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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

NABARANGPUR DISTRICT
ODISHA

दक्षिण पूर्वी क्षेत्र, भुवनेश्वर

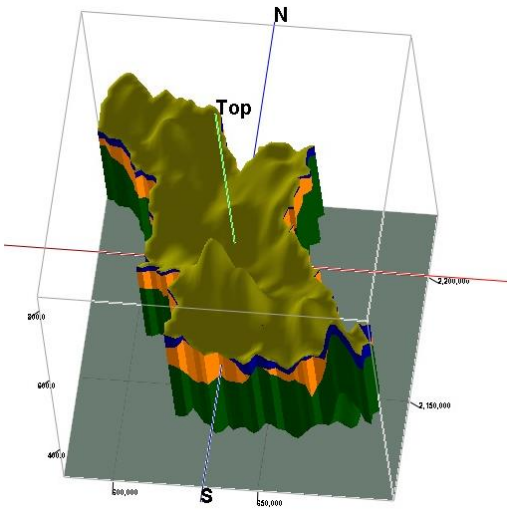
South Eastern Region, Bhubaneswar

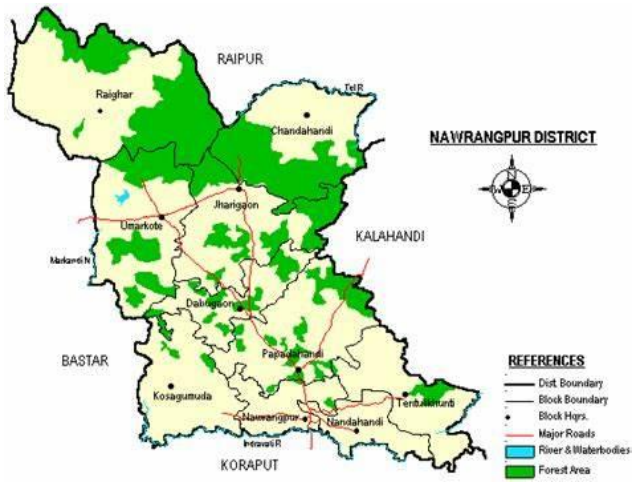
Government of India

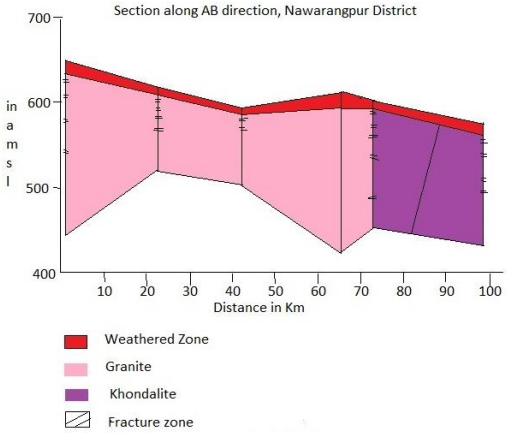
MINISTRY OF JAL SHAKTI, DEPARTMENT OF WATER RESOURCES, RIVER DEVELOPMENT & GANGA REJUVENATION

REPORT ON

AQUIFER MAPPING AND MANAGEMENT PLAN IN NABARANGPUR DISTRICT, ODISHA







CENTRAL GROUND WATER BOARD

South Eastern Region, Bhubaneswar

June-2022

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FOREWORD

Nabarangpur district is situated in the south-western part of Odisha state.The district came into being with effect from 2nd October 1992 carved out from erstwhile Koraput district. Boundaries of the district stretch in the north to Raipur and west to Bastar district of Chhatisgarh. The river Indravati is the border between Nabarangpur and Koraput district. Nabarangpur district covers an area of 5291 sq km.

The administrative headquarters of the district is located at Nabarangpur town.Nabarangpur has an ancient tradition of art & culture.Widely performed dances are folk dance like Rinjodi,Dhemsa,Sailodi,Gond and Ghumura.

Nawarangpur has more than 90 per cent of its inhabitants depending on farming for their livelihood. The farming community largely depends on rains due to lack of irrigation facility.

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. Proper site selection holds the key to the success of sustainable ground water development, which requires a thorough knowledge of hydrogeology and pattern of water usage in the terrain.

The hard crystalline rocks of the district form two distinct aquifer systems. The shallow aquifer formed by the weathered mantle where water is stored under phreatic condition. The deeper aquifer is formed by fracture zones, joints etc where water occurs in semi-confined condition. Granitic hardrock aquifers have water yielding fracture zones and have average success rate with 2-5 lps of discharge.

The present stage of ground water development is only 33.63%, leaving a vast scope for future ground water development in the district. Ground water irrigation practices can insure increased agricultural production by enhancing the area irrigated and scope of irrigation.

Based on the available data and the earlier hydrogeological studies taken up in 10 blocks of the district viz. Chandahandi, Dabugaon, Jharigaon, Kosagumuda, Nandahandi, Nabarangpur, Papadahandi, Raighar, Tentulikhunti and Umerkote covering 5291 Sq. Km. of mappable area, an attempt has been made in this report to compile all relevant information, such as hydrogeological, agriculture, irrigation, land use, rain fall, chemical quality of water and other collateral data. **Shri S. K. Naik, Scientist-'B' and Shri Munna Sutradhar, Asstt. Hg**, have compiled and prepared the present report on **"Aquifer Mapping and Management Planin Nabarangpur District, Odisha"**. Their sincere efforts in preparation of the report will no doubt be very useful and benefit the state. It is hoped that, it will be of immense help to different ground water user agencies, administrators and planners in preparation of ground water development plans and will be a handy tool in effective management of ground water resources in the district.

Place : Bhubaneswar

Date : 06th June 2022

(P. K. Mohapatra)
Regional Director

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AQUIFER MAPPING AND MANAGEMENT PLAN NABARANGPUR DISTRICT (5291 Sq. Km)

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1 INTRODUCTION

1.1 Objective

Central Ground Water Board (CGWB) has taken up National Aquifer Mappingand Management (NAQUIM) programme during the XIIIth five year plan to carry out integration of micro level hydrogeological, geophysical, hydrochemical data and information on geology, geomorphology, soil, hydrometeorology, hydrology, landuse, cropping pattern etc on a GIS platform to formulate district, block or aquifer-wise Ground Water Management Plan. The formulation of a sustainable ground water management plan would help in achieving the demand for drinking, irrigation and industrial need for water with minimal stress on the aquifer.

The activities under NAQUIM are aimed at identifying the aquifer geometry, aquifer characteristics their yield potential along with the quality of water occurring at various depths, aquifer-wise assessment of ground water resources and development. Aquifer mapping itself is an improved form of groundwater management – recharge, conservation, harvesting and protocols of managing groundwater.

With these aims, aquifer mapping was carried out in the hard rock terrain ofNabarangpurdistrict in Odisha covering 10 blocks of the district namely, Chandahandi, Dabugaon, Jharigaon, Kosagumuda, Nabarangpur, Nandahandi, Papadahandi, Raighar, Tentulikhunti and Umerkote.

1.2 Scope of the Study

Aquifer mapping is a multidisciplinary exercise wherein a combination of geological, geophysical, hydrological, hydrogeological, meteorological and hydro-chemical information is integrated to characterize the spatial and temporal variation of quantity and quality of the aquifer system and identification of local ground water related problems and issues.

To resolve such issues, the NAQUIM study was carried out with the following broad objectives: to define the aquifer geometry with precise lateral and vertical demarcation down to the depth of 200 mbgl, to define the behaviour of ground water regime in time and space, to study the hydraulic characteristics of both shallow and deeper aquifers,to study the hydrochemistry of aquifer systems,to prepare Aquifer Maps indicating disposition of aquifers along with their characterization and to formulate the Aquifer Management Plans for

sustainable development and management of ground water resources.

1.3 Approach and Methodology

Multi-disciplinary approach involving geological, geophysical, hydrological, hydrogeological and hydro-geochemical survey would be carried out to meet the aim and objectives listed above. GIS would be used to prepare the maps.

The entire Nabarangpur district has been geologically mapped by the Geological Survey of India. The systematic Hydrogeological surveys have been conducted in different parts of the district by Sh. S.K. Guha and Sh. P. Nag, Geologists of GSI during the season 1966-67 and by Sh. S.V. Choughla, Sh. M.V. Rao and Sh. D.P. Pati, Scientist-B of CGWB, SER on 1 : 50,000 scale during the season 1976-77 and 1987-88. The Reappraisal hydrogeological surveys were conducted on 1:50,000 scale by Sh. A.D. Rao, Jr. Hydrogeologist and Sh. G.Y. Setty, Assistant Hydrogeologist in the district.

1.3.1 Compilation of Existing Data and Identification of Data Gaps

Preliminary work will consist of the collection and review of all existing data which relate to the area. This usually included the results of previous hydrogeological studies and exploratory drilling carried out by CGWB and state agencies and compiled to identify the data gaps in the study area. After the data compilation all the data were integrated and analysed.

1.3.2 Hydrogeological Investigations

Review of background information leads the study teams to carry out further studies in the field, where they will employ various techniques to determine the three-dimensional extent and aquifer characteristics of the significant water-bearing formations. Key Observation wells representing the different aquifers have to be established and monitoring carried out. Well inventory and collection of relevant data are to be carried out to strengthen the data base. The analysis of the data will be carried out to prepare maps.

1.3.3 Geo -hydrochemical Investigations

Water Samples to be collected, analyzed and interpreted to bring out ground water quality scenario of the study area.

1.3.4 Generation of Thematic Layers Using GIS

Based on the available spatial data thematic maps of land elevation, drainage, soil, landuse, geomorphology, geology, hydrogeology, depth to water level, seasonal fluctuation of water level, water level contour, aquifer disposition, water quality parameters were prepared on GIS platform.

1.3.5 Development of Aquifer-Wise Management Plan

The dimension and disposition of the aquifer is figured out on the basis of integrated study of the geologic, hydrogeological, hydrological, geochemical and geophysical information.Determining aquifer potential and characteristicsare essential for their effective management and sustainable development. Local ground water related issues should be identified and studied in detail to make plans to solve them.

1.4 Study area

During XIII five year plan, the National Aquifer Mapping and Management (NAQUIM) programme were taken up under Annual Action Plan (AAP) 2021-22, for detailed hydrogeological investigation and Aquifer Mapping in Nabarangpur district. Nabarangpur districts situated in the greeneries of south-western part of Orissa lying between the north latitudes $19^0$09' and $20^0$06'N and east longitudes $81^0$51' and $82^0$52' E, falling in Survey of India degree sheet Nos. 64 H, L, and 65 E and I. It is bordered by Bastar district of Chhattisgarh in the West, Raipur district of Chhattisgarh in the North, Kalahandi district of Orissa in East and Koraput district of Orissa in the South. The district covers an area of 5291 sq. km. The district is having 1 Subdivision (Nabarangpur), 10 administrative blocks (Chandahandi,Dabugaon,Jharigaon,Kosagumuda,Nabarangpur,Nandahandi,Papadahandi ,Raighar, Tentulikhunti and Umerkote), 2 towns (Nabarangpur Municipality and Umerkote Municipality), 169 Gram Panchayats and 885 villages.

The river Indravati, Tel and Bhaskel are the main surface water sources which provide water to the district. The district headquarters at Nabrangpur approachable by National Highway 43, which passes through the southern border of the district and connects the headquarters Vishakhapatnam port. The major towns of the district are connected to the district headquarters by road. The administrative map of the study area is presented in **Fig.1.1**.The block-wise demographic details are shown in **Table-1.1.**

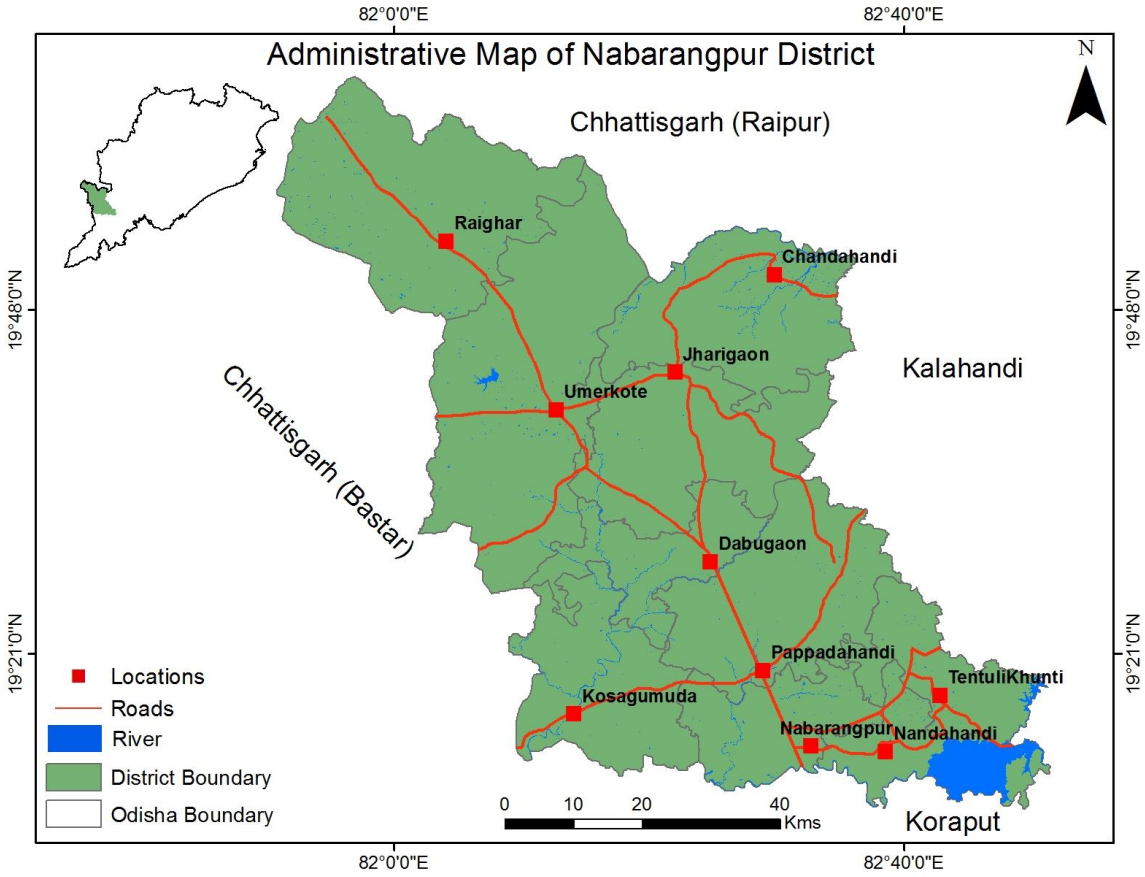

Fig. 1.1: Administrative Map of Nabarangpur District.

Table-1.1: Block-Wise Demographic Details in Nabarangpur District as per Census 2011.

Sl No	Name of Blocks	Total Population	Male	Female	SC Population	ST Population	General Population
1	Chandahandi	73953	36460	37493	7877	25990	40086
2	Dabugaon	67654	33297	34357	7769	40496	19389
3	Jharigaon	150063	74107	75956	18583	93605	37875
4	Kosagumuda	160785	79515	81270	21243	98951	40591
5	Nabarangpur	79484	39351	40133	12684	46109	20691
6	Nandahandi	61533	30258	31275	8765	27320	25448
7	Papadahandi	134145	65981	68164	16129	76358	41658
8	Raighar	182285	91362	90923	29810	119560	32915
9	Tentulikhunti	85182	41645	43537	13871	38373	32938
10	Umerkote	166909	83253	83656	26195	108008	32706
	Total	**1161993**	**575229**	**586764**	**162926**	**674770**	**324297**

Source: District Census Hand Book

1.5 Climate and Rainfall

The district enjoys a tropical climate characterized by hot summer, cold winters & rainy seasons. The winter season generally commences from late November & continues up to the end of February. The temperature in winter drops below 10^0C; otherwise, it is in the range of 10^0C to 13.5^0C in the valley plains. The summer season commences from March & continues till the middle of June. The summer is quite pleasant here with the mean daily maximum temperature around 40^0C, while the mean daily minimum temperature is around 14^0C.

The south-west monsoon is the principal source of rainfall in the area. Generally the monsoon breaks in the middle of June and continues till the end of September or middle of October, which forms the rainy season. Average rainfall in the district in 2021 was 1233 mm with average rainy days of 88 days (**Table-1.2**).About 80% to 85% of the annual rainfall occurs during monsoon period between mid Juneto mid October. The district is drought-prone because of the irregular and uneven pattern of rainfall.The Isohyetal map (**Fig 1.2**) shows large variation in rainfall with rain reducing drastically from south-east to north-west in the district.

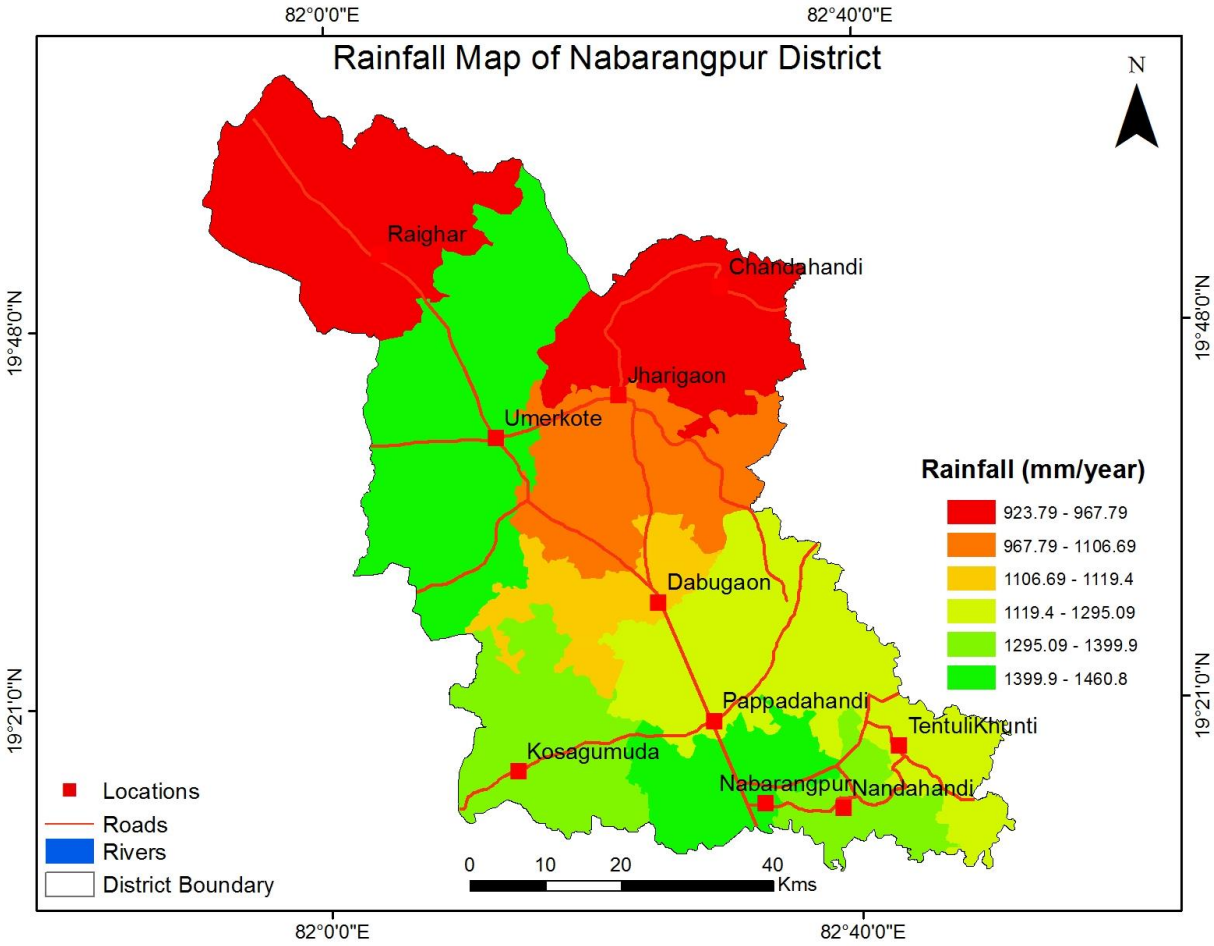

Fig. 1.2: Rainfall Isohyets in NabarangpurDistrict.

Table-1.2: Block wise Annual Rainfall and Number of Rainy Days (Year 2021)

Sl No	Name of the Block	Rainfall	
		No. of Rainy days	Average Rainfall (mm)
1	Chandahandi	72	976.8
2	Dabugaon	94	1119.4
3	Jharigaon	78	1106.7
4	Kosagumuda	82	1399.9
5	Nabarangpur	101	1434
6	Nandahandi	85	1357
7	Papadahandi	101	1295.1
8	Raighar	93	923.8
9	Tentulikhunti	96	1253.1
10	Umerkote	81	1460.8
	Average	**88**	**1232.66**

Data on rainfall (**Table-1.3**) reveals that onset of monsoon in all blocks starts in June and continues till October with average rainfall more than normal.

Table-1.3: Block wise Monthly Rainfall Data (Year 2021)

Sl No	Block	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
1	Chandahandi	0	2	0	15.1	71.5	199.6	252.80	185.30	227.32	1.00	22.20	0
2	Dabugaon	0	3	0	40	39	105	243.80	454.80	202.80	19.00	12.00	0
3	Jharigaon	0	0	5.2	8.3	108.1	268.1	282.04	172.60	183.80	66.40	12.20	0
4	Kosagumuda	0	1	0	25.4	131.7	180	251.06	489.08	188.90	47.00	85.80	0
5	Nabarangpur	17	9	0	82.7	34.6	350.2	249.50	407.20	234.60	26.60	19.60	3.00
6	Nandahandi	0	4	0	121	63	280.6	217.50	333.00	240.10	45.80	52.00	0
7	Papadahandi	0	2	0	67.4	51.4	201.3	325.40	323.60	229.00	59.00	36.00	0
8	Raighar	0	2	0	75	26	90	235.40	146.80	248.40	26.20	74.00	0
9	Tentulikhunti	0	1	0	76.4	41.6	227.6	249.20	303.10	259.60	55.00	35.60	4.00
10	Umerkote	0	0	30	28.8	104.6	197.6	394.20	346.80	236.00	84.40	41.40	0
	Total	**17**	**24**	**35.2**	**540.1**	**671.5**	**2100**	**2700.9**	**3159.28**	**2250.52**	**430.4**	**390.80**	**7**
	Average	1.70	2.40	3.52	54.01	67.15	210.0	270.09	315.93	225.05	43.04	39.08	0.70
	Normal	6.7	14.1	15.1	34.1	66.1	251.8	356.6	407.5	225.6	168.6	18.7	4.6

Source: Odisha Rainfall Monitoring System

Analysis of rainfall of the last 20 years (2002 – 2021) shows moderate variation of rainfall in the district. The average annual rainfall is around 1679.2 mm. As per IMD classification, mild drought (0-25% deficient rainfall) occurs during the year 2002 and 2021. However excessive rainfall occurs during the year 2007, which exceeds average rainfall by 36%. Year and Block wise Annual Rainfall is given in **Table No.1.4**.

Table-1.4: Year and Block wise Annual Rainfall of Nabarangpur District (2002 to 2021) (data in mm)

Year	Chandahandi	Dabugaon	Jharigaon	Kosagumuda	Nabarangpur	Nandahandi	Papadahandi	Raighar	Tentulikhunti	Umerkote	District Average
2002	946.2	1020.1	909.5	1135.6	1150.1	983.2	992.6	1392.9	671.5	803.1	1000.48
2003	1438	1893.6	1409.3	1470.8	1656.2	1798	1145.7	2288	1330	1517.9	1594.75
2004	2266.05	1413.8	1516	1819.3	2223.42	1210.3	1538.8	1447.1	1985.45	1504.1	1692.432
2005	1888	1408.9	1989.5	2124	2308.3	990.2	1596.8	1346.5	1347	996.2	1599.54
2006	2518.5	1715.1	3152.5	2336.5	2644	1304	1850	1841	1853	2300	2151.46
2007	2780	1920	3032	2639	2594	1573.3	1974.2	1664.5	2096.2	2663	2293.62
2008	2216.2	1452	2395	2399	2166.6	1547	1665.4	1437.2	1454.4	1649	1838.18
2009	1672	1528.5	1882.5	1799.5	1676.7	1375.4	1481.6	1214.5	1406.4	1031	1506.81
2010	2334.5	2245.2	3025	3015.2	2213.1	1727	1927	1742.5	1905.2	1928	2206.27
2011	1436	1143.6	1986	2299	1352.6	1220	1485.7	1091.5	1256.4	1057	1432.78
2012	1965	1528.8	1895.6	2484.4	1678.1	1774.8	1638.2	1134	1583	1173.6	1685.55
2013	2232	1850.1	2319.5	2322.3	2007	2097.5	2040	1591	2088	1439.4	1998.68
2014	2405	1803.3	2691	2034	1891	1912	1881	1551	2035	1368.4	1957.17
2015	2267	1488.8	2428	1363	1723	1842.6	1544	1234	1837	1163.5	1689.09
2016	1435.9	1446.8	1562	1487.5	1919.9	1571.5	1626	1404.8	1860.9	1203.8	1551.91
2017	1207.8	1479.1	1383.1	1555.6	1694.2	1516.5	1749.1	1181.5	2028.8	1359	1515.47
2018	1276.1	1284.4	1318.8	1127.7	1510.2	1546.5	1522.2	1307	1812.3	1121.9	1382.71
2019	1353.2	1858.5	1320	1916	1811.2	1846.6	2172.2	1567	1852.1	1256.2	1695.3
2020	1351.6	1537	1534.2	1960	1844.1	1366.3	1830.2	1336.4	1404.1	1417.9	1558.18
2021	976.8	1119.4	1106.7	1399.9	1434	1357	1295.1	923.8	1253.1	1460.8	1232.66
Mean	1874.9	1528.0	1653.0	1647.8	1934.4	1556.9	1420.7	1434.8	1942.8	1798.3	1679.2

Source: Officer of Special Relief Commissioner, Govt. of Odisha

1.6 Physiographic Setup

The entire Nabarangpur district has a unique physiographic setup. Except for the north-western and west - west-central part, the rest of the district is occupied by dense forest with highly rugged mountains, interspersed with intermontane valleys. The average land elevation being 245 m to 984 m above mean sea level.The variation in land elevations above MSL is shown in **Fig. 1.3**.

1.7 Geomorphology

The major geomorphic units of the district are classified as - Flood plain, Mesa/butte, Denudational hills, Pediment, Deeply weathered pediplain, Inselberg, Structural hills, Severely dissected plateau, Intermontane valley, Structural valley, Residual hill and Bazada.The geomorphology of the area is shownin**Fig. 1.4**.The study area comprises of the following geomorphic units.

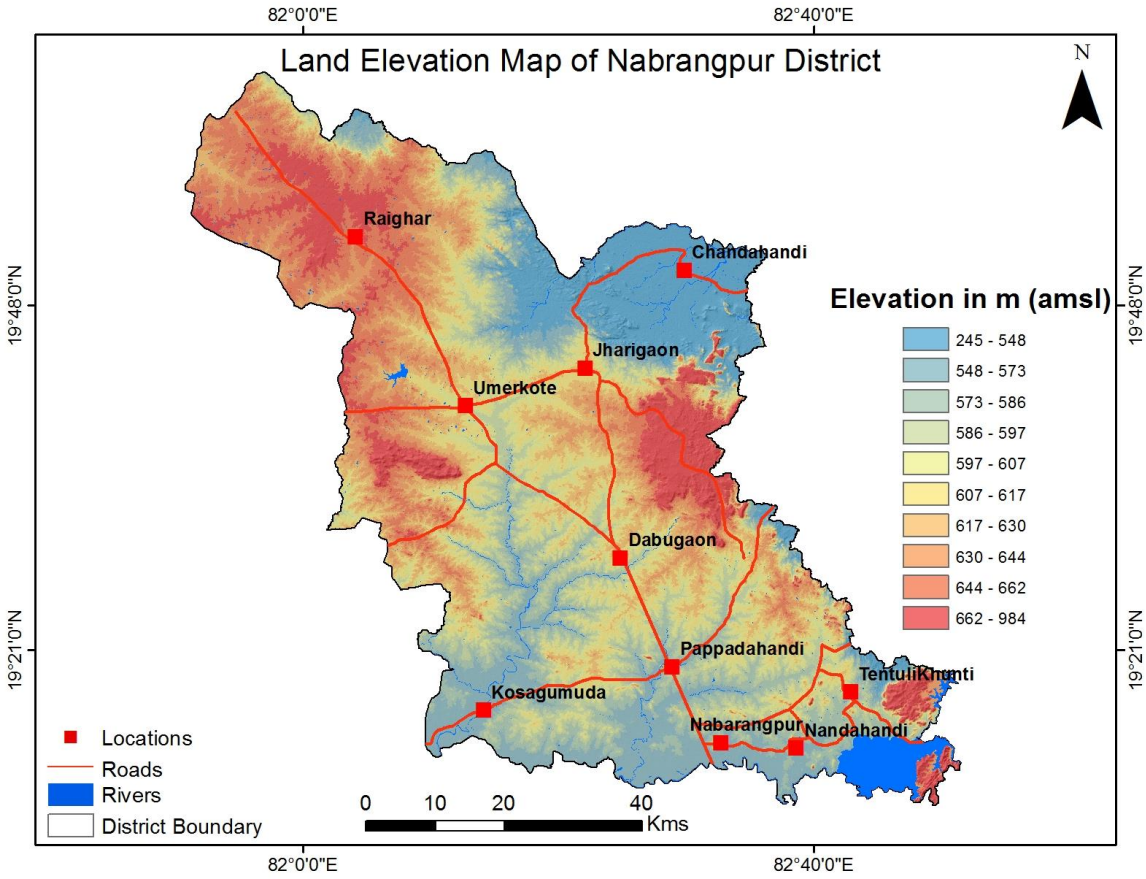

Fig. 1.3: Land Elevations in Nabarangpur District.

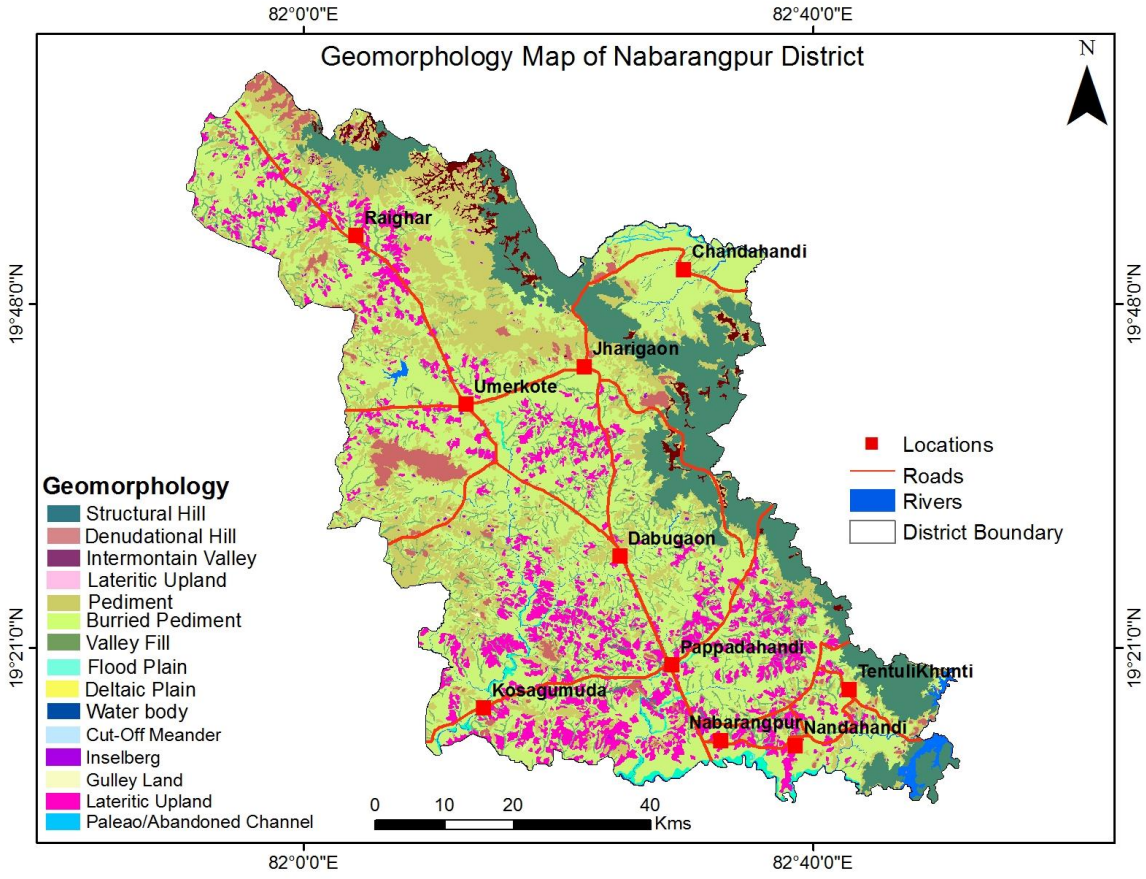

Fig. 1.4: Geomorphology of Nabarangpur District.

1.7.1 Flood Plain:

These are the narrow stretch of alluvium occurring along the major rivers and include buried channels & migrated river courses. Depending upon the thickness of the alluvium, the flood plain can be suitable for the shallow aquifer.

1.7.2 Mesa/Butte:

These are the flat-topped hill with escarpment or both the sides. Perched water bodies of a limited extent may occur depending on the width of the plateau.

1.7.3 Denudational Hill:

These are represented by a group of massive hill ranges intersected with narrow intermontane valleys. Weathered zones in intermontane valleys are favorable for forming shallow aquifers, while deeper aquifers are controlled by faults & fractures.

1.7.4 Pediment:

These are gently undulating bedrocks with little or no weathering. Both the shallow and deeper aquifers are controlled by lithology & structures.

1.7.5 Deeply Weathered Pediplain:

The pediplain generally present gently undulating topography with the thickness of the weathered zone ranging between 5 to 20 m with the average thickness around 12 to 15 m. These are favorable locales for ground water occurrences. Deeper aquifers are controlled by lithology & structures.

1.7.6 Inselberg:

These are isolated hills of limited Areal extent surrounded by plain all around.

1.7.7 Structural Hills:

These are linear to curvilinear hills at large Areal extent showing definite structural control. However, a moderate amount of infiltration takes place through fractures.

1.7.8 Severely dissected plateau:

It is characterized by several sharp-crested hills embraced by the deep irregular valley. Weathered residuum in the valley forms shallow aquifers while the deeper aquifers are controlled by structurally weak planes in the valley.

1.7.9 Intermontane Valleys:

These are flat valleys surrounded by hills all around. These are highly favorable locales for groundwater occurrence due to good recharge from surrounding hills.

1.7.10 Structural Valleys:

These are narrow valleys within the structural hills formed along the structurally weak planes and are highly favorable for groundwater occurrence & are sometimes marked with spring.

1.7.11 Residual hills:

These are massive hills of moderate areal extent surrounded by plain and are not favorable for groundwater occurrence.

1.7.12 Bajada

It is characterized by gently sloping plain at the foot hill region & is highly favorable for shallow aquifers depending on the thickness of deposits.

1.8 Landuse, Cropping and Irrigation Pattern

Nabarangpur district shows a wide variation in land use patterns. The land utilization pattern indicates that out of the total geographical area, the forest area constitutes 58,046 hectares. The net sown area is 238,542 hectares.The Cropping Intensity of the district is 122.4%. The block-wise landuse pattern is shown in **Table 1.5** and the thematic map on landuse is shown in **Fig. 1.5**.

Table 1.5: Land Use Pattern in Nabarangpur District (Area in hectares*)*

Block	Forest area	Misc. tree crop &grooves	Permanent pasture & grazing land	Cultivable waste	Land put to non-agriculture use	Barren and Uncultivable land	Current fallows	Old fallows	Net Sown Area
Chandahandi	359	26	623	36	1931	3451	4113	505	13470
Dabugaon	2149	1760	243	212	2068	164	860	52	14942
Jharigaon	5881	1094	2022	1639	1408	2544	2112	1087	26016
Kosagumuda	6105	4547	1706	2442	4583	458	5295	1082	32419
Nabarangpur	3092	310	1879	4140	462	3085	2134	1077	9573
Nandahandi	738	1961	726	548	1676	247	3493	750	9993
Papadahandi	4205	1825	1255	407	3426	257	2259	1581	30538
Raighar	19674	65	456	514	1687	436	2318	361	43817
Tentulikhunti	7490	738	405	394	922	497	2240	214	20092
Umerkote	7798	373	1424	1188	3605	832	1652	892	35841
Urban	555	21	34	172	369	30	207	287	1841
Total	58046	12720	10773	11692	22037	12001	26683	7888	238542

Source: District Statistical Handbook, Nabarangpur 2018

Agriculture is the main stay for the rural population of the district. The cultivation is mainly in the Kharif season. Rabi cultivation is restricted to areas with irrigation facilities. The different crops grown in the area are cereals, coarse cereals, pulses, oil seeds, fibers, vegetables, condimends and spicesetc. The major crop of the district is paddy. Theblock & area-wise irrigation status is given in **Table 1.6**.

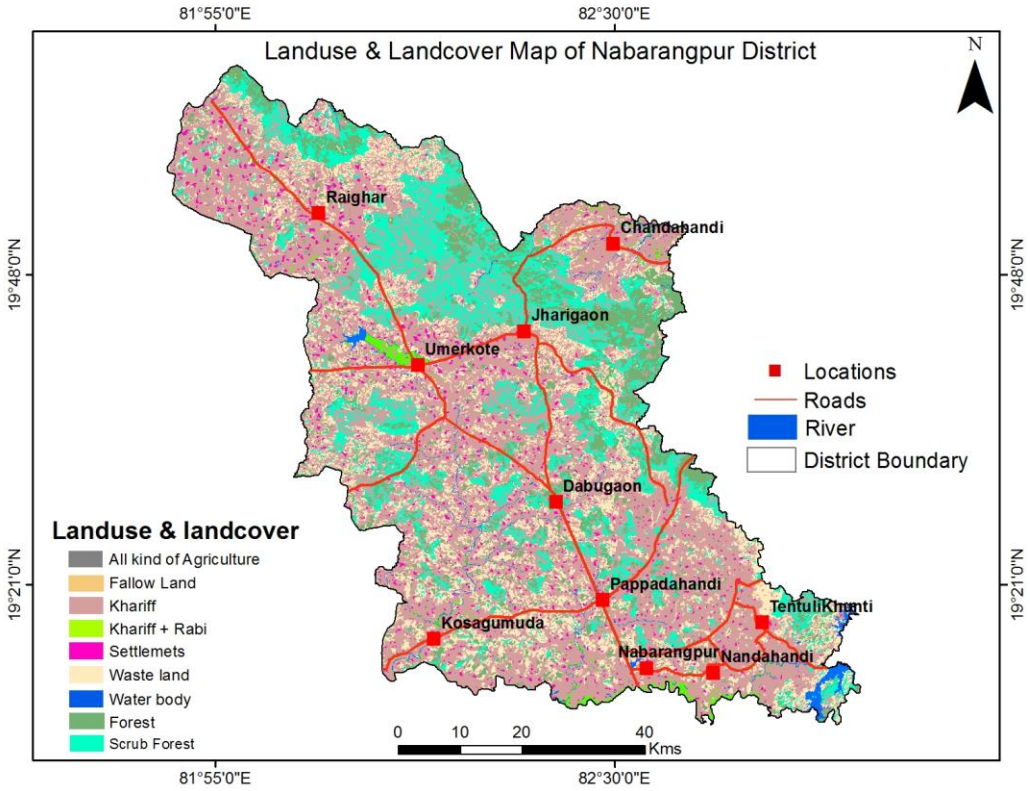

Fig. 1.5: Landuse in Nabarangpur District.

Table 1.6: Area-wise Irrigation Status in Nabarangpur District. (in Ha)

Block	Kharif			Rabi			Summer			Total		
	Irrigated	Rainfed	Total	Irrigated	Rainfed	Total	Irrigated	Rainfed	Total	Irrigated	Rainfed	Total
Chandahandi	2051	15869	17920	838	1010	1848	0	0	0	2889	16879	19768
Dabugaon	2051	6569	8620	838	1540	2378	0	0	0	2889	8109	10998
Jharigaon	3691	14236	17927	1901	225	2126	0	0	0	5592	144561	20053
Kosagumuda	6787	23725	30512	4564	1918	6482	0	0	0	11351	25643	36994
Nabarangpur	4886	20457	25343	4417	1132	5549	0	0	0	9303	21589	30892
Nandahandi	4436	8040	12476	2872	1286	4158	0	0	0	7308	9326	16634
Papadahandi	5197	29561	34758	1912	2940	4852	0	0	0	7109	32501	39610
Raighar	4545	33584	38129	4477	1668	3145	0	0	0	9022	35252	44274
Tentulikhunti	3148	11492	14640	618	697	1315	0	0	0	3766	12189	15955
Umerkote	5466	25041	30507	2735	1080	3815	0	0	0	8201	26121	34322
Total												

Source: District Irrigation Plan, Nabarangpur, March 2016

The district has limited irrigation facilities as per available data. The net irrigated area from different sources is 39,273 ha and 22,418 ha for Kharif and Ravi, respectively. The source wise Irrigation potential created in the district from various sources has been tabulated in **Table 1.7.**

Table 1.7: Irrigation Potential Created in Nabarangpur District

Block	Major/Medium Irrigation Projects		Minor Irrigation Project				Other Sources		Total	
			Flow		Lift					
	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
Chandahandi	-	-	2431	96	2242	2245	1070	820	5743	3161
Dabugaon	-	-	60	2	740	65	1047	1103	1847	1170
Jharigaon	-	-	677	123	1723	459	1241	1172	3641	1754
Kosagumuda	-	-	84	12	2125	741	3012	2121	5221	2874
Nabarangpur	-	-	1020	120	2326	891	1151	1876	4501	2887
Nandahandi	-	-	179	40	1622	752	1300	1939	3101	2731
Papadahandi	-	-	213	92	1107	249	1496	2132	2816	2473
Raighar	-	-	309	187	633	356	2493	1206	3435	1749
Tentulikhunti	-	-	270	22	467	177	1214	753	1951	952
Umerkote	4250	1150	976	105	566	232	1225	1180	7017	2667
Total	**4250**	**1150**	**6219**	**799**	**13551**	**6167**	**15253**	**14302**	**39273**	**22418**

1.9 Soil

Soils of the district are generally having average to good fertility status. All common types of crops can be grown in the district. Based on the physical and chemical characteristics, mode of origin and occurrence, soils of the district can be grouped into two major groups 1) Alfisols and 2) Ultisols.

1.9.1 Alfisols:

It includes red sandy soils and red loamy soils. The red loamy and sandy soils are occurring throughout the district. The characteristic features of red soils are (1) light texture, porous and friable structure, (2) absence of lime Kankar and free carbonates, and (3) soluble

salts in a small quantity usually not exceeding 0.05%. These are generally deficient in nitrogen, phosphate, organic matter and lime. These soils are suitable for the cultivation of paddy and other crops.

1.9.2 Ultisols:

These are medium black soils found in the North Eastern Corner of the district in the Chandahandi block. The soils are highly argillaceous and contain a high amount of iron, calcium, and magnesium. These are poor in organic matter, nitrogen, and phosphorous but rich in potash and lime. The pH varies from neutral to alkaline and texture varies from loam to clayey loam. These are quite fertile soils.

1.10 Drainage and Hydrology

The Indravati River is the most prominent in the district. It is a tributary of the Godavari and sustains perennial flow. It originates in the Kalahandi district flows through Nabarangpur and Koraput districts and enters in Bastar district of Chhattisgarh. The Tel and Bhaskel are the other rivers flowing through the district. The hilly streams are perennial in nature and many of the tributaries are ephemeral in nature. The drainage pattern of the district is of dendritic, radial and centripetal types. The drainage is effluent in nature.

River Tel which rises in the north of Nabarangpur district forms a sort of its geographical boundary with Kalahandi district and finally unites with a bigger Mahanadi river in Sonepur town. It is not perennial and dries up during the summer.

The important river Indravati flows through Nabarangpur and beyond till it mergers with the mighty Godavari in Andhra Pradesh. It runs through a total distance of about 530 km out of which the Nabarangpur and Koraput districts contain about 130 km of its length. At Nabarangpur town the old girder bridge is replaced by a new span. Before reaching the Jagadalpur town in Chatishgarh state, it is joined by another river Bhaskal that drains the north of Nabarangpur. During the flood Indravati swells up to 450 ft wide and 24 ft deep. The drainage map of the district is shown in **Fig. 1.6**.

The Upper Indravati, Tel and Bhaskel are the main irrigation projects providing irrigation facilities in the district. Tank/ponds/reservoirs is a well-known source of surface irrigation and total of 2052 community ponds, 1757 private/individual pond and 72 Govt. reservoirs were existing in Nabarangpur district. Maximum no. of ponds are in Raighar block (396 Nos.) followed by Umerkote (332 Nos.), however all the block are having a good number of

community ponds. There are quite good numbers of individual ponds in all the blocks of the district except Chandahandi, Tentulikhunti, Nandahandi blocks.Maximum nos. of govt. reservoir is available in found in Umerkote block (15 Nos.) followed by Raighar and Nabarangpur. However, all the block are having at least few number of government reservoirs.

Among the ground water source of irrigation, there is no tubewell and community based open well in Nabarangpur district. There are about 7214 private open wells in the district used for irrigation with maximum in Kosagumuda block (2110) followed by Raighar (1489 nos.) and good numbers in the remaining blocks. A total of 2532 govt. borewells and only 128 private borewells are available in the district. Govt. borewells are well distibuted among the blocks where as few blocks are having nil or very negligible nos. of private borewll.

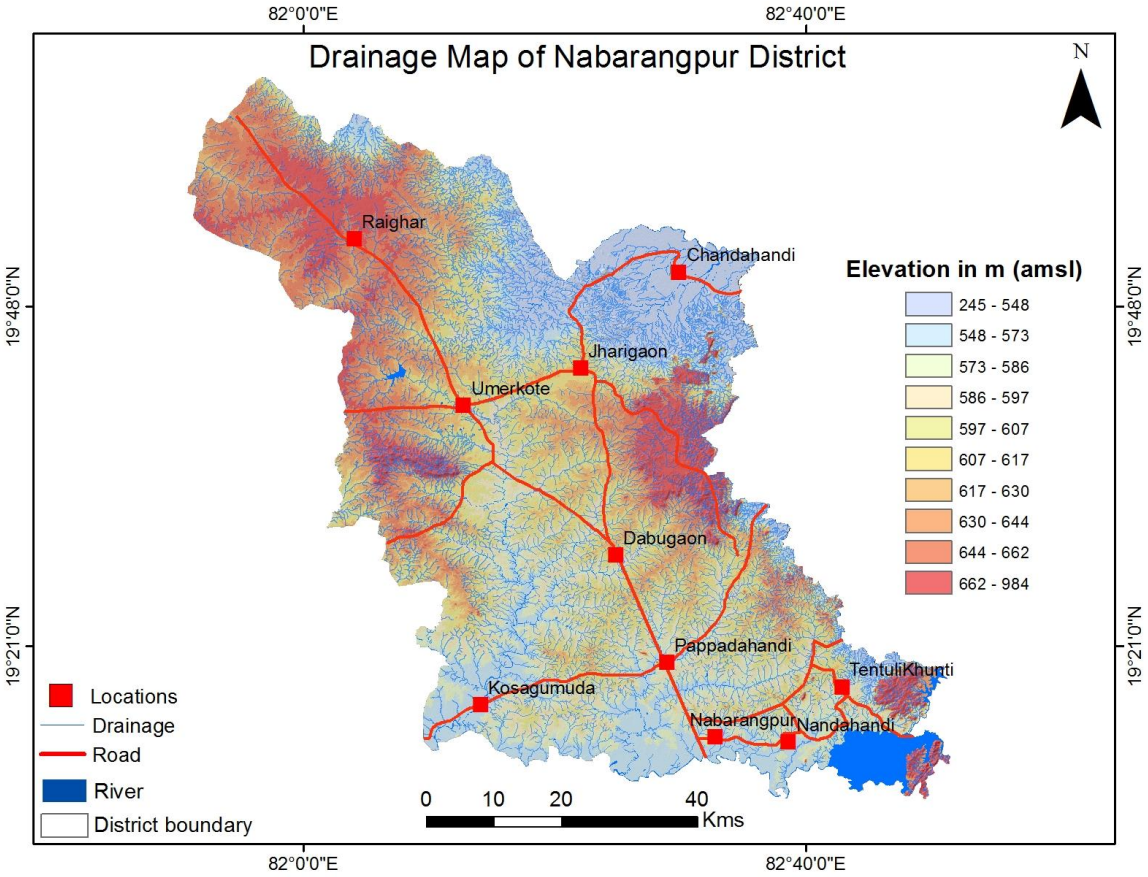

Fig. 1.6: Drainage Map of Nabarangpur District.

2 DATA COLLECTION AND GENERATION

2.1 Geology

A major part of the Nabarangpur district is underlain by hard rocks of Pre-Cambrian age. The consolidated rocks of upper to middle Proterozoic age occupy a small portion of the north-western part of the district. Recent to sub-Recent alluvium occurs as thin and discontinuous patches in a limited scale along the prominent drainage channel. The Laterite occurs as their capping over the country rocks in isolated pockets. The generalized stratigraphic sequence in the district is depicted in **Table 2.1** and the geological map of the study area is shown in **Fig. 2.1.**

Table 2.1: **Generalized Stratigraphic Sequence in Nabarangpur District.**

Recent to Sub Recent		**Alluvium, Laterite**
Upper to middle Proterozoic	Chhattisgarh Group	Purple shale, limestone, Basal quartzite.
Proterozoic to Archaean	Bengal group	Quartzite, Quartz and biotite gneiss
	Eastern Ghat group	Biotite bearing garnetiferous granite. Gneiss with mega-crystal of white Feldspar
		Acid, intermediate, basic Charnockite
Archaean		Garnet-sillimanite Schist, green khondalite Quartzite & calcgranulite.

Granite Gneisses -These rock types of Eastern Ghat Group generally occur in the undulating plains and sometimes form hills and hillocks. These rocks are mostly represented by biotite gneiss, porphyritic granitic gneiss, etc. They are porphyritic and non-porphyritic and are usually grey to light grey in color.

Khondalites - This suite of rocks comprises mainly of quartz - garnet sillimanite gneiss and schist, garnetiferous sillimanite gneiss and schist, garnetiferous sillimanite quartzite and calc-granulite, which occurs in an interbedded sequence. Khondalite is found associated with charnockite and porphyroblastic granitoid gneiss. The rocks are greyish brown to reddish-brown in color and are well foliated. The occurrence of quartzite and calc granulites are very limited and sporadic.

Charnockite-This suite of rocks comprises of pyroxene granulite (basic), hypersthene granite and granodiorite (acid and intermediate). These are generally found to occur in the

south and central part of the district. The acid and intermediate variety of charnockite is more prominent and form longer bodies than the basic variety. The charnockite is fine to coarse-grained, greenishgrey colour having greasy luster.

Quartzite-These include quartzite, garnet, andalusite gneiss of Bengal Group. These are metasediments occupying a limited area in the western part of the district.

Shale, limestone, and Quartzite - These belong to Chattisgarh Group of middle to upper Proterozoic age. These rocks occur unconformably over granite gneisses. These are slightly metamorphosed and consist of white nonfeldspathic quartzites, impure limestone, and purple shales. These rocks are generally exposed in the north-eastern part of the district.

Laterite and Alluvium -These are reddish, porous; concretionary material that occurs as capping over the country rocks. The considerable thickness of Laterite mainly of detrital origin has also been formed or shaly formation. Laterite generally occurs due to intensive weathering under extreme oxidizing conditions in tropical to a sub-tropical climate characterized by strongly contrasting wet and dry seasons. The alluvium of recent origin comprising of sand, silt, and clay of limited extension and thickness occurs in pockets along significant drainage channels. They are generally fire to the coarse grain in nature. The major part of Nabarangpur district is underlain by the rocks of the eastern ghat group which has undergone multiple deformations as revealed by the presence of structural features like fold, faults, joints, foliation, etc.: There are at least five major tectonic events represented by NE-SW, ENE-WSW, N-S, NW-SE, and NNE-SSW tectonic patterns in chronological order. Granite gneisses exhibit gneissosity in the NNE-SSW direction. Khondalite are highly fractured and sheared. Charnockite is usually massive and compact in nature. The rocks of Chhattisgarh group are gently folded with low dips of both the limbs (4°-11°). The fold axis trends in N 35° E - S 35 °E.

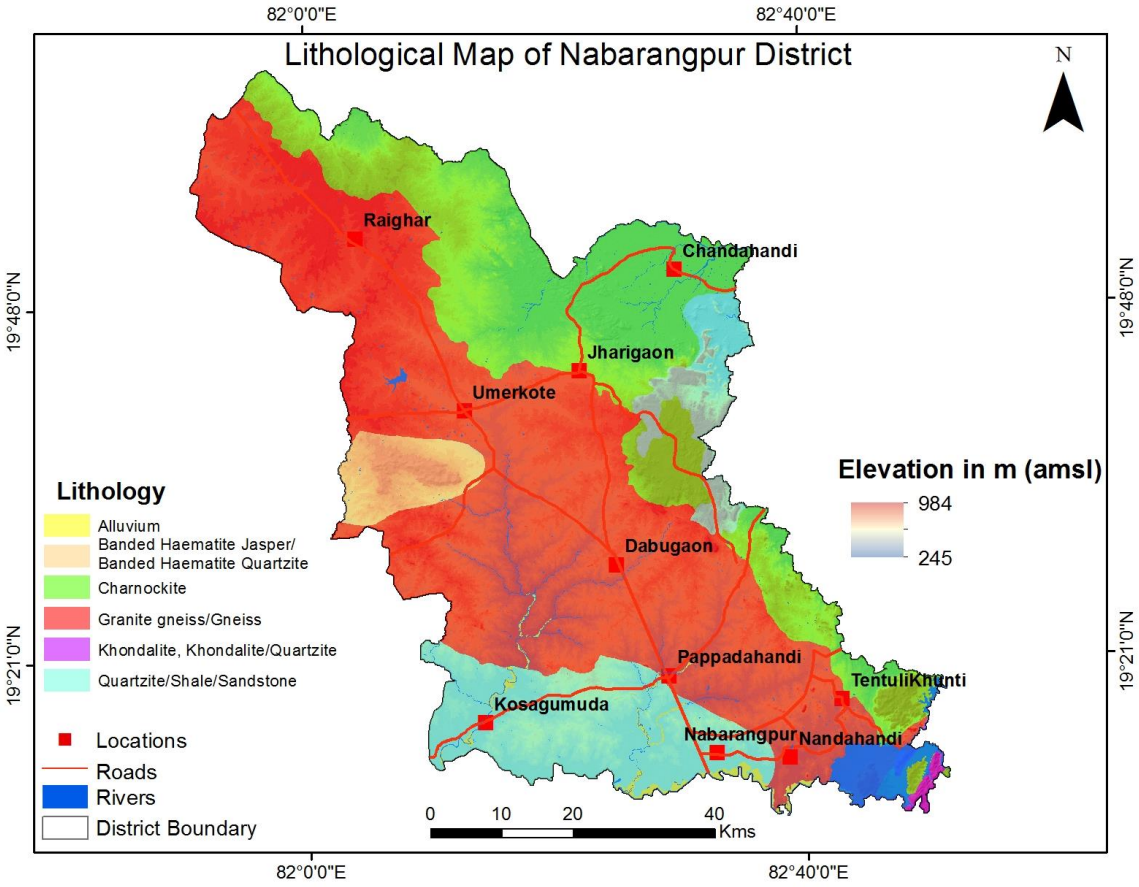

Fig. 2.1: Geological Map of Nabarangpur District.

2.2 Hydrogeology

The hydrogeological conditions vary from place to place depending upon the aquifer characteristics of the litho units, sources of groundwater recharge and the structural setting of the area. The hydrogeological units of the area are broadly categorized into three groups namely:The hydrogeological map of the area is presented in **Fig. 2.2**.

- Consolidated formations.
- Semi Consolidated formations
- Unconsolidated formations

A.Consolidated Formations:

This hydrogeological unit comprises hard crystalline rocks like Granites, Granite gneisses, Khondalites, Charnokites, Schists, Quartzites and also Pre Cambrian Sediments like Sandstone and Shale. These formations lack primary porosity. The weathered residuum

and jointed and fractured zones of the hard rocks formthe main repository of ground water. Ground water occurs under phreatic condition in the weathered zone and circulates through fractures and fissures below. The yield potentials of the fractured zones depend upon intensity of fracturing and interconnection of the fractures with the near surface saturated zone.

Granites and Granite Gneisses: The granite and granite gneisses occupy low-lying plains and are foliated, jointed, highly weathered. On weathering and leaching of Kaolinised clay these rocks are reduced to a losse quartzose assemblage. The depth of weathering varies from 9 to 20 metres below ground level. Three sets of intersecting joints are present in this litho unit striking ESEWNW, NE-SW and NW-SE with steep dips ranging from 55 0 to vertical. The opening of the joints vary from few millimeters to about 35 mm. Joints are often closely spaced. The depth to water level varies from 1.77m to 11.45m below ground level during Pre-monsoon period and 1.08m to 10.41m below ground level during Post – monsoon period. The specific capacity Index varies from 0.44-9.02 lpm/m/m2. The yield potential is good to moderate ranging upto 6 lps for shallow aquifers and 10 lps for deeper fractured aquifers.

Charnockite & Khondalites: The weathered residuum of these rocks constitutes the aquifers. Three sets of joints are encountered in these litho units. But these rock types generally form hilly, rugged terrain and hence do not form potential aquifers except in narrow valleys. The yield is low ranging upto 3 LPS.

Bengpal Group of Rocks: The Schists and Amphibolites of Bengpal group of rocks are generally poor water yielder. Weathering is limited to a depth of 8-10m only.

Quartzite –Shale – Sandstone: These groups of rocks are weathered down to a depth of about 15 m below ground level. Due to pronounced weathering and existence of two sets of open joints, this formation act as good aquifers. Shale and sandstone form potential water yielder in the fissured and fractured portions. The depth to water table during pre-monsoon period varies from 5 to 10 m below ground level and during post monsoon period between 3 to 6.5 m. The Specific Capacity Index of wells in these formations varies from 3.2 to 4.86 lpm/m/m2. These formations sometimes yield upto 5 lps.

B. Semi-Consolidated Formation:

Laterites: Laterites are porous and have generally developed on granite gneiss formations.The thickness of the laterites varies from 5 to 15 m. The depth to water table in pre monsoon period varies from 8.50 to 12.20 m below ground level and 6.85 m to 12.00 m below ground level in post monsoon period. The seasonal fluctuation of water table varies from 0.2 to 2.8 m. The yield of the dug wells in this formation is less than 7 Ips for a drawdown of 3-4 m.

C. Unconsolidated Formation: The sand and gravel layers occurring as valley fills and along the riverbanks from potential aquifers. The yield potential of the formation is upto 15 lps.

Aquifer Characteristics of Crystalline: In the hard-crystalline rock recharge of ground water from precipitation or seepage from surface water bodies percolate into the weathered (saprolite) zone. In case the underlying basement rocks (both weathered and fresh) are incised by open fractures, the downward movement of the water from the upper regolith zone (comprising the topsoil and saprolite horizon) is facilitated. In the saprolite/regolith horizon, ground water generally occurs under unconfined condition, whereas is the fractured bedrock aquifers it occurs under semiconfined to confined conditions. The ground water potentials of various zones, i.e., saprolite (tapped by dug wells), weathered basement rock and shallow fractured basement rock horizon (tapped by the hand pumps) and deeper fractured basement rock (tapped by the deep boreholes by CGWB) vary considerably depending upon their lithological and structural characteristics. A perusal of all results related to the pumping test indicates that granite gneiss forms the most potential aquifer both in shallow and deeper horizons, followed by Khondalite.

Laterites: The specific capacity Index of dug wells vary from 2.32-to 10.27- lpm/m/m2. In a limited extent the alluvium forms potential shallow aquifers.

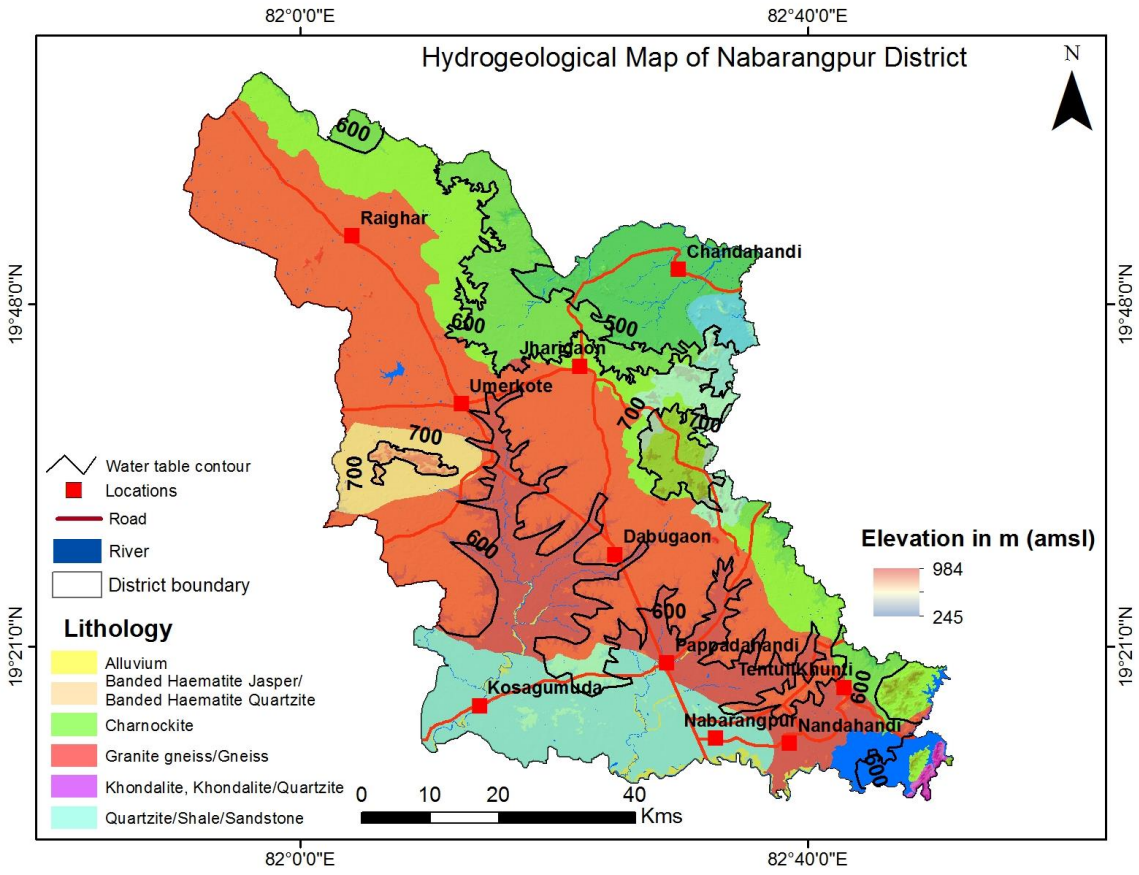

Fig. 2.2: Hydrogeological Map of Nabarangpur District.

2.3 Ground Water Exploration

In order to decipher the aquifer system of the area, CGWB has constructed 40 Exploratory Wells (EW), 13 Observation Wells (OW) under in-house departmentalGround Water Exploration and outsourcing programme, which are shown in **Fig. 2.3** and the data generated has beenshown in **Table 2.2** and **Table 2.3**.

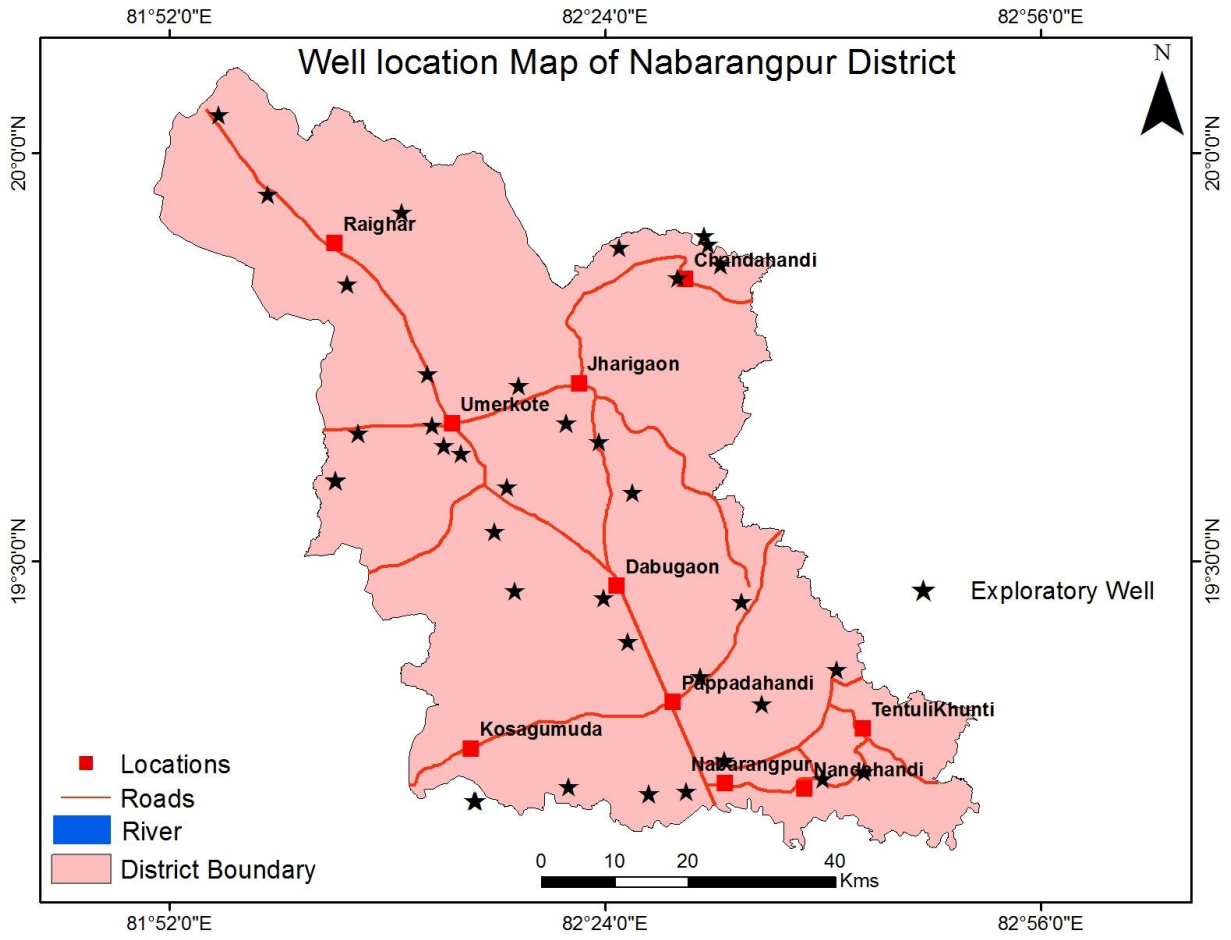

Fig. 2.3: Locations of Exploratory Wells Drilled by CGWB (in-House) in Nabarangpur District.

2.4 Monitoring of Ground Water Regime

CGWB is also engaged in ground water regime monitoring through 25 National Hydrograph Stations (NHS) spreading over the study area. The ground water level data of two seasons and the water quality analysis result is given in **Table 2.4 & 2.5**. The NHS wells location map is depicted in **Fig. 2.4.**

Quality of ground water from deeper aquifers is assessed during the drilling and pumping tests.The chemical data of 10 water samples collected during the exploration is given in **Table 2.6**.

Under NAQUIM, 77 dug wells were established during 2021-22 and water level is monitored both in pre and post monsoon and is given in **Table – 2.7**. During the NAQUIM programme, 77 water samples from shallow aquifer were collected during pre-monsoon period and results is given in **Table No.2.8**. The Key wells location map is depicted in **Fig. 2.5.**

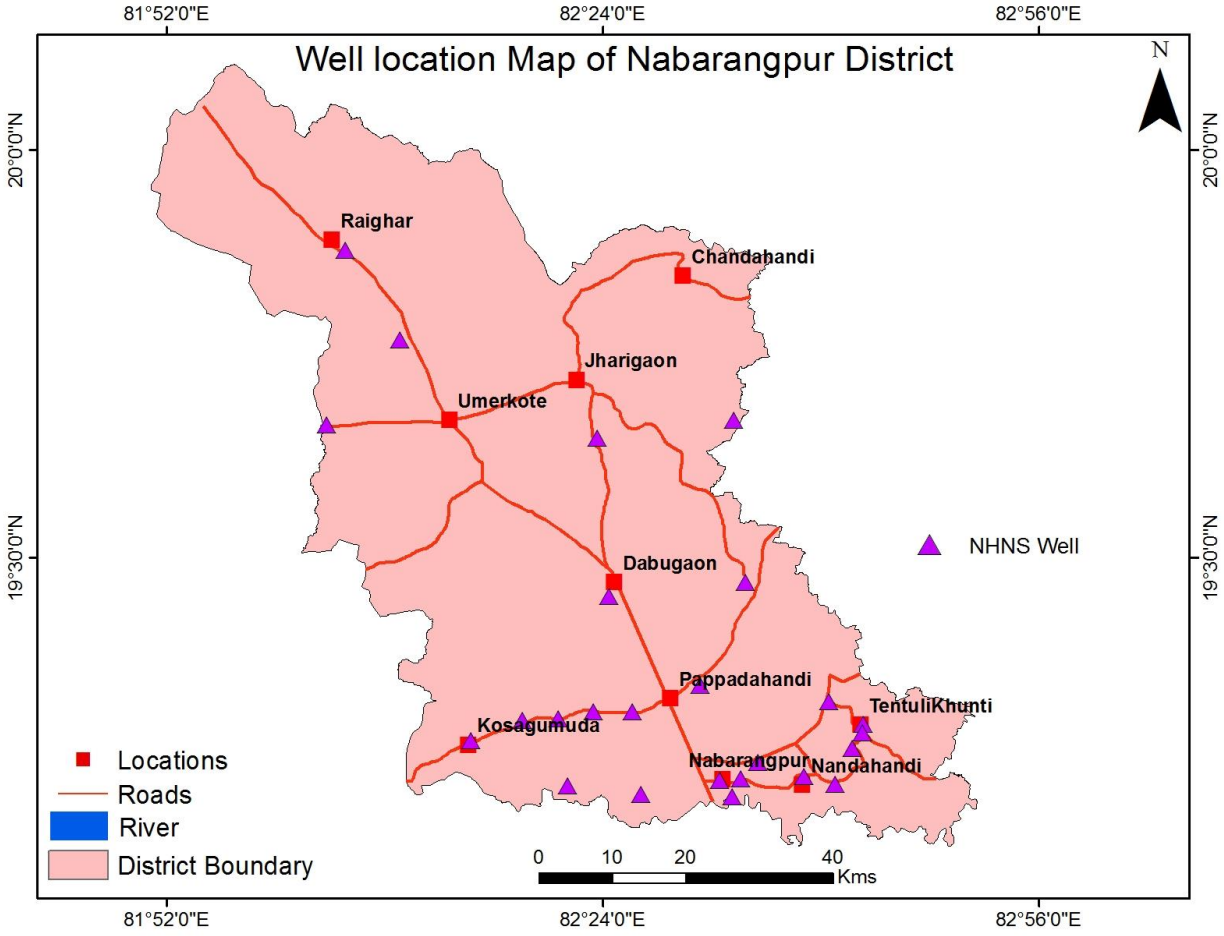

Fig. 2.4: Locations of Ground Water Monitoring Stations in Nabarangpur District

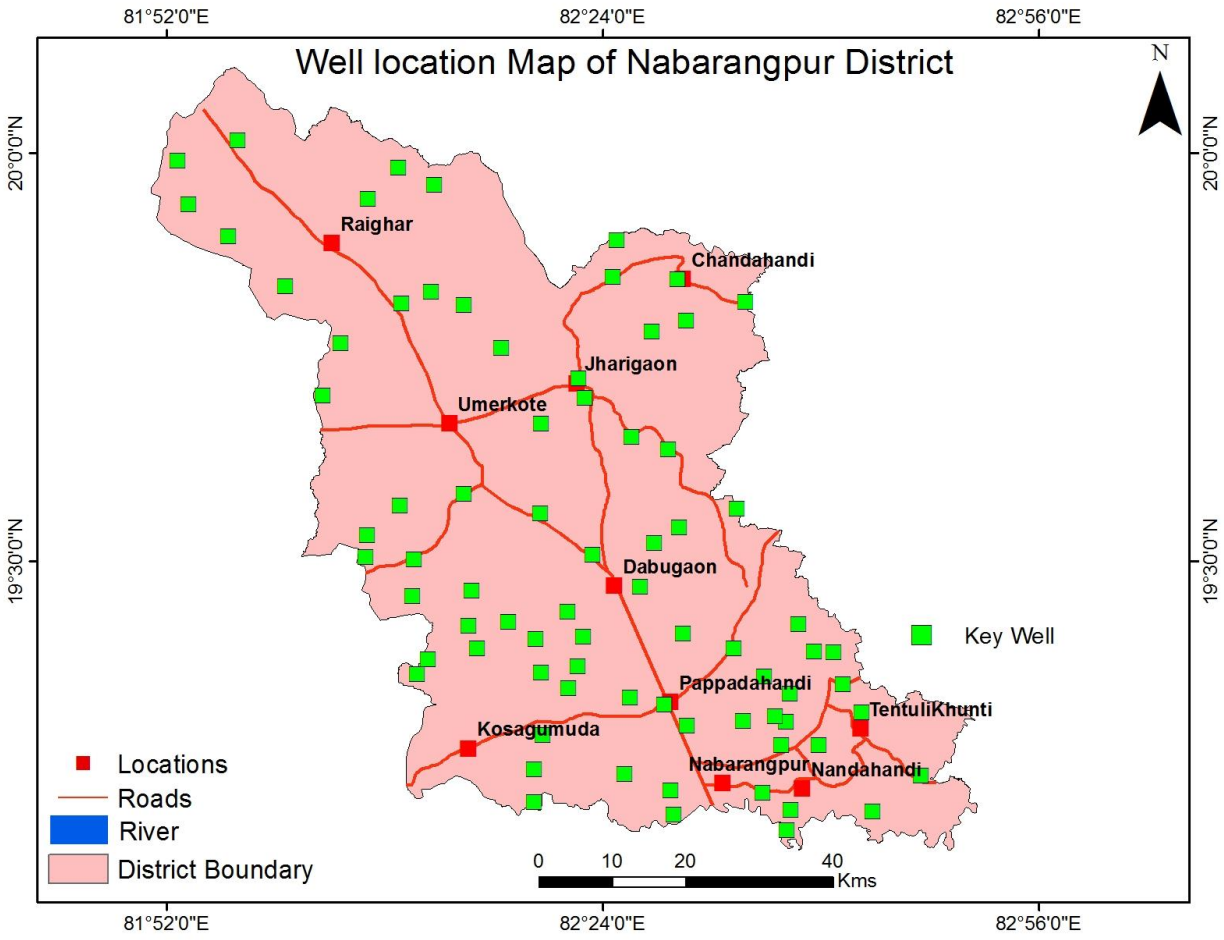

Fig. 2.5: Locations Key Wells Map in Nabarangpur District

Table-2.2: Basic Data of Exploratory Wells Drilled by CGWB (In-House) in Nabarangpur District.

Sl. No	Block	Location	Latitude	Longitude	Depth drilled (mbgl)	Lithology	Depth to Bed rock (mbgl) Casing Pipe Lowered	Granular zones/ deciphered (mbgl)	SWL (mbgl)	Discharge (lps)	Drawdown (m)	EC	Cl
1	Nawarangpur	Nawarangpur	19.2185	82.4989	162.45	Quartzite, shale, list	14.8	19,21,27,32, 37,10,01,100	3.63	3.75	26.25	324	7.1
2	Papdahandi	Papdahandi	19.3316	82.5203	108	Granite	21	21,27,38,74, 84,94	3.05	5.76	28.46	502	14
3	Papdahandi	Papdahandi	19.3316	82.5203	147.4	Granite	18.5	19,44,56,60, 67,89,103, 128,131	3.53	2.5	29.98		
4	Nandahandi	Dongarbhaga	19.2182	82.6574	124.15	Khondalite, Gr. Gneiss	26.77	25,26,33,36, 70	7.85	2	40.38	182	21
5	Umerkote	Umerkote	19.7155	82.1992	87.3	Gr. Gneiss	24.67	25,31,36,39		6.5	11.49	381	53
6	Umerkote	Umerkote	19.7155	82.1992	138.1	Gr. Gneiss	24.85	26		0.25	40.12		
7	Raighar	Raighar	19.8878	82.0666	191.45	Gr. Gneiss	27.50	28,30,33,63, 83	7.56	3	13.39		
8	Chandanhandi	Chandahandi	19.8766	82.4831	162.2	Gr. Gneiss	26.30	18,62,86,96	4.43	4	6	450	16
9	Jarigaon	Jharigaon	19.7164	82.3867	154	Gr. Gneiss	19.80	39,11,21,15, 146	3.89	5.9	9.16	219	8.9
10	Jarigaon	Jharigaon	19.7164	82.3867	165.85	Gr. Gneiss	34.85	39,51,56,89, 125	2.21	9.2	4.98		
11	-do-	Dhodra	19.5659	82.268	82.1	Gr. Gneiss	21.20	27,31	1.81	9.2	2.2	215	7.1
12	Papdahandi	Maidalpur	19.4708	82.5923	187.2	Gr. Gneiss	21.20	3,38,91,70,1 80	2.8	5	7.48		
13	Papdahandi	Maidalpur	19.4708	82.5923	147.9	Gr. Gneiss	20.60	70,93	2.95	4	11.95		
14	Papdahandi	Dhansuli	19.4184	82.5519	193.7	Charnockite	19.35	30,40,49	5.44	7.6	28.86	354	28
15	Papdahandi	Dhansuli	19.4184	82.5519	104.30	Charnockite	19.90	22,27,36,87	5.62	7.5	16.55		
16	Kosagumda	Kosagumda	19.2573	82.2349	125.6	Purple shale	17.17	18,20,56,65, 74	3.9	16.3	6.33	181	7.1
17	Kosagumda	Kosagumda	19.2573	82.2349	160.00	Purple shale	19.70	19,23,28,34, 41	4.49	14.3	6.55		

18	Tentulikhunti	Tentulikhunti	19.286	82.7141	181	Gr. Gneiss charnockite	28.5	4,54,98,31,00,113	10.7	7.6	12.81	361	5.3
19	Tentulikhunti	Anchalguma	19.3032	82.6766	177.9	Gr. Gneiss charnockite	20.40		3.68	8.1	10.85	750	85
20	Tentulikhunti	Anchalguma	19.3032	82.6766	177.90	Gr. Gneiss charnockite	19.90		4.02	9.9	11.74		
21	Tentulikhunti	Patraput	19.3436	82.6842	177.9	Gr. Gneiss charnockite	22.40		9.02	Ngl			
22	Nandahandi	Dongerbheja	19.2182	82.6574		Gr. Gneiss	-		8.9	3	24.72		
23	Papdahandi	Nisanhandi	19.4014	82.4281		Gr. Gneiss	36.36		8.24	2.6	31.46	130	7.1
24	Papdahandi	Nisanhandi	19.4014	82.4281		Gr. Gneiss	7.6	104	8.27	0.5			

Table-2.3: Basic Data of Exploratory Wells Drilled by WAPCOS (Outsourcing) in Nabarangpur District

Sl. No	Block	Location	Type of Well	Co-Ordinates	Depth drilled (mbgl)	Lithology	Depth to Bed rock (mbgl) /Casing Pipe Lowered	Granular zones/ deciphered (mbgl)	SWL (mbgl)	Discharge (lps)	Drawdown (m)	EC	Cl
1	Dabugam	Borigam	EW	N19°27'47.53" E82°17'20.28"	203	Granite	44.81			Dry			
2	Nabarangpur	Sanamasinagam	EW	N19°12'55.9" E82°27'13.5"	200	Quartzite	9.14	11.5 - 12		Dry			
3	Dabugam	Dongriguda	EW	N19°27'19.16" E82°23'52.83"	165	Granite	14.93			Dry			
4	Jharigaon	Phuphugaon	EW	N19°38'45.6" E82°23'33.2"	200	Amphibolite	30	31 - 32,34.5 - 35	4.67	1.6	24.88	514	30
5	Raighar	Chelidongri	EW	N19°50'18.76" E82°05'02.83"	200	Amphibolite	11.58			Dry			
6	Jharigam	Deulakona	EW	N19°40'5.72" E82°21'08.91"	200	Granite	46.34	143 - 146	9.15	3	24.19	484	10
7	Jharigam	Deulakona	OW	N19°40'6.05" E82°21'09.03"	200	Granite	38		9.85		8.05	416	15
8	Raighar	Kacharapara	EW	N19°12'55.99" E82°27'13.37"	200	Granite	40	45 - 45.5, 48 - 54	8.68	0.8		456	15
9	Raighar	Gona	EW	N19°55'35.95" E82°09'04.14"	200	Granite	28.5			Dry			
10	Raighar	Kurdei	EW	N20°02'43.0" E81°55'36.3"	200	Granite	35	36 - 37, 45 - 46	10.31	0.8		346	10
11	Jharigam	Purla DNK	EW	N19°35'26" E82°16'46"	104	Granite	35	84 - 85, 94 - 96	31.2	2.15	15.45	516	25
12	Jharigam	Purla DNK	OW	N19°35'25" E82°16'46"	104	Granite	34.5		30.8	5.94	13.86	526	25
13	Umerkote	Khutuguda	EW	N19°37'51.8" E82°13'24.6"	200	Granite	25	80 - 81		0.13		470	50
14	Umerkote	Anchala DNK UV- 23	EW	N19°42'53" E82°17'38"	200	Granite	34	42 - 44, 127 - 127.5		Dry			

15	Umerkote	Silati UV - 16	EW	N19°34'54.5" E82°04'10.2"	134	Granite	6	126 - 132	14.12	14.87	18.45	526	50
16	Umerkote	Silati UV - 16	OW	N19°35'55.7" E82°04'12.2"	138	Granite	4		3.54	14.87	0.56	152	20
17	Umerkote	Badakumari UV -16	EW	N19°38'26.27" E82°12'09.85"	200	Granite	28.5	33 - 33.5	8.5	0.78		558	40
18	Umerkote	Purja UV - 5	EW	N19°43'44.2" E82°10'57.409"	200	Granite	31			Dry			
19	Dabugam	Nandpur	EW	N19°32'08.06" E82°15'52.4"	200	Granite	4	6 - 6.5	20.94	0.13		518	100
20	Kasagumuda	Karchamal	EW	N19°13'24.4" E82°21'19.2"	200	Quartzite	40			Dry			
21	Chandahandi	Boriguda	EW	N19°53'14" E82°31'34"	200	Granite	25.5			Dry			
22	Chandahandi	Chandahandi	EW	N19°53'53" E82°31'17"	200	Granite	25			Dry			
23	Chandahandi	Sadapur	EW	N19°51'44.135" E82°32'27.862"	200	Granite	19.5	83 - 84, 90 - 93		Dry			
24	Kasagumuda	Sanaambda	EW	N19°12'23.30" E82°14'29.49"	132	Quartzite	49	64 - 72, 88 - 91	10.04	15	3.51	568	10
25	Kasagumuda	Sanaambda	OW	N19°12'24.80" E82°14'21.03"	129	Quartzite	44		9.62		2.86	598	10
26	Nandahandi	Majiguda	EW	N19°15'23.90" E82°32'45.16"	200	Granite	45.12	50 - 53, 94 - 95	6.34	0.13		360	20
27	Umerkote	Jamarunda UV 14	EW	N19°39'22.4" E82°05'49.1"	200	Granite	30.5	130 - 131	6.84	0.13		452	20
28	Chandahandi	Dogrikota	EW	N19°51'44.13" E82°32'27.86"	200	Granite	43.5			Dry			
29	Raighar	Jodenga	EW	N19°56'54.10" E81°59'13.28"	200	Granite	25			Dry			

Table 2.4: Details of Ground Water Monitoring wells in Nabarangpur District

Sl No	Location	Block	Type	Longitude	Latitude	Elevation (maMSL)	Pre-Monsoon DTWL (mbgl)	Post-Monsoon DTWL (mbgl)
1	Anchalguma1,	Tentulikhunti	NHNS	82.676578	19.324041	600	4.95	3.2
2	Baheda, DW	Umarkote	NHNS	82.151495	19.767191	615	6.12	5.06
3	Baksaguda, DW	Nabarangapur	NHNS	82.388513	19.312113	617	6.68	5.4
4	Bhaskel-dam sit,	Umarkote	NHNS	82.135646	19.681986	642	7.41	6.3
5	Chandahandi	Chandahandi	NHNS	82.49194	19.84528	301	6.45	5.66
6	Dadia-	Kosagumuda	NHNS	82.301302	19.301197	570	5.05	4.23
7	Daibata, DW	Nandahandi	NHNS	82.558503	19.207319	562	5.65	5.88
8	Debugaon, DW	Dabugan	NHNS	82.407901	19.453049	591	3.1	2.88
9	Dengaguda, DW	Paparahandi	NHNS	82.436224	19.311867	582	6.91	4.8
10	Digi, DW	Tentulikhunti	NHNS	82.705716	19.26726	585	4.29	3.65
11	Dondasora, DW	Umarkote	NHNS	82.061774	19.662897	656	4.59	3.57
12	Fupugaon, DW	Jharigan	NHNS	82.393629	19.647049	632	5.07	3.53
13	Jharigan, DW	Jharigan	NHNS	82.37083	19.72389	623	7.42	6.72
14	Karchamal, DW	Kosagumuda	NHNS	82.356661	19.221215	576	8.84	5.02
15	Kodinga, DW	Kosagumuda	NHNS	82.345577	19.303519	592	2.49	3.07
16	Kosagumunda	Kosagumuda	NHNS	82.239049	19.276423	564	6.92	4.04
17	Kurlaghati, DW	Nandahandi	NHNS	82.590081	19.250091	577	3.72	2.6
18	Maidalpur1, DW	Paparahandi	NHNS	82.574577	19.46975	608	4.82	3.87
19	Nandahandi,	Nandahandi	NHNS	82.684389	19.223262	582	5.49	3.9
20	Nowrangpur 1,	Nabarangapur	NHNS	82.542739	19.228183	569	4.15	2.68
21	Papadahandi1,	Paparahandi	NHNS	82.519231	19.343728	583	9.07	7.16
22	Raighar, DW	Raighar	NHNS	82.084816	19.876925	659	5.11	3.77
23	Rangamatiguda,	Nandahandi	NHNS	82.569283	19.229398	578	10.69	8.45
24	Sagarmunda,	Nandahandi	NHNS	82.646419	19.232915	579	4.32	3.45
25	Sonamasigan 1,	Nabarangapur	NHNS	82.447184	19.210229	563	3.61	3
26	Tentulikunti 1,	Tentulikhunti	NHNS	82.718846	19.295973	595	4.18	3.12
27	Udaipur, DW	Tentulikhunti	NHNS	82.71819	19.285761	590	4.65	3.71
						MIN	**2.49**	**2.6**
						MAX	**10.69**	**8.45**
						AVG	**5.62**	**4.40**

Table-2.5: Ground Water Quality Data of Monitoring Wells in Nabarangpur District

Sl No	Location	Block	Latitude	Longitude	pH	EC	TDS	Hardness	Alkalinity	Ca++	Mg	Na+	K+	CO3=	HCO3-	Cl-	SO4=	F-
						µS/cm		as CaCO3 mg/L		mg/L								
1	Debugaon	Dabugan	19°27'10"	82°24'30"	7.62	400	206	150	154.92	38	13.42	11	17.8	0	189	25	8.3	0.13
2	Fufugaon	Jharigan	19°38'49"	82°23'37"	7.88	470	239	160	180.33	40	14.64	25.6	11.6	0	220	35	4.8	0.26
3	Jharigan	Jharigan	19°42'42"	82°22'6" E	7.65	770	386	285	154.92	42	43.81	41.2	5.6	0	189	85	75.8	0.33
4	Kodinga	Kosagumuda	19°18'12"	82°20'45"	7.81	260	128	90	95.08	24	7.32	17	0.9	0	116	22	0	0.04
5	Kosagumunda	Kosagumuda	19°16'35"	82°14'34"	7.23	1180	647	355	295.08	66	46.28	106	2.9	0	360	172	77.5	0.54
6	Kosagumunda	Kosagumuda	19°16'33"	82°14'16"	7.59	780	413	235	250	64	18.31	62.8	10.6	0	305	85	23	0.13
7	Karchamal	Kosagumuda	19°13'28"	82°21'39"	7.7	350	174	160	145.08	44	12.21	4	4.4	0	177	15	7.6	0.09
8	Sonamasigan	Nabarangapur	19°12'40"	82°27'7" E	7.91	520	236	245	240.16	34	38.94	5.4	1.2	0	293	12	1	0.1
9	Nowrangpur 1	Nabarangapur	19°14'9"	82°32'56"	8.11	580	295	175	154.92	26	26.78	49	4.2	0	189	95	1.1	0.07
10	Baksaguda	Nabarangapur	19°19'13"	82°23'31"	7.84	390	184	150	169.67	24	21.91	18	2	0	207	17	0	1.31
11	Sagarmunda	Nandahandi	19°14'37"	82°39'19"	8.02	400	193	165	164.75	34	19.49	10.3	7.5	0	201	17	6.4	0.16
12	Nandahandi	Nandahandi	19°14'13"	82°40'12"	8.23	480	231	180	195.08	28	26.78	23	5.6	0	238	22	8.9	0.26
13	Daibata	Nandahandi	19°12'44"	82°33'51"	8.1	390	178	165	154.92	22	26.77	11	1	0	189	25	0	0.06
14	Kurlaghati	Nandahandi	19°15'2"	82°35'41"	7.91	390	195	155	190.16	28	20.7	15.5	2.7	0	232	12	2	0.37
15	Rangamatiguda	Nandahandi	19°14'5"	82°34'18"	8.07	240	118	105	95.08	26	9.76	3.2	5.2	0	116	15	1.8	0.05
16	Dengaguda	Paparahandi	19°19'5"	82°25'57"	7.57	320	161	130	119.67	42	6.13	10	3.6	0	146	27	0.6	0.41
17	Maidalpur1	Paparahandi	19°28'2"	82°34'32"	7.89	850	426	305	295.08	62	36.55	50.5	6.8	0	360	82	11.6	0.32
18	Papadahandi1	Paparahandi	19°21'0"	82°31'19"	7.96	710	380	185	230.33	32	25.57	61.6	27	0	281	75	21.5	0.32
19	Tentulikunti 1	Tentulikhunti	19°18'16"	82°43'16"	7.96	410	203	150	135.25	26	20.7	19.5	7.7	0	165	47	1.7	0.14
20	Anchalguma1	Tentulikhunti	19°19'25"	82°40'42"	7.38	890	462	310	225.41	44	48.68	39.3	35	0	275	140	20	0.31
21	Udaipur	Tentulikhunti	19°17'16"	82°43'9" E	8.16	730	377	250	259.84	48	31.67	24.3	47.9	0	317	57	13	0.48
22	Digi	Tentulikhunti	19°16'2"	82°42'33"	8.25	560	296	160	130.33	30	20.7	50.6	7.8	0	159	90	19.3	0.29
23	Umarkot	Umarkote	19°39'50"	82°12'25"	8.03	1120	594	315	235.25	68	35.34	106	10.91	0	287	212	21.3	0.51
24	Bhaskel-dam	Umarkote	19°41'58"	82°7'47" E	7.32	1540	797	570	200	130	59.73	84.9	9.7	0	244	385	8.3	0.52
25	Umerkote	Umarkote	19°40'2"	82°9'5" E	8.03	1120	594	315	235.25	68	35.34	106	10.91	0	287	212	21.3	0.51
26	Dondasora	Umarkote	19°39'35"	82°4'10" E	8.13	320	156	125	119.67	30	12.19	11.4	6.6	0	146	22	2.6	0.28
27	Baheda	Umarkote	19°39'35"	82°12'46"	7.51	850	424	300	250	60	36.54	53.4	3.7	0	305	102	19	0.27
				MIN	**7.23**	**240**	**118**	**90**	**95.08**	**22**	**6.13**	**3.2**	**0.9**	**0**	**116**	**12**	**0**	**0.04**
				MAX	**8.25**	**1540**	**797**	**570**	**295.08**	**130**	**59.73**	**106**	**47.9**	**0**	**360**	**385**	**77.5**	**1.31**

Table-2.6: Ground Water Quality Data of Exploratory Wells in Nabarangpur District

Sl No	Location	Block	Latitude	Longitude	pH	EC	TDS	Hardness	Ca++	Mg	Na+	K+	CO3=	HCO3-	Cl-	SO4=	NO_3^-	F^-	Fe
						µS/cm	mg/L	as CaCO3 mg/L	mg/L										
1	Papdahandi	Papdahandi	19.3316	82.5203	7.22	486			62	85	20	2.2		262	21	13	23		18
2	Papdahandi	Papdahandi	19.3316	82.5203	7.51	502	306		58	18	18	2.9		262	18	14	14	0.43	30
3	Maidalpur	Papdahandi	19.4708	82.5923	7.4	236	214		24	8.5	12	1.2		140	5.3		4.3		0.83
4	Maidalpur	Papdahandi	19.4708	82.5923	8.24	218	194		22	8.5	11	1		116	7.1	0.3	5.1	0.51	0.77
5	Dhansuli	Papdahandi	19.4184	82.5519	7.81	854	269		34	12	12	1.8		140	28	1.5	17	0.46	1.5
6	Dhansuli	Papdahandi	19.4184	82.5519	8.22	335	207		28	13	19	2		116		0.8	15	0.61	0.6
7	Kosagumda	Kosagumda	19.2573	82.2349	8.25	200			16	13	1.4	1.4		104	9	0.4	7	0.21	0.1
8	Kosagumda	Kosagumda	19.2573	82.2349	7.79		197		44	13	3	2.1		195		0.5	3.7	0.33	0.02
9	Tentulikhunti	Tentulikhunti	19.286	82.7141	8.28	398	115		22	15	37	6.2		232	5.3	4.3	0.15	0.77	0.03
				MIN	**7.22**	**200**	**115**		**16**	**8.5**	**1.4**	**1**		**104**	**5.3**	**0.3**	**0.15**	**0.21**	**0.02**
				MAX	**8.25**	**854**	**306**		**62**	**85**	**37**	**6.2**		**262**	**28**	**14**	**17**	**0.77**	**30**

Table-2.7: Depth to water level data of Monitoring Dug wells established during 2021-22 under NAQUIM

Sl No	Village	Block	Latitude	Longitude	Water level (mbgl)
1	Batajhari	Chandahandi	19.8483	82.4128	3.43
2	Jhulanbara	Chandahandi	19.8931	82.4167	5.96
3	Chandahandi	Chandahandi	19.8453	82.4919	4.66
4	Dephaguda	Chandahandi	19.8175	82.5742	2
5	Dalbeda	Chandahandi	19.7946	82.502	2.63
6	Bandhkana	Chandahandi	19.7814	82.4603	4.6
7	Chacharaguda	Dabugaon	19.5223	82.4625	4.43
8	Kosaguda	Dabugaon	19.439	82.3574	4.26
9	Chheraguda	Dabugaon	19.4056	82.3182	0.79
10	Kurupa	Dabugaon	19.464	82.2401	1.88
11	Pujariguda	Dabugaon	19.5086	82.3878	5.74
12	Chitapara	Jharigaon	19.5413	82.4932	5.34
13	Dangriguda	Jharigaon	19.5589	82.3239	2.96
14	Debadora	Jharigaon	19.7614	82.2761	5.06
15	Jharigaon	Jharigaon	19.7239	82.3708	6.36
16	Chitabeda	Jharigaon	19.6683	82.3247	5.09
17	Kalegaon	Jharigaon	19.6997	82.3783	2.98
18	Chocha	Jharigaon	19.6528	82.435	5.46
19	Santemra	Jharigaon	19.6372	82.4797	4.91
20	Bhandri	Kosagumuda	19.2056	82.3164	4.06
21	Jabaguda	Kosagumuda	19.2458	82.3158	2.82
22	Ramnaguda	Kosagumuda	19.2877	82.3262	2.2
23	Alekguda	Kosagumuda	19.3639	82.3247	3.45
24	Bada-Attigam	Kosagumuda	19.4263	82.2845	6.97
25	Papuni	Kosagumuda	19.3939	82.2464	4.21
26	Motigaon	Kosagumuda	19.3809	82.1858	2.94
27	Keragaon	Kosagumuda	19.3626	82.1729	2.6
28	Bhandimal	Kosagumuda	19.4218	82.2362	2.47
29	Sindhigaon	Nabarangpur	19.19	82.4873	1.5
30	Daspur	Nabarangpur	19.2198	82.4833	3.46
31	Betal	Nabarangpur	19.2399	82.4262	1.95
32	Mantriguda	Nabarangpur	19.299	82.5029	3.66
33	Atakabeda	Nabarangpur	19.305	82.5715	2.74
34	Sindhiguda	Nandahandi	19.2171	82.5956	4.91

35	Nishnahandi	Nandahandi	19.1962	82.6298	3.61
36	Jagannathpur	Nandahandi	19.1946	82.7299	2.37
37	Dhandra	Nandahandi	19.2751	82.6643	1.61
38	Bania	Nandahandi	19.1715	82.6251	1.34
39	Sikaraguda	Papadahandi	19.3333	82.4333	3.46
40	Dongara	Papadahandi	19.3723	82.3697	5.62
41	Kutubai	Papadahandi	19.3455	82.3575	3.63
42	Hatibeda	Papadahandi	19.4082	82.3757	5.35
43	Manigam	Papadahandi	19.4692	82.4461	5.12
44	Khaliguda	Papadahandi	19.4123	82.4983	6.62
45	Sirisi	Papadahandi	19.325	82.4756	6
46	Tumberlla	Papadahandi	19.3937	82.5606	6.48
47	Khajuri	Papadahandi	19.5642	82.5642	3.49
48	Duglipara	Raighar	19.8364	82.0119	1.1
49	Pourbella	Raighar	19.8978	81.9414	8.52
50	Kibekonga	Raighar	19.9367	81.8936	6.17
51	Kaudola	Raighar	19.9903	81.8803	3.31
52	Keradih	Raighar	20.0147	81.9533	4.91
53	Timanpur	Raighar	19.9439	82.1128	3.76
54	Binaypur	Raighar	19.9819	82.1503	2.18
55	Rahaspara	Raighar	19.9603	82.1942	4.75
56	Khatiguda	Tentulikhunti	19.2381	82.7896	5.86
57	Nuaguda	Tentulikhunti	19.316	82.717	4.85
58	Bhidor Mengra	Tentulikhunti	19.3495	82.6935	4.25
59	Jharigumma	Tentulikhunti	19.3886	82.6822	1.9
60	Kantagaon	Tentulikhunti	19.3898	82.6587	1.36
61	Kongra	Tentulikhunti	19.3037	82.6246	3.22
62	Janiguda	Tentulikhunti	19.3105	82.611	2.08
63	Bhaspur	Tentulikhunti	19.3596	82.5971	2.95
64	Merei	Tentulikhunti	19.4236	82.6397	3.5
65	Kamta	Tentulikhunti	19.3382	82.6292	3.48
66	Kukudabai	Tentulikhunti	19.2751	82.6184	2.47
67	Toraguda	Umerkote	19.7028	82.0572	0.98
68	Andriguda	Umerkote	19.7667	82.0792	3.47
69	Nagaguda	Umerkote	19.8156	82.1536	5.54
70	Banipadar	Umerkote	19.8303	82.1897	4.47
71	Tohra	Umerkote	19.8142	82.23	3.33
72	Banuaguda	Umerkote	19.5825	82.23	7.02

73	Bhandariguda	Umerkote	19.5689	82.1522	9.55
74	Rajpur	Umerkote	19.5325	82.1117	3.88
75	Singhsari	Umerkote	19.5031	82.1689	7.58
76	Panar	Umerkote	19.4578	82.1675	2.11
77	Jholla	Umerkote	19.505	82.1103	1.77

Table-2.8: Ground Water Quality data of Monitoring Dug wells established during 2021-22 under NAQUIM

Sl No	Location	Block	Lat	Long	pH	EC	TDS	Hardness	Alkalinity	Ca++	Mg++	Na+	K+	CO3-	HCO3-	Cl-	SO4=	NO3-	F -	U
						µS/cm	mg/l	as $CaCO_3$ mg/l		mg/l										
1	Batajhari	Chandahandi	19.8483	82.4128	7.00	1050	402	46.00	275.00	18.00	91.00	47.00	0.57	0.00	336.00	51.00	157.00	60.00	0.50	BDL
2	Jhulanbara	Chandahandi	19.8931	82.4167	7.80	300	324	71.00	115.00	29.00	12.00	17.00	1.04	0.00	140.00	16.00	30.00	4.50	0.35	0.004
3	Chandahandi	Chandahandi	19.8453	82.4919	7.50	1050	441	46.00	175.00	18.00	56.00	110.00	10.82	0.00	214.00	100.00	180.00	60.00	0.25	0.003
4	Dephaguda	Chandahandi	19.8175	82.5742	8.20	600	338	41.00	240.00	16.00	52.00	28.00	2.50	0.00	293.00	33.00	41.00	4.50	1.26	BDL
5	Dalbera	Chandahandi	19.7946	82.5020	8.10	500	317	41.00	170.00	16.00	41.00	26.00	6.84	0.00	207.00	19.00	63.00	9.50	0.93	BDL
6	Bandhkana	Chandahandi	19.7814	82.4603	7.90	850	336	61.00	200.00	25.00	74.00	30.00	0.89	0.00	244.00	65.00	107.00	70.00	0.38	BDL
7	Chacharaguda	Dabugaon	19.5223	82.4625	8.09	217	149	52.00	38.48	13.20	6.23	14.79	4.88	0.00	46.95	22.16	5.32	29.31	0.46	BDL
8	Kosaguda	Dabugaon	19.4390	82.3574	7.83	335	226	69.00	87.64	29.60	8.40	28.08	5.30	0.00	106.91	44.01	6.96	26.01	0.07	BDL
9	Chheraguda	Dabugaon	19.4056	82.3182	7.94	183	128	39.00	31.19	18.60	4.40	12.41	2.35	0.00	38.05	22.16	10.35	22.04	0.25	BDL
10	Kurupa	Dabugaon	19.4640	82.2401	7.62	89	200	100.00	61.86	21.60	11.04	2.87	3.82	0.00	75.47	17.23	0.00	23.90	0.14	BDL
11	Pujariguda	Dabugaon	19.5086	82.3878	7.74	385	267	79.00	76.71	24.20	14.64	45.49	4.54	0.00	93.58	78.78	15.26	37.68	0.10	BDL
12	Chitapara	Jharigaon	19.5413	82.4932	7.86	268	185	59.00	25.33	9.60	12.80	32.70	2.51	0.00	30.90	54.01	13.61	39.81	0.10	BDL
13	Dangriguda	Jharigaon	19.5589	82.3239	7.61	379	261	81.00	89.61	29.20	11.04	51.15	2.61	0.00	109.32	78.48	31.04	1.48	0.07	BDL
14	Debadora	Jharigaon	19.7614	82.2761	8.00	700	402	92.00	165.00	37.00	56.00	18.00	0.55	0.00	201.00	35.00	100.00	70.00	0.83	BDL
15	Jharigaon	Jharigaon	19.7239	82.3708	7.40	300	218	36.00	75.00	14.00	17.00	29.00	2.91	0.00	92.00	46.00	22.00	8.50	0.16	BDL
16	Chitabeda	Jharigaon	19.6683	82.3247	7.70	850	461	77.00	170.00	31.00	63.00	35.00	7.00	0.00	207.00	128.00	64.00	28.00	0.16	BDL
17	Kalegaon	Jharigaon	19.6997	82.3783	8.11	1000	508	82.00	280.00	33.00	44.00	36.00	129.00	0.00	342.00	81.00	96.00	42.00	0.21	BDL
18	Chocha	Jharigaon	19.6528	82.4350	8.00	400	225	61.00	125.00	25.00	27.00	12.00	7.50	0.00	153.00	53.00	17.00	3.60	0.14	BDL
19	Santemra	Jharigaon	19.6372	82.4797	7.30	450	207	66.00	90.00	27.00	21.00	13.00	39.00	0.00	110.00	39.00	26.00	80.00	0.07	BDL
20	Bhandri	Kosagumuda	19.2056	82.3164	7.63	926	590	232.00	256.00	52.00	36.00	65.00	12.00	0.00	312.00	96.00	16.30	23.60	0.33	BDL
21	Jabaguda	Kosagumuda	19.2458	82.3158	7.98	695	485	204.00	165.58	41.20	31.44	24.65	16.25	0.00	202.01	46.93	25.01	43.44	0.07	BDL
22	Ramnaguda	Kosagumuda	19.2877	82.3262	8.16	944	634	249.00	268.99	52.80	40.08	63.48	16.83	0.00	328.17	105.87	6.35	43.59	0.06	0.002
23	Alekguda	Kosagumuda	19.3639	82.3247	7.65	887	618	289.00	243.00	61.20	28.84	46.98	13.38	0.00	296.46	78.78	23.19	9.65	0.45	BDL
24	Bada-Attigam	Kosagumuda	19.4263	82.2845	7.75	42	296	149.00	139.19	27.60	19.20	5.41	2.10	0.00	169.81	2.46	0.00	9.48	0.04	0.003
25	Papuni	Kosagumuda	19.3939	82.2464	8.21	896	628	239.00	233.22	48.80	30.08	87.85	31.12	0.00	284.52	124.95	31.86	19.55	0.29	0.004
26	Motigaon	Kosagumuda	19.3809	82.1858	8.07	870	582	224.00	218.99	57.20	31.24	65.45	11.20	0.00	267.17	98.48	56.87	4.63	0.60	BDL

27	Keragaon	Kosagumuda	19.3626	82.1729	7.77	871	557	229.00	224.03	39.20	31.44	73.59	16.69	0.00	273.32	108.33	24.30	8.41	0.18	BDL
28	Bhandimal	Kosagumuda	19.4218	82.2362	7.98	265	180	54.00	61.79	21.60	9.20	24.41	4.93	0.00	75.38	42.39	23.65	5.51	0.21	BDL
29	Sindhigaon	Nabarangpur	19.1900	82.4873	8.07	285	195	69.00	72.17	22.20	8.44	22.97	2.46	0.00	88.05	34.47	20.12	6.48	0.06	BDL
30	Daspur	Nabarangpur	19.2198	82.4833	7.85	676	456	169.00	180.23	45.60	28.40	38.27	10.12	0.00	219.88	66.47	13.41	43.22	0.14	BDL
31	Betal	Nabarangpur	19.2399	82.4262	7.65	244	170	49.00	18.86	13.20	5.84	26.94	7.53	0.00	23.01	39.39	8.77	46.94	0.11	BDL
32	Mantriguda	Nabarangpur	19.2990	82.5029	8.24	803	485	204.00	181.36	41.20	28.24	48.88	5.89	0.00	221.25	80.49	30.15	17.97	0.16	0.003
33	Atakabeda	Nabarangpur	19.3050	82.5715	7.68	214	145	54.00	46.71	13.20	8.24	16.81	2.01	0.00	56.98	26.63	6.35	16.25	0.05	BDL
34	Sindhiguda	Nandahandi	19.2171	82.5956	8.03	1267	879	403.00	247.44	69.20	23.20	104.54	28.52	0.00	301.88	145.26	57.67	44.89	0.47	BDL
35	Nishnahandi	Nandahandi	19.1962	82.6298	7.77	477	336	109.00	117.33	38.40	18.92	35.71	5.53	0.00	143.14	66.47	14.52	43.54	0.09	0.004
36	Jagannathpur	Nandahandi	19.1946	82.7299	8.21	1120	761	314.00	342.09	86.80	35.08	58.00	9.79	0.00	417.35	91.09	24.40	27.90	0.39	BDL
37	Dhandra	Nandahandi	19.2751	82.6643	7.89	289	212	79.00	87.64	29.20	9.44	10.08	3.08	0.00	106.91	14.77	0.81	27.89	0.26	BDL
38	Bania	Nandahandi	19.1715	82.6251	7.44	148	98	35.00	26.39	11.60	3.44	6.66	3.54	0.00	32.20	12.65	5.63	16.52	0.07	BDL
39	Sikaraguda	Papadahandi	19.3333	82.4333	8.07	1070	632	234.00	298.99	51.60	43.20	70.00	12.46	0.00	364.77	115.71	31.76	9.34	0.20	0.019
40	Dongara	Papadahandi	19.3723	82.3697	7.99	752	788	364.00	258.00	71.20	36.64	86.08	6.75	0.00	314.76	123.10	54.85	14.17	0.24	BDL
41	Kutubai	Papadahandi	19.3455	82.3575	8.08	572	379	134.00	130.12	36.20	18.24	28.02	19.00	0.00	158.74	46.78	18.65	47.08	0.15	BDL
42	Hatibeda	Papadahandi	19.4082	82.3757	7.95	806	466	195.00	158.57	45.20	21.84	44.76	6.29	0.00	193.45	73.86	12.91	44.74	0.09	0.005
43	Manigam	Papadahandi	19.4692	82.4461	7.98	936	608	238.00	242.29	65.20	33.60	64.81	5.82	0.00	295.59	107.87	36.10	18.70	0.35	0.002
44	Khaliguda	Papadahandi	19.4123	82.4983	7.80	345	242	74.00	87.79	37.20	10.24	21.28	1.63	0.00	107.10	36.78	6.45	38.31	0.12	BDL
45	Sirisi	Papadahandi	19.3250	82.4756	8.14	686	478	214.00	160.43	45.20	24.24	36.13	4.59	0.00	195.72	64.01	12.20	45.00	0.09	BDL
46	Tumerlla	Papadahandi	19.3937	82.5606	7.93	786	433	198.00	164.65	37.60	15.36	41.80	27.48	0.00	200.87	77.87	1.21	12.70	0.15	BDL
47	Khajuri	Papadahandi	19.5642	82.5642	7.91	395	272	75.00	72.57	26.00	11.60	35.40	20.23	0.00	88.53	57.23	22.18	38.15	0.14	BDL
48	Duglipara	Raighar	19.8364	82.0119	8.10	450	270	46.00	175.00	18.00	32.00	22.00	1.50	0.00	214.00	16.00	31.00	2.00	0.37	BDL
49	Pourbella	Raighar	19.8978	81.9414	8.00	650	279	31.00	170.00	12.00	56.00	19.00	29.20	0.00	207.00	53.00	76.00	26.00	0.25	BDL
50	Kbekonga	Raighar	19.9367	81.8936	7.70	200	110	66.00	75.00	27.00	1.00	14.00	2.81	0.00	92.00	16.00	8.00	5.00	0.55	BDL
51	Kaudola	Raighar	19.9903	81.8803	7.30	200	103	41.00	65.00	16.00	10.00	9.00	5.11	0.00	79.00	21.00	4.00	12.00	0.10	BDL
52	Keradih	Raighar	20.0147	81.9533	7.30	200	114	51.00	55.00	20.00	7.00	7.00	7.79	0.00	67.00	21.00	3.00	24.00	0.10	BDL
53	Timanpur	Raighar	19.9439	82.1128	7.90	600	291	46.00	160.00	18.00	46.00	33.00	3.72	0.00	195.00	86.00	18.00	1.60	0.16	BDL
54	Binaypur	Raighar	19.9819	82.1503	7.70	300	152	56.00	95.00	22.00	12.00	19.00	0.57	0.00	116.00	12.00	9.00	41.00	0.65	BDL
55	Rahaspara	Raighar	19.9603	82.1942	7.90	450	276	71.00	100.00	29.00	27.00	22.00	1.64	0.00	122.00	37.00	30.00	55.00	0.31	BDL

56	Khatiguda	Tentulikhunti	19.2381	82.7896	7.53	264	182	65.00	51.55	22.20	6.48	21.31	1.95	0.00	62.89	36.93	18.75	15.28	0.43	BDL
57	Nuaguda	Tentulikhunti	19.3160	82.7170	7.88	1200	842	345.00	315.51	80.40	30.88	96.09	16.29	0.00	384.92	140.33	39.22	44.82	0.17	BDL
58	Bhidor Mengra	Tentulikhunti	19.3495	82.6935	7.74	670	459	159.00	165.02	42.80	22.08	48.85	16.87	0.00	201.32	75.87	26.82	43.47	0.08	BDL
59	Jharigumma	Tentulikhunti	19.3886	82.6822	8.04	481	334	98.00	138.00	38.80	16.48	27.98	18.86	0.00	168.36	44.62	18.87	32.01	0.52	0.024
60	Kantagaon	Tentulikhunti	19.3898	82.6587	7.98	1100	773	344.00	301.16	63.20	46.64	72.00	8.76	0.00	367.42	103.40	52.03	5.31	0.62	BDL
61	Kongra	Tentulikhunti	19.3037	82.6246	7.48	345	238	89.00	72.33	31.20	8.84	26.81	4.14	0.00	88.24	46.78	9.78	24.91	0.23	0.002
62	Janiguda	Tentulikhunti	19.3105	82.6110	7.92	485	336	101.00	124.65	32.80	18.32	31.97	20.90	0.00	152.07	51.70	9.58	46.87	0.48	0.003
63	Bhaspur	Tentulikhunti	19.3596	82.5971	7.93	1110	778	307.00	289.51	88.20	39.28	61.34	21.53	0.00	353.20	98.48	45.58	41.06	0.50	BDL
64	Merei	Tentulikhunti	19.4236	82.6397	8.01	178	124	24.00	21.86	13.20	6.24	16.02	3.44	0.00	26.67	24.62	15.82	31.79	0.19	BDL
65	Kamta	Tentulikhunti	19.3382	82.6292	8.04	1003	640	234.00	320.84	35.20	56.64	89.20	10.20	0.00	391.42	132.95	7.36	14.57	0.33	0.004
66	Kukudabai	Tentulikhunti	19.2751	82.6184	7.96	311	201	64.00	78.26	28.20	8.64	23.49	3.62	0.00	95.47	39.09	18.36	7.97	0.23	BDL
67	Toraguda	Umerkote	19.7028	82.0572	8.11	232	127	39.00	30.65	14.20	4.64	18.49	1.37	0.00	37.39	29.54	8.47	22.05	0.13	BDL
68	Andriguda	Umerkote	19.7667	82.0792	8.10	289	197	42.00	47.51	19.20	8.04	32.31	15.10	0.00	57.96	53.86	19.56	32.01	0.29	BDL
69	Nagaguda	Umerkote	19.8156	82.1536	8.22	621	425	199.00	124.65	37.20	15.44	36.95	20.80	0.00	152.07	64.16	28.50	12.29	0.33	BDL
70	Banipadar	Umerkote	19.8303	82.1897	6.90	300	284	41.00	135.00	16.00	22.00	7.00	7.00	0.00	165.00	5.00	23.00	21.00	0.21	BDL
71	Tohra	Umerkote	19.8142	82.2300	7.90	1300	635	46.00	250.00	18.00	108.00	62.00	9.00	0.00	305.00	151.00	146.00	60.00	0.59	BDL
72	Banuaguda	Umerkote	19.5825	82.2300	8.10	1000	464	41.00	275.00	16.00	69.00	75.00	27.00	0.00	336.00	74.00	138.00	24.00	0.28	0.003
73	Bhandariguda	Umerkote	19.5689	82.1522	7.90	550	272	56.00	130.00	22.00	38.00	15.00	21.00	0.00	159.00	49.00	38.00	60.00	0.23	BDL
74	Rajpur	Umerkote	19.5325	82.1117	7.90	450	225	41.00	105.00	16.00	29.00	18.00	22.00	0.00	128.00	46.00	49.00	14.00	0.11	BDL
75	Singasari	Umerkote	19.5031	82.1689	7.50	400	170	71.00	95.00	29.00	23.00	13.00	4.60	0.00	116.00	42.00	14.00	55.00	0.14	BDL
76	Panar	Umerkote	19.4578	82.1675	7.80	175	88	56.00	65.00	22.00	5.00	6.00	1.17	0.00	79.00	14.00	2.00	3.56	0.11	BDL
77	Jholla	Umerkote	19.5050	82.1103	7.70	150	84	51.00	60.00	20.00	4.00	2.00	9.73	0.00	73.00	12.00	1.00	5.96	0.17	BDL

3 DATA INTEGRATION, INTERPRETATION AND AQUIFER MAPPING

3.1 Shallow Aquifer

Ground water occurs in phreatic condition in shallow aquifers and is utilized by means of dug wells or shallow tube wells. The depth of the dug wells used as observation points vary from 2 to 12 meter below ground level with average depth of around 7 mbgl and their diameter ranges from 0.85 m to 6.2 m. The wells are generally lined to the total depth.

3.1.1 Pre-monsoon Depth to Water Level

Depth to water level in pre-monsoon period varies from 2.75 mbgl (Nabarangpur in Nabarangpur block) to 9.72 mbgl (Rangamatiguda in Nandahandi block), the average being 5.85 m bgl. In general the study area has the depth to water level in between 4 to 6 mbgl during the pre-monsoon. Water logging condition (<3 mbgl) is found in small patches in Nabarangpur block. Generally the depth to water level is shallow and within 4 mbgl covering parts of Nandahandi and Tentulikhunti block and the same gradually becomes deeper southern part of the district. Deepest pre- monsoon water levels of 6-9 mbgl are also found as patches in the central part of the district in the Umerkote and Jharigaon block and also in the southern-most part of the district in the Nandahandiblock.

3.1.2 Post-monsoon Depth to Water Level

Depth to water level in post-monsoon period varies from 0.79 mbgl (Chheraguda in Dabygaon block) to 9.55 (Bhandariguda in Umerkote block) mbgl, the average being 3.94 mbgl. The depth to water level of the study area during post monsoon is in general within 3-5 mbgl. Deeper water level of 7-10 mbgl is observed in small patch of Umerkote and Raighar block. It has been observed that 27 out of total 77 stations show less than 3 mbgl, indicating clearly the instance of water logging condition existing in the area due to the application of excess irrigation water. The post-monsoon depth to water level map is shown below in **Fig. 3.1.**

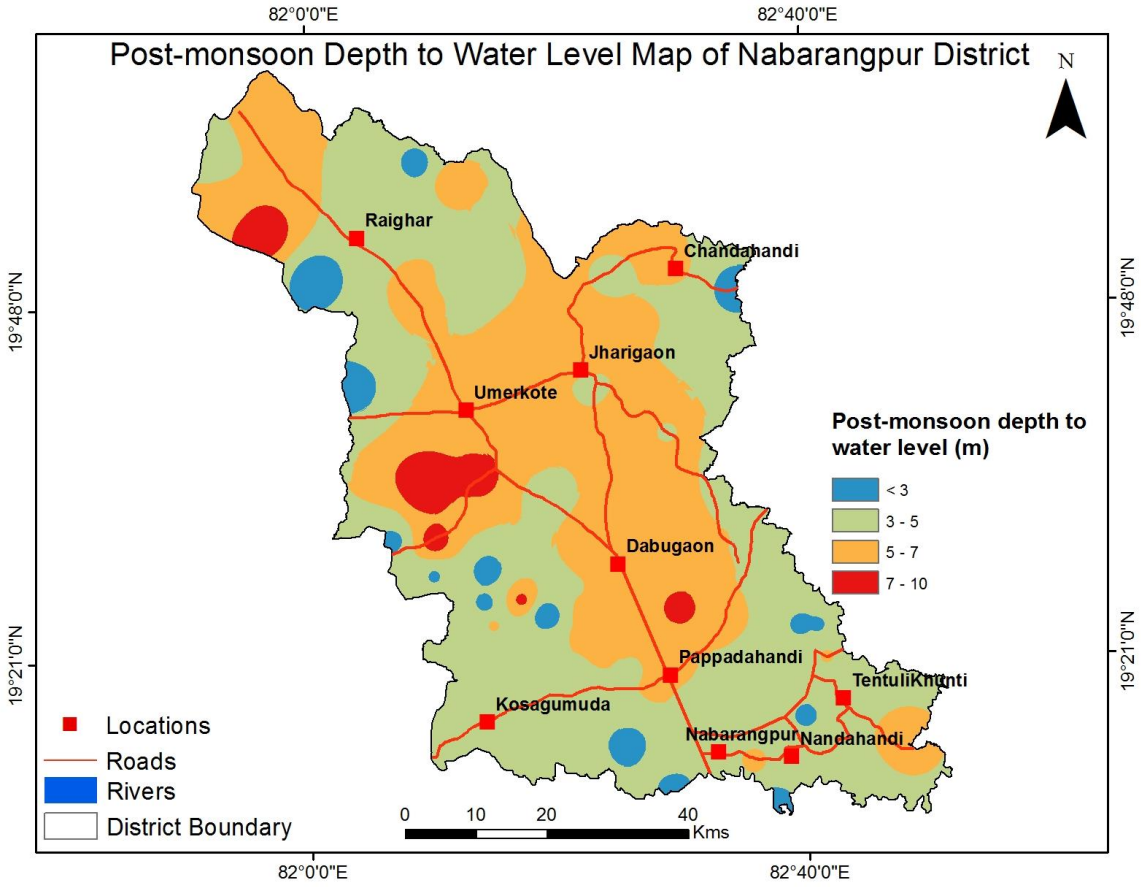

Fig. 3.1: Depth to Water Level in Phreatic Aquifer during Post-Monsoon

3.1.3 Decadal Water Level Trend

There are 17 National Hydrograph Station (NHS) in the district, having long term data available were considered for analysis of decadal trend for the period 2011-2020. The decadal trend of water level for both pre-monsoon and post-monsoon periods has been analysed and the results shown in **Table-3.1**.

Table-3.1: Analysis of Decadal Water Level Trend (2011-2020) in Nabarangpur District.

Location	Pre-monsoon		Post-monsoon	
	Trend (m/Yr)	Remark	Trend (m/Yr)	Remark
Jharigaon	-0.1526	**Fall**	-0.0679	**Fall**
Baksaguda	0.1482	Rise	-0.0205	**Fall**
Rangamatiguda	0.1105	Rise	-0.2633	**Fall**
Baheda	-0.3996	**Fall**	-0.2031	**Fall**
Daibata	-0.0554	**Fall**	-0.0908	**Fall**
Karchamal	-0.0752	**Fall**	-0.2042	**Fall**
Kurlaghati	0.0086	Rise	0.1142	Rise
Fufugaon	-0.1961	**Fall**	-0.0844	**Fall**
Digi	-0.2886	**Fall**	-0.0524	**Fall**
Nandahandi	-0.0982	**Fall**	-0.0480	**Fall**
Maidalpur1	-0.0842	**Fall**	0.0011	Rise
Anchalguma1	-0.0340	**Fall**	0.0148	Rise
Dengaguda	-0.0021	**Fall**	-0.0277	**Fall**
Kodinga	0.0372	Rise	0.0195	Rise
Debugaon	-0.0192	**Fall**	-0.0717	**Fall**
Kosagumunda	0.0818	Rise	0.1204	Rise
Umarkot	-0.0188	**Fall**	0.0354	**Fall**
17		**Rise-5 Fall-12**		**Rise-5 Fall-12**

The long term trend analysis indicates that out of 17 stations, during the pre-monsoon 5 (29.41%) show rising trend and the rest 12 stations (44.44%) show falling trend. Similarly during the post-monsoon, 5 (29.41%) show rising trend and the rest 12 stations (44.44%) show falling trend. During the pre-monsoon, the range of fall is from -0.0021 to -0.3996 m/yr, whereas the range of rising trend is from 0.0086 to 0.1482 m/yr. Similarly during the post-monsoon, the range of fall is from -0.0205 to -0.2633 m/yr and the range of rise is from 0.0011 to 0.1204 m/yr.

3.1.4 Hydrograph Analysis

The hydrographs of 9 ground water monitoring stations were analysed. The variation in short term and long-term water level trends may be due to variation in natural recharge due to rainfall and withdrawal of groundwater for various agricultural activity, domestic requirement and mining & industrial needs.

The water level hydrographs of selected National Hydrograph Network Stations (NHNS) are shown in **Fig. 3.2a** to **3.2i**. An annual rising limb in hydrographs, indicate the natural recharge of groundwater regime due to monsoon rainfall, as the monsoon rainfall is the only source of water. However, the groundwater draft continuously increases as indicated by the recessionary limb. The groundwater resources where not replenished / recharged fully, the groundwater levels come under continuous stress and deplete. It has also been observed that there were few years when the recharge exceeded draft for a particular period or year but in the next successive year, the draft again exceeded recharge.

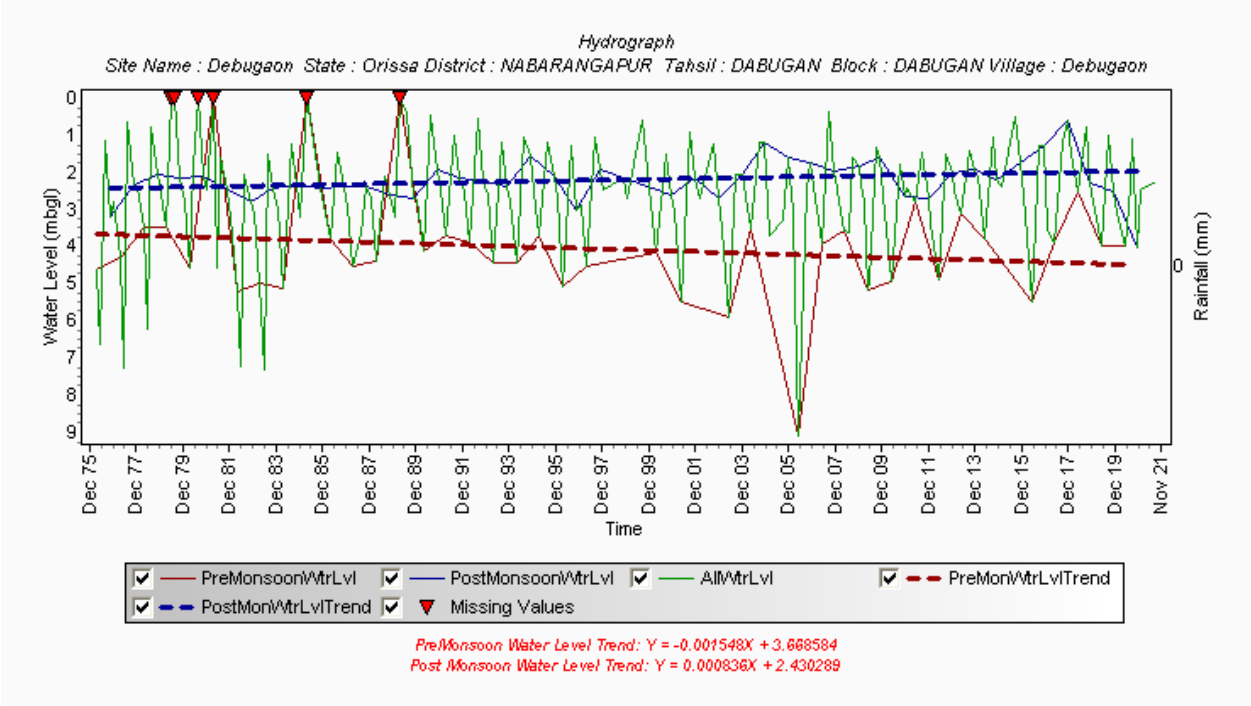

Fig. 3.2a: Hydrograph, Debugaon, Dabugaon Block.

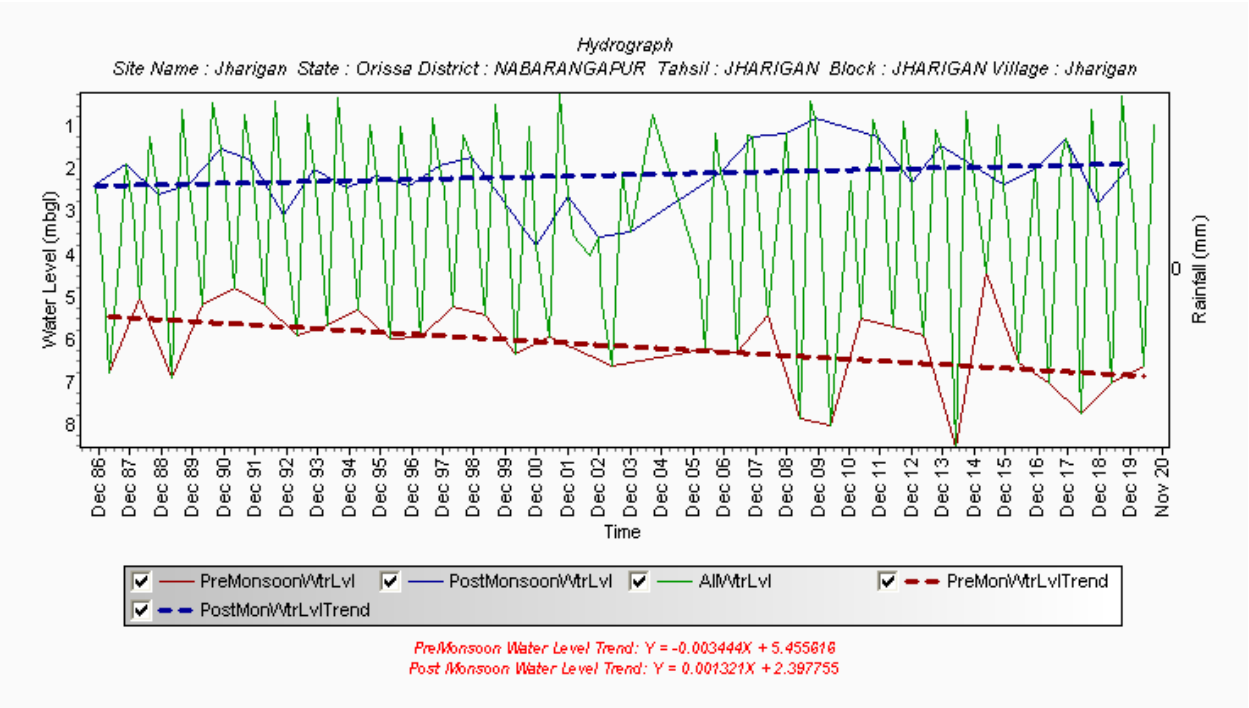

Fig.3.2b: Hydrograph, Jharigaon, Jharigaon Block.

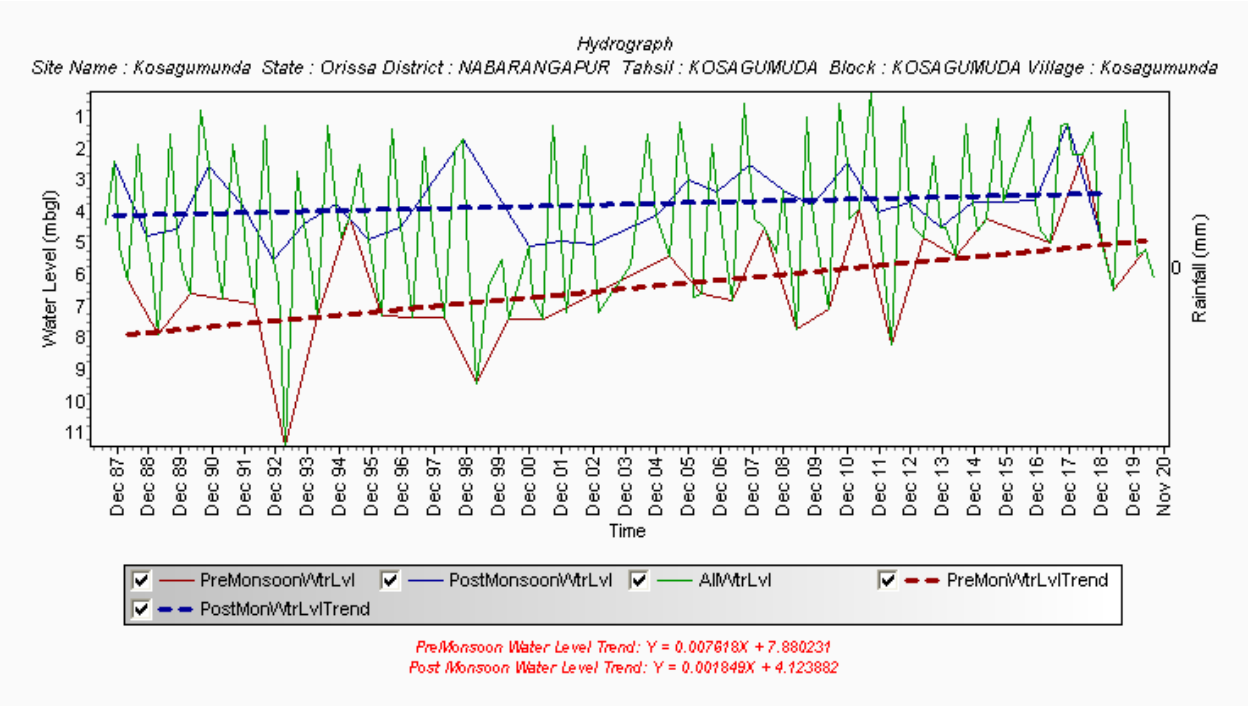

Fig.3.2c: Hydrograph, Kosagumuda, Kosagumuda Block.

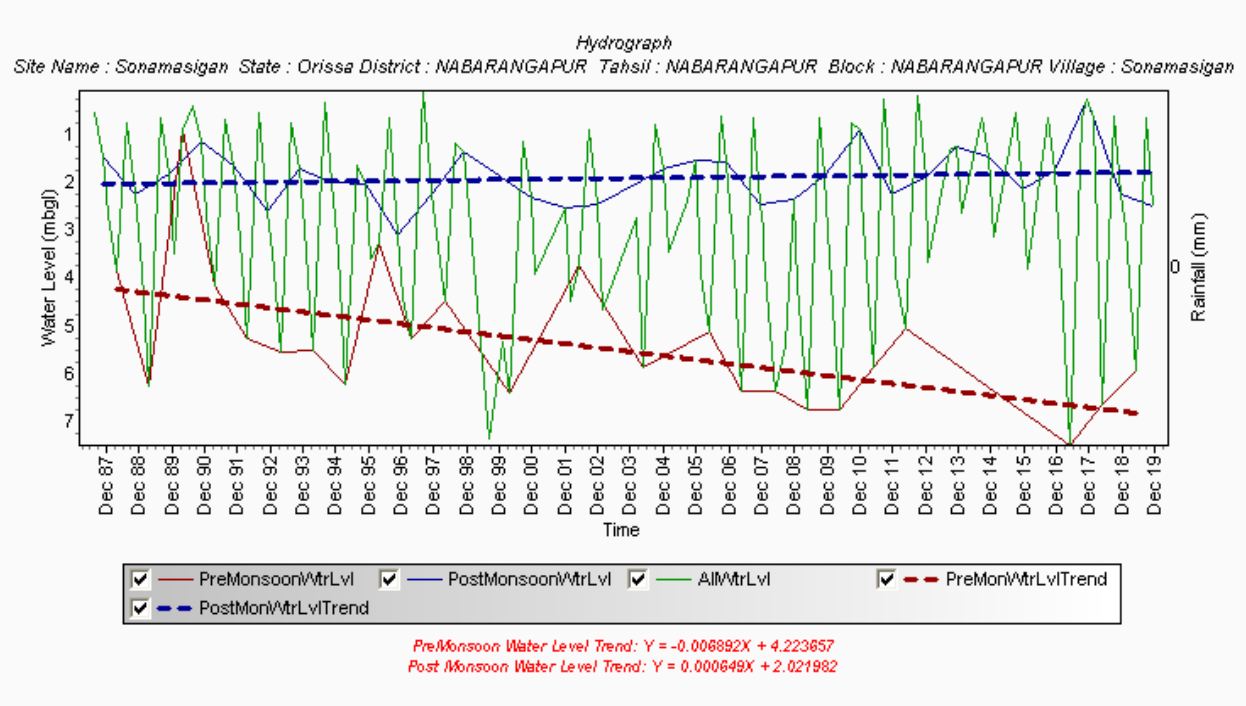

Fig.3.2d: Hydrograph, Sonamasigan, Nabarangpur Block.

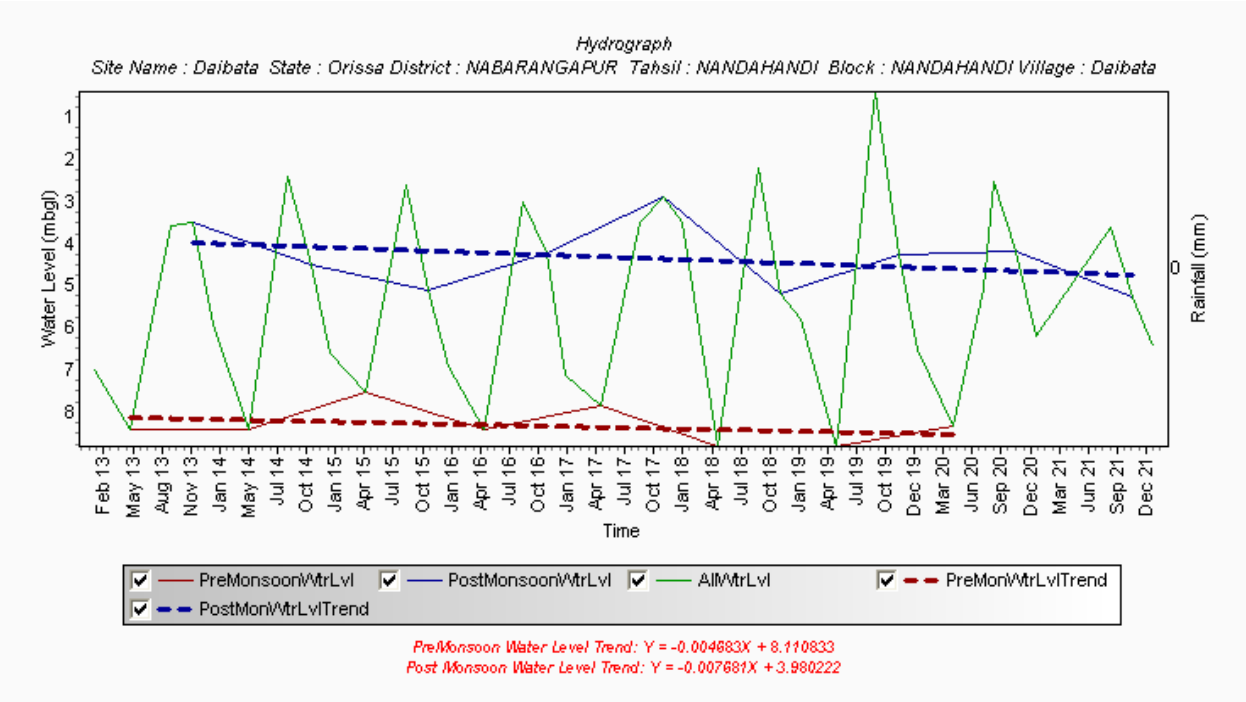

Fig.3.2e: Hydrograph, Daibata, Nandahandi Block.

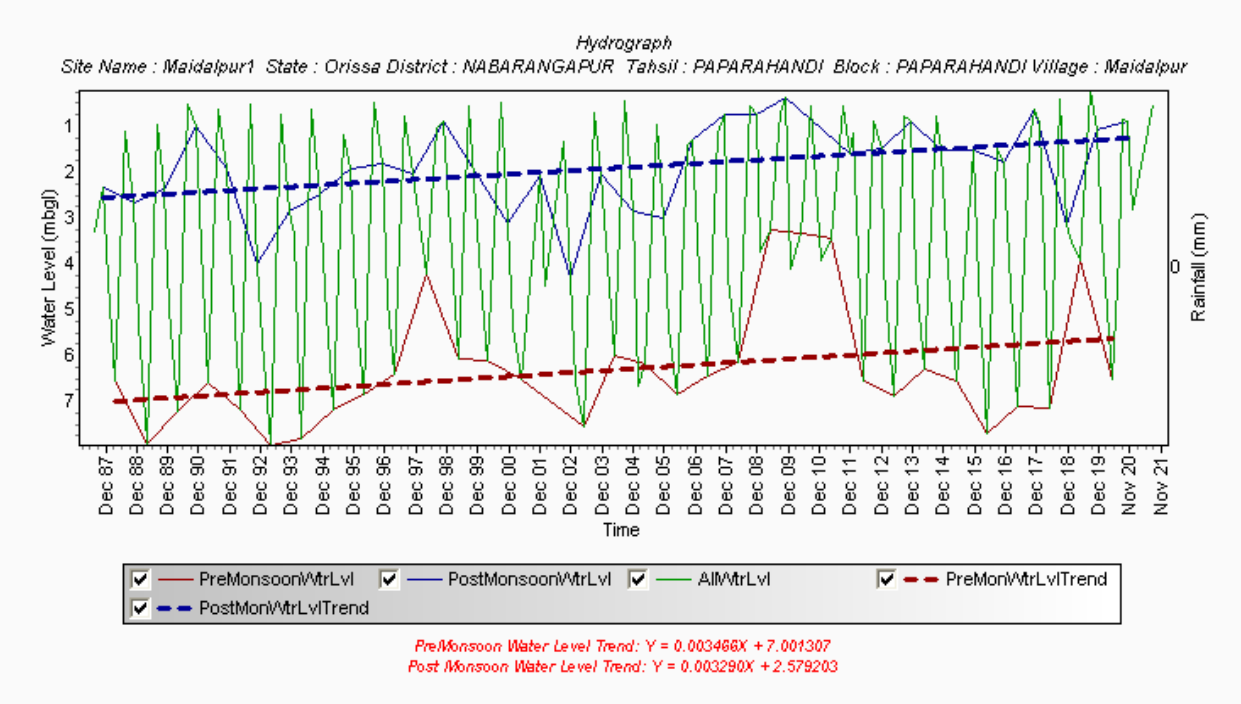

Fig.3.2f: Hydrograph, Maidalpur, Paparahandi Block.

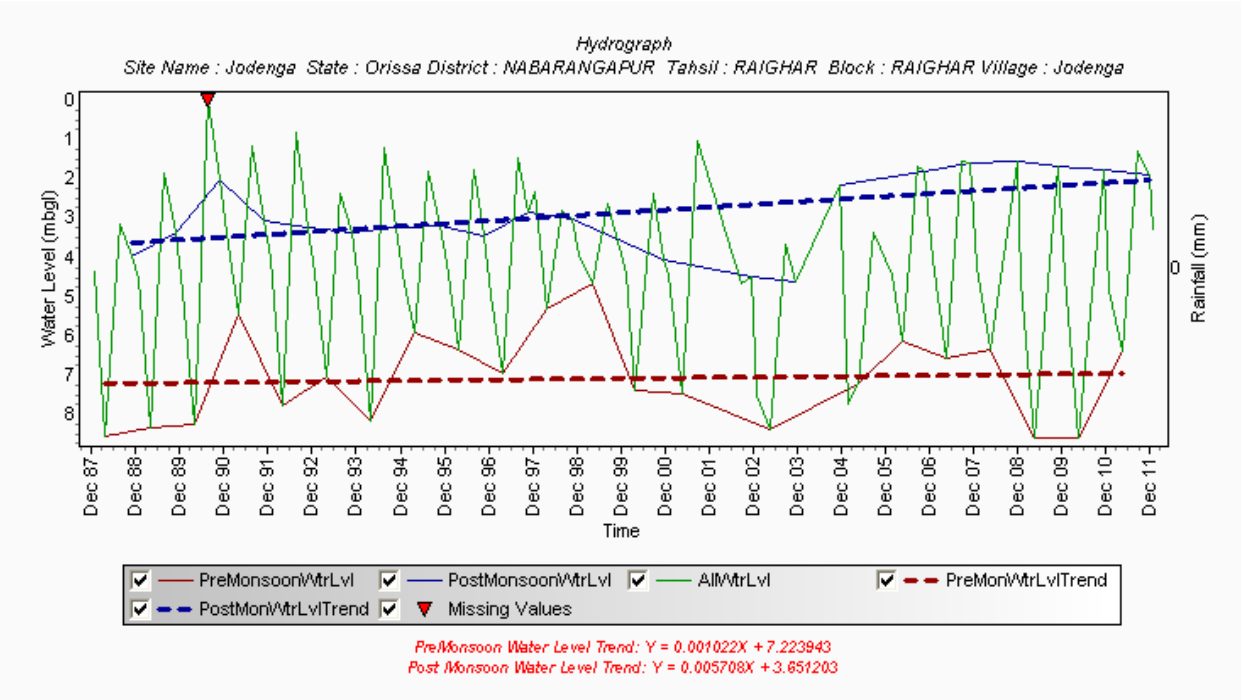

Fig.3.2g: Hydrograph, Jodenga, Raighar Block.

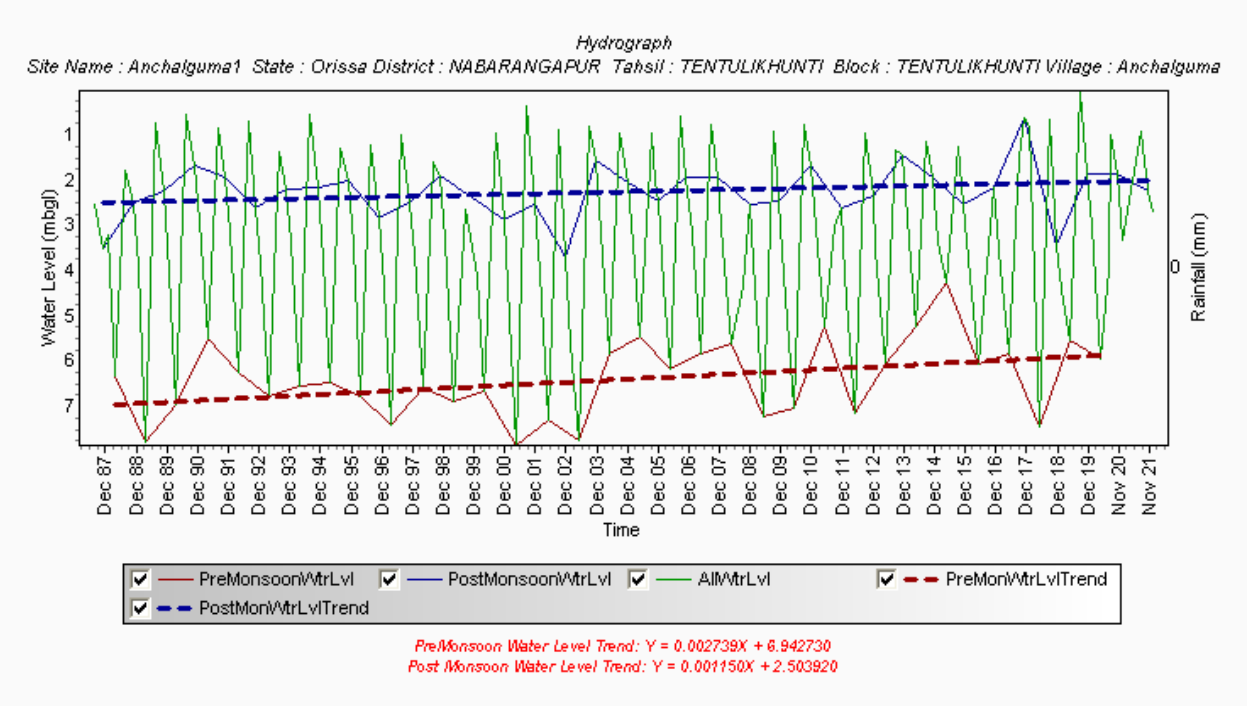

Fig.3.2h: Hydrograph, Anchalguma, Tentulikhunti Block.

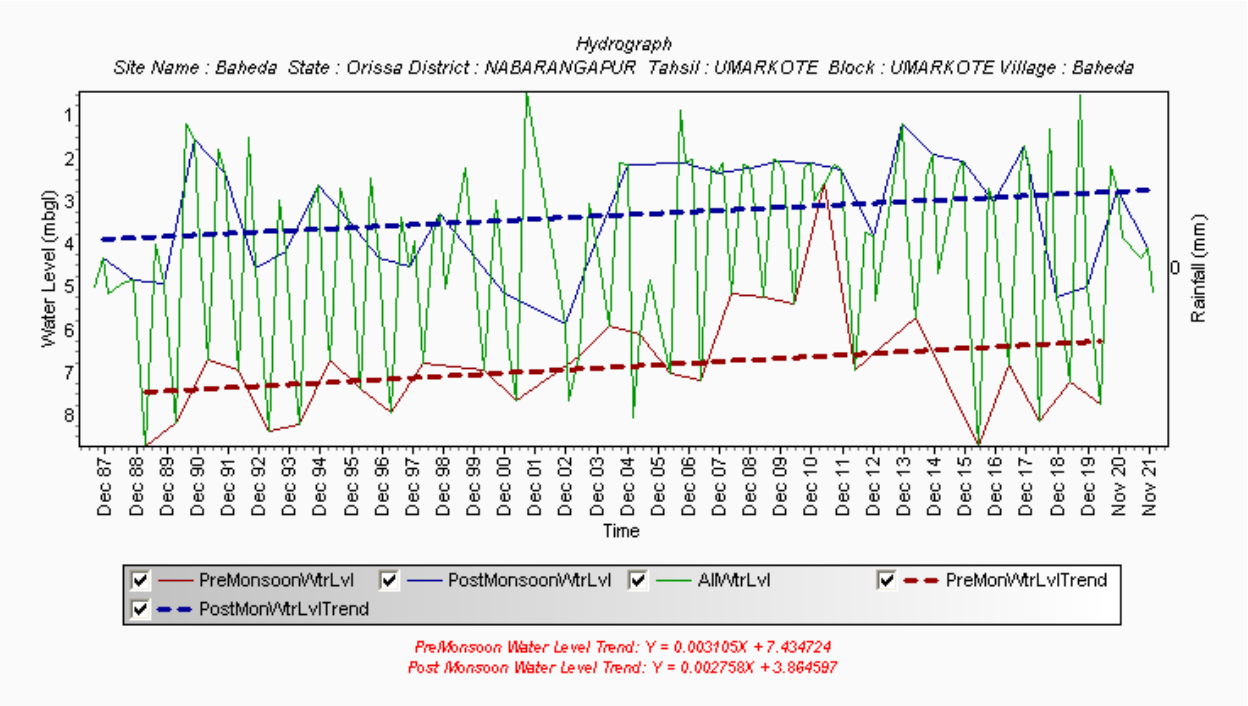

Fig.3.2i: Hydrograph, Baheda, Umerkote Block.

3.2 Deeper Aquifer

Unlike phreatic aquifer, ground water occurs under confined to semi-confined condition in deeper aquifer. The deeper aquifer comprises of the jointed and fractured consolidated or crystalline formations as well as the semi-consolidated formations.

CGWB has constructed 40 EWs (Exploratory Well) and 13 OWs (Observation Wells) in Nabarangpur district through its Ground Water Exploration Programme whose depths range from 87.30 m bgl (Duarsuni) to 200 m bgl (Taragaon, Sanmasingaon etc). The static water level varies from 1.81 m bgl (Dhodra) to 10.7 m bgl (Tentulikhunti). The discharge of successful borewells varies from 0.5 lps to a maximum of 7.5 lps (Dhansuli). The maximum drawdown recorded during PYT/APT varies from 2.20 m (Dhodra) to 40.38 m (Dongarbhaga). The transmissivity (T) of the aquifers ranges from 0.3 m^2/day (Taragaon) to 96.9 m^2/day (Dhodra). The details of the exploratory wells are given in **Table-2.2.** Generally 1 to 4 potential fracture zones are encountered within the depth range of 200 m. The first promising zone occurs in the depth range of 18 to 50 m, which is just below the zone of weathering. The second depth range of prime importance is from 70 to 130 m. Normally, the fracture zones in this depth range of 15.0 to 40.0 m have high water yielding capabilities and majority of successful bore wells in the study area tapped zones within this depth range. The other potential fracture zones are found at the depth ranges of 40-60, 70-110, 115-145 and 160-185 mbgl. Granite suites rocks have better yield prospect in comparison to other rocks like charnockites, khondalites and anorthosites. However the success of bore wells is site specific and depends on topographic and hydrogeological conditions.

3.3 Ground Water Quality

The chemical quality of ground water in the district is monitored annually on a routine basis by CGWB through its national Hydrograph Network Stations. Quality of ground water from deeper aquifers was assessed during the exploration activities like drilling and pumping tests. The suitability of ground water for drinking/irrigation/industrial purposes is determined keeping in view the effects of various chemical constituents present in water.

Taking the results of chemical analysis during NAQUIM work and the available historical chemical data, the aquifer wise ranges of different chemical constituents present in ground water, are determined and shown in **Table 3.2.**

Table 3.2: Aquifer-Wise Ranges of Chemical Constituents in Nabarangpur District.

Parameter	Unit	Shallow (Aquifer-I)		Deep (Aquifer-II)	
		Minimum	Maximum	Minimum	Maximum
pH	-	6.90	8.24	7.22	8.25
EC	µS/cm	42	1300	200	854
TDS	mg/L	84	879	115	306
TH	mg/L	24	403	3	720
TA	mg/L	18.86	342.09	-	-
Ca^{++}	mg/L	9.60	88.20	16	62
Mg^{++}	mg/L	1	108	8.5	85
Na^{+}	mg/L	2	110	1.4	37
K^{+}	mg/L	0.55	129	1	6.2
$CO_3^{=}$	mg/L	0	0	0	0
HCO_3^{-}	mg/L	23.01	417.35	104	262
NO_3^{-}	mg/L	1.48	80	0.15	17
Cl^{-}	mg/L	2.46	151	5.3	28
$SO_4^{=}$	mg/L	0	180	0.3	14
F^{-}	mg/L	0.04	1.26	0.21	0.77
Fe	mg/L	-	-	0.02	30
U	mg/L	0.002	0.024	-	-

Based on the chemical analysis of water samples from different sources, it was observed that, almost all chemical parameters lie within permissible limit for drinking and irrigation purpose except few samples of some isolated pockets. The quality of ground water is generally good with EC ranging from 42 to 1300 µs/cm in shallow and 200 to 854 µs/cm in deeper aquifers. The EC map is given in **Figure 3.3.**

The fluoride concentration is within permissible limit in all location except except few samples of some isolated pockets. The Fluoride concentration map is given in **Figure 3.4**. The chloride map is given in **Figure 3.5.**

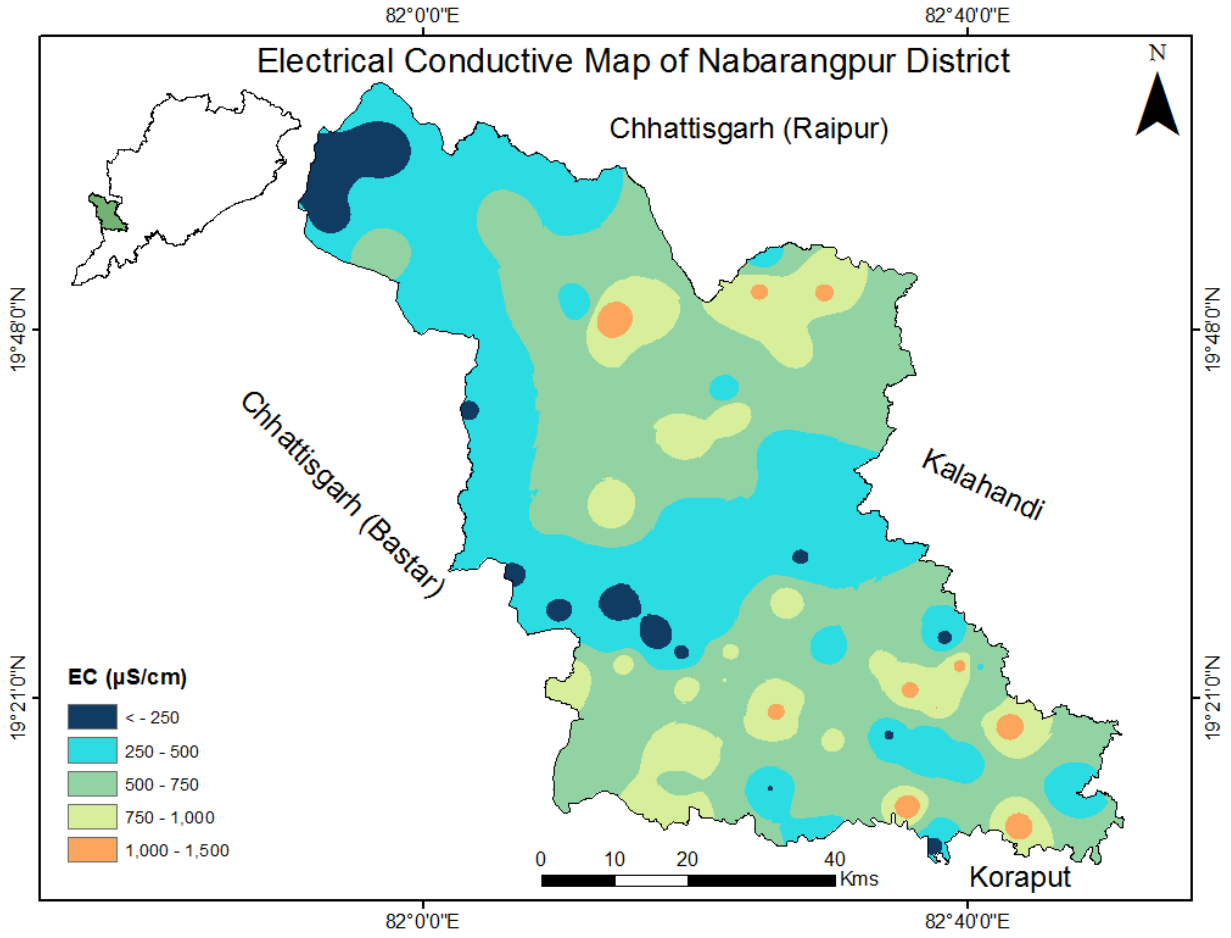

Fig. 3.3: Electrical Conductivity Map, Phreatic Aquifer in Nabarangpur District.

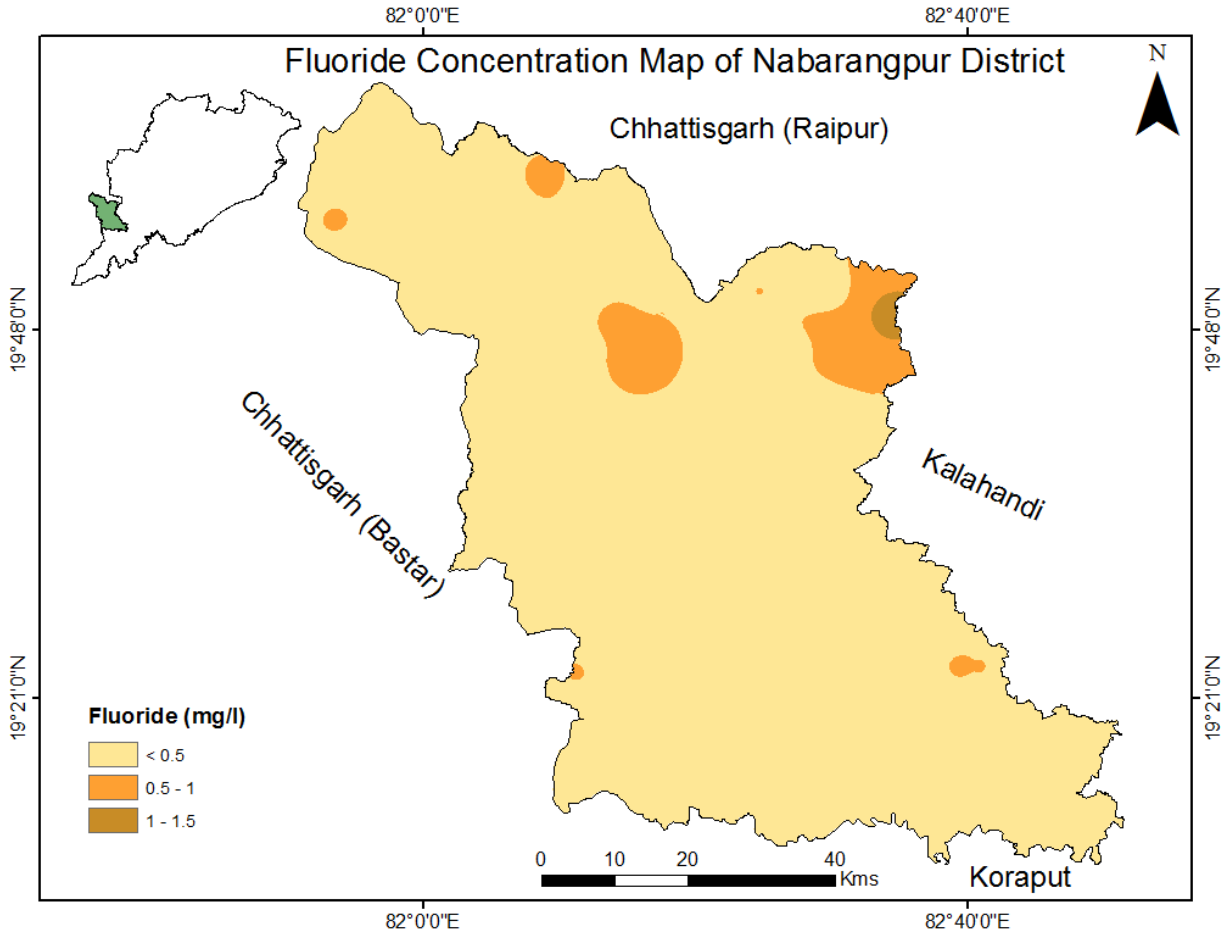

Figure 3.4: Fluoride Concentration Map, Phreatic Aquifer in Nabarangpur District.

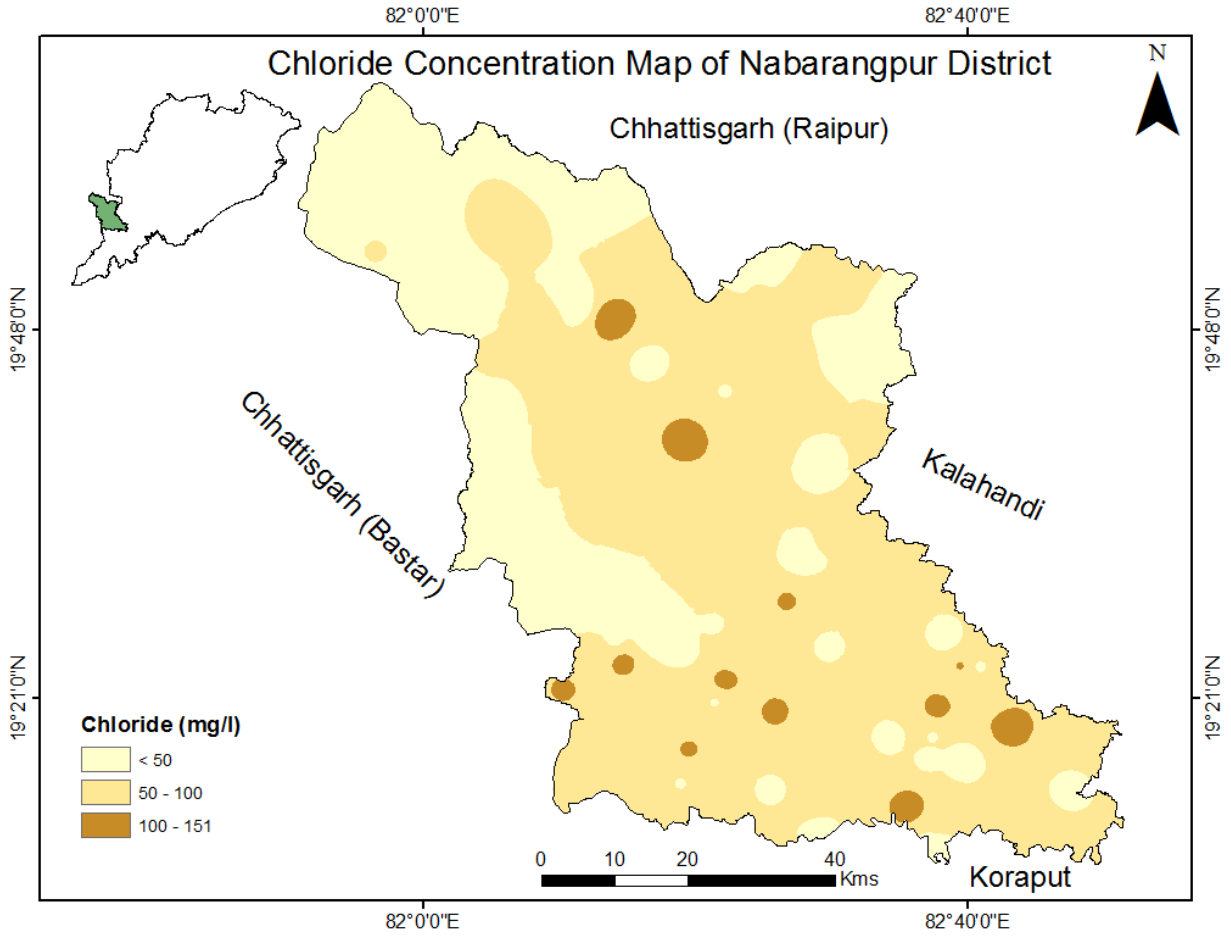

Figure 3.5: Chloride ConcentrationMap, Phreatic Aquifer in Nabarangpur District.

3.4 Aquifer Groups and Their Demarcation

Based on extensive analysis of historical data, micro-level hydrogeological survey data generated and ground water exploration carried out in the area, the following two types of aquifers can be demarcated and the details are given below:

Aquifer- I (Unconfined Aquifer): Unconfinedaquifer occurs in entire area except the rocky outcrops, formed by the weathered mantle atop all crystalline as well as laterite formations and discontinuous alluvial tracts along major river channels. This aquifer generally occurs down to maximum depth of 50mbgl.

Aquifer-II (Semi-Confined to Confined Aquifer): Semi-confined to confined aquifer occurs as fracture zone aquifers in the entire area irrespective of rock types. However the aquifer properties, the yield of bore wells constructed in them depends on the rock type.

As per the ground water exploration, carried out by CGWB, fractured granitic rocks have better yield in comparison to charnockites and khondalites. In general, most of the fracture zones are encountered within 0 to 150 mbgl and seldom beyond that. Thus that maximum depth for the Aquifer-II has been taken as 200 mbgl.

3.5 Aquifer Disposition

The ground water exploration data has been used to generate the 2D disposition of deeper alluvial aquifers. It comprises of all existing litho-units and the zones tapped during the ground water exploration, forming an aquifer. Based on the ground water exploration and micro-level hydrogeological survey data and aquifer delineation method, three 2D schematic sections were drawn along lines A-B and C-D which are shown in plan view in **Fig.3.6** and the 2D sections are shown in **Figure 3.7 and Figure 3.8.**

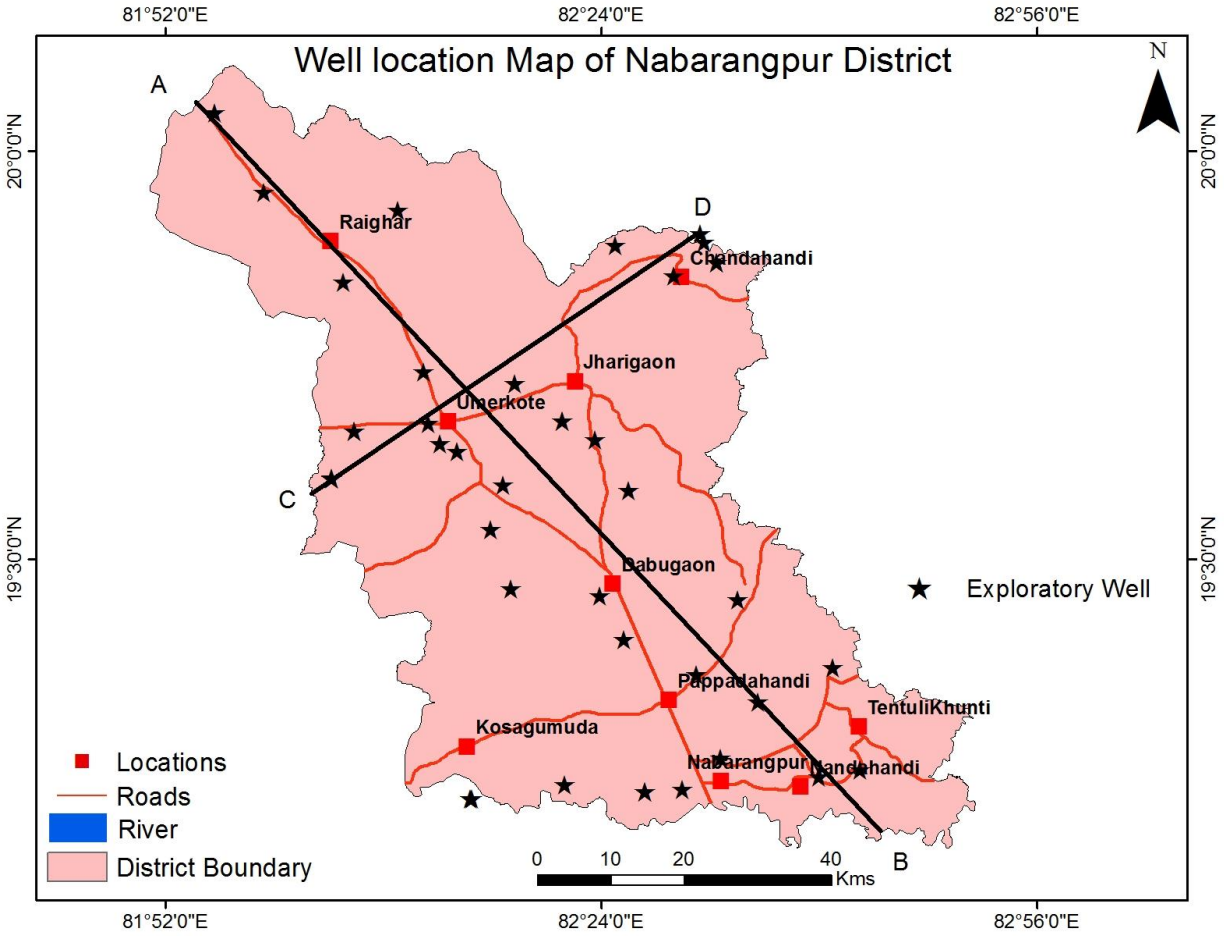

Fig. 3.6: Aquifer 2D Section Lines along A-B and C-D

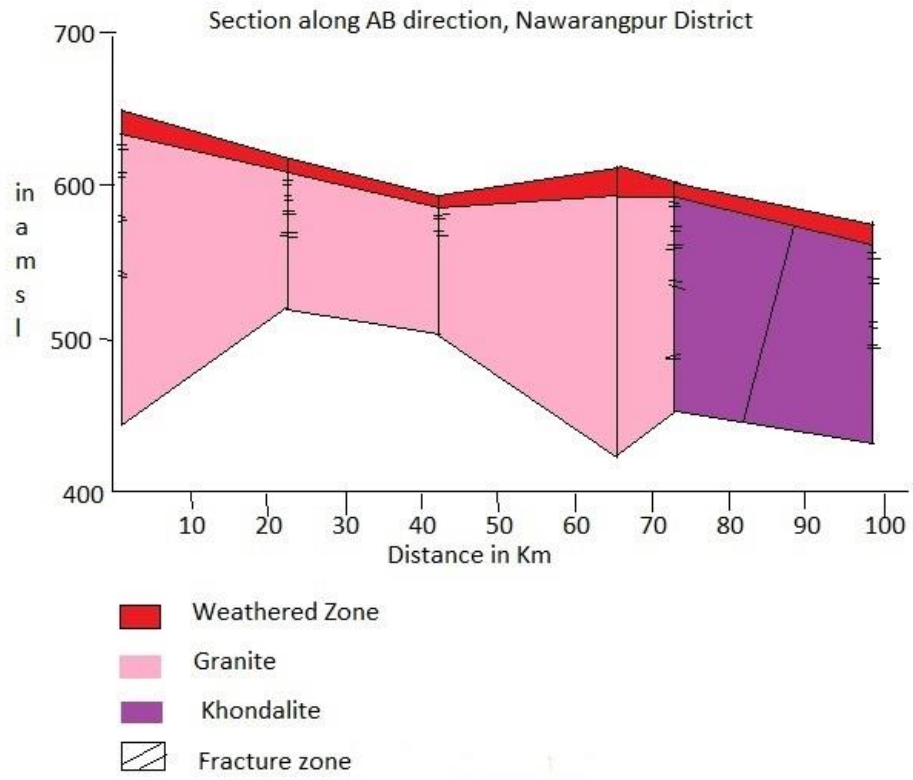

Fig. 3.7: Schematic Aquifer Cross-Section along A-B in Nabarangpur District

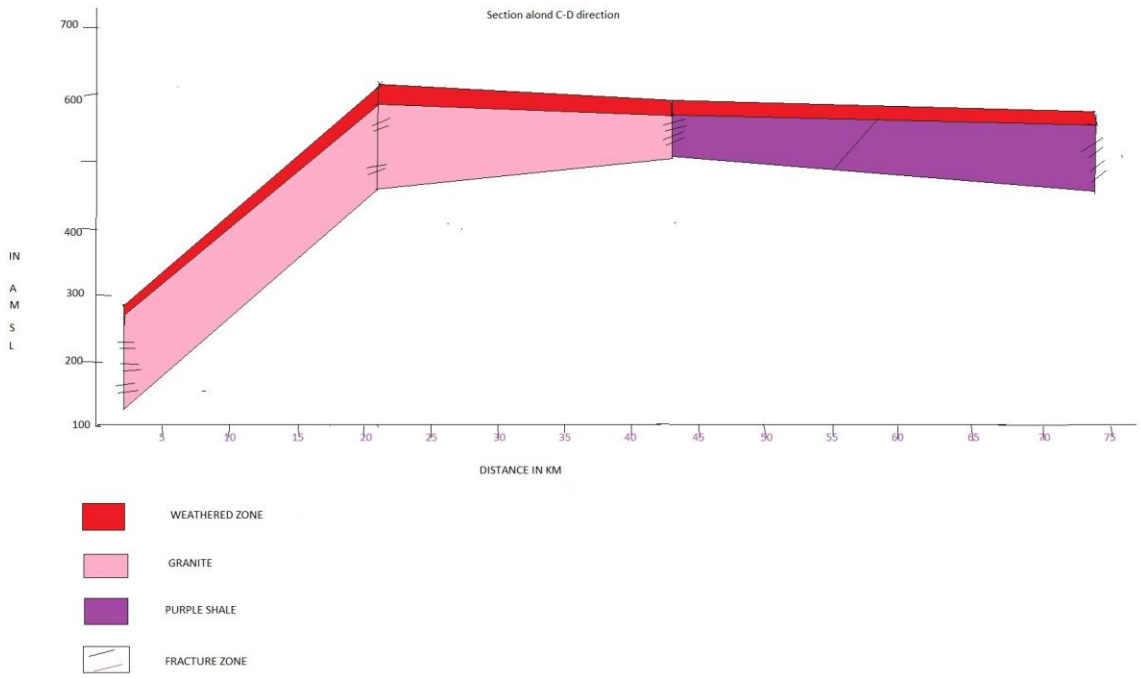

Fig. 3.8: Schematic Aquifer Cross-Section along C-D in Nabarangpur District.

3.6 Geophysical Studies

74 VES were conducted in the Nabarangpur District, to study about the Ground water availability in this area during Annual Action Plan 2021 – 2022 using Signal Stacking Resistivity Meter CRM 20 (Aquameter) of Anvic Systems, Pune. VES location map is given in Figure 3.9 and results are given in Table 3.3.

Table 3.3: The geo-electric parameters in the surveyed area of Nabarangpur district

No. of layer	Resistivity Range in Ωm	Lithology	Thickness(meter)
I	2 to 470	Top soil	0.3 to 4
II	9 to 60	Weathered formation	1 to 27
III	14 to 600	Less Compact	2.5 to 131
IV	>600	Bed Rock	Infinite

Based on VES, two 2D schematic sections were drawn along section lines A-A' and B-B' are shown in plain view in Figure 3.10 and 2Dcross section along A-A', 2Dcross section along B-B', 3D cross section and fence diagram have been prepared and shown in Figure 3.11, 3.12, 3.13 and 3.14 respectively.

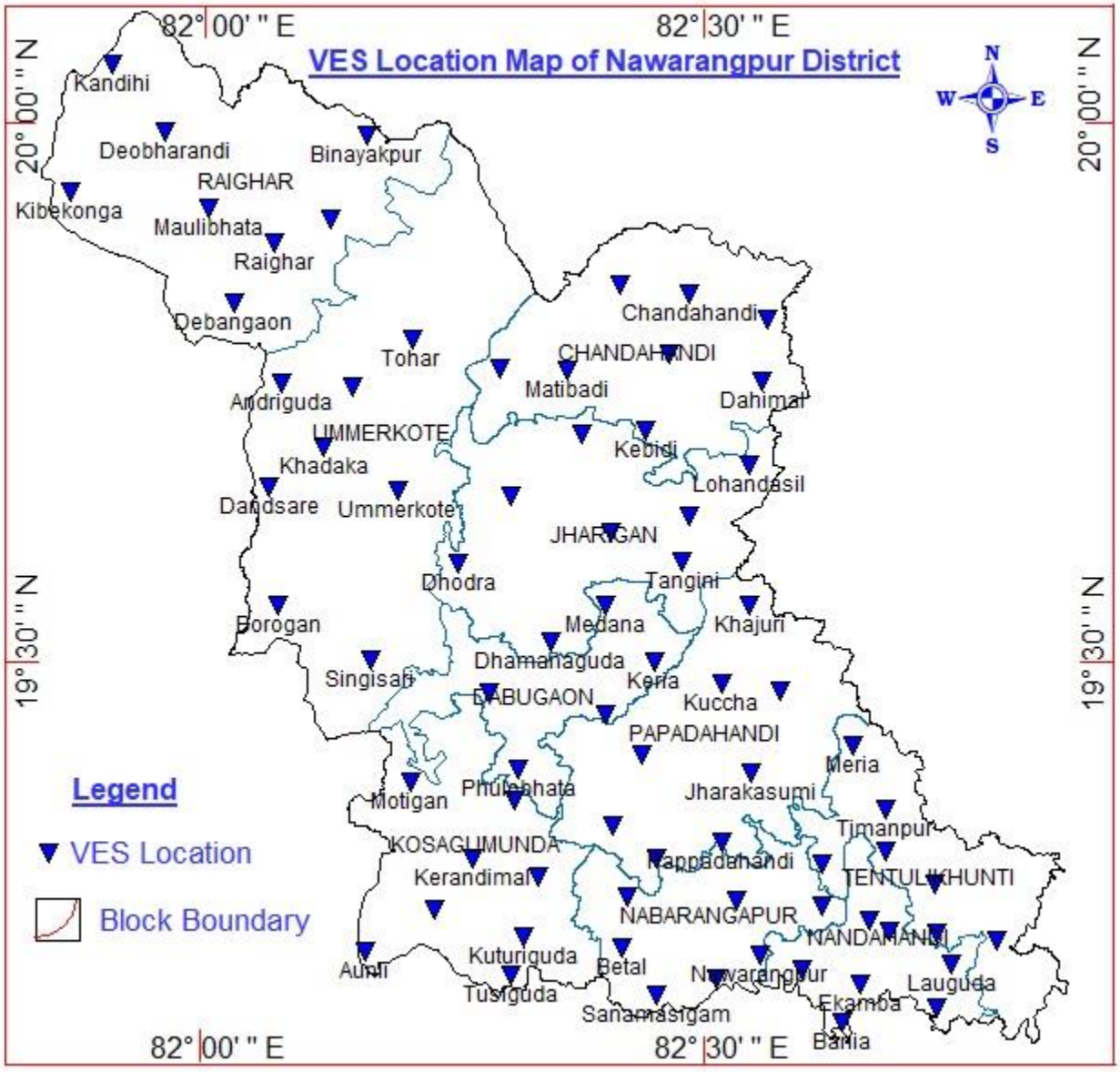

Figure 3.9: VES location Map

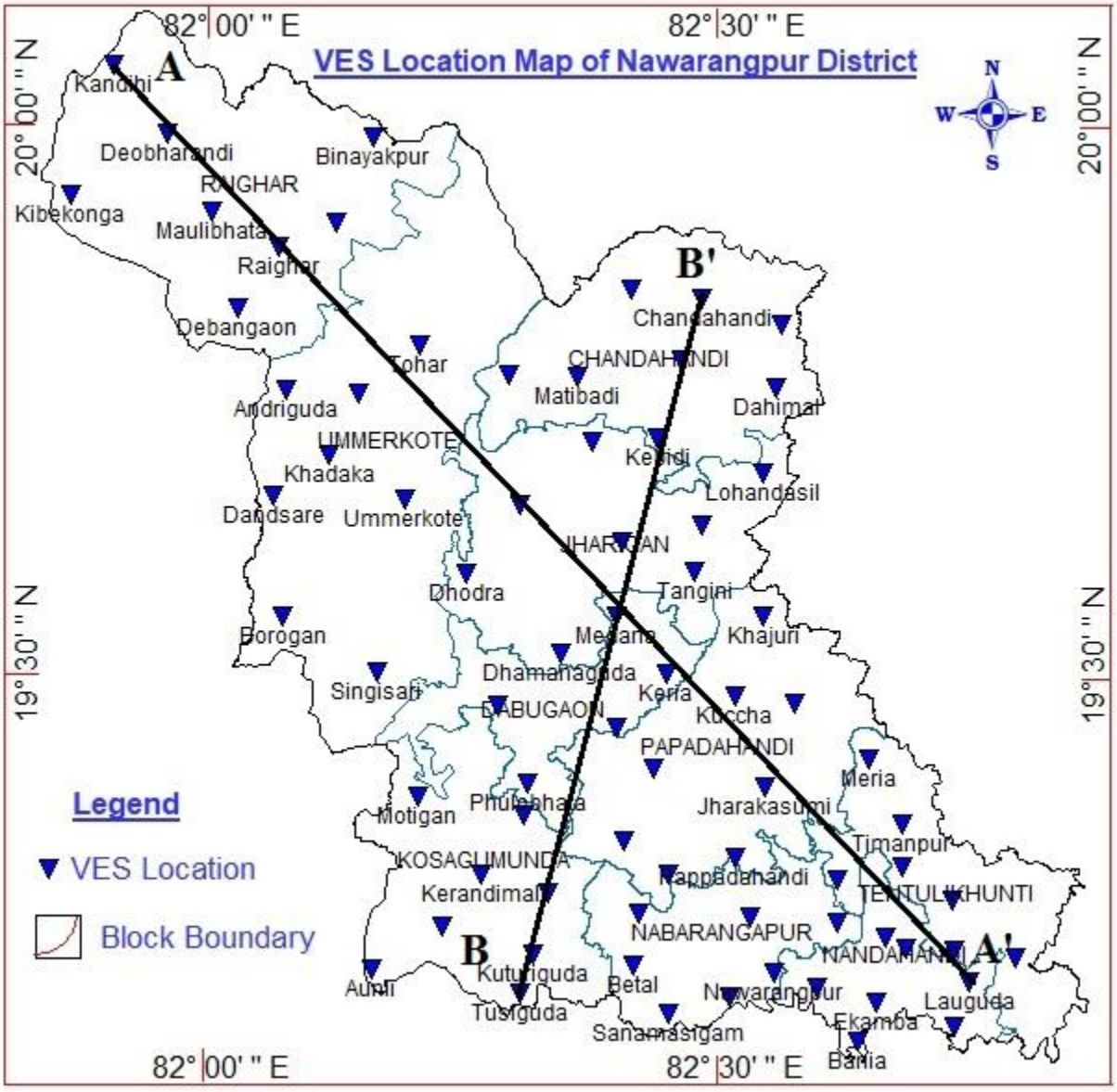

Figure 3.10: Aquifer 2D Section Lines Along A-A’ and B-B’ in Plain View

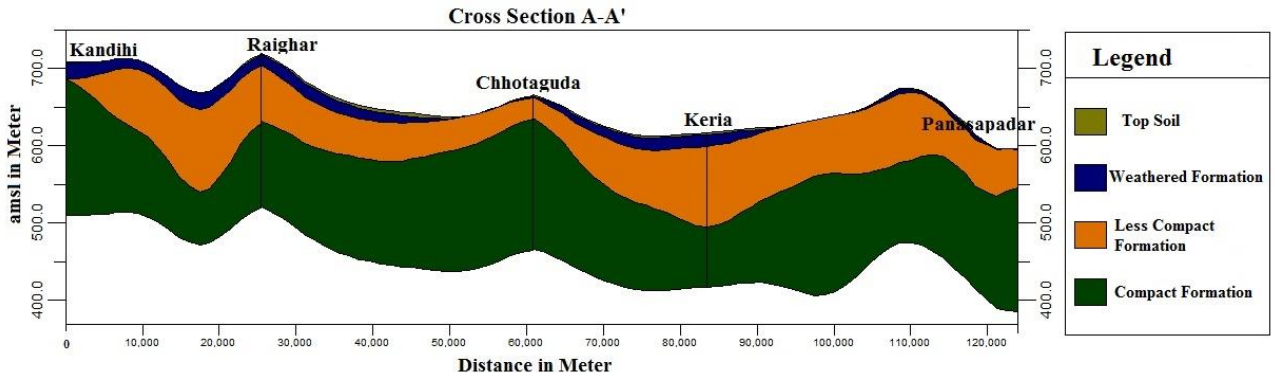

Figure 3.11: Schematic Aquifer Cross-Section along A-A' in Nawarangpur District.

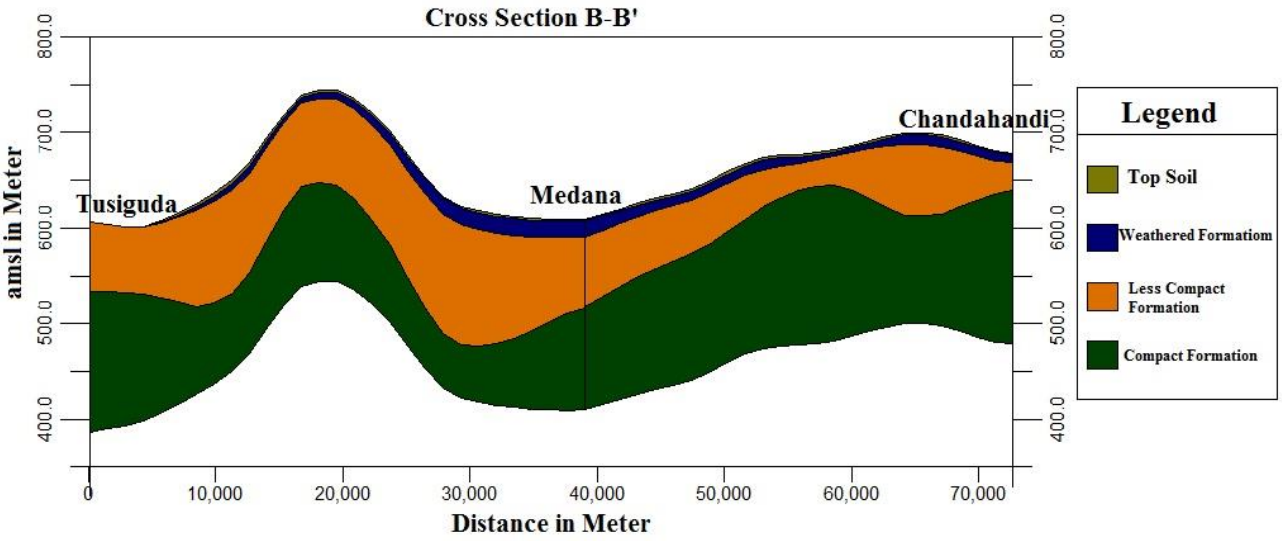

Figure 3.12: Schematic Aquifer Cross-Section along B-B' in Nawarangpur District.

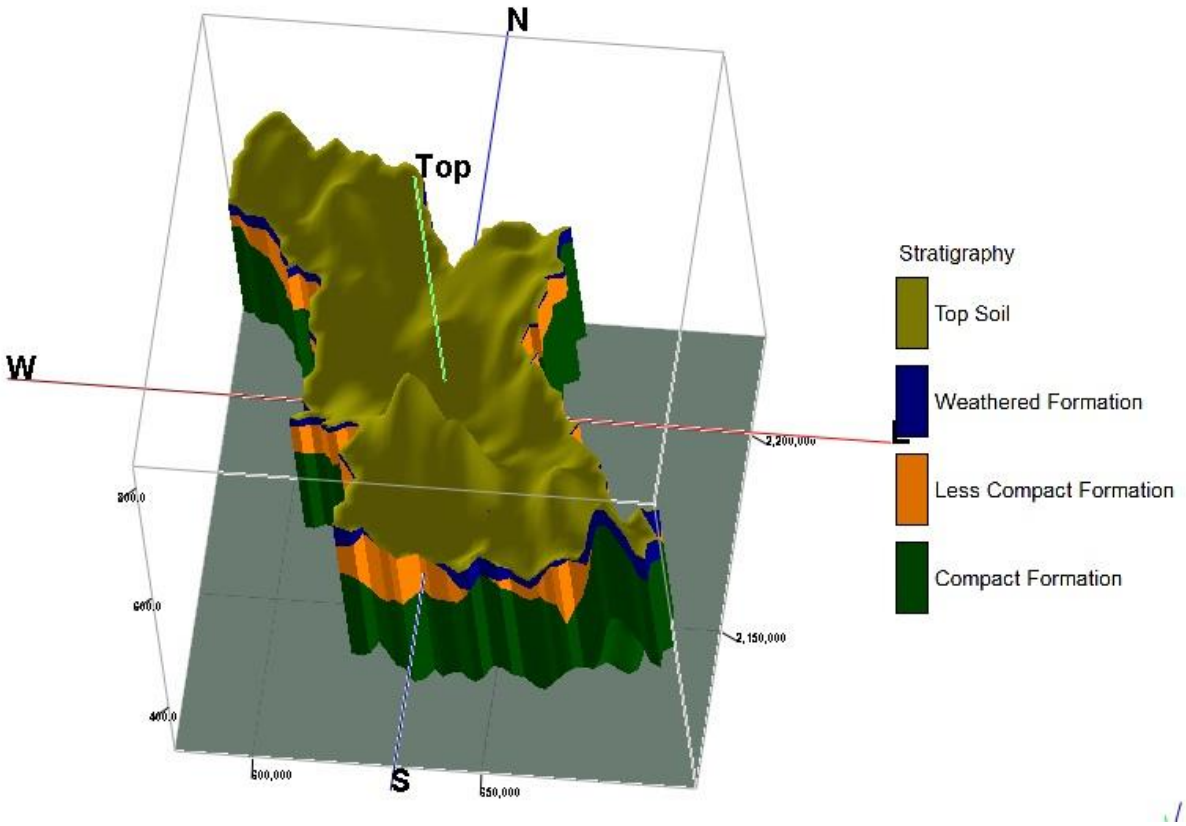

Figure 3.13: 3D Aquifer Cross-Section

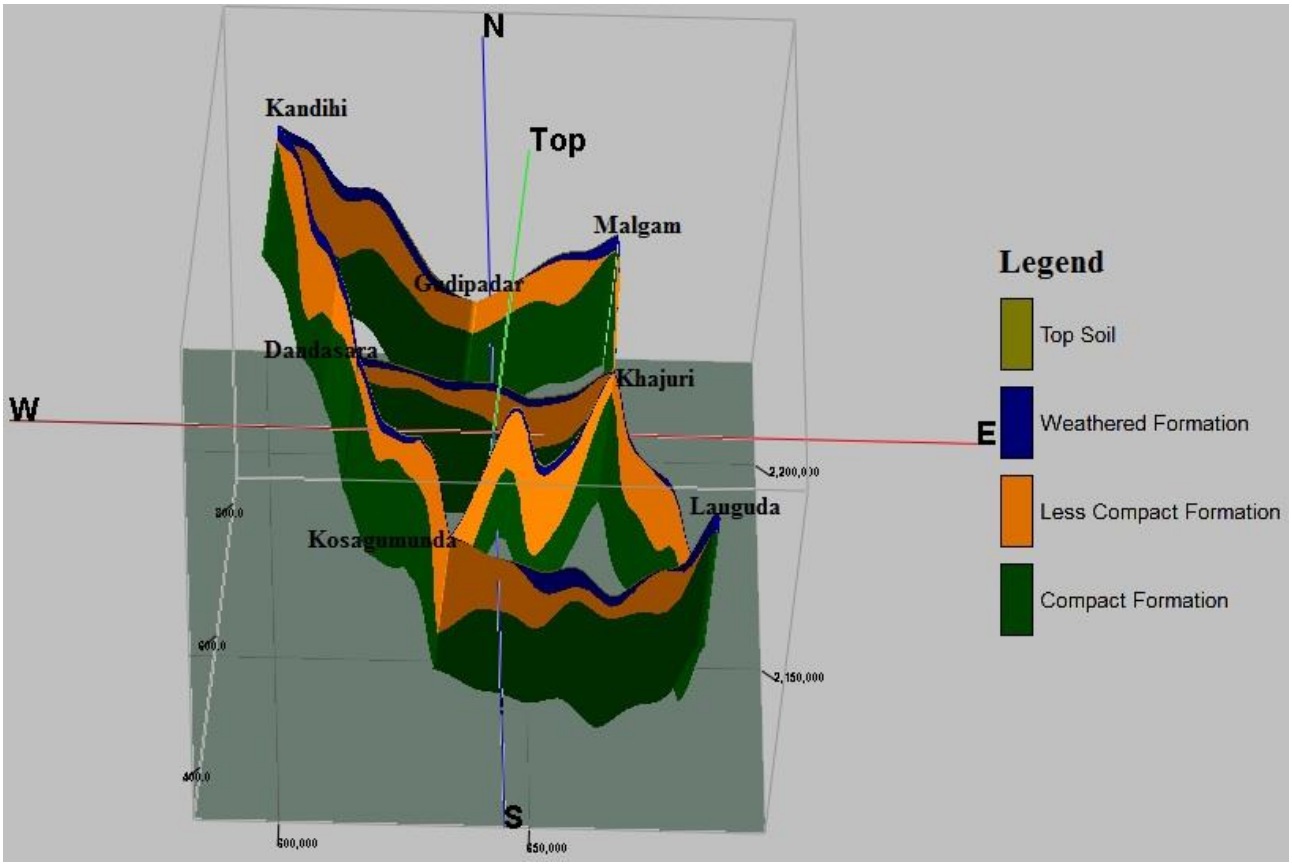

Figure 3.14: Fence Diagram

4 GROUND WATER RESOURCES

The dynamic ground water resource of the district was jointly carried out in 2020 by Central Ground Water Board (CGWB) and Ground Water Survey and Investigation (GWS&I) adopting the methodology recommended by GEC 2015. The ground water resource can be aquifer wise divided into Dynamic and Static resource. The dynamic resource is the part of resource within the water level fluctuation zone which is also the annual replenishable resource. The resource below the water level fluctuation zone is termed as the In-storage (Static) resource. Mainly the water level fluctuation method was adopted for calculation of recharge.The block-wise resource of the aquifer mapping blocks as on 2020 is given below in **Table 4.1.**

Table-4.1: Dynamic Ground Water Resources of Aquifer-I in Nabarangpur District. (2020)

Sl No	Block	Net Annual Ground Water Availability	Existing Gross Ground Water Draft for Irrigation	Existing Gross Ground Water Draft for domestic & Industrial Supply	Existing Gross Ground Water Draft for all uses	Annual ground water allocation for domestic water supply as on 2025	Net Ground Water Availability for future irrigation development	Stage of Ground Water Extraction
		(Ham)	(Ham)	(Ham)	(Ham)	(Ham)	(Ham)	(%)
1	Chandahandi	4452.58	873.88	235.6042	1109.49	254.21	3313.68	24.917912
2	Dabugaon	2335.38	464.89	217.5017	682.39	234.19	1625.25	29.219655
3	Jharigaon	5179.38	969.07	463.0424	1432.11	516.33	3687.35	27.650220
4	Kosagumuda	10904.15	3018.42	495.7666	3514.18	540	7332.48	32.227913
5	Nabarangpur	3803.38	1068.23	164.7129	1232.95	163.71	2562.59	32.417218
6	Nandahandi	2720.88	1112.76	379.1472	1491.91	403.38	1176.84	54.831892
7	Papadahandi	5759.02	850.33	422.1473	1272.47	425.99	4460.61	22.095252
8	Raighar	8096.24	4177.47	533.2156	4710.68	564.85	3349.51	58.183551
9	Tentulikhunti	3171.87	816.1	274.5668	1090.67	276.91	2061.18	34.385709
10	Umerkote	10421.89	1873.58	707.9288	2581.51	762.29	7753.47	24.770075
	Total	**56844.77**	**15224.73**	**3893.634**	**19118.36**	**4141.86**	**37322.96**	**33.63**

The combined net ground water available is 56844.77 Ham and gross annual draft is 19118.36 Ham. The stage of ground water extraction is minimum in Papadahandi block which is 22.09%. The highest ground water extraction is in Raighar block that is 58.18 % and all the blocks are in Safe category.

The in-storage resources are calculated for Aquifer-I and II separately. However the semi-confined to confined deeper aquifers have been connected to the unconfined aquifer through the fractures and receive continuous recharge. The In-storage ground water resources of Aquifer-I are given in **Table 4.2** and the total resources of Aquifer-I in **Table 4.3** below.

Table-4.2: In-Storage Ground Water Resources of Aquifer-I in Nabarangpur District.

Sl No	Block	Assessment Area	Bottom Depth of Aquifer	Average Pre-monsoon Water Level	Total Effective Saturated Thickness (2-3)	Average Specific Yield	In Storage Ground Water Resources [(1)*(4)*(5)]
		(Ha) (1)	(mbgl) (2)	(mbgl) (3)	(m) (4)	(5)	(Ham) (6)
1	Chandahandi	57699	50	7.23	42.77	0.03	74033.59
2	Dabugaon	30354	50	3.98	46.02	0.03	41906.73
3	Jharigaon	60116	50	6.28	43.72	0.02	52565.43
4	Kosagumuda	84347	50	7.01	42.99	0.02	72521.55
5	Nabarangpur	21285	50	5.16	44.84	0.02	19088.39
6	Nandahandi	31887	50	6.24	43.76	0.02	27907.50
7	Papadahandi	60425	50	6.25	43.75	0.02	52871.88
8	Raighar	81681	50	5.26	44.74	0.02	73088.16
9	Tentulikhunti	35533	50	5.13	44.87	0.02	31887.31
10	Umerkote	102254	50	5.42	44.58	0.02	91169.67
	Total	**565581**					**537040.21**

Table-4.3: Total Ground Water Resources of Aquifer-I in Nabarangpur District.

Sl No	Block	Dynamic Resource	In Storage Resource	Total
1	Chandahan	4452.58	74033.59	124031.1
2	Dabugaon	2335.38	41906.73	53020.68
3	Jharigaon	5179.38	52565.43	62998.11
4	Kosagumud	10904.15	72521.55	51215.75
5	Nabarangpu	3803.38	19088.39	68625.02
6	Nandahandi	2720.88	27907.50	17790.57
7	Papadahan	5759.02	52871.88	21444.27
8	Raighar	8096.24	73088.16	48699.89
9	Tentulikhunt	3171.87	31887.31	46769.89
10	Umerkote	10421.89	91169.67	94231.49
	Total	**56844.77**	**537040.21**	**593884.98**

The in-storage ground water resource in Aquifer- II i.e. the semi-confined to confined aquifer is shown in **Table 4.4**.

Table-4.4: In-Storage Ground Water Resources of Aquifer-II in Nabarangpur District.

Sl No	Block	Assessment Area (Ha)	Top Depth of Aquifer (mbgl)	Bottom Depth of Aquifer (mbgl)	Total Satu- rated Thickness (m)	Productive Zone (5% of Total Thickness) (m)	Avg. Sp. Yield	In Storage Ground Water Resources (Ham)
		(1)	(2)	(3)	(4)=(3-2)	(5)	(6)	(7)=(1*5*6)
1	Chandahandi	57699	50	200	150	7.5	0.03	12982.28
2	Dabugaon	30354	50	200	150	7.5	0.03	6829.65
3	Jharigaon	60116	50	200	150	7.5	0.02	9017.40
4	Kosagumuda	84347	50	200	150	7.5	0.02	12652.05
5	Nabarangpur	21285	50	200	150	7.5	0.02	3192.75
6	Nandahandi	31887	50	200	150	7.5	0.02	4783.05
7	Papadahandi	60425	50	200	150	7.5	0.02	9063.75
8	Raighar	81681	50	200	150	7.5	0.02	12252.15
9	Tentulikhunti	35533	50	200	150	7.5	0.02	5329.95
10	Umerkote	102254	50	200	150	7.5	0.02	15338.10
	Total	**565581**						**91441.13**

5 AQUIFER MANAGEMENT PLAN

The highly diversified occurrence and considerable variations in the availability and utilization of groundwater makes its management a challenging task. Scientific development and management strategy for groundwater has become imperative to avert the looming water crisis. In this context, various issues such as, prioritization of areas for development of groundwater resources vis-a-vis its availability, augmentation of groundwater through rainwater harvesting and artificial recharge, pricing and sectoral allocation of resources and participation of the stakeholders must be considered.

5.1 Ground Water Related Issues

5.1.1 Under Utilisation of Ground Water Resources

As per the ground water resource estimated jointly by CGWB and State Govt. in 2020, the Net Ground Water Availability of Chandahandi, Dabugaon, Jharigaon, Kosagumuda, Nabarangpur, Nandahandi, Papadahandi, Raighar, Tentulikhunti and Umerkote4452.58, 2335.38, 5179.38, 10904.15, 3803.38, 2720.88, 5759.02, 8096.24, 3171.87 and 10421.89 ham respectively. The stages of ground water development are 24.91, 29.21, 27.65, 32.22, 32.41, 54.83, 22.09, 58.18, 34.38 and 24.77%respectively. Thus there exists sufficient scope for further ground water development in these blocks.

5.1.2 Less Productive Deeper Aquifer

The exploratory drilling in the district reveals that the deep fractured aquifer is less productive. Many of the borewells drilled in the district have very poor discharge. The failure rate of borewells is very high in the Easternghat Group of rocks like the anothosites, charnockites and khondalites. Granitic formations have comparatively better yield prospect for laying bore wells.

5.1.3 Depleted Water Level in Phreatic Aquifer

Ground water level in the phreatic aquifer is found to be deep in many parts of Nabarangpur district. Depth to water level during pre-monsoon periods is deeper (4-8mbgl) in most of Umerkote, Chandahandi, Kosagumuda, Nandahandi and Dabugaon.

5.2 Aquifer Management Plan

5.2.1 Demand vs Supply Scenario of Ground Water

The water demand and supply scenario of the district is shown in **Table 5.1.**

Table-5.1: Water Demand and Supply Scenario in Nabarangpur District.

Block	Existing Water Demand for 2011 (MCM)					Water Demand for 2025 (MCM)	Existing Water Availability(MCM)			Demand-Supply Gap (MCM)		Further Ground Water Development Potential (MCM)
	Domestic	Livestock	Irrigation	Industrial	Total	Total	Surface Water	Ground Water	Total	2011	2025	
Chandahandi	1.6	0.8	74.8	0.2	77.5	211.1	54.69	6.2	60.8	16.63	150.2	15.62
Dabugaon	1.5	0.7	21.5	0.2	23.9	71.7	19.24	1.18	20.4	3.51	51.27	7.18
Jharigaon	3.3	1.7	48.3	0.5	53.7	154.1	32.86	6.11	38.9	14.75	115.0	16.75
Kosagumuda	3.5	1.5	114	0.5	119.	341.8	55.97	15.31	71.2	48.27	270.4	30.28
Nabarangpur	1.8	0.7	90.7	0.3	93.4	256.2	41.91	6.48	48.3	44.98	207.7	10.49
Nandahandi	1.4	0.5	86.5	0.2	88.6	239.7	39.43	6.32	45.7	42.87	193.9	1.40
Papadahandi	3	1.3	44.8	0.5	49.5	149.1	34.12	3.43	37.5	11.99	111.6	21.82
Raighar	4	2	49.6	0.6	56.3	176.5	23.40	23.51	46.9	9.34	129.5	1.47
Tentulikhunti	1.9	0.8	34	0.3	37	109.6	22.26	5.15	27.4	9.55	82.23	8.12
Umerkote	3.7	2.3	86	0.5	92.4	259.3	79.14	15.58	94.7	-2.29	164.5	36.71
Total	**25.7**	**12.3**	**650.2**	**3.8**	**691.8**	**1969.1**	**403.02**	**89.27**	**492.29**	**199.6**	**1476.7**	**149.88**

Source: District Irrigation Plan of Nabarangpur, DLIC Nabarangpur, March 2016

The water demand domestic and livestock use is 38 MCM, calculatedfor the year 2011, which is about 4% of the total water demand. At present, crop water demand is highest i.e. 94% of total water demand, followed by domestic demand (4%).During 2025, the crop water demand will increase to nearly 96 % of total water demand.Further ground water potential is calculated and taken from **Table 5.2**. Thus, about 10% of the irrigation water gap can be filled up by further utilizing the available ground water resource.

Proposed Demand Side Interventions: There is very little scope for the demand side interventions as the district experiences acute shortage of water during the lean seasons. But for the sustainability of the present scenario and for enhancing the agriculture production, the following demand side interventions can be suggested:

1. Optimization of irrigation water requirement by use of water efficient farm techniques such as drip, sprinkler and mulching.
2. Switching over cropping pattern from water intensive paddy to green gram, wheat or millets in high and mid land areas.

Proposed Supply Side Interventions: As already discussed, only ground water cannot meet the future irrigation demand of the district. Thus following supply sidemeasures are suggested:

1. Further ground water development in under-utilized blocks Chandahandi, Dabugaon, Jharigaon, Kosagumuda, Nabarangpur, Nandahandi, Papadahandi, Raighar, Tentulikhunti and Umerkote the details of which are discussed in section 5.2.2.
2. Creation of additional surface water irrigation potential through river lift water schemes and minor irrigation projects.
3. Enhancement of surface and ground water storage through rain water harvesting and artificial recharge.

5.2.2 Management Plan for Under-Utilisation of Ground Water Resources

For the supply side intervention, further development of ground water resource is possible as there is sufficient scope for this is available in all the blocks of the districtviz. Chandahandi, Dabugaon, Jharigaon, Kosagumuda, Nabarangpur, Nandahandi, Papadahandi, Raighar, Tentulikhunti and Umerkote. The present ground water extraction rate in these blocks ranges from 22.09 % to 58.18 %. The quantum of water available for extraction from the phreatic aquifer is thus calculated, keeping the percentage of ground

water development within 60%. The same is shown in the **Table 5.2**. The calculations are based on, unit draft for dugwell taken as 0.96 Ham and the irrigation potential per dugwell taken as 2 Ha at an estimated 200% cropping intensity. Thus additional 15613 structures are feasible with irrigation potential of 31226 Ha in these blocks.

Table-5.2: Ground Water Development Potential of Nabarangpur District.

Block	Net Ground Water Availability (Ham)	Stage of Ground Water Development in 2020 %	Present Ground Water Draft (Ham)	Ground Water draft at 60% Stage of development (1)*0.6 (Ham)	Surplus Ground Water at Present Stage of development (4)-(3) (Ham)	Number of additional structure feasible for irrigation use assuming unit draft as 0.96 ham per Dug Well (Number)	Additional irrigation potential to be created(2.0 ha per Dug Well) (Ha)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Chandahandi	4452.58	24.9179128	1109.49	2671.55	1562.06	1627	3254
Dabugaon	2335.38	29.2196559	682.39	1401.23	718.84	749	1498
Jharigaon	5179.38	27.6502207	1432.11	3107.63	1675.52	1745	3491
Kosagumuda	10904.15	32.2279132	3514.18	6542.49	3028.31	3154	6309
Nabarangpur	3803.38	32.4172184	1232.95	2282.03	1049.08	1093	2186
Nandahandi	2720.88	54.8318926	1491.91	1632.53	140.62	146	293
Papadahandi	5759.02	22.0952523	1272.47	3455.41	2182.94	2274	4548
Raighar	8096.24	58.1835519	4710.68	4857.74	147.06	153	306
Tentulikhunti	3171.87	34.3857094	1090.67	1903.12	812.45	846	1693
Umerkote	10421.89	24.7700753	2581.51	6253.13	3671.62	3825	7649
Total	**56844.77**	**33.63**	**19118.36**	**34106.86**	**14988.50**	**15613**	**31226**

5.2.3 Management Plan for Less Productive Deeper Aquifer

Selection of proper site for drilling of bore wells, based on the favourable hydrogeological conditions has tobe done. As discussed earlier, a lot of scope exists for ground water development. Priority should be given to the phreatic aquifer for extraction of

ground water throughlarge diameter dugwells and dug-cum-borewells at hydrogeologically suitable locations.

Low topographic areas, abandoned and buried stream channels, close vicinity to the river are the most favourable site for large diameter dugwells.In general, the shallow medium black clayey soil layer does not facilitate ground water recharge. Construction of farm ponds and percolation tank in such areas is a viable option for recharging the phreatic aquifer. In these ponds, due to the excavated clay layer, the phreatic aquifer easily gets recharged and provide yield to the dugwells.

5.2.4 Management Plan for Depleted Water Level in Phreatic Aquifer

The problem of water level depletion in the phreatic aquifers can be addressed through artificial recharge through various water conservation structures. However, as already discussed, water level between 2-4 mbgl during post-monsoon period in most of the district shows adequate natural recharge and replenishment of phreatic aquifer.But there is still a lot of scope for artificial recharge to address the sustenance of phreatic aquifer to address the summer period water crisis due to deepening of water level. All the existing 1st order streams are suitable for construction of nala bunds.Similarly 2nd and 3rd order drainages are suitable for the construction of check dams.For the mitigation of deeper water level areas in thedistrict, the following measures can be taken up:

1. Contour trenching, staggered trenching and gabian structures to arrest the surface runoff in foot-hill areas.
2. Construction of farm ponds and renovation of existing water bodies.
3. Construction of 14 percolation tanks, 11 checkdams can be done.

The proposed sites for artificial recharge structures are shown in **Fig. 5.1**.

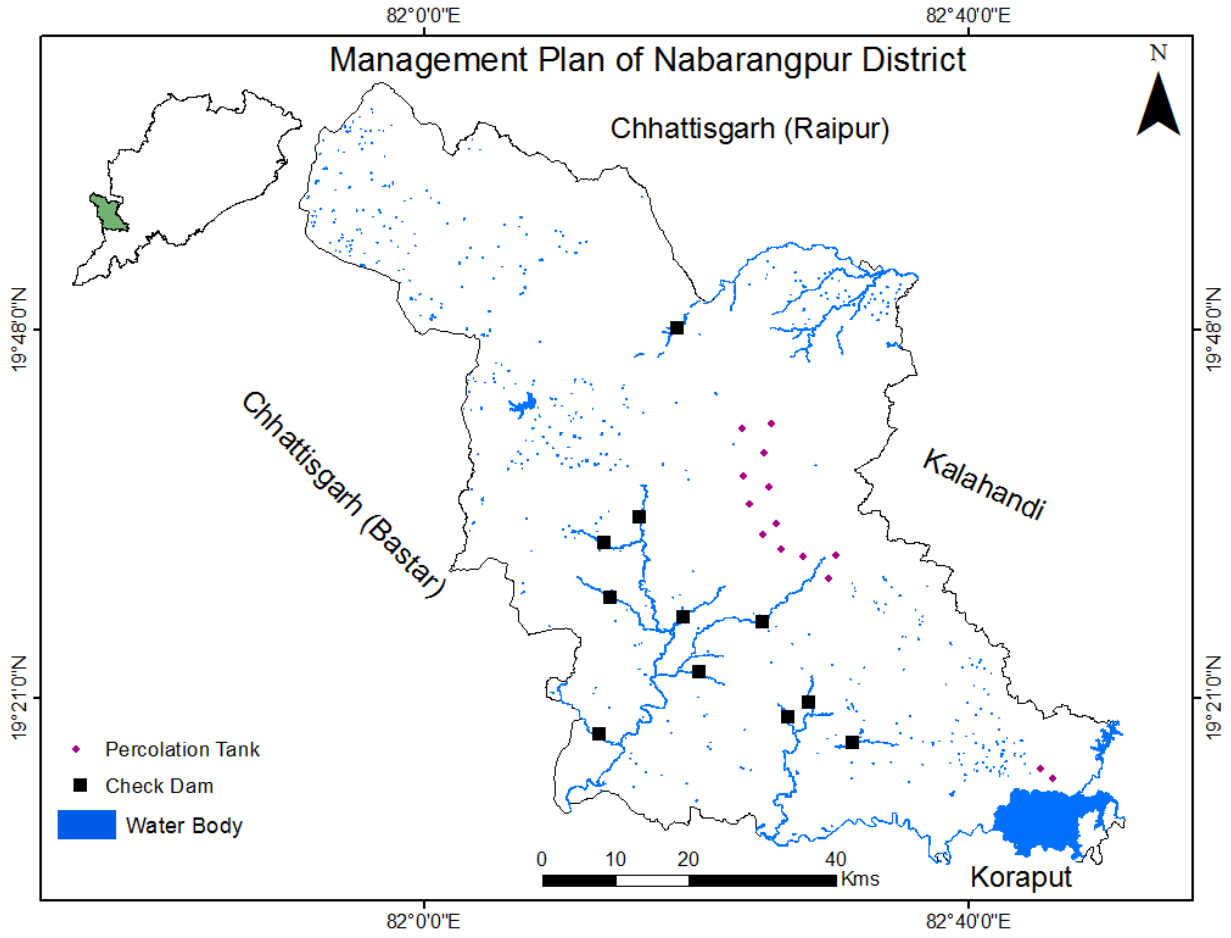

Fig. 5.1: Tentative sites for Artificial Recharge Structures Proposed in Nabarangpur District

6 SUMMARY AND RECOMMENDATIONS

6.1 Summary

National Aquifer Mapping Programme (NAQUIM) was taken up for detailed hydrogeological investigation, data-gap analysis and Aquifer Mapping and Management in the district of Nabarangpur, covering 10 blocks of Chandahandi, Dabugaon, Jharigaon, Kosagumuda, Nabarangpur, Nandahandi, Papadahandi, Raighar, Tentulikhunti and Umerkote during the period 2021-2022. The following are the summarised details.

1 Nabarangpurdistrictis bounded by 81°51'E and 82°52' E longitudes and 19°09' N and 20°06' N latitudes covering 5291 Sq. Km under the SOI Toposheet Numbers64 H, 64 L, 65 E and 65 I.The total mappable area under NAQUIM is 5291 sq. Km, which was taken up for the study.

2 The district is having 1 Subdivision (Nabarangpur), 10 administrative blocks (Chandahandi,Dabugaon,Jharigaon,Kosagumuda,Nabarangpur,Nandahandi,Papadahandi, Raighar, Tentulikhunti and Umerkote), 2 towns (Nabarangpur Municipality and Umerkote Municipality), 169 Gram Panchayats and 885 villages.

3 The normal annualrainfall in the district in 2021 was 1233 mm with average rainy days of 80 days.About 80% to 85% of the annual rainfall occurs during monsoon period between mid Juneto mid October.

4 The river Indravati, Tel and Bhaskel are the main surface water sources which provide water to the district.

5 The area covered by forest in the district is 20.87%. The net area sown is highest in Dabugaon, Chandahandi and Papadahandi blocks with cropping intensity of 127%.

6 Twotypes of soil are found in the district viz. AlfisolandVertisols.

7 The Upper Indravati, Tel and Bhaskel are the main irrigation projects providing irrigation facilities in the district.

8 The district is underlain by Precambrian crystallines, Quaternary laterites and alluvium.

9 The crystalline formations like charnockite, khondaliteand granite gneiss are classified asconsolidated water bearing formations. Here ground water exists in

unconfined conditions in the weathered mantle and in semi-confined to confined conditions in deeper fractured aquifers. The alluvium on major river courses and valley fill deposits are classified under unconsolidated formations.

10 CGWB has constructed 40 EWs and 13 OWs during the departmental ground water exploration programme. For the monitoring of ground water level and quality CGWB has established 25 National Hydrograph Network Stations (NHNS) in the district.

11 The discharge of successful borewells varies from 0.5 lps to a maximum of 7.5 lps. Generally 1 to 4 potential fracture zones are encountered within the depth range of 200 m.

12 Depth to water level in pre-monsoon period varies from 2.75 mbgl (Nabarangpur in Nabarangpur block) to 9.72 mbgl (Rangamatiguda in Nandahandi block), the average being 5.85 m bgl. Depth to water level in post-monsoon period varies from 0.79 mbgl (Chheraguda in Dabygaon block) to 9.55 (Bhandariguda in Umerkote block) mbgl, the average being 3.94 mbgl. The long term trend analysis indicates that out of 17 stations, during the pre-monsoon 5 (29.41%) show rising trend and the rest 12 stations (44.44%) show falling trend. Similarly during the post-monsoon, 5 (29.41%) show rising trend and the rest 12 stations (44.44%) show falling trend. During the pre-monsoon, the range of fall is from -0.0021 to -0.3996 m/yr, whereas the range of rising trend is from 0.0086 to 0.1482 m/yr. Similarly during the post-monsoon, the range of fall is from -0.0205 to -0.2633 m/yr and the range of rise is from 0.0011 to 0.1204 m/yr.

13 The chemical quality of ground water both from shallow and deeper aquifers are good and can be suitably utilised for domestic as well as irrigation purposes.

14 The estimated dynamic ground water resource is 56844.77Ham and the stages of extraction of ground water range from 22.09 to 58.18 %.The ground water development is minimum in Papadahandi block and maximum inthe Raighar block.

6.2 Recommendations

For a sustainable ground water development in the area, a systematic, economically sound and politically feasible framework for groundwater management is required.Considering the local physiographical and hydrogeological set up the following ground water management strategy is suggested.

1 Proper guidance has to to be provided to the farmers siting proper ground water structure in favourable hydrogeological setting.

2 Priority should be given to the phreatic aquifer for extraction of ground water through large diameter dugwells and dug-cum-borewells at hydrogeologically suitable locations. Selection of proper site for drilling of bore wells, based on the favourable hydrogeological conditions has to be done.

3 For the irrigation requirement in relatively water deficient areas, efficient irrigation techniques such as drip and sprinkler should be practiced.

4 In the foot hill regions, contour trenching, staggered trenching along with gabion structures should be constructed to arrest the surface runoff and improve rainfall recharge.

5 Artificial recharge projects may be taken up in the district especially in hard rock areas for augmentation of ground water resources throughconstruction of percolation tanks, check dams, farm ponds etc.

6 Conjunctive use of surface and ground water is must in the command areas.

7 Rain water harvesting should be adopted in all govt. and public buildings.

8 The farmers should be educated through agricultural extension services for adopting suitable cropping patterns for optimal utilization of available ground water and surface water resources.

9 Industrial waste waters and effluents should be treated and disposed off properly under an effective monitoring mechanism.

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