केंद्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण

विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board

Department of Water Resources, River Development and Ganga Rejuvenation,

Ministry of Jal Shakti

Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

SUNDARGARH DISTRICT, ODISHA

दक्षिण पूर्वी क्षेत्र, भुवनेश्वर

South Eastern Region, Bhubaneswar

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FOREWORD

Sundargarh district is situated in the north-western part of the state of Odisha. It is the second largest district in the state having geographical area of 9,712 km^2 and accounts for 6.23% of the total area of the State. As per 2011 census, the district has a population of 20.93 lakhs of which 8.30% reside in urban areas. The projected population of the district in the year 2022 has been calculated as 24.64 lakhs. With the increase in population over the past years, the ground water extraction in the district has also increased and the stage of ground water extraction has increased from 22.11% in the year 2011 to 39.56% in 2022. Groundwater forms the major source of drinking and domestic needs in the district. The district is underlain mainly by hard rocks of different geological ages. The major rock types available in the district are granites, quartzites, limestone, dolomite, phyllite and mica schist. These rocks are devoid of any primary porosity and ground water occurs in the top weathered and deeper fracture zones in these rocks. Due to wide variation in hydrogeological set up in the district, the occurrence and distribution of aquifers are non-uniform and so also their yielding properties. The common modes of ground water exploitation in the district are dug well, dug-cum-bore well, shallow tube well etc.

The present report **"Aquifer Mapping and Management Plan of Sundargarh District"** is the output of the study taken up under the National Aquifer Mapping Programme of Central Ground Water Board in order to compile all the relevant information related to hydrogeological studies and to suggest a ground water management plan for the district. An attempt has been made to formulate ground water management plan in this report with the help of all relevant information collected through field investigation and earlier hydro geological studies taken up in the district. In addition to the information on the vertical and horizontal disposition of aquifers, their yielding capacity, quality of water in them, the gap between availability and demand of water in future has been assessed and suitable measures to bridge the gap has been suggested in the report.

Sh. Arijit Mitra Scientist-C (HG) and Sh. Satyam Shukla, Assistant Hydrogeologist jointly have compiled and prepared the present report under the supervision of Dr. B K Sahoo, Scientist-E. Their sincere efforts in the compilation of this report will no doubt be very useful and beneficial for different groundwater user agencies, administrators, and planners in preparation for groundwater development plans and will be a handy tool in the functional management of groundwater resources.

Bhubaneswar
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P K Mohapatra

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CONTENT

1. Introduction

Objectives

The objective of the study is to prepare aquifer map of the area in 1:50,000 scale, identify the aquifer system of the study area and prepare a groundwater management plan.

Scope of the study

Sundargarh district has vast groundwater and surface water resources. However, the Agro based economy of the area has very less irrigation facility and the stage of ground water extraction been low. Proper hydrogeological knowledge of the area can be helpful to prepare a sustainable management plan for groundwater utilization.

Approach and methodology

The approach is to identify the major aquifers and to conceptualize the aquifer system. This will help to formulate an aquifer management plan. Finally, the scientific knowledge will be disseminated to farmers, state government and stake holders.

The methodology can be illustrated as follows:

1. Data compilation and data gap analysis: The preliminary works consisted of collection and review of all existing hydrogeological and exploration data of CGWB, PHED, Agriculture department, Irrigation department, Water resource department. All data were plotted in base map on GIS Platform. On the basis of available data, Data Gaps were identified.

2. Data Generation: Efforts were made to fill the data gaps by hydro-geochemical analysis, besides detailed hydrogeological surveys.

3. Aquifer Map Preparation: On the basis of integration of data generated from various studies of hydrogeology & geophysics, aquifers have been delineated and characterized in terms of quality and potential. Various maps have been prepared bringing out Characterization of Aquifers, which can be termed as Aquifer maps providing spatial variation (lateral & vertical) in reference aquifer extremities, quality, water level, potential and vulnerability (quality & quantity).

4. Aquifer Management Plan Formulation: Based on aquifer map and conceptual model a sustainable development plan of the aquifer is formulated.

Demographic details

Sundargarh is the second largest district in the Odisha State. Sundargarh district is bounded by Jharkhand & Chhattisgarh state on the North, Keonjhar, Angul and Deogarh in East; and Jharsuguda, Sambalpur district on South. The study area for aquifer mapping falls under Survey of India Toposheet No. 64N/14, 73B/2, 64N/15, 73B/3, 73B/7, 73B/11, 73B/15,

73F/3, 64N/12,64N/16, 73B/4, 73B/8, 73B/12, 73B/16, 73F/4, 64O/9, 64O/13, 73C/1, 73C/5, 73C/9, 73C/13, 73G/1, 73G/5, 73O/10, 73C/14, 73G/2 bounded by 22.5344°N, 84.0062°E in northern side and 21.59154°N, 85.03674°E in southern side while 21.9797°N, 83.5522°E in western side and 21.9403°N, 85.3454°E in eastern side covering an area of 9712 sq. km of Sundargarh district of Odisha. The climate of the district is characterized by hot summer and is generally dry except during the south- west monsoon season. The mercury touches 48ºC during summer and drops 5ºC during the winter. The cold weather commences towards the end of November, when the temperature begins to fall rapidly. The average annual rainfall in the district is 1564.2 mm, out of which about 80% occurs during south-west monsoon. Brahmani is the major river, which enters the district near Rourkela. Its main tributaries are Sankh & Koil. Most of the area of the district is under hilly track. The district comprises of 17 blocks, 262 G.P.s and 1779 villages. There are 4 municipalities in the district. The district is conveniently divided into 3 irrigation divisions viz. Sundargarh (2 nos.) and Panposh.

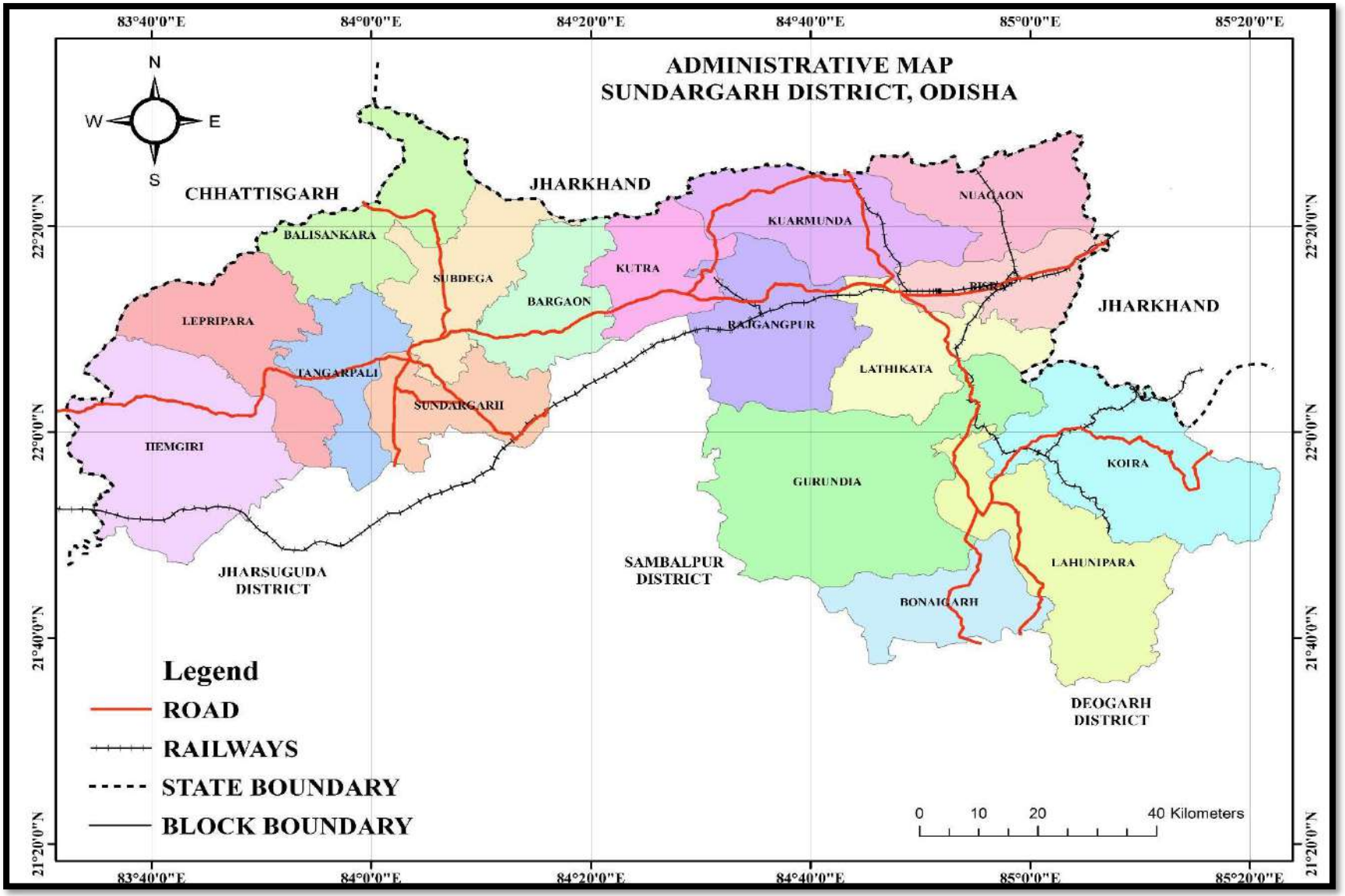
As per 2011 census, the district has a population of 20.93 lakhs of which 91.69% is rural and 8.30% is urban. The decadal growth rate is 14.4 % with a population density of 216 persons/ km2. The literacy rate is 73.34% and the male-female sex ratio is 973 females per 1000 males.

Table 1.1 – Block wise demographic details, Sundargarh district, Odisha.

Sr. no.	Block	Area (Ha)	No. of GP	No. of Villages	Total Household			Total Population		
					Rural	Urban	Total	Rural	Urban	Total
1	Hemgir	94028	19	153	20953	0	20953	84559	0	84559
2	Lephripada	55751	17	108	19750	0	19750	78808	0	78808
3	Tangarpali	35656	13	80	16597	0	16597	64374	0	64374
4	Balisankara	53441	16	101	21656	0	21656	85690	0	85690
5	Subdega	46050	14	63	15517	0	15517	64254	0	64254
6	Sundargarh	38769	16	86	18046	0	18046	70911	0	115947
7	Baragaon	39972	13	69	16730	0	16730	71242	0	71242
8	Kutra	35421	16	54	17598	0	17598	80470	0	80470
9	Kuarmunda	58160	20	107	20995	2060	23055	97870	9043	140355
10	Nuagaon	44862	20	120	23133	0	23133	106156	0	106156
11	Bisra	33327	15	69	14159	4698	18857	68629	21556	575620
12	Lathikata	47812	16	82	17511	14490	32001	82324	63988	146312
13	Rajagangpur	59576	12	76	20155	2236	22391	95142	9923	156427
14	Gurundia	125296	13	146	14701	0	14701	66988	0	66988
15	Bonaigarh	42228	13	117	15251	1686	16937	62811	7080	69891
16	Lahunipara	78811	17	220	22953	0	22953	99526	0	99526
17	Koida	85909	12	111	16792	2921	19713	75586	11232	86818
	Total	**971244**	**279**	**1762**	**451018**	**28091**	**479109**	**1970615**	**122822**	**2093437**

Source – District Statistical Handbook 2018, Sundargarh District, Odisha.

Figure 1.1 – Administrative Map of Sundargarh District, Odisha.



Data availability, data adequacy, data gap analysis and data generation

The preliminary works consisted of collection and review of all existing hydrogeological and exploration data of CGWB. All data were plotted in base map on Arc GIS Platform. The available data, data gap and data generation work are tabulated in Table: 1.2 and shown in Figure 1.2 and 1.3.

Table 1.2 – Exploration and monitoring database, Sundargarh district, Odisha.

Sr No.	Theme	Type	Data available	Data generation	Total	Data gap	Remark
1	Borehole Lithology Data		153	8	161	25	
2	Geophysical Data	VES	0	92	92	8	
3	Groundwater Level Data	Dug Well	70	103	173	26	
4	Groundwater Quality Data	Dug Well	45	103	148	26	
5	Specific Yield		Nil	Nil	Nil	Nil	
6	Soil Infiltration Test		0	3	3		

Figure 1.2 – GWMS Data Gap Map, Sundargarh District, Odisha.

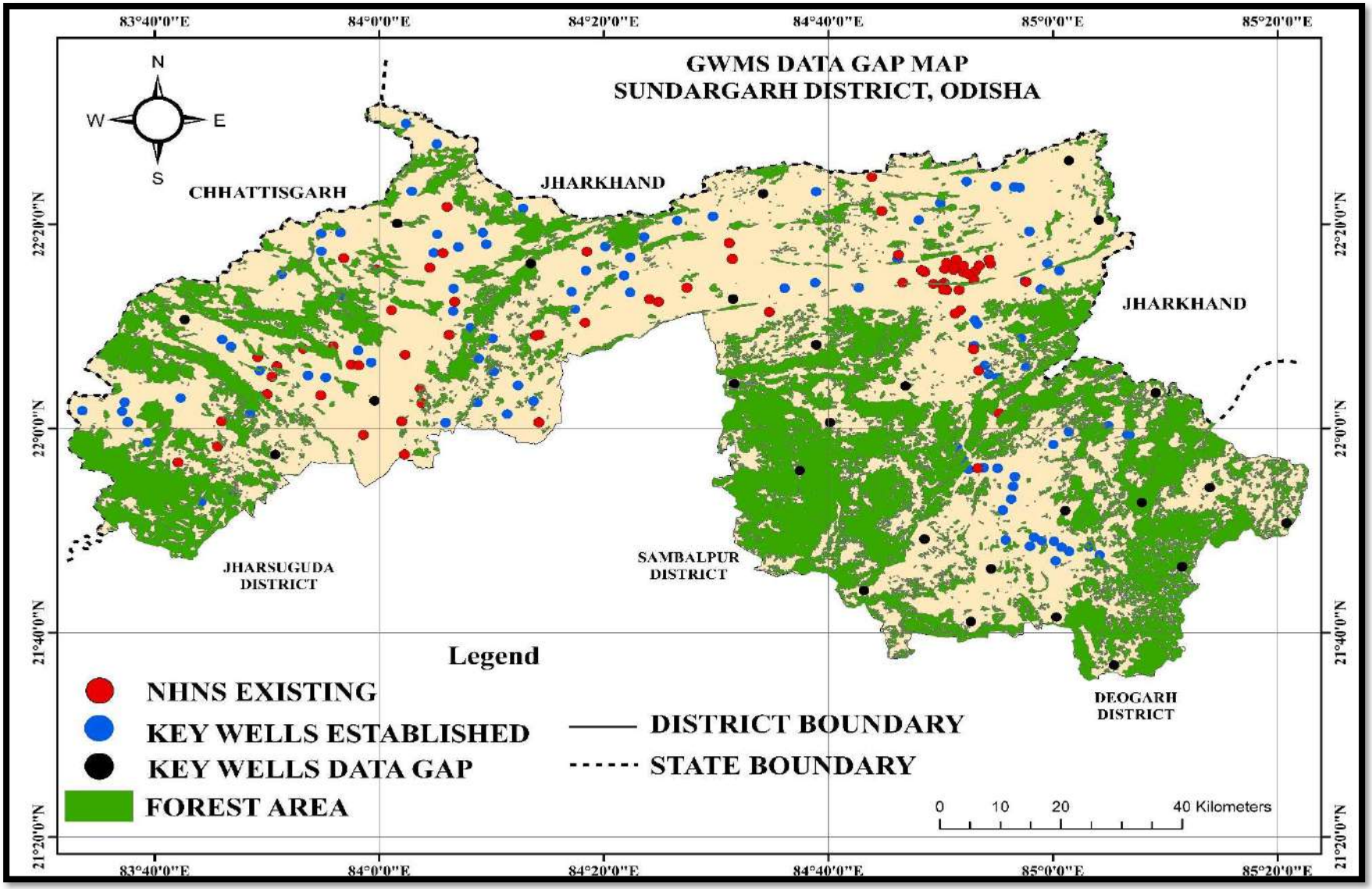
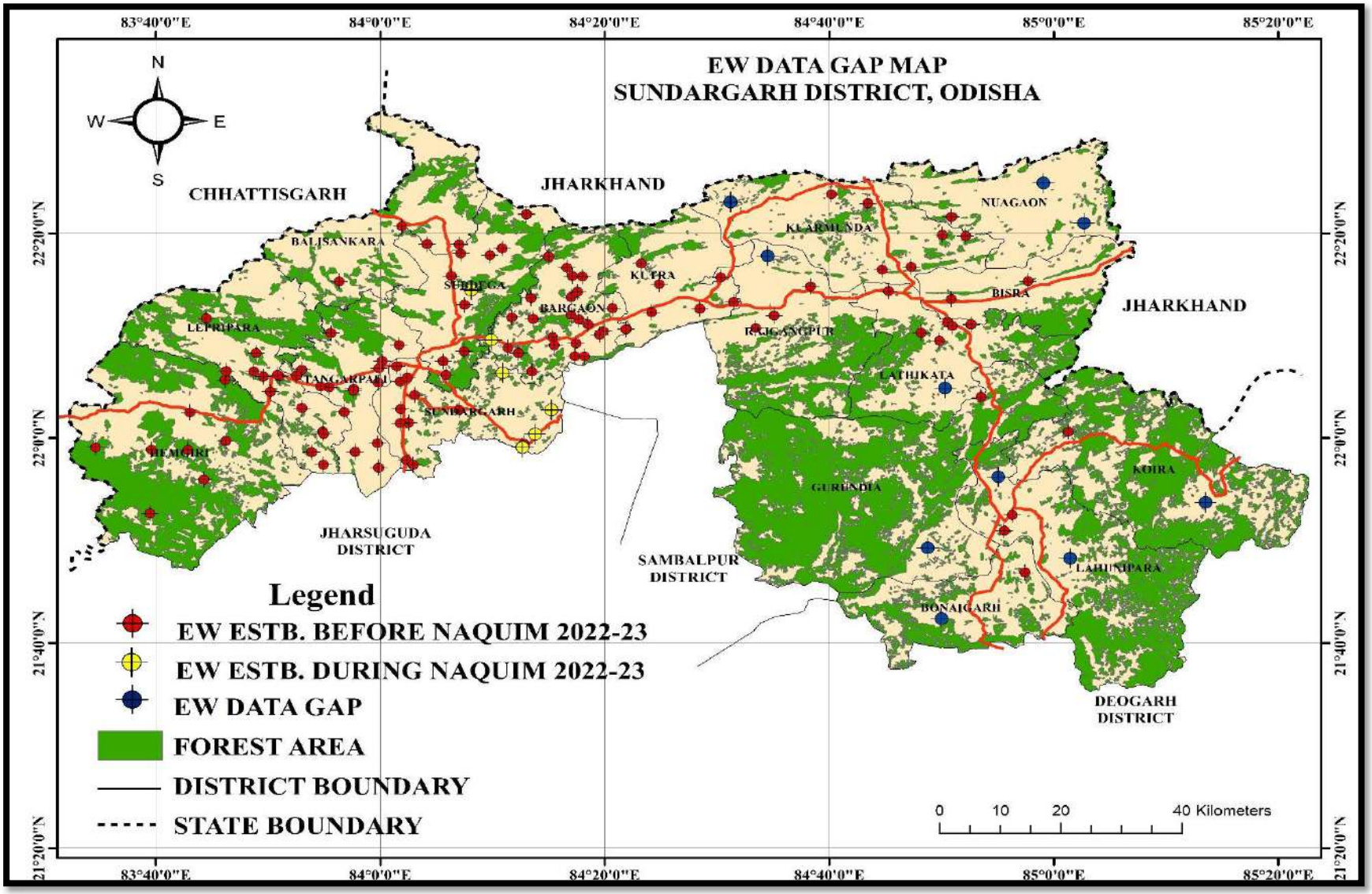


Figure 1.3 – CGWB EW Data Gap, Sundargarh District, Odisha



Hydrometeorology

Rainfall

The area enjoys tropical to sub-tropical climate and is therefore subjected to high temperature and rainfall. The summer season extends from March to middle of June followed by rainy season from mid-June to mid-October. The average annual rainfall is 22953 mm and normal annual rainfall is about 21753 mm of which more than 80 % is precipitated from southwest monsoon between June-September. The winter season extends from November till the end of February. The block - wise annual rainfall from 2012 to 2021 is given in Table-2.1.

Table 1.3 – Year wise, block wise Rainfall data from 2012 to 2021

Sr.No.	BLOCK	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	NORMAL
1	Hemgir	1622	1511	1230	1424	1176	1317	1295	1769	1907	1210	1346
2	Lephripara	1392	1399	1244	1337	954	1150	892	1395	1548	959	1267
3	Tangarpali	1402	1488	1272	1572	838	1282	837	1479	1555	1138	1139
4	Sundargarh	1467	1271	1150	1569	899	1485	1095	1524	1650	1255	1334
5	Subdega	1672	1210	1341	1261	1254	1403	1153	1328	1196	1007	1062
6	Balisankara	1645	1378	998	1020	1267	925	955	1481	1372	1081	1243
7	Bargaon	1566	1400	1571	1640	1032	1157	1300	1464	1217	1266	1109
8	Kutra	1350	1314	1537	1090	981	1170	1367	1175	1329	1125	1182
9	Rajgangpur	1152	1683	1348	1097	1070	1287	1449	1098	1484	1561	1040
10	Kuarmunda	1555	1507	1345	1143	951	1443	1543	1691	1790	1552	1365
11	Nuagaon	1208	1384	1153	851	906	1342	1520	1362	1508	1308	1211
12	Bisra	1597	1393	1161	1099	1052	1410	1546	1348	1767	1478	1155
13	Lathikata	1408	1360	1640	1112	1104	1375	1631	1333	1763	1680	1478
14	Bonai	1344	1533	1389	1116	857	1095	1315	1230	1776	1594	1575
15	Lahunipara	1501	1669	1287	1428	1118	1352	1358	1291	1581	1678	1484
16	Gurundia	1516	1566	1494	1646	1299	1562	1389	1598	1833	1640	1388
17	Koira	1110	1594	1488	1137	1131	1141	1665	1317	1674	1726	1375
	Total	**24507**	**24659**	**22646**	**21543**	**17885**	**21897**	**22309**	**23883**	**26948**	**23258**	**21753**
	Average	**1442**	**1451**	**1332**	**1267**	**1052**	**1288**	**1312**	**1405**	**1585**	**1368**	**1292**

Temperature

The winter season is felt November February when mean temperature drops down to 8°C with temperature recorded so far 1.9 °C (Jan 2000 Jan 2001). winter followed by (March-Mid June) and the month of May is usually the month when the temperature in day time is about 43° C. The temperature recorded so far is 46° C (May 2001).

The temperature of the study area starts rising from March to May which is the hottest month of the year with mean daily maximum temperature 42° C. With the advent of monsoon temperature starts reducing and the winter season starts from November. December end and early January is the coldest month of the year with mean daily maximum temperature of about 220 C, the minimum temperature sometimes comes down to 2-3°C at night.

Humidity and Wind velocity

Humidity of the air is generally high during southwest monsoon period and low during winter months. The relative humidity varies from 90 to 95% in August to around 16 to 20% in the month of May. The mean potential evapotranspiration value ranges from 4mm in December to 470mm in May.

Wind is essentially moderate. Wind velocity increases during summer and southwest monsoon months. The mean annual wind speed is 4 km/hr.

Geomorphology

Physiography

In the western part of the district, the area is characterized by a long stretch of table land with isolated hills. Average height of the table land is 300 m above mean sea level. Hilly area in the north western parts (covering parts of Hemgiri, Lefripada and Balisankara blocks) is having hill peaks of 500 to 573 m amsl and the regional slope of the study area is towards south. The north-western parts, southern parts of Subdega block and central parts of Hemgiri blocks are having hill peaks of 487, 406 & 598 m amsl.

In the north eastern part of the district, the study area is characterized by a hilly rugged topography, which is dissected by a number of streams. The study area can be broadly divided into three distinct physiographic units, namely a) table land dotted with isolated hills of considerable relief, b) undulating plains with residual hills and c) east west trending valley of the easterly flowing Sankh river and westerly flowing Koel river. The areas with high relief and hills are situated in the central and southern part of the district. The important peaks include Mankar Nacha (1109 m), Chatikota (1017 m) and Bicha (903 m). The undulating plain occupy the northern, north eastern and south eastern part of the study area. with elevation of 300 m to 450 m above sea level. The general slope of the country is towards south while the hills and ridges trend in NE-SW or ENE WSW direction.

In the south eastern part of the district, the study area is divided in to three units. They are highly elevated hilly terrain in the eastern part (the hills like Mankamacha (1117m), Kumritar (1065m) & Chihatoka (1015m), Medium elevated hilly terrain in the western part (the hills like Baghbindha (808m), Kantamunda (769m) & Dantapahar (607m) and Undulating terrain in the central part. The hills and ridges roughly trend towards NE-SE direction and the general slope of the country is towards south. The Brahmani River flows in the central part of the area, which is connected by number of Nallas like Rukura, Korapani, Amrudi, Katangrhdrha

and Kurhadi, flowing from both the sides of elevated catchment's area. River alluviums of late Pleistocene to Recent sediments occur in the flood plain.

Geomorphologic features

Flood Plain: The hydromorphic unit has been mapped along the course of the river Ib and its main tributary such as Basundhara, Ichha and Sapai. In this unit, point bar, natural levee, back swamps form the important hydromorphogeologic units. Ground water prospect is very good in point bar and meanders, whereas in backswamp it is very poor. This geomorphic unit occurs as small discontinuous patches along river Ib (particularly in southern portion of the study area covering parts of Sundargarh and Tangarpalli blocks)).

Valley fills: These hydromorphic units are confined to linear depressions which mostly contains fractured rock fragments and acts as very good area for storage and movement of ground water. Dug wells located in these areas yield fairly a good amount of water.

Alluvial Plain: It occurs along a narrow stretch with limited thickness in the southern part of the study area adjoining the river Ib covering southern parts of Sundargarh and Tangarpalli blocks. Fine to coarse sand form potential aquifer zones and yield a good quantity of water. Ground water in these areas may be developed through dug wells and shallow filter point tube wells.

Palaeo-channel: Palaeo channel of Ib river is found out from Satellite imagery in the southwestern parts of the imagery covering Toposheet No. 73 B/4 (covering the areas of Sundargarh, Tangarpalli and Subdega blocks). This is the potential area from ground water point of view.

Piedmont Plain : This unit can be further subdivided into upper and lower piedmont plain. The piedmont plain is developed in the foot hill region and occurs in north western parts (covering parts of Hemgiri, Lephripada and Balisankara blocks) and southern parts of Subdega block and central parts of Hemgiri blocks. The lower piedmont plain consist of sand, silt and clay and has attained peneplanation by loosing gradient due to natural weathering and erosion process and human activity for cultivation. Ground water potential is moderately good in this unit and the ground water can be developed through open/dug wells.

Lateritic upland: This unit has developed over Gondwana group of rocks in the southern parts of Hemgiri block. Groundwater potential is moderately good.

Buried Pediment: This is a most extensire, common unit in the area, thickness of weathered zones varies from 10-15 m. and forms potential phreatic aquifer. Groundwater development can be through dug wells and dug-cum-bore wells.

Pediment: This geomorphic unit is found bordering the hilly terrain. Groundwater condition is moderate to poor.

Inselbergs: This land form occurs as isolated hillocks. These are developed due to active weathering and denudation in a humid tropical climatic condition. This unit does not have any significance on occurrence and movement of ground water.

Residual Hills: This unit mainly consists of residual masses of granites. This unit behaves as a run off zone.

Denudational Hills: Denudational hills are identified by their high relief. Granite hills represent this geomorphic land form in the area. Rate of infiltration is very poor except along fractures/joints. These generally act as run-off zone.

Structural Hills: These are structurally controlled hills with complex folding, faulting and traversed by numerous joints/fractures facilitating infiltration and mostly act as run-off zone.

Lineaments: Major lineaments are picked up from satellite data interpretation. Most of them are trending in NW-SE, NE-SW directions.

The slope map of the district is shown in Figure 1.5 and surface elevation map is shown in Figure 1.6.

Geology

Major parts of the district are underlain by Pre-Cambrian metasedimentaries (Gangpur series) and intrusives. Lower Gondwana group of rocks occupy southwestern parts of the study area (Hemgiri area). Laterites, both ferruginous and manganiferous, cap this formation on discontinuous patches in the central part of the study area. The recent alluvium occurs in limited patches along the river courses. In the south eastern part of the study area of Bonai sub-division, consist of mainly Precambrian rocks such as Granite and Mica schist, patches of Epidiorite, Amphibolites etc (belonging to the age of Upper Carboniferous to Permian) and the recent Alluvium occuring in limited patches along river courses.

Gangpur Series:
Gangpur series of rocks occupy Panposh sub-division and part of Sundergarh sub-division. The majority of the hills and ridges of the area are formed by carbonaceous phyllite. Mica schist, dolomite and limestone occupy the plains.in the western parts of the district, occasional veins of quartzite and pegmatite traverse the mica schists and phyllites. The assemblage is characterized by a repetitive sequence of rudaceous, arenaceous, carbonaceous, calcareous

and argillaceous sediments having basic volcanics as sills. They have undergone tectonic deformation in several phases with a typical E-W to ENE-WSW tectonic trend and are metamorphosed to staurolite grade. The contact between Gangpur series of rocks and Iron ore series is marked by a zone of sheared conglomerate and quartzite. Occasional veins of quartz and pegmatite traverse the mica schists and phyllites of the area.

The generalized stratigraphic sequence of the district is given in the following table and geological map of the study area is presented in Fig.

Table 1.4 Stratigraphic Sequence in the study area (Western parts of Sundargarh district, Orissa)

Stratigraphic Sequence in the study area (western parts of Sundargarh district, Orissa)

Age	Group/Formation	Lithology
Recent to Sub – recent	Alluvium	Sand, Silt, clay and gravels in varying proportions
	Laterites	Laterite and Lateritic gravels
	~~ Unconformity ~~~~~~~~~~~~~~~~	
Upper carboniferous to permian	Lower Gondwana group	Kamthi (Himgiri)(sandstone, red shales etc.) Barren measure(Carbonaceous shale, iron stone and sandstone Barakars (Sandstone, shale, coal seams) Talcher (Fine grained sandstone, shale)
	~~ Unconformity ~~~~~~~~~~~~~~~~	
Pre-Cambrian	Intrusives	Granite (Bonai), Pegmatite, Quartz veins etc., Basic igneous rocks i.e., amphibolites, epidiorite etc.
	Gangpur series	Limestone & Dolomite (Biramitrapur stage) Carbonaceous slates and phyllite (Kuarmunda stage). Phyllite and garnetiferous mica schist and manganese bearing rocks(Ghoriajore stage)

Iron Ore series:

The Iron ore series of metasediments comprises different litho units like Mica schist, phyllites, shale, quartzite's, Banded Hramatite Jasper (BHJ), lava and tuffs. These rocks are intruded by granites (Bonai granite) and ultra-basics. The occurrence of Iron ore series of rocks are confined to Bonai sub-division.

Granites and Granite gneiss:

The northern and north eastern part of the study area is occupied by granites and granite gneiss. The granite gneiss of the study area can be broadly classified into three major types, viz. 1. Biotite granite gneiss, 2. Garnetiferous granite gneiss and 3. Porphyroblastic granite gneiss. Biotite granite gneiss is pale to dark green in colour, fine to coarse grained, banded, consisting mainly of quartz and feldspar as essential minerals and biotite as accessory

mineral. The general trend of foliation is NE-SW. Three sets of joints with opening ranging from 5 to 25 mm and spacing ranging from 25 cm to 1 m are encountered in these rocks

Table 1.5 Stratigraphic Sequence in the study area (North eastern parts of Sundargarh district, Orissa)

Recent to Sub-recent (Quarternary)	Alluvium	Sand, silt, clay and gravels in varying proportions
	Laterites	Laterite and lateritic gravel
---------- Unconformity ----------		
Pre Cambrian	Intrusive Rocks	Granite (Bonai), Pegmatite, Quartz veins etc. Basic igneous rocks i.e. amphibolite, Epidiorite etc.
	Iron ore series	Mica schist & phyllite with Quartzites and carbon phyllite Sheared conglomerate (Raghnathpalli satge). Mica schist and phyllite with a zone of carbonaceous rocks.
	Gangpur series	Lime stone & dolomite (Biramitrapur stage), carbonaceous slates and phyllite (Kuarmunda stage). Phyllite and granetiferous mica schist and manganese bearing rocks (Goriajore stage).

The garnetiferous granite gneiss is pinkish in colour, well banded consisting mainly of quartz and feldspar as essential mineral and garnet as accessory mineral. The general trend is ENEWSW. Two to three sets of joints are encountered in these rocks. Porphyroblastic granite gneiss are encountered in different patches in the study area. Three sets of vertical joints trending NNE-SSW, WNW-ESE and NE-SW are found in these types of rocks.

Table 1.6 Stratigraphic Sequence in the study area (South eastern parts of Sundargarh district, Orissa)

Table No. 3.1

Stratigrapic Sequence in the study area (Bonai Sub-division):

Recent to sub recent	Alluvium	Sand, Silt, Clay and gravels
	Laterite	Laterite and lateritic gravels
Unconformity		
Precambrian	Intrusive Rocks	Granite (Bonai), Pegmatite, Quartz Basic igneous rocks i.e.
	Iron ore series	Mica schist & phyllite with quartzite's Carbon phyllite, sheared Mica schist and phyllite with a Carbonaceous rocks.
	Gangpur series	Limestone & Dolomite carbonaceous and phyllite. Garnetiferous mica & Manganese bearing rocks.

Lower Gondwana Group

Southwestern parts (Hemgiri area) comprise coal bearing sandstone, shale, carbonaceous shales of Lower Gondwana Group in the study area. The Kamthi occupy the rugged hills and plateau. The Kamthis consists of conglomarate, sandstones and shales and are devoid of carbonaceous shales, and coal seams. The Talchers consists of shales, siltstones and fine grained sandstones.

Laterite

Both ferruginous and manganeferous laterites are developed as discontinuous patches in the study arca.

Alluvium

Alluvium occurs as thin discontinuous pockets adjoining the courses of major streams and southern tips of the study area adjoining Ib river (parts of Sundargarh and Tangarpalli blocks). The alluvial sediments are clays, sands, silts and gravels.

Structure

The rocks of the Gangpur series have been folded into an anticlinorium plunging to the east with the axis of the fold tending East-West to East North East-West South West directions. The general strike of the rocks in the study area is NE-SW. The area is traversed by a number of major lineaments which are traces of major fractures trending NE-SW and NW-SE. The structure of the Gangpur anticlinorium is very well brought out by the outcrops of limestone and dolomite with associated lower and upper horizons of carbon phyllites. The general strike of the rocks in the area varies from east-west in the central part and estern part. The dip of the rocks is very steep (60-90°) both towards north in the northern part and towards south in the southern part. Rocks are fractured and jointed and the trending in NE-SW, E-W and NW-SE directions with steep dips. The area is traversed by number of major lineaments, which are traces of major fractures trending in NW-SE and NE-SW directions. The fracturing of the country rocks is intense in central and eastern parts in Rajgangpur, Bisra and Lathikata blocks.

The Geology map of the district is shown in Figure 1.7.

Figure 1.4 – Geomorphological Map, Sundargarh District, Odisha.

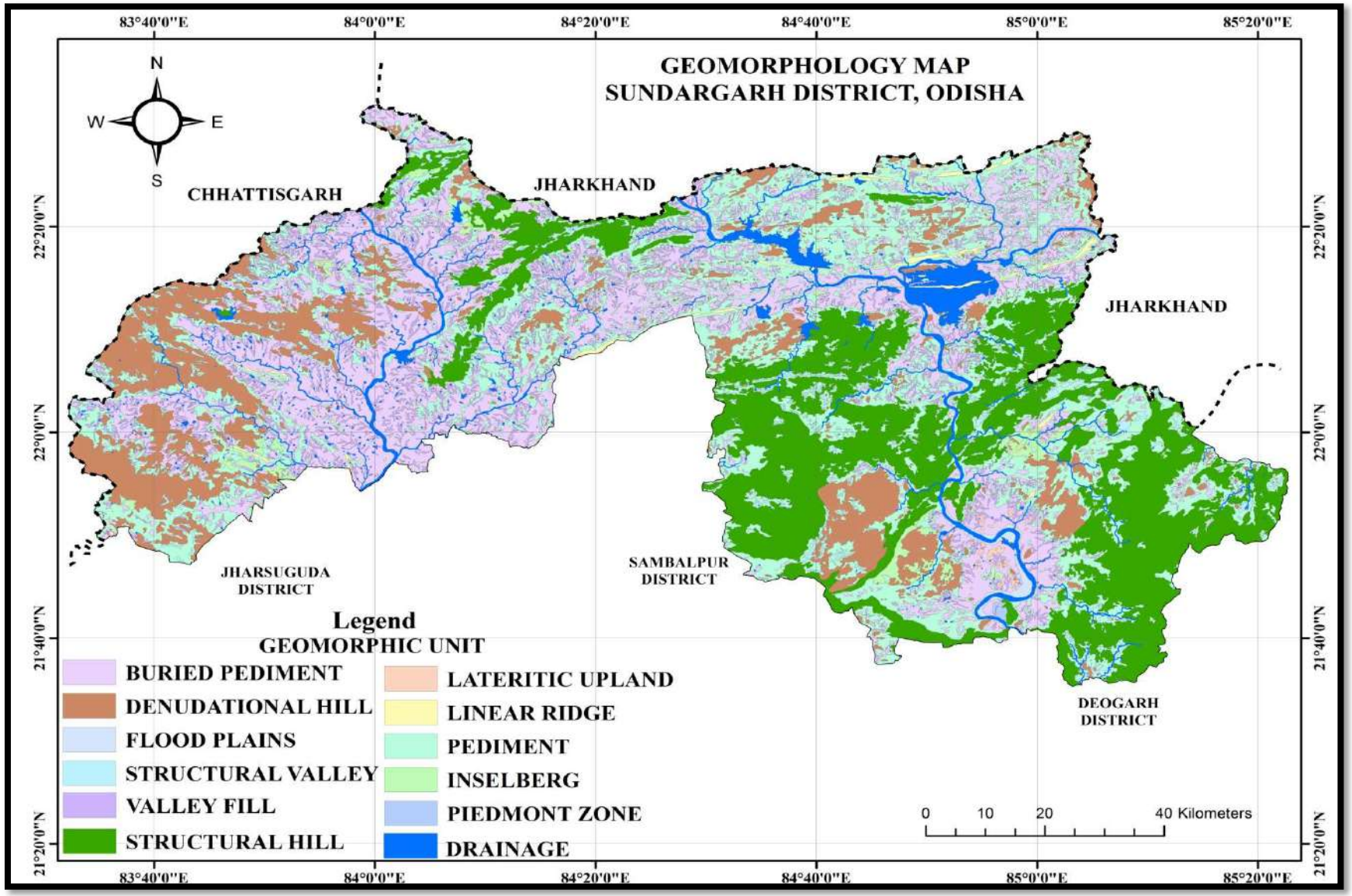


Figure 1.5 – Slope Map, Sundargarh District, Odisha.

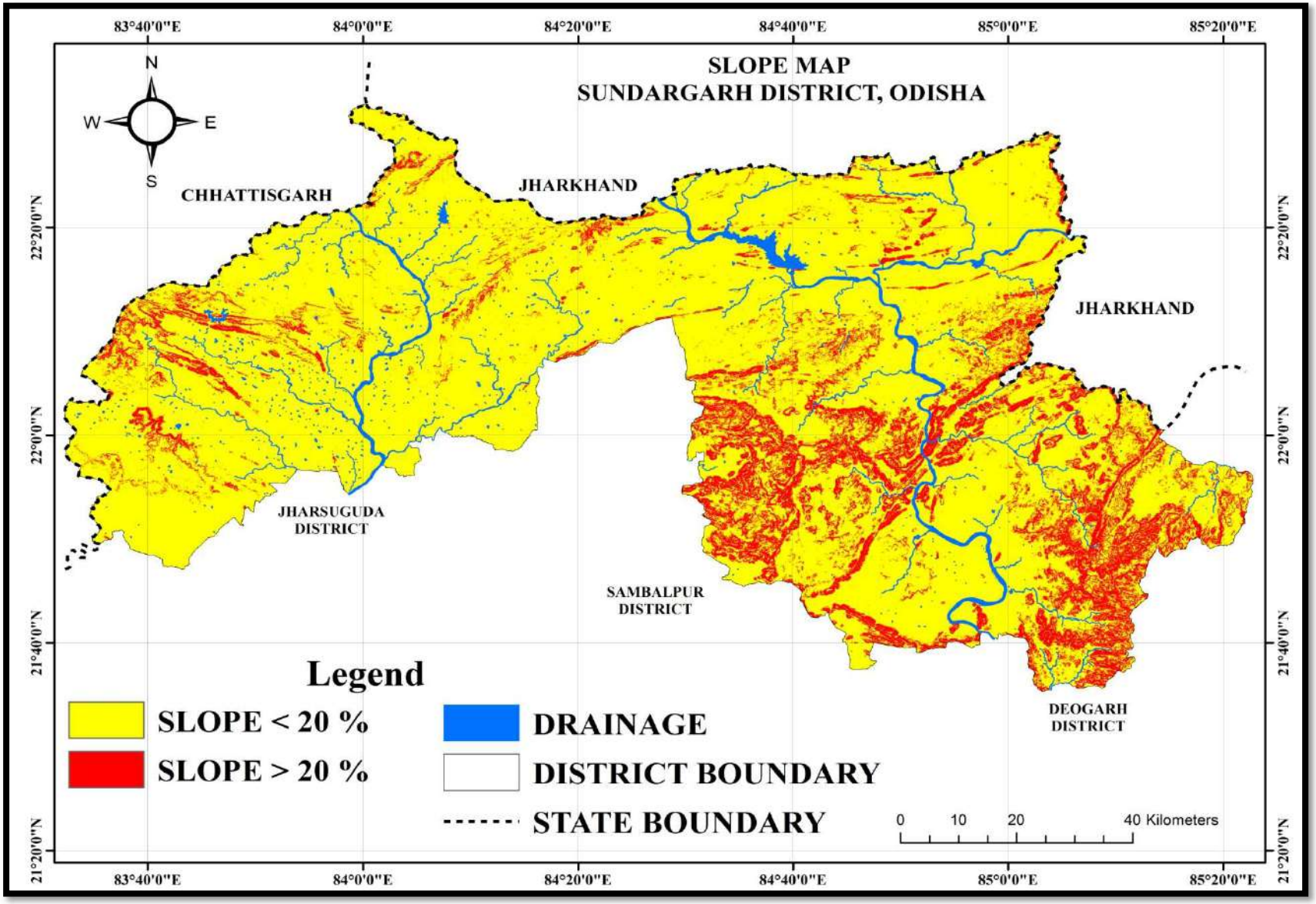


Figure 1.6 – Surface Elevation Map, Sundargarh District, Odisha.

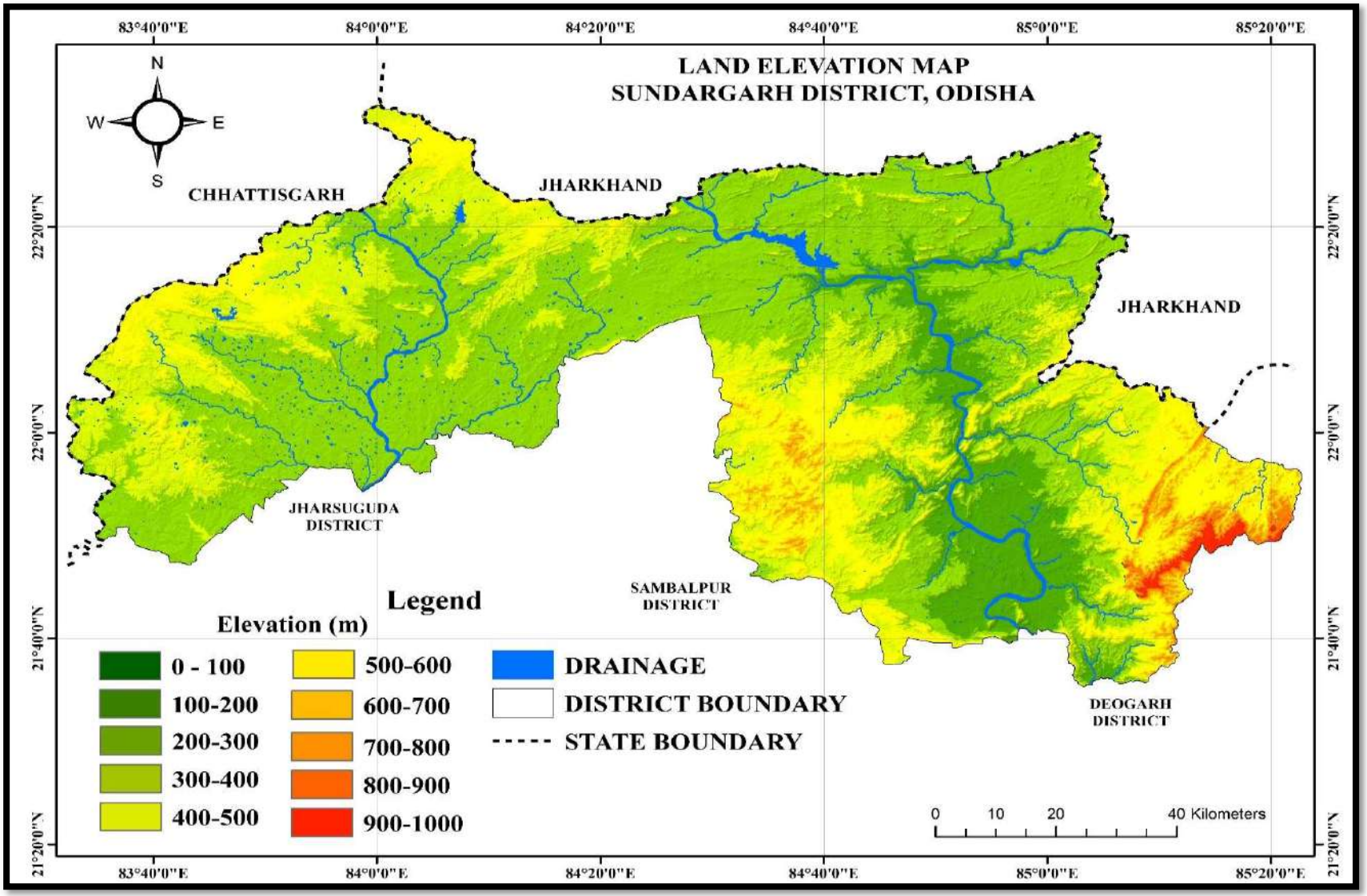
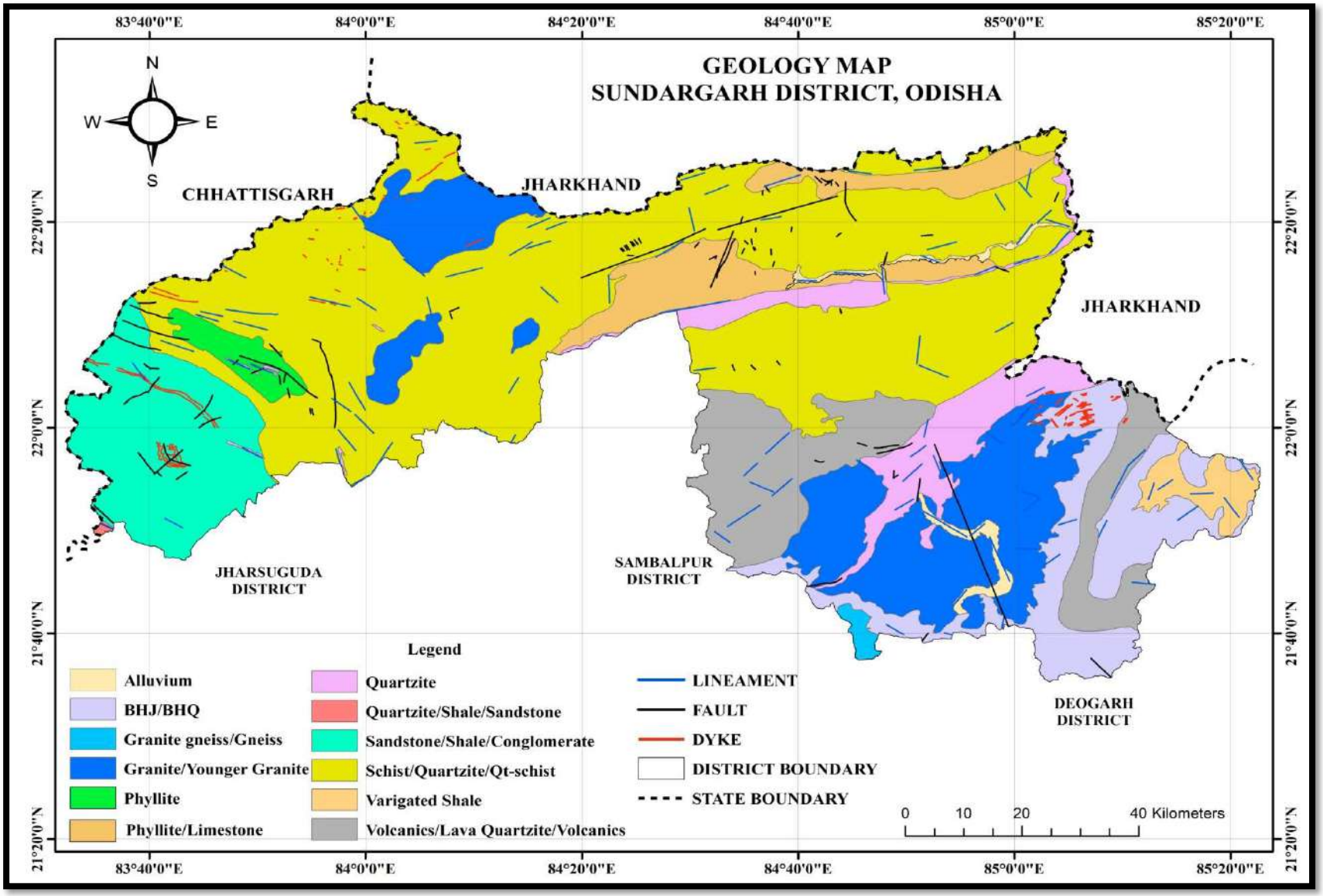


Figure 1.7 – Geology Map, Sundargarh District, Odisha.



River and Drainage

River Ib and its tributaries form the major drainage system in the western part of the study area. The general slope of the terrain is towards south. The river Ib that originates from the Chhattisgarh high lands flows along the central parts of the study area towards south direction. The topographic slope mainly controls the flow of this river. Basundhara, Ichha and Safei are important tributaries of river Ib. The drainage pattern is mainly dendritic. The drainage map of the area is given in Fig.-1.8.

In the north eastern part of the study area, a network of rivers and streams drains the study area, Brahmani being the most important. The easterly flowing Sankh and westerly flowing Koel rivers join at Vedavyas near Rourkela to form the Brahmani River. The Brahmani River along with its numerous tributaries and streams control the drainage of the eastern part of the district. The overall drainage pattern is dendritic in nature but at some places rectangular and controlled by the Joints, Fractures and lineaments. The drainage density is moderately high in eastern part of the area representing high hill ranges constituted by Iron Ore Group of rocks which suggest that high run off and low infiltration. Hydro geological surveys and remote sensing studies have revealed that the drainage pattern in the study area is controlled by the fracture system, which is developed due to the tectonic deformation in the area several phases. River alluviums of late Pleistocene to Recent sediments occur in the flood plain.

Soil

The distribution of different soil types in the area depends much on its physiographic and lithologic variations. The soil types in the study area can broadly be divided into three major groups namely 1) Alfisol; 2) Ultisol; and 3) Inceptisols.

1. Alfisols: red sandy, loamy, mixed red, black and alluvial soils are under this category in the study area. These soils are light textured and slightly alkaline to neutral in nature. Red sandy soils are found in major parts of the study area (particularly western parts) and areas having hilly terrains. The older alluvial soils are found in the extreme south-eastern parts in Sundargarh block.

2. Ultisol: The ultisols comprise mainly of Lateritic soils and red and yellow soils. These soils are mildly acidic in nature and deficient in nitrogen, phosphorous, potassium and organic matters. Lateritic soil occurs in small patches in the southern part of Hemgiri block. Red and yellow soils occur in low lying areas of the study area having good drainage network.

1. Inceptisols: Shallow black soil occurring in small patches in the northern part of Balisankara block falls under this category of soil in the study area.The soil map of the district is shown in Figure 1.9.

Figure 1.8 – Drainage Map, Sundargarh District, Odisha.

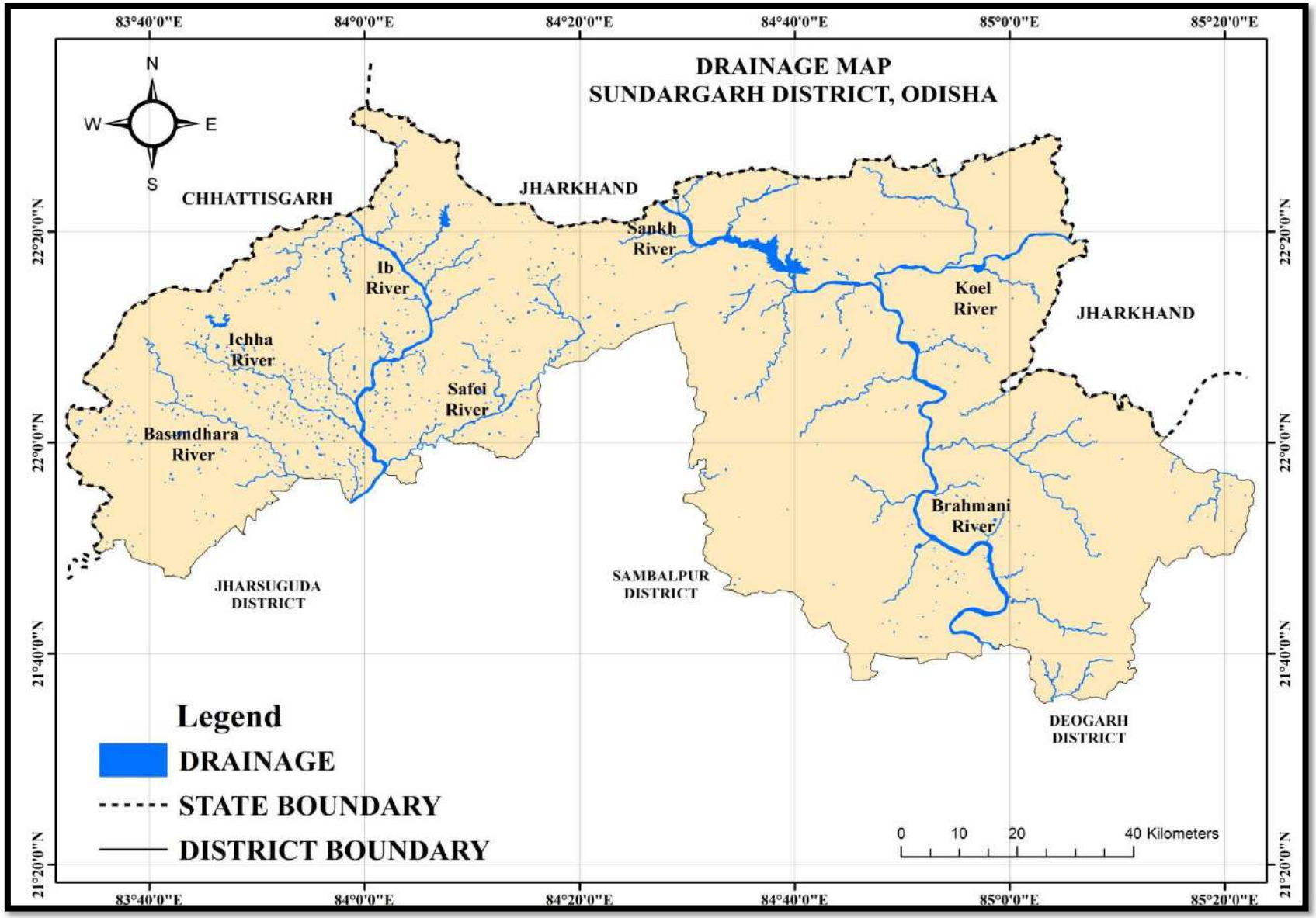
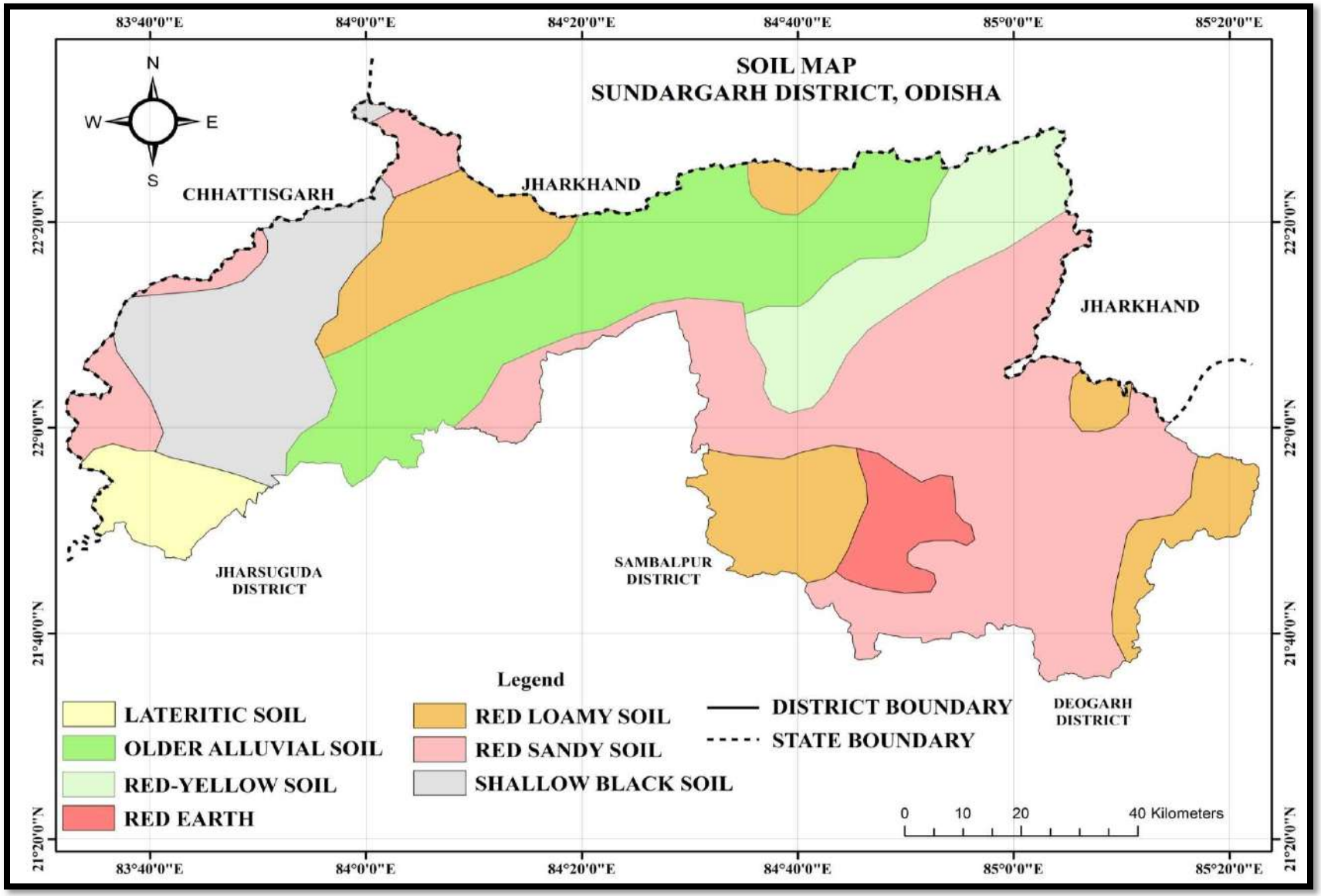


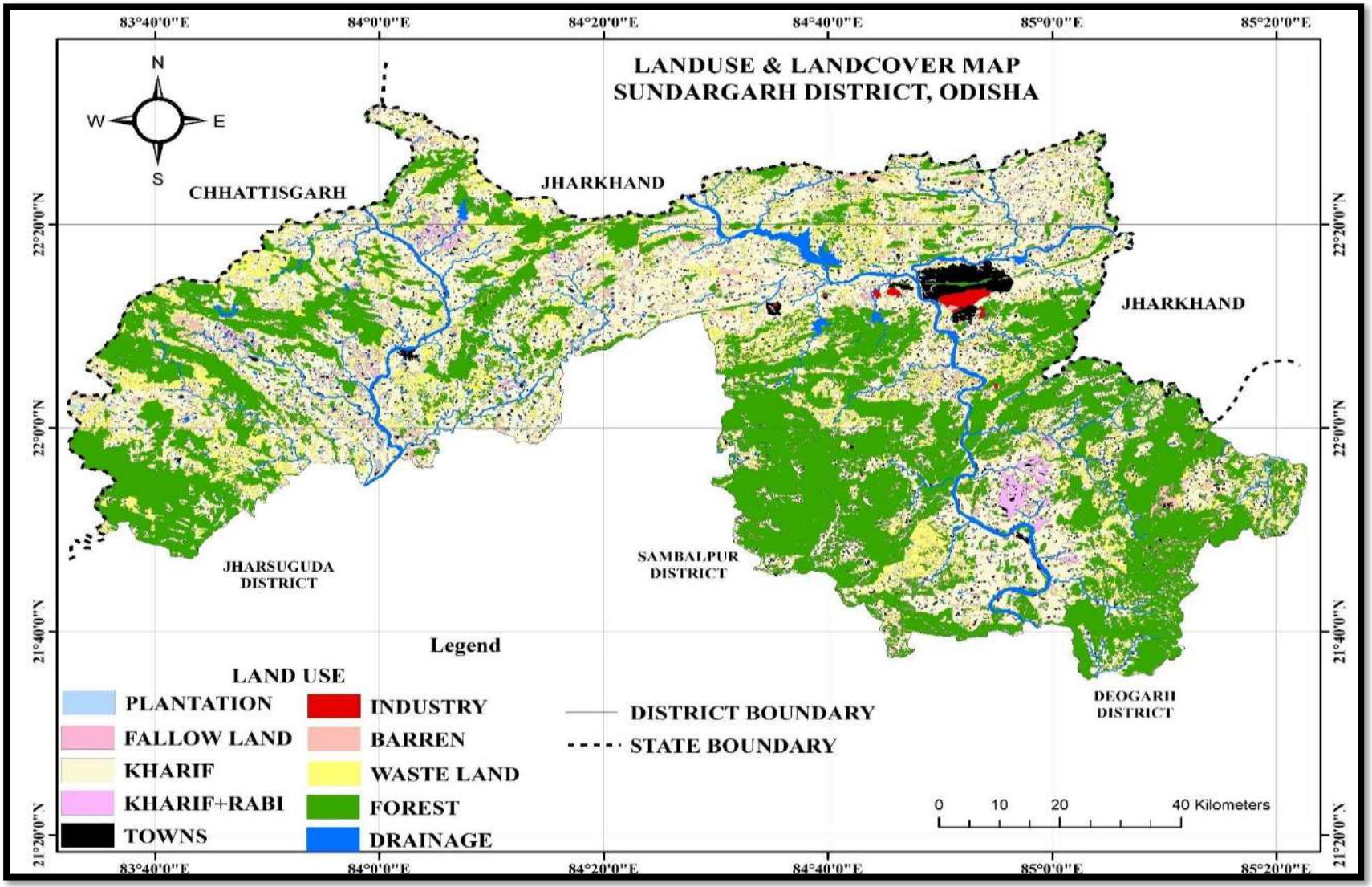
Figure 1.9 – Soil Map, Sundargarh District, Odisha.



1.7 Land use and agriculture – (Area given in Ha) (Source – Irrigation Plan, Sundargarh District, Odisha)

Sl. No.	Block	Total area	Forest Area	Land put to non agricul. use	Barren & Non cultivable land	Perm. pastures	Cultivable waste	Ols fallows	Current fallows	Net sown area	Gross cropped area (1)	Net sown Area (2)	Area sown more than once (1-2)	Cropping Intensity (%)	Area under Wasteland
1	Balisankara	53441	6030	2697	634	2558	2288	3396	5353	12642	22870	18418	4452	124	6725
2	Bargaon	39972	7720	2648	1839	2511	6894	4653	5948	11988	20383	16314	4069	125	995
3	Bisra	33327	2414	2149	102	1018	1659	1622	720	7345	14704	9364	5340	157	508
4	Bonaigarh	42228	11029	1950	1139	1280	1332	1751	3282	10947	21492	17088	4404	126	1756
5	Gurundia	125296	16789	2949	12528	2616	1864	3268	5961	11292	21124	16779	4345	126	2783
6	Hemagiri	94028	18951	2600	1752	2244	3778	6354	8840	10566	23055	19324	3731	119	1122
7	Koida	85909	16944	3518	9830	2213	4533	4921	6873	7245	18317	14269	4048	128	4865
8	Kuanarmunda	58160	9468	5802	2866	2521	4410	3569	6783	15119	28090	22519	5571	125	3955
9	Kutra	35421	2542	2937	3114	1440	1875	3055	4094	12505	23938	19433	4505	123	1947
10	Lahunipada	78811	20481	6576	11151	1627	2924	5047	6224	14616	24527	19244	5283	127	3135
11	Lathikata	47812	5299	4786	942	1477	677	2186	3557	13006	31188	24695	6493	126	956
12	Lephripada	55751	14484	2160	361	3167	3064	2809	3690	10265	20407	16174	4233	126	1639
13	Nuagaon	44862	2683	2743	810	1290	1608	4051	6529	19581	33649	27480	6169	122	1816
14	Rajgangpur	59576	4525	4816	5096	3567	1981	3634	4540	10918	24390	18865	5525	129	2071
15	Subdega	46050	6579	3169	911	1629	4620	2974	2962	11208	21064	16607	4457	127	3889
16	Sundargarh	38769	5640	4065	748	2092	1230	3015	3886	15384	23717	19176	4541	124	900
17	Tangarpalli	35656	4281	2472	263	1577	1474	1996	2440	10981	20707	17251	3456	120	919
TOTAL		975069	155859	58037	54086	34827	46211	58301	81682	205608	393622	313000	80622	2154	39981

Figure 1.10 – Land use & land cover Map, Sundargarh District, Odisha.



Hydrology

The district is underlain by hard crystalline rock of Precambrian age, such as Granite, Granite gneiss, Mica schist, Phyllite, Meta basics, limestone and dolomite. The maximum yield of the ground water found in Metabasics and granite gneiss up to 7.5 lps. The major contribution of ground water for shallow aquifer stored in weathered zone up to depth of 30.0 mbgl. For deep aquifer study, Aquifer exploration, drilling programme up to depth of 200m operated by Central Ground Water Board, South eastern region, Bhubaneswar and find out that fracture zone depth, varies from 30 to 120 m having discharge from 0.2 lps to 11 lps. The average fluctuation of the ground water level varies from 0.5 to 5.5 m during pre and post monsoon interval.

As Sundargarh is the second largest district in Odisha state by area, it associated with four rivers namely, Brahmani, sankh, koel, and IB covering almost 9712 sq. km., which is major draining system of the area in monsoon season, due to undulating terrain of the sundargarh district, ground water recharge phenomena is affected, by which ground water declining trend found in some hilly blocks area.

The mining-affected areas of Sundargarh are rural areas spread across eight blocks. These include Koida, Kutra, Gurundia, Hemgir, Kuanrmunda, Nuagaon, Rajagangapur, Lahunipara, most of them are iron manganese mines, disturbed natural slope system of watershed area by which adversely affected the ground water recharge system.

Due to high weathering index of the crystalline rock of the area, loamy soil and clay percentage increases at surface by which permeability intensity decreases at many places, mostly area which is more involved in anthropogenic activity.

According to agricultural pattern of the district it is observed and calculated that, better hydrogeological setup and management plan can improve declining water level and agricultural production.

2. Data collection

Data collection includes collection of rainfall data from state government, compilation of CGWB's earlier survey data, exploration, and geophysical data. Population and agricultural data are collected from Census of India website.

2.1 Hydrogeological data

The entire study area is covered by regular monitoring of existing 70 GWMS (NHNS) and another 103 Key wells have been established. All these wells are monitored after establishment. Table 2.1 shows the existing ground water monitoring stations (GWMS) under NHNS and Table 2.2 shows the details of the Key wells established in Sundargarh district in AAP 2022-23.

2.2 Water Quality

To understand the chemical quality of groundwater in the study area and its suitability for domestic, drinking, and agricultural utilization, pre monsoon and post monsoon water samples were collected from 148 locations across sources of dug well, tube well and hand pumps. The samples collected were for analyzed for base, iron, heavy metals and arsenic.

2.3 Geophysical survey

To understand the sub surface lithology, VES has been conducted in 92 locations across the Sundargarh district during AAP 2022-23. Table 2.3 shows the details of the locations where VES was conducted.

Table 2.1 - Details of GW monitoring stations under NHNS in Sundargarh District, Odisha

Sr No.	LOCATION	LATITUDE	LONGITUDE	WELL	WL	RL	DEPTH
1	Kinjrikela	22.27778	83.94722	DW	5.95	310.1	8.12
2	Putudihi	22.26222	84.07500	DW	5.9	247.3	7
3	Talsara	22.36167	84.10056	DW	4.73	323.7	13.5
4	Bargaon	22.17278	84.30556	DW	5	252.8	8.7
5	Deokaranpur	22.15333	84.23778	DW	6.75	272	8.04
6	Ekma	22.28861	84.30806	DW	4.25	283.4	8.94
7	Panderpali	22.15167	84.23250	DW	8.7	280	11.5
8	Shahajbahal	22.20694	84.41444	DW	5.4	272.3	6
9	Bondamunda	22.23944	84.95972	DW	2.4	221.7	7.82
10	R-01 Jalda C-Block	22.19306	84.86250	DW	3.5	214.7	6.9
11	R-02 Jalda Rangila Chhak	22.18750	84.85500	DW	2.75	199	6.7
12	R-06 Basanti Colony	22.23750	84.83833	DW	2.88	223	5.5
13	R-07 Udit Nagar-1	22.23306	84.83667	DW	0.52	206	4
14	R-09 Power House Road	22.22611	84.86083	DW	2.62	194.3	6.08

15	R-10 Raghunathpalli	22.23583	84.82250	DW	2.6	223	5.2
16	R-11 Hanuman Batika	22.22583	84.84222	DW	1	202	10.54
17	R-13 Chhend	22.25556	84.80944	DW	3.1	201.7	8.23
18	R-14 Banposh (Urban)	22.25833	84.80500	DW	8.62	195	15
19	R-17 Jhumpudibasti	22.24333	84.88250	DW	1.35	216	6.1
20	R-18 Koel Nagar	22.26611	84.89056	DW	2	192.8	3.98
21	R-19 Jagada	22.26889	84.90722	DW	6.74	193.4	13.9
22	R-20 Jhirpani	22.27583	84.90528	DW	12.23	185	14.35
23	R-23 Sector-3	22.25722	84.88500	DW	5.02	215	6
24	R-24 Sector-5	22.25528	84.86667	DW	2.9	203.7	5.5
25	R-25 Ambagaon	22.25278	84.87306	DW	3.03	205.9	5.95
26	R-27 Sector-7	22.25917	84.85222	DW	2.25	205.7	4.97
27	R-30 Sector-13	22.26028	84.83944	DW	3.42	205.1	6.4
28	R-31 Sector-14	22.27000	84.84194	DW	7.1	194.7	9.05
29	R-32 Sector-20	22.26556	84.89083	DW	5	194	6.28
30	R-33 Sector 18	22.26583	84.86722	DW	5.83	200.3	7.18
31	R-34 Sector-17	22.27556	84.85639	DW	2.32	185.1	3.8
32	R-36 Sector-15	22.26250	84.85333	DW	2.6	196	11.9
33	R-38 Kalunga	22.23778	84.77694	DW	6.57	207.3	4.6
34	Uditnagar(rkl)	22.22639	84.83778	DW	0.52	203.4	11.82
35	Balichuan	22.05556	83.83333	DW	2.32	268	6.6
36	Durubaga	21.97056	83.75972	DW	4.5	276.8	8.25
37	Garjan Bahal	22.01167	83.76611	DW	2.65	272	7.8
38	Himgiri	21.94444	83.70139	DW	5.75	346.8	17.9
39	Kuarmunda	22.28333	84.77083	DW	8.2	211	11.07
40	Kumajharia	22.35500	84.74583	DW	3.3	238	8.7
41	Birangatoli	22.21083	84.40111	DW	7.8	277.3	10.6
42	Kutra	22.22972	84.45667	DW	5.07	256.7	9
43	Laxmipos	22.30278	84.51944	DW	2.58	219.8	6.7
44	Darjin	21.93500	84.88833	DW	6.7	167	18
45	Banki	22.09444	84.88972	DW	9.15	185.2	14
46	Chandiposh	22.02500	84.91944	DW	7.06	217.7	8.5
47	Lathikata	22.12944	84.88222	DW	3.68	194.7	7.65
48	Lefripada	22.11611	83.81944	DW	10.66	261.1	13
49	Lokedega	22.08444	83.84056	DW	6.7	262.9	8.6
50	Sargipali	22.05389	83.91306	DW	3.6	235	8.7
51	Surguda	22.10139	83.84778	DW	11.25	261.8	13.3

52	Birmitrapur	22.41028	84.73111	DW	2.52	287.4	5.68
53	Bihabandh Chawk	22.27667	84.52417	DW	9.4	249	12.7
54	Rajgangpur	22.19028	84.57917	DW	7.64	237.3	11
55	Alikera	22.19306	84.01806	DW	9.29	250.1	11.38
56	Panchomahala 1	22.20694	84.11194	DW	4.35	250.6	9.5
57	Sabdega	22.28611	84.09444	DW	3.44	278.3	8.5
58	Sundargarh	22.12028	84.03833	DW	3.56	241.7	11.5
59	Badbahal	22.01167	84.03333	DW	3.7	233	7.8
60	Bargad	22.04167	84.06306	DW	5.85	243	8.1
61	Bhasma	21.95750	84.03750	DW	5.4	225	7.2
62	Jagimal	21.98944	83.97639	DW	6	235.4	8.25
63	Karamdihi	22.15278	84.10389	DW	6.54	254.2	10.74
64	Medinipur	22.06472	84.06083	DW	9.1	261.3	12.7
65	Moshani Kani	22.25944	83.99556	DW	5.8	362.2	6.5
66	Rabandihi	22.01000	84.23694	DW	8.3	263.7	10.1
67	Balijori	22.13000	83.88694	DW	4.3	286	5.4
68	Katra (Limidihi Para)	22.13417	83.93139	DW	9	269.3	10
69	Mahulapali 1	22.10278	83.96944	DW	5.7	244.4	7.35
70	Rangiamunda	22.10417	83.95833	DW	6.09	249	9.5

Table 2.2 - Details of Key Wells established in Sundargarh District, Odisha

Sl No	Village	Well	Latitude	Longitude	RL	MP	Depth mbmp	Aquifer
1	Kinjrikela	DW	22.1948	84.2904	267.5	0.6	7.1	Dolomite,Limestone
2	Sahajbahal	DW	22.2232	84.2855	272.1	0.5	11.1	Dolomite,Limestone
3	Pamra	DW	22.2578	84.3066	280.1	0.7	9.3	Dolomite,Limestone
4	Timna	DW	22.2971	84.3356	309.8	GL	5.6	Dolomite,Limestone
5	Bhojpur	DW	22.1470	84.1682	263.3	0.8	8.2	Dolomite,Limestone
6	Khamarimunda	DW	22.2166	83.9432	373.7	0.6	9.1	Granite Gneiss
7	Deobhuvanpur	DW	22.2893	83.9139	325.5	0.6	7.8	Granite Gneiss
8	Tildega	DW	22.3198	83.9424	305.2	0.4	10.2	Granite Gneiss
9	Rasti	DW	22.3178	83.9136	326.1	0.4	9.2	Granite Gneiss
10	Bagiaberni	DW	22.3872	84.0482	309.4	GL	5.9	Granite Gneiss
11	Sagbahal	DW	22.4643	84.0855	448.9	0.5	7.1	Granite Gneiss
12	Bandega	DW	22.4976	84.0396	405.7	GL	8.9	Granite Gneiss
13	Tumlia	DW	22.3169	84.0862	276.3	GL	9.8	Granite Gneiss

14	Jodabandh	DW	22.2578	85.0094	224.2	0.5	7.5	Gondwana sand stone/shale
15	Bhalulata	DW	22.2274	84.9821	247.1	0.3	4.1	Gondwana sand stone/shale
16	Sarubahal	DW	22.2697	84.9919	221.6	GL	5.3	Gondwana sand stone/shale
17	Dimrikada	DW	21.8178	84.9297	159.1	0.3	5.1	Granite
18	Khandadhar	Spring	21.7647	86.1069	644			Dolomite,Limestone
19	Talabahari	DW	21.7931	85.0692	208.7	.55	4.7	Dolomite,Limestone
20	Rangmati	DW	21.8069	85.0539	210.7	0.6	2.2	Dolomite,Limestone
21	PWD IB Bonoigarh	DW	21.8078	84.9658	155.7	0.4	11.6	Granite Gneiss
22	Gopalpur	DW	22.1025	84.8989	187	0.4	6.1	Granite Gneiss
23	Kucheta	DW	22.0883	84.9047	195.7	0.5	10.5	Granite/Mica-scist
24	Sargigad	DW	22.0833	84.9181	266.7	0.5	2.6	Granite/Mica-scist
25	Kendughati	DW	22.1003	84.9606	294.8	0.6	2.2	Granite/Mica-scist
26	Duduka	DW	22.0243	83.8080	252.4	0.8	8.2	Gondwana sand stone/shale
27	Gopalpur	DW	22.0497	83.7051	291.2	0.6	9.1	Gondwana sand stone/shale
28	Bilaimunda	DW	22.0429	83.6221	304.5	0.5	9.4	Gondwana sand stone/shale
29	Nuadihi	DW	22.0279	83.6182	300.1	0.9	13.1	Gondwana sand stone/shale
30	Taparia (Khamar para)	DW	22.0290	83.5592	306.2	GL	7.9	Gondwana sand stone/shale
31	Kuanrkela	DW	22.0107	83.6264	298	0.6	9.1	Gondwana sand stone/shale
32	Badibahal	DW	21.9773	83.6564	307.9	0.6	7.6	Gondwana sand stone/shale
33	Kanika	DW	21.8799	83.7355	273.1	0.3	8.6	Gondwana sand stone/shale
34	Bheluantikra	DW	21.8896	83.7823	268.7	0.8	14.25	Gondwana sand stone/shale
35	Bakartola	DW	21.9947	85.0236	231.3	.75	5.9	Granite
36	Jamudih	Bw	21.9897	85.1136	321.8	.5	5.4	Granite
37	Jamudih	DW	21.9900	85.1103	320.3	GL	1.2	Granite
38	Raksi	DW	22.0047	85.0822	305.2	0.2	4.5	Granite
39	Fakir munda	DW	21.9736	85.0006	212.4	0.5	7.9	Granite
40	Basjore	DW	22.3678	84.8328	264.3	0.5	2.35	Granite
41	Putrikhaman	DW	22.3403	84.8008	224.3	0.25	4.7	Granite Gneiss
42	Kuarmunda	DW	22.2764	84.7694	204.8	0.65	5.9	Granite Gneiss
43	Panchra	DW	22.2795	84.3725	292.6	GL	6.3	Dolomite,Limestone

44	Nuagan	DW	22.3127	84.3931	267	0.5	8.15	Dolomite,Limestone
45	Badmal	DW	22.3393	84.4425	260.7	0.6	9.2	Dolomite,Limestone
46	Tarkera	DW	22.3462	84.4953	219	0.4	9.1	Dolomite,Limestone
47	Kusumdegi	DW	22.2495	84.3635	282.4	0.3	7.9	Dolomite,Limestone
48	Gangajal	DW	22.2219	84.3725	261.6	GL	7.6	Dolomite,Limestone
49	salaipalli	DW	21.9358	84.8969	171.3	0.82	6.1	Granite Gneiss
50	Koiradi	DW	21.9350	84.9178	165	0.1	2.2	Granite Gneiss
51	Lamsi	DW	21.9211	84.9436	188.3	.55	6.1	Granite Gneiss
52	Luhanipada	DW	21.8667	84.9256	165.7	.7	7	Granite Gneiss
53	Lathikata	DW	22.1350	84.8831	200	0.8	6.1	Granite Gneiss
54	Ramjhodi	DW	22.1478	84.9528	221.9	0.7	9.8	Granite
55	Sonaparvat	DW	22.1703	84.8878	204.8	0.3	9.1	Granite
56	Asurchhapal	DW	22.1769	84.8839	204.7	0.4	8.8	Granite
57	Ludhini	DW	21.9334	84.8747	173.4	0.2	6	Granite
58	Koelijhar	DW	21.9689	84.8581	181	0.5	5.9	Granite
59	Purnapani	DW	21.9483	84.8669	169.7	GL	1.2	Granite
60	Surguda	DW	22.1016	83.8479	261.1	0.4	13.5	Granite/Mica-scist
61	Kulabira	DW	22.0943	83.8225	280	0.5	8.4	Granite/Mica-scist
62	Kharalchhapal	DW	22.2517	83.8549	381.5	0.5	5.95	Granite/Mica-scist
63	Telendihi	DW	22.1451	83.7669	286.6	0.3	11.6	Granite/Mica-scist
64	Giringkela	DW	22.1335	83.7798	283	0.6	9.8	Granite/Mica-scist
65	Gadarua	DW	21.7994	85.0242	171.7	0.6	3	Granite Gneiss
66	Bhoagra	DW	21.8061	85.0128	165	0.2	5.6	Granite Gneiss
67	Jatrapadia	DW	21.8847	84.9378	167.1	0.4	8.9	Granite
68	Sagadiposh	DW	21.9053	84.9408	180	.55	5.5	Granite
69	Lalei Chhak	DW	21.8169	84.9833	161.7	0.5	4.6	Granite
70	Lalei Village	DW	21.8222	84.9722	151.8	GL	3.6	Dolomite,Limestone
71	Kurda	DW	21.8156	85.0017	162.7	GL	2.3	Granite Gneiss
72	Bandhberna	DW	21.7839	85.0039	167.9	GL	5.8	Granite Gneiss
73	Nuagaon	DW	22.2300	84.7117	217	0.3	5.8	Granite/Mica-scist
74	Kukdagate	DW	22.2406	84.9581	220.1	0.5	2.7	Granite/Mica-scist
75	Saraitali	DW	22.3217	84.9650	215	0.4	7.3	Gondwana sand stone/shale
76	Bishpur	DW	22.3866	84.6483	246.5	0.6	7.8	Gondwana sand stone/shale
77	Limda	DW	22.3941	84.9425	217.8	0.5	7.6	Gondwana sand stone/shale
78	Nuagaon	DW	22.3931	84.9506	225.7	0.3	8.5	Gondwana sand stone/shale

79	Jharpada	DW	22.3953	84.9153	214	0.3	8.2	Gondwana sand stone/shale
80	Purnapani	DW	22.4031	84.8717	229	0.3	9	Gondwana sand stone/shale
81	Rajgangpur	DW	22.1894	84.5789	235.1	0.4	3.7	Granite
82	Jhagarpur	DW	22.2289	84.6019	217.2	0.6	4.3	Granite
83	Laing	DW	22.2378	84.6469	199.8	0.3	8.8	Granite
84	Katingidihi	DW	22.1915	84.1098	245.5	0.4	9.6	Granite
85	Sudarshanpur	DW	22.2282	84.1103	249.1	0.75	6.1	Granite
86	Gaibira	DW	22.2962	84.1172	291.2	0.6	7.3	Granite
87	Simdega	DW	22.3194	84.1537	297.1	GL	6.2	Granite
88	Kurumker	DW	22.3007	84.1589	295.5	0.7	6.9	Granite
89	Tangargaon	DW	22.3592	84.2135	400.1	0.4	7.9	Granite
90	Rasipatra	DW	22.2866	84.0809	273.2	0.5	6.9	Granite
91	Dasrajpur	DW	22.1644	84.1357	272.5	0.5	6.8	Granite
92	Selangabud	DW	22.1142	84.1476	279.7	0.6	7.6	Granite Gneiss
93	Lahandabud	DW	22.0926	84.1698	259	0.7	7.9	Granite Gneiss
94	Birbira	DW	22.0701	84.2059	236.9	0.5	13.4	Granite Gneiss
95	Bijadihi	DW	22.0701	24.2471	542.2	GL	9.4	Granite Gneiss
96	Philingibahal	DW	22.0446	84.2291	243.5	0.5	8.6	Granite Gneiss
97	Majhapada	DW	22.0234	84.1899	238.9	0.5	8.3	Granite Gneiss
98	Gadiajore	DW	22.0424	84.1455	234.1	0.4	9.2	Granite Gneiss
99	Kinjrima	DW	22.0095	84.0985	235.2	0.3	7.8	Granite Gneiss
100	Bandhpali	DW	22.1078	83.9881	243.7	0.5	7.8	Granite
101	Ujjalpur	DW	22.0834	83.9206	252.6	0.7	10.4	Granite
102	Jhariapali	DW	22.0866	83.8941	245	0.6	7.6	Granite
103	Tasladihi	DW	22.1272	83.9686	262.8	0.3	6.8	Granite

Table 2.3 - Details of VES conducted in Sundargarh District, Odisha

Sr No.	Location	Latitude	Longitude
1	Aunla Bahal	22.03861	83.861272
2	Badgogua	21.7443	84.957704
3	Baghlata	22.06767	84.850993
4	Balisankara	22.35055	84.031514
5	Barangakachhar	22.21614	84.218568
6	Bargaon	22.16607	84.287228
7	Bargarh	22.03951	84.112886

8	Barilepta	22.38172	84.991843
9	Barmal	22.3341	84.440458
10	Bartaghutu	22.34228	84.793812
11	Belmunda	22.30313	83.875843
12	Bijadihi	22.27063	84.923327
13	Bileimunda	22.04275	83.614975
14	Bimalagarh	21.9834	85.006411
15	Biribira	22.07172	84.202212
16	Birikera	22.11973	84.801682
17	Birmitrapur	22.40415	84.741917
18	Bisra	22.24625	84.998904
19	Bonaigarh	21.81551	84.952984
20	Budakata	22.20641	84.406433
21	Chhatasargi	22.22218	84.128708
22	Darlipali	21.97217	83.916855
23	Deuli	21.98194	84.032346
24	Dharuadhihi	21.98695	84.216694
25	Dhokamunda	21.64361	85.073436
26	Dumabahal	22.15171	83.719589
27	Ekma	22.29424	84.308112
28	Fuldhudi	22.09411	83.891172
29	Fuljhar	21.70913	85.088309
30	Gadabudu	22.45224	85.027862
31	Gargadbahal	22.19636	84.352937
32	Garjan	22.19948	84.814028
33	Garjanbahal	22.00483	83.763005
34	Gurundia	21.86036	84.782245
35	Hatibari	22.45224	85.027862
36	Hemgir	21.95087	83.699108
37	Jammal	22.30139	85.111046
38	Jamudihi	21.98694	85.110157
39	Japanga	22.04365	84.013224
40	Jharangloi	22.15946	84.178106
41	Jhirdapali	21.74169	84.883788
42	Kadalimunda	22.00495	83.974357
43	Kanakjora	22.14838	83.961315
44	kansbahal	22.2192	84.672595

45	Karamdihi	22.15583	84.10156
46	Karlaghati	22.2221	84.060715
47	Karmunda	22.27814	84.775793
48	Kendudihi	21.98901	83.65311
49	Kesramal	22.26411	84.58757
50	Khajurdihi	21.70812	84.802629
51	Khanditatoli	22.30848	84.980988
52	Kharalchhap	22.24287	83.85251
53	Khatkhur Bahal	22.28201	84.466476
54	Kinikibandh	22.34132	83.96387
55	Kinjirkela	22.28446	83.946661
56	Kirlaga	22.30421	84.16922
57	koida	21.89897	85.240828
58	Kulabira	22.08093	83.81885
59	Kuliposh	21.79104	85.027888
60	Kundheidiha	21.80255	84.694303
61	Kutra	22.23089	84.452396
62	Lahunipara	21.87849	84.942215
63	Lathikata	22.13053	84.878502
64	Lephripara	22.1101	83.818446
65	Lulkidhi	22.51101	84.021712
66	Mahipani	22.26673	85.056368
67	Majhapara	22.02363	84.183272
68	Malidih	22.13251	84.612384
69	Mangaspur	21.9578	83.992983
70	Masabira	22.21334	83.771525
71	Mendra	22.09809	83.583719
72	Nuniapali	21.91839	84.793029
73	Panchora	22.27247	84.376897
74	Patrapali	22.04793	83.680241
75	patua	22.06414	84.77931
76	Raiboga	22.39202	84.609163
77	Rajganpur	22.20974	84.588964
78	Ratakhandi	22.32669	84.69821
79	Sagbahal	22.46785	84.085401
80	Salangabahal	22.3592	84.516097
81	Salangabud	22.11074	84.149427

82	Satkuta	21.85821	84.860727
83	Saurijore	22.14728	83.830369
84	Sihidiha	21.70147	84.997708
85	Singarmunda	22.26715	84.261829
86	Subdega	22.27968	84.103392
87	Sunajore	22.19554	84.003811
88	Sundargarh	22.1008	84.049649
89	Talsara	22.35789	84.098879
90	Tangardihi	21.89355	83.795465
91	Tangarmunda	22.1516	84.032307
92	Tangarpali	22.08744	83.930958

2.4 Exploratory Drilling

During AAP 2022-23, GW exploration was conducted in the study area. Details of the exploration activity in Sundargarh district is given in Table 2.4.

Table 2.4: Details of exploration wells constructed by CGWB in Sundargarh District, Odisha

Sr.No	Block	Location	Latitude	Longitude	Depth drilled (mbgl)	Source
1	Balisankara	Kinjirkela	22.2547	83.9389	175	CGWB
2	Balisankara	Balisankara	22.3442	84.0318	200	CGWB
3	Baragaon	Baibai	22.1736	84.3308	110	CGWB
4	Baragaon	Baragaon	22.1850	84.3083	166.3	CGWB
5	Baragaon	Bargad	22.0458	84.1167	167	CGWB
6	Baragaon	Bhedabahal	22.0472	84.0300	166.3	CGWB
7	Baragaon	Bheluanbahal	22.2275	84.2236	95	CGWB
8	Baragaon	Bhoipalli	22.1331	84.2889	160	CGWB
9	Baragaon	Chammunda	22.1328	84.3031	51	CGWB
10	Baragaon	Devkaranpur	22.1467	84.1894	160	CGWB
11	Baragaon	Gadgadbahal	22.2111	84.3444	50	CGWB
12	Baragaon	Pamora	22.2625	84.3000	70	CGWB
13	Baragaon	Rengalmal	22.2950	84.2500	130	CGWB
14	Bargaon	Bargaon	22.1537	84.2906	203.3	CGWB
15	Bargaon	Barngakahar	22.1940	84.2268	180.9	CGWB
16	Bargaon	Barpalhi	22.1681	84.3253	83	CGWB
17	Bargaon	Ekma	22.2634	84.2849	137.2	CGWB
18	Bargaon	Itma	22.1081	84.2248	197.2	CGWB

19	Bargaon	Kinjirkela	22.1931	84.2947	142	CGWB
20	Bargaon	Kustuna	22.1383	84.2050	148	CGWB
21	Bargaon	Mahapada	22.1772	84.3653	123.6	CGWB
22	Bargaon	Mundagaon	22.1961	84.1950	172.4	CGWB
23	Bargaon	Pamra	22.2378	84.2926	111.8	CGWB
24	Bargaon	Pandherpally	22.1508	84.2580	120.1	CGWB
25	Bargaon	Petford	22.2769	84.2767	160.2	CGWB
26	Bargaon	Sahajbahal	22.2292	84.2833	70	CGWB
27	Bargaon	Tiklipada	22.1639	84.2556	151	CGWB
28	Bargaon	Timana	21.2944	84.3411	172.4	CGWB
29	Bargaon	Tudalaga	22.3642	84.2169	75	CGWB
30	Bargaon	Tunmura	22.2000	84.2833	87	CGWB
31	Birmatrapur	Birmatrapur-I	22.3816	84.7239	197.2	CGWB
32	Birmatrapur	Raibaga	22.3963	84.6698	197.2	CGWB
33	Bisra	Bondamunda	22.2551	84.9616	142.3	CGWB
34	Bonaigarh	Bonai	21.8493	84.9263	166.7	CGWB
35	Bonaigarh	Jamkai	21.7816	84.9571	178.5	CGWB
36	Hemgir	Duduka	21.9953	83.7703	180	CGWB
37	Hemgiri	Gandapara	21.8775	83.6578	150	CGWB
38	Hemgiri	Kamlaga	21.9325	83.7378	62.6	CGWB
39	Himgir	Gopalpur	21.9809	83.6601	200.2	CGWB
40	Himgir	Taparia	21.9846	83.5770	148.4	CGWB
41	Himgir	Tumulia	21.9808	83.7143	200	CGWB
42	Kharmunda	Teliposh	22.2783	84.7878	129.7	CGWB
43	Kuarmunda	Bisra	22.2551	84.9616	160.6	CGWB
44	Kuarmunda	Chhend	22.2260	84.8475	113.3	CGWB
45	Kuarmunda	Kuarmunda	22.2737	84.7451	166.7	CGWB
46	Kuarmunda	Vedavyas	22.2389	84.7547	81.3	CGWB
47	Kutra	Bhagra	22.2500	84.4139	51	CGWB
48	Kutra	Bringatoli	22.2047	84.4028	197	CGWB
49	Kutra	Kutra	22.2101	84.4743	185	CGWB
50	Kutra	Kutra-I	22.2101	84.4743	63	CGWB
51	Kutra	Panchara	22.2839	84.3875	85	CGWB
52	Lahunipara	K.Balang	22.1712	84.8029	172.8	CGWB
53	Lahunipara	Lahunipara	22.0101	85.0212	166.7	CGWB
54	Lahunipara	Rajamunda	21.8749	84.9379	105.45	CGWB
55	Lathikata	Balijodi	22.1844	84.8767	148	CGWB

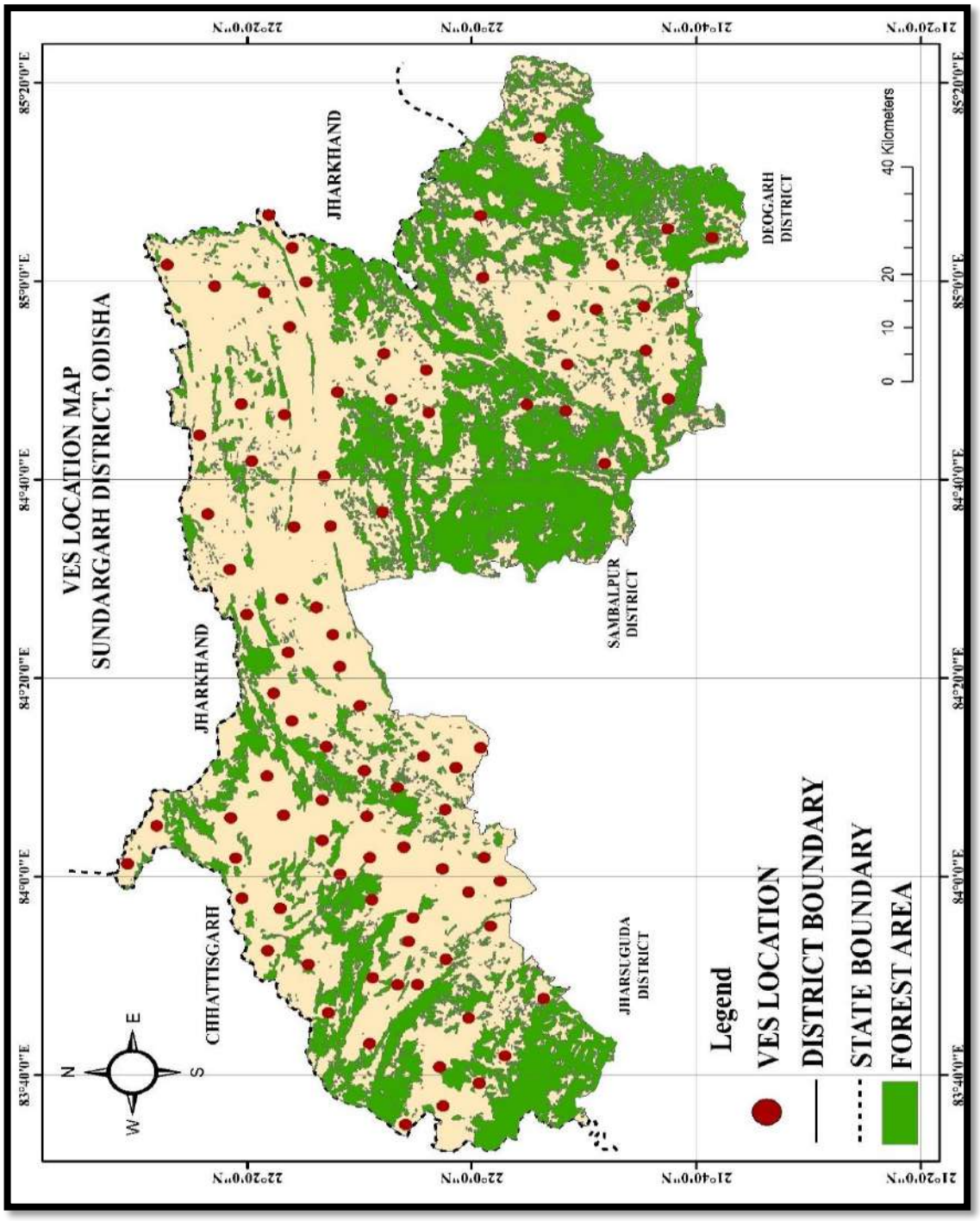
56	Lathikata	Banki	22.1411	84.1243	191.1	CGWB
57	Lathikata	Bolani	22.1584	84.8300	93.5	CGWB
58	Lathikata	Jalda	22.0669	84.8917	178.3	CGWB
59	Lathikata	Lathikata	22.1821	84.8493	191.1	CGWB
60	Lathikata	Old Jalda	22.1883	84.8422	160.2	CGWB
61	Lefripara	Bindujharia	22.0947	83.7697	151	CGWB
62	Lefripara	Borabhagar	22.0069	83.9158	154	CGWB
63	Lefripara	Grinkela	22.1081	83.8119	70	CGWB
64	Lefripara	Kubarikhamnapara	22.1089	83.7714	150	CGWB
65	Lefripara	Kulabira	22.0753	83.8367	148	CGWB
66	Lefripara	Lefripara	22.1000	83.8264	150	CGWB
67	Lefripara	Nuadihi	21.9775	83.9625	150	CGWB
68	Lefripara	Patuadihi	22.1383	83.8156	124	CGWB
69	Lefripara	Ujalpur	22.0822	83.9236	154	CGWB
70	Lifripara	Darlipali	21.9568	83.9153	197.2	CGWB
71	Lifripara	Dharkadihi	21.9911	84.2131	200.2	CGWB
72	Lifripara	Dumabahal	22.1946	83.7416	181.2	CGWB
73	Lifripara	Jhurimal	22.0489	83.8833	105.3	CGWB
74	Lifripara	Pitabhuin	22.1111	83.8833	160.2	CGWB
75	Lifripara	Raidihi	21.9769	83.8979	191.1	CGWB
76	Lifripara	Remda	21.9917	83.9958	160.2	CGWB
77	Lifripara	Surguda	22.1012	83.8749	175.8	CGWB
78	Panposh	Basanti Colony	22.3595	84.8476	185	CGWB
79	Panposh	Nayabazar	22.3284	84.8689	191	CGWB
80	Panposh	Panposh	22.3302	84.8341	197	CGWB
81	Rajgangapur	Bihabandh-II	22.2612	84.5053	185	CGWB
82	Rajgangapur	Liploi	22.1789	84.5574	185.3	CGWB
83	Rajgangpur	Laing	22.2464	84.6387	136.2	CGWB
84	Rajgangpur	Rajgangpur	22.1990	84.5845	197.2	CGWB
85	Subdega	Hamirpur	22.2167	84.1250	160	CGWB
86	Subdega	Jamuna Bhoi Para	22.3153	84.0694	172	CGWB
87	Subdega	Karmdihi	22.2636	84.1051	142.1	CGWB
88	Subdega	Kirlaga	22.3083	84.1806	160	CGWB
89	Subdega	Kurumkela	22.2972	84.1625	166	CGWB
90	Subdega	Latadega	22.3000	84.1194	160	CGWB
91	Subdega	Purajalanga	22.1028	84.0972	160.5	CGWB
92	Subdega	Subalaya	22.1250	84.0931	50.5	CGWB

93	Subdega	Subdega	22.3148	84.1168	189.8	CGWB
94	Subdega	Tangargaon	22.3636	84.2169	90	CGWB
95	Sundargarh	Bhasma	21.9639	84.0389	111.4	CGWB
96	Sundargarh	Deoli	21.9566	84.0487	178.9	CGWB
97	Sundargarh	Masakani	22.0250	84.0417	166.3	CGWB
98	Sundargarh	Sankara	22.0699	84.0508	166.7	CGWB
99	Sundargarh	Sundargarh	22.0919	84.0295	200	CGWB
100	Sundergarh	Bartankela	22.0839	83.9111		CGWB
101	Sundergarh	Jharbeda	22.2211	84.5247	62.6	CGWB
102	Sundergarh	Karla	21.9611	84.2000	172.4	CGWB
103	Sundergarh	Mahapada	22.1767	84.3644	159	CGWB
104	Tangarpali	Bandhapalli	22.1136	83.9978	125	CGWB
105	Tangarpali	Belsara	22.1006	83.8500	170	CGWB
106	Tangarpali	Govt. Women's college	22.1167	84.0244	172.4	CGWB
107	Tangarpali	Laldhipa	22.1250	84.0028	160	CGWB
108	Tangarpali	Mangaspur	21.9517	83.9975	154	CGWB
109	Tangarpali	Meghdega	22.1708	83.9267	160	CGWB
110	Tangarpali	Police line	22.0983	84.0400	172.4	CGWB
111	Tangarpali	Rangyamunda	22.0797	83.9600	95	CGWB
112	Tangarpali	Sukhapada	22.1514	84.0278	172.4	CGWB
113	Tangarpali	Ujalpur	22.0773	83.9599	138.2	CGWB
114	Uijalpur	Mahulpali	22.0901	83.9967	197.2	CGWB
115	Uijalpur	Sargipali	22.0426	83.9463	200.2	CGWB
116	Sundergarh	Ledhimang	21.9851	84.2112	196.5	CGWB
117	Sundergarh	Badasalepalli	22.0069	84.2300	199.5	CGWB
118	Sundergarh	Ghantibud	22.1064	84.1817	100	CGWB
119	Sundergarh	Filingbahal	22.2410	84.1347	105	CGWB
120	Badgaon	Jharmunda	22.1602	84.1647	140	CGWB
121	Kulta	Kulta	22.0462	84.2542	100.9	CGWB

3. Data Interpretation, Integration and Aquifer Mapping

1. **Geophysics and Aquifer Characterization** –
   92 Vertical Electrical Sounding (V.E.S.) under surface geophysical studies have been conducted during AAP 2022-23. The results of interpretation of V.E.S curves, correlation of the data with hydrogeological details of exploratory boreholes and taking the apparent resistivity into account have been presented in Annexure 3.1. The Figure 3.1 shows location of the VES conducted in Sundargarh district.

Figure 3.1 – VES Location Map, Sundargarh District, Odisha.



All the 92 VES were interpreted in terms of layer parameters. The field curves were obtained as H, HK, KH, KQ, HKH and QH type. The long spread VES and Borehole logs spatially distributed were utilized for interpretation.

VES analysis delineates that the true resistivity of the top Soil/Dry soil layer ranges from 15 to 250 Ω.m. This top layer varies in depth from 0.348 to 5.71 m. Next, the second layer has Clay having a resistivity range of 5 to 25 Ω.m. The thickness of this layer varies from 0.96 to 29.33 m.

The mostly third and occasionally 2nd & 4th layer is Highly weathered to weathered formation having a resistivity of 25 to 250 Ω.m, bearing good quality groundwater also. The depth of this layer varies from 5.71 to 69m. Wide range of the resistivities may be due to the variations in the degree of weathering, nature of the formation, etc. Weathered sandstone find In few location of Hemgir block which resistivity varies from 30 to 60 Ω.m and depth of this layer varies from 20 to 102m.

Mostly the 3rd or 4th geoelectric layer, occasionally the 2nd one with resistivities ranging from 250 to 800 Ohm m, occasionally exceeding to more than 800 Ohm m has been inferred as formation with fractures (Fractured granite). Wide range of the resistivities may be due to the variations in the degree of fracturing, nature of the formation, etc. The thickness of the geoelectric layer inferred formation with fractures varies between 15.9and 91.3 m.

Mostly the 3rd, 4th, or 5th geoelectric layer, occasionally, the 2nd or 6th one with resistivities ranging above 800 Ohm m, has been inferred as Granite Formation. The depth to bottom of this layer is, in general, varying from 2.23 to 200 m.

On the basis of geoelectrical layer parameters and the fractured zone analysis a few sites are recommended for borehole drilling or Shallow borehole or Dug well. The lithology and its resistivity ranges are shown in Table No. 3.1. Based on the survey, a 3D stratigraphic model and fence diagram has been prepared and shown in Figure no. 3.2 and 3.3.

Table No. 3.1 – Lithologies encountered vs the resistivity ranges

Sr No	Lithology	Resistivity Range
1.	Top Soil/Dry Soil	15 to 250 Ω.m.
2.	Clay	5 to 25 Ω.m
3	Highly Weathered / Weathered Formation	25 to 250 Ω.m
4	Weathered SST	30 to 60 Ω.m
5	Fractured SST	125 to 300 Ω.m
6.	Fractured granite	250 to 800 Ω.m
7.	Granite	Above 800 Ω.m

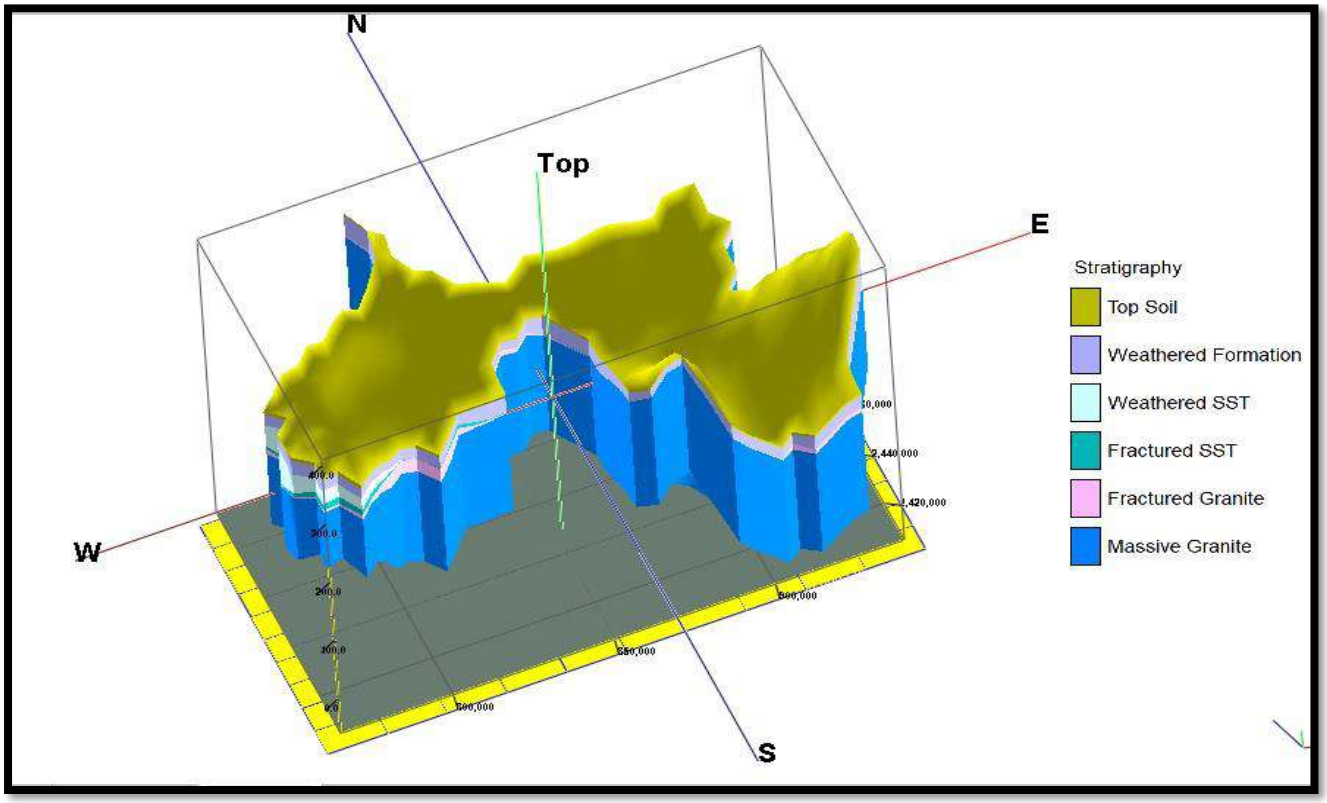


Figure 3.2 - 3D Stratigraphy model

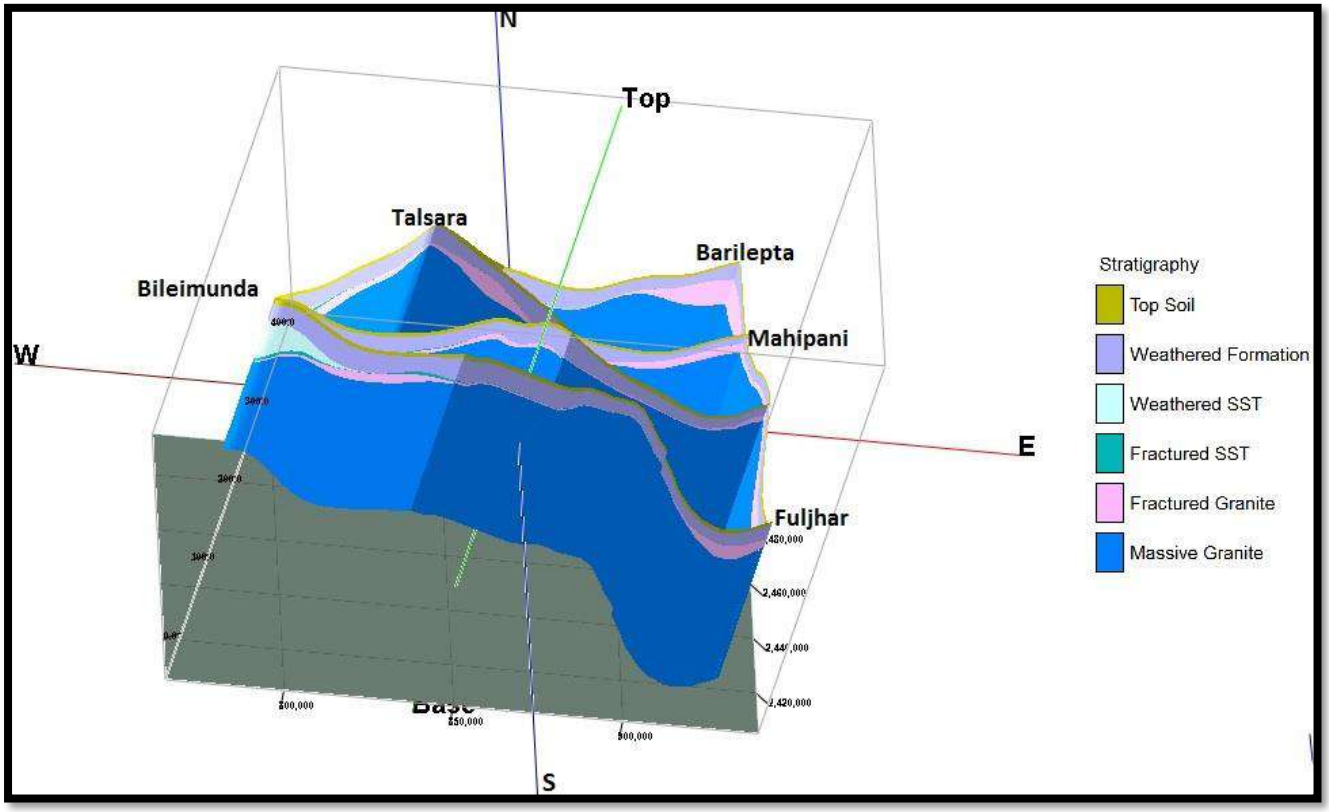


Figure 3.3 - Fence diagram

2. **Aquifer disposition** -

Hydrogeology of the study area is mainly controlled by geomorphological and geological set up, degree of secondary and primary porosities and by climatic conditions. Since major part of the study area are underlain by the hard rocks of diverse lithological composition and structure, the water bearing and transmitting properties of the formations vary. The area has undergone several phases of intense tectonic deformations, which has been responsible for the development of deep-seated intersecting fracture system.

Hydrogeological survey carried out in the study area reveals-

1. The lithological characteristics,
2. Role of tectonic deformation on the occurrence and distribution of ground water reservoirs.
3. Their water bearing and water yielding properties.

Ground water in the study area occurs under phreatic conditions in the weathered mantle of consolidated and semi consolidated formations. Infiltration of the atmospheric precipitation forms the major source of ground water recharge in the study area. However, most part of the precipitation in the high relief areas goes as surface run off.

The major hydrogeologic units in this area can be broadly divided into three groups.

1. Areas underlain by fractured, fissured, and consolidated rock formations.
2. Area underlain by semi-consolidated formation.
3. Area underlain by the recent unconsolidated alluvial formation.

- Water bearing formations

Consolidated Formation

The Consolidated Formation (hard rocks) forms the main hydrogeological unit occurring in the study area. It includes Precambrian metasedimentaries of Gangpur series and granites, granite gneiss, metabasics like amphibolite, epidiorite etc. These rocks lack primary porosity and are rendered porous and permeable by weathering and fracturing. The water yielding capability of these rocks depends entirely on the intensity of fracturing and weathering. The top weathered zone forms phreatic aquifer. The weathered zone thickness varies from a few centimeters to 12.3 m in areas occupied by rocks belonging to Gangpur series with an average thickness of about 8 m. The weathered zone thickness varies from a few centimeters to 14.2 m in areas occupied by rocks belonging to granite suites (Intrusive) with an average thickness of about 9 m. The weathered residuum developed on the hard rock serves as good ground water reservoir in most part of the study area. In plateau areas lateritic capping is developed on the weathered residuum. Dug wells and dug cum bore wells are suitable ground water structures.

Thin weathered zone on hilly and hill slope areas acts as temporary water bearing zone just after monsoon season and in post-monsoon season ground water from this saturated zone is drained out as base flow and water level starts depleting very fast. The wells in this area may go dry in January/February months. Fracture zones form the deeper aquifer systems and ground water occurs under semi-confined to confined conditions.

Generally, 2 to 3 potential fracture zones are encountered within the depth range of 100 m. However, water bearing fractures are also encountered down to the depth of 200 m. Areas occupied by rocks belonging to Gangpur series are having water bearing fracture zones but are less promising as compared to granitic rocks. Granite suites of rocks are having more promising aquifers (may yield 3 to 8 liters per second with moderate drawdown). However, the successes of bore wells are site specific (under suitable topography and hydrogeological conditions).

Granite and Granite gneiss: Ground water occurs in phreatic condition. The thickness of the weathered zone is generally more in topographic lows and undulating plains than in the high land areas. The weathered residuam ranging in depth from 3.25 to 8.85m below ground level constitutes the shallow aquifer zone. On weathering these rocks produce sandy granular material and their water holding and transmitting capacity depends on the percentage of kaolin present. The weathered zone forms the main repository of ground water and aids in circulation of ground water through interconnected fractures and fissures to deeper fracture zones. The pre monsoon water level varies in the range of 3.1 to 9.1 mbgl and in post monsoon 0.1 to 7.2 mbgl in dug wells. In borewells, the water level varies between 3.98 to 10.29 mbgl in pre monsoon and 0.89 to 4.79 mbgl in post monsoon with average discharge of 4.12 lps.

Mica schist: These rocks are highly weathered. The pre monsoon water level varies in the range of 0.6 to 12.9 mbgl and in post monsoon 0 to 8.2 mbgl in dug wells. In borewells, the water level varies between 5.03 to 15.64 mbgl in pre monsoon and 1.37 to 7.97 mbgl in post monsoon with average discharge of 2.33 lps.

Carbonaceous Phyllites: These rocks are highly jointed and well foliated. The pre monsoon water level varies in the range of 6.3 to 13.1 mbgl and in post monsoon 3.1 to 9.4 mbgl in dug wells. In borewells, the water level is 5.19 mbgl in pre monsoon and 1.94 mbgl in post monsoon with average discharge of 3.3 lps.

Metabasics: Amphibolite and Epidiorite are the most common metabasics occurring in the study area. They occur generally as bands towards the northern part in Nuagaon block. These rocks are highly jointed. In borewells, the water level is 6.434 mbgl with average discharge of 5.9 lps.

Limestone and Dolomite: Limestone and dolomites occur in Nuagaon, Kuarmunda and Rajgangpur blocks. These rocks show karstification in varying degrees. Solution cavities are also present in the Biramitrapur Limestones. Vertical as well as low dipping joints

have facilitated karst development. In the limestone quarries of Hatibari seepage of ground water along the quarry floor is reported. In other limestone mines like Panposh and Lanjiberna, near Rajgangpur heavy seepage of ground water is recorded. The pre monsoon water level varies in the range of 1.4 to 9.4 mbgl and in post monsoon 1.3 to 6.6 mbgl in dug wells. In borewells, the water level varies between 4.5 to 9.69 mbgl in pre monsoon and 2.71 to 8.61 mbgl in post monsoon with average discharge of 3.29 lps.

Semi consolidated Formation

Sandstone - Sandstone of Lower Gondwana Group constitute the semi consolidated formations. The Barakar formation is very well developed and often constitutes potential aquifer in the area. The coarse-grained gritty sandstone on weathering gives rise to porous sandy materials. Large diameter dug wells and medium deep tube wells are feasible in this formation. The pre monsoon water level varies in the range of 2.7 to 13.5 mbgl and in post monsoon 0.4 to 7.5 mbgl in dug wells. In borewells, the water level varies between 28.49 to 69.34 mbgl in pre monsoon and 14.57 mbgl in post monsoon with average discharge of 3.44 lps.

Shale- The shales, sandy shales and fine-grained sandstones do not form productive aquifer.

Laterites and Alluvium- Laterites and Alluvium of sub-recent to Recent age constitute the unconsolidated formations. Laterite which occurs as patches as capping over the older formations are usually porous in nature and form very good shallow aquifers, developed through open wells. Alluvium occurs as small discontinuous patches along the courses of the Ib river and their tributaries forming flood plain deposit ranging in thickness even upto 10 m. Alluvium forms good shallow aquifers to be developed through dug wells. The coarse-grained sands with pebbles form the main repository of ground water.

The details of the aquifers delineated through exploratory wells are shown in Table 3.2 in Annexure 3.2.

Based on the data from the exploratory drilling in Sundargarh district, three 2D cross sections have been drawn –

I. Section line A-A’ running west – east across the district, shown in Figure no. 3.4.
II. Section line B-B’ running north- south along the district, shown in Figure no. 3.5.
III. Section line C-C’ running north- south along the district, shown in Figure no. 3.6.

Fig 3.4- 2D section showing Aquifer disposition along (A-A') in West-East direction of Sundargarh district, Odisha.

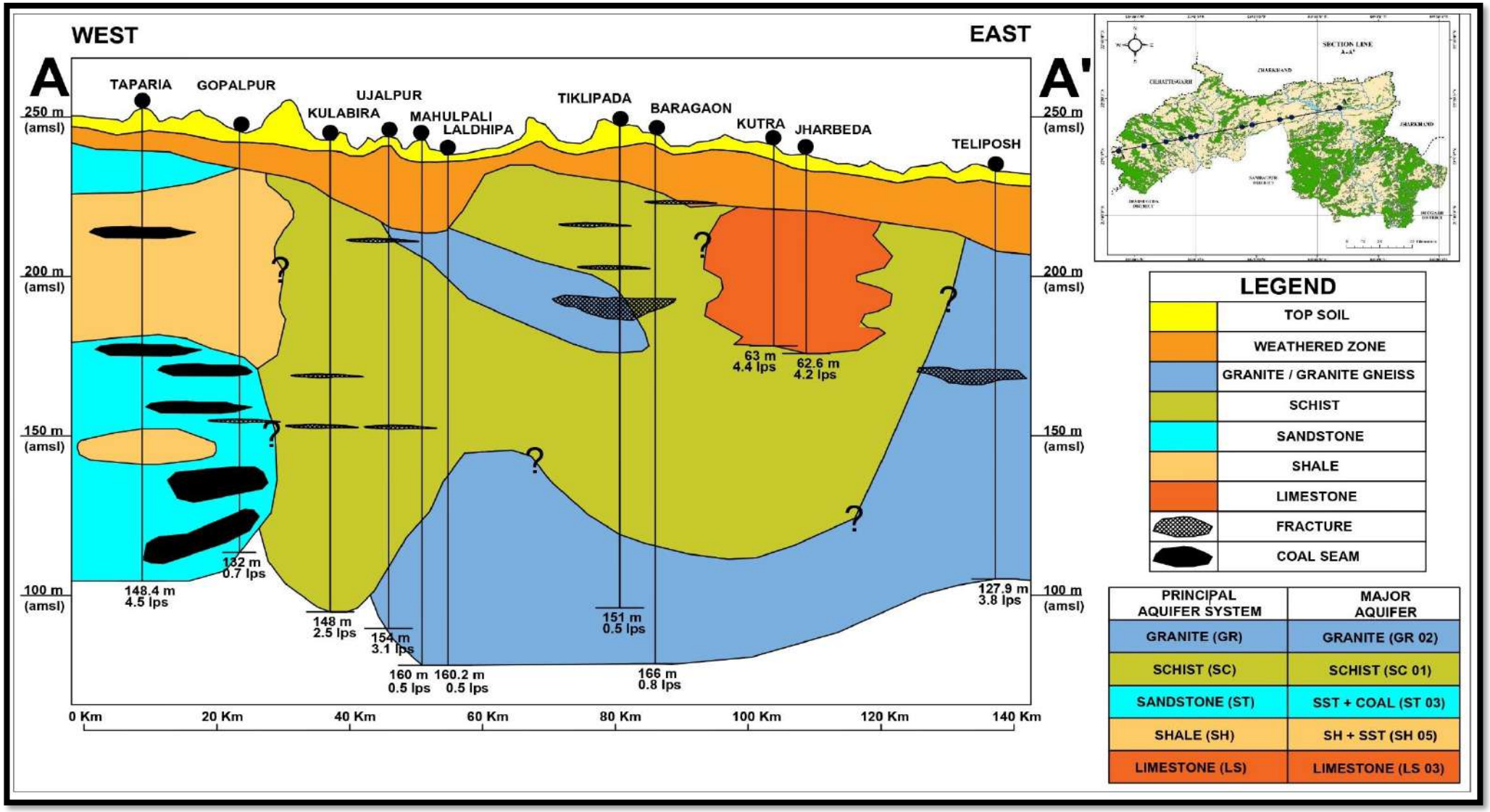


Fig 3.5- 2D section showing Aquifer disposition along (B-B') in South-North direction of Sundargarh district, Odisha.

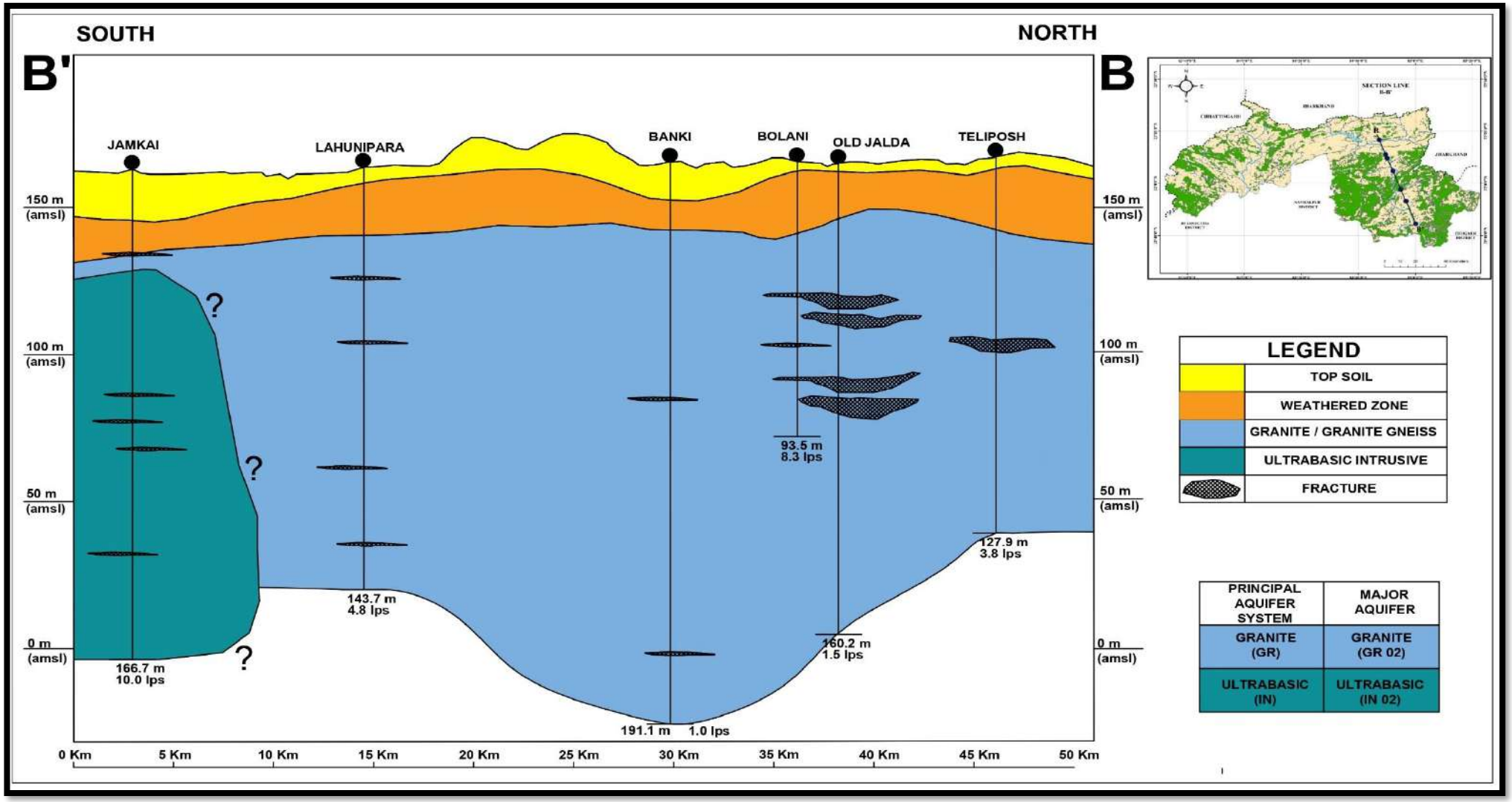
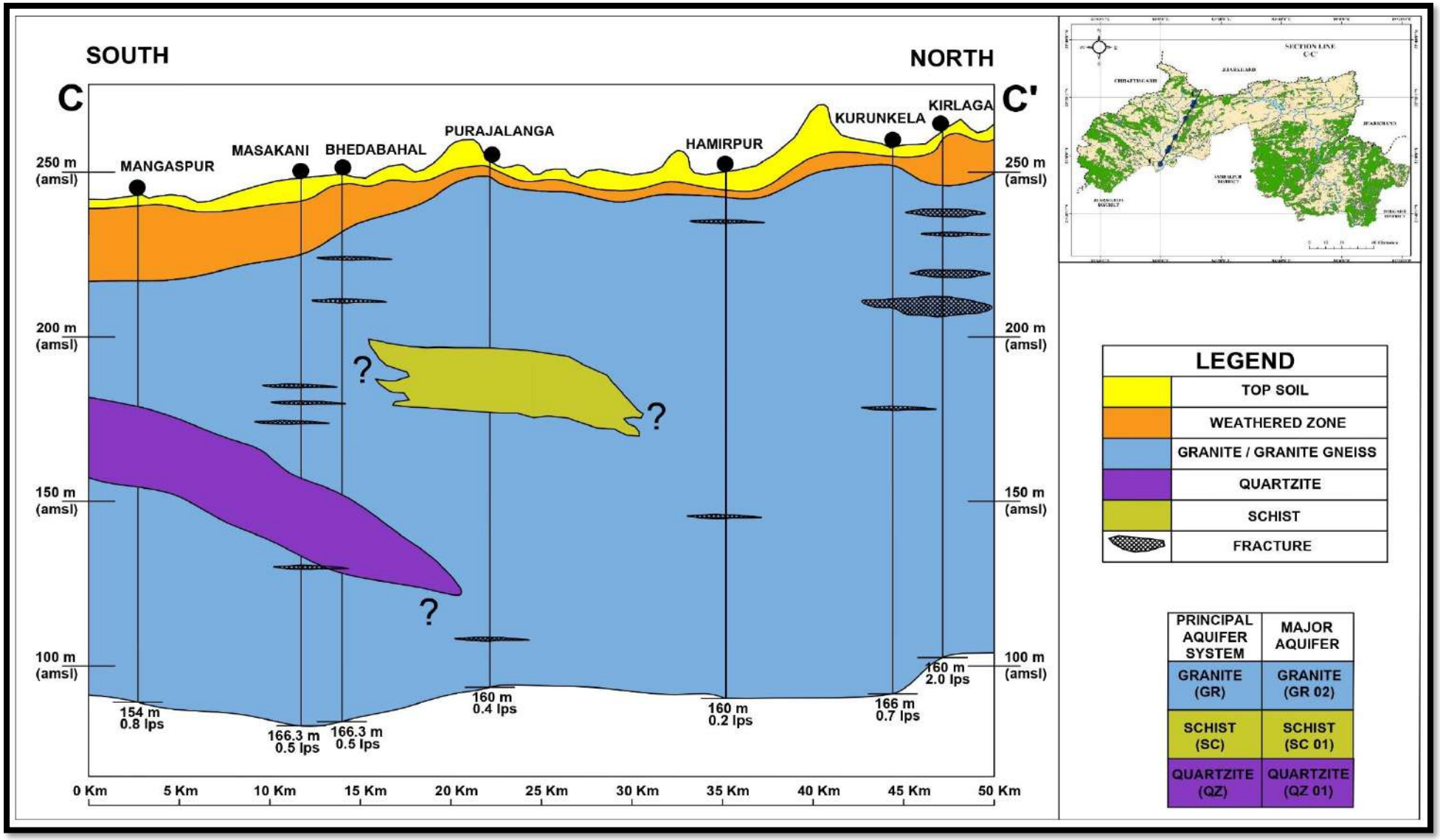


Fig 3.6- 2D section showing Aquifer disposition along (C-C') in South-North direction of Sundargarh district, Odisha.



3. Fracture analysis

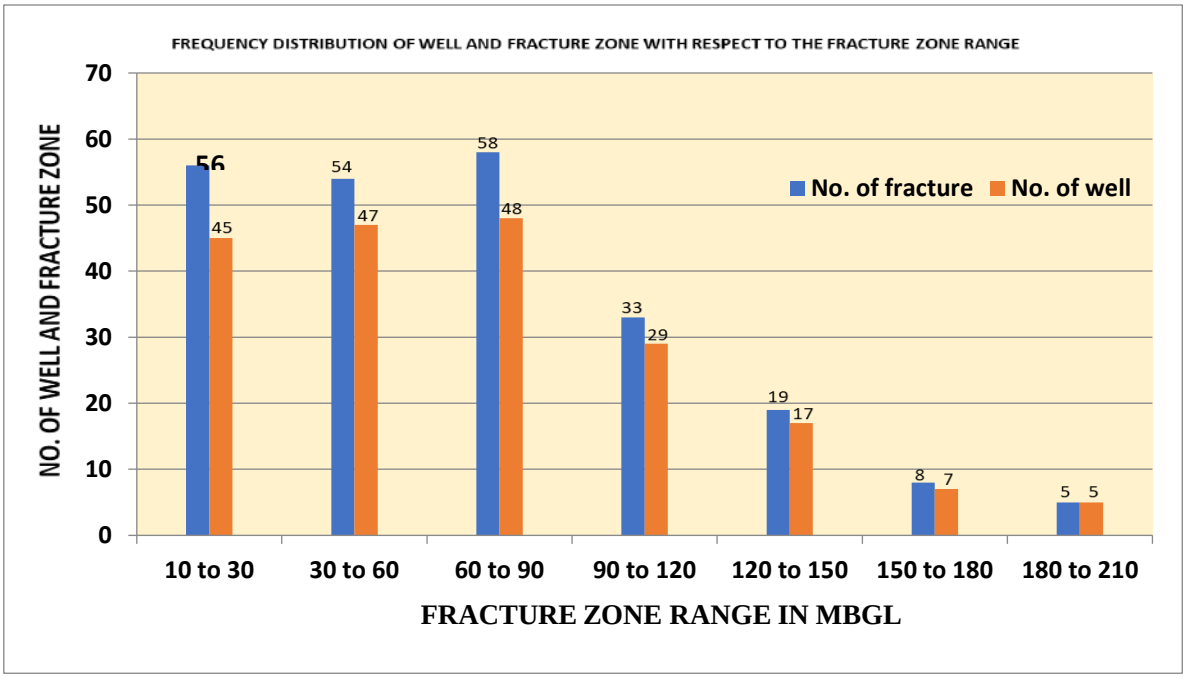
233 number of fracture zone found at the depth range from 10 to 210 mbgl, where 56 number of fracture zone of shallow aquifer in 45 wells while 177 number of fracture zone of deeper aquifer in 153 wells. The highest and lowest Fracture zone found at the depth range of 60 to 90 and 180 to 210 meter below ground level in Exploratory well of Sundargarh district. Granite, granite gneiss and mica schist are the litho units which associating highest number of fracture zone, while Carbonate rock such as limestone and dolomite have least number of fractures. Balisankara is the place in Balisankara block of Sundargarh district having fracture zone at the depth of 200 mbgl that is highest maximum fracture zone depth found in Granite gneiss formation.

Taparia Exploratory well of Hemgir block associating highest number of fracture zone starting from 12 meter to 100 meter at regular intervals in Sandstone, shale of Gondwana formation.

The geological significance of fracture zones in hydrogeology is that it determines the competency of the underlying rocks. The areas that are extensively fractured and where the fractures are deep are considered as weak zones and suitable zones for groundwater exploration and development (Alagbe et al., 2013). Hence there are some exploration site where fracture zone frequency is high but discharge is low, the site can be make use of artificial recharge for ground water development. The suggested site is Taparia exploratory well at Hemgir block and Rajgangpur of Rajgangpur block.

The Competency of Granite, Granite geiss, Mica schist and Gondwana formation rock of Sundargarh district get detached, As per the fracture analysis of Exploratory well of Sundargarh district, while Quartzite, phyllite, and metabasics have normal competency. By which Granite, Granite geiss, Mica schist and Gondwana formation rock have great Ground water exploration and development feasibility. A depth wise fracture zone analysis is given in Figure no. 3.7.

Figure 3.7 – Fracture zone analysis of Exploratory well in Sundargarh District, Odisha.



4. Ground Water Regime Study

The occurrence and movement of ground water and seasonal water table fluctuation are studied through monitoring the key wells (established in the study area) during Groundwater Management Studies. A total number of 103 key wells (excluding Hydrograph stations) were established and monitored during the field season of 2022-23. The details of the GWMS wells are given in Annexure 3.3. The depths and diameters of the dug wells range from 2.9 to 14.2 m.b.g.l. l and 0.8 to 7.4 m respectively. The salient features of water levels as studied from monitoring wells are given in table.

Lithology wise as well as hydro geomorphological unit -wise depth to water level in pre-monsoon, post-monsoon period & water table fluctuation in the study area in bore well and dug well are given in Table 3.3 and 3.4 respectively. Based on the pre & post monsoon depth to water level data collected from monitoring of the key wells, DTWL maps have been drawn and shown in Fig 3.8,3.9. The fluctuation map is shown in Fig 3.10.

Ground Water Movement

The water table contour has been prepared based on the water level of ground water monitoring stations. Regionally the ground water flow direction is from the higher elevation of the north western side and northern side towards the central plains portion which ultimately flows south eastwards. The water table contour map is shown in Fig 3.11. The hydrogeological map of the study area is given in Fig. 3.12.

Spring details:

In hilly terrains like Gurundia and Koira blocks, there are number of springs or streams are flowing even in summer season also. So the people, those who are staying nearby are using the water for drinking purposes as well as irrigation. The discharges of the streams of springs are 2.00 to 1000 lps.

Table 3.3 – Aquifer details in Sundargarh district, Odisha.

Lithology	Bore Well									
	Pre-Monsoon				Post-Monsoon				Fluctuation (m)	Discharge (lps)
	No. of wells	Min WL (mbgl)	Max WL (mbgl)	Avg WL (mbgl)	No. of wells	Min WL (mbgl)	Max WL (mbgl)	Avg WL (mbgl)		
Alluvium	2	10.01	10.28	10.145	2	3.36	5	4.18	6.92	
Granite/Granite gneiss	5	3.98	10.29	7.41	5	0.89	4.79	2.93	9.4	4.12
Phyllite	1	5.19	5.19	5.19	1	1.94	1.94	1.94	3.25	3.3
Limestone	6	4.5	9.69	6.66	6	2.71	8.61	4.6	6.98	3.29
Sandstone	2	28.49	69.34	48.915	2	14.57	14.57	14.57	54.77	3.44
Schist	12	5.03	15.64	9.12	12	1.37	7.97	4.38	14.27	2.33

Table 3.4 – Pre & Post Monsoon DTWL and fluctuation data of GWMS

Lithology	Dug Well								
	Pre-Monsoon				Post-Monsoon				Fluctuation (m)
	No. of wells	Min WL (mbgl)	Max WL (mbgl)	Avg WL (mbgl)	No. of wells	Min WL (mbgl)	Max WL (mbgl)	Avg WL (mbgl)	
Alluvium	2	6.1	11.9	9	2	1.8	8.7	4.7	10.1
BHJ/BHQ	2	4.2	4.3	4.2	2	1.1	2.3	1.9	3.2
Granite/Granite gneiss	23	3.1	9.1	5.8	23	0.1	7.2	2.4	9
Phyllite	6	6.3	13.1	9.5	6	3.1	9.4	5.6	10
Limestone	28	1.4	9.4	5	28	1.3	6.6	3.3	8.1
Quartzite	6	1.9	7.9	4.9	6	0.6	3	2	7.3
Sandstone	12	2.7	13.5	7.3	12	0.4	7.5	2.6	13.1
Schist	64	0.6	12.9	6.3	64	0	8.2	2.4	12.9

Fig 3.8 - Pre monsoon DTWL map of Sundargarh district, Odisha

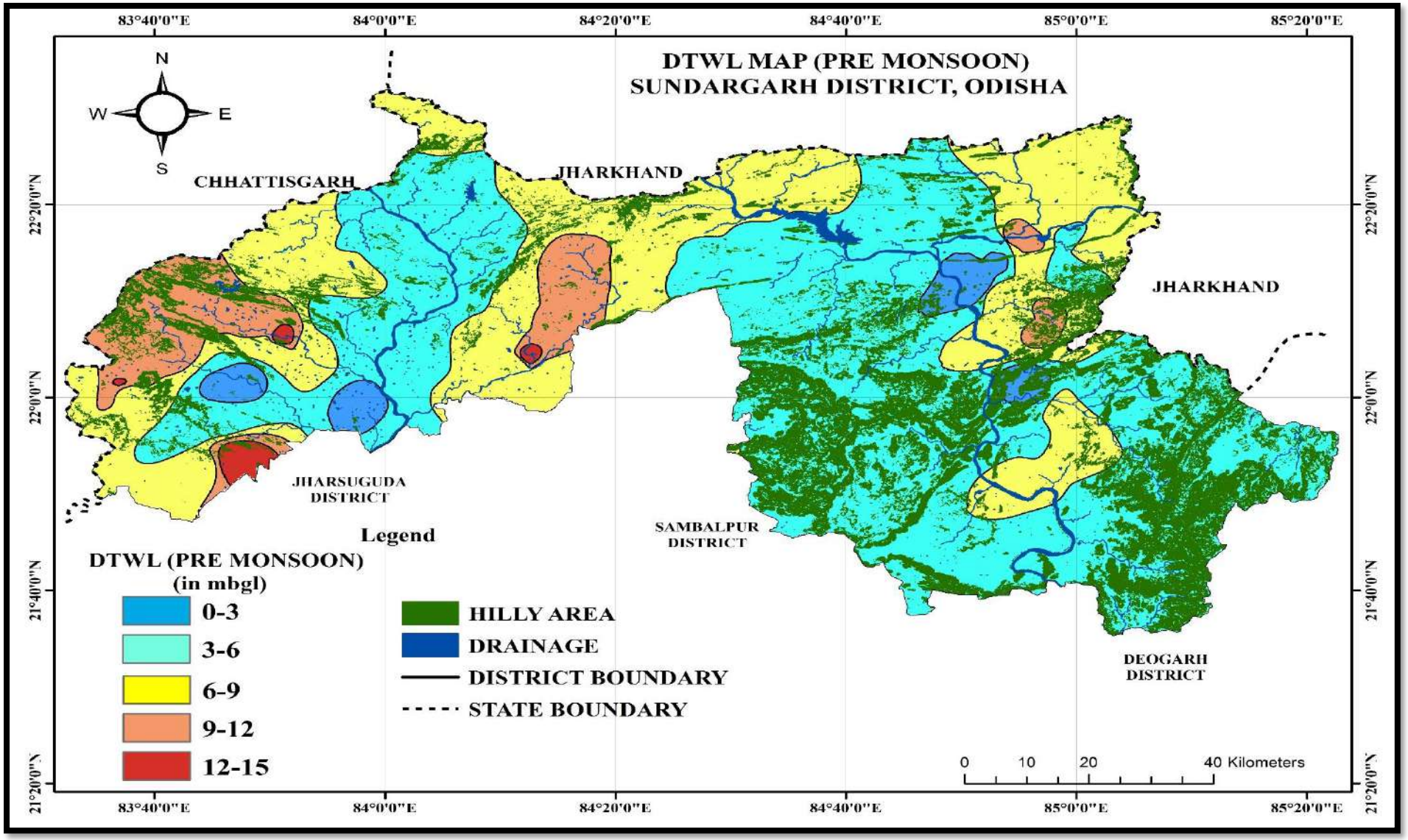


Fig 3.9 - Post monsoon DTWL map of Sundargarh district, Odisha.

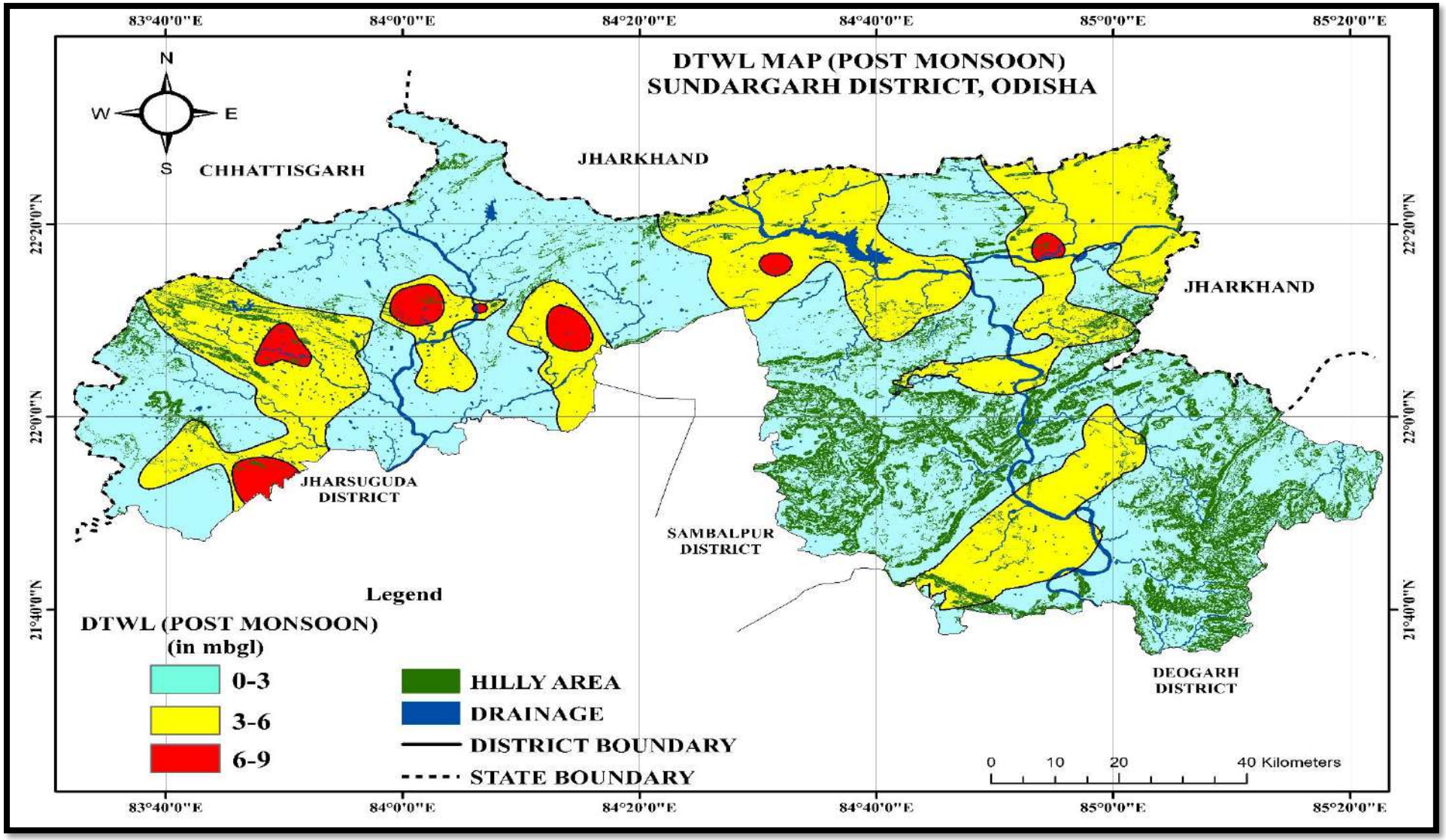


Fig 3.10 – DTWL Fluctuation map of Sundargarh district, Odisha.

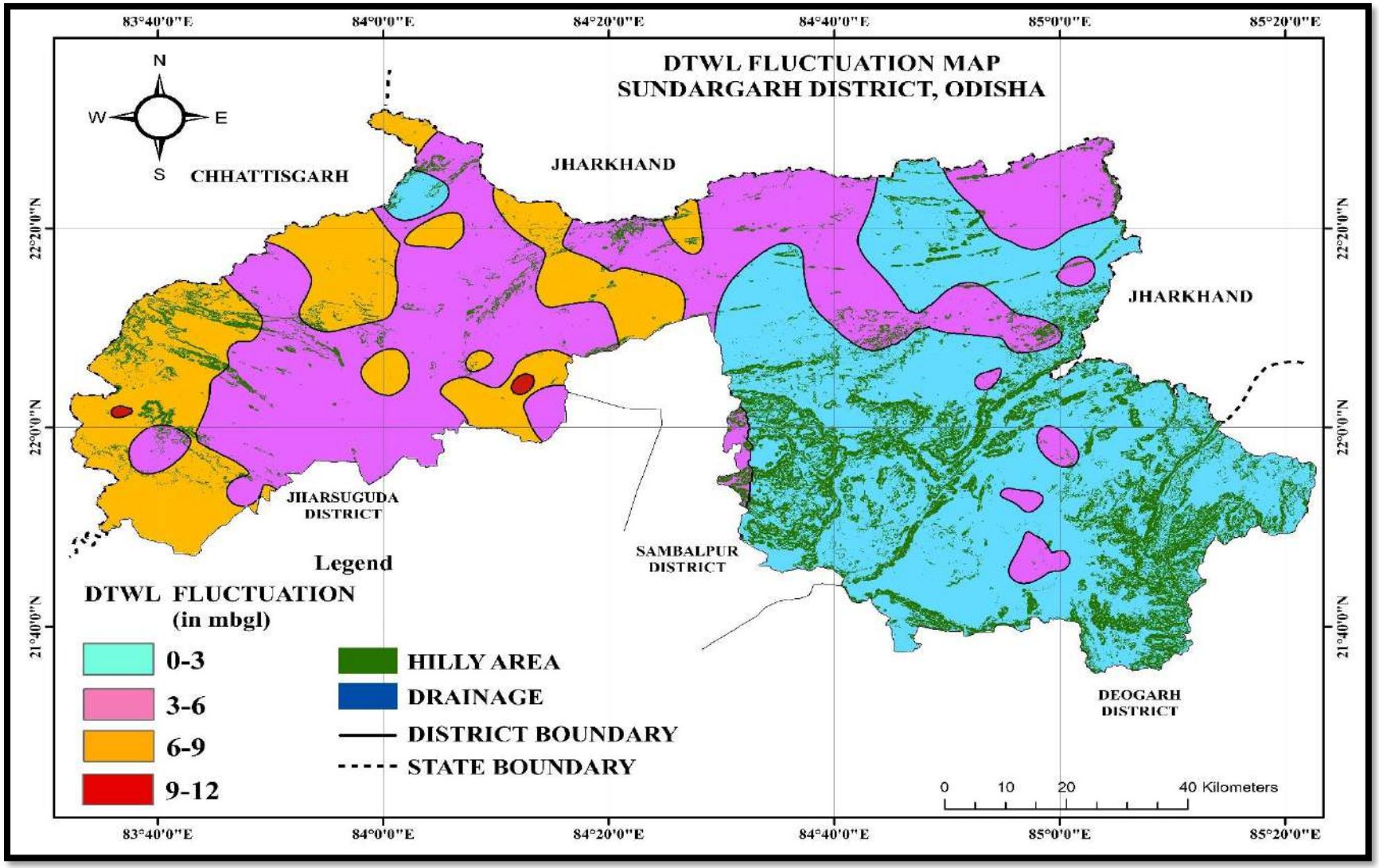


Fig 3.11 – Water table map of Sundargarh district, Odisha.

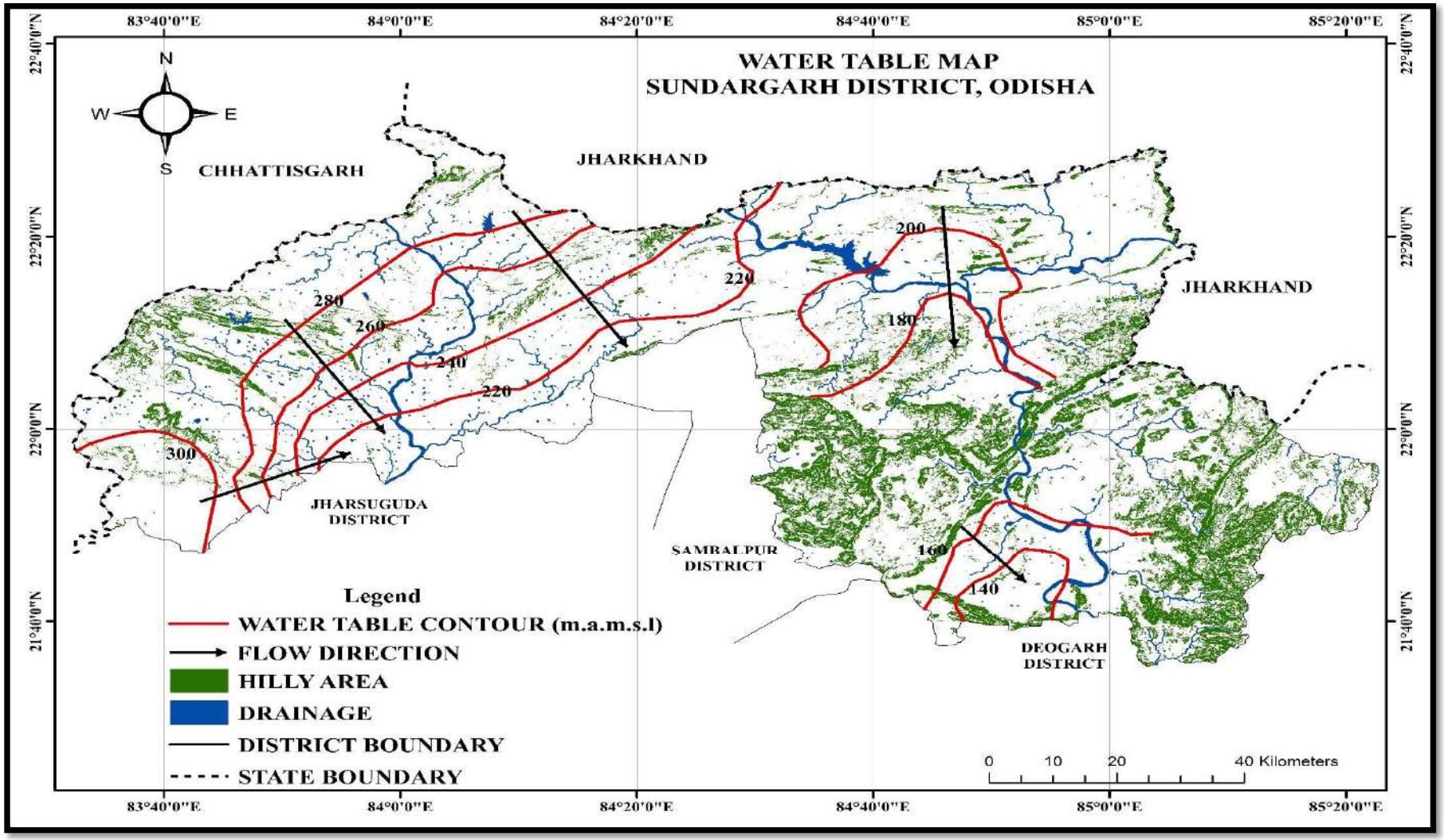
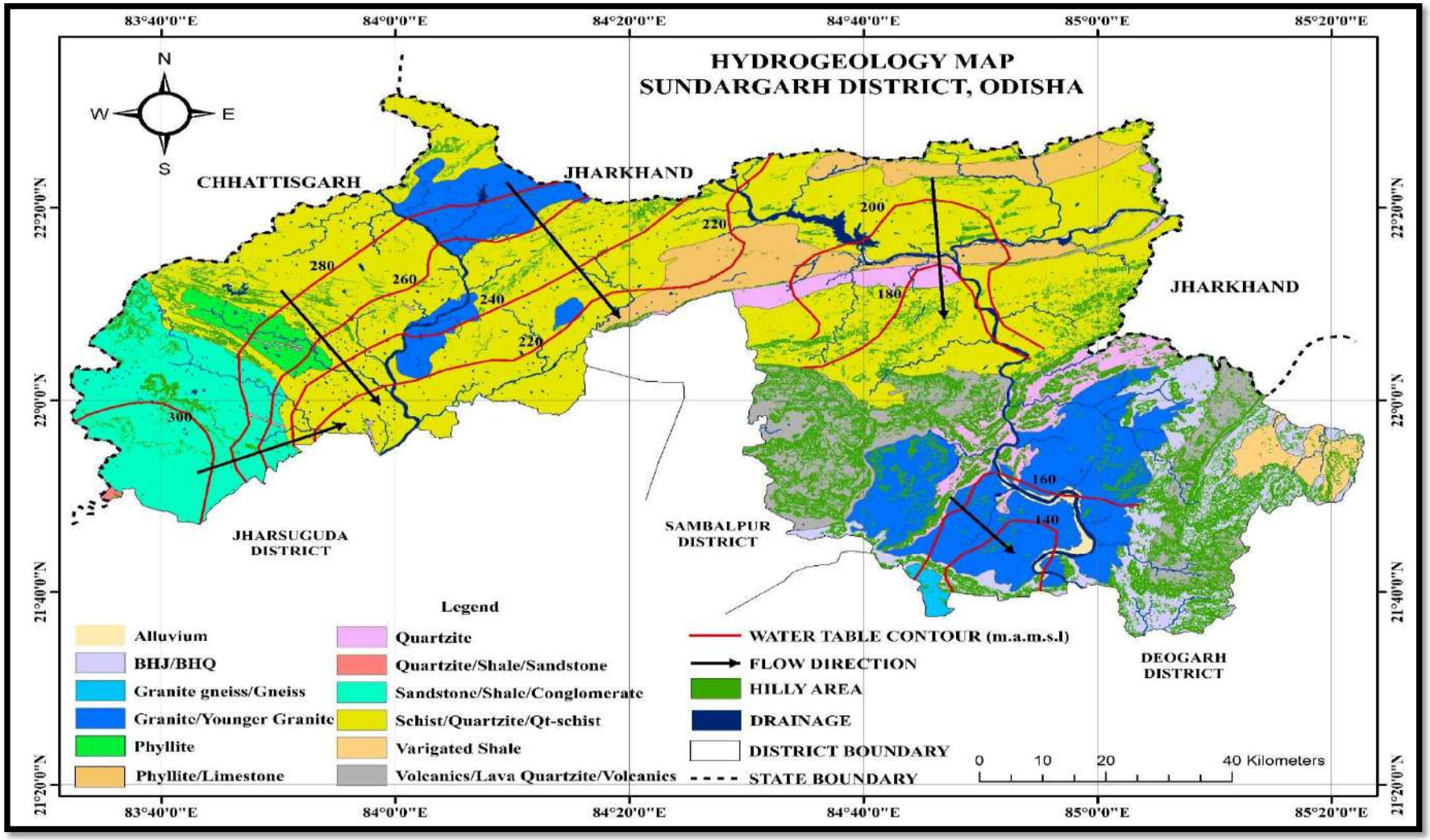


Fig 3.12 – Hydrogeological map of Sundargarh district, Odisha.



4. Ground water quality

To study the ground water quality of the study area water samples from dug wells were collected during pre-monsoon and post monsoon seasons. A total of 103 samples were collected during pre-monsoon. Similarly, 32 samples were collected during post monsoon, 25 samples from dug well and 7 samples from hand pump. Chemical analysis of ground water samples is carried out by regional chemical laboratory of Central Ground Water Board, South Eastern Region, and Bhubaneswar. Samples were analyzed for the parameters like pH, EC, Turbidity, TDS, CO3, Cal, SO4, Na, K, HCO3, NO3, F, Ca, Mg, U, As and Fe. The chemical analysis data of groundwater samples from Sundargarh district during pre-monsoon and post-monsoon season are given in the Table 4.1 and 4.2 as Annexure 4.1 and 4.2 respectively. Table 4.3 and 4.4 summarizes the results of chemical analysis.

Table 4.3 - Chemical quality of water samples from dug well and hand pump in Sundargarh district during pre-monsoon

Sr no.	Chemical constituents (Concentrations in mg/l except pH, and EC)	Maximum	Minimum
1	pH	8.28	7.31
2	EC (µs/cm) 25°C	1917	151
3	TDS	984	80
4	Alkanity	495	55
5	Ca^{+2}	68	12
6	Mg^{++}	142.15	1.2
7	Na^{+}	285	2
8	K^{+}	110	0.4
9	CO_3^{-2}	0	0
10	HCO_3^{-1}	604	67
11	Cl^{-}	310	1
12	SO_4^{-2}	112.7	-0.02
13	NO_3^{-1}	48.06	0.14
14	F^{-}	1.26	0.06

Table 4.4 - Chemical quality of water samples from dug well and hand pumps in Sundargarh district during post-monsoon

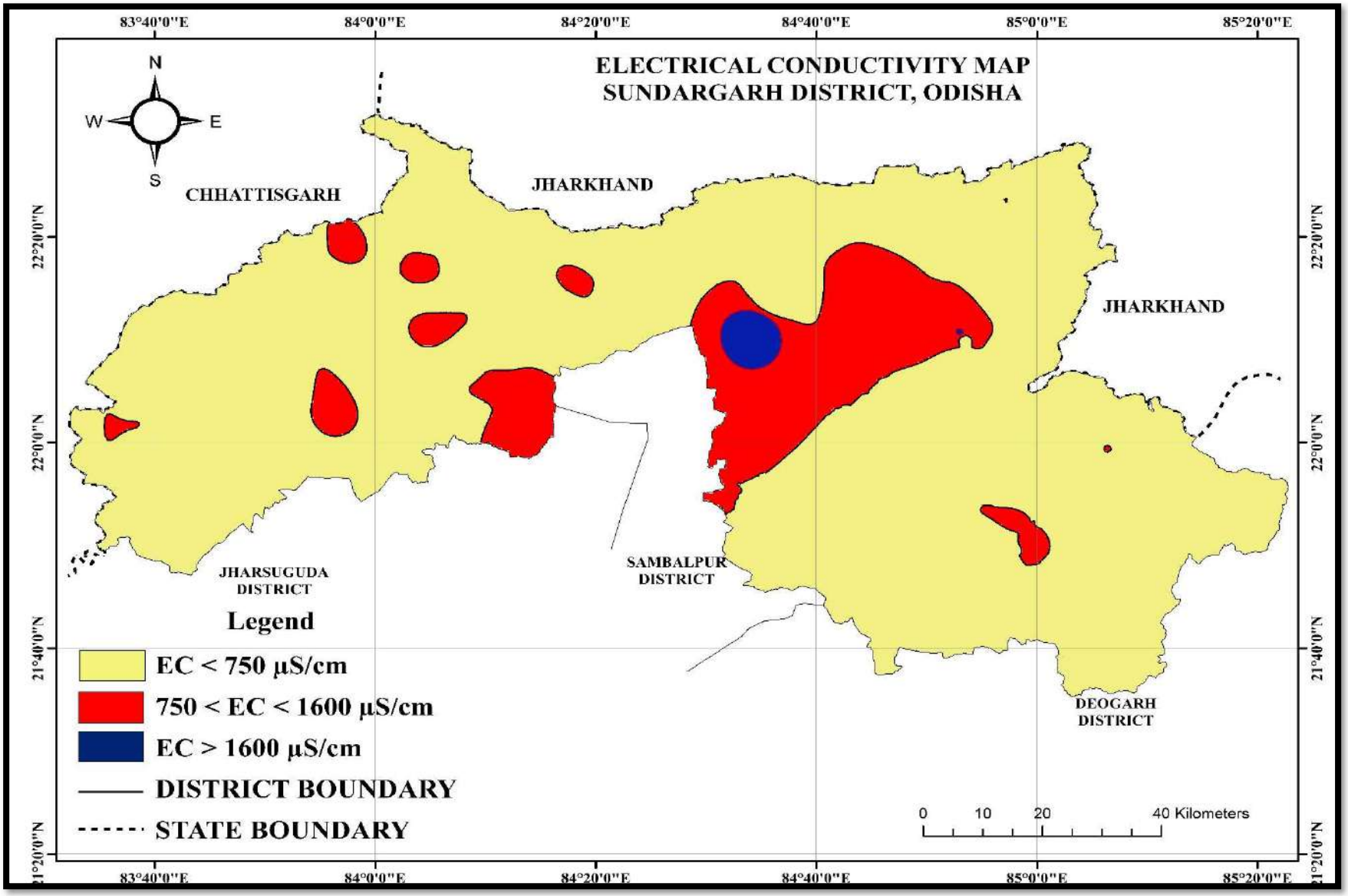
Sr no.	Chemical constituents (Concentrations in mg/l except pH, EC and U)	Maximum	Minimum
1	pH	8.11	7.06
2	EC (µs/cm) 25°C	1339	87
3	TDS	533	76.3
4	Alkanity	303.5	53.4
5	Ca^{+2}	55	11.94
6	Mg^{++}	59.15	3.13
7	Na^{+}	69.3	3.4
8	K^{+}	45.9	0.8
9	CO_3^{-2}	0	0
10	HCO_3^{-1}	370.2	29.9
11	Cl^{-}	105.6	8
12	SO_4^{-2}	86.1	1.8
13	NO_3^{-1}	45.3	0
14	F^{-}	1.21	0.07
15	U (in ppb)	9.6	0

Ground water quality of dug wells

A total of 103 and 25 ground water samples were collected from dug wells during pre-monsoon and post monsoon studies respectively. The range of concentrations of different chemical constituents present in the ground water samples are given in table 4.3 and 4.4.

It is deciphered from table 4.3 and 4.4 that the all the dug wells samples have pH values in the range from 8.28 to 7.06 during pre-monsoon and post monsoon season. No dug wells sample has pH value less than 6.5. So it can be inferred that the nature of ground water in the dug wells in both the seasons is neutral to slightly alkaline. The Fluoride concentration is also in the range of 126 to 0.06 during pre and post monsoon season and in permissible limit according to recommended by WHO Guidelines for Drinking Water Quality. 3rd Edition Vol. 1 Recommendations, 2008, IS 3025 (Part 60).

Figure 4.1 – Electrical conductivity Map, Sundargarh District, Odisha.



Assessment of ground water quality with various chemical diagram

Ground water quality has been assessed with the help of various chemical diagram such as Piper diagram, Wilcox diagram and Stiff diagram prepared with the help of Diagrame software.

Piper diagram

In order to understand water composition and chemical relationship between dissolved ions, Pipers trilinear diagram for graphical analysis (Figure 4.2) is used. This diagram reveals similarities and differences among water samples. Most of the water samples analyzed fall within the no dominant type in case of cations and some sample falls under calcium type and very few found in magnesium type. In case of anions, most of the samples are under bicarbonate type and few other samples under no dominant type and chloride type. These trends are reflected in the central diamond of the diagram where most of the samples fall under the category of alkaline dominant field in case of cations within which around 74 % of the samples falls under Magnesium bicarbonate (Mg-HCO3) type ,23% of the samples falls under mixed type and 3% both under calcium chloride (CaCl) type and sodium chloride (NaCl) type. In case of anions, most of samples are within weak acids (HCO3 - CO3) dominant field with few samples under strong acids (Cl-SO4) dominant type. The results suggest that Magnesium bicarbonate and mixed type are the dominant hydro chemical facies for the studied groundwater samples.

Wilcox diagram

According to Wilcox diagram (US Salinity Laboratory's diagram) in Figure 4.3 salinity and alkalinity hazard class of water samples were C2–S1 (70 %) and C3–S1 (17 %) and C1-S1 (13%). The result shows that most of the ground water samples possess low salinity with low sodium (C1–S1). Such water can be used directly for irrigation purpose. However, water samples falling in medium salinity and low sodium class(C2-S1) should be treated before using for irrigation purposes and water samples (C3-S1) falling under high salinity and low alkanity category which is hazardous for irrigation.

Water quality evaluation for irrigation purpose

To study the water quality for irrigation purpose, 103 water samples are collected during pre-monsoon and 25 water samples during post monsoon. Different chemical parameters like pH, electrical conductivity (EC), total dissolved solids (TDS), Ca2+, Mg2+, Na+, K+, Cl-, HCO3,CO3, SO4, F- and various chemical index such as sodium absorption ratio (SAR), sodium percentage(SP), residual sodium carbonate (RSC), Kelly's ratio and magnesium ratio were analyzed by adopting the standard procedures of water analysis. The feasibility check of ground water for irrigation purpose is given in Table No. 4.7. Suitability of the groundwater for irrigation purpose was discussed by the following basic criteria.

Chemical data plotting for Sundargarh District

Figure 4.2 – Piper Diagram

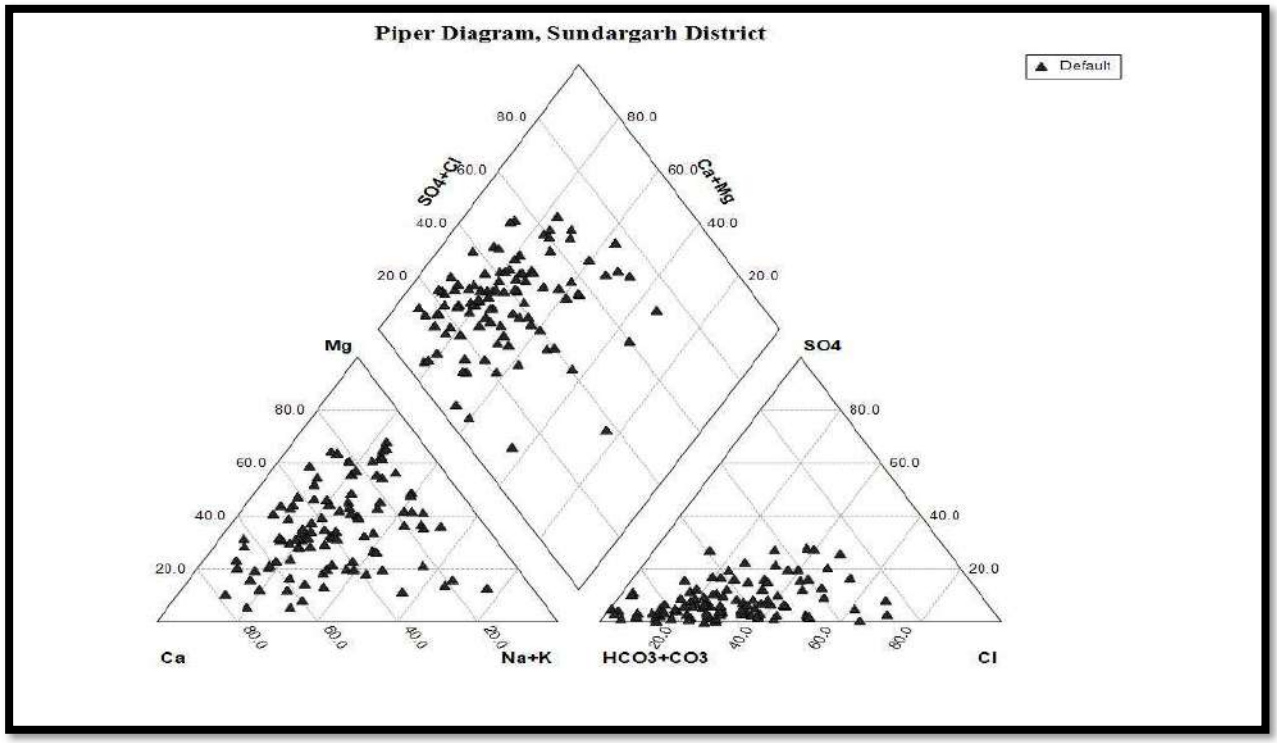
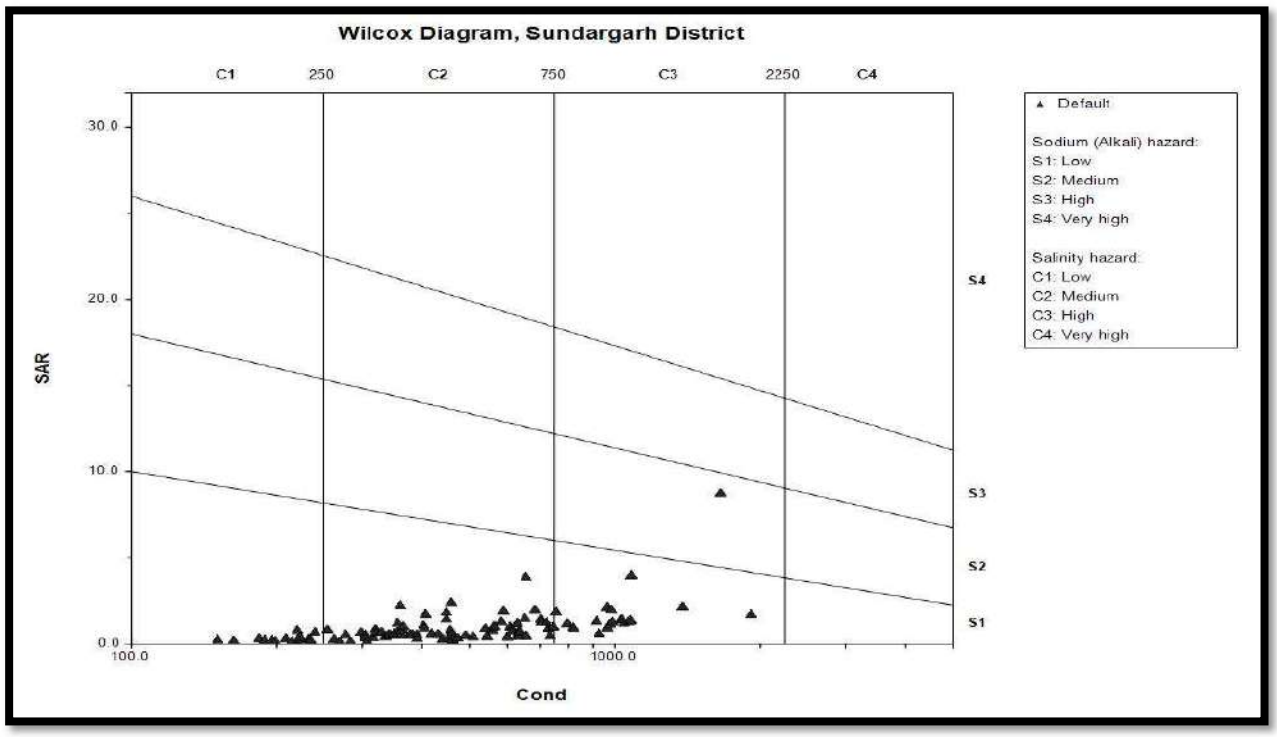


Figure 4.3 – Wilcox Diagram



pH

The pH of the water samples ranges from 7.06 to 8.028 during the pre-monsoon and post monsoon in the study area. All the water samples fall in the safe limit of pH standard (6–8.5) for irrigation purpose.

Salinity hazard

Determination of salinity hazard is very important in irrigation water, as high salt content renders the soil saline. This also affects the salt intake capacity of the plants through the roots. In the present study, the salinity hazard was evaluated by EC and TDS. EC varies from 151 to 1917 µS/cm during pre-monsoon and 87-1339 µS/cm during post monsoon. TDS varies from 80-984 mg/L during pre-monsoon and 76.3-533 mg/L during post monsoon. Based on the classification of TDS as suggested by USSL, all the water samples both from pre and post monsoon are classified as non-saline. According to the EC grading standards as suggested by Wilcox, 83% of from pre monsoon samples are classified as excellent category and 17 % of pre samples as good category. Therefore, the use of this excellent- good quality ground water for irrigation in the study area may not cause any salinity hazard.

Alkalinity Hazard (SAR)

Irrigation water is classified based on SAR. Hence, the assessment of sodium hazard is necessary while considering the suitability for irrigation. The SAR values of the groundwater samples from pre monsoon and post monsoon varies from 0.47-22.7 and 0.82-12.6 respectively. The SAR values of the water samples of the study area greater than 10 and are classified as high for irrigation. To determine the hazardous effect of sodium on water quality for irrigation, Percent Sodium (%Na) and Kelly's Index are calculated. The percent sodium (%Na) of pre monsoon samples varies from 10.91- 76.2% and the post monsoon samples varies from 13.43-70.96 %. Around 90% of the pre monsoon samples are categorized as excellent- permissible while 10% of the samples as doubtful while the 98 % post monsoon samples are categorized as excellent and 2 % are Doubtful for irrigation purpose. Around 92 % of the pre monsoon samples and 99 % of the post monsoon samples has Kelly's Index less than 1 and is classified as suitable for irrigation.

Magnesium Ratio

In the study area, Magnesium absorption ratio varies from 4.1 % to 82.4 % in pre monsoon and 12.42 % to 73.5 % in post monsoon. nearly 75 % of the pre monsoon water samples and 88% of the post monsoon samples has Mg ratio less than 50 % which is suitable for irrigation, as magnesium ratio of more than 50% indicate that the soil is more alkaline which adversely effects the crop yield.

Residual Sodium Carbonate (RSC)

The RSC index varies from -0.06 to 8.08 ppm and 0.061 to 3.16 ppm for pre monsoon and post monsoon water samples respectively.82% of the pre monsoon water samples are suitable for irrigation, 12% are marginally suitable and 6% are unsuitable for irrigation. 92% of the post monsoon water samples are suitable for irrigation and 8% are unsuitable. The water with high RSC has high pH and land irrigated by such water becomes infertile owing to deposition of sodium carbonate as indicated by the black color of the soil.

Table 4.7 - Feasibility check of ground water for irrigation purpose

Parameters	Range	Classification	Pre monsoon (No. samples)	Post monsoon (No. samples)
Total Dissolved Solid (TDS) (mg/L)	<1000	Non-saline	103	25
	1000-3000	Slightly saline	0	0
	3000-10000	Moderately saline	0	0
	>10000	Very saline	0	0
Salinity Hazard (EC) (µS/cm)	<250	Excellent	73	6
	250-750	Good	12	12
	750-2000	Permissible	18	7
	2000-3000	Doubtful	0	0
	>3000	Unsuitable	0	0
Alkalinity Hazard (SAR)	<10	Excellent	91	24
	Oct-18	Good	9	1
	18-26	Doubtful	2	0
	>26	Unsuitable	1	0
Percent Sodium (%Na)	<20	Excellent	15	1
	20-40	Good	56	12
	40-60	Permissible	23	10
	60-80	Doubtful	8	2
	>80	Unsuitable	1	0
Kelly's Index (KI)	<1	Suitable	94	24
	>1	Unsuitable	9	1
Magnesium Absorption Ratio (MR)	>50%	Unsuitable	27	3
	<50%	Suitable	76	22
Residual Sodium Carbonate (RSC)	<1.25	Suitable	71	18
	1.25-2.5	Marginally suitable	27	5
	>2.5	Unsuitable	6	2

5. Groundwater Resources

Dynamic Groundwater Resources of Sundargarh district has been estimated based on the methodology recommended by Groundwater Estimation Committee (GEC'2015). The present methodology used for resources assessment is known as Ground Water Resource Estimation Methodology – 2015 (GEC'2015). GEC 2015 recommends estimation of Replenishable and in-storage ground water resources for both unconfined and confined aquifers. In GEC'2015, two approaches are recommended – water level fluctuation method and norms of rainfall infiltration method. The resources computed for the groundwater year 2022-23. The following sub-units are recommended for the computation of various figures in the methodology and these are considered in details below:

Hilly Area: An area of 1547.21 sq.km which has more than 20% slope has been excluded for the recharge computation. As per Bhuvan, total recharge worthy area in the district is 8203.48 sq.km

Command and Non-Command Area- The methodology envisages computation of various figures separately for command & non-command area. In the district, there is a canal irrigation scheme and thus the rechargeable area has been divided into command and non-command area.

Total rechargeable area	Command area	Non-command area.
8203.48 sq.km	121.22 sq.km	8082.26 sq.km

Recharge from Rainfall- has been computed separately for monsoon and non-monsoon periods for the entire district. The average annual rainfall is 22953 mm and normal annual rainfall is about 21753 mm of which more than 80 % is precipitated from southwest monsoon between June-September The rainfall recharge estimated for both command and non-command area of the entire district and the details are shown in Annexure 5.1.

Recharge from All Sources- Total recharge to groundwater has several components, rainfall being the major one. The other components include seepage from canals, return flow from surface water irrigation, return flow from groundwater irrigation, seepage from tanks/ ponds etc. The recharge from all other sources is estimated for both command and non-command area of the entire district and the details are shown in Annexure 5.1.

Recharge from various sources has been calculated for monsoon as well as non-monsoon periods and details have been shown in Table 5.1.

Table 5.1- Groundwater recharge from various sources (Ham).

Assessment Unit/ District	Command/ Non-Command/ Total	Recharge from rainfall	Recharge from other sources	Total Annual Ground Water Recharge	Provision for Natural Discharges	Annual Extractable Ground Water
Sundargarh	Command	1,118.64	3606.26	4,724.90	472.49	4252.42
	Non-command	70,819.34	10767.11	81,586.45	6,395.79	75190.67
	Total	**71,937.98**	**14373.37**	**86,311.35**	**6868.28**	**79,443.09**

5.1 Groundwater extraction for Various Purposes

Groundwater extraction for domestic use has been estimated based on number of households using groundwater (Census 2011 data). Groundwater draft for domestic purpose is 6139.77 ham, for irrigation 23137.12 ham and for industrial use 2152.54 ham. It was found that groundwater draft for all uses in the district is 31429.43 ham.

5.2 Stage of Groundwater extraction & Categorization of the Blocks

The district falls under "SAFE" category. The stage of GW extraction is 39.56 %. Summary of groundwater resources, stages of development and categorization are given in Annexure 5.1.

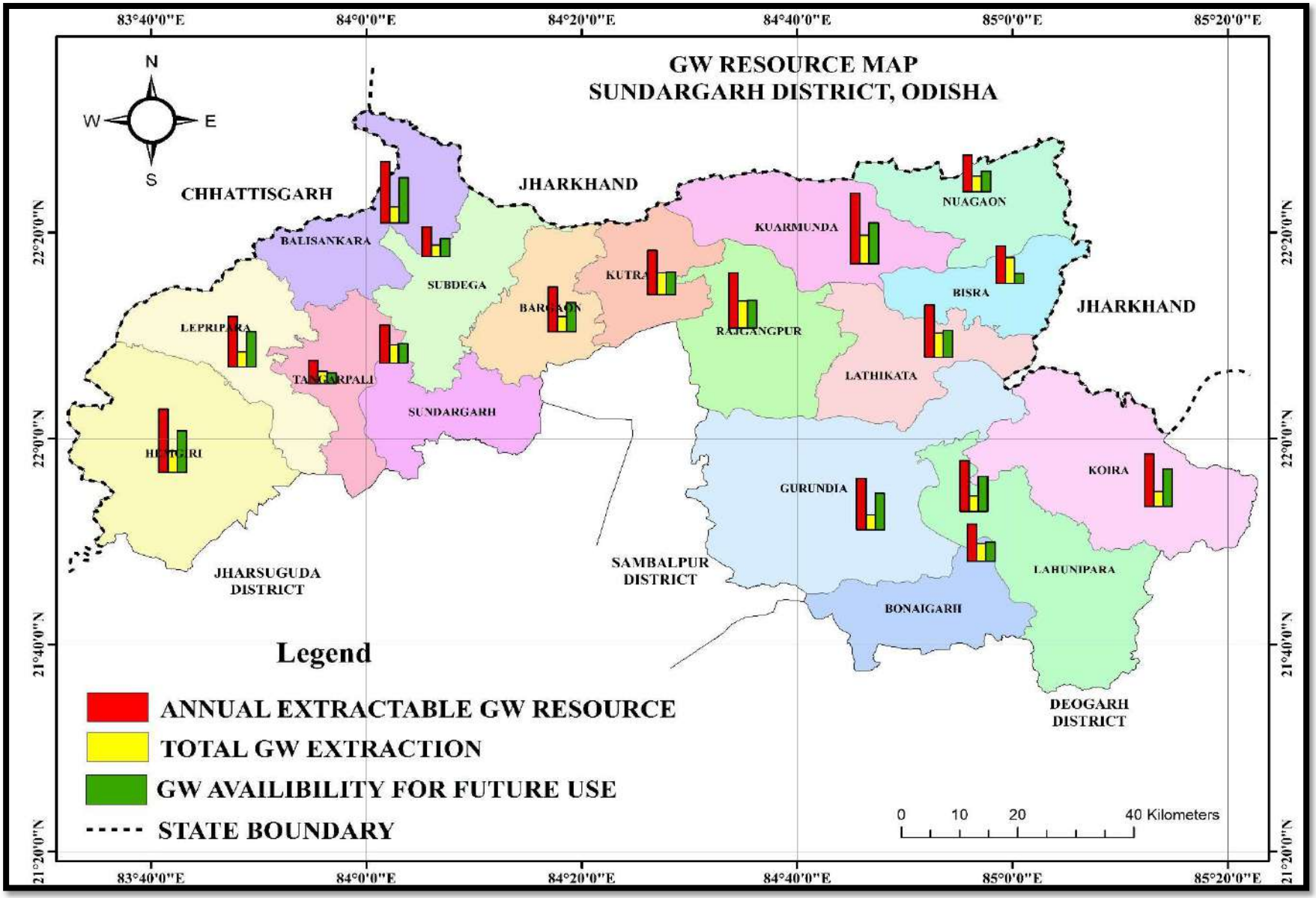
5.3 Summarized results of dynamic ground water resources of Sundargarh district as on March 2023

The summarized results of dynamic ground water resources estimation of Sundargarh district as on March 2023 is shown in the Table 5.2.

Table 5.2- Summarized results of dynamic ground water resources of Sundargarh district as on March 2023

Sl. No.	ITEM	Year, 2021-22
	Methodology	**GEC 2015(in ham)**
1	Total Annual Ground Water Recharge	86,311.35
2	Total Natural Discharges	6868.28
3	Annual Extractable Ground Water Resource	79,443.09
4	Total annual Ground water extraction	31429.43
5	Annual GW Allocation for Domestic Use as on 2025	6671.02
6	Net Ground Water Availability for future use	47482.4
7	Stage of GW Development (%)	39.56 %

Figure 5.1 – GW Resource Map of Sundargarh District, Odisha.



6. Ground Water Related Issues

- **Falling ground water trend and higher stages of GW extraction**

  10 blocks of Sundargarh district are showing falling ground water trend and have higher stage of ground water extraction. In the block of Bisra, stage of ground water extraction is almost 70%. Table 6.1 shows the affected blocks with the stage of ground water extraction. Figure 6.1 shows the area with declining water trend and area having decadal mean water level more than 5mbgl.

Table 6.1 – Affected locks with stage of ground water extraction

Blocks	Stage of Ground Water Extraction (%)
Balishankara	26.1
Baragaon	34.6
Bisra	69.4
Hemgiri	33.8
Kutra	48.8
Lefripada	29.7
Nuagaon	43.2
Subdega	38.6
Sundargarh	48.3
Tangarpalli	52.9

- **High run off zone in Hilly Areas:**

  In the north-western parts of the study area (parts of Hemgiri, Lephripada and Balisankara block); north-eastern parts (parts of Subdega and Balisankara block) and south-eastern parts of Sundargarh block, average annual rainfall is 1274 mm but have high run off zone. Similarly, in the Bonai sub division (in Gurundia block and Koira) comprised of hilly, undulating, and plain terrains, with annual rainfall of 1613 mm but falls in high run off zone. In these areas the thin weathered zone developed on the hard rocks on hill and hill slope areas are the main reservoir of ground water. Once they get saturated, during monsoon the excess water instead of recharging the ground water by percolation, flows as run off and base flow. It acts as recharge area but during the post-monsoon period the thin weathered portion may even lose their entire water due to base flow. So, there is scarcity of water in these areas in lean and summer season.

- **High nitrate concentration**:
  Based on the chemical analyses of water samples collected from different aquifers, it is observed that at some localized patches high nitrate values have been observed according to the Indian standard Drinking water specification IS10500: 2012 as shown in Table 6.2. It is directly attributed to human activities such as improper disposal of human, animal and agricultural wastes and improper use of nitrogenous fertilizers. Since higher concentrations exceeding 45 mg/l is dangerous for consuming too much nitrate can affect how blood carries oxygen and can cause methemoglobinemia (also known as blue baby syndrome). Bottle-fed babies under six months old are at the highest risk of getting methemoglobinemia. Methemoglobinemia can cause skin to turn a bluish color and can result in serious illness or death. Other symptoms connected to methemoglobinemia include decreased blood pressure, increased heart rate, headaches, stomach cramps, and vomiting detrimental to human health and sometimes fatal to the infants. So, better management is required to check 11 further nitrate pollution and steps should be taken to reduce its concentration in water for human consumption

Table 6.2 - Details of wells having Nitrate concentration higher than permissible limit

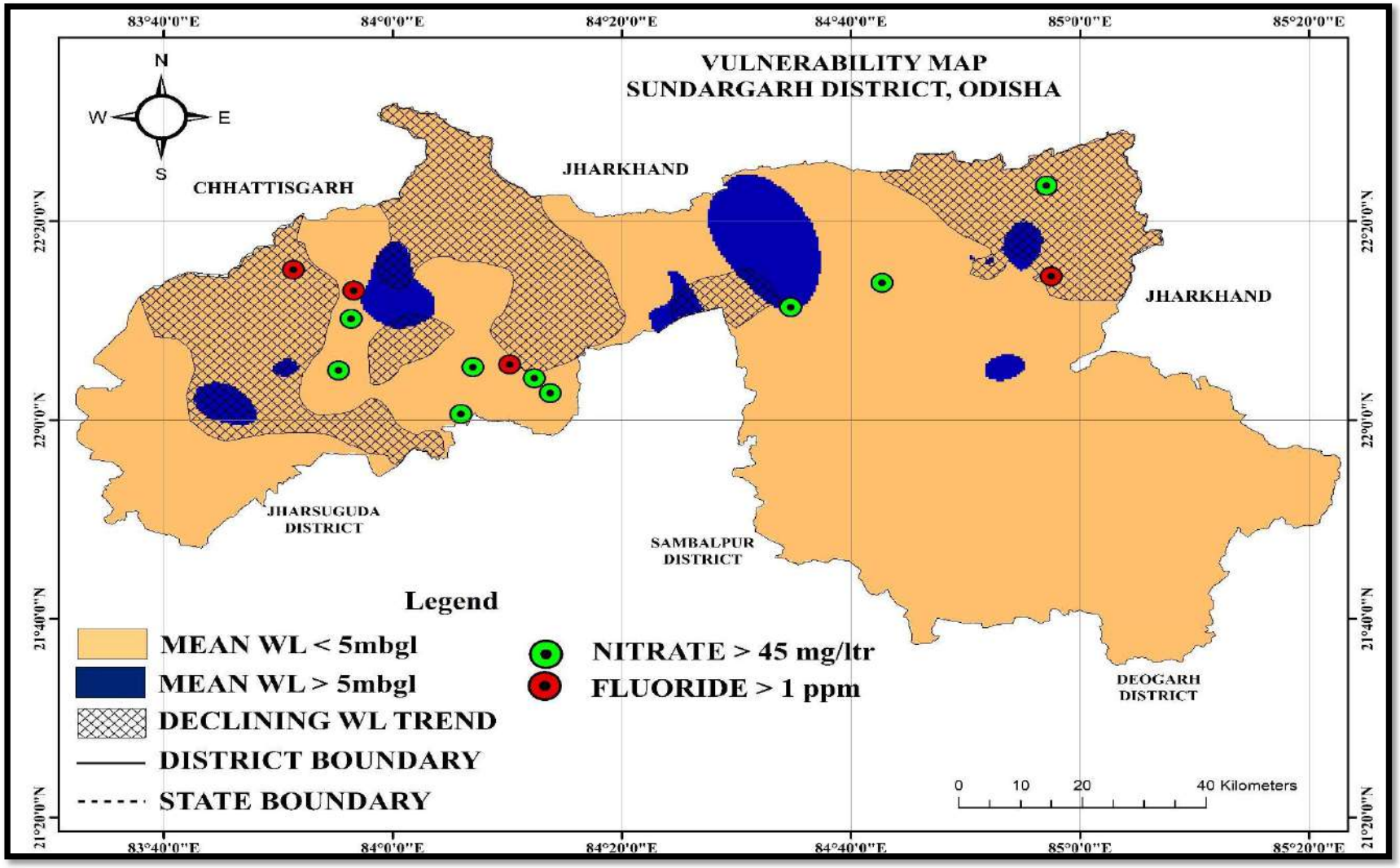
Sr. no.	District	Block	Village	Latitude	Longitude	Nitrate value (mg/l)
1.	Sundargarh	Tangarpali	Ujjalpur	22.0834	83.92059	48.03
2.	Sundargarh	Sundargarh	Lahandabud	22.0926	84.1698	47.26
3.	Sundargarh	Sundargarh	Birbira	22.0701	84.2059	47.61
4.	Sundargarh	Sundargarh	Philingbahal	22.04461	84.22911	48.06
5.	Sundargarh	Sundargarh	Kinjrima	22.0095	84.0985	46.17
7.	Sundargarh	Rajgangpur	Rajgangpur	22.18944	84.57889	46.03
8.	Sundargarh	Nuagaon	Nuagaon	22.23	84.7116	45.8
9.	Sundargarh	Hemgir	Sonajori	22.03	83.78119	45.3

- **High Fluoride concentration**:
  Based on the chemical analyses of water samples collected from different aquifers, it is also observed that at some localized patches high fluoride concentration values have been observed according to the Indian standard Drinking water specification IS10500: 2012 shown in Table 6.3.

Table 6.3 - Details of wells having Fluoride concentration higher than permissible limit

Sr. no.	District	Block	Village	Latitude	Longitude	Fluoride value (ppm)
1.	Sundargarh	Bisra	Kukdagate	22.241	84.958	1.0
2.	Sundargarh	Lephripada	Kharalmunda	22.252	93.855	1.1
3.	Sundargarh	Tangarpali	Khamarimunda	22.217	83.943	1.26
4.	Sundargarh	Sundargarh	Lahandabud	22.093	84.17	1.4

Figure 6.1 – Vulnerability map, Sundargarh district, Odisha.



- **Ground water quality issues for irrigation purposes**:
  According to the chemical data of sample collected from key wells during pre-monsoon and post monsoon, various irrigation related parameter has been calculated such as Total Dissolved Solid (TDS), Salinity Hazard (EC), Alkalinity Hazard (SAR), Percent Sodium (%Na), Kelly's Index (KI), Magnesium Absorption Ratio (MR), Residual Sodium Carbonate (RSC).

Alkalinity Hazard (SAR):

2 location found doubtful category while 1 location is unsuitable in nature, the details of the affected area described in Table no. 6.4.

Table 6.4 - Details of wells having Alkalinity Hazard (SAR) value higher than permissible limit.

Sr. no.	District	Block	Village	Latitude	longitude	(SAR)	Classification
1.	Sundargarh	Tangarpali	Ujjalpur	22.0834	83.92059	22.7	**Doubtful**
2.	Sundargarh	Gurundia	Kucheta	22.08833	84.904722	**21.8**	**Doubtful**
3.	Sundargarh	Lathikata	Asurchhapal	22.17694	84.883889	**50.6**	**Unsuitable**

The higher the sodium adsorption ratio, the less suitable the water is for irrigation. Irrigation using water with high sodium adsorption ratio may require soil amendments to prevent long-term damage to the soil. If irrigation water with a high SAR is applied to a soil for years, the sodium in the water can displace the calcium and magnesium in the soil. This will cause a decrease in the ability of the soil to form stable aggregates and a loss of soil structure and tilth. This will also lead to a decrease in infiltration and permeability of the soil to water, leading to problems with crop production.

Percent Sodium (%Na):

13 % and 8 % are in doubtful category in pre-monsoon and post monsoon respectively. Details of 9 location from pre monsoon and 2 locations from post monsoon which come under doubtful category are listed in Table 6.5.

Table 6.5 - Details of wells having Percent sodium (% Na) value higher than permissible limit

Sr. no.	District	Block	Village	Latitude	longitude	Percent sodium (% Na)	Classification
	Pre-monsoon						
1.	Sundargarh	Tangarpali	Ujjalpur	22.0834	83.92059	76.18	**Doubtful**
2.	Sundargarh	Balisankara	Bagiaberni (Rauldega)	22.38724	84.0482	**65.35**	**Doubtful**
3.	Sundargarh	Balisankara	Sagbahal	22.46434	84.08546	**64.97**	**Doubtful**
4.	Sundargarh	Bargaon	Pamra	22.2578	84.3066	**69.78**	**Doubtful**
5.	Sundargarh	Gurundia	Gopalpur	22.1025	84.898889	**61.81**	**Doubtful**
6.	Sundargarh	Gurundia	Kucheta	22.08833	84.904722	**71.92**	**Doubtful**
7.	Sundargarh	Lathikata	Asurchhapal	22.17694	84.883889	**82.42**	**Unsuitable**
8.	Sundargarh	Luhanipara	Kurda	21.81556	85.001667	**61.72**	**Doubtful**
9.	Sundargarh	Sundargarh	Bijadihi	22.0701	84.2471	**67.43**	**Doubtful**
Post Monson							
1.	Sundargarh	Garjanbahal	Hemgir	22.01197	83.76572	**61.46**	**Doubtful**
2.	Sundargarh	Karlikachar	Hemgir	22.01534	83.74309	**70.96**	**Doubtful**

Kelly's Index (KI):

8.7 % and 4 % sample under unsuitable condition from pre-monsoon and post monsoon respectively. Details of 9 locations from pre monsoon and 1 location from post monsoon which come under unsuitable category are listed in Table 6.6.

Residual Sodium Carbonate (RSC):

6.8 % sample are unsuitable from pre-monsoon and 8 % sample are unsuitable from post monsoon within study area, the details of 7 affected area from pre-monsoon and 2 from post monsoon listed in Table 6.7.

In regions, where underground waters available for irrigation have high residual sodium carbonate (RSC) their indiscriminate use for irrigation often causes excessive accumulation of salts and led to rapid salinization and solidification of the soil profile which adversely affect the crop growth.

Table 6.6 - Details of wells having Kelly's Index value higher than permissible limit

Sr. no.	District	Block	Village	Latitude	longitude	Kelly index	Classification
	Pre-monsoon						
1.	Sundargarh	Tangarpali	Ujjalpur	22.0834	83.92059	2.061	**Unsuitable**
2.	Sundargarh	Balisankara	Bagiaberni (Rauldega)	22.38724	84.0482	**1.66**	**Unsuitable**
3.	Sundargarh	Sabdega	Sudarshanpur	22.22821	84.11033	**1.368**	**Unsuitable**
4.	Sundargarh	Bargaon	Pamra	22.2578	84.3066	**1.162**	**Unsuitable**
5.	Sundargarh	Gurundia	Gopalpur	22.1025	84.898889	**1.594**	**Unsuitable**
6.	Sundargarh	Gurundia	Kucheta	22.08833	84.904722	**2.466**	**Unsuitable**
7.	Sundargarh	Lathikata	Asurchhapal	22.17694	84.883889	**4.487**	**Unsuitable**
8.	Sundargarh	Nuagaon	Nuagaon	22.23	84.7116	**1.005**	**Unsuitable**
9.	Sundargarh	Sabdega	Gaibira	22.2962	84.1172	**1.113**	**Unsuitable**
Post Monsoon							
1.	Sundargarh	Karlikachar	Hemgir	22.01534	83.74309	**1.14**	**Unsuitable**

Table 6.7 - Details of wells having Residual Sodium carbonate (RSC) value higher than permissible limit.

Sr. no.	District	Block	Village	Latitude	longitude	RSC	Classification
	Pre-monsoon						
1.	Sundargarh	Balisankara	Khamarimunda	22.21661	83.94315	2.79	**Unsuitable**
2.	Sundargarh	Balisankara	Tildega	22.31978	83.94236	**2.68**	**Unsuitable**
3.	Sundargarh	Sabdega	Katingidihi	22.19152	84.1098	**2.85**	**Unsuitable**
4.	Sundargarh	Kutra	Nuagan	22.3127	84.3931	**3.63**	**Unsuitable**
5.	Sundargarh	Rajgangpur	Rajgangpur	22.18944	84.57889	**2.72**	**Unsuitable**
6.	Sundargarh	Balisankara	Tumlia	22.31692	84.0862	**3.13**	**Unsuitable**
7.	Sundargarh	Lathikata	Asurchhapal	22.17694	84.883889	**8.08**	**Unsuitable**
Post Monsoon							
1.	Sundargarh	Karlikachar	Hemgir	22.01534	83.74309	**3.16**	**Unsuitable**

- **Future demand -**

The most common use of extracted ground water is for domestic, livestock, irrigation, industrial purpose. The total water demand in 2035 and subsequent water gap for the district was calculated from the available dynamic groundwater resource (GWRE, 2022 of CGWB) and the surface water availability data present in the district report (DIP, Sundargarh district). The projected total water demand in 2035 and subsequent water demand gap has been shown Table no. 6.8.

Table 6.8- Block wise total water availability and gross water demand along with the water demand gap in Sundargarh District.

Block	Water availability			Total Water Demand 2035 (Ham) (2)	Water Demand Gap 2035 (Ham) (1-2)
	Surface water available (Ham)	Ground water available (Ham)	Total water available (Ham) (1)		
Balisankara	11134.73	6093.15	17227.88	13961.92	-
Baragaon	6475.36	4445.63	10920.99	12401.01	1480.02
Bisra	6644.79	3714.96	10359.75	9398.29	-
Bonaigarh	5453.01	3719.62	9172.63	13564.50	4391.87
Gurundia	3358.35	5115.64	8473.99	12729.41	4255.42
Hemgir	4557.41	6296.52	10853.93	13876.86	3022.93
Koida	3333.95	5220.75	8554.7	11359.04	2804.34
Kuanrmunda	5442.05	7020.73	12462.78	18188.25	5725.47
Kutra	6505.52	4404.43	10909.95	12565.40	1655.45
Lahunipara	11075.15	5065.73	16140.88	15249.40	-
Lathikata	11607.3	5171.48	16778.78	21224.34	4445.56
Lephripada	10492.84	5042.55	15535.39	12250.88	-
Nuagaon	6116.25	3592.8	9709.05	23315.03	13605.98
Rajagangapur	13747	5489.46	19236.46	14316.52	-
Subdega	6781.35	2964.17	9745.52	12618.51	2872.99
Sundargarh	7631.5	3798.94	11430.44	14941.53	3511.09
Tangarpali	7303.9	2286.53	9590.43	13106.63	3516.20
Total	**127660.5**	**79443.09**	**207103.55**	**245067.52**	**37963.97**

Chapter 7 - Management Strategy

a. Water demand, availability, and water gap analysis -

To calculation the water demand and water gap, domestic water demand, crop water demand, livestock water demand and industrial water demand data are taken from PMKSY report of Sundargarh District (2015), District Statistical Handbook (2018), Odisha. Then based on interpolation technique demand for 2035 has been extrapolated. The ground water availability data taken from CGWB, Ground water resources assessment (2022).

Domestic Water Demand

The gross population of the district in 2011 census was 2093437. With a decadal growth rate of 14.4 %, in 2035 the projected population will be 2847074. The gross domestic water demand will be 6235.09 Ham.

Projection of population and domestic water demand for 2035 in different blocks have been elaborated in Table-7.1.

Table 7.1 – Domestic water demand, Sundargarh District.

Sr No.	District	Population 2011	Projected Population 2035	Gross Domestic Demand 2035 (Ham)
1	Balisankara	85690	116538.4	255.219096
2	Baragaon	71242	96890	212.1871728
3	Bisra	575620	782843	1714.426608
4	Bonaigarh	69891	95052	208.1633544
5	Gurundia	66988	91104	199.5170592
6	Hemgir	84559	115000	251.8505256
7	Koida	86818	118072	258.5787312
8	Kuarmunda	140355	190883	418.000002
9	Kutra	80470	109439	239.671848
10	Lahunipara	99526	135355	296.4282384
11	Lathikata	146312	198984	435.7756608
12	Lephripada	78808	107179	234.7217472
13	Nuagaon	106156	144372	316.1750304
14	Rajagangpur	156427	212741	465.9021768
15	Subdega	64254	87385	191.3741136
16	Sundargarh	115947	157688	345.3365448
17	Tangarpali	64374	87549	191.7315216
	Total	**2093437**	**2847074**	**6235.092761**

Crop Water Demand:

The Kharif crop (Paddy) water demand is 1.172 bcm while the Rabi crop water demand is 0.36 bcm. The rabi crops include paddy and vegetables, pulses, fruits etc. the gross water demand in 2015 was 1.532 bcm or 153189.85 Ham. Projecting the crop water demand to 2035, the gross water demand in 2035 is 237137.88 Ham. The block wise crop water demand of Sundargarh district has been shown in Table 7.2.

Table 7.2 – Crop water demand, Sundargarh District

Sr No.	Blocks	2015				2035
		Kharif Crop Water Demand (bcm)	Rabi Crop Water Demand (bcm)	Gross Water Demand (bcm)	Gross Water Demand (Ham)	Projected Gross Water Demand (Ham)
1	Balishankara	0.067	0.020	0.088	8774.225	13582.500
2	Bargaon	0.061	0.017	0.078	7800.975	12075.909
3	Bisra	0.035	0.023	0.058	5821.300	9011.372
4	Bonai	0.064	0.018	0.082	8189.500	12677.346
5	Gurundia	0.064	0.017	0.080	8014.350	12406.214
6	Hemgir	0.071	0.016	0.088	8756.800	13555.526
7	Koida	0.055	0.015	0.069	6940.350	10743.662
8	Kuarmunda	0.088	0.024	0.113	11262.175	17433.847
9	Kutra	0.060	0.019	0.079	7863.025	12171.963
10	Lahunipada	0.073	0.022	0.096	9571.775	14817.108
11	Lathikata	0.102	0.031	0.134	13351.750	20668.509
12	Lephripada	0.058	0.019	0.077	7689.325	11903.075
13	Nuagaon	0.117	0.031	0.148	14765.775	22857.420
14	Rajgangpur	0.058	0.029	0.087	8727.525	13510.209
15	Subdega	0.060	0.020	0.080	7976.500	12347.622
16	Sundargarh	0.073	0.022	0.094	9449.950	14628.523
17	Tangarpalli	0.066	0.016	0.082	8234.550	12747.083
Total		**1.172**	**0.360**	**1.532**	**153189.850**	**237137.888**

Livestock Water Demand:

The livestock have been categorized into three types depending on the daily water requirement. The poultry needs 5ltrs/day, small animals consisting of ducks pigs goats, sheep need 10 ltr/day while the larger animals like hybrid cows, buffaloes, other cattle need 25ltrs/day. Based on these specifications, the total poultry water demand is 193.348 Ham, total small animal water demand is 442.56 Ham, while for large animals, the water demand is 354.41 Ham. The total livestock demand is 990.32 Ham. Block wise livestock water demand is presented in Table 7.3.

Table 7.3 – Livestock water demand, Sundargarh District

Block	Poultry Water demand (Ham)	Small Animals Water demand (Ham)	Large Animals Water demand (Ham)	Total livestock demand (Ham)
Balisankra	12.876105	16.447995	21.9921625	51.3162625
Bargaon	9.0332025	12.67134	20.5120875	42.21663
Bishra	11.18141	12.565125	21.679175	45.42571
Bonai	13.942635	207.46673	20.387075	241.79644
Gurundia	13.5905925	17.24771	21.0541125	51.892415
Hemgir	9.834925	10.871525	12.3360875	33.0425375
Koida	11.59897	10.469295	21.168175	43.23644
Kuarmunda	12.995825	21.071085	27.778325	61.845235
Kutra	11.440195	12.37715	19.514725	43.33207
Lahunipara	13.1011275	27.650575	22.223025	62.9747275
Lathikata	9.982385	14.317125	23.96225	48.26176
Lephripara	8.122345	12.52096	20.6526125	41.2959175
Nuagaon	14.5917875	25.788345	22.75045	63.1305825
Rajgangpur	14.9885425	14.386475	19.1104875	48.485505
Subdega	9.33597	12.01799	21.719325	43.073285
Sundargarh	8.97535	8.471285	19.080375	36.52701
Tangarpali	7.757345	6.22252	18.489075	32.46894
Total	**193.3487125**	**442.56323**	**354.409525**	**990.3214675**

Industrial Water Demand:

The industrial growth is considered at 4%. Based on the water demand for industries in 2019 and 2022, the projected industrial water demand in 2035 has been calculated. The total industrial water demand is 2536.75 Ham. Block wise industrial water demand is presented in Table 7.4.

Table 7.4 – Industrial water demand, Sundargarh District

Block	Industrial Water Demand 2019 (Ham)	Industrial Water Demand 2022 (Ham)	Projected Industrial Water Demand 2035 (Ham)
Balishankara	56.358	57.46	72.888
Baragaon	37.572	39.78	70.692
Bisra	56.358	57.46	72.888
Boneigarh	435.24	435.37	437.19
Gurundia	46.965	48.62	71.79
Hemgiri	28.179	28.73	36.444
Koira	290.16	291.72	313.56
Kuanrmunda	345.03	346.97	374.13
Kutra	93.93	95.03	110.43
Lahunipada	56.358	57.46	72.888
Lathikata	46.965	48.62	71.79
Lefripada	46.965	48.62	71.79
Nuagaon	46.5	48.62	78.3
Rajgangpur	439.425	439.79	444.9
Subdega	28.179	28.73	36.444
Sundargarh	47.43	48.62	65.28
Tangarpalli	23.4825	30.94	135.345
Total	**2125.0965**	**2152.54**	**2536.749**

Based on the total surface water and total ground water availability, the total available water is calculated. Blocks of Balishankara, Lahunipara, Lephiripada, Rajagangapur do not show water demand gap in 2035. They have sufficient water resources to meet their total water demand in 2035. Block wise total water availability and gross water demand along with the water demand gap is shown in Table no.7.5.

Table 7.5- Block wise total water availability and gross water demand along with the water demand gap in Sundargarh District.

Block	Water availability			Domestic Water Demand 2035 (Ham)	Irrigation Water Demand 2035 (Ham)	Livestock Water Demand 2035 (Ham)	Industrial Water Demand 2035 (Ham)	Total Water Demand 2035 (Ham) (2)	Water Demand Gap 2035 (Ham) (1-2)
	Surface water available (Ham)	Ground water available (Ham)	Total water available (Ham) (1)						
Balisankara	11134.73	6093.15	17227.88	255.22	13582.50	51.32	72.89	13961.92	-
Baragaon	6475.36	4445.63	10920.99	212.19	12075.91	42.22	70.69	12401.01	1480.02
Bisra	6644.79	3714.96	10359.75	1714.42	9011.37	45.43	72.89	10844.11	484
Bonaigarh	5453.01	3719.62	9172.63	208.16	12677.35	241.80	437.19	13564.50	4391.87
Gurundia	3358.35	5115.64	8473.99	199.52	12406.21	51.89	71.79	12729.41	4255.42
Hemgir	4557.41	6296.52	10853.93	251.85	13555.53	33.04	36.44	13876.86	3022.93
Koida	3333.95	5220.75	8554.7	258.58	10743.66	43.24	313.56	11359.04	2804.34
Kuanrmunda	5442.05	7020.73	12462.78	418.03	17433.85	61.85	374.13	18287.85	5825.06
Kutra	6505.52	4404.43	10909.95	239.67	12171.96	43.33	110.43	12565.40	1655.45
Lahunipara	11075.15	5065.73	16140.88	296.43	14817.11	62.97	72.89	15249.40	-
Lathikata	11607.3	5171.48	16778.78	435.78	20668.51	48.26	71.79	21224.34	4445.56
Lephripada	10492.84	5042.55	15535.39	234.72	11903.08	41.30	71.79	12250.88	-
Nuagaon	6116.25	3592.8	9709.05	316.18	22857.42	63.13	78.30	23315.03	13605.98
Rajagangapur	13747	5489.46	19236.46	465.90	13510.21	48.49	444.90	14469.49	-
Subdega	6781.35	2964.17	9745.52	191.37	12347.62	43.07	36.44	12618.51	2872.99
Sundargarh	7631.5	3798.94	11430.44	345.34	14628.52	36.53	65.28	15075.67	3645.35
Tangarpali	7303.9	2286.53	9590.43	191.73	12747.08	32.47	135.35	13106.63	3516.20
Total	**127660.5**	**79443.09**	**207103.55**	**6235.09**	**237137.89**	**990.32**	**2536.75**	**246900**	**52005.17**

b. Management Strategies –

1. **Crop diversification** - it is observed that in the Rabi season, a significant area comes under the paddy cultivation which would create an extensive irrigation water demand. If that area is diversified into variable crop which are less irrigation water demanding, then a significant amount of water demand can be reduced. Some of the crops are –
   i. Millets, Maize.
   ii. Fruit crops - Grapes, banana, pomegranates, mango, orange, cashew nuts, papaya, litchi, watermelon
   iii. Vegetable plants - Onion, brinjal, bitter gourd, ridge gourd, cucumber, tomato, chilly, capsicum etc.
   iv. Oil seeds - Sunflower, oil palm.
   v. Forest crop – bamboo, teakwood.

2. **Irrigation techniques –** apart from the traditional irrigation techniques which are heavy water demanding, innovative techniques may be utilized for irrigation which are upto 60% less water demanding like –
   i. Sub surface drip irrigation
   ii. Sprinkler irrigation

   Based on the above two strategies, the total irrigation water demand can be reduced. Block wise reduced irrigation demand is shown in Table no.7.6.

Table 7.6- Block wise reduced irrigation water demand in Sundargarh District.

District	Total Irrigation water demand in 2035 (Ham)	Total Irrigation water demand with crop diversification and modern irrigation practises in 2035 (Ham)	Reduced water demand (Ham)
Balishankara	13582.50	11692.83	1890
Bargaon	12075.91	10475.15	1601
Bisra	9011.37	6847.36	2164
Bonai	12677.35	11003.32	1674
Gurundia	12406.21	10866.77	1539
Hemgir	13555.53	12053.42	1502
Koida	10743.66	9379.81	1364
Kuarmunda	17433.85	15181.21	2253
Kutra	12171.96	10436.43	1736
Lahunipada	14817.11	12748.60	2069
Lathikata	20668.51	17771.07	2897
Lephripada	11903.08	10104.11	1799
Nuagaon	22857.42	19982.48	2875
Rajgangpur	13510.21	10796.00	2714
Subdega	12347.62	10466.85	1881
Sundargarh	14628.52	12620.04	2008
Tangarpalli	12747.08	11238.62	1508
	237137.89	**203664.08**	**33474**

Table 7.7- Block wise modified water demand gap after crop diversification and drip irrigation practise in Sundargarh District.

Block	Surface water (ham)	Ground water (ham)	Total water available (ham)	Domestic Demand 2035 (ham)	Irrigation Demand 2035 (ham)	Livestock Demand 2035 (ham)	Industrial Demand 2035 (ham)	Total Water Demand 2035 (ham)	Water Gap 2035 (ham)
Balisankara	11134.73	6093.15	17227.88	255.2191	11692.8335	51.32	72.888	12072.26	0.00
Baragaon	6475.36	4445.63	10920.99	212.1872	10475.1457	42.22	70.692	10800.24	0.00
Bisra	6644.79	3714.96	10359.75	1714.426	6847.36128	45.43	72.888	8680.11	0.00
Bonaigarh	5453.01	3719.62	9172.63	208.1634	11003.3233	241.80	437.19	11890.47	2717.84
Gurundia	3358.35	5115.64	8473.99	199.5171	10866.7742	51.89	71.79	11189.97	2715.98
Hemgir	4557.41	6296.52	10853.93	251.8505	12053.4246	33.04	36.444	12374.76	1520.83
Koida	3333.95	5220.75	8554.7	258.5787	9379.81188	43.24	313.56	9995.19	1440.49
Kuanrmunda	5442.05	7020.73	12462.78	418.0333	15181.205	61.85	374.13	16035.21	3572
Kutra	6505.52	4404.43	10909.95	239.6718	10436.4302	43.33	110.43	10829.86	0.00
Lahunipara	11075.15	5065.73	16140.88	296.4282	12748.6004	62.97	72.888	13180.89	0.00
Lathikata	11607.3	5171.48	16778.78	435.7757	17771.071	48.26	71.79	18326.90	1548.12
Lephripada	10492.84	5042.55	15535.39	234.7217	10104.1056	41.30	71.79	10451.91	0.00
Nuagaon	6116.25	3592.8	9709.05	316.175	19982.4818	63.13	78.3	20440.09	10731.04
Rajagangapur	13747	5489.46	19236.46	465.902	10795.9997	48.49	444.9	11755.29	0.00
Subdega	6781.35	2964.17	9745.52	191.3741	10466.8484	43.07	36.444	10737.74	992.22
Sundargarh	7631.5	3798.94	11430.44	345.3365	12620.039	36.53	65.28	13067.18	1637
Tangarpali	7303.9	2286.53	9590.43	191.7315	11238.6193	32.47	135.345	11598.16	2007.73
Total	127660.5	79443.09	207103.6	6235.1	203664.075	990.32	2536.749	213426.24	28883.25

With crop diversification and drip irrigation techniques now blocks of Balishankara, Baragaon, Bisra, Lahunipara, Lephiripada, Kutra, Rajagangapur do not show water demand gap in 2035.

The total water gap in the remaining blocks is 28883.25 Ham in 2035.

3. **Artificial recharge structures** –

Based on the calculations for the water demand gap, blocks of Bonaigarh, Gurundia, Hemgir, Koida, Kuanrmunda, Lathikata, Nuagaon, Subdega, Sundargarh, Tangarpali are having water demand gap. These blocks need groundwater to be artificially recharged. To recharge, the vadose zone available to be recharged is calculated. The effected blocks with water demand gap and vadose zone available is shown in Table no. 7.8. Artificial recharge aims to bring up the depth to water table upto 3mbgl.

Table 7.8- Block wise water demand gap and available vadose zone for artificial recharge in Sundargarh District.

Block	Total Block Area (Ha)	Water Demand Gap (Ham)	Water Demand Gap (MCM)	Vadose Zone Available Upto 3m (Ham)	Vadose Zone Available Upto 3m (MCM)
Bonaigarh	42228	2717.843	27.2	0	0
Gurundia	125296	2715.984	27.2	1049.95	10.50
Hemgir	94028	1520.832	15.2	2916.61	29.17
Koida	85909	1440.487	14.4	0	0
Kuanrmunda	58160	3572.0	35.7	1590	15.9
Lathikata	47812	1548.118	15.5	371.08	3.71
Nuagaon	44862	10731.04	107.3	13479.45	134.79
Subdega	46050	992.2198	9.9	381.04	3.81
Sundargarh	38769	1637.0	16.4	308.25	3.08
Tangarpali	35656	2007.735	20.1	781.25	7.81

The vadose zone (upto 3m depth) can be artificially recharged by means of percolation tanks, sub surface dykes, nala bunds, check dam. Bonaigarh and Koida blocks do not have vadose zone available for artificial recharge. To prevent water logging condition it is advised that no artificial recharge structure be constructed. Number of artificial recharge structures like percolation tank, sub surface dykes, nala bond, check dam in each affected block is shown in the Table no. 7.9. Roof top rain water harvesting structures are recommended for the urban area as shown in Table no. 7.10.

Table 7.9- Block wise artificial recharge structures in Sundargarh District.

Block	Percolation Tank		Sub surface dykes		Nala bund		Check dam	
	Water allocation for percolation tank (40%) (MCM)	No. of Percolation tank @ 0.2 MCM	Water allocation for sub surface dyke (15%) (MCM)	No. of sub surface dyke @0.15 MCM	Water allocation for nala band/ contour bunding (15%) (MCM)	No. of nala band @0.15 MCM	Water allocation for check dam (30%) (MCM)	No. of Check dam @0.15 MCM
Gurundia	4.1998	21	1.5749	10	1.5749	10	3.1498	21
Hemgir	11.6664	58	4.3749	29	4.3749	29	8.7498	58
Kuanrmunda	6.3600	32	2.3850	16	2.3850	16	4.7700	32
Lathikata	1.4843	7	0.5566	4	0.5566	4	1.1132	7
Nuagaon	53.9178	270	20.2192	135	20.2192	135	40.4383	270
Subdega	1.5241	8	0.5716	4	0.5716	4	1.1431	8
Sundargarh	1.2330	6	0.4624	3	0.4624	3	0.9248	6
Tangarpali	3.1250	16	1.1719	8	1.1719	8	2.3437	16
TOTAL	**83.5104**	**418**	**31.3164**	**209**	**31.3164**	**209**	**62.6328**	**418**

Table 7.10- Block wise roof top rain water harvesting structures in urban areas of Sundargarh District.

Block	Total area of the Block (Ha)	Rainfall (m)	Rooftop RWH					
			Number of House- holds (urban)	50% of affected households	Total no of Roof top rain water harvesting structure	Avg. Rooftop area (Sq m)	Annual Rainfall runoff available for recharge (cubic m)	Annual rainfall runoff available for recharge (Ham)
Bonaigarh	42228	1.29	1686	843	843	150	130496.4	0.13
Gurundia	125296	1.29	0	0	0	150	0	0
Hemgir	94028	1.29	0	0	0	150	0	0
Koida	85909	1.29	2921	1460.5	1460.5	150	226085.4	0.23
Kuanrmunda	58160	1.29	9206	4603	4603	150	712544.4	0.71
Lathikata	47812	1.29	76207	38103.5	38103.5	150	5898421.8	5.90
Nuagaon	44862	1.29	0	0	0	150	0	0
Subdega	46050	1.29	0	0	0	150	0	0
Sundargarh	38769	1.29	10127	5063.5	5063.5	150	783829.8	0.78
Tangarpali	35656	1.29	0	0	0	150	0	0
TOTAL	618770				**50073.5**		**7751377.8**	**7.8**

Based on the number of artificial recharge structures to be constructed, the overall number of structures is as following in Table no. 7.11.

Table 7.11- Block wise artificial recharge structures to be constructed Sundargarh District.

Block	Water gap (MCM)	Vadose zone avail upto 3m (MCM)	No. of Percolation tank @ 0.2 MCM	No. of sub surface dyke @0.15 MCM	No. of nala band @0.15 MCM	No. of Check dam @0.15 MCM	Total no. of roof top rain water harvesting structures	To be managed from surface water (MCM)
Bonaigarh	27.1784	0.00	0	0	0	0	843	27.18
Gurundia	27.1598	10.50	21	10	10	21	0	16.7
Koida	14.4049	0.00	0	0	0	0	1461	14.4
Kuanrmunda	35.7283	15.90	32	16	16	32	4603	19.8
Lathikata	15.4812	3.71	7	4	4	7	38104	11.8
Subdega	9.9222	3.81	8	4	4	8	0	6.1
Sundargarh	16.42	3.08	6	3	3	6	5064	13.3
Tangarpali	20.0773	7.81	16	8	8	16	0	12.3
Total	**289**	**208.78**	**418**	**209**	**209**	**418**	**50075**	**121.58**

4. **Surface water** – From the table 6.8, we can see the total volume of water demand that needs to be managed from surface water. Construction of minor irrigation tanks using surface water can be beneficial. A total volume of 121.58 MCM water must be utilized from the surface water sources to cater the domestic, irrigational, livestock and industrial needs in 2035.

5. **Trenches -** In hilly areas where high surface run off issue persists, trenches can constructed to check the run off and utilize the water for groundwater recharge and surface storage purposes in tanks.

6. **Dug wells** -Dug wells are feasible in all the blocks of the district. The depth of the dug wells in hard rocks and semi consolidated rocks should be 10 to 12m while the depth of the wells in unconsolidated formations may be 8-10m. The diameter of the wells in both the case may be 4 to 5m. Dug wells can be utilized for both domestic and irrational uses.

8. Conclusion

Data collection includes collection of rainfall data from state government, compilation of CGWB's earlier survey data, exploration, and geophysical data. Population and agricultural data are collected from Census of India website.

The district has ground water resources as the stage of extraction is 39.56 %. Most of the blocks of Sundargarh district in showing declining water level trend and has mean decadal water level more than 5mbgl. With its population growth of 14.4%, the population in 2035 is expected to be around 2847074. The total gross domestic demand in 2035 will increase to 6235.09 Ham. Crop water demand will be 237137.88 Ham. The livestock demand will be 990.32 Ham. And industrial demand will be 2536.75 Ham. The gross water demand in 2035 will be 246900 Ham and with available water resources of 207103.55 Ham, there will be a water demand gap of 52005.17 Ham.

Following recommendations are suggested -

- Most of the fractures that contribute to productivity are situated at a depth of 100 meters below the ground. Within this depth, the aquifers can be utilized for drinking and irrigation purposes. The aquifer system is replenished by rainfall on a regular basis.
- Considering the significant potential for groundwater development, it would be beneficial to implement appropriate schemes aimed at increasing agricultural productivity in the district.
- Water distribution mechanism should minimize water loss by using lining distribution canals. Locally available materials are to be preferred as these materials are cheap and eco-friendly.
- Conservation of rain water – catch the rain where it falls. The rain water can be utilized at household level in form of rooftop rain water harvesting. In rural areas, where there is no infrastructure for rooftop harvesting, storage tanks and community farm ponds can be constructed to store the excess water and prevent the surface run off lose. Existing and abandoned dug wells may be utilized as recharge structure after cleaning and desilting for the purpose.
- In certain areas, the level of iron in the groundwater is elevated. The origin of this iron pollution in the deeper aquifers can be attributed to natural geological processes. Prior to human consumption, it is necessary to remove this excess iron using iron removal filters. Government water supplying should use iron removal plants in community level to remove excess iron.
- Intensive groundwater exploration should be carried out to delineate deeper potential water saturated fracture zones and to compute aquifer parameter.
- Large scale planning for ground water development should be preceded by intensive hydrogeological and geophysical surveys aided by remote sensing studies.

- Existing dug wells should be deepened to tap the maximum saturated thickness of the weathered zones or vertical bores may be drilled through the bottom to enhance the well yield.
- The farmers should be educated through agricultural extension services for adopting suitable cropping pattern for optimal utilization of available groundwater resources. Diversification of the areas under paddy cultivation to millets, fruits, and vegetables, should be encouraged which reduces the stress on irrigational water demand.
- Apart from the available recharge structures in the district, extensive programmes for artificial recharge may also be taken up for augmentation of groundwater through construction of percolation tanks, subsurface dykes, and check dams and through contour bunding etc.
- Afforestation – mass scale plantation work can be taken up in the abandoned coal mines, Iron ore mines, Limestone mines, etc. the abandoned open cast mines can be converted into reservoir for water storage.
- Mass awareness – public interaction and involvement should be conducted to educate the people regarding the water crisis, water conservation techniques, water reuse and optimum utilization of available water resources.

Table no. 3.1: Layer Parameters of VES of Sundargarh District.

SL NO.	LOCATION	Longitude	Latitude	Direct interpretation of VES layer parameters by software				Inferred lithology	Aquifer Characteristics		
				Layer	Resistivity(ohm.m)	Thickness(m)	Depth (m)		Aquifer	Depth Range(m)	Inferred aquifer water quality
1	Kanakjora	22.14838	83.96132	1	30.6	5.73	5.73	Top Soil			
				2	13.5	5.44	11.2	Clay			
				3	153	33.2	44.4	Weathered Formation	Aquifer	12-44	Potable
				4	VH			Massive Granite			
2	Tangarmunda	22.1516	84.03231	1	13.9	2.01	2.01	Top Soil			
				2	5.46	2.58	4.59	Clay			
				3	73.4	27.6	32.2	Weathered Formation	Aquifer	5-32	Potable
				4	VH			Massive Granite			
3	Sunajore	22.19554	84.00381	1	20.3	1.07	1.07	Top Soil			
				2	7.14	4.56	5.63	Clay			
				3	46.3	18.91	24.6	Highly Weathered Formation	Aquifer	6-24	Potable
				4	3514			Massive Granite			
4	Mangaspur	21.9578	83.99298	1	27.7	1.2	1.2	Top Soil			
				2	9.583	1.308	2.508	Clay			
				3	24.46	5.713	10.95	Highly Weathered Formation			
				4	213.1	25	35.95	Weathered Formation	Aquifer	3-35	Potable
				5	VH			Massive Granite			
5	Kadalimunda	22.00495	83.97436	1	321.4	1.2	1.2	Top Soil			
				2	123.5	4.042	5.242	Dry Soil			
				3	94.57	17.66	22.9	Weathered Formation			
				4	1542			Massive Granite			
6	Tangarpali	22.08744	83.93096	1	173	1.2	1.2	Top Soil			
				2	58.2	4.05	5.25	Highly Weathered Formation			
				3	143	17.8	23.1	Weathered Formation	Aquifer	5-23	Potable
				4	1564			Massive Granite			

7	Fuldhudi	22.09411	83.89117	1	29.8	2.62	2.62	Top Soil			
				2	16.4	5.13	7.75	Clay			
				3	67.4	32.7	40.4	Weathered Formation	Aquifer	8-40	Potable
				4	VH			Massive Granite			
8	Lephripara	22.1101	83.81845	1	187.9	0.3855	0.3855	Top Soil			
				2	13.48	6.243	6.629	Clay			
				3	72.07	22.6	29.3	Weather Formation	Aquifer	7-29	Potable
				4	VH			Massive Granite			
9	Kulabira	22.08093	83.81885	1	463	0.4	0.4	Top Soil			
				2	15.1	4.87	5.27	Clay			
				3	79.9	67	72.2	Weathered Formation	Aquifer	6-72	Potable
				4	VH			Massive Granite			
10	Aunla Bahal	22.03861	83.86127	1	124	0.994	0.994	Top Soil/Dry soil			
				2	38.7	1.88	2.87				
				3	137	14.8	17.7	Weathered Formation			
				4	VH			Massive Granite			
11	Darlipali	21.97217	83.91686	1	30.4	0.865	0.865	Top Soil/Dry soil			
				2	130	4.99	5.85				
				3	637	64.8	70.6	Fractured Granite	Aquifer	6-70	Potable
				4	VH			Massive Granite			
12	Saurijore	22.14728	83.83037	1	36.8	1.26	1.26	Top Soil			
				2	53.6	15.5	16.7	Weathered Formation			
				3	VH			Massive Granite			
13	Dumabahal	22.15171	83.71959	1	242.7	0.943	0.943	Top Soil			
				2	92.7	7.803	8.746	Highly Weather Formation			
				3	140.4	27.72	36.46	Weathered Formation	Aquifer	9-36	Potable
				4	VH			Massive Granite			

14	Masabira	22.21334	83.77153	1	37	2.52	2.52	Top Soil			
				2	328	2.73	5.26	Dry Soil			
				3	81.7	5.71	11	Weathered Formation			
				4	563	91.5	103	Fractured Granite	Aquifer	11-103	Potable
				5	VH			Massive Granite			
15	Kharalchhap	22.24287	83.85251	1	326	1.14	1.14	Top Soil			
				2	37.7	1.34	2.48	Dry soil			
				3	132	14.6	17.1	Weathered Formation			
				4	1720			Massive Granite			
16	Garjanbahal	22.00483	83.76301	1	4.39	0.959	0.959	Top Soil			
				2	30.7	3.23	4.19	Highly Weathered Formation			
				3	1282	8.73	12.9	Fractured Granite			
				4	25.5	27.1	40	Weathered SST	Aquifer	13-40	Potable
				5	VH			Massive Granite			
17	Hemgir	21.95087	83.69911	1	364.5	0.556	0.556	Top Soil			
				2	200.1	6.641	71.97	Dry soil			
				3	51.19	20.95	28.14	Weathered SST			
				4	124.5	32.41	60.56	Fractured SST	Aquifer	28-60	Potable
				5	35.6			Weathered SST			
18	Tangardihi	21.89355	83.79547	1	18.6	0.717	0.717	Top Soil			
				2	203	5.22	5.93	Compact Clay			
				3	3816	3	8.93	Granite			
				4	105	12.6	21.6	Weathered Formation			
				5	VH			Massive Granite			
19	Kendudihi	21.98901	83.65311	1	68.81	1.394	1.394	Top Soil			
				2	359.4	1.856	3.259	Dry Soil			
				3	29.48	4.531	7.79	Highly Weathered Formation			
				4	55.03	48	55.8	Weathered Formation	Aquifer	8-55	Potable

				5	VH			Massive Granite			
20	Patrapali	22.04793	83.68024	1	128.3	1.284	1.284	Top Soil			
				2	10.21	29.33	30.61	Clay/ Highly Weathered Formation			
				3	116.4			Weathered Formation			
21	Bileimunda	22.04275	83.61498	1	13	0.449	0.449	Top Soil			
				2	37.7	6.27	6.72	Highly Weathered Formation			
				3	11.3	8.7	15.4	Clay			
				4	30.9	102	117	Weathered SST			
				5	VH			Massive Granite			
22	Mendra	22.09809	83.58372	1	160	2.53	2.53	Top Soil			
				2	58.2	2.73	5.26	Highly Weathered Formation			
				3	179	42.9	48.2	Weathered Formation	Aquifer	5-48	Potable
				4	VH			Massive Granite			
23	Kinjirkela	22.28446	83.94666	1	33.6	4.56	4.56	Top Soil			
				2	74.9	25.4	29.9	Weathered Formation	Aquifer	5-29	Potable
				3	VH			Massive Granite			
24	Kinikibandh	22.34132	83.96387	1	44.7	2.19	2.19	Top Soil			
				2	113	7.2	9.39	Weathered Formation			
				3	560	54.3	63.7	Fractured Granite	Aquifer	10-63	Potable
				4	VH			Massive Granite			
25	Balisankara	22.35055	84.03151	1	164	1.16	1.16	Top Soil			
				2	42.4	24.1	25.2	Highly Weathered Formation			
				3	VH			Massive Granite			
26	Belmunda	22.30313	83.87584	1	211	1.2	1.2	Top Soil			
				2	59.9	4.04	5.24	Highly Weathered Formation			
				3	212	17.8	23	Weathered Formation			
				4	2028			Massive Granite			

27	Lulkidhi	22.51101	84.02171	1	327.3	0.9588	0.9588	Top Soil			
				2	79.19	9.812	10.77	Highly Weathered Formation			
				3	226.6	31.74	42.51	Weathered Formation	Aquifer	11-42	Potable
				4	2203			Massive Granite			
28	Sagbahal	22.46785	84.0854	1	160	1.16	1.16	Top Soil			
				2	55.1	15.9	17.1	Highly Weathered Formation			
				3	238	43.6	60.7	Weathered Formation	Aquifer	18-60	Potable
				4	VH			Massive Granite			
29	Talsara	22.35789	84.09888	1	307	1.59	1.59	Top Soil			
				2	44.5	5.81	7.41	Highly Weathered Formation			
				3	185	18	25.4	Weathered Formation	Aquifer	8-25	Potable
				4	VH			Massive Granite			
30	Kirlaga	22.30421	84.16922	1	45.7	0.845	0.845	Top Soil			
				2	6.86	1.4	2.25	Clay			
				3	82	19.9	22.1	Weathered Formation			
				4	VH			Massive Granite			
31	Karamdihi	22.15583	84.10156	1	94.8	0.348	0.348	Top Soil			
				2	7.51	4.52	4.87	Clay			
				3	VH			Massive Granite			
32	Chhatasargi	22.22218	84.12871	1	149	0.984	0.984	Top Soil			
				2	28.6	3.76	4.75	Clay			
				3	177.3	6.36	11.1	Weathered Formation			
				4	VH			Massive Granite			
33	Subdega	22.27968	84.10339	1	8.732	0.9319	0.9319	Top Soil			
				2	5.346	6.697	7.629	Clay			
				3	355			Weathered Formation			

34	Karlaghati	22.2221	84.06072	1	423.2	0.6657	0.6657	Top Soil			
				2	16.32	12.79	13.46	Clay			
				3	218.2	54.3	67.76	Weathered Formation	Aquifer	14-67	Potable
				4	VH			Massive Granite			
35	Jharangloi	22.15946	84.17811	1	29.5	2.69	2.691.3	Top Soil			
				2	8.44	3.03	5.72	Clay			
				3	VH			Massive Granite			
36	Barangakachhar	22.21614	84.21857	1	899	0.426	0.426	Top Soil			
				2	48.9	6.82	7.25	Weathered Formation			
				3	19.1	7.52	14.8	Highly Weathered Formation			
				4	VH			Massive Granite			
37	Singarmunda	22.26715	84.26183	1	1.81	1.81		Top Soil			
				2	17.9	10.6	12.4	Highly Weathered Formation			
				3	VH			Massive Granite			
38	Ekma	22.29424	84.30811	1	35.9	1.2	1.2	Top Soil/ Dry Soil			
				2	102	1.31	2.51				
				3	9.63	2.73	5.24	Clay			
				4	754	80.3	85.5	Fractured Rock Formation	Aquifer	6-85	Potable
				5	VH			Massive Granite			
39	Gargadbahal	22.19636	84.35294	1	31.5	4.11	4.11	Top Soil			
				2	10.6	5.12	9.23	Clay			
				3	VH			Massive Granite			
40	Bargaon	22.16607	84.28723	1	107.9	5.341	5.341	Top Soil			
				2	178.8	11.26	16.6	Weathered Formation			
				3	434	19.4	36	Fractured Granite	Aquifer	16-36	Potable
				4	VH			Massive Granite			
41	Salangabud	22.11074	84.14943	1	419.3	3.714	3.714	Top Soil			
				2	26.67	1.768	5.482	Clay			

				3	131.9	6.779	12.26	Weathered Formation			
				4	30.4	15.69	27.95	Highly Weathered Formation	Aquifer	12-27	Potable
				5	VH			Massive Granite			
42	Biribira	22.07172	84.20221	1	43.4	0.536	0.536	Top Soil			
				2	12.6	7.94	8.48	Clay			
				3	44.8	49.8	58.3	Weathered Formation	Aquifer	9-58	Potable
				4	VH			Massive Granite			
43	Majhapara	22.02363	84.18327	1	22.09	1.2	1.2	Top Soil			
				2	5.192	1.308	2.508	Clay			
				3	22.27	8.517	11.02	Highly Weathered Formation			
				4	58.66	37.45	48.47	Weathered Formation	Aquifer	11-48	Potable
				5	836.9			Fractured Granite			
44	DHARUADIHI	21.98695	84.21669	1	96.9	2.78	2.78	Top Soil			
				2	81.5	3.66	6.44	Weathered Formation			
				3	VH			Massive Granite			
45	Bargarh	22.03951	84.11289	1	76.7	0.654	0.654	Top Soil			
				2	15.6	3.03	3.68	Clay			
				3	255	24.3	28	Weathered Formation	Aquifer	3-28	Potable
				4	VH			Massive Granite			
46	Sundargarh	22.1008	84.04965	1	14.85	1.2	1.2	Top Soil			
				2	40.14	9.764	10.96	Weathered Formation			
				3	777.7			Fractured Granite			
47	Japanga	22.04365	84.01322	1	8.383	1.2	1.2	Top Soil			
				2	14.22	4.049	5.249	Clay			
				3	32.78	5.713	10.96	Highly Weathered Formation			
				4	185.3	38.44	49.4	Weathered Formation	Aquifer	10-49	Potable
				5	VH			Massive Granite			
48	Deuli	21.98194	84.03235	1	104	0.874	0.874	Top Soil			

				2	4.91	0.96	1.83	Clay			
				3	362	80	81.8	Fractured Granite	Aquifer	2-81	Potable
				4	VH			Massive Granite			
49	Kutra	22.23089	84.4524	1	174	0.896	0.896	Top Soil			
				2	21.7	0.9	1.8	Clay			
				3	166	25.9	27.7	Highly Weathered Formation	Aquifer	2-50	Potable
				4	60.7	22.4	50.1	Weathered Formation			
				5	VH			Massive Granite			
50	Budakata	22.20641	84.40643	1	15.99	0.9081	0.9081	Top Soil			
				2	40.42	6.81	7.718	Highly Weathered Formation			
				3	288.1	35.82	43.54	Weathered Formation	Aquifer	8-43	Potable
				4	50641			Massive Granite			
51	Khatkhur Bahal	22.28201	84.46648	1	56.05	0.8574	0.8574	Top Soil			
				2	11.37	0.9685	1.826	Clay			
				3	56.43	9.429	11.26	Highly Weathered Formation			
				4	VH			Massive Granite			
52	Panchora	22.27247	84.3769	1	90.2	0.589	0.589	Top Soil			
				2	38.6	16.6	17.2	Highly Weathered Formation			
				3	VH			Massive Granite			
53	Barmal	22.3341	84.44046	1	138	0.867	0.867	Top Soil			
				2	28.2	5.55	6.42	Highly Weathered Formation			
				3	214	23	29.4	Weathered Formation	Aquifer	7-29	Potable
				4	VH			Massive Granite			
54	Salangabahal	22.3592	84.5161	1	6.86	1.54	1.54	Top Soil			
				2	24.7	13.1	14.7	Highly Weathered Formation			
				3	14806			Massive Granite			
55	Karmunda	22.27814	84.77579	1	86.55	1.2	1.2	Top Soil			
				2	61.18	9.798	11	Highly Weathered Formation			

				3	378.7	37.23	48.23	Fractured Granite	Aquifer	11-48	Potable
				4	VH			Massive Granite			
56	Birmitrapur	22.40415	84.74192	1	22.7	1	1	Top Soil			
				2	3.3	1.36	2.37	Clay			
				3	115	9.5	11.37	Weathered Formation			
				4	21056			Massive Granite			
57	Raiboga	22.39202	84.60916	1	6.861	4.878	4.878	Top Soil			
				2	15.42	11.5	16.38	Highly Weathered Formation			
				3	764.5			Fractured Granite			
58	Ratakhandi	22.32669	84.69821	1	88.5	1.2	1.2	Top Soil			
				2	15.3	1.58	2.78	Clay			
				3	71.6	12.3	15	Weathered Formation			
				4	VH			Massive Granite			
59	Bartaghutu	22.34228	84.79381	1	77.93	0.9839	0.9839	Top Soil			
				2	8.652	1.132	2.116	Clay			
				3	97.36	22.27	24.39	Weathered Formation			
				4	VH			Massive Granite			
60	Hatibari	22.45224	85.02786	1	30.72	1.18	1.18	Top Soil			
				2	76.1	1.51	2.691	Dry Soil			
				3	160.7	22.13	24.82	Weathered Formation	Aquifer	3-29	Potable
				4	276.1	59.58	84.4	Fractured Granite	Aquifer	30-84	Potable
				5	VH			Massive Granite			
61	Barilepta	22.38172	84.99184	1	972.6	1.165	1.165	Top Soil			
				2	325	0.6738	1.839	Dry Soil			
				3	509.9	58.99	60.83	Fractured Granite	Aquifer	2-60	Potable
				4	VH			Massive Granite			
62	Gadabudu	22.45224	85.02786	1	44.4	2.46	2.46	Top Soil			
				2	186	41.9	44.4	Weathered Formation	Aquifer	3-44	Potable

				3	1519			Massive Granite			
63	Khanditatoli	22.30848	84.98099	1	654	6.44	6.44	Top Soil			
				2	833	28.1	34.6	Fractured Granite	Aquifer	7-34	Potable
				3	VH			Massive Granite			
64	Jammal	22.30139	85.11105	1	17	1.2	1.2	Top Soil			
				2	17.1	5.25	6.45	Clay			
				3	930			Fractured Granite			
65	Mahipani	22.26673	85.05637	1	21.7	1.2	1.2	Top Soil			
				2	8.11	1.31	2.51	Clay			
				3	31.3	8.45	11	Highly Weathered Formation			
				4	VH			Massive Granite			
66	Bisra	22.24625	84.9989	1	31.7	1.1	1.1	Top Soil			
				2	65.2	17	18.1	Highly Weathered Formation			
				3	4152			Massive Granite			
67	Kesramal	22.26411	84.58757	1	434	0.838	0.838	Top Soil			
				2	48.9	7.98	8.82	Highly Weathered Formation			
				3	148	56	64.8	Weathered Formation	Aquifer	10-68	Potable
				4	VH			Massive Granite			
68	Rajganpur	22.20974	84.58896	1	432.6	1.461	1.461	Top Soil			
				2	88.39	17.04	18.5	Weathered Formation			
				3	VH			Massive Granite			
69	Malidih	22.13251	84.61238	1	831	0.357	0.357	Top Soil			
				2	25.8	8.42	8.77	Highly Weathered Formation			
				3	1021			Massive Granite			
70	kansbahal	22.2192	84.6726	1	57.5	0.343	0.343	Top Soil			
				2	24.7	12	12.3	Highly Weathered Formation			
				3	VH			Massive Granite			

71	Lathikata	22.13053	84.8785	1	50.01	1.2	1.2	Top Soil			
				2	16.92	1.308	2.508	Clay			
				3	80.77	8.469	10.98	Weathered Formation			
				4	VH			Massive Granite			
72	Birikera	22.11973	84.80168	1	62.9	0.631	0.631	Top Soil			
				2	14.8	3.44	4.07	Clay			
				3	34	11.6	15.7	Highly Weathered Formation			
				4	VH			Massive Granite			
73	Garjan	22.19948	84.81403	1	12.6	1.2	1.2	Top Soil			
				2	8.74	1.31	2.51	Clay			
				3	VH			Massive Granite			
74	Bijadihi	22.27063	84.92333	1	43.12	0.5945	0.5945	Top Soil			
				2	8.879	1.673	2.267	Clay			
				3	VH			Massive Granite			
75	patua	22.06414	84.77931	1	57.9	0.575	0.575	Top Soil			
				2	17.1	7	7.57	Clay			
				3	106	22.4	30	Weathered Formation	Aquifer	8-30	Potable
				4	VH			Massive Granite			
76	Baghlata	22.06767	84.85099	1	30.9	0.544	0.544	Top Soil			
				2	7.28	1.68	2.23	Clay			
				3	VH			Massive Granite			
77	Bonaigarh	21.81551	84.95298	1	4.78	2.84	2.84	Top Soil			
				2	8.28	6.85	9.69	Clay/ Highly Weathered Formation			
				3	VH			Massive Granite			
78	Badgogua	21.7443	84.9577	1	26.98	1.382	1.382	Top Soil			
				2	9.34	10.08	11.47	Clay/ Highly Weathered			

								Formation			
				3	VH			Massive Granite			
79	Jhirdapali	21.74169	84.88379	1	9.81	5.01	5.01	Top Soil			
				2	43.2	15.7	20.7	Highly Weathered Formation			
				3	VH			Massive Granite			
80	Khajurdihi	21.70812	84.80263	1	38.2	0.814	0.814	Top Soil			
				2	522	1.07	1.89	Dry Soil			
				3	36.3	22.4	24.2	Highly Weathered Formation	Aquifer	2-24	Potable
				4	VH			Massive Granite			
81	koida	21.89897	85.24083	1	145.8	1.072	1.072	Top Soil			
				2	47.14	68.42	69.5	Highly Weathered Formation/Weathered SST	Aquifer	2-68	Potable
				3	VH			Massive Granite			
82	Jamudihi	21.98694	85.11016	1	171	1.27	1.27	Top Soil			
				2	488	0.852	2.12	Dry Soil			
				3	84.1	4.14	6.26	Weathered Formation			
				4	260	15.9	22.2	Fractured Granite	Aquifer	7-22	Potable
				5	VH			Massive Granite			
83	Bimalagarh	21.9834	85.00641	1	48	1.99	1.99	Top Soil			
				2	20.7	10.8	12.8	Highly Weathered Formation			
				3	VH			Massive Granite			
84	Lahunipara	21.87849	84.94222	1	48.7	0.773	0.773	Top Soil			
				2	14.3	0.463	1.24	Clay			
				3	27.5	24.4	25.7	Highly Weathered Formation	Aquifer	2-25	Potable
				4	VH			Massive Granite			
85	Kuliposh	21.79104	85.02789	1	655	3.48	3.48	Top Soil			
				2	2599	4.46	7.94	Compact Clay			
				3	252	74.8	82.7	Fractured Granite	Aquifer	8-82	Potable

				4	VH			Massive Granite			
86	Fuljhar	21.70913	85.08831	1	224	0.757	0.757	Top Soil			
				2	99.4	7.62	8.38	Weathered Formation			
				3	24.8	14.4	22.7	Highly Weathered Formation			
				4	VH			Massive Granite			
87	Sihidiha	21.70147	84.99771	1	16.7	0.7861	0.7861	Top Soil			
				2	7.39	1.872	2.658	Clay			
				3	60.17	35.38	38.04	Highly Weathered Formation	Aquifer	3-38	Potable
				4	VH			Massive Granite			
88	Satkuta	21.85821	84.86073	1	15.2	1	1	Top Soil			
				2	4.77	4.06	5.06	Clay			
				3	VH			Massive Granite			
89	Gurundia	21.86036	84.78225	1	24.1	2.4	2.4	Top Soil			
				2	14.7	20.6	23	Highly Weathered Formation			
				3	VH			Massive Granite			
90	Nuniapali	21.91839	84.79303	1	57.8	1.63	1.63	Top Soil			
				2	19.5	10.8	12.4	Highly Weathered Formation			
				3	VH			Massive Granite			
91	Kundheidiha	21.80255	84.6943	1	220	0.565	0.565	Top Soil			
				2	14.7	5.97	6.54	Clay			
				3	VH			Massive Granite			
92	Dhokamunda	21.64361	85.07344	1	219	0.777	0.777	Top Soil			
				2	113	6.04	6.82	Weathered Formation			
				3	22.1	13	19.8	Highly Weathered Formation			
				4	VH			Massive Granite			

Table No. 3.2 – Exploration data of Sundargarh District

Block	Location	Latitude	Longitude	Depth drilled (mbgl)	Lithology	Granular zones/ deciphered (mbgl)	SWL (mbgl)	Discharge (lps)	Drawdown (m)	T (m^2 / day)
Balisankara	Kinjirkela	22.25	83.94	175	Mica Schist		4.46	0.2		
Balisankara	Balisankara	22.34	84.03	200	Granite Gneiss	22, 25, 42.6, 74, 152, 7, 200	3.75	1.23	36.65	
Baragaon	Bhedabahal	22.05	84.03	166.3	Granite Gneiss	38	6.1	0.5	-	-
Baragaon	Baragaon	22.19	84.31	166.3	Mica Schist,Quartz vein	21	7.09	0.8	-	-
Baragaon	Bhoipalli	22.13	84.29	160	Mica Schist	37	8.62	0.5	-	-
Baragaon	Baibai	22.17	84.33	110	Metasedimantary - Slate	75	13.8	4.5	-	-
Baragaon	Devkaranpur	22.15	84.19	160	Mica Schist	72	6.2	0.5	-	-
Baragaon	Bheluanbahal	22.23	84.22	95	Quartzite	42, 89	5.5	0.8	-	-
Baragaon	Chammunda	22.13	84.30	51	Unconsolidated Sand	-	-	-	-	-
Baragaon	Pamora	22.26	84.30	70	Bonai Granite	169-170	15.87	0.7		-
Baragaon	Rengalmal	22.30	84.25	130	Granite gneiss	40.2-48.3	5.65	3		14.4
Baragaon	Gadgadbahal	22.21	84.34	50	Granite gneiss		-	.-		-
Baragaon	Bargad	22.05	84.12	167	Granite gneiss	57.5 - 58.5	4.95	0.2		-
Bargaon	Tunmura	22.20	84.28	87	Dolomite and limestone	38.2-44.3, 48.3-56.5	5.5	1		-
Bargaon	Sahajbahal	22.23	84.28	70	Granite gneiss	17.8-40.2	4.65	10		111.9
Bargaon	Sahajbahal	22.23	84.28	70	Granite gneiss	27.0-38.2		9		111.9
Bargaon	Tudalaga	22.36	84.22		Mica Schist	23.9-25.0,27.0-32.1,103.2-105.3	1.15	4.5		39.74
Bargaon	Tudalaga	22.36	84.22	75	Mica Schist	25.9-32.10	5.2	4		42.34

Bargaon	Tiklipada	22.16	84.26	151	Mica Schist	57.5-61.5	5.5	0.5		-
Bargaon	Pandherpally	22.15	84.26	120	Mica Schist	117	10.6	7	11.75	
Bargaon	Pandherpally	22.15	84.26	120.1	Mica Schist	117	8.72	7.5	12.02	
Bargaon	Kustuna	22.14	84.21	99.2	Schist	82.98	0.36	5.5	13.5	
Bargaon	Kustuna	22.14	84.21	148	Granite gneiss	36	5.2	0.8	30.6	
Bargaon	Timana	21.29	84.34	172.4	Mica Schist	36	4.75	1	36.23	
Bargaon	Mundagaon	22.20	84.20	172.4	Schist	26-28	4.02	2.5	17.6	
Bargaon	Mahapada	22.18	84.37	123.6	Granite gneiss					
Bargaon	Barpalhi	22.17	84.33	83	Granite gneiss	25 - 27,47 - 48	4.59	7	4.55	184.7
Bargaon	Barpalhi	22.17	84.33	56.5	Granite gneiss	24 - 26	4.5	2.1	7.39	47.48
Bargaon	Kinjirkela	22.19	84.29	142	Mica Schist		6.12		-	342.2
Bargaon	Petford	22.28	84.28	160.2	Granite gneiss		3.10			195.5
Bargaon	Pamra	22.24	84.29	110.7	Granite Gneiss	109.7	2.94	9.5	27	
Bargaon	Pamra	22.24	84.29	111.8	Granite Gneiss	99.6,198.7	2.94	9	-	
Bargaon	Bargaon	22.15	84.29	203.3	Phyllite		3.47	0.34	33.95	
Bargaon	Ekma	22.26	84.28	137.2	Granite Gneiss	18, 131.3	4.88	5	29.07	
Bargaon	Ekma	22.26	84.28	87.4	Granite Gneiss	17.2, 85	4	7	22.65	
Bargaon	Barngakahar	22.19	84.23	180.9	Mica Schist		5.92	Negligible		
Bargaon	Itma	22.11	84.22	197.2	Gr.Gneiss & Schist	37, 148	4.61	1.42	15.8	
Birmatrapur	Birmatrapur-I	22.38	84.72	197.2	Dolomitic Limestone	21, 140	2.87	1.8	20.68	
Birmatrapur	Birmatrapur-II	22.38	84.72	160.6	Limestone	11.1	8.68	0.25	-	
Birmatrapur	Raibaga	22.40	84.67	197.2	Epidiorite	20.30, 39.80	5.65	1.36	29.6	
Bisra	Bondamunda	22.26	84.96	142.3	Schist	57,73,109,137	2.67	6	18.06	

Bisra	-do-	22.26	84.96		-do-	Abandoned				
Bonaigarh	Bonai	21.85	84.93	139.9	Granite	34,99,136	6.3	8.5	31.9	
Bonaigarh	Bonai	21.85	84.93	166.7	Granite	76,82,91,161	5.9	8.51	31.4	
Bonaigarh	Bonai	21.85	84.93	35.5	Granite	Abandoned	-	-	-	
Bonaigarh	Jamkai	21.78	84.96	178.5	Granite	28,76,85,95,130	12.17	10	21.13	
Bonaigarh	Jamkai	21.78	84.96	166.7	Granite	28,76,85,95,130	12.74	8.5	10.25	
Hemgir	Duduka	22.00	83.77	180	Granite Gneiss	21.30, 26.40	6.31	0.6	31.38	
Hemgir	Duduka	22.00	83.77	20.3	Granite Gneiss		7.2	0.5		
Hemgiri	Gopalpur	22.04	83.72	155	Shale, Sandstone, Coal	89	23.1	0.7	-	-
Hemgiri	Gandapara	21.88	83.66	150	Shale	63	25	1.25	-	-
Hemgiri	Kamlaga	21.93	83.74	62.6	Shale, Siltstone and Sandstone	45	9.80	6	20.90(1)	21.58
Hemgiri	Kamlaga	21.93	83.74	62.6	Shale, Siltstone and Sandstone	50	6.00	6	20.90(1)	21.58
Himgir	Taparia	21.98	83.58	148.4	Gondwana sand stne and shale	12.10,25.40,77.20,96.50,97.50,100.60	12.99	4.2	18.96	
Himgir	Taparia	21.98	83.58	67	-do-	Abondoned	12.0	4.5		
Himgir	Tumulia	21.98	83.71	200	-do-	90, 95, 199.20	14.7	1.6	42	
Himgir	Tumulia	21.98	83.71	97.5	-do-		9.74	2.3	42.19	
Himgir	Gopalpur	21.98	83.66	200.2	-do-	27.30,81.01,200.20	13.37	0.37	0.69	
Kharmunda	Teliposh	22.28	84.79	129.7	Granite gneiss	62.5	9.16	3.8	16.92	100.2
Kuarmunda	Vedavyas	22.24	84.75	81.3	Phyllite	29.5	7.8	1.5		
Kuarmunda	Chhend	22.23	84.85	104.4	Carbon Phylite	22.6,57.7,100.4	1.35	11	5.05	
Kuarmunda	Chhend	22.23	84.85	113.3	Carbon Phylite	77.7,81.8,91.9	1.42	10		
Kuarmunda	Kuarmunda	22.27	84.75	166.7	Carbon Phyllite	18.2, 34.5, 37.5, 44.7	3.96	0.4	-	
Kuarmunda	Bisra	22.26	84.96	160.6	Lime Stone	65.2, 70.10	9.36	3	26.32	
Kutra	Panchara	22.28	84.39	85	Granite	72, 81		4.5	19.53(7)	6.08

Kutra	Bhagra	22.25	84.41	51	Dolomite and limestone	-	-	-		-
Kutra	Bringatoli	22.20	84.40	197	Carbon Phyllite	44, 46	-	1	30.89	
Kutra	Kutra	22.21	84.47	185	Silicified dolomite/ lime stone	58.8, 61, 90	3.012	1	34.49	
Kutra	Kutra-I	22.21	84.47	63	-do-		0.01	4.35	4.07	
Kutra	Kutra-II	22.21	84.47	43.5	-do-		0.51	4.07	3.84	
Lahunipara	K.Balang	22.17	84.80	172.8	Gr.Gn. with Basic Intrusive	26,44,77,94,131	8.05	10	8.77	
Lahunipara	K.Balang	22.17	84.80	148.4	Gr.Gn.with.Basic Intrusi	26, 30.4, 104.5, 123, 139	8.61	10	6.31	
Lahunipara	K.Balang	22.17	84.80	19.3	Granite	10.3,16.5	8.24	1	2.33	
Lahunipara	K.Balang	22.17	84.80	16.2	Granite	7.3,13.5	8.1			
Lahunipara	Rajamunda	21.87	84.94	104.7	Bonai Granite	54,79.3,96	3.3	8	16.25	
Lahunipara	Rajamunda	21.87	84.94	105.45	Bonai Granite	47,68,88,103	3.16	10	23.77	
Lahunipara	Lahunipara	22.01	85.02	143.7	Bonia Granite	37,59,102,128	3.18	4.8	32.85	
Lahunipara	Lahunipara	22.01	85.02	166.7	Granite Gneiss	84.3,136.2,152.4	3.52	2.5	15.68	
Lathikata	Old Jalda	22.19	84.84	160.2	Granite gneiss	85 - 86	6.23	1.5	18.2	29.67
Lathikata	Balijodi	22.18	84.88	148	Granite gneiss	46 - 47, 77 - 78	17.51	4.4	12.76	243.8
Lathikata	Balijodi	22.19	84.88	123.6	Granite gneiss	48 - 49, 77 - 78	18.02	9.24		
Lathikata	Bolani	22.16	84.83	93.5	Granite Gneiss		4.4	6.6	-	
Lathikata	Bolani	22.16	84.83	64.5	Granite Gneiss		4.53	8.3	-	
Lathikata	Lathikata	22.18	84.85	191.1	Mica Schist		4.53	0.4	-	
Lathikata	-do-	22.18	84.85	27.4	-do-	abandoned	-	-	-	
Lathikata	Jalda	22.07	84.89	178.3	Mica Schist	26.4,44.7	2.19	2	9.89	
Lathikata	Banki	22.14	84.12	191.1	Mica Schist	8.2,166.7	8.64	1		
Lefripara	Bindujharia	22.09	83.77	151	Mica Schist	75	8.1	0.2	-	-
Lefripara	Kubarikhamnapara	22.11	83.77	150	Mica Schist	62	8.2	0.8	-	-

Lefripara	Lefripara	22.10	83.83	150	Granite	55	11.6	0.6	-	-
Lefripara	Darlipalli	22.01	83.91	156	Mica Schist	89-90	5.70	0.5	-	-
Lefripara	Borabhagar	22.01	83.92	154	Mica Schist	73	5.45	0.4	-	-
Lefripara	Ujalpur	22.08	83.92	154	Granite	48	4.05	0.4	-	-
Lefripara	Nuadihi	21.98	83.96	150	Granite	87	20.1	0.5	-	-
Lefripara	Kulabira	22.08	83.84	148	Mica Schist	74	4.4	2.5	18.01(1)	6.59
Lefripara	Grinkela	22.11	83.81	70	Siliceous Limestone	26	3.71	10	3.36(6)	58.6
Lefripara	Patuadihi	22.14	83.82	124	Mica Schist	42	4.65	3	17.05(1)	5.3
Lifripara	Remda	21.99	84.00	160.2	Granite gneiss	17-18,102	4.71	0.5	19.78	
Lifripara	Jhurimal	22.05	83.88	105.3	Schist	20-21	2.11	4	11.02	
Lifripara	Pitabhuin	22.11	83.88	38.2	Schist	20-30	3.14	7.5	0.35	
Lifripara	Pitabhuin	22.11	83.88	160.2	Schist	31	3.00	0.25		
Lifripara	Raidihi	21.98	83.90	191.1	Mica Schist		9.85	Negligible		
Lifripara	Darlipali	21.96	83.92	197.2	Granite Gneiss	10, 34.5, 50.8, 74.1	7.5	1		
Lifripara	Surguda	22.10	83.87	175.8	Dolomite Marble		3.57	Negligible		
Lifripara	Dharkadihi	21.99	84.21	200.2			6.3	Negligible		
Lifripara	Dumabahal	22.19	83.74	181.2	Mica Sc. Quartzite	13.20,24.40,83.30	4	2.6	20.55	
Panposh	Panposh	22.33	84.83	197	Phyllite	2,71,11,135	1.36	3	15.9	
Panposh	-do-	22.33	84.83	135.1	-do-	-	1.5	1.8	17.02	
Panposh	Nayabazar	22.33	84.87	191	Phyllite		0.5	0.5	-	
Panposh	Basanti Colony	22.36	84.85	185	Phyllite		2.4	2.5	34	
Rajgangapur	Liploi	22.18	84.56	185.3	Carbon Phyllite	48, 99.5	9.24	2	25.59	
Rajgangapur	Bihabandh-I	22.26	84.51	38.7	Carbon Phyllite	29.5	8.22	Negligible		
Rajgangapur	Bihabandh-II	22.26	84.51	185	Carbon Phyllite	29.5, 30.5	8.224	Negligible	-	

Rajgangpur	Rajgangpur	22.20	84.58	197.2	Epidiorite	14.1, 79, 87.1, 124, 132	1.81	1.1	33.63	
Rajgangpur	Laing	22.25	84.64	136.2	Epidiorite	44.2, 79, 87.1, 124, 132	8.05	7.33	24.72	
Subdega	Hamirpur	22.22	84.13	160	Granite gneiss	14.8-15.8, 104.3-105.3	6.80	0.2		-
Subdega	Kirlaga	22.31	84.18	160	Granite gneiss	22.8-26.0, 41.2-44.3	3.05	2		4.464
Subdega	Kurumkela	22.30	84.16	166	Granite	90 - 91	12.10	0.7		-
Subdega	Tangargaon	22.36	84.22	90	Granite	40.2 - 48.3	3.65	7.5		66.96
Subdega	Tangargaon	22.36	84.22	65	Granite	18.8-20.9, 36.1-41.2,47.3-50.4	4.04	12		72
Subdega	Latadega	22.30	84.12	160	Granite	-	3.05	0.1		-
Subdega	Jamuna Bhoi Para	22.32	84.07	172	Granite	11.4-112.4	5.00	0.4		-
Subdega	Purajalanga	22.10	84.10	160.5	Granite	144.9 - 145,9	5.95	0.4		-
Subdega	Subalaya	22.13	84.09	50.5	Granite		-	-		-
Subdega	Subdega	22.31	84.12	189.8	Granite Gneiss	56	8.2	Negligible		
Subdega	Karmdihi	22.26	84.11	142.1	Granite Gneiss	39.6, 83.7, 123.8, 134.0	5.34	1.5	52.21	
Sundargarh	Masakani	22.03	84.04	166.3	Granite gneiss	62.6-63.6	22.00	0.5		-
Sundargarh	Bhasma	21.96	84.04	111.4	Granite	20.9 - 26.0, 30.0-31.0, 36.1-39.2	4.39	12		25.49
Sundargarh	Sankara	22.07	84.05	166.7	Carb.Phy.Mica Schist	22, 42, 110.7	7.9	1.76	28.38	
Sundargarh	Bhedabahal	22.02	84.03	160.6	Ca.Phy.Mica Sc.Gr.Gn	Not significant	7.87	Negligible	-	
Sundargarh	Deoli	21.96	84.05	178.9	Mica Schist & Gr.Gn	176.8, 178.8	4.3	7.1	31	
Sundargarh	Deoli	21.96	84.05	148.4	Mica Schist & Gr.Gn	23.4, 29.0	4.63	4.05	17.62	
Sundargarh	Sundargarh	22.09	84.03	154.4	Granite Gneiss	24,50.60,87.30	11.11	7	14.19	
Sundargarh	Sundargarh	22.09	84.03	200	Granite Gneiss	53.8,91.4,124,172.86, 199	7.62	4.88	-	
Sundergarh	Karla	21.96	84.20	172.4	Schist & gneiss	36	5.23	0.2		
Sundergarh	Bartankela	22.08	83.91							
Sundergarh	Jharbeda	22.22	84.52	62.6	Limestone	Cavernous	7.32	4.16	14.38	65.84

Annexure 3.2

Sundergarh	Mahapada	22.18	84.36	159	Granite gneiss	52-53,102-103	7.03	2.5	7.26	49.46
Tangarpali	Bandhapalli	22.11	84.00	125	Granite	61	3.5	3.3	-	-
Tangarpali	Mangaspur	21.95	84.00	154	Granite	66	3.5	0.8	-	-
Tangarpali	Rangyamunda	22.08	83.96	95	Granite intruded by Pegmatite	74.8	12.05	8.5	16.75(1)	2.66
Tangarpali	Rangyamunda	22.08	83.96	95	Granite intruded by Pegmatite	77	12.05	8.5	16.75(1)	2.66
Tangarpali	Meghdega	22.17	83.93	160	Granite intruded by Pegmatite	106	6.91	1	-	-
Tangarpali	Laldhipa	22.13	84.00	160	Mica Schist		-	0.5		-
Tangarpali	Belsara	22.10	83.85	170	Granite		2.30	0.5		-
Tangarpali	Belsara A Ashram	22.10	83.85	160	Granite		27.10	0.4		-
Tangarpali	Sukhapada	22.15	84.03	172.4	Schist	27	6.15	0.25		
Tangarpali	Police line	22.10	84.04	172.4	Schist	62	12.10	0.5		
Tangarpali	Govt. WC	22.12	84.02	172.4	Schist	81	3.85	0.5		
Tangarpali	Ujalpur	22.08	83.96	138.2	Granite Gneiss	83.3, 97.5	4.1	3.06	39.63	
Uijalpur	Mahulpali	22.09	84.00	197.2	Mica Sc. Quartzite		2.93	Negligible		
Uijalpur	Sargipali	22.04	83.95	200.2	Granite Gneiss	21.50,84.30	8.34	2.8	27.63	
Uijalpur	Sargipali	22.04	83.95	16.2	-do-	Abandoned	-	-	-	

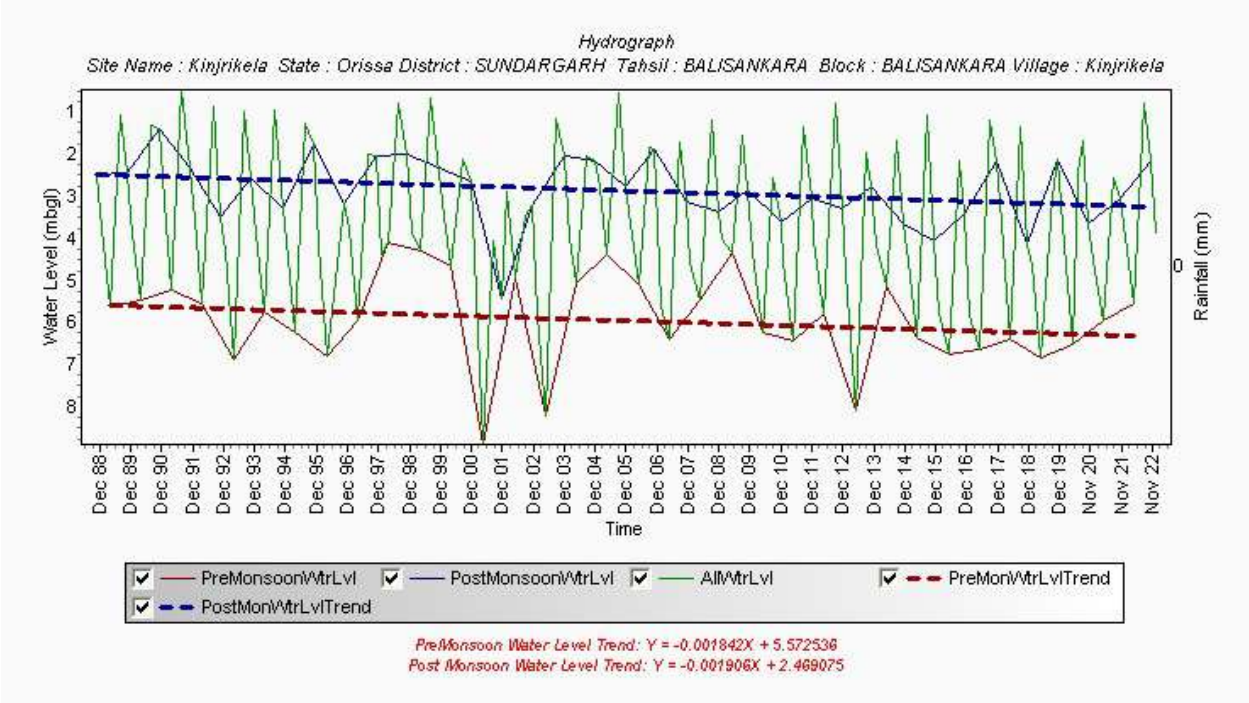
Table No. 4.1 – Chemical data of GWMS of Sundargarh District (Pre-Monsoon)

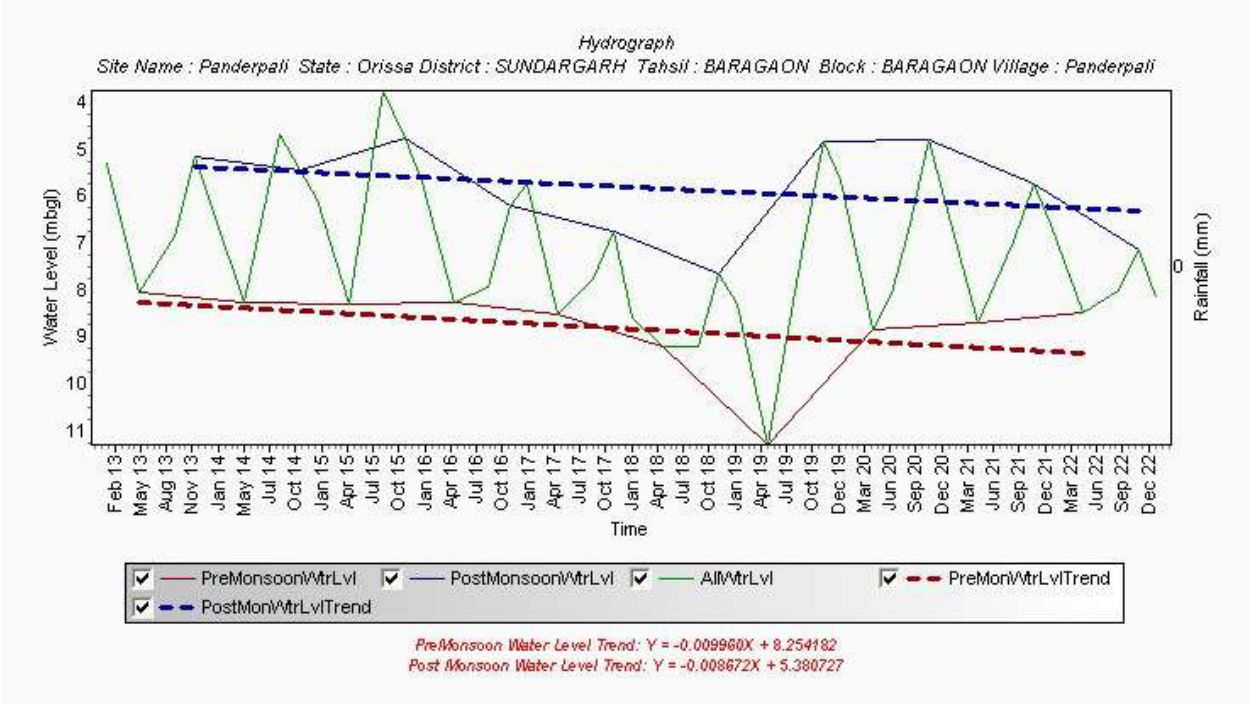
Village	Latitude	Longitude	RL	DTWL (Pre) mbgl	DTWL (Post) mbgl	DTWL Fluctuation (m)	Aquifer
Bhojpur	22.147	84.168	263.3	7.4	4	3.4	Dolomite,Limestone
Kinjrikela	22.195	84.290	267.5	6.5	2	4.5	Dolomite,Limestone
Pamra	22.258	84.307	280.1	8.6	2.05	6.55	Dolomite,Limestone
Sahajbahal	22.223	84.286	272.1	10.6	2.75	7.85	Dolomite,Limestone
Timna	22.297	84.336	309.8	5.6	1.4	4.2	Dolomite,Limestone
Rauldega	22.387	84.048	309.4	5.9	5	0.9	Granite Gneiss
Bandega	22.498	84.040	405.7	8.9	0	8.9	Granite Gneiss
Deobhuvanpur	22.289	83.914	325.5	7.2	0.5	6.7	Granite Gneiss
Khamarimunda	22.217	83.943	373.7	8.5	0.2	8.3	Granite Gneiss
Rasti	22.318	83.914	326.1	8.8	1.06	7.74	Granite Gneiss
Sagbahal	22.464	84.085	448.9	6.6	1.65	4.95	Granite Gneiss
Tildega	22.320	83.942	305.2	9.8	0.9	8.9	Granite Gneiss
Tumlia	22.317	84.086	276.3	9.8	1.3	8.5	Granite Gneiss
Bhalulata	22.227	84.982	247.1	3.8	2.34	1.46	Gondwana sst/shale
Jodabandh	22.258	85.009	224.2	7	3.7	3.3	Gondwana sst/shale
sarubahal	22.270	84.992	221.6	5.3	2.67	2.63	Gondwana sst/shale
Dimrikada	21.818	84.930	159.1	4.8	2.8	2	Granite
Bonoigarh	21.808	84.966	155.7	11.2	5.23	5.97	Granite Gneiss
Rangmati	21.807	85.054	210.7	1.6	1.12	0.48	Dolomite,Limestone
Talabahari	21.793	85.069	208.7	4.15	2.32	1.83	Dolomite,Limestone
Gopalpur	22.103	84.899	187	5.7	3.26	2.44	Granite Gneiss
Kendughati	22.100	84.961	294.8	1.6	0.8	0.8	Granite/Mica-scist
Kucheta	22.088	84.905	195.7	10	5.94	4.06	Granite/Mica-scist
Sargigad	22.083	84.918	266.7	2.1	0.75	1.35	Granite/Mica-scist
Badibahal	21.977	83.656	307.9	7	1.55	5.45	Gondwana sst/shale
Bheluantikra	21.890	83.782	268.7	13.45	7.5	5.95	Gondwana sst/shale
Bilaimunda	22.043	83.622	304.5	8.9	2.75	6.15	Gondwana sst/shale
Duduka	22.024	83.808	252.4	7.4	3.4	4	Gondwana sst/shale
Gopalpur	22.050	83.705	291.2	8.5	2.35	6.15	Gondwana sst/shale

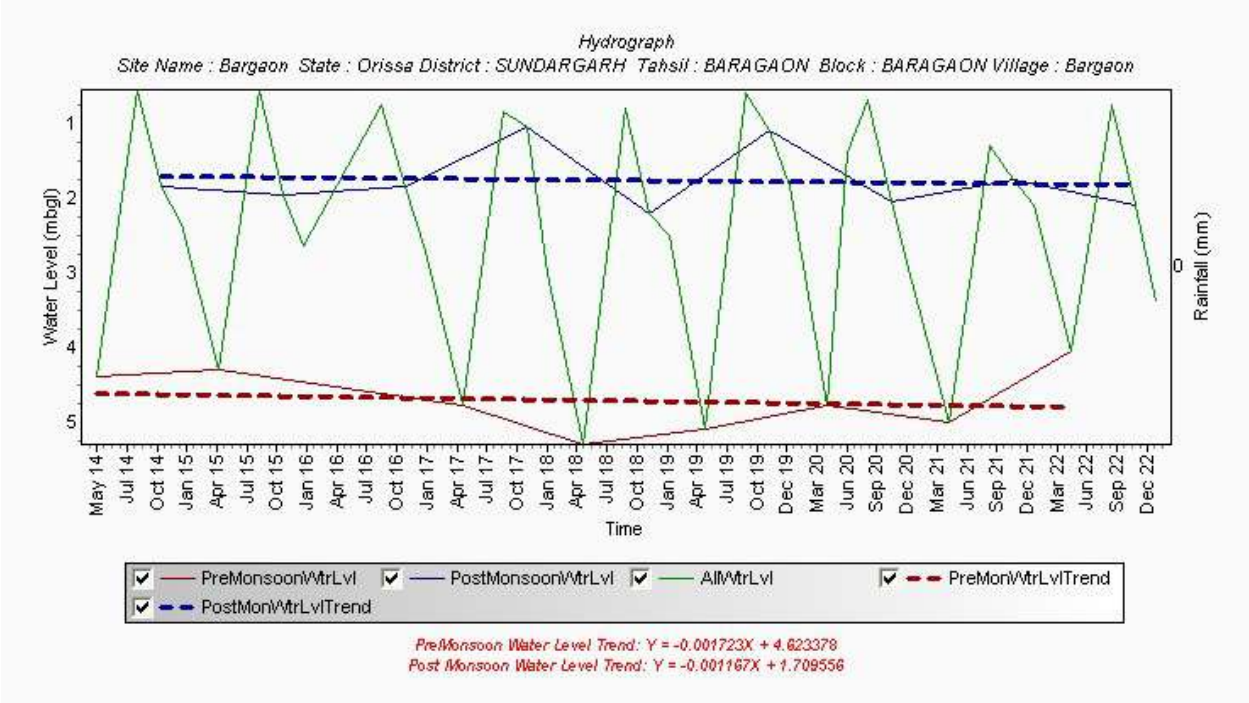
Kanika	21.880	83.736	273.1	8.3	0.65	7.65	Gondwana sst/shale
Kuanrkela	22.011	83.626	298	8.5	1.8	6.7	Gondwana sst/shale
Nuadihi	22.028	83.618	300.1	12.2	2.05	10.15	Gondwana sst/shale
Taparia	22.029	83.559	306.2	7.9	0.4	7.5	Gondwana sst/shale
Bakartola	21.995	85.024	231.3	5.15	2.8	2.35	Granite
Fakir munda	21.974	85.001	212.4	7.4	3.98	3.42	Granite
Jamudih	21.990	85.114	321.8	4.9	2.1	2.8	Granite
Jamudih	21.990	85.110	320.3	1.2	0.65	0.55	Granite
Raksi	22.005	85.082	305.2	4.3	2.16	2.14	Granite
Basjore	22.368	84.833	264.3	1.85	0.86	0.99	Granite
Kuarmunda	22.276	84.769	204.8	5.25	3.11	2.14	Granite Gneiss
Putrikhaman	22.340	84.801	224.3	4.45	2.29	2.16	Granite Gneiss
Gangajal	22.222	84.372	261.6	7.6	0.4	7.2	Dolomite,Limestone
Kusumdegi	22.250	84.364	282.4	7.6	1.2	6.4	Dolomite,Limestone
Nuagan	22.313	84.393	267	7.65	4.45	3.2	Dolomite,Limestone
Panchra	22.280	84.373	292.6	6.3	0.7	5.6	Dolomite,Limestone
Tarkera	22.346	84.495	219	8.7	3.9	4.8	Dolomite,Limestone
Koiradi	21.935	84.918	165	2.1	1.1	1	Granite Gneiss
Lamsi	21.921	84.944	188.3	5.55	3.24	2.31	Granite Gneiss
Luhanipada	21.867	84.926	165.7	6.3	3.86	2.44	Granite Gneiss
salaipalli	21.936	84.897	171.3	5.28	3.2	2.08	Granite Gneiss
Asurchhapal	22.177	84.884	204.7	8.4	4.66	3.74	Granite
Koelijhar	21.969	84.858	181	5.4	2.69	2.71	Granite
Lathikata	22.135	84.883	200	5.3	3.94	1.36	Granite Gneiss
Ludhini	21.933	84.875	173.4	5.8	3.69	2.11	Granite
Purnapani	21.948	84.867	169.7	1.2	0.72	0.48	Granite
Ramjhodi	22.148	84.953	221.9	9.1	4.98	4.12	Granite
Sonaparvat	22.170	84.888	204.8	8.8	4.79	4.01	Granite
Giringkela	22.133	83.780	283	9.2	3.5	5.7	Granite/Mica-scist
Kharalchhapal	22.252	83.855	381.5	5.45	0.5	4.95	Granite/Mica-scist
Kulabira	22.094	83.822	280	7.9	2.9	5	Granite/Mica-scist
Surguda	22.102	83.848	261.1	13.1	8.6	4.5	Granite/Mica-scist
Telendihi	22.145	83.767	286.6	11.3	3.7	7.6	Granite/Mica-scist

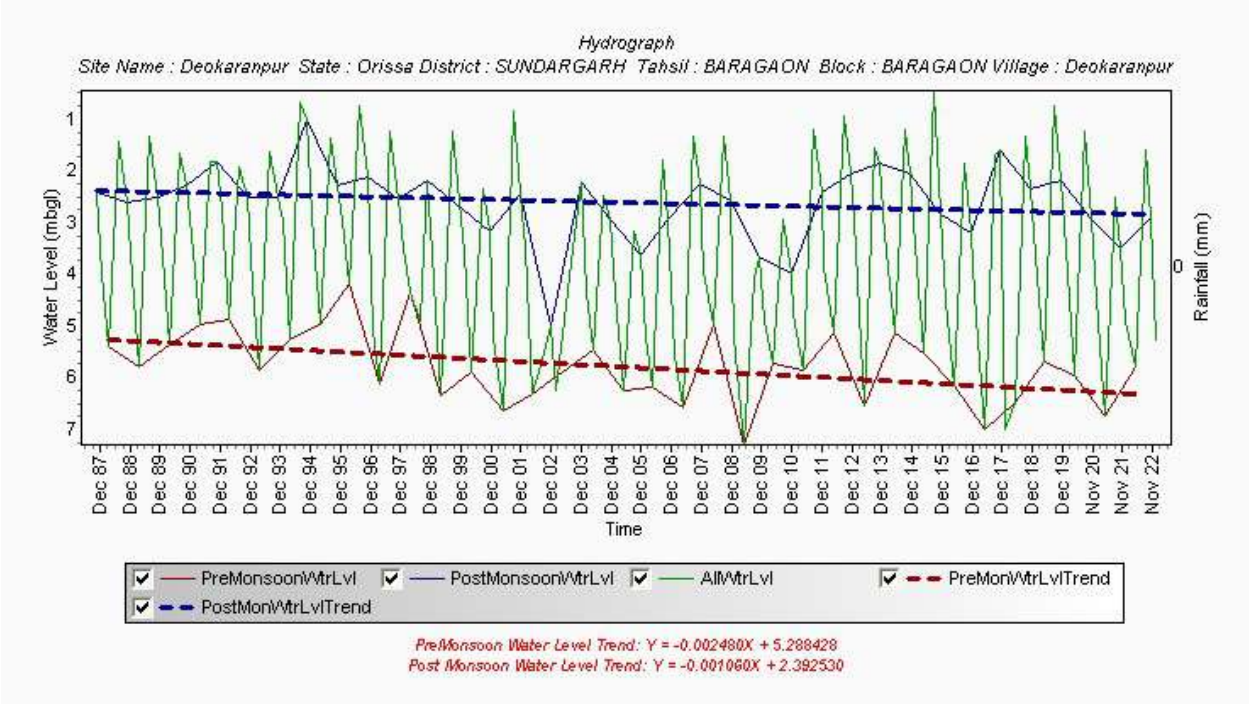
Bhoagra	21.806	85.013	165	5.4	2.46	2.94	Granite Gneiss
Gadarua	21.799	85.024	171.7	2.4	1.23	1.17	Granite Gneiss
Bandhberna	21.784	85.004	167.9	5.8	2.58	3.22	Granite Gneiss
Jatrapadia	21.885	84.938	167.1	8.5	4.16	4.34	Granite
Kurda	21.816	85.002	162.7	2.3	1.12	1.18	Granite Gneiss
Lalei Chhak	21.817	84.983	161.7	4.1	2.3	1.8	Granite
Lalei Village	21.822	84.972	151.8	3.6	1.75	1.85	Dolomite,Limestone
Sagadiposh	21.905	84.941	180	4.95	2.76	2.19	Granite
Bishpur	22.387	84.648	246.5	7.2	3.25	3.95	Gondwana sst/shale
Jharpada	22.395	84.915	214	7.9	3.98	3.92	Gondwana sst/shale
Kukdagate	22.241	84.958	220.1	2.2	1.15	1.05	Granite/Mica-scist
Limda	22.394	84.943	217.8	7.1	4.1	3	Gondwana sst/shale
Nuagaon	22.230	84.712	217	5.5	1.98	3.52	Granite/Mica-scist
Nuagaon	22.393	84.951	225.7	8.2	4.23	3.97	Gondwana sst/shale
Purnapani	22.403	84.872	229	8.7	4.8	3.9	Gondwana sst/shale
Saraitali	22.322	84.965	215	6.9	3.78	3.12	Gondwana sst/shale
Jhagarpur	22.229	84.602	217.2	3.7	2.7	1	Granite
Laing	22.238	84.647	199.8	8.5	4.1	4.4	Granite
Rajgangpur	22.189	84.579	235.1	3.3	2.3	1	Granite
Dasrajpur	22.164	84.136	272.5	6.3	1.85	4.45	Granite
Gaibira	22.296	84.117	291.2	6.7	1.16	5.54	Granite
Katingidihi	22.192	84.110	245.5	9.2	6.2	3	Granite
Kurumker	22.301	84.159	295.5	6.2	2.5	3.7	Granite
Rasipatra	22.287	84.081	273.2	6.4	1.9	4.5	Granite
Simdega	22.319	84.154	297.1	6.2	1.47	4.73	Granite
Sudarshanpur	22.228	84.110	249.1	5.35	0.7	4.65	Granite
Tangargaon	22.359	84.213	400.1	7.5	0.1	7.4	Granite
Bijadihi	22.070	24.247	542.2	9.4	2.95	6.45	Granite Gneiss
Birbira	22.070	84.206	236.9	12.9	3.4	9.5	Granite Gneiss
Lahandabud	22.093	84.170	259	7.2	2.3	4.9	Granite Gneiss
Majhapada	22.023	84.190	238.9	7.8	1.6	6.2	Granite Gneiss
Philingibahal	22.045	84.229	243.5	8.1	3.15	4.95	Granite Gneiss
Selangabud	22.114	84.148	279.7	7	0.75	6.25	Granite Gneiss

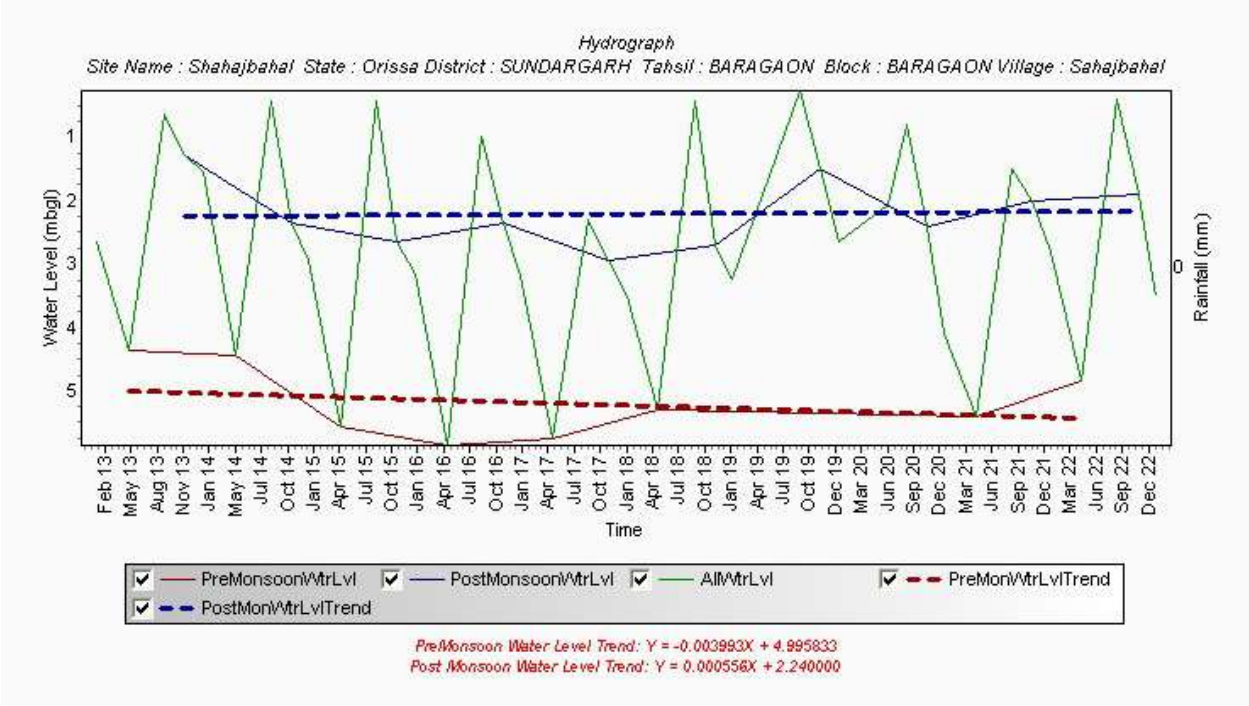
Bandhpali	22.108	83.988	243.7	7.3	0.72	6.58	Granite
Jhariapali	22.087	83.894	245	7	1.35	5.65	Granite
Tasladihi	22.127	83.969	262.8	6.5	1.98	4.52	Granite
Ujjalpur	22.083	83.921	252.6	9.7	4.65	5.05	Granite

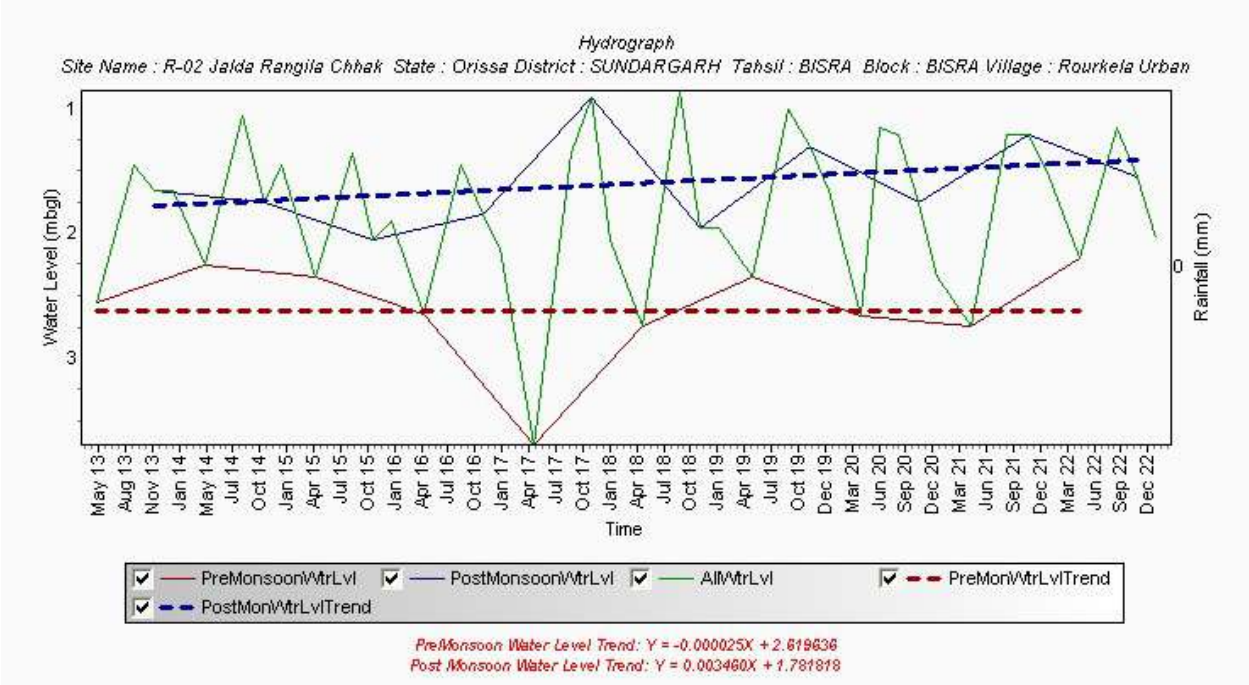

Hydrograph
Site Name : Kinjrikela State : Orissa District : SUNDARGARH Tahsil : BALISANKARA Block : BALISANKARA Village : Kinjrikela
Water Level (mbgl)
Raintall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.001842X + 5.572536
Post Monsoon Water Level Trend: Y = -0.001906X + 2.469075

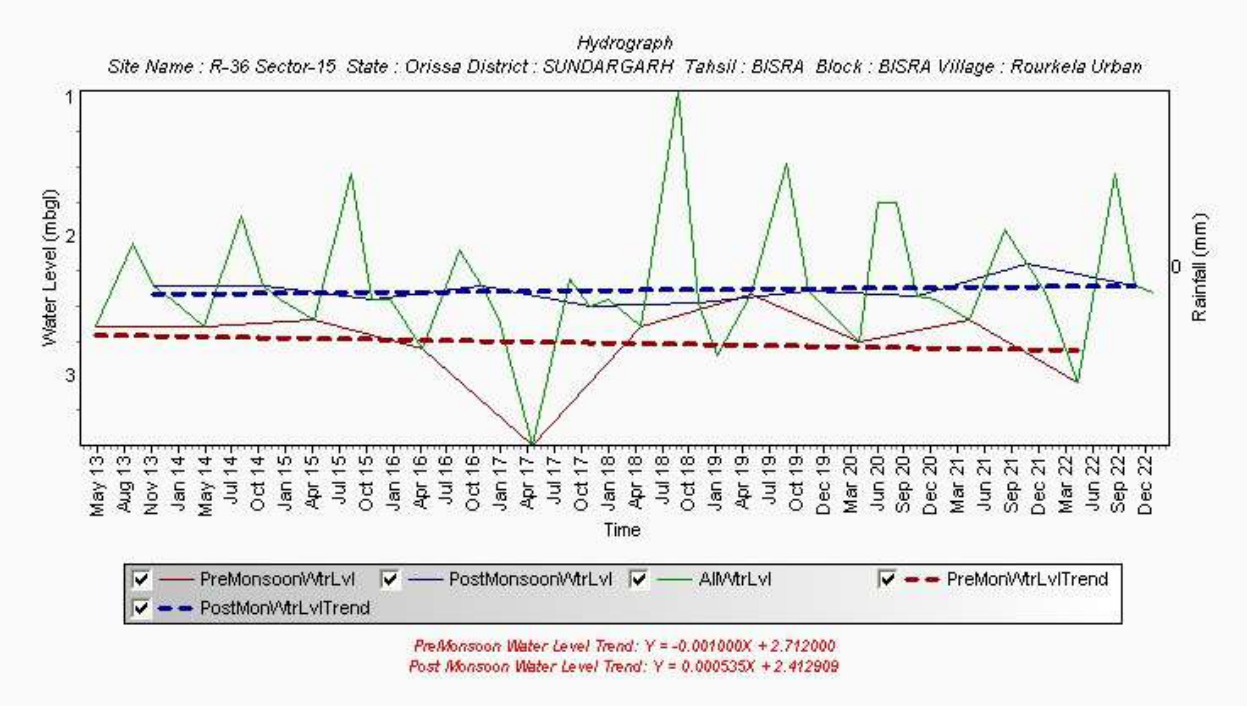

Hydrograph
Site Name : Panderpali State : Orissa District : SUNDARGARH Tahsil : BARAGAON Block : BARAGAON Village : Panderpali
Water Level (mbgl)
Raintall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.009960X + 8.254182
Post Monsoon Water Level Trend: Y = -0.008672X + 5.380727

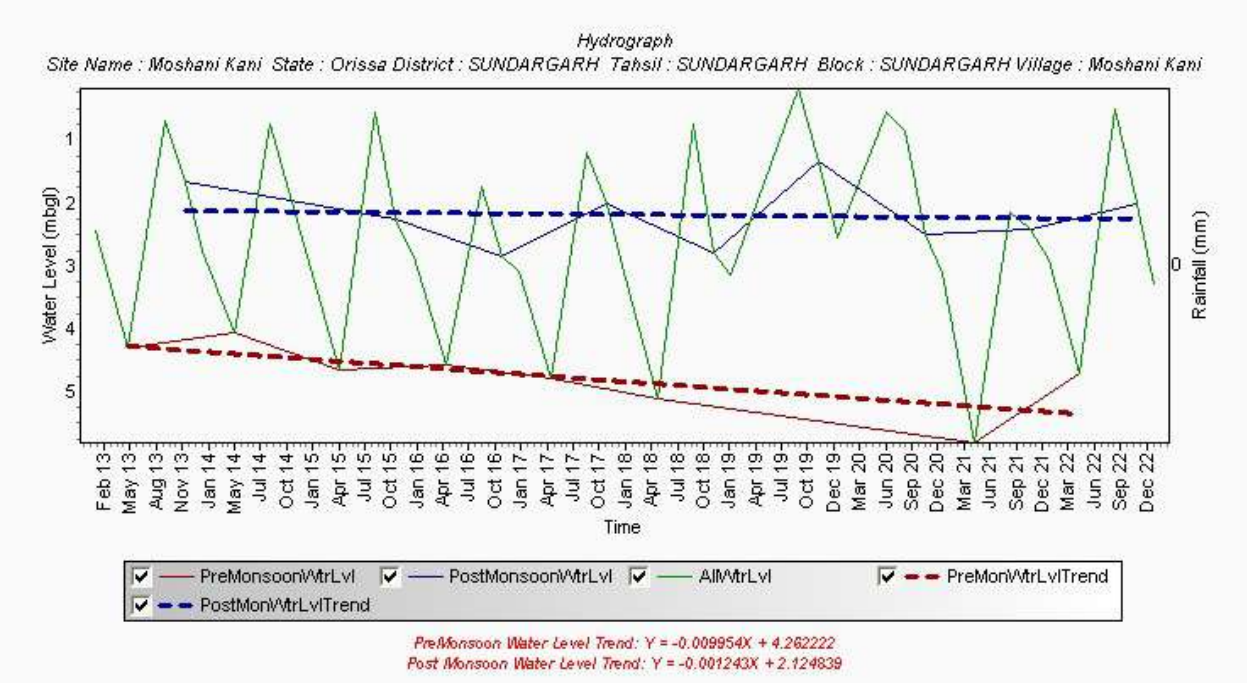

Hydrograph
Site Name : Bargaon State : Orissa District : SUNDARGARH Tahsil : BARAGAON Block : BARAGAON Village : Bargaon
Water Level (mbgl)
Raintall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.001723X + 4.623378
Post Monsoon Water Level Trend: Y = -0.001167X + 1.709556

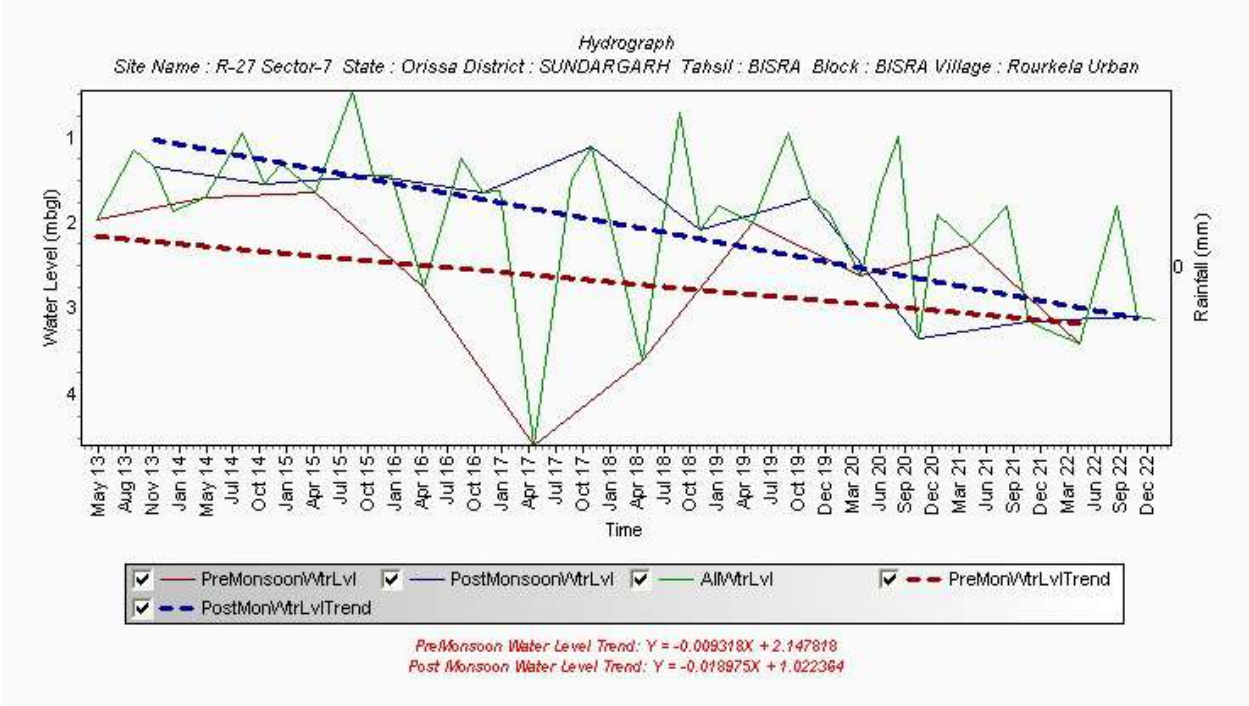

Hydrograph
Site Name : Deokaranpur State : Orissa District : SUNDARGARH Tahsil : BARAGAON Block : BARAGAON Village : Deokaranpur
Water Level (mbgl)
Raintall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.002480X + 5.288428
Post Monsoon Water Level Trend: Y = -0.001060X + 2.392530

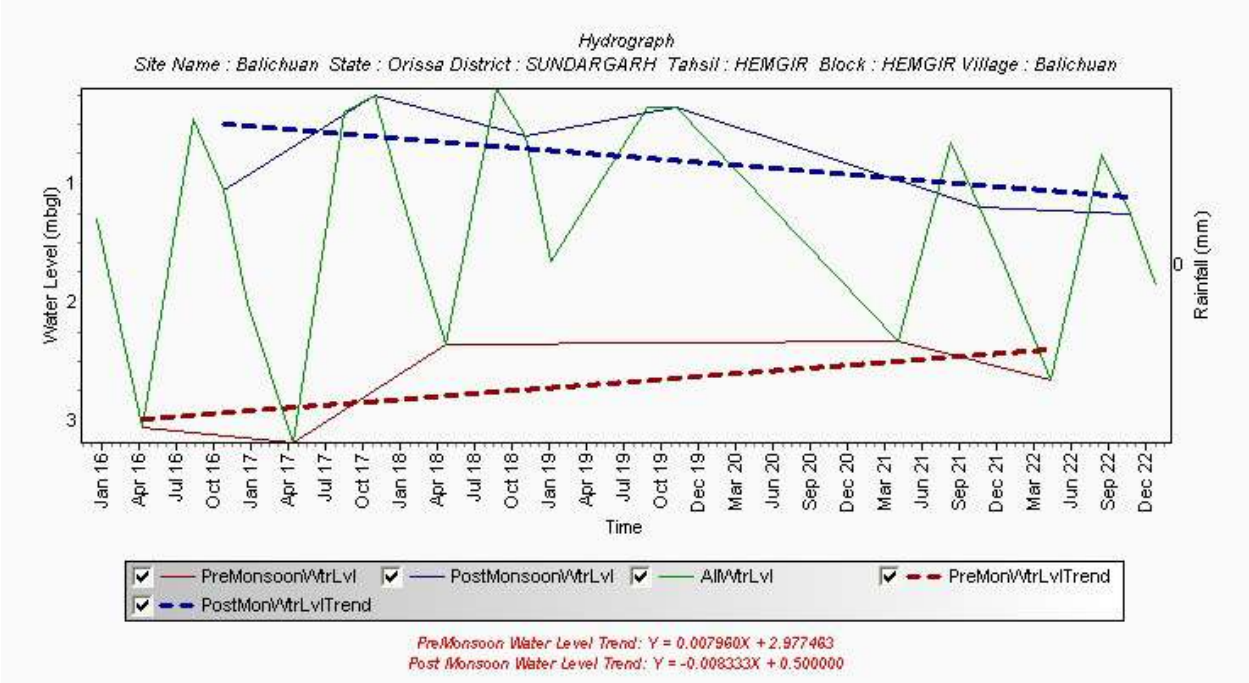

Hydrograph
Site Name : Shahajbahal State : Orissa District : SUNDARGARH Tahsil : BARAGAON Block : BARAGAON Village : Sahajbahal
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.003993X + 4.995833
Post Monsoon Water Level Trend: Y = 0.000556X + 2.240000

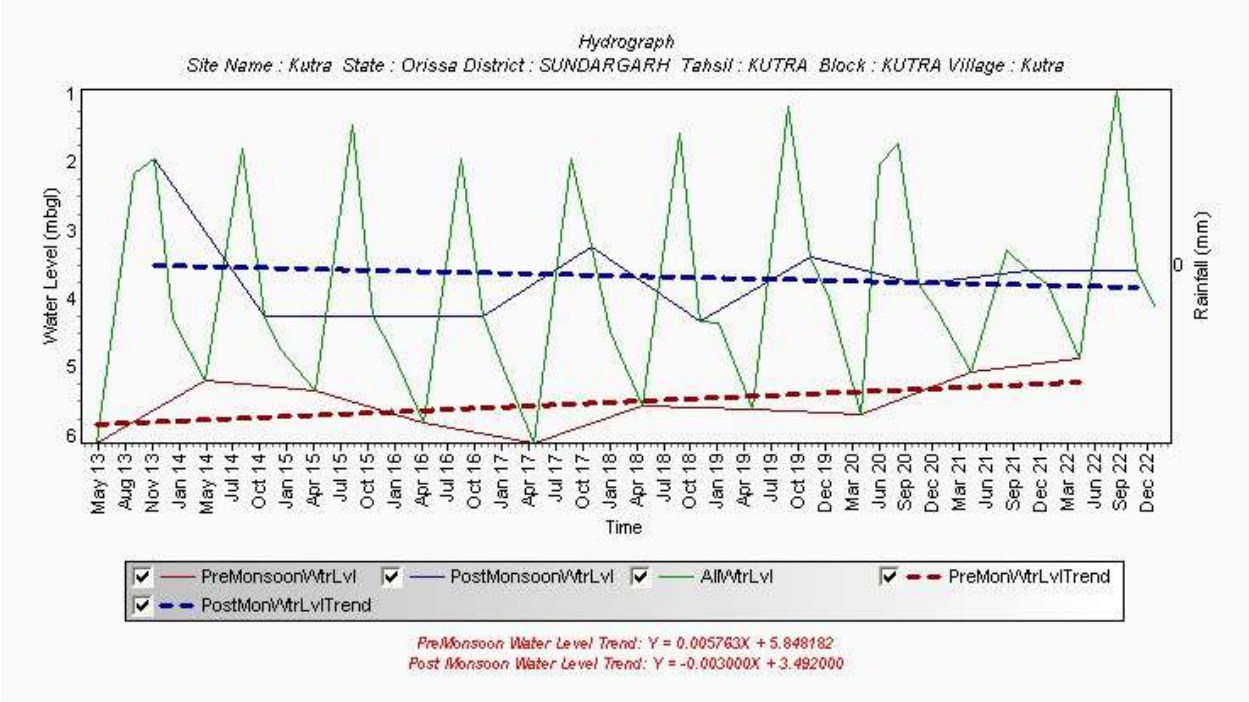

Hydrograph
Site Name : R-02 Jalda Rangila Chhak State : Orissa District : SUNDARGARH Tahsil : BISRA Block : BISRA Village : Rourkela Urban
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.000025X + 2.619636
Post Monsoon Water Level Trend: Y = 0.003460X + 1.781818

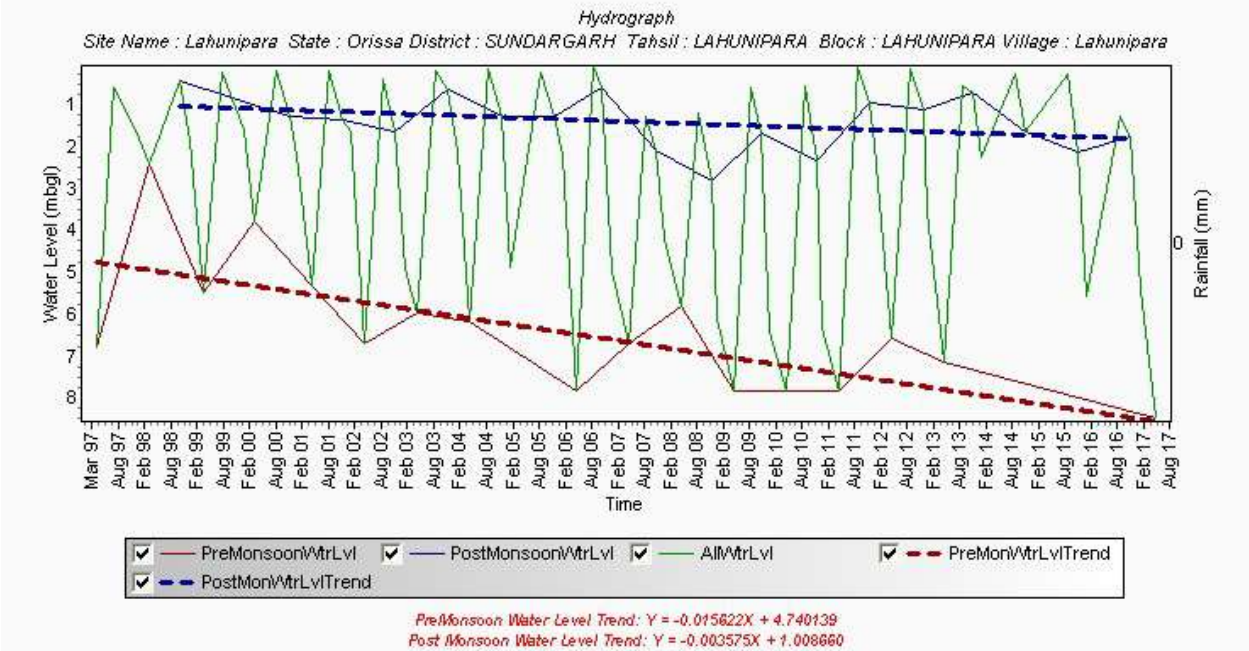

Hydrograph
Site Name : R-36 Sector-15 State : Orissa District : SUNDARGARH Tahsil : BISRA Block : BISRA Village : Rourkela Urban
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.001000X + 2.712000
Post Monsoon Water Level Trend: Y = 0.000535X + 2.412909

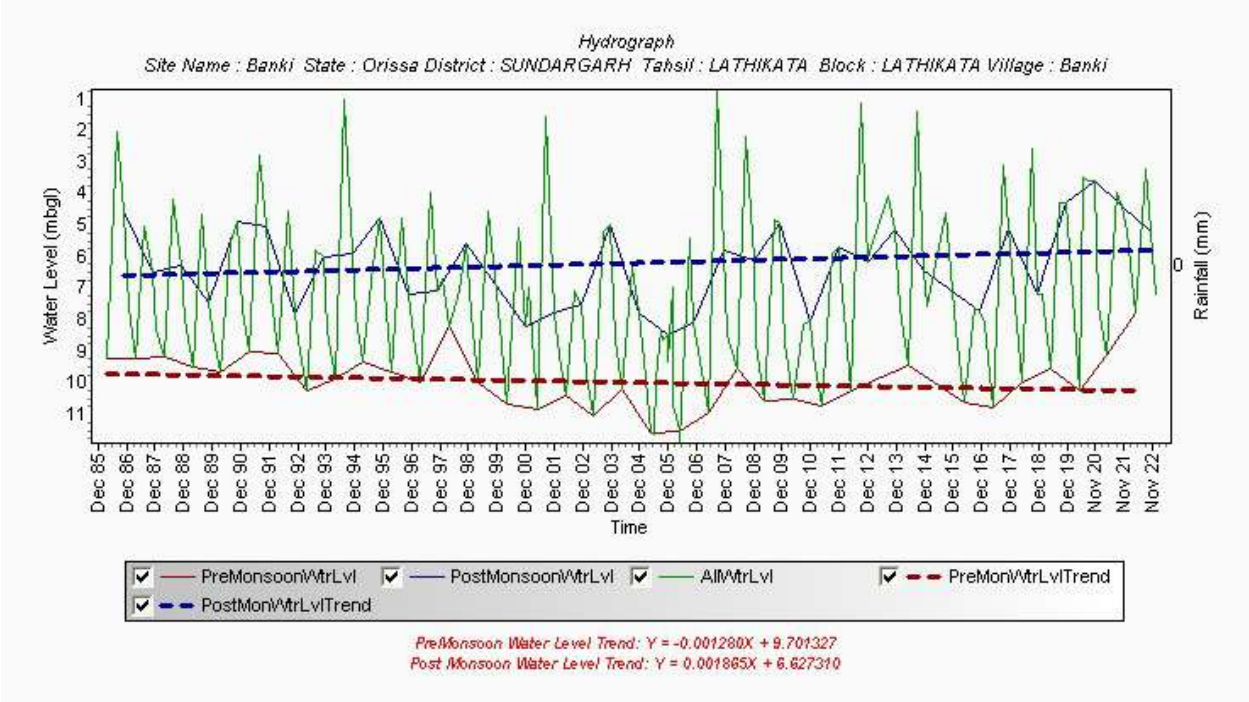

Hydrograph
Site Name : Moshani Kani State : Orissa District : SUNDARGARH Tahsil : SUNDARGARH Block : SUNDARGARH Village : Moshani Kani
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.009954X + 4.262222
Post Monsoon Water Level Trend: Y = -0.001243X + 2.124839

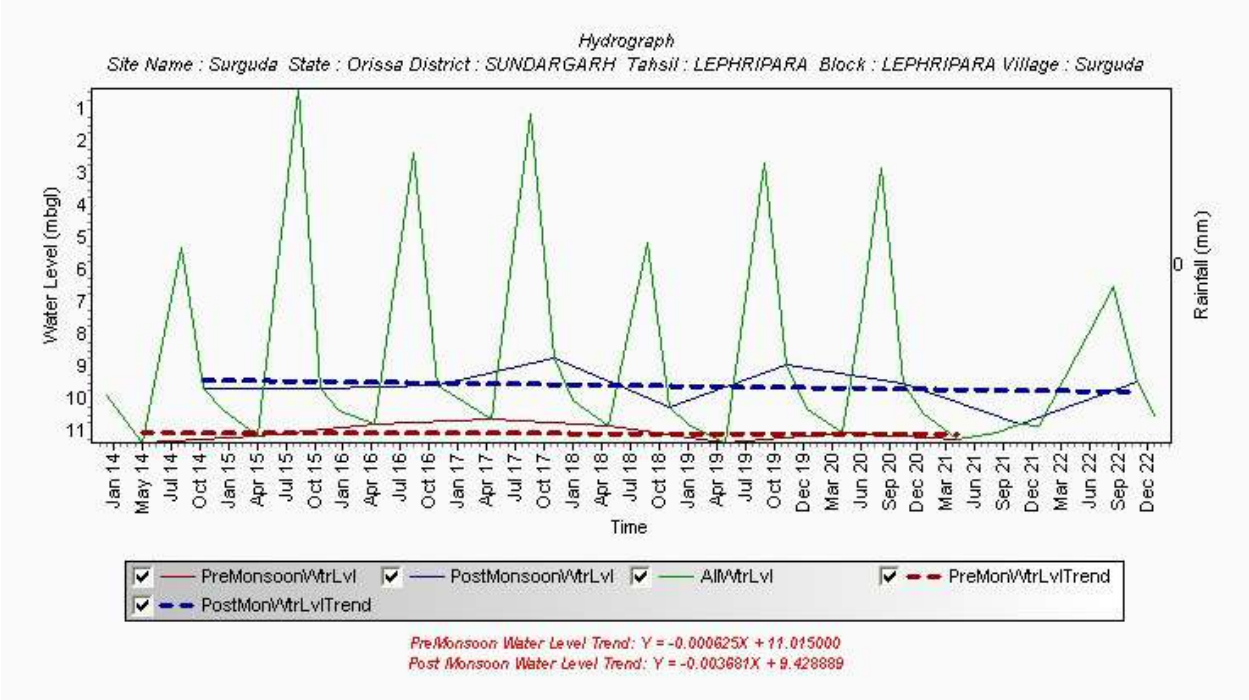

Hydrograph
Site Name : R-27 Sector-7 State : Orissa District : SUNDARGARH Tahsil : BISRA Block : BISRA Village : Rourkela Urban
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.009318X + 2.147818
Post Monsoon Water Level Trend: Y = -0.018975X + 1.022364

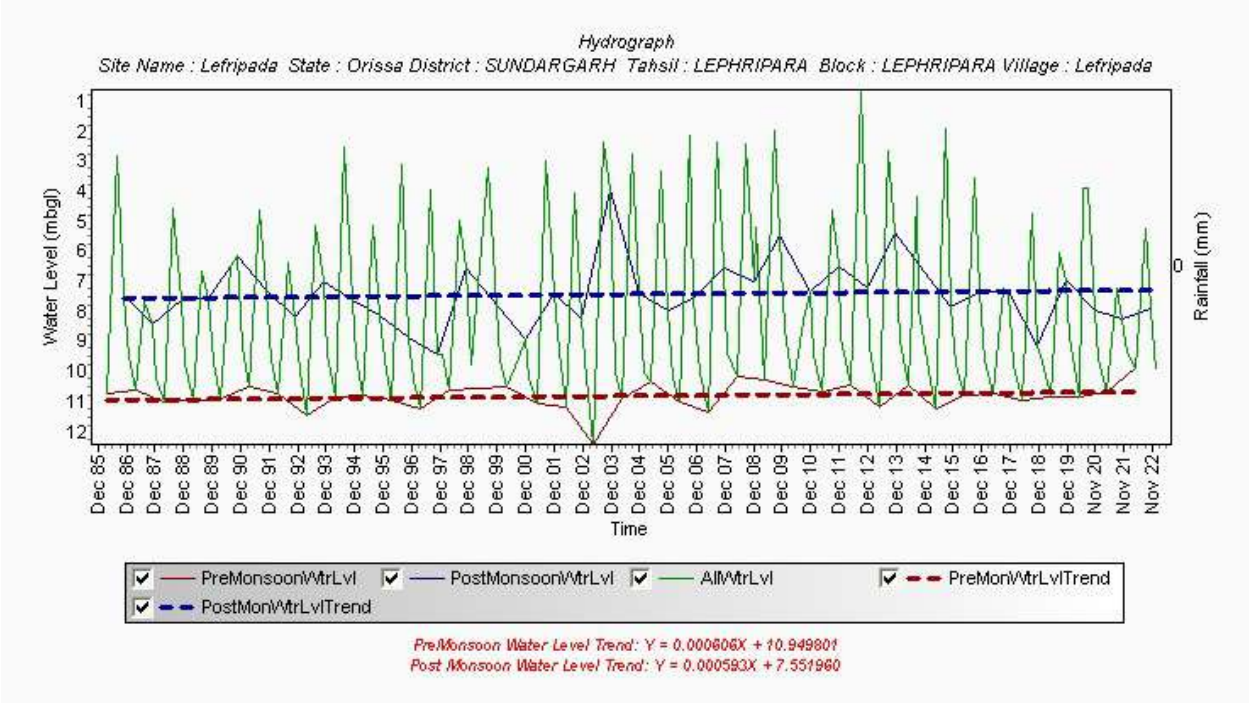

Hydrograph
Site Name : Balichuan State : Orissa District : SUNDARGARH Tahsil : HEMGIR Block : HEMGIR Village : Balichuan
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.007960X + 2.977463
Post Monsoon Water Level Trend: Y = -0.008333X + 0.500000

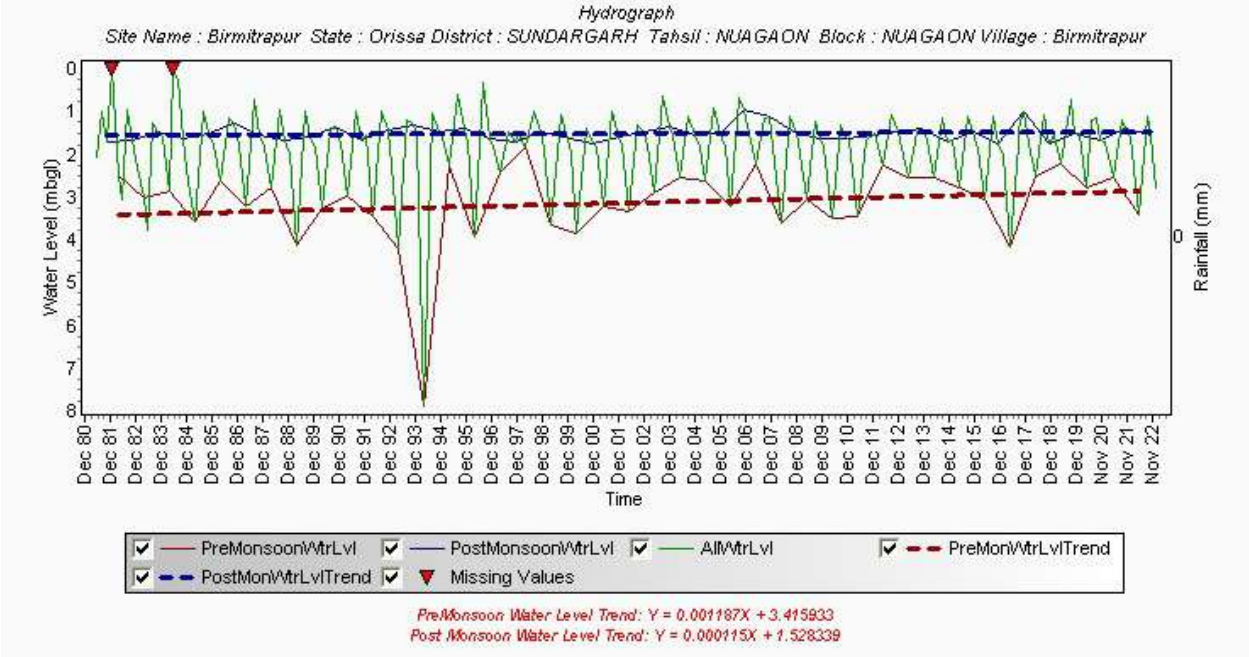

Hydrograph
Site Name : Kutra State : Orissa District : SUNDARGARH Tahsil : KUTRA Block : KUTRA Village : Kutra
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.005763X + 5.848182
Post Monsoon Water Level Trend: Y = -0.003000X + 3.492000

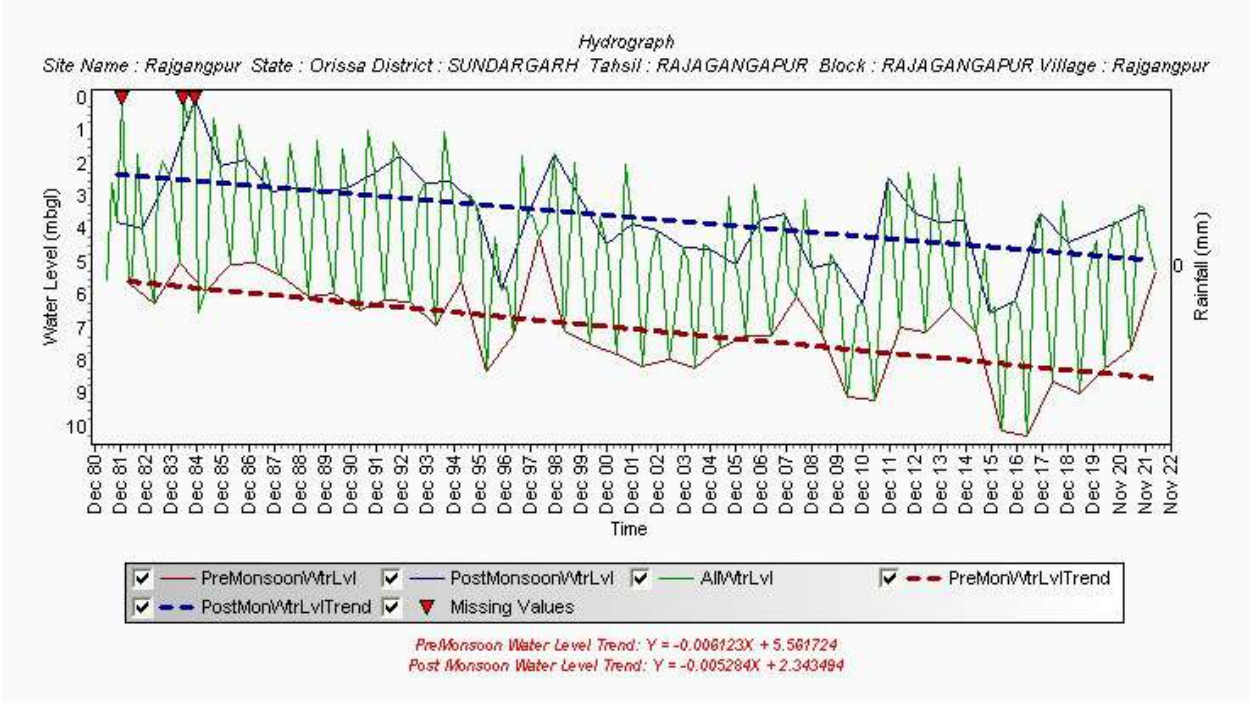

Hydrograph
Site Name : Lahunipara State : Orissa District : SUNDARGARH Tahsil : LAHUNIPARA Block : LAHUNIPARA Village : Lahunipara
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.015622X + 4.740139
Post Monsoon Water Level Trend: Y = -0.003575X + 1.008660

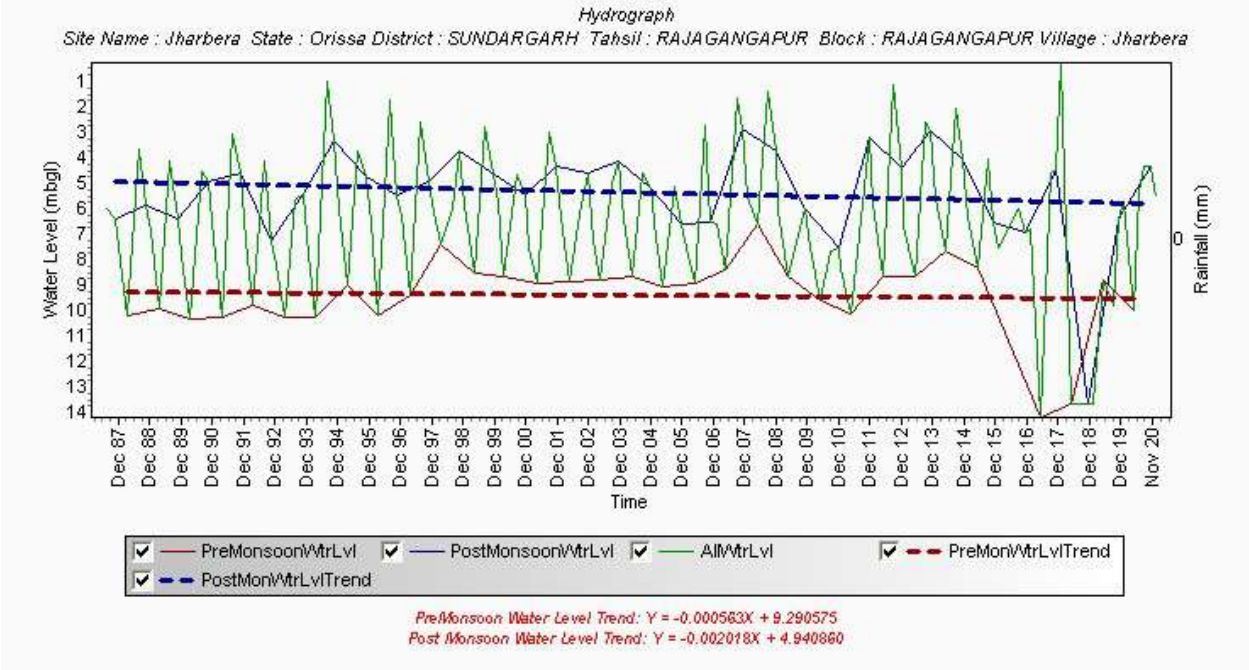

Hydrograph
Site Name : Banki State : Orissa District : SUNDARGARH Tahsil : LATHIKATA Block : LATHIKATA Village : Banki
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.001280X + 9.701327
Post Monsoon Water Level Trend: Y = 0.001865X + 6.627310

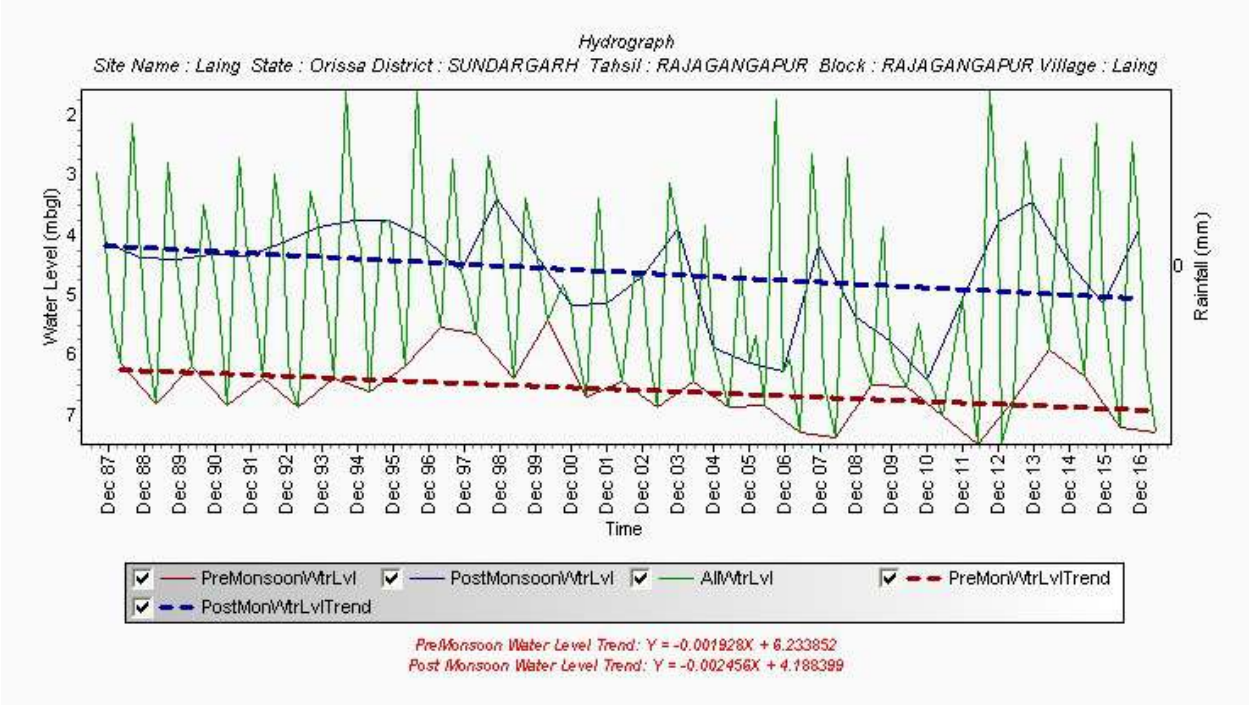

Hydrograph
Site Name : Surguda State : Orissa District : SUNDARGARH Tahsil : LEPHRIPARA Block : LEPHRIPARA Village : Surguda
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.000625X + 11.015000
Post Monsoon Water Level Trend: Y = -0.003681X + 9.428889

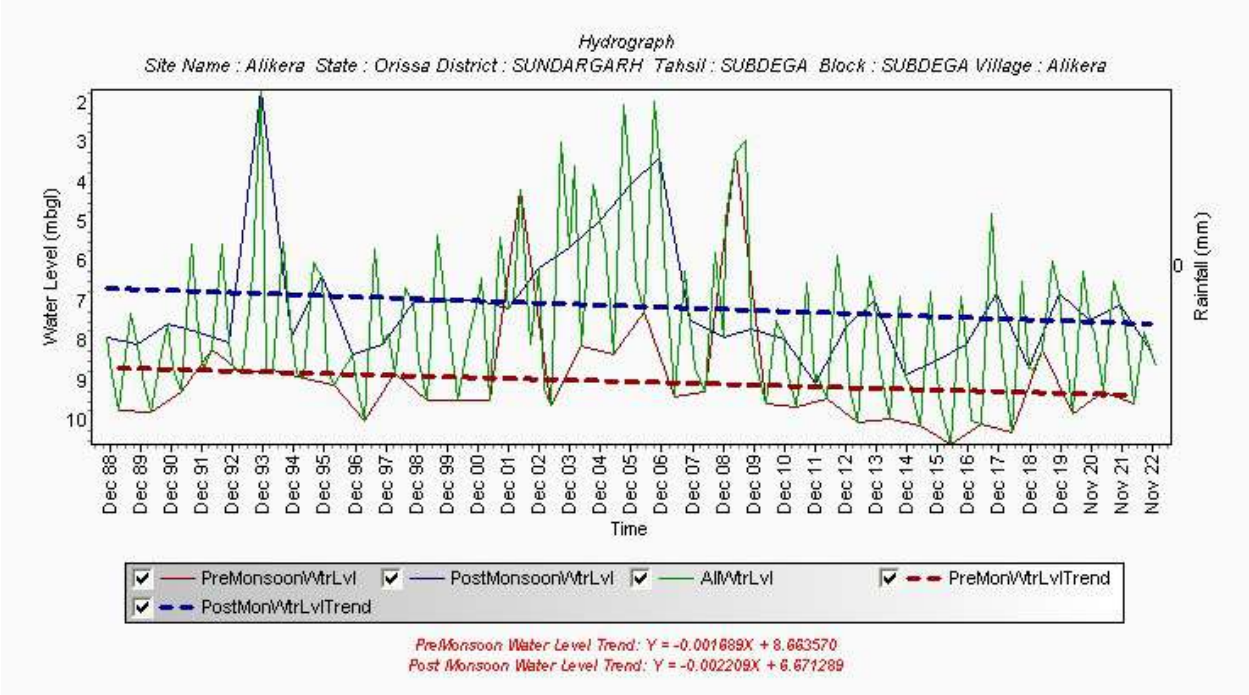

Hydrograph
Site Name : Lefripada State : Orissa District : SUNDARGARH Tahsil : LEPHRIPARA Block : LEPHRIPARA Village : Lefripada
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.000606X + 10.949801
Post Monsoon Water Level Trend: Y = 0.000593X + 7.551960

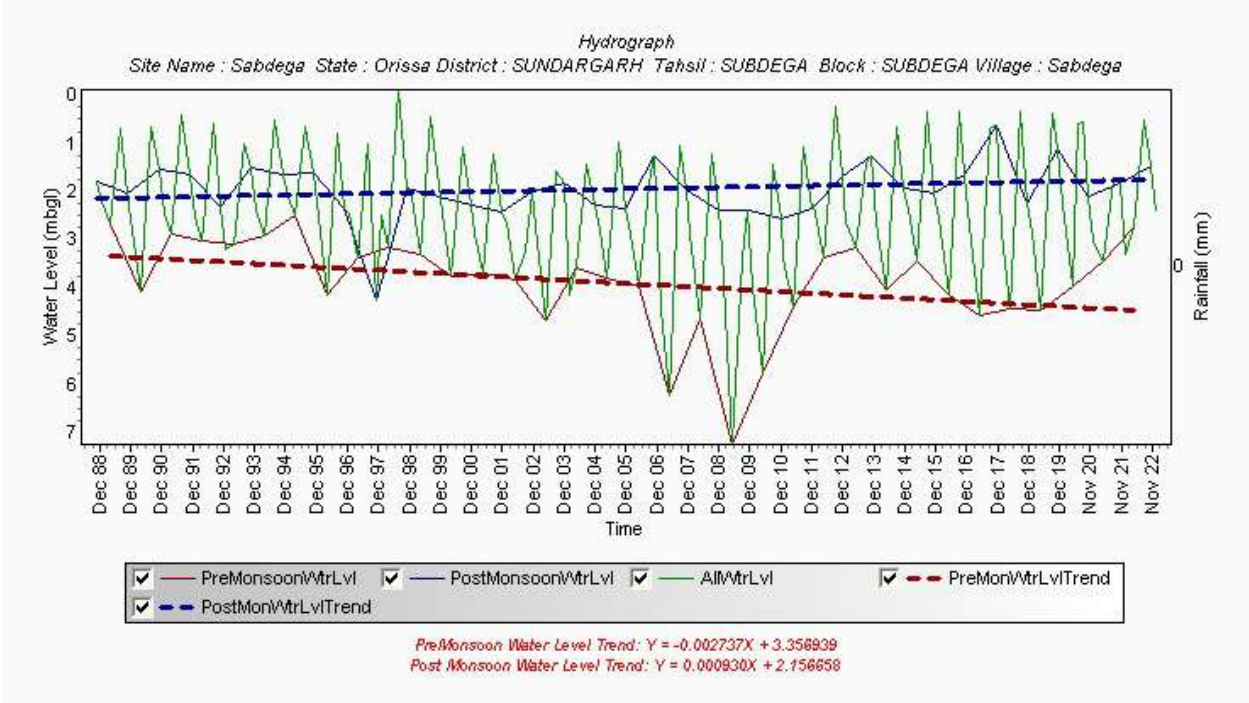

Hydrograph
Site Name : Birmitrapur State : Orissa District : SUNDARGARH Tahsil : NUAGAON Block : NUAGAON Village : Birmitrapur
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
Missing Values
PreMonsoon Water Level Trend: Y = 0.001187X + 3.415933
Post Monsoon Water Level Trend: Y = 0.000115X + 1.528339

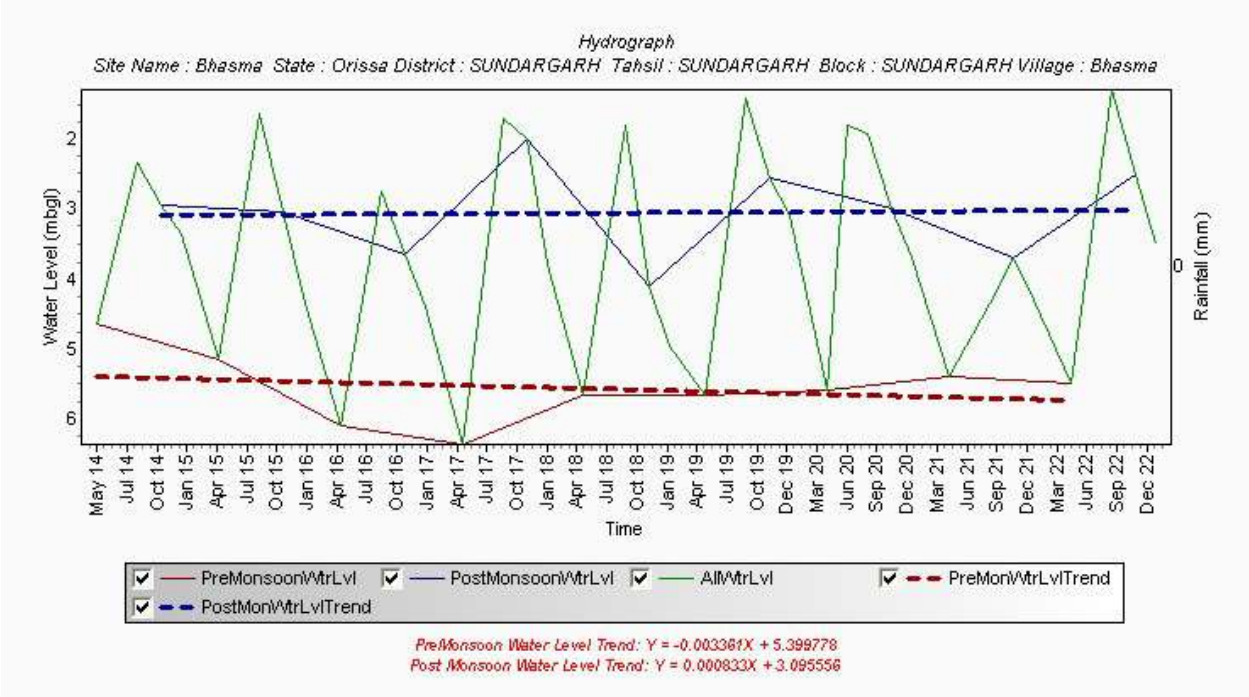

Hydrograph
Site Name : Rajgangpur State : Orissa District : SUNDARGARH Tahsil : RAJAGANGAPUR Block : RAJAGANGAPUR Village : Rajgangpur
Water Level (mbgl)
Raintall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
Missing Values
PreMonsoon Water Level Trend: Y = -0.006123X + 5.561724
Post Monsoon Water Level Trend: Y = -0.005284X + 2.343494

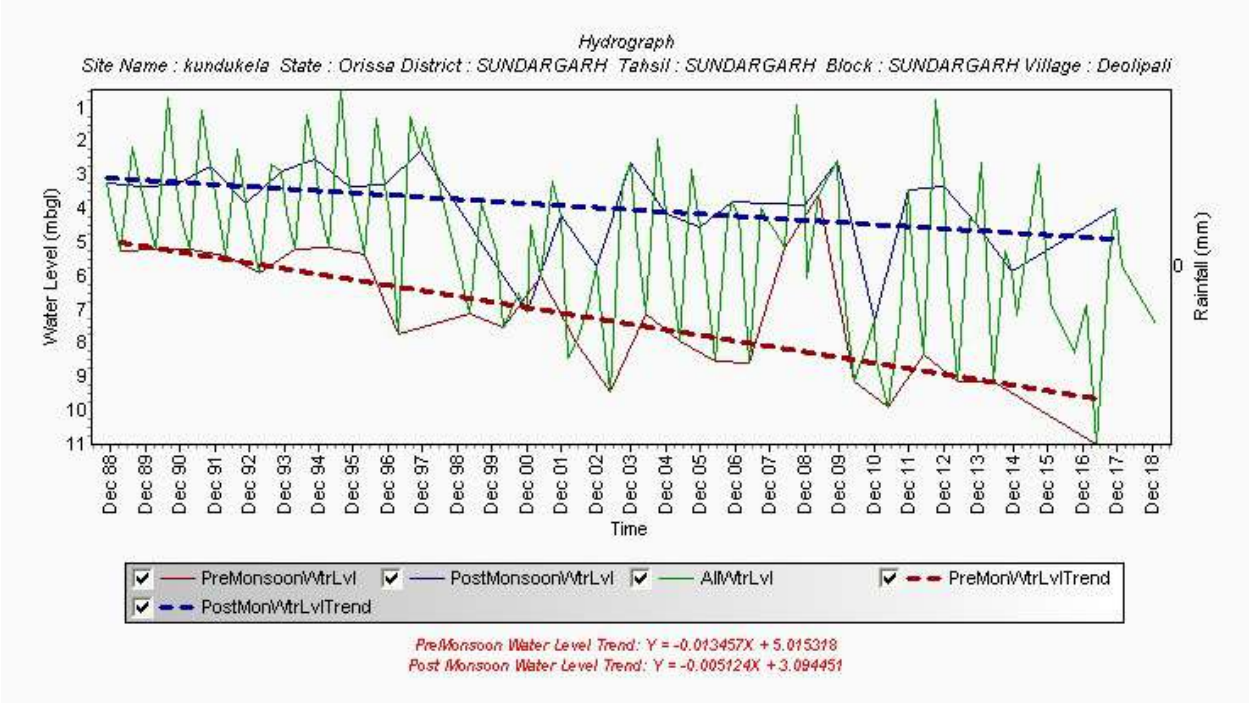

Hydrograph
Site Name : Jharbera State : Orissa District : SUNDARGARH Tahsil : RAJAGANGAPUR Block : RAJAGANGAPUR Village : Jharbera
Water Level (mbgl)
Raintall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.000563X + 9.290575
Post Monsoon Water Level Trend: Y = -0.002018X + 4.940860

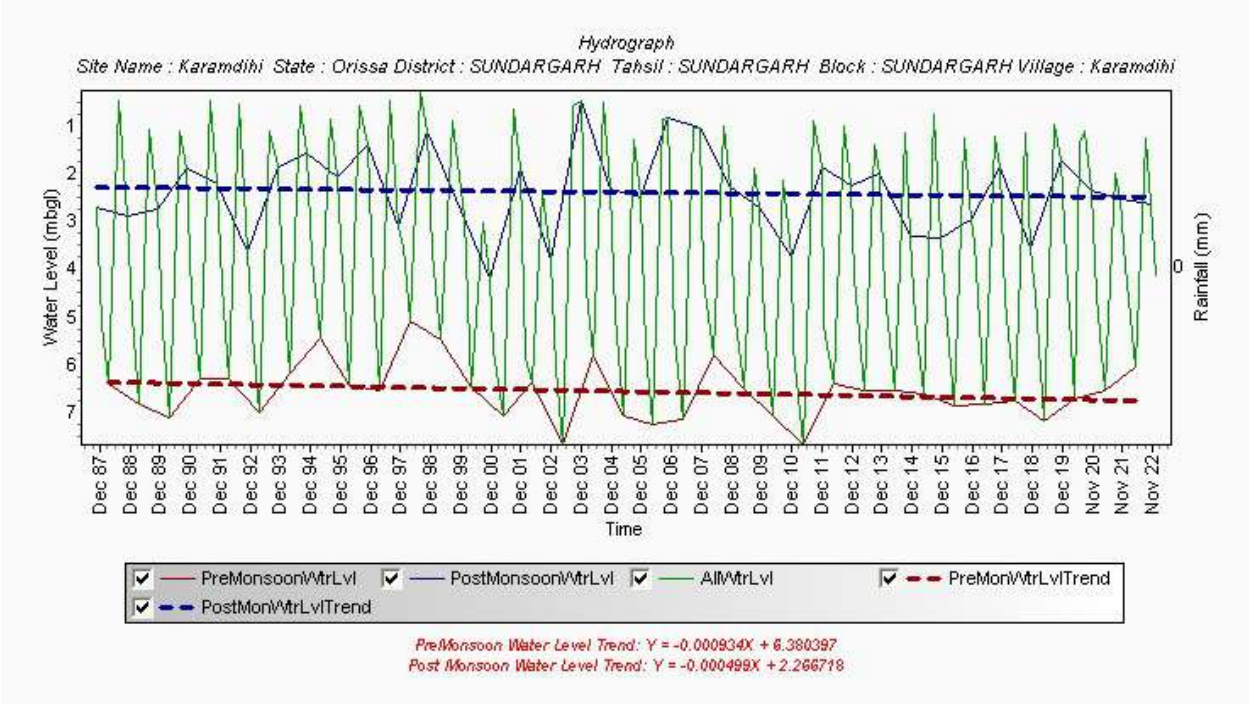

Hydrograph
Site Name : Laing State : Orissa District : SUNDARGARH Tahsil : RAJAGANGAPUR Block : RAJAGANGAPUR Village : Laing
Water Level (mbgl)
Raintall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.001928X + 6.233852
Post Monsoon Water Level Trend: Y = -0.002456X + 4.188399

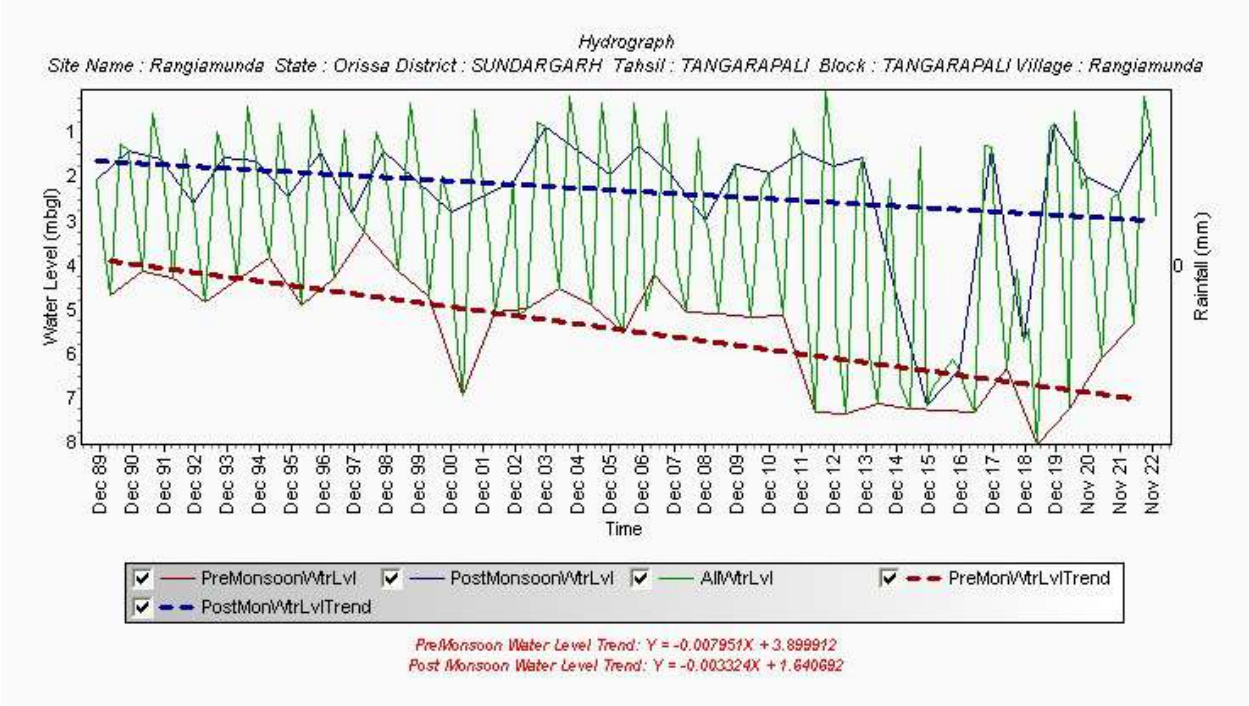

Hydrograph
Site Name : Alikera State : Orissa District : SUNDARGARH Tahsil : SUBDEGA Block : SUBDEGA Village : Alikera
Water Level (mbgl)
Raintall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.001689X + 8.663570
Post Monsoon Water Level Trend: Y = -0.002209X + 6.671289


Hydrograph
Site Name : Sabdega State : Orissa District : SUNDARGARH Tahsil : SUBDEGA Block : SUBDEGA Village : Sabdega
Water Level (mbgl)
Raintall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.002737X + 3.356939
Post Monsoon Water Level Trend: Y = 0.000930X + 2.156658


Hydrograph
Site Name : Bhasma State : Orissa District : SUNDARGARH Tahsil : SUNDARGARH Block : SUNDARGARH Village : Bhasma
Water Level (mbgl)
Raintall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.003361X + 5.399778
Post Monsoon Water Level Trend: Y = 0.000833X + 3.095556


Hydrograph
Site Name : kundukela State : Orissa District : SUNDARGARH Tahsil : SUNDARGARH Block : SUNDARGARH Village : Deolipali
Water Level (mbgl)
Raintall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.013457X + 5.015318
Post Monsoon Water Level Trend: Y = -0.005124X + 3.094451


Hydrograph
Site Name : Karamdihi State : Orissa District : SUNDARGARH Tahsil : SUNDARGARH Block : SUNDARGARH Village : Karamdihi
Water Level (mbgl)
Raintall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.000934X + 6.380397
Post Monsoon Water Level Trend: Y = -0.000499X + 2.266718


Hydrograph
Site Name : Rangiamunda State : Orissa District : SUNDARGARH Tahsil : TANGARAPALI Block : TANGARAPALI Village : Rangiamunda
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.007951X + 3.899912
Post Monsoon Water Level Trend: Y = -0.003324X + 1.640692

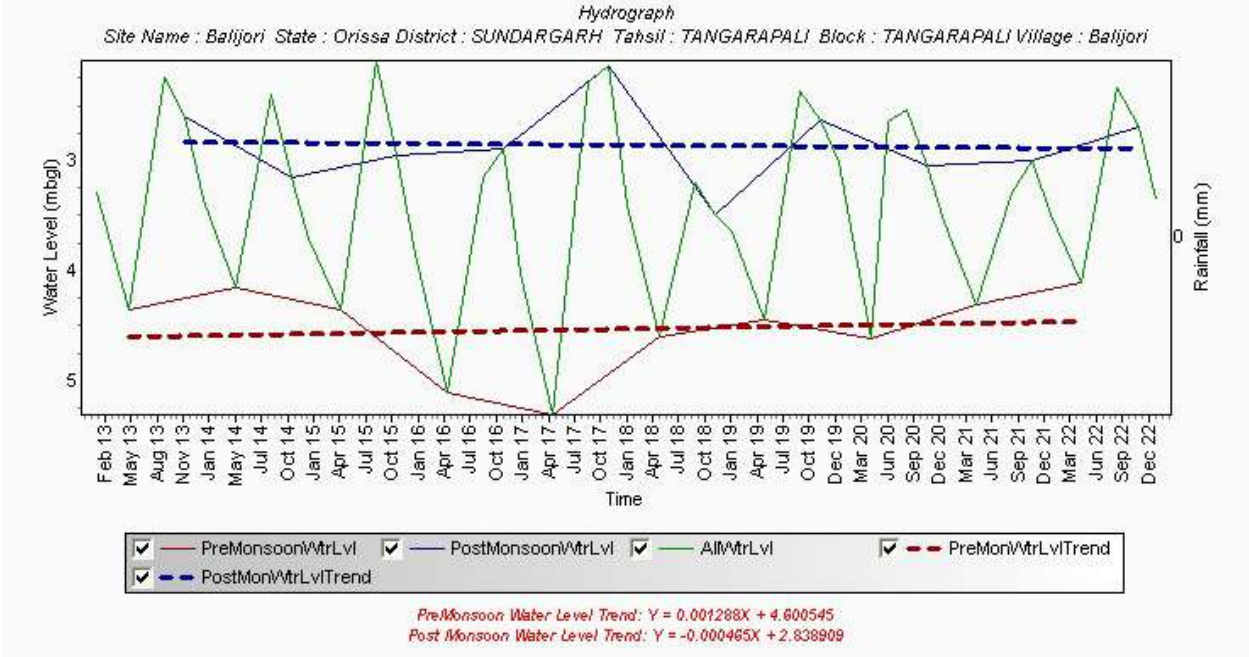

Hydrograph
Site Name : Balijori State : Orissa District : SUNDARGARH Tahsil : TANGARAPALI Block : TANGARAPALI Village : Balijori
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.001288X + 4.600545
Post Monsoon Water Level Trend: Y = -0.000465X + 2.838909

Table No. 4.1 – Chemical data of GWMS of Sundargarh District (Pre-Monsoon)

VILLAGE	pH	EC µS/cm	TDS	Hardness	Alkalinity	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO_3^{=}$	HCO_3^{-}	Cl^{-}	SO_4	NO_3	F^{-}	U
Asurchhapal	8.0	1656	916	200	505	38	25.5	285	13	0	616	147	96.2	9.6	0.9	0.01
Badibahal	7.8	390	203	155	105	40	13.4	16	6	0	128	57	2.0	6.2	0.2	BDL
Badmal	8.0	317	174	125	85	22	17.0	10	8.9	0	104	32	9.6	23.2	0.3	BDL
Bagiaberni	7.8	460	257	105	130	22	12.2	57	7.4	0	159	22	56.7	1.6	0.4	BDL
Bakartola	7.5	441	226	185	150	42	19.4	9.3	18	0	183	37	6.2	4.7	0.2	BDL
Bandega	8.0	454	217	200	160	22	35.2	11	1.6	0	195	42	3.7	5.9	0.5	0
Bandhberna	7.9	163	81	75	55	14	9.7	4	1	0	67	10	5.5	3.5	0.1	BDL
Bandhpali	8.1	704	374	225	200	42	29.2	50	20	0	244	85	7.6	20.7	0.3	BDL
Basjore	7.8	235	116	100	100	20	12.2	5.49	1.3	0	122	11	5.9	0.1	0.2	BDL
Bhalulata	8.2	366	192	120	130	34	8.5	26	1.2	0	159	30	13.2	1.4	0.4	BDL
Bheluantikra	7.9	209	108	85	70	20	8.5	7	4.4	0	85	20	0.0	6.1	0.1	BDL
Bhoagra	8.3	635	344	250	145	50	30.4	30	2.9	0	177	80	27.5	36.5	0.2	BDL
Bhojpur	7.9	308	159	135	95	30	14.6	5	1.8	0	116	38	5.2	7.2	0.3	BDL
Bijadihi	8.0	1033	620	275	135	34	46.2	56	110	0	165	177	72.5	43.4	0.3	BDL
Bilaimunda	8.0	614	322	235	190	56	23.1	27	5.4	0	232	72	9.1	15.4	0.2	BDL
Birbira	8.1	929	500	370	155	22	76.5	28	44	0	189	140	49.2	47.6	0.4	BDL
Bishpur	7.9	305	186	95	60	26	7.3	12	24	0	73	45	3.1	33.3	0.1	BDL
Bonoigarh	8.2	458	232	175	155	44	15.8	25	1	0	189	45	8.3	0.2	0.2	BDL
Dasrajpur	8.1	330	182	125	90	42	4.9	18	4.8	0	110	28	23.7	6.7	0.9	BDL
Deobhuvanpur	8.1	657	346	285	145	46	41.3	19	2.3	0	177	75	65.5	10.4	0.4	BDL
Dimrikada	8.2	748	410	290	130	46	42.5	39.3	9.9	0	159	102	50.0	42.0	0.4	0.01
Duduka	7.9	609	348	200	165	64	9.7	33	29	0	201	65	16.3	32.8	0.2	BDL
Fakir munda	8.2	350	184	140	110	36	12.2	17	1	0	134	27	16.3	9.0	0.1	BDL
Gadarua	8.0	196	101	85	80	30	2.4	4.6	1.3	0	98	10	3.0	1.7	0.1	BDL
Gadiajore	8.0	199	106	90	70	28	4.9	3.7	1.5	0	85	14	1.4	10.5	0.1	BDL
Gaibira	7.7	407	250	110	55	28	9.7	42	3.6	0	67	47	43.6	43.1	0.3	BDL
Gangajal	8.0	285	155	130	95	36	9.7	4	1.6	0	116	19	0.7	27.1	0.4	BDL
Giringkela	8.0	492	234	205	225	22	36.5	17	5.5	0	275	1	10.7	6.3	0.3	BDL

Gopalpur	7.9	728	412	250	200	68	19.4	33	40	0	244	75	13.1	44.3	0.4	BDL
Gopalpur	7.4	361	187	80	160	24	4.9	46	0.7	0	195	10	5.4	0.8	0.6	BDL
Jamudih	8.3	432	219	180	140	46	15.8	18	1	0	171	40	11.9	2.7	0.1	BDL
Jamudih	7.3	824	435	325	195	36	57.1	38	3.9	0	238	90	58.7	34.8	0.2	BDL
Jatrapadia	8.1	1385	778	400	160	44	70.5	100	65	0	195	310	48.7	44.8	0.3	BDL
Jhagarpur	8.1	341	177	140	105	30	15.8	15	1.8	0	128	27	16.2	8.1	0.4	BDL
Jhariapali	8.3	449	232	140	195	38	10.9	40	3.2	0	238	7	2.2	13.7	0.4	BDL
Jharpada	7.9	270	139	125	100	26	14.6	4	3	0	122	11	1.3	19.6	0.4	BDL
Jodabandh	8.2	541	272	205	140	14	41.3	30	1.9	0	171	72	16.1	12.7	0.3	BDL
Kanika	7.9	364	194	125	125	40	6.1	21	6	0	153	37	4.5	4.1	0.1	BDL
Katingidihi	7.6	1071	543	410	350	22	86.3	61	1	0	427	47	73.6	42.8	0.7	0.03
Kendughati	8.3	263	134	110	100	28	9.7	7	4	0	122	17	7.2	1.0	0.3	BDL
Khamarimunda	8.2	685	361	200	240	44	21.9	65	1.3	0	293	40	36.3	8.9	1.3	BDL
Khandadhar	7.4	419	207	170	185	42	15.8	18	1	0	226	12	3.6	3.5	0.2	BDL
Kharalchhapal	8.0	221	119	75	75	22	4.9	16	1	0	92	15	6.6	8.5	1.1	BDL
Kinjrikela	7.8	189	102	80	60	26	3.6	5	3	0	73	18	3.0	7.7	0.2	BDL
Kinjrima	7.7	562	315	195	85	34	26.7	33	12	0	104	112	0.5	46.2	0.3	BDL
Koelijhar	8.3	391	190	175	150	36	20.7	10.6	0.5	0	183	22	8.7	2.2	0.2	BDL
Koiradi	8.1	357	178	135	130	24	18.2	19.7	1	0	159	25	9.8	2.5	0.1	BDL
Kuanrkela	7.7	629	357	190	165	42	20.7	39	35	0	201	75	4.2	42.6	0.3	BDL
Kuarmunda	8.1	1034	567	370	205	64	51.0	63	6	0	250	145	72.2	42.9	0.3	BDL
Kucheta	8.1	656	378	115	120	28	10.9	96	3.7	0	146	110	26.0	31.4	0.2	BDL
Kukdagate	8.2	363	196	145	115	34	14.6	15	2	0	140	25	14.9	21.6	1.0	0
Kulabira	8.0	510	260	215	200	64	13.4	15	11	0	244	30	2.6	5.0	0.4	BDL
Kurda	7.4	990	585	280	200	40	43.7	50	85	0	244	122	86.3	38.0	0.2	0
Kurumker	7.9	321	180	110	100	40	2.0	21	1.7	0	122	22	25.4	7.2	0.3	BDL
Kusumdegi	7.8	151	80	60	60	18	3.6	5	1.5	0	73	7	1.5	8.0	0.2	BDL
Lahandabud	8.1	978	577	305	150	26	58.3	47	76	0	183	117	115.8	47.3	1.4	BDL
Laing	8.1	633	325	280	160	30	49.8	19	1	0	195	60	41.0	28.4	0.3	BDL
Lalei Chhak	7.4	918	459	335	230	32	62.0	57	1.5	0	281	140	25.6	3.7	0.4	0
Lalei Village	7.3	736	366	320	170	48	48.6	21	1	0	207	132	5.9	8.4	0.3	BDL

Lamsi	7.3	474	252	200	165	62	10.9	11.8	7.4	0	201	30	27.9	3.4	0.3	BDL
Lathikata	7.3	590	322	175	120	48	13.4	59	4	0	146	87	32.2	6.6	0.5	BDL
Limda	8.1	221	114	105	85	28	8.5	2	1.9	0	104	10	0.0	12.6	0.4	BDL
Ludhini	8.2	299	163	115	75	36	6.1	17	1	0	92	35	8.7	14.4	0.2	BDL
Luhanipada	8.2	240	124	90	90	20	9.7	15.2	0.4	0	110	10	2.8	12.0	0.2	BDL
Majhapada	8.0	1082	562	365	305	26	72.9	61	27	0	372	142	14.6	36.6	0.2	BDL
Nuadihi	7.9	1047	552	355	260	46	58.3	54	46	0	317	155	30.8	6.6	0.3	0
Nuagan	8.0	653	313	225	295	32	35.2	52	1.4	0	360	5	8.4	2.8	0.9	BDL
Nuagaon	8.1	985	555	300	195	24	58.3	80	15	0	238	97	118.4	45.9	0.4	BDL
Nuagaon	7.8	758	414	220	165	26	37.7	64	11	0	201	125	6.8	45.3	0.1	BDL
Pamra	8.0	967	579	230	125	22	42.5	75	74	0	153	154	112.7	23.4	0.3	BDL
Panchra	7.7	404	208	140	170	24	19.4	25.5	3.6	0	207	4	20.6	9.4	0.1	BDL
Philingibahal	7.9	968	508	385	145	32	74.1	42	21	0	177	185	19.5	48.1	0.5	BDL
Purnapani	8.0	463	222	210	175	30	32.8	8.7	1	0	214	33	5.7	5.9	0.4	BDL
Purnapani	8.1	224	112	90	105	26	6.1	8.9	0.8	0	128	2	4.4	1.4	0.1	BDL
Putrikhaman	8.2	356	183	110	140	28	9.7	30	0.7	0	171	22	6.8	1.6	0.8	BDL
Rajgangpur	7.5	1917	984	710	495	50	142.2	107	7.6	0	604	227	107.9	46.0	0.8	0.03
Raksi	7.3	561	292	220	175	50	23.1	27	1	0	214	50	25.2	11.3	0.2	BDL
Ramjhodi	7.5	632	309	265	220	28	47.4	22	8	0	268	42	25.0	5.0	0.6	BDL
Rangmati	7.4	545	267	235	230	52	25.5	16	1.4	0	281	22	8.2	4.3	0.2	BDL
Rasipatra	8.1	821	442	305	160	14	65.6	40	4.8	0	195	110	73.0	39.4	0.3	0
Rasti	8.0	707	405	250	105	56	26.7	47	1.3	0	128	105	62.0	44.5	0.4	0
Sagadiposh	7.3	382	208	155	95	38	14.6	16.2	4.4	0	116	32	38.4	7.6	0.4	BDL
Sagbahal	8.2	584	319	150	175	18	25.5	37	44	0	214	80	5.9	4.4	0.4	BDL
Sahajbahal	7.9	305	158	135	75	34	12.2	10	1.4	0	92	42	3.2	10.5	0.4	BDL
salaipalli	7.9	184	100	75	60	28	1.2	6.6	3.3	0	73	15	4.9	5.6	0.1	BDL
Saraitali	8.0	601	328	235	155	28	40.1	15	23	0	189	65	21.6	43.0	0.5	BDL
Sargigad	7.9	222	115	95	80	24	8.5	6.3	2.9	0	98	12	8.9	4.4	0.2	BDL
sarubahal	7.9	215	109	100	75	30	6.1	3.7	0.8	0	92	17	5.2	1.5	0.6	BDL
Selangabud	8.1	636	339	250	175	36	38.9	26	19	0	214	44	45.5	24.9	0.9	BDL
Simdega	7.8	278	152	100	80	24	9.7	13	7.5	0	98	22	25.6	2.0	0.2	BDL

Sonaparvat	8.2	566	319	205	125	46	21.9	34	4.5	0	153	60	35.6	41.9	0.4	BDL
Sudarshanpur	8.0	449	233	125	130	12	23.1	48	1.3	0	159	45	16.7	8.6	0.8	BDL
Surguda	8.0	336	177	135	120	46	4.9	12	5.3	0	146	30	-0.4	7.5	0.2	BDL
Talabahari	8.3	378	193	150	150	42	10.9	16	5	0	183	17	11.6	0.4	0.1	BDL
Tangargaon	7.9	322	164	120	110	26	13.4	17	1.8	0	134	32	7.2	0.7	0.4	BDL
Taparia	8.0	403	206	130	140	26	15.8	29	6.9	0	171	40	2.0	3.0	0.3	BDL
Tarkera	8.0	462	265	170	105	36	19.4	18	20	0	128	52	15.0	41.9	0.2	BDL
Tasladihi	7.6	343	189	140	80	24	19.4	15	1	0	98	35	6.6	39.8	0.1	BDL
Telendihi	8.0	255	135	85	100	30	2.4	18	1.2	0	122	15	4.9	3.4	0.2	BDL
Tildega	8.3	798	403	290	280	48	41.3	47	2.2	0	342	65	23.3	8.1	0.7	0.01
Timna	7.8	233	116	100	70	18	13.4	6.8	3.5	0	85	27	2.9	3.1	0.1	BDL
Tumlia	8.1	724	374	255	285	24	47.4	47	2.2	0	348	7	31.7	44.2	0.3	BDL
Ujjalpur	7.9	1085	646	185	135	40	20.7	125	69	0	165	250	12.2	48.0	0.2	BDL

Table No. 4.2 – Chemical data of GWMS of Sundargarh District (Post-Monsoon)

Location	pH	EC	TDS	TH	TA	Ca++	Mg++	Na+	K+	CO3-	HCO3-	Cl-	SO4(2-)	NO3-	F-	U (ppb)
Balinga PS	7.89	450	231.3	153.2	85.3	35.55	15.64	16.9	7.5	0	104	42.1	22.8	39.5	0.41	4.0
Barpali RS	7.53	286	141.8	80.6	53.7	26.16	3.71	10.8	11.5	0	65.5	19.8	29.1	8.4	0.31	0.1
Bharatpur	7.37	502	248.9	159.6	87.4	45.34	11.27	13.8	14.1	0	106.6	41	30.8	40.3	0.16	0.3
Bharatpur	7.37	299	155.3	98.2	60.7	25.89	8.14	10.6	8.8	0	74	26.1	19.6	19.8	0.08	0.0
Bharatpur	8.00	652	278	214.7	141.3	45.61	24.49	17.6	2.3	0	172.4	14.9	86.1	1.2	1.21	0.6
Gadabhanga	7.80	230	116.6	77.5	67.4	20.39	6.47	10.3	6.1	0	82.3	18.7	11.1	3.1	0.07	0.1
Gadabhanga	7.07	153	83.9	61.1	62.4	12.88	7.02	9.8	1.2	0	76.1	13.5	1.8	0	0.25	0.0
Garjanbahal	7.33	634	300.9	113.1	67.3	32.33	7.87	34	30.1	0	82.1	68.3	44	43.9	0.26	0.1
Gopalpur	7.79	607	253.6	153.6	126.4	35.55	15.74	30	5.6	0	154.2	30	39.6	21	0.59	0.7
Haldibahal	7.52	853	404.9	215.1	168.9	38.77	28.73	45.8	32.7	0	206.1	80.2	52.3	25	0.42	0.3
Karlikachar	7.98	1128	514.8	180.3	248.7	43.06	17.67	69.3	79.1	0	303.4	77.5	49.8	29.1	0.6	1.3
Khulapada	7.75	372	189.9	97.1	61.2	29.24	5.84	20.4	5.6	0	74.7	37	12.5	42.7	0.15	0.1
Kulda	7.06	87	47.7	36.9	31.3	11.94	1.72	3.4	1.1	0	38.2	8	2.7	0	0.12	0.0
Lokdega	8.13	655	268.5	243	199.7	46.55	30.79	5.1	6.9	0	243.6	17.5	20.3	21.1	0.97	0.2
Lokdega	8.13	776	354.2	239.5	124.4	55	24.81	37.4	3	0	151.7	105.6	35.8	18	0.22	0.9
Lokdega village	7.81	1110	466.6	263.1	202.8	23.74	49.48	40.2	38.5	0	247.5	83.7	65	44.5	0.24	1.9
Narsinghpur	7.31	145	76.3	42.7	24.5	11.94	3.13	9.9	0.9	0	29.9	18.7	4.6	12.5	0.06	0.0
Sardega	8.11	1339	533.6	299.2	303.5	21.46	59.65	63.3	45.9	0	370.2	81.1	58.9	21.3	0.56	9.6
Sardega railway	7.80	910	393.6	230.9	164.5	29.51	38.18	30	27.5	0	200.7	70.9	57	41.8	0.42	8.5
Sargipali NV	7.64	220	104.7	54.4	53.4	16.1	3.45	17.4	1.4	0	65.1	17.5	11.3	5.3	0.18	1.5
Sargipali PS	8.06	555	226	162.1	160	33.53	19.02	24.1	3.1	0	195.2	15	35.4	0	0.25	2.2
Siaramal	7.67	490	250.9	170.4	127.9	25.89	25.69	7.7	27.5	0	156	23.9	41.5	22	0.32	0.1
Sonajori	7.50	772	370.3	194.4	124.3	33.67	26.8	49.7	2.5	0	151.7	70.6	67.3	45.3	0.16	1.3
Tikilipara	7.90	535	233.5	160	155.8	32.33	19.26	27.5	3.4	0	190	19.3	37.8	0	0.76	8.4
Ujalpur	7.53	198	106.9	77.5	69.3	22.53	5.15	10.8	0.8	0	84.6	13.7	12.3	0	0.13	0.0

a) General Description of Ground Water Assessment in Sundargarh district for 2022-23 (Area in ha)

Name of Ground Water Assessment Unit	Sundargarh
Type of Ground Water Assessment Unit	District
Type of rock formation	Granite, Schist, Phyllite, Sandstone, Shale, Limestone, etc.
Total area of Groundwater Assessment Unit	975069
Hilly area	154721
Command area	12122
Non-command area	808226
Poor ground water quality area	0
Area considered for groundwater recharge	820348

b) Ground Water Recharge Potential in Sundargarh district during 2022-23

Source	**Command area**	**Non Command area**	**Total**
Rainfall Recharge	1118.64	70819.34	71937.98
Canal Recharge	390.5	-	390.5
Surface Water Irrigation	3124.91	0	3124.91
Ground Water Irrigation	0	6742.62	6742.62
Water Conversation Structures	0.79	558.71	559.51
Tanks and Ponds	90.06	3465.78	3555.84
Total	4724.91	81586.46	86311.37

c) Ground Water extraction for All Uses in Sundargarh district (in ham)

District	Sundargarh		
Area	Command area	Non command area	Total
Total extraction for domestic purpose	61.25	6078.52	6139.77
Total extraction for industrial purpose	0	2152.54	2152.54
Total extraction for irrigation purpose	1108.79	22028.33	23137.12
Total groundwater extraction	1170.05	30259.38	31429.43

d) Balance Ground Water Resources Available and Stage of Groundwater extraction in the Study Area as On 31st March 2023

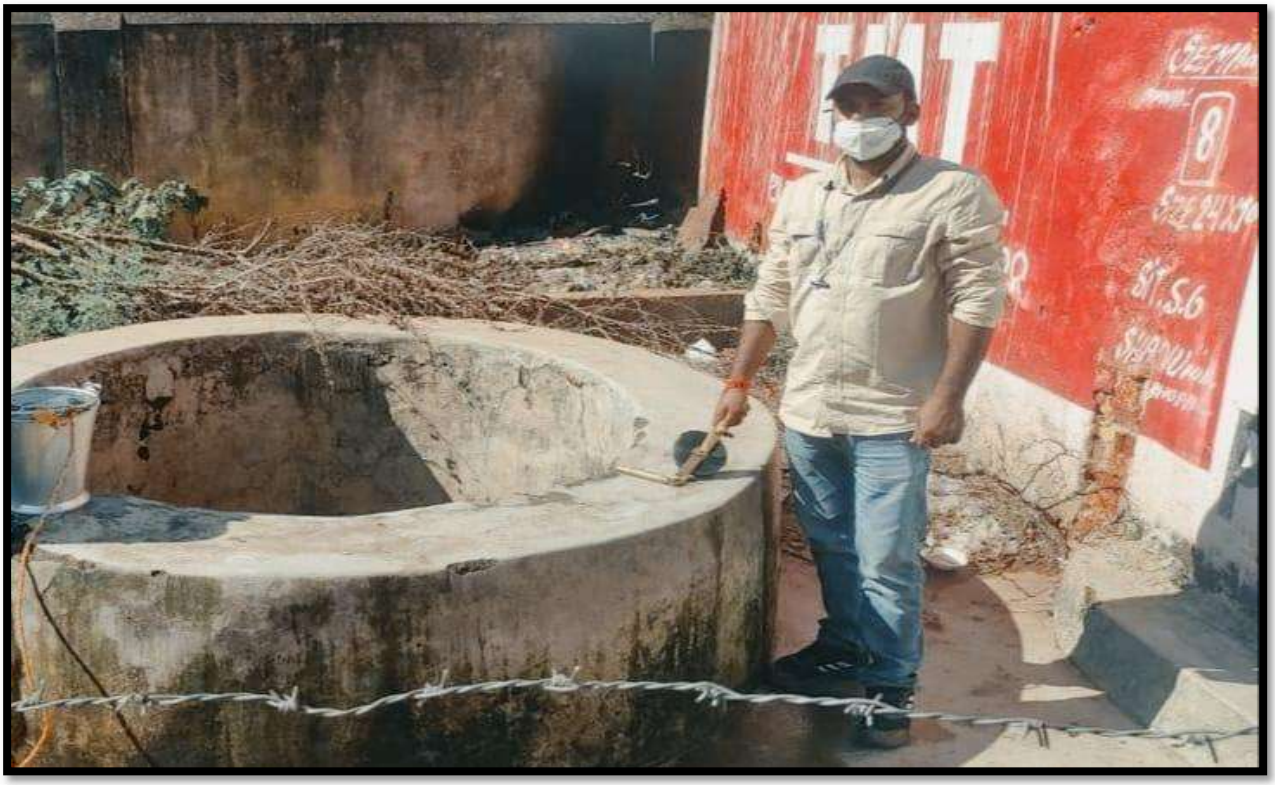
Assessment Unit / District	Sundargarh
Total Annual Ground Water Recharge	86311.35
Total Natural Discharges	6868.28
Annual Extractable Ground Water	79443.09
Existing Gross Ground Water extraction for All Uses	31429.43
Net Annual Ground Water Availability for future development	47482.4
Stage of ground water extraction	39.56 %

e) Categorization for Ground Water Development of Sundargarh district during 2022-23

Assessment/ Administrative Unit	**Stage of Ground Water extraction %**	**Quantity Categorization (Safe/Semi-Critical/ Critical/ Over Exploited)**	**Quality Tagging**	**Validation of Assessment using GW Level Trends (Valid/To be Re-assessed)**
Sundargarh	39.56	Safe	Fresh	Could not validate, WL data not sufficient/ representative

Photograph 1- Monitoring of WL in GWMS

Photograph 2- Chemical sampling from Handpumps



Photograph 3- Monitoring of WL in GWMS

Photograph 4- Monitoring of WL in GWMS

Photograph 5- Basundhara Open Cast Mine (MCL)

Photograph 6- Rain water harvesting structure in Hemgir block, Sundargarh district.

Acknowledgement

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