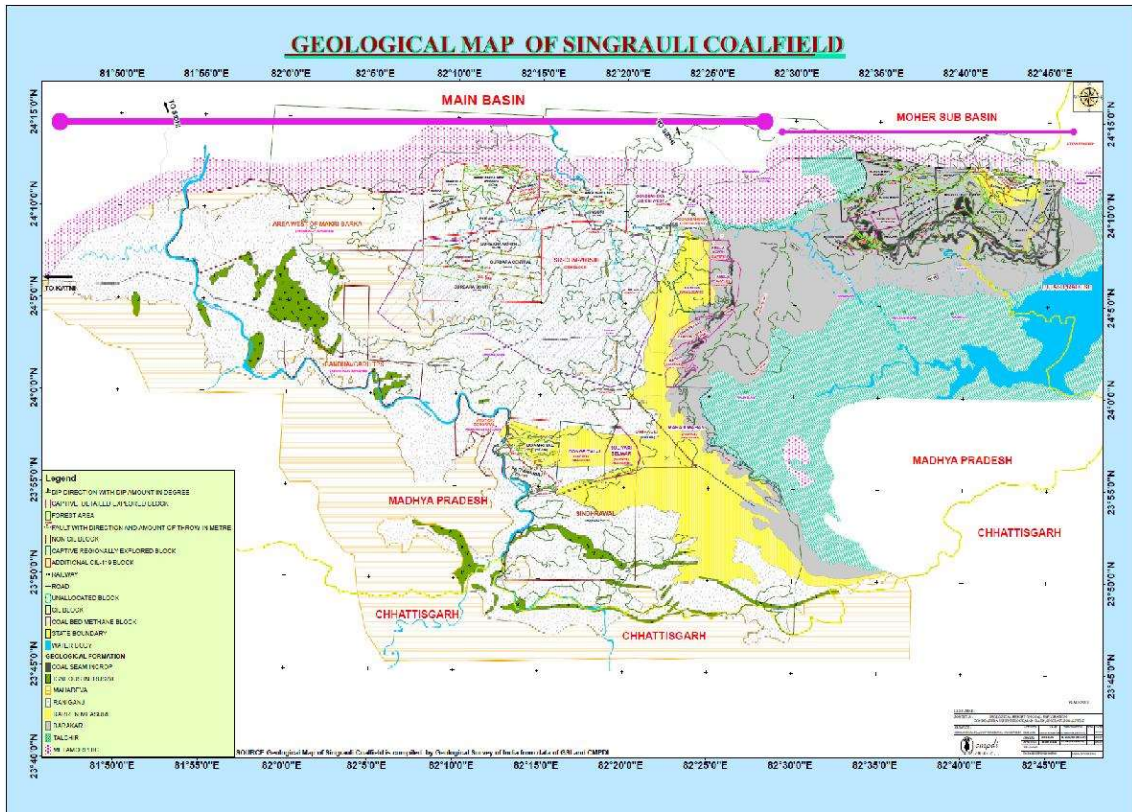


Fig 3.7 Geological map of the study area

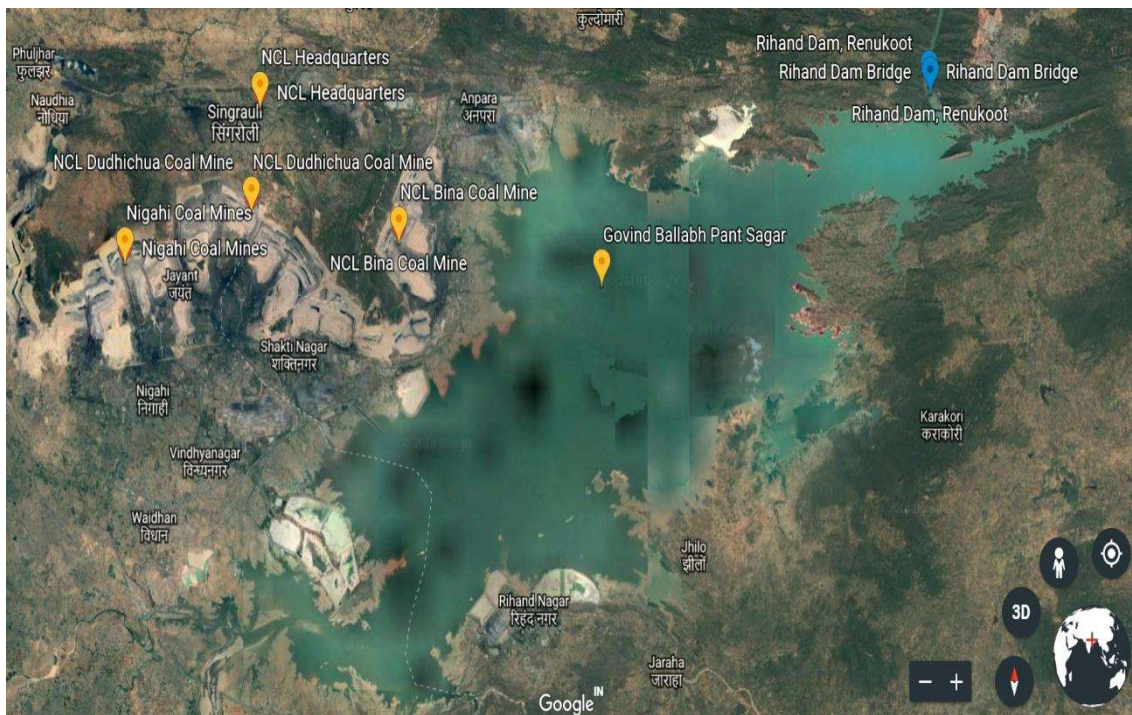


Fig 3.8 Google Earth View of study area

Geological Age	Group	Formation	Lithology	Thickness (m)
Cretaceous		Intrusive	Dolerite dykes and sills	Not estimated
Upper Triassic	Upper Gondwana	Mahadeva	Coarse grained, ferruginous sandstone with bands of shale, clay and conglomerate	Not estimated
Lower Triassic	Lower Gondwana	Panchet	White, greenish white and pink micaceous, medium to coarse grained sandstone with red beds, greenish-brown silty shales and conglomerates	Not estimated
Upper Permian		Raniganj	Fine grained sandstones and shales with coal seams	215-403
Middle Permian		Barren Measures	Very coarse grained to ferruginous sandstones, green clay and shales	125-300
Lower Permian		Barakar	Medium to coarse-grained sandstones, shales, clays and coal seams	325-600
Upper Carboniferous		Talchir	Tillite, sandstones, siltstones, needle shales	75-130
----- Unconformity -----				
PreCambrian			Phyllites, quartzites, schists and gneisses	

Source: (Rao, 1983)

Table 3.2 Stratigraphy of study area

3.9.1 Precambrian Basement

The metamorphosed Precambrian rocks form the Precambrian basement upon which the Gondwana sediments rests with a profound unconformity. In the south, it consists of gneisses and schists whereas on the northern side, phyllites and quartzites are found in the area. The northern boundary of the basin in the northeastern part is delineated by a series of ridges composed of metasediments. However, on the west, the sediments are colligated against the metasediments of Bijawar consisting of phyllites, quartzites, etc.

3.9.2 Talcher Formation

The Talcher formation is one of the oldest formations of the Gondwana Supergroup. The rocks belonging to the formation unconformably overly above the basement. The formation is mainly exposed over large areas in the plains on the eastern side of the coalfield as well as on the south-eastern parts of the coalfield. The rocks of this formation mainly comprises tillites, boulders, pebbles of granite, gneisses, quartzite, basic rocks, blue quartz, jasper, conglomerate, flints, etc. Where the boulders are egg shaped or wedge like and few are faceted with distinct striations indicative of their glacial derivation. However, the Tillite bed is successively overlain by shale, siltstone and sandstone (Rabindranath Thesis). In the southeast of the area under study, the maximum portion of the Talcher formation is under submergence by Govind Ballabh Pant Reservoir. Only a small strip of it is exposed around the Parari village in the North-western part of the coalfield. The thickness of the outcrop varies between 3 km to 8 km having a tendency to get widened towards the west. Though the strata are only about 50 m in thickness they show restricted development as compared to the main Talcher outcrop in the south.

3.9.3 Barakar Formation

In the eastern part of the coalfield, a prominent landmark of hard and compact lithology is found covering a large area in this region. The formation mainly consists of medium to coarse grained, light grey, pink and white arkose with thin interbands of shale and pink clay. Fine grained sandstones also occur within the formation but its proportion to the coarse grained sandstones is comparatively lower. Here, Kaolinised feldspar usually acts as a cementing material. The most common sandstone found in this formation is the red sandstone and the red colour of the sandstone is due to the deposition of iron along the bedding planes. These sandstones are mostly interbanded with pebble beds which are usually round and composed of quartzites. The sandstone found locally in this area is having a significant concentration of garnet, thereby imparting a pinkish tint to it. In between the multistoried sandstones thin bands of arenaceous sequence are common as compared to the thick shale beds to attain a thickness of about 50 m to 60 m. The grey sandy shale beds are found interbedded within the coal seam constituting most of the dirt bands within the seams. However, some of the coal seams found in the area show absence of sandstone in them but the thickness of this kind of strata is much lower as compared to the non-coal bearing strata.

The Singrauli coalfield is characterized by the presence of many coal seams with clay beds occurring in their outcrop. Such an arrangement is mainly found in the Moher sub-basin. Here, the clay associated with coal shows a variety of colours varying from light yellow to creamy white and pink. These clay beds are continuous along the incrops of the total seams. The Barakar Formation covers an approximate area of 515.18 km² with remarkable lateral variation in thickness. In the eastern part of the coalfield a maximum thickness of 585 to 600 m has been found while in the western part of the coalfield it

attenuates to 325 to 400m. It is most probably possible that a further decrease in thickness has taken place below the cover of younger formation, further in the west.

3.9.4 Barren Measures

This formation was first identified in the north-eastern part of the coalfield around Jhingurdah village. Characterized by a thick sequence of approximately 125 m of strata the formation lies above the whitish very coarse grained, pebbly sandstone of the Barakar while ferruginous and yellow sandstones with greenish sandstone, red and green clay bands prevails between the Barakar coal measures comprising Kota-Tura-Purewa-Panipahari seams below and an upper coal measure containing the Jhingurdah seam above has been provisionally termed as Barren measures. This formation is deprived of carbonaceous material and is identified by presence of red and green clays present especially near the outcrop. A large tract of Barren measures on the western part of the coalfield is found in the Ujheni-Majhauri areas which is superseded by the Raniganj Formation. This formation is represented by coarse to very coarse grained, white to yellow feldspathic sandstones thereby turning into its ferruginous constituent near the outcrop. In this part of the coalfield, the vulnerability of carbonaceous and greenish shale are common.

3.9.5 Raniganj Formation

In the western part of the Singrauli Coalfield, a large portion of the area is covered by Raniganj Formation. The outcrop of it is semicircular in shape usually found in Jhingurdah region attaining a thickness of about 400 m. In the Jhingurdah sub-basin this formation is constituted by the presence of white, grey clays and carbonaceous shales of various grain sizes. This 134 m thick coal seam of the Gondwana group is the country's thickest Gondwana coal seam commonly known by the name of Jhingurdah seam. In the

western part of the Singrauli coalfield in Jhaleri-Majhauri area, the Raniganj Formation exhibits prevalence of shale with finer facies. The sandstone found in this formation is usually fine grained in nature.

3.9.6 Panchet Formation

In the southern part of the coalfield, this formation is commonly found in the Latajharria, Harauri nalas and Gopal river section. The rocks of this formation, in the Mahadeva range are present in the form of deep gorges. The beds of this formation seem to rest conformably over the Raniganj sediment overlapped by Mahadeva sandstones with an angular discordance.

3.9.7 Mahadeva Formation

The beds of Mahadeva formation are exposed in the western, south-western and southern part of the Gopal River. This formation covers a large portion in the southern and south-western parts of the coalfield up to the southern periphery having a great thickness. Within the coalfield at few places, they occur as outliers. These outliers are present in the form of isolated hills towards the south of Bendul. The beds of this formation give rise to high hillocks and occur along the scarp faces overlooking the peneplained country. They regionally dip towards the south with a practical horizontal outlook. The formation mainly consists of massive, medium to coarse grained with a yellow or dark brown colour and are thickly bedded in nature. This sandstone is hard and resistant to weathering due to the presence of quartz grains cemented with ferruginous material.

3.10 Geology of Coal Seam

3.10.1 Barakar Formation

3.10.1.1 Kota Seam: The thickness of the seam lies between 0.35 to 3.16 m. This is the lowest coal seam in the Moher basin and is very inconsistent and erratic in both lateral and horizon extremes. It usually occurs in the form of splits. The composition of the seam ranges between interbanded coals to carbonaceous shale.

3.10.1.2 Turra Seam: This is the most prominent coal seam of the Moher basin found in all blocks from Kakri in the east to Block B in the west. Here, its thickness ranges between 12 to 26 m. The upper part of the seam is interbedded with dirt while the lower part is free from dirt bands varying from block to block.

3.10.1.3 Purewa Bottom Seam: The thickness of the seam ranges from 8 to 15 m occurring in the eastern and southern part of the Moher Basin. The seams of this are highly interbanded and are more or less parallel to Turra Seam.

3.10.1.4 Purewa Top Seam: Unlike the above seam, this seam too is highly interbanded with a thickness of about 5 to 9 m. In the western part of the coalfield, both the sections consolidated into Purewa merged seam.

3.10.1.5 Purewa Merged Seam: The thickness of this seam is about 25 m. Being a highly interbanded seam, the seam occurs in the western part of the Moher and Block 'B' basin.

3.10.1.6 Khadia Seam: The seam occurs above the Purewa top at a height of about 40m. This seam is not a workable seam but is a locally developed seam developed in Khadia ranging between 1 to 2 m in thickness.

3.10.1.7 Pani Pahari Seam: Like the above, this seam too is local in nature and a workable section is also not available in this. This seam is having a thickness of 1 to 2m occurring at a height of 150 m above Purewa Top.

3.10.2 Raniganj Formation

3.10.2.1 Jhingurdah Bottom Seam: This seam is only restricted in Jhingurdah colliery with a thickness ranging between 6.5 – 19 m. This seam too is highly interbanded with carbonaceous shale and grey shale.

3.10.2.2 Jhingurdah Top Seam: Found in the Jhingurdah colliery particularly, this seam is India's thickest coal seam so far, ranging between 105 to 160 m in thickness showing high interbanded outlook.

Therefore, this chapter provides a detailed description of the study area chosen for the study whereas the next chapter focuses on the methodologies adopted for the achieving the objectives of the study.