केन्द्रीय भूमि जल बोर्ड

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विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board

Department of Water Resources, River Development and Ganga Rejuvenation,

Ministry of Jal Shakti

Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

Kalahandi District
Odisha

दक्षिण पूर्वी क्षेत्र, भुवनेश्वर

South Eastern Region, Bhubaneswar

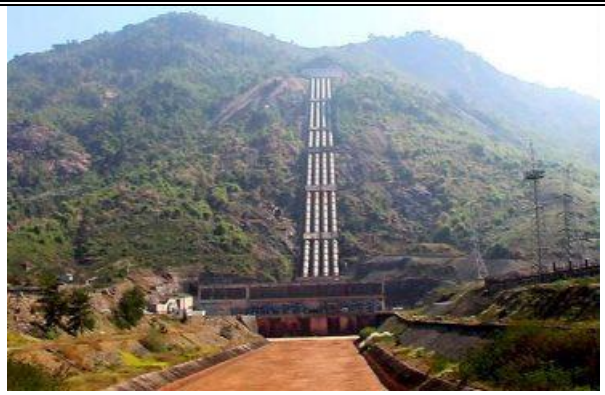
Government of India

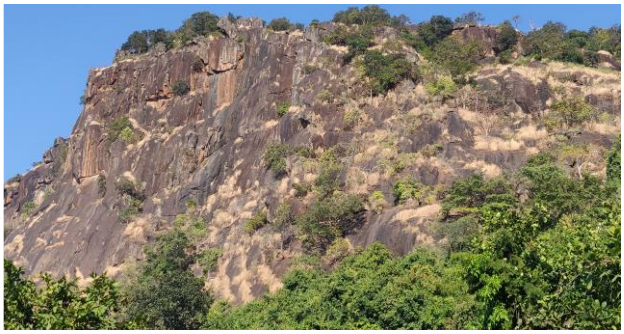
MINISTRY OF JAL SHAKTI, DEPARTMENT OF WATER RESOURCES, RIVER DEVELOPMENT & GANGA REJUVENATION

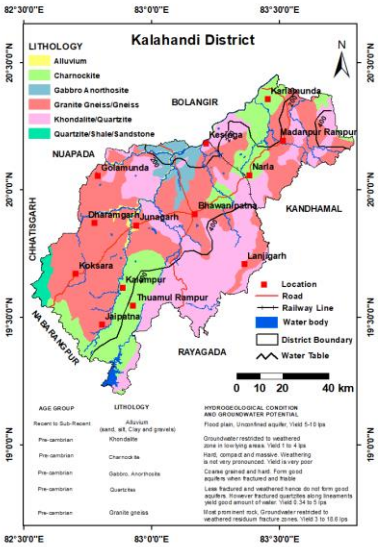
REPORT ON

AQUIFER MAPPING AND MANAGEMENT PLAN

IN KALAHANDI DISTRICT, ODISHA







CENTRAL GROUND WATER BOARD

South Eastern Region, Bhubaneswar

March-2022

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FOREWORD

Kalahandi is one of the important districts of western Odisha, famous since prehistoric times as an ancient place of human habitation. Kalahandi District had a glorious past and great civilization in ancient time. Archaeological record of Tel valley reveals the presence of the primates in its various zones during the Pleistocene phase. The discovered archaeological wealth of Tel valley suggest a well civilized, urbanized, cultured people inhabited on this land mass around 2000 years ago and Asurgarh was its capital. Kalahandi district along with Koraput and Bastar was part of Kantara referred in Ramayana and Mahabharata.The district is endowed with vast natural resources and is one of the agriculturally developed districts of Odisha. The district is underlain mostly by hard crystalline formations of EasternGhat Supergroup. The river Tel and its tributaries are the main surface water sources which provide water to the district. However, large part of the district still lacks surface water irrigation facility. The agrarian development of the district can be boosted by tapping the ground water resources through dug wells and medium-deep bore wells.

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. Borewells in Anorthosites, charnockites and khondalites have very poor yield. The places where weathering thickness is more and condition is favourable, the phreatic aquifer attains good yield potential and large diameter dug wells are suitable structures to extract water from them.

The present stage of ground water development is only 39.96%, 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. Apart from irrigation, drinking water scarcity can also be mitigated through judicious utilization of ground water.

Based on the available data and the earlier hydrogeological studies taken up in 13 blocks of the district viz. Bhawanipatna, Dharmagarh, Golamunda, Jaipatna, Junagarh, Kalampur, Karlamunda, Kesinga, Koksara, Lanjigarh, M. Rampur, Narla and Thuamul Rampur covering 6160 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. Mohanty, Scientist-'B' and Shri S. K. Naik, Scientist-'B'**, have compiled and prepared the present report on **"Aquifer Mapping and Management Planning of Kalahandi 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 : 14th March 2022

(P. K. Mohapatra)
Regional Director

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AQUIFER MAPPING AND MANAGEMENT PLAN KALAHANDIDISTRICT (6160 Sq. Km)

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1 INTRODUCTION

1.1 Objective

Central Ground Water Board (CGWB) has taken up National Aquifer Mapping and 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 of Kalahandi district in Odisha covering 13 blocks of the district namely, Bhawanipatna, Dharmagarh, Golamunda, Jaipatna, Junagarh, Kalampur, Karlamunda, Kesinga, Koksara, Lanjigarh, M. Rampur, Narla and Thuamul Rampur.

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 Kalahandi district has been geologically mapped by the Geological Survey of India. Hydrogeological surveys have been conducted in different parts of the district by S/Shri B.B. Basak (1975-76, 1977-78, 1978-79, 1979-80, 1980-81), A.D. Rao (1986-87), S.C. Behera (1987-88), G. C. Pati (1992-93), S. Brahma and R.K. Nayak (2005-06) of CGWB, SER on 1 : 50,000 scale.

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 characteristics are 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) 2020-21, for detailed hydrogeological investigation and Aquifer Mapping in Kalahandi district. Kalahandi is one of the economically backward district of western Odisha with a geographical area of 7920 sq. km and is an integral part of Western Odisha Development Council constituted by Govt. of Odisha very often reels under severe drought condition.Kalahandi district is bounded by 82°18'E and 83°48' E longitudes and 19°03' N and 21°45' N latitudes covered under the SOI Toposheet Numbers 64 L, 64 P, 65 I and 65 M.The total mappable area under NAQUIM is 6160 sq. Km, which was taken up for the study after excluding the hilly areas. The district is having 2 Subdivisions (Bhawanipatna and Dharmagarh), 13 administrative blocks (Bhawanipatna, Karlamunda, Kesinga, Lanjigarh, Madanpur-Rampur, Narla, Thuamul-Rampur, Dharamgarh, Golamunda, Jaipatna, Junagarh, Kalampur and Koksara),3 towns (Bhawanipatna Municipality, Junagarh NAC and Kesinga NAC),310 Gram Panchayats and 2255 villages including two Census towns (Mukhiguda and Madanpur-Rampur).

The river Tel and its tributaries constitute the main drainage system in the district. Some important rivers like Indravati, Nagavalli and Vansadhara owe their origin to the hill ranges in the south-eastern parts of the district. The District occupies the South Western portion of Odisha, bordered to the North by Balangir District and Nuapada District, to the South by Nabarangpur District, Koraput District and Rayagada District, and to the East by Rayagada, Kandhamal District and Boudh District.The district headquarter Bhawanipatnais connected by all-weather metalled road from capital city Bhubaneswar (400 km) via Kandhamal, Boudh, Nayagarh. The administrative

map of the study area is presented in **Fig.1.1**.The block-wise demographic details are shown in **Table-1.1.**

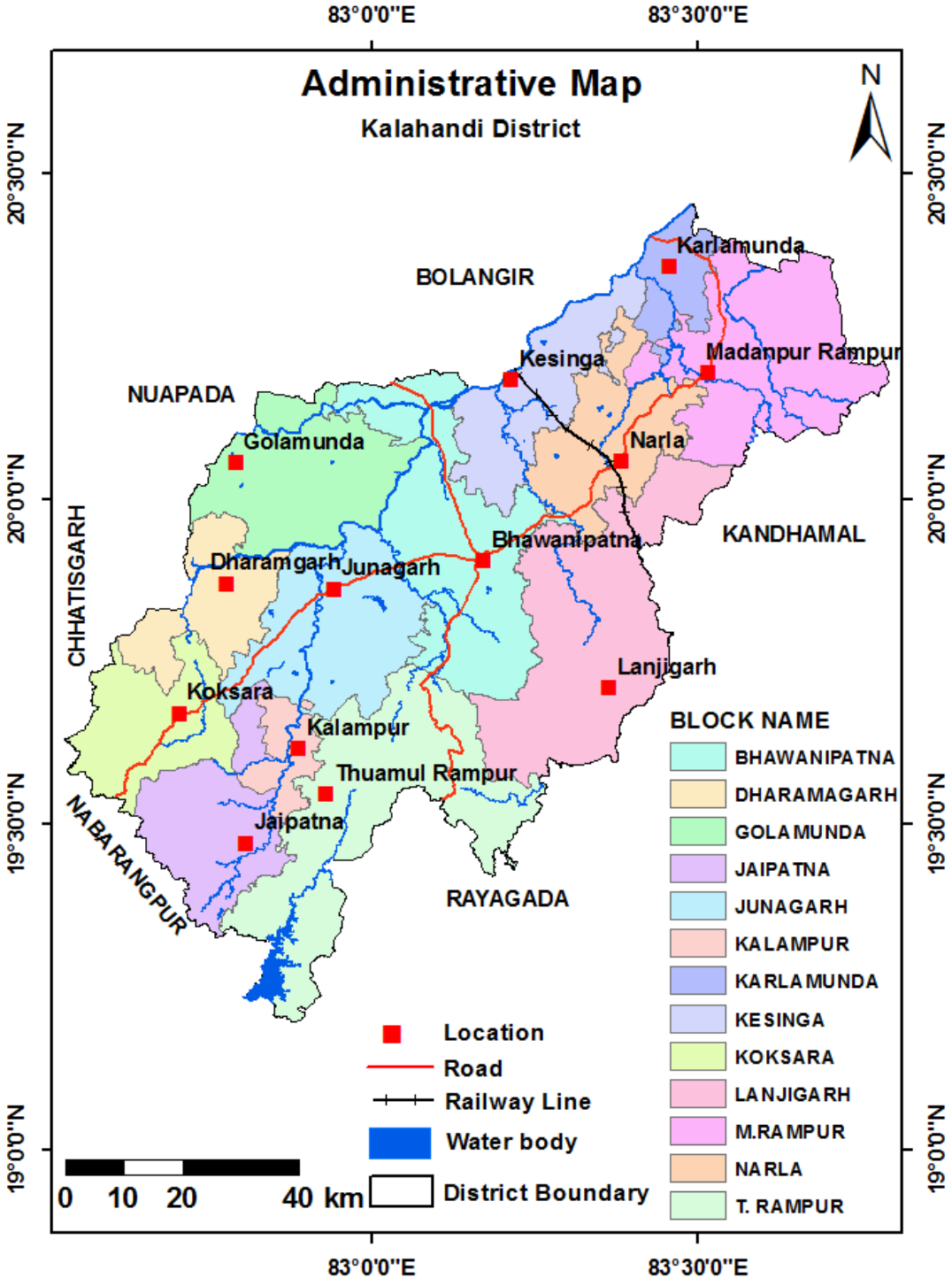

Fig. 1.1: Administrative Map of Kalahandi District.

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

Sl No	Block	Geographical Area in Sq.Km	GPs	Villages	Population			SC Population	ST Population
					Male	Female	Total		
1	Bhawanipatna	629.24	36	283	85,252	85,275	1,70,527	34,711	56,564
2	Dharamgarh	378.28	24	79	69,994	69,365	1,39,359	25,407	24,071
3	Golamunda	434.19	28	130	64,917	64,582	1,29,499	22,480	32,655
4	Jaipatna	403.81	22	94	61,437	63,132	1,24,569	19,812	49,506
5	Junagarh	504.86	34	171	86,606	87,054	1,73,660	29,585	29,902
6	Kalampur	155.99	11	55	29,531	30,544	60,075	9,778	15,673
7	Karlamunda	195.10	12	62	28,975	28,443	57,418	9,686	8,411
8	Koksara	357.16	22	72	58,953	60,351	1,19,304	19,555	41,119
9	Kesinga	377.98	26	106	58,245	57,583	1,15,828	19,078	31,849
10	Lanjigarh	660.59	26	483	45,887	47,292	93,179	22,146	42,703
11	M-Rampur	302.61	19	249	36,041	36,591	72,632	10,031	31,009
12	Narla	442.19	26	173	60,695	60,297	1,20,992	22,963	32,026
13	T-Rampur	338.86	24	298	38,113	39,727	77,840	19,742	45,287
	Urban								
	Bhawanipatna(M)	15.40	-	-	35,506	33,539	69,045	12,889	4,016
	Junagarh(NAC)	15.54	-	-	9,835	9,821	19,656	2,835	1,091
	Kesinga(NAC)	14.50	-	-	9,844	9,395	19,239	3,662	2,341
	Mukhiguda(CT)	2.24	-	-	3,236	2,919	6,155	1,109	707
	M-Rampur(CT)	7.01	-	-	4,034	3,858	7,892	1,111	526
Total			**310**	**2255**	**787101**	**789768**	**1576869**	**286580**	**449456**

Source: District Census Hand Book

1.5 Climate and Rainfall

The district enjoys a sub-tropical monsoon climate with hot and dry in summer, pleasant winter and erratic rainfall in monsoon. The maximum temperature varies from 35°C to 43.5°C. May is the hottest month with the mean daily maximum temperature of about 40°C. December is the coldest month when temperature sometimes comes down to a minimum of 6°C. The humidity of the area is generally high during southwest monsoon season and decreases from the end of November due to cold wave. The Relative humidity varies from 27% to 87% during different periods of the year.The mean monthly potential evapo-transpiration value ranges from 45 mm in December to 470 mm during May.

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 2020 was 1482 mm with average rainy days of 80 days (**Table-1.2**).About 80% to 85% of the annual rainfall occurs during monsoon period between mid June to mid October. The Isohyetal map (**Fig 1.2**) shows large variation in rainfall with rain reducing drastically from south-east to north-west in the district.

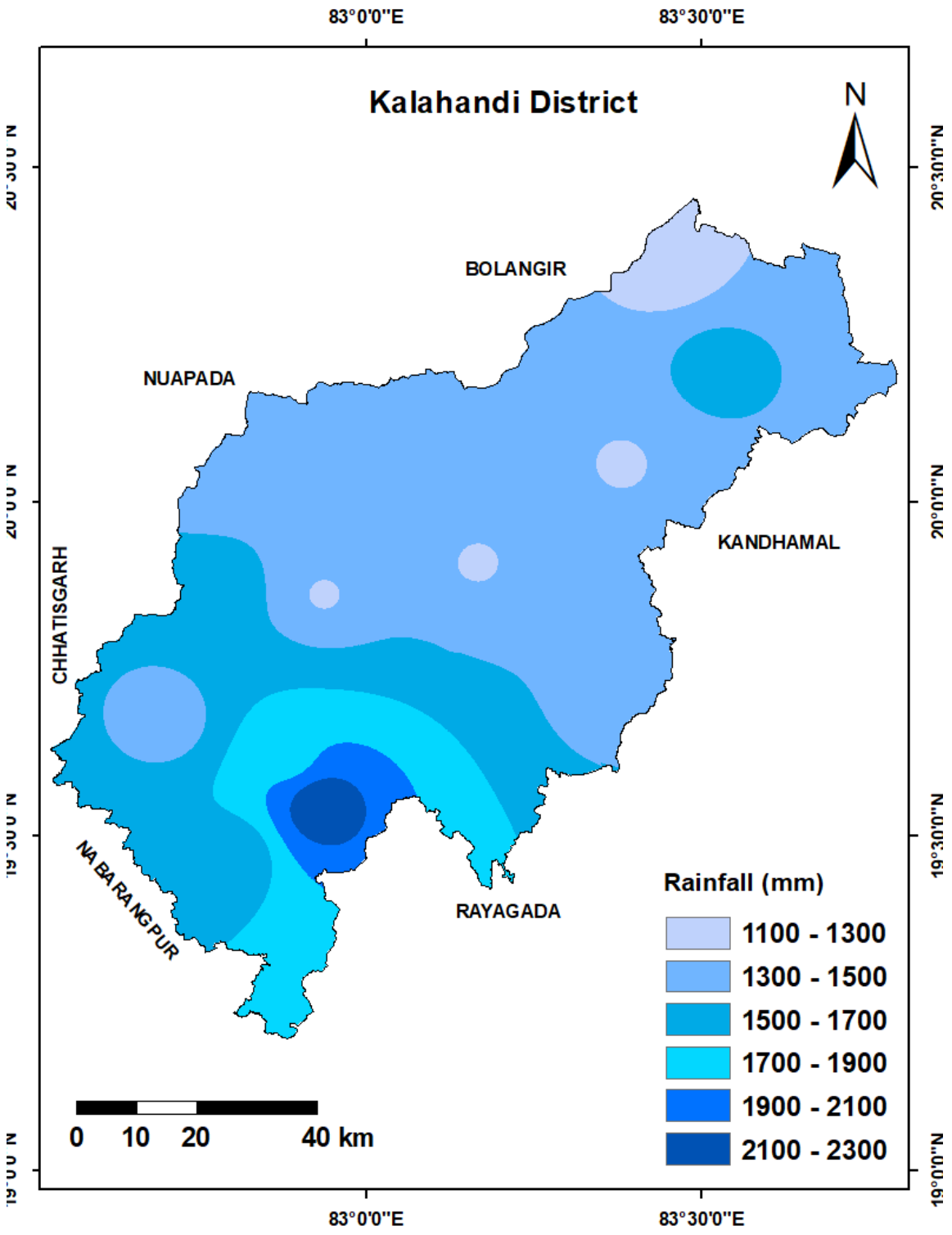

Fig. 1.2: Rainfall Isohyets in Kalahandi District.

Table-1.2: Block wise Annual Rainfall and Number of Rainy Days (Year 2020)

Sl No	Name of the Block	Rainfall	
		No. of Rainy days	Average Rainfall (mm)
1	Bhawanipatna	90	1282.9
2	Kesinga	65	1366
3	Karlamunda	60	1114.2
4	Madanpur Rampur	87	1586.2
5	Narla	55	1283
6	Langigarh	96	1435
7	Th. Rampur	108	2282.8
8	Dharamgarh	81	1569.4
9	Junagarh	83	1276.6
10	Kalampur	81	1817.7
11	Jaipatana	79	1523
12	Koksara	77	1361.5
13	Golamunda	73	1372.4
	Average	80	1482

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 2020)

Sl No	Block	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
1	Bhawanipatna	11.0	36.0	57.0	40.6	15.0	316.0	280.4	236.9	172.2	117.8	0.0	0.0
2	Kesinga	8.0	26.0	67.6	13.2	43.2	335.8	376.6	277.8	126.6	91.2	0.0	0.0
3	Karlamunda	17.4	44.4	57.6	54.2	0.0	240.0	178.2	293.8	146.4	82.2	0.0	0.0
4	Madanpur Rampur	14.2	34.0	77.0	42.0	64.0	314.0	294.0	423.0	156.0	168.0	0.0	0.0
5	Narla	12.0	33.0	57.0	3.0	6.0	312.0	207.0	252.0	187.0	214.0	0.0	0.0
6	Langigarh	Nil	43.6	54.8	98.2	23.0	284.4	274.0	242.0	202.6	212.4	0.0	0.0
7	Th. Rampur	7.2	8.2	57.5	39.0	65.0	389.4	368.0	980.5	237.1	130.9	0.0	0.0
8	Dharamgarh	5.5	6.4	76.5	63.0	118.0	290.0	185.0	440.0	231.0	154.0	0.0	0.0
9	Junagarh	10.0	6.0	52.4	27.0	13.0	314.0	221.0	315.2	252.0	66.0	0.0	0.0
10	Kalampur	11.4	0	45.9	65.4	42.0	292.7	280.5	623.4	311.2	145.2	0.0	0.0
11	Jaipatana	2.0	1.0	90.0	37.0	79.0	299.0	302.0	444.0	201.0	68.0	0.0	0.0
12	Koksara	0	3.6	53.8	109.3	26.9	219.0	314.4	325.3	168.4	140.8	0.0	0.0
13	Golamunda	17.0	45.7	42.0	17.0	42.0	383.3	250.9	317.2	155.1	102.2	0.0	0.0
	Total	**115.7**	**287.9**	**789.1**	**608.9**	**537.1**	**3989.6**	**3532.0**	**5171.1**	**2546.6**	**1692.7**	**0.0**	**0.0**
	Average	8.9	22.15	60.7	46.8	41.3	306.9	271.7	397.8	195.9	130.2	0.0	0.0
	Normal	10.3	14.4	23.7	25.7	41.8	240.9	327.7	355.4	204.6	74	10.9	1.6

Source: Odisha Rainfall Monitoring System

Analysis of rainfall of the last 20 years (2001 – 2020) shows moderate variation of rainfall in the district. The average annual rainfall is around 1650.9 mm. The standard deviation is around 366.9 mm. As per IMD classification, mild drought (0-25% deficient rainfall) occurs during the year 2005, 2009, 2010, 2011, 2012, 2015, 2016, 2017& 2020 while moderate drought (25-50 % deficient rainfall) occur during 2002. However excessive rainfall occurs during the year 2001, which exceeds average rainfall by 43%. Year and Block wise Annual Rainfall is given in **Table No.1.4**.

Table-1.4: Year and Block wise Annual Rainfall of Kalahandi District (2001 to 2020) (data in mm)

Year	Bhawanipatna	Kesinga	Karlamunda	Madanpur Rampur	Narla	Langigarh	Th. Rampur	Dharamgarh	Junagarh	Kalampur	Jaipatana	Koksara	Golamunda	District Average
2001	2412.5	2527	2225	2506	3519.8	2079	4037	1341	2260	1947	1838	2374	1708.2	2367.2
2002	432.5	724	876.6	837.2	997.1	933.2	2357	431	795	711	844.7	698	890.7	886.7
2003	1596	1669.7	1970.7	2427	1935	2016	4275.3	1339.5	1727.6	2567	2029	2149.2	1362.1	2081.8
2004	1387.5	1563.5	1319	1668	1314	1553	4357	1334.2	1620.4	2186.7	1849	1153	1358.7	1743.3
2005	1148	999	1967	1101	1048	1305.4	3249	1162.3	1247.8	1686.8	1103	923	1233.6	1397.9
2006	1988	1784.6	2940.4	2161	1946.4	1847.8	4320	1759	2005.1	2739.1	1984.1	1745	1956.2	2244.3
2007	1477	1230	1269	1513.5	1438	1647	3796	2237.8	2466.8	2096.5	1780.1	1761.4	1692	1877.3
2008	1395	1592.5	1830.7	2091.9	1879.6	1773.6	4066.5	1220.5	2049.5	2349.8	1511	1797.9	952	1885.4
2009	1224.2	1686.5	1512	1538.6	1449	1455.8	3234	656	1444.6	1745.1	1644	1102	864.2	1504.3
2010	1094	1186.5	1385	1543	1163.5	1573.2	3325	1228	1366.4	1905.6	1624	1898	759	1542.4
2011	872	1130.8	1406	1215.2	1085	1264.6	2050	621.5	1213.8	1610	1314	1087	393	1174
2012	1215	1556	1310	1583	1145	1392	3587	690	1437	1623	1376	1114	486	1424.1
2013	1262	1487	1960	1693	1408	1429	4141	1118	2138	2389	1984	1888	1225	1855.5
2014	1435	1752	1454	1628	1540	1720	4069	1078	1718	1679	1742	1355	1450	1740
2015	1001	1014	1102	1185	1093.5	1135	2565	1242	1570	1605	1655	1519	1087	1367.1
2016	1222.5	1254	1253	1499.7	1202.4	1314.4	2005.3	1162.3	1256.8	1494.1	1492.8	1182	973.5	1331.7
2017	1362.5	1051	916.6	1331.7	1726.8	1452.8	1913.6	1163.9	1190	1826	1612.3	1829.4	1154	1425.4
2018	1960.8	1769.2	1667.5	2424.2	1966.5	1952.2	3288.9	1496.6	1953	2557.5	1645.1	1821.3	1451.1	1996.4
2019	1089.2	1360.2	2011.4	2014	1421	1668.2	2873.7	1347.7	1097.2	2063.7	2071	1493.9	1492.9	1692.6
2020	1282.9	1366	1114.2	1586.2	1283	1435	2282.8	1569.4	1276.6	1817.7	1523	1361.5	1372.4	1482.3
Mean & SD	1342.8424.5	1435.1394.9	1574.5501.7	1677.3461.9	1528.1566.2	1547.3296.5	3289.6848.5	1209.9410.5	1591.7439.3	1929.9465.1	1631.1310.7	1512.6437.4	1193.1401.1	1650.9366.9

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

1.6 Physiographic Setup

Physiographically, the district comprises diverse landforms consisting of rugged hill ranges, plateaus, undulating plains dotted with residual hills and mounds and fertile erosional plains and valleys. A gently undulating terrain with a vast stretch of cultivable land characterizes the major parts of west of Bhawanipatna in the district; the average land elevation being 120 m to 1311 m above mean sea level.The variation in land elevations above MSL is shown in **Fig. 1.3**.

1.7 Geomorphology

The geomorphology of the area is shownin **Fig. 1.4**.The study area comprises of the following geomorphic units.

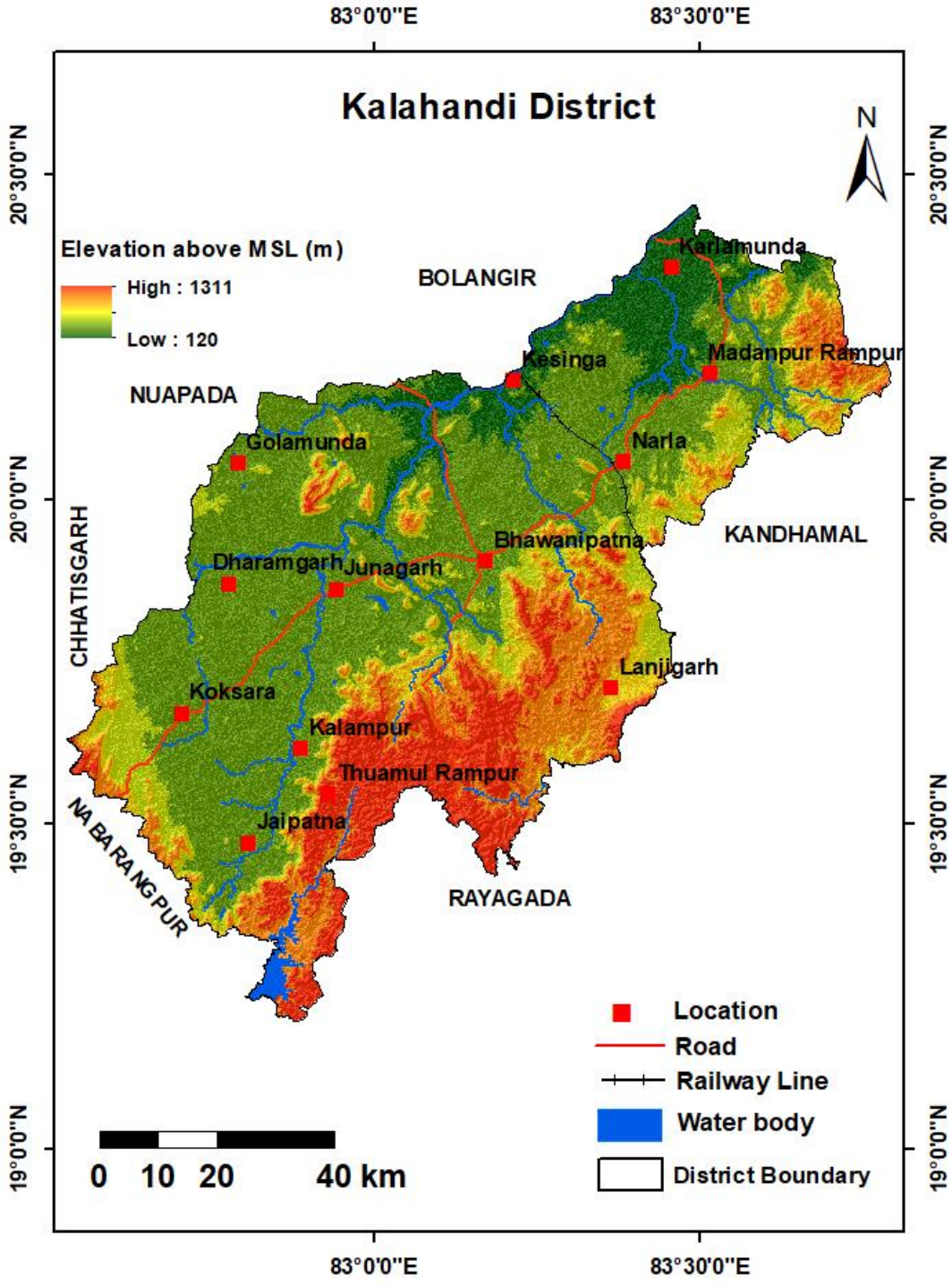

Fig. 1.3: Land Elevations in Kalahandi District.

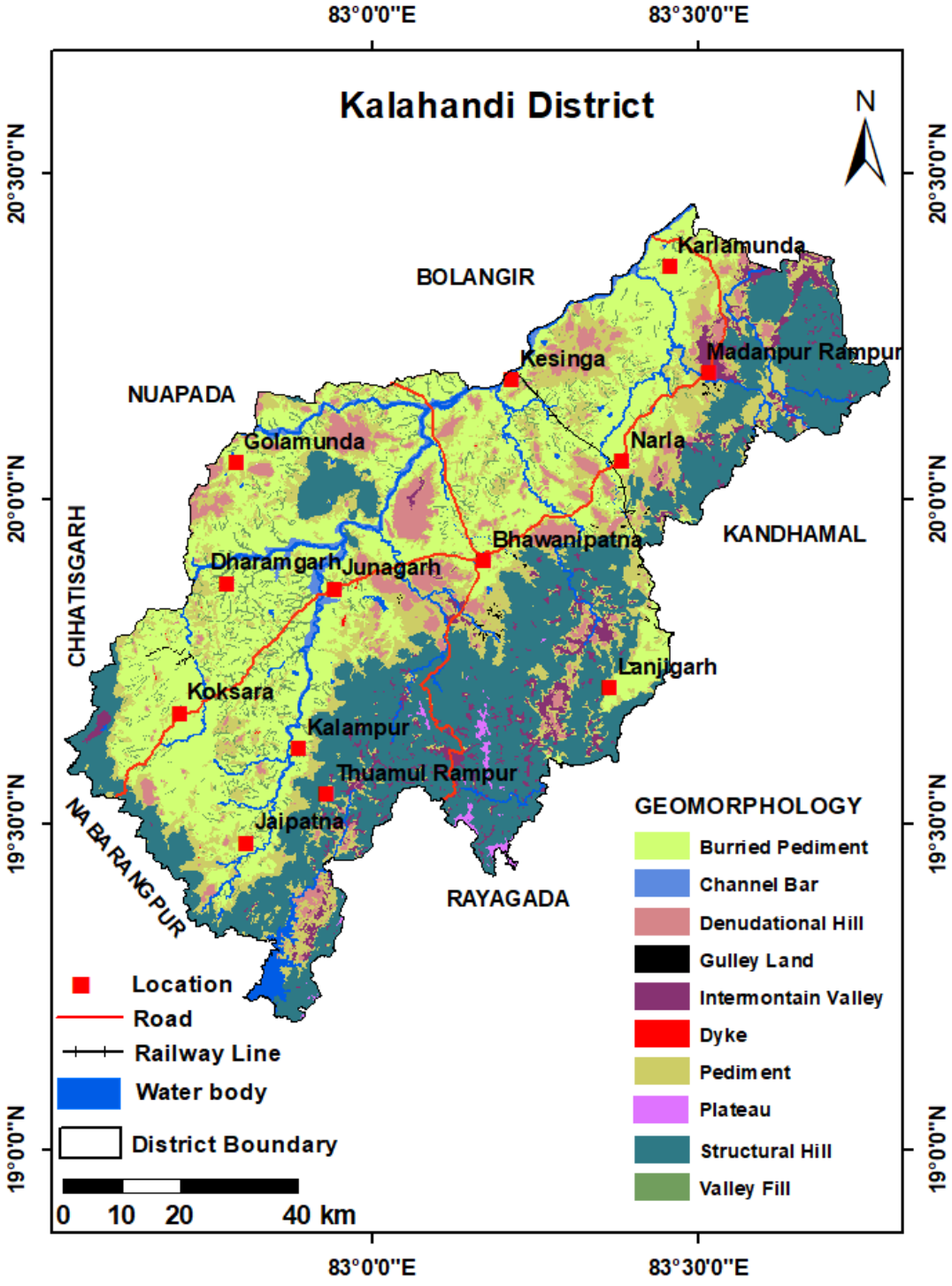

Fig. 1.4: Geomorphology of Kalahandi District.

1.7.1 Eastern Ghat Hills:

The presence of structural and denudational hills form the characteristic landforms with narrow intermontane valleys covering mainly Madanpur-Rampur and parts of Narla and Karlamunda blocks.

1.7.2 Buried Pediments

This is the most extensive, common unit in the area covering parts of each block of the district. They are characterized by thick weathered zone with thickness varying from less than 10 to 15m. The unit generally possesses greater moisture content and denser vegetation than pediments. The water table fluctuation is relatively less and recharge to groundwater is large. Hence, they form potential zones for groundwater development by dug wells and bore wells.

1.7.3 Pediments:

This is a gently undulating rocky surface with a thin veneer of soil cover. These are mostly restricted to mountain front and act as run off zones. They are often chracterized by topographies with a number of gullies. They bear very poor to limited groundwater potential.

1.7.4 Valley Fills

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

1.7.5 Structural Hills

The hills with escarpment characterize the feature steep slopes and narrow gorges. These are structurally controlled hills with complex folding, faulting and traversed by numerous joints/fractures facilitating infiltration and mostly act as run-off zone.

1.7.6 Residual Hills

This unit mainly consists of residual masses of granites, Khondalites. This unit behaves as a runoff zone. Groundwater potential is very poor.

1.7.7 Denudational Hills

Denudational hills are identified by their high relief representing resistant hill ranges. Rate of infiltration is very poor except along fractures/joints. These generally act as run-off zone.

1.8 Landuse, Cropping and Irrigation Pattern

Kalahandi district comes under Western Ghats undulating type agro-ecological zone.

The study area shows wide variation in the pattern of land utilization. The Cropping Intensity of the district is 175%.The forest area is about 31% of total geographical area. The net sown area is highest in the Bhawanipatna block. 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 Kalahandi 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
Bhawanipatna	29053	387	2097	1026	6597	875	16513	8113	26882
Kesinga	6643	301	1000	1876	5099	1208	10620	2422	14538
Karlamunda	905	155	1172	2056	2214	855	1650	1353	8526
Madanpur Rampur	53835	153	2717	1589	2948	115	7186	2235	12807
Narla	8046	1287	3705	673	5004	1684	5682	1116	20501
Lanjigarh	52217	81	1930	8410	10531	5655	8433	8604	10256
Th. Rampur	50019	142	678	3637	5842	443	5625	3763	7837
Dharamgarh	34	88	1691	818	4738	352	5065	1850	21718
Junagarh	11416	147	2922	2027	5444	594	6866	4190	24111
Kalampur	126	81	760	1241	1767	56	1858	1021	7681
Jaipatana	8636	381	2496	2435	6096	274	7668	2711	14979
Koksara	10100	1540	3653	3667	4633	2724	2258	1447	13280
Golamunda	18420	53	3467	1292	5825	1012	6612	4558	17228
Total	249450	4796	28288	30747	66738	15847	86036	43383	200344

Source: District Statistical Handbook, Kalahandi 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, spices,sugarcane, tobacco etc. The major crop of the district is paddy. The block & area-wise irrigation status is given in **Table 1.6**.

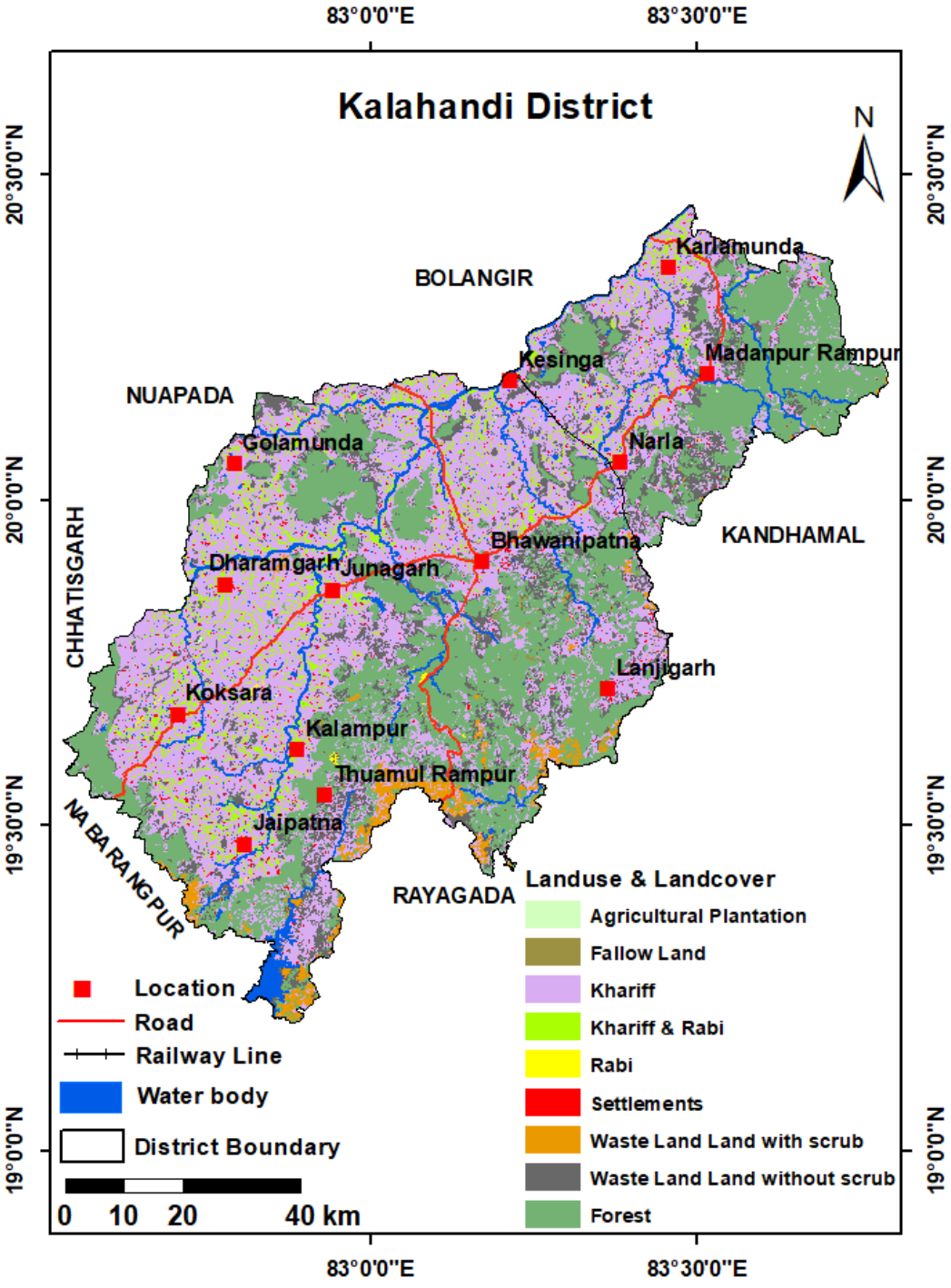

Fig. 1.5: Landuse in Kalahandi District.

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

Block	Kharif			Rabi			Summer			Total		
	Irrigated	Rainfed	Total	Irrigated	Rainfed	Total	Irrigated	Rainfed	Total	Irrigated	Rainfed	Total
Bhawanipatna	4484	43637	48121	4043	17252	19795	0	0	0	8527	60889	69415
Kesinga	5900	22234	28134	4508	14623	19131	0	0	0	10408	36857	47265
Karlamunda	6631	8540	15171	4008	6154	10162	0	0	0	10639	14694	25333
Madanpur Rampur	1195	18008	19203	4881	8837	13718	0	0	0	6076	26845	32921
Narla	4169	26931	31100	2770	10218	12988	0	0	0	6939	37141	44088
Lanjigarh	2141	17627	19768	3023	9021	12044	0	0	0	5164	26648	31812
Th. Rampur	1379	10763	12502	2115	8785	10900	0	0	0	3854	19548	23402
Dharamgarh	17174	18566	35740	10671	14481	25152	0	0	0	27845	33047	60892
Junagarh	30540	15942	46582	22667	4855	27522	0	0	0	53207	20797	74004
Kalampur	13045	4751	17796	4659	2380	7039	0	0	0	17704	7131	24835
Jaipatana	15973	13718	29691	22952	7291	19243	0	0	0	27925	21009	48934
Koksara	6223	30162	36385	3604	11465	15069	0	0	0	9827	41627	51454
Golamunda	7156	34011	41167	4799	17988	22787	0	0	0	11955	51999	63954
Total	116010	264890	381360	94700	133350	215550	0	0	0	200070	398232	598309

Source: District Irrigation Plan, Kalahandi, March 2016

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. The soil map of Kalahandidistrict is shown in **Fig. 1.6**.Based on the physical and chemical characteristics, mode of origin and occurrence, soils of the district can be grouped into following types:-

1.9.1 Inceptisols:

Red soils are the most predominant soil type in Kalahandi district covering about 45% of the total area. These soils occur in foothills terrain and as capping over the hillocks. These soils are poor in nitrogen, phosphate, potassium and organic matters. These soils are light textured and the P^H ranges from 4.5 to 6.0.

1.9.2 Alfisols

The Alfisols include red sandy soils, red loamy soils, mixed red and black soils. These soils cover about 27% of the total area of the district and occur at lower elevations with undulating topography. These soils are neutral to slightly alkaline in nature (P^Hvaries from 5.5 to 8.5). The characteristic features of red soils are (i) light texture, porous and friable structure, (ii) absence of lime kankar and free carbonates and (iii) soluble salts in small quantity usually not exceeding 0.05 %. These soils are suitable for cultivation of paddy and other crops.

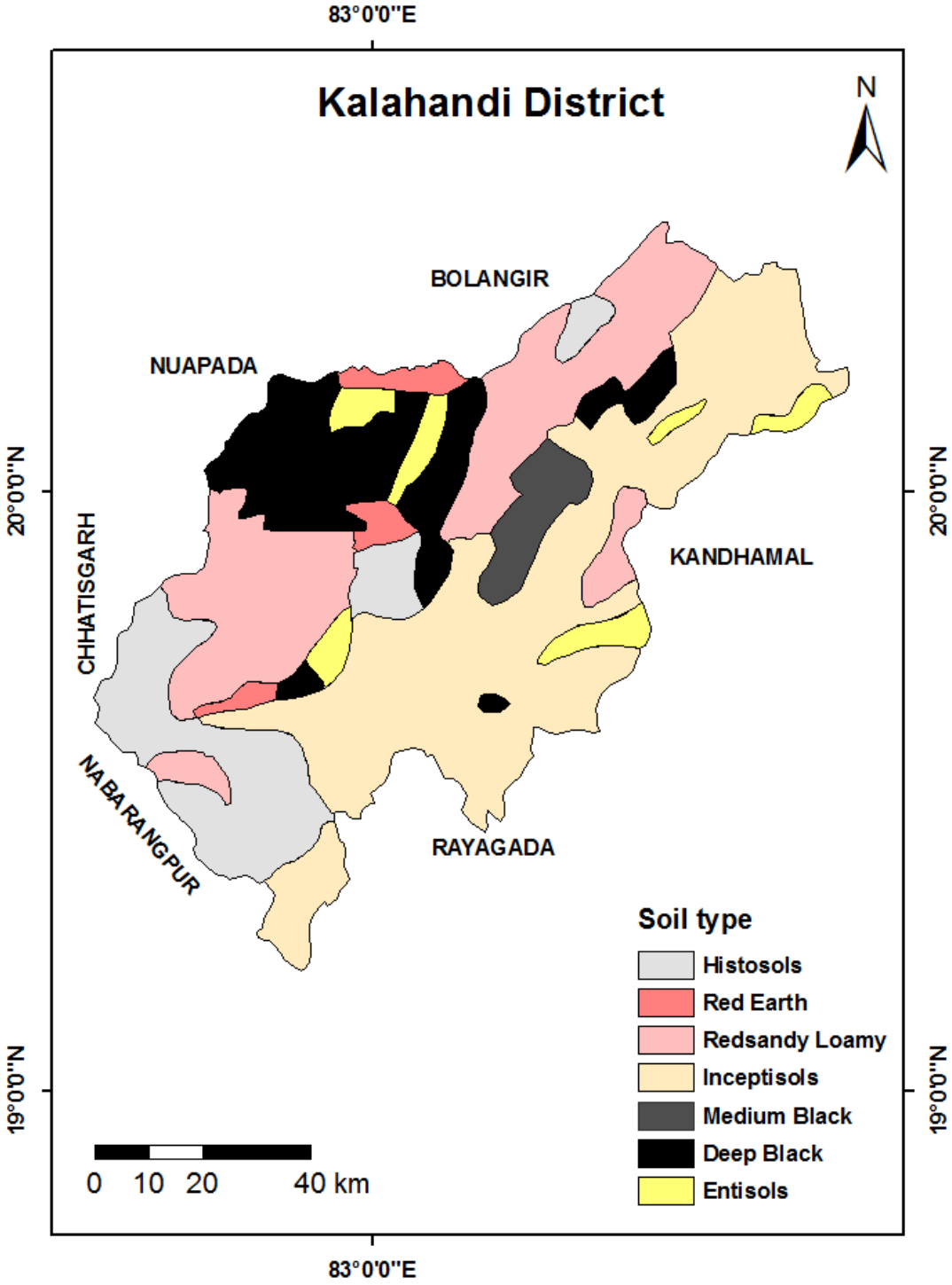

Fig. 1.6: Soil Map of Kalahandi District.

1.9.3 Histosols:

Black soil is an important soil type in the district occupying parts of Bhawanipatna, Narla, Kesinga, Dharamgarh, Golamunda and Koksara blocks. These soils are rich in potassium and nitrogen but poor in phosphorus. These soils are most favorable for cotton cultivation which is a generally draught resistant, labour intensive but a highly remunerative crop.

1.9.4 Vertisols

These are medium black soils found around the course of Mahanadi and Tel rivers in the southern part of the district. They are highly argillaceous and contain high amount of iron, calcium and magnesium. They are usually poor in nitrogen, phosphate and organic matter but rich in potash and lime. The pH varies from neutral to alkaline and texture varies from loam to clay loam. They are quite fertile soils and crops grown are usually cotton, wheat, tobacco and chilly.

1.9.5 Entisols:

These consist of alluvial soil occupying the flood plains of major rivers and streams in the district. These are deficient in nitrogen, phosphoric acid and lumbers but not in potash and lime. These soils are alkaline in nature and fertile.

1.10 Drainage and Hydrology

The river Tel and its tributaries constitute the main drainage system of the district. Some important rivers like Indravati, Nagavalli and Vansadhara owe their origin to the hill ranges in the southeastern parts of 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.

The river Tel, a major tributary of river Mahanadi, originates in the Nawarangpur highlands and enters the district near Dharamgarh. Udanti, Indra, Sagada, Ret, Hatti and Uttei are important tributaries of river Tel. These streams are ephemeral in nature.

River Indravati originates from north of Thuamal Rampur at about 900 m above MSL. It drains a small area in the southern part of the district and then enters Nawarangpur district.

The river Vansadhara drains a limited area of Kalahandi district in the south-eastern part. River Nagavalli originates from the south-eastern hilly tract and drains a very small part of the district. The drainage map of the district is shown in **Fig. 1.7**.

The Upper Indravati and Uttei are the main irrigation projects providing irrigation facilities in the district. There are 3547 community ponds irrigating an area of 16932 ha, 5285 Individual/private pond irrigating an area of 2643 ha and 19 government reservoirs irrigating an area of 672 ha in the district. From the ground water source, the irrigation existing is only through private open wells (12,595 nos. irrigating 6734 ha) and govt. and private bore wells. There are 1900 govt. Bore well irrigating an area of 3800 ha and 1477 private bore wells irrigating an area of 2954 ha. Total area irrigated from all source of irrigation is 167145 ha in the entire district.

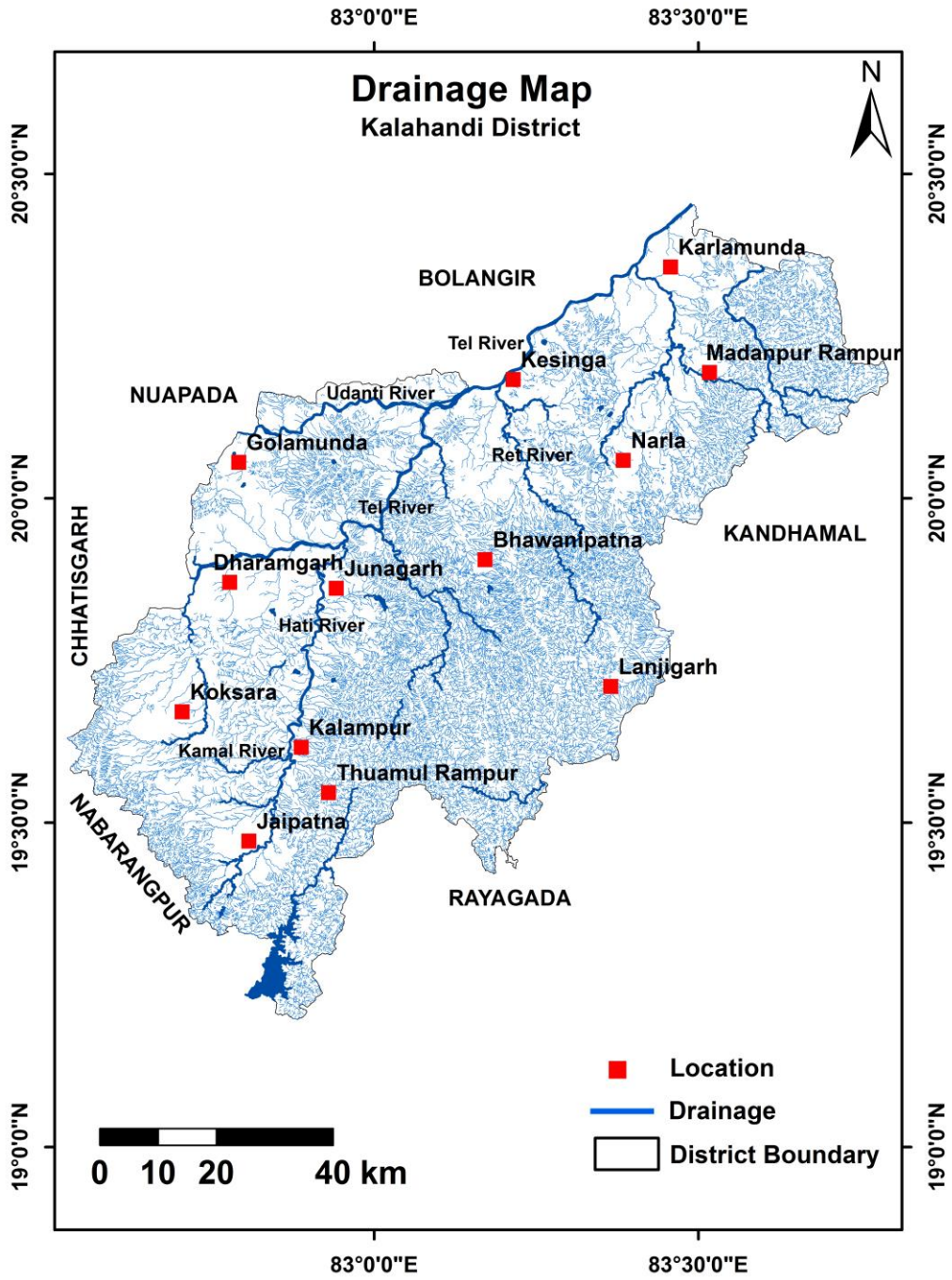

Fig. 1.7: Drainage Map of Kalahandi District.

2 DATA COLLECTION AND GENERATION

2.1 Geology

The district is underlain by Precambrian crystallines, metamorphics intrusives and Quaternary laterites and alluvium.The Quaternary alluvium is restricted to the close vicinity of the major drainage courses and occurs in thin patches. The generalized stratigraphic sequence is given 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 KalahandiDistrict.**

Group/Formation	Lithology	Age
Alluvium/ Laterite	Sand, silt, clay and gravels Laterites	Quaternary Recent to Sub-recent
~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~	~ ~ ~~ ~ ~ ~ ~ Unconformity ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~	~ ~ ~ ~ ~ ~ ~ ~ ~ ~
Easternghat Super Group	Younger intrusive (Anorthosite, gabbro, diorite, norite) Granitic suite (Porphyritic granite gneiss, garnetiferous granite,biotite granite gneiss, Pegmatite, Quartz veins) Charnockite suite (Acid and intermediate basic/ultrabasic Charnockites) Khondalite suite (Quartz-garnet-sillimanite schist and gneiss, garnetiferous quartzites, calc-silicates and granulites	Precambrian

Easternghat Super Group:

The Easternghat Super Group comprising Granite, Khondalite and Charnockite suite of rocks occupy major parts of the district. These groups of rocks represent a high grade metamorphism as evident from the abundant occurrence of garnet and sillimanite.

Khondalite Suite of Rocks: They are widely distributed in the district. The Khondalitic suit of rocks consists of mainly quartz-garnet-sillimanite-schist and gneiss and garnetiferous sillimanite-quarzite and calc silicate granulites. Khondalites are dark red or purple and grayish brown to pinkish brown in colour. These rocks are fine to medium grained in texture and well foliated. On weathering they give rise to laterite and bauxite.

Charnockite Suite of Rocks: The Charnockite suite of rocks consists of mainly of hypersthene bearing rocks varying from acid to basic in composition. Charnockite exhibits intrusive relationship with the Khondalites and forms hybrid gneisses both with the Khondalites and other ancient gneisses. Main rock types are hypersthene granite, pyroxene, amphibolite, andalusite gneisses etc. These are greenish grey to brownish black in colour. Spheroidal weathering is a common feature noticeable in Charnockite areas. However, weathering is not pronounced and foliations and joints are not well developed in them.

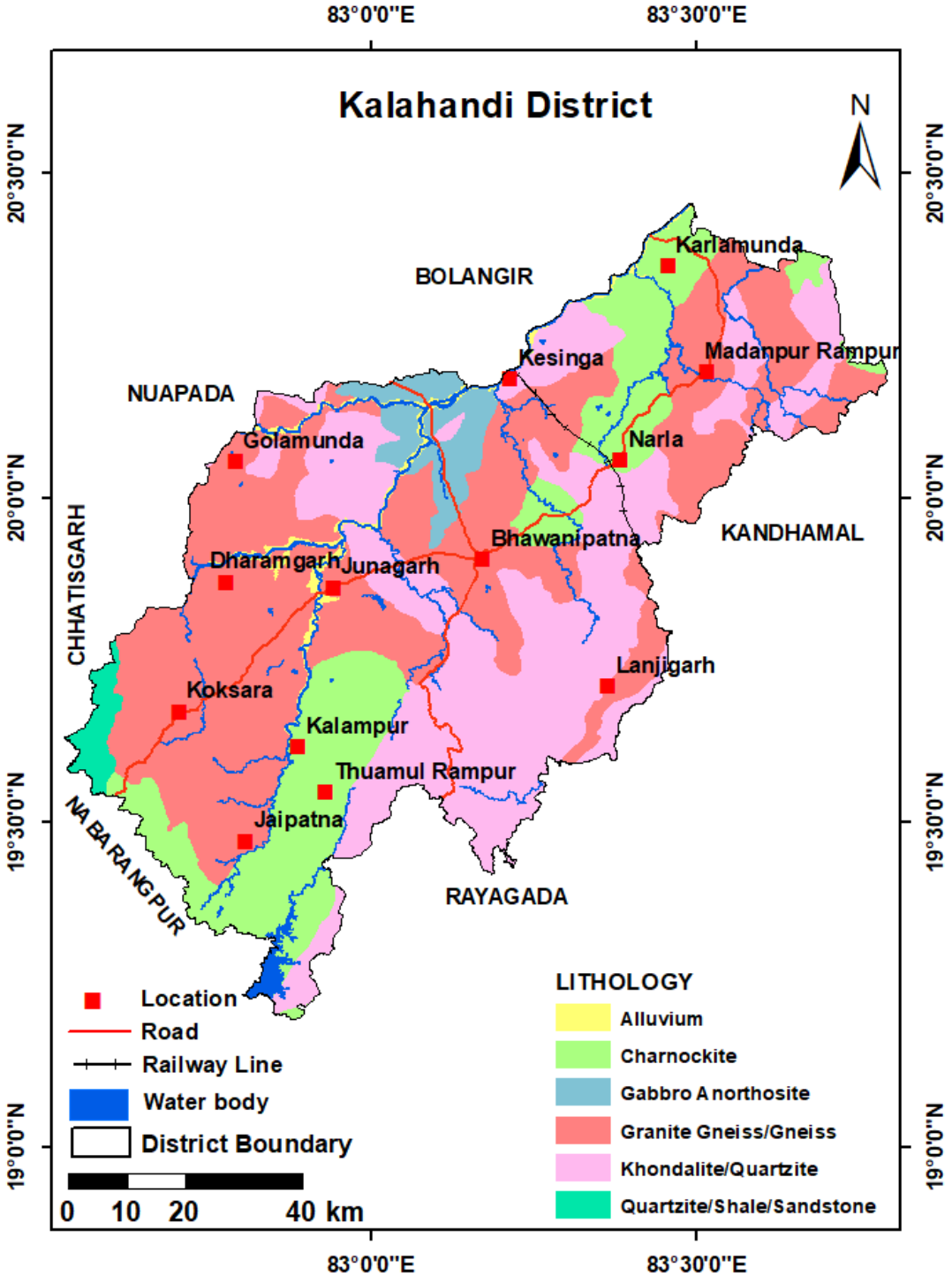

Fig. 2.1: Geological Map of Kalahandi District.

Granite and Granite Gneiss: These are the most predominant rock type in the district comprising porphyritic granite gneiss, garnetiferous granite gneiss, biotite granite gneiss and granite gneiss etc. These are light gray to gray in colour, fine to coarse grained and composed of quartz, feldspar, biotite, garnet etc. Phenocrysts of feldspar are common in the porphyritic granite gneisses. Granite gneisses exhibit wide variations in texture and composition due to different cycles of igneous activities and different grades of metamorphism. The granitic rocks exhibits well developed foliation but at places are compact and massive. In a few places the granite gneisses are intruded by dolerite dykes and intersected by veins of pegmatite and quartz.

In addition to these a number of quartz and pegmatite veins occur as intrusives in the district. These are coarse grained and hard and form good aquifers when fractured and friable.

Quaternary Group:

Laterites: Laterite in the district occurs as capping over the older formations as also in the valleys. Laterites of both high and low level environments occur extensively in the district. The laterite-covered plateaus probably represent uplifted and dissected erosional surfaces possibly of different generations. The Khondalite hills occurring in the southern parts of the district are capped with thick laterite ranging from 24 to 60 m.

Alluvium: Alluvium consisting mainly of sand, gravel, silt and clay occurs as thin discontinuous patches in the close vicinity of the major river/stream channels like Tel River and its tributaries.

Structure: The rocks of Easternghat group are highly metamorphosed, structurally deformed to considerable extent and transformed to various degrees. The regional trend of foliation and schistosity of the rocks of the Easternghat group is NE-SW and NNE-SSW. Foliations have steep (ranging from 40^0 to 70^0) easterly dips. The foliation trend of the porphyritic granite gneiss is $N30^0$-40^0E with 50^0 to 60^0 easterly dips. The most prominent open joints in this litho unit are $N50^0$E - $S50^0$W having steep dips. The rocks of Khondalite suite are highly foliated in conformity with the foliation trend of the granite gneisses. The most common and important sets of joints with opening ranging up to 20 mm are

(i) N-S dipping 50^0towards east. (ii) $N50^0E - S50^0W$ with steep dips and (iii) $N80^0E - S80^0W$ with steep dips.

Charnockites are usually compact and massive but at places exhibitst two sets of prominent joints trending (i) N – S with steep dips and (ii) $N50^0E - S50^0W$ with steeps dips.

There is a fault zone at the contact between the Easternghats groups and the Chhatisgarh group with the fault plane running in N – S direction.

2.2 Hydrogeology

The varied geological and structural set up primarily controls the Hydrogeological condition of the district. The geological formations of the district have diverse lithological composition and structure. Hence the hydrogeological condition too shows wide variations. Depending upon the geology, water bearing and water yielding properties, two major hydrogeological units have been identified in the district.

These are: Consolidated formations and
Unconsolidated formations.

In the former, comprising mostly the crystalline rocks devoid of primary porosity, ground water occurs mainly in the weathered zone as also in the weaker zone such as joints, shears, foliation planes and fractures etc. in the latter ground water occurs in the inter granular pore spaces.

Rainfall, climate, topography, depth of weathering, soil condition and landuse are the other factors controlling the ground water potentials of the area.The hydrogeological map of the area is presented in **Fig. 2.2**.

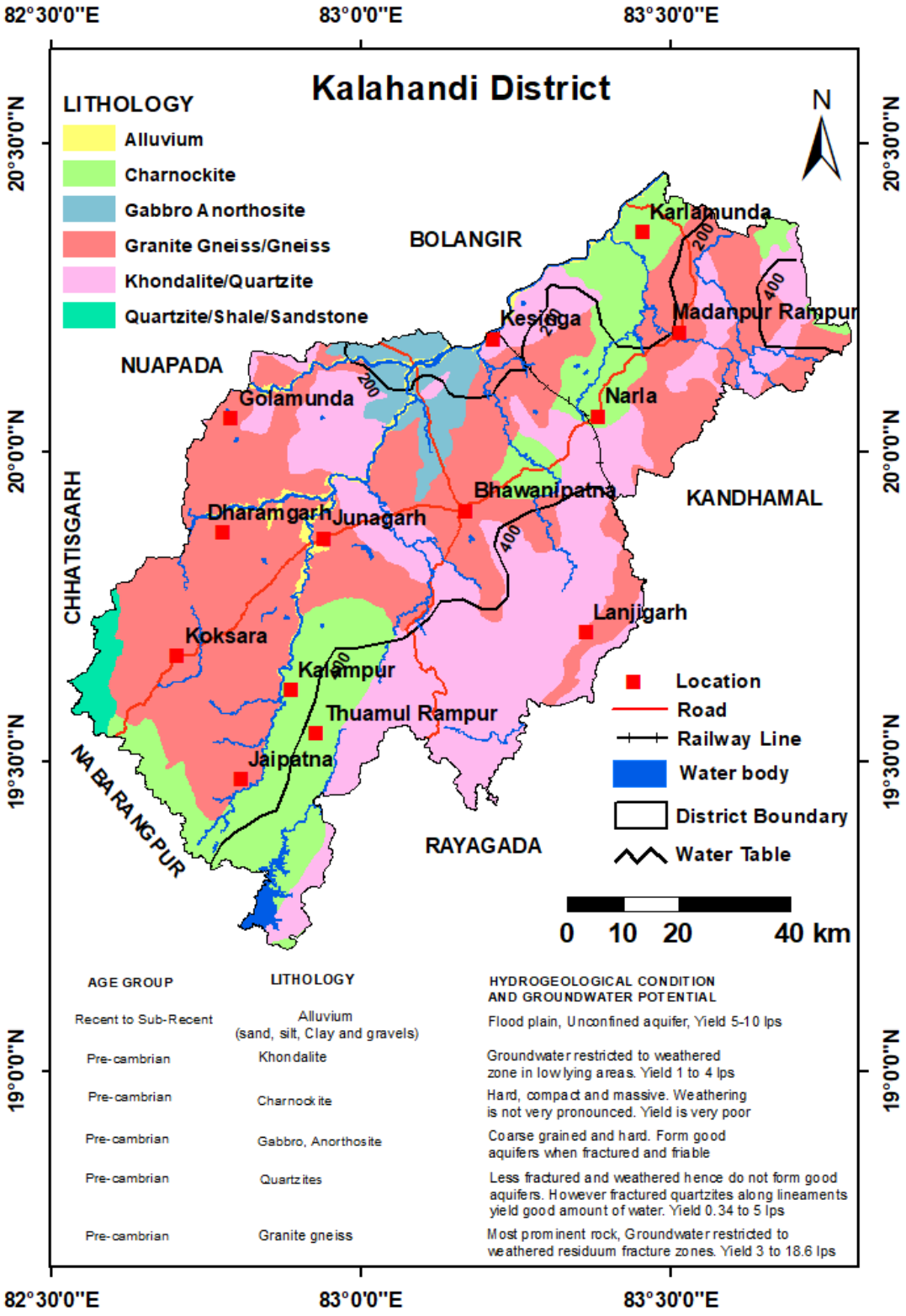

Fig. 2.2: Hydrogeological Map of Kalahandi District.

2.2.1 Water Bearing Formations

A. Consolidated Formations:

Except for a few thin alluvial patches occurring as small strips along major rivers, almost the entire district is occupied by the consolidated formations comprising granite gneisses, Khondalites, Quartzites, Charnockite, gabbro etc. these rocks are very hard and compact and lack of primary porosity. Ground water is stored mainly in the secondary porosity resulting from weathering and fracturing of the rocks. The aquifer materials are highly heterogeneous in character showing both vertical and lateral variations depending on the extent and nature of weathering and degree of fracturing and jointing. The weathered residium form the main repository of ground water, in which ground water occurs under water table condition and circulates through deeper fractures, crevices, open joints and movement. Ground water occurs under confined to semi-confined condition in the deeper fracture zones. The water yielding capacity of fractured rocks largely depends on the extent of fracturing, openness and size of fractures and extent of their interconnections to the near surface weathered zone. Usually two to four water bearing fracture zones occur down to a depth of 100 mbgl. Considering the water holding and water bearing properties two zones as directed below can be identified in consolidated formations.

(i) Weathered zone: The weathered zone forms the most potential ground water reservoir and the shallow aquifer in the consolidated formations. This is the so called dug well zone and is the popularly exploited zone in the hard rock areas. Weathering is most pronounced in granite gneisses occupying undulating plains and topographic lows. The weathered residuum generally ranges in thickness from 5 to 20 m (occasionally up to 30 m) in granite gneisses and is of lesser thickness in Khondlites and least in Charnockite. In the weathered zone ground water occurs under phreatic condition.

(ii) Fractured zone: Ground water in the fractured zones occurs under semi confined to confined conditions. Usually three to five water bearing fractured zones are encountered within a depth of 170 m and beyond this depth fracture zones are found to be less developed. The water bearing and yielding capability of the fractured zones depends largely on the extent of fracturing, size and openness of the fractures and the nature and degree of their interconnection.

Granite Gneiss: Theseare the most predominant rock types in the district occupying undulating terrain and topographic lows. On weathering these rocks yield sandy residuum and the intensity of weathering is controlled by the presence of open joints and foliations. Joints and fractures are well connected creating free circulation of ground water. In general these rocks can sustain yield between 3 and 18.6 lps depending on topographic setting, thickness of weathered residuum, number of saturated fracture zones encountered and their interconnection as inferred from the ground water exploration carried out by CGWB in the district. The weathered zones in the granite gneisses can be developed through open wells and bore wells.

Khondalites: The Khondalites, in general occupy the hills and have limited ground water development potentials except when they occupy low laying areas. Due to well foliated nature of these rocks, weathering is quite deep in low laying areas. These rocks are also well jointed. The thickness of the weathered zone ranges from 12 to 20 m. Ground water development potential of these rocks is meager except in low laying areas. The yield of the bore wells ranges from 1 to 4 lps as revealed by the ground water exploration carried out by CGWB in the district.

Charnockites: In these rocks weathering is not pronounced and foliations and joints are not well developed. These rocks are mostly hard, compact and massive. The thickness of weathered zone ranges from 6 to 10 m. Due to hard and compact nature of the rocks ground water development prospects in the Charnockite is not good and the yield from the bore wells is very poor.

Pegmatite and Quartz Veins: These are generally coarse grained and hard. When fractured and friable, they can form good aquifer.

B. Unconsolidated Formation

Laterites belonging to the Pleistocene age and alluvium of Sub-recent to Recent age constitute the unconsolidated formations in the district.

Laterites and lateritic gravels: Laterites of both high and low level environments occur extensively in the district forming capping over the older formations. Laterites occurring as capping over older formations are vesicular, ferruginous and highly porous in nature and at places

form good near surface aquifers to be tapped through dug wells. Ground water generally occurs under phreatic condition in the shallow zone.

Alluvial deposits: The alluvial sediments of recent origin occur as thin discontinuous patches long the prominent drainage channels and form prolific aquifers under favourable conditions. Of particular interest are the alluvial deposits occurring as discontinuous patches in the flood plains of major rivers such as Tel, Udanti, Ret and the alluvial fan deposits in Indravati, Nagavalli and Vansadhara sub basins. The thickness of alluvial deposits varies from 10 to 30 m in the Indravati and Tel sub basins. These mainly consist of silt, sand with gravel and clay and form potential shallow aquifers. Ground water occurs under phreatic condition and the water table lies at shallow depths. These deposits are very suitable for ground water development through dug wells and shallow tube wells. Yield of tube wells in the alluvium varies from 5 to 10 lps for drawdown ranging from 5 to 8 m.

2.3 Ground Water Exploration

In order to decipher the aquifer system of the area, CGWB has constructed 90 Exploratory Wells (EW), 29 Observation Wells (OW) under in-house departmental Ground Water Exploration programme, which are shown in **Fig. 2.3** and the data generated has been shown in **Table 2.2**. Apart from them, to mitigate the drinking water scarcity in the drought prone areas, 32 Nos. EWs were drilled under Accelerated Exploratory Drilling Programme (AEDP) on contractual basis in two phases. The exploration data generated has been given in **Table 2.3**.

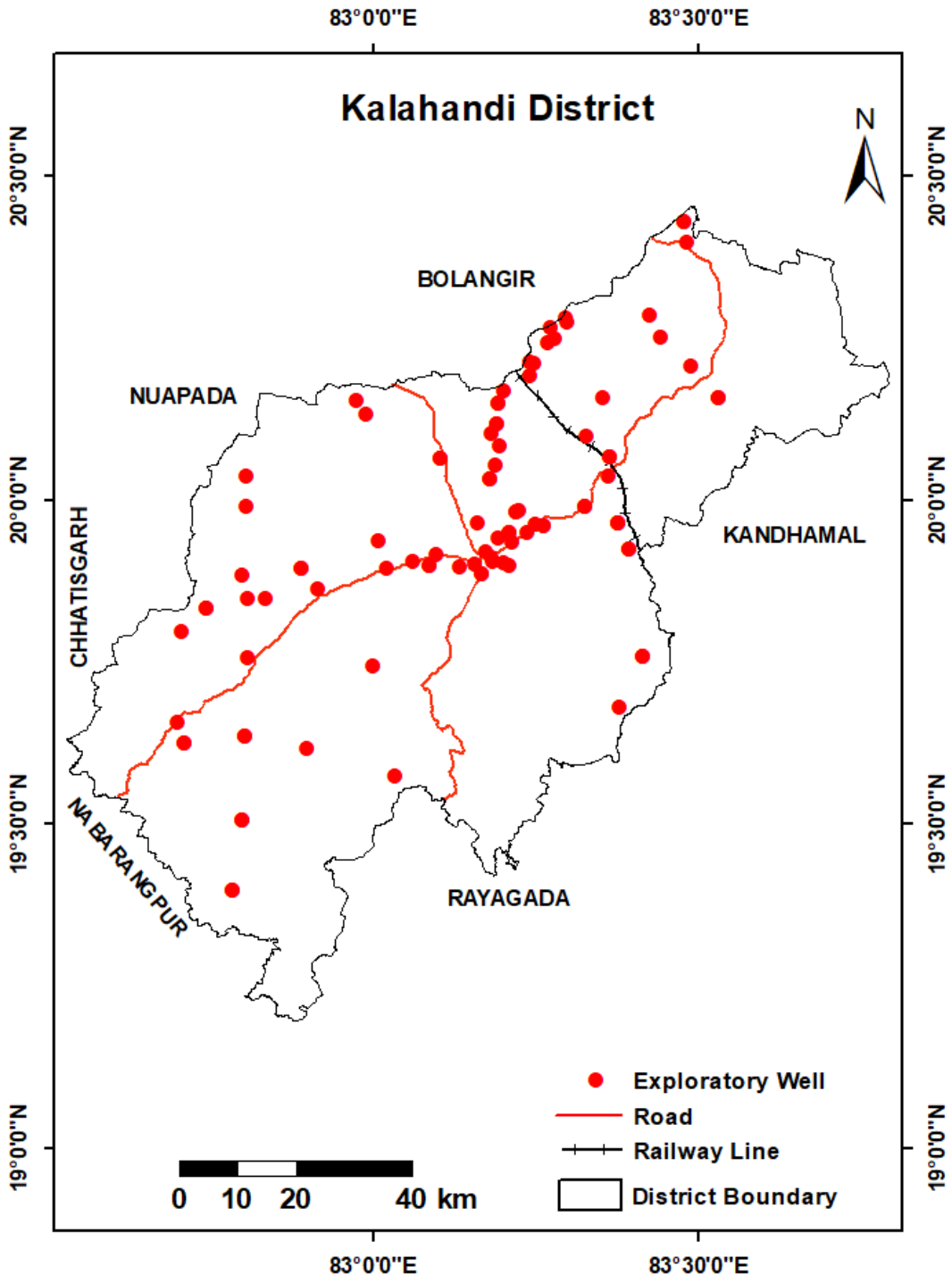

Fig. 2.3: Locations of Exploratory Wells Drilled by CGWB (In-House) inKalahandi District.

2.4 Monitoring of Ground Water Regime

CGWB is also engaged in ground water regime monitoring through 32 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**.

Quality of ground water from deeper aquifers is assessed during the drilling and pumping tests.The chemical data of 51 water samples collected during the exploration is given in **Table 2.6.**

Under NAQUIM, 123 dug wells were established during 2020-21 and water level is monitored both in pre and post monsoon and is given in **Table – 2.7**. During the NAQUIM programme, 123 water samples from shallow aquifer were collected during pre-monsoon period and results is given in **Table No.2.8**.

Table-2.2: Basic Data of Exploratory Wells Drilled by CGWB in Kalahandi District.

S.No	Location	Type	Latitude	Longitude	Depth Drilled (mbgl)	Lithology	Casing Depth (mbgl)	Depth of Fractured zone (mbgl)	SWL (mbgl)	Disch-arge (lps)	Draw-down (m)	T (m^2/day)	S
Block : BHAWANIPATNA													
1	Aarkabahalipada	EW	19.91389	83.16444	160.57	Gr. Gneiss	12.80	93-94	4.28	0.5			
2	Badili	EW	19.9000	83.0861	160.07	Gr. Gneiss	7.50	27,54,139	4.80	3.0	5.81	86.5	
3	Badili	OW	19.9000	83.0861	129.57	Gr. Gneiss	13.97	25,53,75	4.82				
4	Bhikapada	EW	19.8986	83.2083	153.97	Gr. Gneiss	20.30	24.77-25.87	5.30	1			
5	Bhawanipatna College	EW	20.1903	83.9250	123.55	Gr. Gneiss	12.30	52-53, 67-68.50	4.80	3.8	13.02	10.01	
6	Bhawanipatna Reserve Police Ground	EW	19.9206	83.1731	176.35	Gr. Gneiss	17.50	58-59, 88-89, 123.5-124.5	8.4	5.0	18.19	5.86	
7	Bhawanipatna Reserve Police Ground	OW	19.9206	83.1731	170	Gr. Gneiss	19.32	52-53, 94-95		5.0			
8	Bhawanipatna ITI	EW	19.8347	83.1872	197.20	Gr. Gneiss	24.30	68,73,78,99,108		2.5	33.15	1.34	
9	Bhawanipatna ITI	OW	19.8347	83.1872	179	Gr. Gneiss	22.20	22,30,43,48,65,79,94		4.0	28.22	3.23	
10	Bhawanipatna	EW	19.9130	83.1821	160.0	Gr. Gneiss	16.45	20.63,117,160	4.61	9.17	2.81		
11	Bhoothkothi	EW	19.9214	83.1736	184.47	Gr. Gneiss	6.40	88-88.50	4.08	0.5			
12	Borda	EW	20.1548	82.9741	220	Gr. Gneiss	15.20			0.5			
13	Borighat	EW	19.9006	83.1553	160.7	Gr. Gneiss	6.40	68-68.30	4.71	0.5			
14	Circuit House Bhawanipatna	EW	20.1889	83.9156	124.47	Gr. Gneiss	12.13	21,35,110		12.0			
15	Circuit House Bhawanipatna	OW	20.1889	83.9156	127.47	Gr. Gneiss	13.38	23,57		3.2			
16	Dadpur	EW	19.9806	83.2347	114.80	Gr. Gneiss	19.30	37,39,86	5.70	3.70	26.50	6.15	
17	Dadpur	OW	19.9806	83.2347	197.20	Gr. Gneiss	21.45	33,58,80,83,134,173	6.33	6.33	27.93	10.54	
18	Deypur	EW	19.9614	83.2626	100.65	Gr. Gneiss	7.50	100	5.33	14.00	5.95		
19	Deypur	OW	19.9614	83.2626	133.30	Gr. Gneiss	5.80	120,131	4.79	7.50	6.42		
20	Duarsuni	EW	20.1736	83.8750	97.95	Gr. Gneiss	19.97	24,52,61	3.11	17	7.24	70.74	
21	Duarsuni	OW	20.1736	83.8750	84.87	Gr. Gneiss	23.10	23,57,67,74					
22	Dungargarh	EW	19.9500	83.2375	141.77	Gr. Gneiss	20.50	30,130	1.70	2.50	13.57	2.67	
23	Gachkhola	EW	19.9575	83.2472	160	Gr. Gneiss	14.50	112	4.71	0.50			

24	Gananathpur	EW	19.9417	83.1917	140	Kh. Gneiss	14.80	32-33	1.30	1.0			
25	Gopinathpur	EW	19.9625	83.2506	129.57	Kh. Gneiss	11.25	18,110	1.52	1.50			
26	Gudialipadar	EW	19.9506	83.2083	86.87	Gr. Gneiss	14.70	19.77-20.77,56.37-57.37	1.99	5.0	24.08	4.95	
27	Gudialipadar	OW	19.9506	83.2083	86.87	Gr. Gneiss	16.75	27.87-28.87,52.27-53.27	1.91	5.0			
28	Ichapur	EW	19.9419	83.2292	86.87	Gr. Gneiss	11.26	32-33,45-47,56-58,78,85	3.60	12.0	9.70	22.5	
29	Ichapur	OW	19.9419	83.2292	89.87	Gr. Gneiss	11.50	85-86, 88-89					
30	Irrigation Colony	EW	19.9056	83.1847	148.87	Gr. Gneiss	21.50	78-78.50	3.40	0.5			
31	Jamunabahal	EW	19.9833	83.2250	146.77	Gr. Gneiss	18.0	68.57-69.57	1.0	0.5			
32	Jaring	EW	19.8958	83.0208	155.97	Gr. Gneiss	11.50	26.87-27.87,90.87-91.97	4.90	4	17.38	3.48	
33	Kamthana	EW	20.1250	83.9639	160.15	Gr. Gneiss	5.65	6-8,92	5.0	0.5			
34	Karlapada	EW	20.0641	83.1032	148.40	Gr. Gneiss			1.90	5.0	27.13		
35	Karlapada	OW	20.0641	83.1032	191.10	Gr. Gneiss			4.25	1.0			
36	Kutrukhamar	EW	19.9061	83.0600	153.87	Gr. Gneiss	6.42	84-84.30	4.21	0.50			
37	Malgaon	EW	20.1139	83.9222	185.47	Gr. Gneiss	19.30		4.71				
38	Medinipur	EW	19.9225	83.2100	191.0	Gr. Gneiss	28.40						
39	Naktiguda	EW	20.1417	83.9125	86.77	Gr. Gneiss	7.16	59-59.50		<0.5			
40	Risigaon	EW	19.8972	83.1333	167	Gr. Gneiss	20.20	26.87-27.87		1.0			
41	Singhjharani	EW	19.9164	83.0972	153.97	Gr. Gneiss	7.50	22,31,46	4.98	4.30	3.37	44.28	
42	Sitabadi	EW	19.9042	83.2000	153.97	Gr. Gneiss	15.33	38-38.30	3.40	<1			
43	Uditnarayannpur	EW	20.1528	83.9431	117.57	Gr. Gneiss	13.0	90-92,	1.65	4.3	26.29	6.79	
44	Uditnarayannpur	OW	20.1528	83.9431	105.17	Gr. Gneiss	13.0	89-90.50		4			
Block : Dharamgarh													
45	Boden	EW	20.2486	82.5750	131.5	Granite	16.40	24,50,75,95,107,130	6.63	12.94	5.5	34.10	
46	Dharamgarh	EW	19.9117	82.9322	200	Granite	11.50	26.4,56.9, 81.3	4.54	0.41			
47	Dharamgarh	EW	19.8481	82.8344	200.0	Gr. Gneiss	10.00	24	4.06	0.34			
48	Dharamgarh	OW	19.3977	82.7829	136.4	Gr. Gneiss	4.15		4.17	0.71			
49	Kasibahal	EW	19.8567	82.8069	200.2	Gr. Gneiss	17.0	20.30-21.30	6.80	2.0	26.4	2.32	
50	Parla	EW	19.8056	82.7056	158.50	Gr. Gneiss	10.60	147.30-148.40	10.41	3.0	17.53	10.90	
51	Parla	OW	19.8056	82.7056	200.20	Gr. Gneiss	10.50	127-128,187-188	6.74	1.0	20.87	0.50	
Block : Golamunda													
52	Brundabahal	EW	19.9769	82.8264	160.20	Gr. Gneiss	13.0	96,123,156	2.35	2.50	25.60	2.20	
53	Chaparia	EW	20.0944	82.4194	197.20	Gr. Gneiss	20.90	22,35	1.37	1.80	11.74	3.0	

54	Golamunda	EW	20.0731	82.7931	180	Gr. Gneiss	11.40	14-15	5.20	0.54	33.77	0.23	
Block : Jaipatna													
55	Baner	EW	19.5077	82.7987	166.00	Gr. Gneiss	10.60	15,70,147	5.99	5.00	18.69	8.5	
56	Baner	OW	19.5077	82.7987	109.00	Gr. Gneiss	14.50	35,74,106	5.86	5.50	23.27	4.26	
57	Jaipatna	EW	19.4700	82.8114	174.80	Gr. Gneiss	8.10	68-69,148.4-149.4,172	4.20	3.66	27.13	1.46	
58	Jaipatna	OW	19.4700	82.8114	136.20	Gr. Gneiss	4.65	21,81	3.10	0.7	35.8	1.48	
59	Ranmal	EW	19.6556	82.8050	172.80	Gr. Gneiss	14.40	23,76,159	45.63	2.50	5.88	7.06	
60	Ranmal	OW	19.6556	82.8050	191.10	Gr. Gneiss	9.10	14,24,75,95,179	3.49	4.50	14.92	16.94	
Block : Junagarh													
61	Charbahal	EW	19.7633	83.4500	197.20	Gr. Gneiss	16.60	20,37,60	1.66	0.34	30.62	0.14	
62	Chichiguda	EW	19.8903	82.8783	174.0	Gr. Gneiss	32.50	36,87,171	6.20	2.40	45	0.61	
63	Choriagarh	EW	19.8275	82.89306	200.20	Gr. Gneiss	17.40	38,187	7.52	3.0	24.92	2.98	
64	Junagarh	EW	19.9381	83.0086	154.50	Quarzite	47.40	75,93	5.38	5.00	19.72		
65	Nandul	EW	19.8706	82.9597	136.30	Gr. Gneiss	26.0	26,59,68,134		12.0	18.12	24.55	
66	Nandul	OW	19.8706	82.9597	178.90	Gr. Gneiss	31.50	35	3.15	0.3			
Block : Kalampur													
67	Dasigaon	EW	19.6972	82.9042	187.60	Gr. Gneiss	27.0	28,40,151	3.64	2.50	30.56	0.96	
68	Kalampur	EW	19.6147	82.9747	172.80	Gr. Gneiss	26.40	29,50,59,75	4.60	1.30	33.74	0.33	
Block : Karlamunda													
69	Risida	EW	20.3974	83.4838	191.00	Gr. Gneiss	2.00	8,43,59,116,125	3.58	1.90	27.48		
70	Teresinga	EW	20.3933	83.4492	190.70	Gr. Gneiss	5.60	9.6-14.8,33.1-34.1,91-93	1.87	5	9.03	14.91	
71	Teresinga	OW	20.3933	83.4492	184.60	Gr. Gneiss	3.0	9,14,18-28	2.33	4.2	23.73	14.43	
Block : Kesinga													
72	Boria	EW	20.1180	83.1893	185.0	Granite		41,45,55,79,85	6.33	4.20	33.72		
73	Boria	OW	20.1180	83.1893	200.20	Granite			6.85	4.00	26.65		
74	Chancher	EW	20.0908	83.1903	171.83	Gr. Gneiss	15.70	84-84.50	4.31	0.5			
75	Gaigaon	EW	20.0550	83.1881	166.17	Gr. Gneiss	12.0		5.68				
76	Ghatpada	EW	20.2667	83.2722	153.97	Gr. Gneiss	13.0	94	4.57	0.5			
77	Kantaswari	EW	20.1928	83.2412	195.00	Granite							
78	Kashrupada	EW	20.2437	83.2689	200.20	Granite			7.72	0.50			
79	Kesinga	EW	20.1889	83.2100	160	Quarzite	14.50	14,21,113,120	1.65	0.88	7.50	1.12	
80	Kikiya	EW	20.1458	83.1514	159.97	Gr. Gneiss	17.42	67-68		<1			

81	Kinerkela	EW	20.2817	83.2958	123.47	Gr. Gneiss	12.20	32-33,72-73	4.37	6.0	14.02	14.38	
82	Kinerkela	OW	20.2817	83.2958	99.07	Gr. Gneiss	9.90	71-72.50		3.5			
83	Kurlupada	EW	20.2103	83.2472	113.17	Gr. Gneiss	11.0	18-19,50-51,93-94	3.42	7.5	9.7	22.50	
84	Kurlupada	OW	20.2103	83.2472	105.17	Gr. Gneiss	13.50	29-30, 93-94		7.0			
85	Kusrupada	EW	20.2489	83.2783	166.07	Gr. Gneiss	13.85	38-39, 87-89		2.50			
86	Nasigaon	EW	20.0075	83.2111	161.07	Gr. Gneiss	17.0	54-54.50	5.31	<0.5			
87	Pastikudi	EW	20.0178	83.1650	172.0	Gr. Gneiss	9.70	10,19,66,88,172	6.30	4.50	29.75	4.97	
88	Pastikudi	OW	20.0178	83.1650	170.0	Gr. Gneiss	9.70	12,18,29,47,51,167	6.15	5.70	27.15	3.28	
89	Phatkamal	EW	20.0317	83.1672	161.07	Gr. Gneiss	8.57	62-62.50	5.10	<0.5			
90	Turlakhaman	EW	20.2856	83.4250	153.97	Gr. Gneiss	25.90						
91	Utkela	EW	20.1036	83.1808	153.97	Gr. Gneiss	11.57	4-6,69	5	<0.5			
Block : Koksara													
92	Koksara	EW	19.6667	82.7042	166.70	Granite	8.74	50,56,75,93,124,154	5.0	6.47	19.09	8.47	
93	Kaudola	EW	19.7969	82.7050	178.80	Gr. Gneiss	17.70	19		0.5			
94	Ladugaon	EW	19.6111	82.7050	146.30	Gr. Gneiss	12.20	15,22,82,124	4.20	4.0	22.02	5.44	
95	Ladugaon	OW	19.6111	82.7050	148.60	Gr. Gneiss	15.20	17,20,71,90,95	3.99	2.36	15.33	4.55	
Block : Lanjigarh													
96	Biswanathpur	EW	19.7597	83.4155	99.60	Gr. Gneiss	10.75	52	13.40	10.00	4.35		
97	Biswanathpur	OW	19.7597	83.4155	60.70	Gr. Gneiss	6.90	40,47,60	20.90	18.60	6.17		
98	Kiding	EW	19.9364	83.3864	148	Gr. Gneiss	37.30	42.60-45.70	1.42				
99	Lanjigarh Road	EW	19.9469	82.4078	184	Gr. Gneiss	33.20	45,57,76,102,106,136	7.17	5.0	14.75	20.80	
100	Lanjigarh Road	OW	19.9469	82.4078	69.10	Gr. Gneiss	26.0	32,52	8.54	9.0	11.95	26.35	
101	Lanjigarh Road	OW	19.9469	82.4078	80.20	Gr. Gneiss	24.30	31,43,57,75	8.57	9.0	25.70	34.70	
102	Lanjigarh	EW	19.6756	83.3681	166.70	Gr. Gneiss	30.25	25.3-29.4,32.5-34.5	6.55	0.6	18.60	0.48	
Block : M Rampur													
103	Jalko	EW	20.1486	83.1927	149.00	Gr. Gneiss			5.19	4.50			
104	Jalko	OW	20.1486	83.1927	187.50	Gr. Gneiss			5.17	3.50			
105	Madanpur	EW	20.3083	83.5333	186	Gr. Gneiss	20.60	34.10-38.20,84.9-85.9	6.14	0.75			
106	M.Rampur	EW	20.1576	83.5316	200	Gr. Gneiss	23	21,63,106,180	3.5	1.11	8		
107	Narla Road	EW	20.0659	83.3631	136.00	Gr. Gneiss	13.20	59,133	7.05	2.50	25.28		
108	Narla Road	OW	20.0659	83.3631	145.70	Gr. Gneiss	19.00	75,145	6.35	3.33			
109	Turchi	EW	20.2486	83.4722	185	Gr. Gneiss	11.0	33-38.60	2.8	3.75	22.60	13.17	

Block : Narla													
110	Bagpur	EW	20.10611	83.39861	68.58	Gr. Gneiss	24.50	36-36.40	4.71	0.5			
111	Ghantamal	EW	20.0203	83.3442	171.83	Gr. Gneiss	13.36	86					
112	Mandel	EW	20.0794	83.3628	198	Gr. Gneiss	13.80	38.6-39.6,134.1-136.2	8.24	1.20		0.77	
113	Narla	EW	20.0372	83.3616	200.20	Gr. Gneiss		24,37,53,56		0.80	29.32		
114	Rupra	EW	20.1574	83.3527	192.00	Gr. Gneiss	11.40	26,61	4.52	0.40			
115	Rupra Road	EW	20.0994	83.3289	200.20	Gr. Gneiss	8.60	13,16,48	1.55	2.00	30.98		
116	Santpur	EW	19.9897	83.3263	114.80	Gr. Gneiss		13,74,97		4.0			
117	Santpur	OW	19.9897	83.3263	94.50	Gr. Gneiss		13,74,92		4.0			
118	Tulapada	EW	20.1300	83.4308	160	Gr. Gneiss	10.10	146-146.50	4.71	<0.5			
Block : T Rampur													
119	Gopalpur	EW	19.5647	83.5569	185	Granite	9.60	77,167,185	11.95	5.0	21.81	8.33	

Table 2.3: Basic Data of Exploratory Wells Drilled by CGWB under AEDP in Kalahandi District.

S.No	Location	Block	Type	Depth Drilled (mbgl)	Casing Depth (mbgl)		Hard Rock Depth (mbgl)	Fractures	SWL (mbgl)	Disch-arge (lps)
					Dia 250 mm	Dia 203 mm	Dia 152 mm			
PHASE-I ofAEDP										
1	Madigurha	Bhawanipatna	EW	129.5	5.14	5.64	123.86	76.5,85	11.22	2.5
2	Pastikudi	Bhawanipatna	EW	150	5.50	6.10	144.50	57,129	-	5.0
3	Jagannathpur	Bhawanipatna	EW	150	17.66	18.16	120.34	32	-	1.0
4	Kutrakhamar	Bhawanipatna	EW	150	11.80	12.20	138.2	14,21	-	3.0
5	College area	Bhawanipatna Municipality	EW	150	20.23	20.73	129.77	28	-	1.0
6	Uchhla	Jaipatna	EW	150	11.60	12.10	138.40	17,59	-	3.5
7	Barpujariguda	Jaipatna	EW	22	11.70			Abandoned		
8	Charbahal	Junagarh	EW	150	20.74	21.34	129.26	50,105		2.5
9	Matigaon	Junagarh	EW	25	45.50			Abandoned		
10	Pondigaon	Kalampur	EW	150	8.65	9.15	141.35	58	10.82	1.0
11	Kandel	Kesinga	EW	145	17.65	18.16	127.94	82	-	4.0
12	Kasibahal	Koksara	EW	150	8.50	9.00	141.50	13,30		5.0
13	Ampani	Koksara	EW	123	17.80	18.30	105.20		5.21	8.0
14	Kamardha	Koksara	EW	128	14.70	15.20	113.30	45.5	-	2.5

15	Lanjigarh	Langigarh	EW	150	22.30	22.80	127.7	91	12.62	1.0
16	Nishanpur	Narla	EW	150	11.70	12.20	138.3	30		1.0
17	Rekhpur	Narla	EW	150	17.80	18.20	132.2	32		1.0
18	Thuamal Rampur	Thuamal Rampur	EW	150	8.65	9.15	141.35	75	11.22	1.0
PHASE-I I of AEDP										
19	Borbhatta	Bhawanipatna	EW	150	13.4	14	136.6	94.5		2.0
20	College Pada	Bhawanipatna MNC	EW	150	13.7	14	136.3	19,137		3.0
21	Kenagaon	Dharamgarh	EW	150	23.8	24.4	126.2	54,146.5		1.0
22	Goudchendia	Junagarh	EW	150	23.17	23.77	126.83	35		1.0
23	Bhairiguda	Junagarh	EW	150	32.45	33.5	117.55	73		3.3
24	Patharla	Kesinga	EW	76	19	19.5	57	39,75		10
25	Kikia	Kesinga	EW	150	11.7	12.2	138.3	73		0.5
26	Ward no.9/Boringpadar	Kesinga NAC	EW	150	39	39.6	111	66,88,100,119.5		0.8
27	Kantasir/Tansir	Kesinga NAC	EW	150	27	27.4	123	-		Negligible
28	Ward No.8/Boringpadar	Kesinga NAC	EW	150	14.65	15.25	135.35	63.5		Negligible
29	Moter	Koksara	EW	150	20.59	21.34	129.41	48.8,78,129.3		4.3
30	M.Rampur	M.Rampur	EW	136.6	9.46	10.06	127.14	136.6		2.0
31	Narla Road	Narla	EW	150	29.9	30.5	120.1			Negligible
32	Tulapada	Narla	EW	150	8.08	8.53	141.92	34		1.5

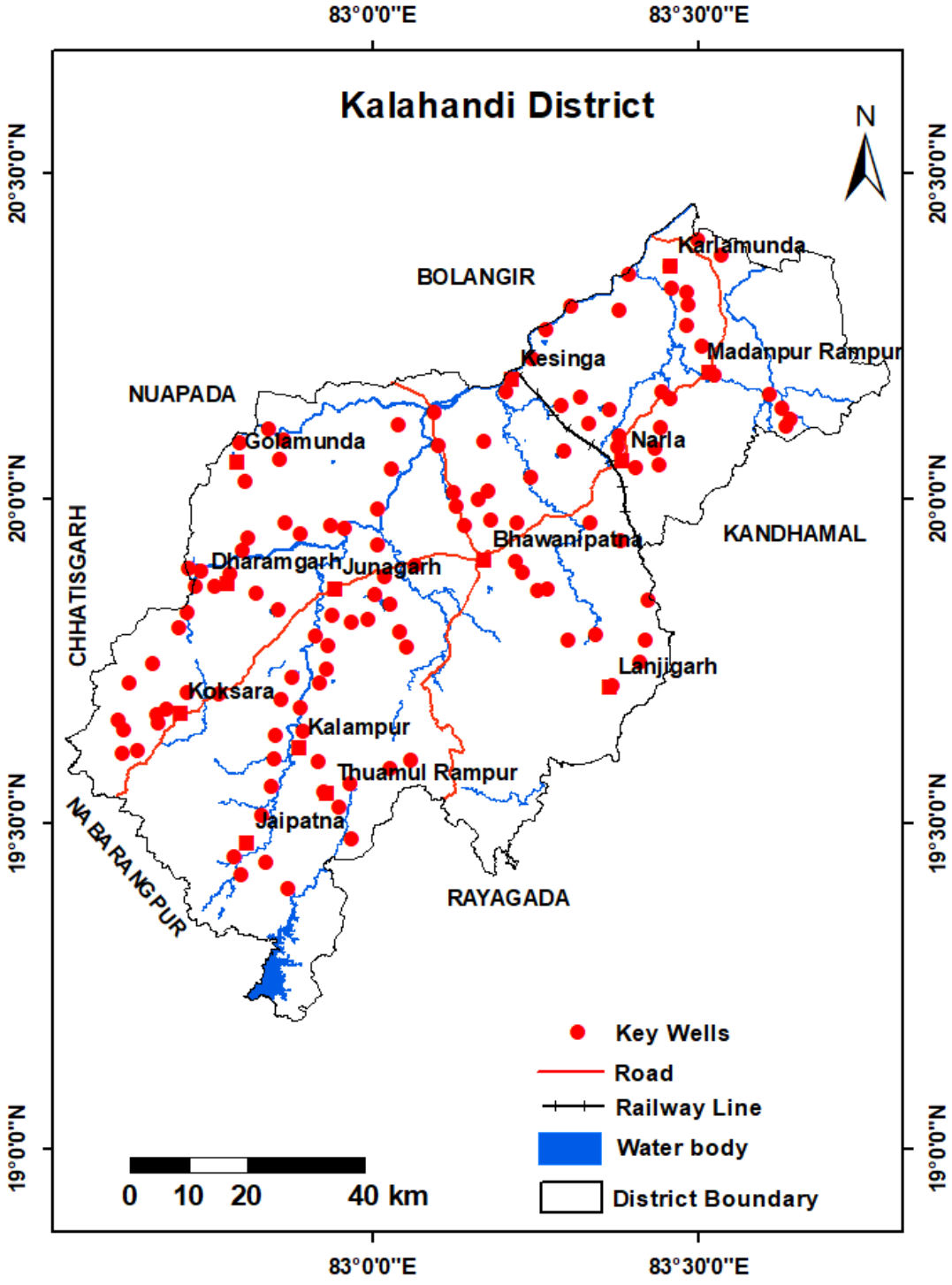

Fig. 2.4: Locations of Ground Water Monitoring Stations in Kalahandi District.

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

Sl No	Location	Block	Type	Longitude	Latitude	Elevation (maMSL)	Pre-Monsoon DTWL (mbgl)	Post-Monsoon DTWL (mbgl)
1	Dalguma	Bhawanipatna	NHNS	83.1208	19.8167	255	9.3	7.92
2	Sargigora	Bhawanipatna	NHNS	82.9900	20.1708	221	10.1	6
3	Bawanipatna	Bhawanipatna	NHNS	83.1592	19.9081	252.7	8.06	3.64
4	Attanguda	Bhawanipatna	NHNS	83.1589	19.8658	256	5.1	1.66
5	Malgaon	Bhawanipatna	NHNS	83.1139	19.9275	237.3	5.6	1.49
6	Dharamgarh	Dharamagarh	NHNS	82.7797	19.8700	249.3	6.94	3.7
7	Kegaon	Golamunda	NHNS	82.8958	20.1042	214	6.54	3.37
8	Golamunda	Golamunda	NHNS	82.7883	20.0556	241	5.1	3.06
9	Bijamara	Jayapatna	NHNS	82.8200	19.5583	249	4.4	3.1
10	Baner	Jayapatna	NHNS	82.8139	19.5311	242.1	3.98	0.94
11	Badbasul	Junagarh	NHNS	82.8375	19.8356	227	6.4	4.1
12	Chiliguda1	Junagarh	NHNS	82.9106	19.7325	222.3	3.4	2.86
13	Junagarh 1	Junagarh	NHNS	82.9386	19.8650	224	5.1	2.49
14	Mahichala	Junagarh	NHNS	82.8458	19.7778	232	2.07	1.68
15	Tal Jaring	Junagarh	NHNS	83.0208	19.8947	228	4.4	1.61
16	Charbahal	Junagarh	NHNS	82.8114	19.7408	239.7	5.3	1.29
17	Baldiamal	Junagarh	NHNS	82.9069	19.8439	212.3	3.6	0.87
18	Bandigaon	Kalampur	NHNS	82.8139	19.6069	240.9	3.1	1.81
19	Kalampur	Kalampur	NHNS	82.8833	19.6222	229.3	2.63	1.6
20	Risida	Karlamunda	NHNS	83.4728	20.4014	164.3	6.57	1.89
21	Tundala	Kesinga	NHNS	83.3561	20.2994	167.2	5.6	3.23
22	Sunamala	Kokasara	NHNS	82.6894	19.6194	283.2	4.4	2.19
23	Ampani	Kokasara	NHNS	82.6244	19.5822	325.8	4.83	1.98
24	Koksara	Kokasara	NHNS	82.6950	19.6756	274.3	3.9	1.19
25	Biswanathppur	Lanjigarh	NHNS	83.4319	19.8172	388.7	7.1	3.85
26	Bakatpur	Lanjigarh	NHNS	83.4239	19.8433	420	4.05	3.84
27	Pokaribandh	Lanjigarh	NHNS	83.4208	19.8528	444.7	8.1	1.78
28	Madanpur1	Madanpur Rampur	NHNS	83.5325	20.3078	200	6.5	3.86
29	M-rampur	Madanpur Rampur	NHNS	83.5250	20.1972	210.3	5.12	3.71
30	Santapur	Narala	NHNS	83.3211	19.9689	277.9	4.23	3.03
31	Tulapada	Narala	NHNS	83.4178	20.1275	218.7	2.52	0.45
32	Gunupur	Thuamul Ram Pur	NHNS	83.1167	19.6083	712	1.56	1.18
						MIN	**1.56**	**0.45**
						MAX	**10.1**	**7.92**
						AVG	**5.17**	**2.66**

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

Sl No	Location	Block	Latitude	Longitude	pH	EC	Hardness	Alkalinity	Ca++	Mg	Na+	K+	CO3=	HCO3-	Cl-	SO4=	F-	SAR
						µS/cm	as CaCO3 mg/L		mg/L									
1	Dalguma	Bhawanipatna	19.8167	83.1208	8.09	800	340	285.25	72	38.99	20	10	0	348	87	12	0.24	0.47
2	Sargigora	Bhawanipatna	20.1708	82.9900	7.92	1150	345	280.33	30	65.68	104	1.8	0	342	177	40	1.6	2.44
3	Bawanipatna	Bhawanipatna	19.9081	83.1592	8.3	1530	450	400	32	90	143	2.8	0	488	187	38	1.44	2.93
4	Attanguda	Bhawanipatna	19.8658	83.1589	7.92	1330	550	285.25	130	54.86	51	1.49	0	348	242	43	0.22	0.95
5	Malgaon	Bhawanipatna	19.9275	83.1139	8.08	600	250	264.75	32	41.37	20	2.8	0	323	20	5	1.53	0.55
6	Dharamgarh	Dharamagarh	19.8700	82.7797	7.8	1120	370	200	52	58.41	85	1.8	0	244	210	46	0.18	1.92
7	Kegaon	Golamunda	20.1042	82.8958	7.57	890	325	209.84	38	55.97	52	3.8	0	256	141	19	0.36	1.25
8	Golamunda	Golamunda	20.0556	82.7883	8.44	1460	185	530.33	40	20.71	245	6.1	60	525	92	39	1.7	7.84
9	Bijamara	Jayapatna	19.5583	82.8200	7.86	1100	425	154.92	68	62.08	54	5.6	0	189	212	52	0.29	1.14
10	Baner	Jayapatna	19.5311	82.8139	7.67	670	265	145.08	54	31.67	31	1.6	0	177	102	26	0.16	0.83
11	Badbasul	Junagarh	19.8356	82.8375	8.27	2970	450	609.84	42	83.93	474	3.35	0	744	280	434	3.32	9.72
12	Chiliguda1	Junagarh	19.7325	82.9106	7.64	1090	380	140.16	88	39.01	72	2.8	0	171	250	36	0.11	1.61
13	Junagarh 1	Junagarh	19.8650	82.9386	7.76	720	255	154.92	38	38.95	45	2	0	189	106	29	0.2	1.23
14	Mahichala	Junagarh	19.7778	82.8458	7.89	1430	460	264.75	40	87.58	100	25.8	0	323	250	81	0.17	2.03
15	Tal Jaring	Junagarh	19.8947	83.0208	8.21	460	180	190.16	34	23.14	19	5.8	0	232	26	1	0.28	0.62
16	Charbahal	Junagarh	19.7408	82.8114	7.98	390	185	109.84	38	21.93	2	2	0	134	42	15	0.21	0.06
17	Baldiamal	Junagarh	19.8439	82.9069	7.48	1000	365	340.16	46	60.84	59	5	0	415	87	35	0.71	1.34
18	Bandigaon	Kalampur	19.6069	82.8139	7.99	520	250	250	74	15.89	2	1.5	0	305	20	4	0.25	0.06
19	Kalampur	Kalampur	19.6222	82.8833	7.96	490	150	180.33	32	17.06	41	1.8	0	220	26	9	0.26	1.46
20	Risida	Karlamunda	20.4014	83.4728	7.98	440	175	185.25	26	26.78	19	2.1	0	226	15	6	0.2	0.62
21	Tundala	Kesinga	20.2994	83.3561	7.56	1580	615	325.41	48	120.41	79	1.2	0	397	295	44	0.6	1.39
22	Sunamala	Kokasara	19.6194	82.6894	7.98	3030	770	535.25	44	160.52	341	2.8	0	653	488	250	0.93	5.35
23	Ampani	Kokasara	19.5822	82.6244	7.73	730	280	285.25	62	30.47	36	4.95	0	348	55	1	0.54	0.94
24	Koksara	Kokasara	19.6756	82.6950	8.26	1330	315	395.08	38	53.54	156	5.8	0	482	145	16	0.54	3.82
25	Biswanathppur	Lanjigarh	19.8172	83.4319	8.13	580	175	169.67	42	17.07	51	0.4	0	207	71	23	0.43	1.68
26	Bakatpur	Lanjigarh	19.8433	83.4239	7.91	220	100	100	34	3.69	1	3.21	0	122	10	0	0.25	0.04
27	Pokaribandh	Lanjigarh	19.8528	83.4208	7.8	510	205	164.75	34	29.22	20	2.1	0	201	49	18	0.17	0.61

28	M-rampur	Madanpur Rampur	20.1972	83.5250	8.15	370	130	130.33	40	7.34	20	5.2	0	159	37	0	0.23	0.76
29	Santapur	Narala	19.9689	83.3211	7.63	800	280	250	32	48.67	53	1.8	0	305	95	14	1.52	1.38
30	Tulapada	Narala	20.1275	83.4178	7.95	430	165	180.33	42	14.64	20	1.8	0	220	20	2	0.2	0.68
31	Gunupur	Thuamul Rampur	19.6083	83.1167	7.92	300	145	104.92	36	13	1	1	0	128	20	4	0.21	0.04
				MIN	**7.42**	**220**	**100**	**100**	**22**	**3.69**	**1**	**0.4**	**0**	**122**	**10**	**0**	**0.09**	**0.04**
				MAX	**8.55**	**3030**	**770**	**609.84**	**130**	**160.52**	**474**	**25.8**	**84**	**744**	**488**	**434**	**3.32**	**9.72**

Table-2.6: Ground Water Quality Data of Exploratory Wells in Kalahandi 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	Badli	Bhawanipatna	19.9000	83.0861	6.68	630		220	72	9.73	37	6			16			0.68	
2	Bhawanipatna College	Bhawanipatna	20.1903	83.9250	7.86	773		2.55	56	28	63	0.7		339	50	18	0	1.15	0.07
3	Bhawanipatna Reserve Police Ground	Bhawanipatna	19.9206	83.1731	7.98	156		60	16	4.9	8.6	1.6		73	7.1	1.2	7.6	0.49	
4	Bhawanipatna ITI	Bhawanipatna	19.8347	83.1872	7.61	767	449	205	48	21	86	1.4	0	363	51	37		0.95	0.91
5	Dadpur	Bhawanipatna	19.9806	83.2347	7.98	481	316	115	34	7.3	49	5.1	0	195	30	6.8	22	0.56	0.39
6	Duarsuni	Bhawanipatna	20.1736	83.8750	7.67	656		240	46	30	47	0.4		372	21	4.2	0	0.90	
7	Dungargarh	Bhawanipatna	19.9500	83.2375	7.84	500		205	46	22	20	3			24		<1	0.88	
8	Gudialipadar	Bhawanipatna	19.9506	83.2083	7.56	370		135	46	5	18	7			22		<1	1.41	
9	Ichapur	Bhawanipatna	19.9419	83.2292	7.86	753		2.55	56	28	42	0.9		389	50	13	0	1.15	0.07
10	Irrigation Colony	Bhawanipatna	19.9056	83.1847	7.73	370	237	135	46	4.9	24	3		140	35	8	15	0.34	
11	Jaring	Bhawanipatna	19.8958	83.0208	7.79	530		205	72	8.51	18	1			18		<1	0.78	
12	Singhjharani	Bhawanipatna	19.9164	83.0972	7.79	420		155	52	6.08	21	2			18		<1	0.78	
13	Uditnarayannpur	Bhawanipatna	20.1528	83.9431	8.16	812		240	76	12	69	1		244	106	0.6	1.4	0.51	
14	Boden	Dharamagarh	20.2486	82.5750	7.45	361	217	105	40	1.2	34	1.2		177	25				0.43
15	Kasibahal	Dharamagarh	19.8567	82.8069	7.6	823	497	220	72	22	31	37		244	74	18	49	0.58	0.33
16	Parla	Dharamagarh	19.8056	82.7056	8.16	534	316	145	36	13	49	3.5		262	14	1	7.2	0.2	0.12
17	Brundabahal	Golamunda	19.9769	82.8264	7.32	324	272	110	26	11	32	2		134	11	6.7	38	0.5	0.09

18	Chaparia	Golamunda	20.0944	82.4194	6.8	1680	990	720	194	57	48	5.1		336	11	6.7	38	0.5	2.4
19	Golamunda	Golamunda	20.0731	82.7931	7.29	1120	645	375	72	47	49			494	78				
20	Baner	Jaipatna	19.5077	82.7987	7.1	564	318	175	34	22	36	4.3		183	67	28	4.4	0.96	0.02
21	Jaipatna	Jaipatna	19.4700	82.8114	8.17	885	517	185	46	17	83	14		159	152	52	1.5	0.9	<0.01
22	Ranmal	Jaipatna	19.6556	82.8050	7.54	401	243	145	40	11	20	2.9		177	18	3.9	14	0.1	0.08
23	Charbahal	Junagarh	19.7633	83.4500	7.55	460	276	170	48	12	23	12		232	28	13			
24	Chichiguda	Junagarh	19.8903	82.8783	7.58	555	335	165	50	9.7	26	7.8		226	50	17	5.9	0.43	1.07
25	Choriagarh	Junagarh	19.8275	82.89306	7.7	459	302	145	30	17	34	6.2		238	18	15	3	0.51	0.38
26	Junagarh	Junagarh	19.9381	83.0086	8.04	798	471	335	64	43	21			500	35				
27	Nandul	Junagarh	19.8706	82.9597	7.19	1739	979	615	106	85	81	15		360	216	76	192	0.41	5.8
28	Dasigaon	Kalampur	19.6972	82.9042	7.72	359	254	140	44	7.3	14	4.9		195	7.1	2	1.2	0.87	0.36
29	Kalampur	Kalampur	19.6147	82.9747	8.22	432	285	115	28	11	36	6.4		226	14	7	12	0.5	<0.01
30	Teresinga	Karlamunda	20.3933	83.4492	7.92	970	648	250	26	45	152	7.8		628	21	14	1.3	1.6	0.38
31	Boria	Kesinga	20.1180	83.1893	8.08	1090	589	190	26	30	143	62		134	163	152	1.3	0.3	0.69
32	Ghatpada	Kesinga	20.2667	83.2722	7.32	441		173	60	5.2	22.8	0.4		147	39	11	26	0.43	
33	Kesinga	Kesinga	20.1889	83.2100	8.17	519	311	180	22	12	35	<1		220	53	13			
34	Kinerkela	Kesinga	20.2817	83.2958	7.68	60	38	25	6	2.4	2	2		18	9	18	<1	0.03	
35	Kurlupada	Kesinga	20.2103	83.2472	7.76	48		20	6	1.2	2	1		12	10	<1	<1	0.04	
36	Kusrupada	Kesinga	20.2489	83.2783	7.72	1070		435	114	37	49	2		128	201	56	46	0.36	
37	Pastikudi	Kesinga	20.0178	83.1650	7.98	455	283	80	26	3.6	69	1.2		220	35	12	6	0.35	0.72
38	Koksara	Koksara	19.6667	82.7042	7.9	927	556	190	32	27	117	6.6		488	18	34			
39	Kaudola	Koksara	19.7969	82.7050	8.26	532	285	190	56	12	32	37		93	124	11	0.3	1.1	0.9
40	Ladugaon	Koksara	19.6111	82.7050	7.92	970	648	250	26	45	152	7.8		628	21	14	1.3	1.6	0.38
41	Lanjigarh Road	Lanjigarh	19.9469	82.4078	8.07	302	232	123	34	9.1	17	2.3		171	14	3.4	3.6	0.51	0.8
42	Lanjigarh	Lanjigarh	19.6756	83.3681	8.20	702	414	325	64	60	16	2		410	11				
43	Madanpur	M.Rampur	20.3083	83.5333	7.71	532	288	140	24	19.5	52	3.9		293	7.1	3.6	1	1	4.3
44	M.Rampur	M.Rampur	20.1576	83.5316	8.2	500		155	42	12	58	3.7		275	21				
45	Turchi	M.Rampur	20.2486	83.4722	7.95	436		85	22	7.3	67	1.7		238	18				
46	Ghantamal	Narla	20.0203	83.3442	8.04	58		25	8.02	1.2	2.2	1.3		18	7.1	0.79	5	0.14	
47	Mandel	Narla	20.0794	83.3628	7.96	721	436	172	40	18	78	17		329	50	22	1.5	2.6	

48	Narla	Narla	20.0372	83.3616	7.88	823	474	255	24	47	81	1.4		451	32	9	22	1.1	0.6
49	Santpur	Narla	19.9897	83.3263	7.46	505	269	145	16	26	51	1.2		195	25	8.8	0.4	1	0.11
50	Tulapada	Narla	20.1300	83.4308	8.11	138		58	14	5.5	9.3	0.5		73	11	2.4	1	0.57	
51	Gopalpur	T Rampur	19.5647	83.5569	7.65	296	178	115	44	1.2	21	2.1		183	7.1				0.26
				MIN	**6.68**	**48**	**38**	**2.55**	**6**	**1.2**	**2**	**0.4**		**12**	**7.1**	**0.6**	**0**	**0.03**	**0.02**
				MAX	**8.26**	**1739**	**990**	**720**	**194**	**85**	**152**	**62**		**628**	**216**	**152**	**192**	**2.6**	**5.8**

Table-2.7: Depth to water level data of Monitoring Dug wells established during 2020-21 under NAQUIM

Sl No	Village	Block	Lat	Long	Wl(mbgl)
1	Dongripadar	Bhawanipatna	19.9676	83.1812	4.48
2	Kapsera	Bhawanipatna	19.8979	83.0659	6.68
3	Kandoljhar	Bhawanipatna	20.1139	83.0395	1.5
4	Turkel	Bhawanipatna	20.1328	83.0949	1.27
5	Karlapada	Bhawanipatna	20.0826	83.1012	2.78
6	Balijhara	Bhawanipatna	19.9583	83.1417	2.84
7	Thuapadar	Bhawanipatna	19.9993	83.1626	3.3
8	Karlaguda	Bhawanipatna	20.0095	83.1238	3.04
9	Bhimadanga	Bhawanipatna	19.9881	83.1288	1.61
10	Sujanpur	Bhawanipatna	19.9039	83.2194	4.51
11	Kalebhata	Bhawanipatna	19.9621	83.2229	1.43
12	Shradhapur	Dharamgarh	19.8556	82.8202	2.97
13	Bikramguda	Dharamgarh	19.8660	82.7573	2.12
14	Pipala	Dharamgarh	19.8258	82.7146	2.22
15	Rajmuter	Dharamgarh	19.8662	82.7286	1.67
16	Sandhikuliari	Dharamgarh	19.8922	82.7177	1.35
17	Chhilipa	Dharamgarh	19.8881	82.7354	2.4
18	Pipalpada	Dharamgarh	19.7457	82.6624	2.7
19	Parla	Dharamgarh	19.8008	82.7021	2.96
20	Kebadi	Dharamgarh	19.8839	82.7801	2.38
21	Putiachira	Golamunda	19.9586	82.9362	3
22	Gunduri	Golamunda	19.9841	83.0069	7.5
23	Gargab	Golamunda	20.0453	83.0291	4.42
24	Khar Haldi	Golamunda	19.9200	82.8004	2.08
25	Pharang	Golamunda	19.9451	82.8881	2.92
26	Dashpur	Golamunda	19.9637	82.8658	2.35
27	Tingipadar	Golamunda	20.0601	82.8579	3.48
28	Chhapria	Golamunda	20.0899	82.8644	3.9
29	Leter	Golamunda	20.1076	82.8394	3.5
30	Manajhari	Golamunda	20.0868	82.7960	2.23
31	Khaliakani	Golamunda	20.0265	82.8045	2.21
32	Ambaguda	Golamunda	19.9402	82.8082	3.55
33	Pataguda	Jaipatna	19.5139	82.8290	4.72
34	Patiguda	Jaipatna	19.4411	82.8359	2.42
35	Mangalpur	Jaipatna	19.4229	82.7976	3.14
36	Chhatapadar	Jaipatna	19.4494	82.7860	6.22
37	Nandul	Junagarh	19.9285	83.0082	2.35
38	Makarshola	Junagarh	19.9554	82.9565	7.19
39	Chermahul	Junagarh	19.8803	83.0183	3.61

40	Ranpur	Junagarh	19.8532	83.0029	2.65
41	Golamunda	Junagarh	19.8381	83.0278	2.78
42	Dedara	Junagarh	19.7946	83.0410	3.59
43	Sinakhunti	Junagarh	19.7724	83.0516	4.31
44	Tentulikhunti	Junagarh	19.8135	82.9928	2.11
45	Kandhasargiguda	Junagarh	19.8096	82.9684	2.74
46	Chhoriagarh	Junagarh	19.8289	82.8556	1.95
47	Dabjharan	Junagarh	19.8211	82.9387	1.61
48	Barabesal	Junagarh	19.7883	82.9131	2.5
49	Karlakot	Junagarh	19.7736	82.9312	5.07
50	Purunasor	Junagarh	29.7607	82.9077	2.68
51	Karli	Junagarh	19.7381	82.9291	1.58
52	Mundraguda	Junagarh	19.7178	82.9183	3.4
53	Kurchela	Junagarh	19.7258	82.8757	3.97
54	Bankapala	Kalampur	19.6794	82.8899	2.93
55	Babukenduguda	Kalampur	19.6436	82.8934	2.18
56	Gouda Kenduguda	Kalampur	19.5963	82.9170	2.28
57	Katagaon	Kalampur	19.6919	82.8592	0.8
58	Dhanpur	Kalampur	19.6359	82.8512	2.12
59	Sankutru	Kalampur	19.5993	82.8483	4.35
60	Panigaon	Kalampur	19.5581	82.8438	4.15
61	Jamunapur	Karlamunda	20.2987	83.4841	2
62	Deogaon	Karlamunda	20.3236	83.4597	3.73
63	Bhatapalaa	Karlamunda	20.3180	83.4829	2.8
64	Abujbahal	Karlamunda	20.3976	83.5004	2.75
65	Karlamunda	Karlamunda	20.3570	83.4565	4.37
66	Amatha	Kesinga	20.2966	83.3048	2.85
67	Ghatapada	Kesinga	20.2590	83.2655	3.74
68	Kanteshir	Kesinga	20.2161	83.2459	1.45
69	Boringpadar	Kesinga	20.1648	83.2042	2.95
70	Kokomunda	Kesinga	20.0889	83.1712	1.47
71	Plastikuda	Kesinga	20.0120	83.1784	3.26
72	Kachharpadar	Kesinga	20.1432	83.2899	3.19
73	Belkhandi	Kesinga	20.3448	83.3943	3.05
74	Kusumkhunti	Koksara	19.7008	82.7647	2.98
75	Jhariaguda	Koksara	19.7014	82.7140	4.53
76	Majhiguda	Koksara	19.6755	82.6833	1.66
77	Temra	Koksara	19.6691	82.6685	3.51
78	Badapodaguda	Koksara	19.6126	82.6391	3.19
79	Talagaon	Koksara	19.6094	82.6147	1.77
80	Bandhapada	Koksara	19.6441	82.6183	2.05

81	Doben Poda	Koksara	19.6605	82.6099	2.8
82	Gotamunda	Koksara	19.7161	82.6255	3.55
83	Kanikupa	Lanjigarh	19.8864	83.2300	4.14
84	Sulia	Lanjigarh	19.8617	83.2697	1.86
85	Kandama	Lanjigarh	19.7833	83.3011	7.3
86	Bandhapari	Lanjigarh	19.7907	83.3438	5.75
87	Lanjigarh	Lanjigarh	19.7133	83.3684	1.46
88	Nangalbeda	Lanjigarh	19.7491	83.4109	2.17
89	Champadeipur	Lanjigarh	19.7819	83.4199	4.6
90	Bakatpur	Lanjigarh	19.8431	83.4239	3.95
91	Kiding	Lanjigarh	19.9349	83.3813	4.25
92	Muskaguda	Lanjigarh	20.0523	83.4408	4.15
93	Chandapada	Madanpur Ramapur	20.1907	83.5246	3
94	Turkhaman	Madanpur Ramapur	20.1592	83.6102	5.53
95	Urladani	Madanpur Ramapur	20.1380	83.6294	4.05
96	Harlnga	Madanpur Ramapur	20.1228	83.6422	2.77
97	Khalia Munda	Madanpur Ramapur	20.1123	83.6366	0.03
98	Nunpur	Madanpur Ramapur	20.2339	83.5073	3.6
99	Bamak	Madanpur Ramapur	20.2664	83.4825	2.11
100	Kumerpatta	Madanpur Ramapur	20.3745	83.5366	2.81
101	Baddharpur Nuapada	Narla	19.9637	83.3338	2.12
102	Jampadar	Narla	20.1535	83.4573	6.25
103	Boringpadar	Narla	20.1104	83.4428	3.22
104	Kurmer	Narla	20.0785	83.4331	4.17
105	Regedimal	Narla	20.0486	83.4037	2.32
106	Rekhpur	Narla	20.0786	83.3759	3.04
107	Kerandikhunti	Narla	20.0967	83.3791	4.15
108	Titkela	Narla	20.1364	83.3646	3.52
109	Tuting	Narla	20.1562	83.3205	4.91
110	Surpadar	Narla	20.1165	83.3321	3.12
111	Rakshi	Narla	20.0729	83.2947	1.15
112	Ulikupa	Narla	20.0327	83.2424	2.45
113	Ratanpur	Narla	20.1651	83.4442	3.3
114	Kendu Bahali	Narla	20.2907	83.3785	0.95
115	Jagesh Padar	Thuamul Rampur	19.5493	82.9259	5.07
116	Kathokura	Thuamul Rampur	19.5261	82.9488	2.99
117	Badaderela	Thuamul Rampur	19.4772	82.9682	6.82
118	Dhamanguda	Thuamul Rampur	19.5613	82.9652	4.82
119	Ranidumer	Thuamul Rampur	19.5853	83.0273	5.52
120	Amathaguda	Thuamul Rampur	19.5981	83.0595	6.56
121	Mahulpatna	Thuamul Rampur	19.4005	82.8688	0.3

Table-2.8: Ground Water Quality data of Monitoring Dug wells established during 2019-20 under NAQUIM

Sl No	Location	Block	Lat	Long	pH	EC	TDS	Hardness	Alkalinity	Ca++	Mg++	Na+	K+	CO3=	HCO3-	Cl-	SO4=	NO3-
						µS/cm	mg/L	as CaCO3 mg/L		mg/L								
1	Dongripadar	Bhawanipatna	19.9676	83.1812	8.04	650	311.67	253	282	38	38	32.55	1.81	0	344	11	20	1.75
2	Kapsera	Bhawanipatna	19.8979	83.0659	7.82	680	339.62	207	272	34	29	53.52	7.57	0	332	32	16	4.85
3	Kandoljhar	Bhawanipatna	20.1139	83.0395	8.02	800	402.94	172	307	24	27	95.12	0.86	0	374	39	27	6.7
4	Turkel	Bhawanipatna	20.1328	83.0949	7.9	810	401.92	273	297	38	43	51.72	4.72	0	362	43	41	3.1
5	Karlapada	Bhawanipatna	20.0826	83.1012	8.12	670	306.7	293	292	36	49	15.78	1.13	0	356	21	6	3.35
6	Balijhara	Bhawanipatna	19.9583	83.1417	8.08	870	411.39	288	322	24	55	58.16	1.26	0	393	64	16	0.4
7	Thuapadar	Bhawanipatna	19.9993	83.1626	7.46	1400	804.22	444	237	123	33	79.23	12.58	0	289	174	62	178.8
8	Karlaguda	Bhawanipatna	20.0095	83.1238	8.16	2030	1207.02	591	317	55	109	127.53	52.6	0	387	199	117	357.26
9	Bhimadanga	Bhawanipatna	19.9881	83.1288	8.32	1200	594.28	303	443	38	50	121.23	2.25	42	540	28	25	23.2
10	Sujanpur	Bhawanipatna	19.9039	83.2194	8.134	440	199.05	182	181	24	29	13.81	1.45	0	221	14	1	7.5
11	Kalebhata	Bhawanipatna	19.9621	83.2229	7.696	1260	658.22	389	317	113	26	84.23	0.26	0	387	138	96	11.1
12	Shradhapur	Dharamgarh	19.8556	82.8202	8.05	1040	500.58	263	443	18	52	110.67	1.21	0	540	32	15	7.1
13	Bikramguda	Dharamgarh	19.8660	82.7573	7.96	940	538.86	283	211	46	40	72.03	10.1	0	258	85	37	122.31
14	Pipala	Dharamgarh	19.8258	82.7146	8.1	500	249.71	167	202	28	23	30.68	8.39	0	246	25	13	1.1
15	Rajmuter	Dharamgarh	19.8662	82.7286	8.32	510	247.16	202	156	34	28	19.17	1.49	15	190	25	14	17.4
16	Sandhikuliari	Dharamgarh	19.8922	82.7177	8.03	1450	778.85	470	327	53	81	89.67	26.97	0	399	163	104	65.7
17	Chhilipa	Dharamgarh	19.8881	82.7354	8.36	570	280.5	182	202	30	26	45.43	0.83	21	246	18	3	15.7
18	Pipalpada	Dharamgarh	19.7457	82.6624	8.365	1010	542.6	187	418	26	29	163.55	4.25	45	510	21	3	0.9
19	Parla	Dharamgarh	19.8008	82.7021	7.867	1040	533.18	414	181	91	45	36.53	9.46	0	221	184	42	16.9
20	Kebadi	Dharamgarh	19.8839	82.7801	7.958	1050	504.14	429	242	65	64	35.44	0.65	0	295	117	41	36.5
21	Putiachira	Golamunda	19.9586	82.9362	7.9	790	397.98	283	302	48	39	44.03	1.63	0	368	28	9	48
22	Gunduri	Golamunda	19.9841	83.0069	7.09	210	102.95	66	80	16	6	15.81	1.02	0	98	11	3	2.1
23	Gargab	Golamunda	20.0453	83.0291	7.86	640	322.97	227	252	36	33	34.16	15.18	0	307	18	18	18.2
24	Khar Haldi	Golamunda	19.9200	82.8004	8.159	450	219.45	172	176	36	19	22.43	3.37	0	215	21	8	4.3
25	Pharang	Golamunda	19.9451	82.8881	8.131	240	117.64	96	96	36	1	7.2	1.28	0	117	11	3	0.83
26	Dashpur	Golamunda	19.9637	82.8658	7.889	1680	853.66	520	302	53	94	125.36	1.88	0	368	266	112	21.1
27	Tingipadar	Golamunda	20.0601	82.8579	8.306	840	397.38	278	292	38	44	65.27	2.07	0	356	50	16	7.6

28	Chhapria	Golamunda	20.0899	82.8644	8.175	740	368.3	253	231	48	32	36.24	5.98	0	282	57	26	24.9
29	Leter	Golamunda	20.1076	82.8394	7.96	2510	1475.58	980	176	101	175	68.02	3.09	0	215	308	121	594.12
30	Manajhari	Golamunda	20.0868	82.7960	8.266	810	433.22	273	287	61	29	50.38	11.64	0	350	32	37	40.7
31	Khaliakani	Golamunda	20.0265	82.8045	8.217	1120	545.62	465	307	42	86	42.54	2.72	0	374	96	25	68.1
32	Ambaguda	Golamunda	19.9402	82.8082	8.328	890	440.97	242	287	38	35	67.17	22.15	33	350	53	21	0.15
33	Pataguda	Jaipatna	19.5139	82.8290	7.976	1020	535.8	323	242	85	27	60.23	9.66	0	295	149	8	52.36
34	Patiguda	Jaipatna	19.4411	82.8359	8.116	770	347.98	308	352	36	52	22.96	3.22	0	430	18	2	3.1
35	Mangalpur	Jaipatna	19.4229	82.7976	8.067	1500	798.18	424	367	65	63	102.36	37.1	0	448	177	65	69.2
36	Chhatapadar	Jaipatna	19.4494	82.7860	7.969	1290	693.44	338	423	34	61	139.15	4.15	0	516	82	29	91.3
37	Nandul	Junagarh	19.9285	83.0082	7.59	250	132.7	96	75	24	9	6.9	4.82	0	92	14	4	24.9
38	Makarshola	Junagarh	19.9554	82.9565	7.53	510	303.96	187	111	38	22	19.81	14.5	0	135	35	29	79.5
39	Chermahul	Junagarh	19.8803	83.0183	7.74	150	72.38	56	61	10	7	6.13	2.78	0	74	7	2	1.21
40	Ranpur	Junagarh	19.8532	83.0029	7.29	150	80.18	51	56	14	4	7.9	5.35	0	68	11	3	1.61
41	Golamunda	Junagarh	19.8381	83.0278	7.85	1160	592.28	283	473	30	50	109.5	39.25	0	577	60	2	18.8
42	Dedara	Junagarh	19.7946	83.0410	7.93	1050	710.87	419	317	36	79	92.53	2.48	0	387	138	33	140.23
43	Sinakhunti	Junagarh	19.7724	83.0516	7.83	1050	501.87	338	473	28	64	85.33	3.01	0	577	21	13	4.8
44	Tentulikhunti	Junagarh	19.8135	82.9928	8.16	1190	651.49	364	383	36	66	62.6	75.06	0	467	71	48	64
45	Kandhasargigud	Junagarh	19.8096	82.9684	8.28	1210	612.48	212	518	24	36	179.85	4.05	0	632	35	12	11.9
46	Chhoriagarh	Junagarh	19.8289	82.8556	7.64	140	72.15	40	50	10	4	13.4	0.74	0	61	11	2	1.12
47	Dabjharan	Junagarh	19.8211	82.9387	8.22	970	482.29	313	231	32	56	75.4	5.61	0	282	128	47	0.1
48	Barabesal	Junagarh	19.7883	82.9131	8	1550	785.07	566	388	38	113	95.43	2.07	0	473	209	45	50.8
49	Karlakot	Junagarh	19.7736	82.9312	8.32	1490	822.84	515	277	73	80	83.84	32.38	30	338	181	70	107
50	Purunasor	Junagarh	29.7607	82.9077	8.115	3280	1943.65	859	574	73	163	210.47	189.05	0	700	454	205.13	306
51	Karli	Junagarh	19.7381	82.9291	8.315	1320	693.56	444	226	67	67	81.36	7.06	24	276	227	62	22.9
52	Mundraguda	Junagarh	19.7178	82.9183	8.107	1030	575.06	313	176	51	45	71.54	35.17	0	215	145	46	76
53	Kurchela	Junagarh	19.7258	82.8757	7.984	570	327.36	187	136	26	29	24.4	32.02	0	166	50	27	57.6
54	Bankapala	Kalampur	19.6794	82.8899	7.885	1180	606.79	444	292	51	77	63.69	3.16	0	356	145	39	53.5
55	Babukenduguda	Kalampur	19.6436	82.8934	8.04	840	400.17	268	332	30	46	58.46	2.36	0	405	43	16	5.9
56	Gouda Kenduguda	Kalampur	19.5963	82.9170	8.279	940	505.91	359	221	38	63	46.42	11.19	0	270	96	28	91
57	Katagaon	Kalampur	19.6919	82.8592	7.575	260	136.27	96	75	24	9	9.64	2.65	0	92	25	2	18.9
58	Dhanpur	Kalampur	19.6359	82.8512	8.06	1820	968.36	540	438	113	62	130.95	39.45	0	534	252	89	20.3

59	Sankutru	Kalampur	19.5993	82.8483	7.492	350	192.83	116	111	40	4	14.02	10.3	0	135	18	8	32.36
60	Panigaon	Kalampur	19.5581	82.8438	8.142	1670	1117.57	566	282	127	60	75.23	78.55	0	344	156	62	390.23
61	Jamunapur	Karlamunda	20.2987	83.4841	7.815	870	498.07	313	131	87	23	49.7	3.87	0	160	110	30	116.1
62	Deogaon	Karlamunda	20.3236	83.4597	8.014	995	492.15	364	337	36	66	44.12	4.94	0	411	53	44	42.7
63	Bhatapalaa	Karlamunda	20.3180	83.4829	8.517	2130	1147.52	207	428	26	34	345.21	21.3	54	522	266	91	54.23
64	Abujbahal	Karlamunda	20.3976	83.5004	7.906	550	301.73	172	161	40	17	29.34	13.16	0	196	28	20	58.19
65	Karlamunda	Karlamunda	20.3570	83.4565	7.923	1170	713.55	374	131	79	43	56.23	16.8	0	160	96	70	274.12
66	Amatha	Kesinga	20.2966	83.3048	7.39	470	241.38	177	151	40	18	17.85	8.57	0	184	21	12	33.8
67	Ghatapada	Kesinga	20.2590	83.2655	7.85	1360	813.63	424	322	113	34	41.43	110.0	0	393	96	65	161.6
68	Kanteshir	Kesinga	20.2161	83.2459	8.03	2300	1398.39	576	513	137	56	109.1	241.3 5	0	626	216	134	198.2
69	Boringpadar	Kesinga	20.1648	83.2042	8.05	480	228.81	212	146	40	27	10.25	1.64	0	178	28	15	19.7
70	Kokomunda	Kesinga	20.0889	83.1712	7.88	500	251.85	202	191	53	17	16.8	1.88	0	233	32	7	10
71	Plastikuda	Kesinga	20.0120	83.1784	7.8	490	258.18	152	166	44	10	40.03	1.89	0	203	32	14	16.79
72	Kachharpadar	Kesinga	20.1432	83.2899	7.947	700	369.01	187	216	30	27	72.17	2.28	0	264	53	24	31.2
73	Belkhandi	Kesinga	20.3448	83.3943	8.212	1050	582	258	302	48	33	44.15	98.45	0	368	82	68	28.08
74	Kusumkhunti	Koksara	19.7008	82.7647	8.055	720	334.04	288	307	36	47	28.23	2.22	0	374	21	15	1.33
75	Jhariaguda	Koksara	19.7014	82.7140	8.109	1090	555.36	389	297	83	44	51.23	2.05	0	362	110	37	50.7
76	Majhiguda	Koksara	19.6755	82.6833	8.662	1710	928.22	263	443	24	49	265.32	11.6	42	540	117	113	41.7
77	Temra	Koksara	19.6691	82.6685	7.677	1620	1054.77	525	75	95	69	110.23	4.1	0	92	234	95	402.36
78	Bobria	Koksara	19.6553	82.6704	7.986	970	497.77	217	407	28	35	112.31	8.03	0	497	18	20	32.9
79	Badapodaguda	Koksara	19.6126	82.6391	7.806	2460	1247.24	879	493	57	177	98.36	34.5	0	602	362	94	129.4
80	Talagaon	Koksara	19.6094	82.6147	8.118	780	379.43	298	266	51	41	35.5	12.68	0	325	53	27	0
81	Bandhapada	Koksara	19.6441	82.6183	7.947	1100	712.68	364	91	46	60	61.28	10.78	0	111	89	50	341.23
82	Doben Poda	Koksara	19.6605	82.6099	8.079	510	241.73	212	207	26	35	11.21	7.24	0	252	18	4	16.8
83	Gotamunda	Koksara	19.7161	82.6255	7.984	820	414.09	303	216	46	45	43.9	6.73	0	264	67	31	45.1
84	Kanikupa	Lanjigarh	19.8864	83.2300	7.712	370	175.41	136	146	20	21	19.88	1.01	0	178	21	1	4.3
85	Rabandhar	Lanjigarh	19.8590	83.2535	8.35	140	64.78	51	45	14	4	4.76	1.07	6	55	7	1	0
86	Sulia	Lanjigarh	19.8617	83.2697	7.734	420	207.55	177	161	22	29	12.94	3.67	0	196	14	5	24.9
87	Kandama	Lanjigarh	19.7833	83.3011	8.06	270	150.29	101	66	26	9	8.44	2.42	0	80	18	1	46.23
88	Bandhapari	Lanjigarh	19.7907	83.3438	8.078	530	286.71	167	181	36	18	25.61	21.5	0	221	32	7	38.31
89	Lanjigarh	Lanjigarh	19.7133	83.3684	7.921	470	235.63	167	176	32	21	26.54	1.04	0	215	32	5	12.7
90	Nangalbeda	Lanjigarh	19.7491	83.4109	8.062	570	282.71	162	221	38	16	55.52	1.89	0	270	32	7	0

91	Champadeipur	Lanjigarh	19.7819	83.4199	7.974	220	112.4	81	75	18	9	7.79	5.83	0	92	14	1	11.7
92	Bakatpur	Lanjigarh	19.8431	83.4239	7.56	200	98.77	71	91	20	5	12.37	2.01	0	111	4	1	0
93	Kiding	Lanjigarh	19.9349	83.3813	7.289	260	124.97	111	106	20	15	6.56	1.9	0	129	11	2	5.3
94	Muskaguda	Lanjigarh	20.0523	83.4408	7.94	320	172.47	136	106	24	18	9.1	0.76	0	129	11	4	42.4
95	Chandapada	Madanpur Ramapur	20.1907	83.5246	7.875	670	347.1	182	186	46	16	58.23	0.94	0	227	64	33	17.7
96	Turkhaman	Madanpur Ramapur	20.1592	83.6102	7.884	390	215.81	162	80	36	17	11.78	7.01	0	98	43	4	49
97	Urladani	Madanpur Ramapur	20.1380	83.6294	7.945	430	202.98	197	141	32	28	8.1	1.2	0	172	28	6	15.4
98	Harlnga	Madanpur Ramapur	20.1228	83.6422	7.038	730	420.88	313	85	59	40	12.74	16.08	0	104	67	47	128.1
99	Khalia Munda	Madanpur Ramapur	20.1123	83.6366	7.503	170	77.19	66	61	12	9	5.96	1.97	0	74	11	1	0
100	Nunpur	Madanpur Ramapur	20.2339	83.5073	8.181	1110	580.77	268	367	44	38	87.97	55.18	0	448	96	37	3.1
101	Bamak	Madanpur Ramapur	20.2664	83.4825	8.014	500	237.79	227	186	40	30	11.08	0.58	0	227	21	9	14.9
102	Kumerpatta	Madanpur Ramapur	20.3745	83.5366	8.3	840	373.47	369	292	30	70	23.16	1.27	0	356	64	10	0.6
103	Baddharpur Nuapada	Narla	19.9637	83.3338	7.79	880	475.61	283	247	51	38	52.34	21.88	0	301	82	32	50.9
104	Jampadar	Narla	20.1535	83.4573	7.842	500	239.24	207	207	36	28	13.05	2.31	0	252	14	5	17.4
105	Kurmer	Narla	20.0785	83.4331	7.823	650	374.21	227	111	48	26	34.74	2.42	0	135	78	17	101.9
106	Regedimal	Narla	20.0486	83.4037	8.127	580	292.46	212	231	48	22	24.27	6.01	0	282	14	4	36
107	Rekhpur	Narla	20.0786	83.3759	7.634	4360	2549.19	566	438	107	72	678.23	5.8	0	534	893	202	329.5
108	Kerandikhunti	Narla	20.0967	83.3791	7.793	1605	920.4	626	418	65	112	89.3	3	0	510	202	44	155.2
109	Titkela	Narla	20.1364	83.3646	8.075	1490	798.62	298	412	34	51	195.5	1.75	0	503	170	48	51.9
1101	Tuting	Narla	20.1562	83.3205	8.212	770	467.97	182	191	42	18	40.02	81.68	0	233	67	41	64.1
112	Surpadar	Narla	20.1165	83.3321	0.805	1080	616.19	333	247	99	21	64.23	10.24	0	301	78	48	148.23
113	Rakshi	Narla	20.0729	83.2947	7.7	1470	717.37	399	589	24	81	139.8	3.45	0	718	60	30	27.3
114	Ulikupa	Narla	20.0327	83.2424	7.811	1240	748.18	313	242	79	28	75.23	70.23	0	295	103	58	190.17
115	Ratanpur	Narla	20.1651	83.4442	7.797	1180	601.94	434	231	57	70	58.41	12.75	0	282	124	62	79.6
116	Kendu Bahali	Narla	20.2907	83.3785	8.267	1150	564.14	404	443	69	56	73.05	1.79	0	540	64	11	24.7
117	Jagesh Padar	Thuamul Rampur	19.5493	82.9259	8.203	170	88.14	66	45	14	7	6.8	2.49	0	55	14	4	12.9
118	Kathokura	Thuamul Rampur	19.5261	82.9488	7.888	300	141.6	111	116	20	15	11.61	3.7	0	141	18	1	3.2

119	Badaderela	Thuamul Rampur	19.4772	82.9682	8.176	140	70.21	56	50	12	6	3.12	2.9	0	61	7	1	8.3
120	Dhamanguda	Thuamul Rampur	19.5613	82.9652	7.35	260	125.74	101	101	22	11	12.57	0.9	0	123	18	1	0
121	Ranidumer	Thuamul Rampur	19.5853	83.0273	6.652	100	48.11	35	30	10	2	2.91	1.97	0	37	7	1	5.1
122	Amathaguda	Thuamul Rampur	19.5981	83.0595	7.138	160	77.05	66	66	20	4	4.65	1.2	0	80	7	1	0
123	Mahulpatna	Thuamul Rampur	19.4005	82.8688	7.269	200	99.54	81	80	26	4	5.75	1	0	98	11	2	1.77
				MIN	**0.81**	**100**	**48.11**	**35**	**30**	**10**	**1**	**2.91**	**0.26**	**0**	**37**	**4**	**1**	**0**
				MAX	**8.66**	**4360**	**2549.2**	**980**	**589**	**137**	**177**	**678.2**	**241**	**54**	**718**	**893**	**205.1**	**594.1**

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 0.8 m to6.5 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 1.56 mbgl (Gunupur in Thuamul Rampur block) to 10.10 mbgl (Sargigora in Bhawanipatna block), the average being 5.17 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 Thuamul Rampur, Kalampur, Junagarh and Narla block. Generally the depth to water level is shallow in southern part of the district and within 4 mbgl covering parts of Jaipatna, Koksara, Kalampura and Thuamul Rampurblock and the same gradually becomes deeper westward and northward. Deepest pre-monsoon water levels of 6-8 mbgl are also found as patches in the central part of the district near the boundary of Lanjigarh and Bhawanipatna blocks with Golamunda block and also in the northern-most part of the district in the Karlamunda block. The shallow water table in Thuamul Rampur and Kalampur block is because of being the tail end section of Indravati command area with water logging condition in some villages. The pre-monsoon depth to water level map is shown in **Fig. 3.1**.

3.1.2 Post-monsoon Depth to Water Level

Depth to water level in post-monsoon period varies from 0.45 mbgl (Tulapada in Narla block) to 7.92 (Dalguma in Bhawanipatna block) mbgl, the average being 2.66 mbgl. The depth to water level of the study area during post monsoon is in general within 2-4 mbgl. Deeper water level of 4-6 mbgl is observed in small patch of Junagarh and Bhawanipatna block. It has been observed that 4 out of total 32 NHNS stations show less than 3 mbgl throughout the year, 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. 3.2**.

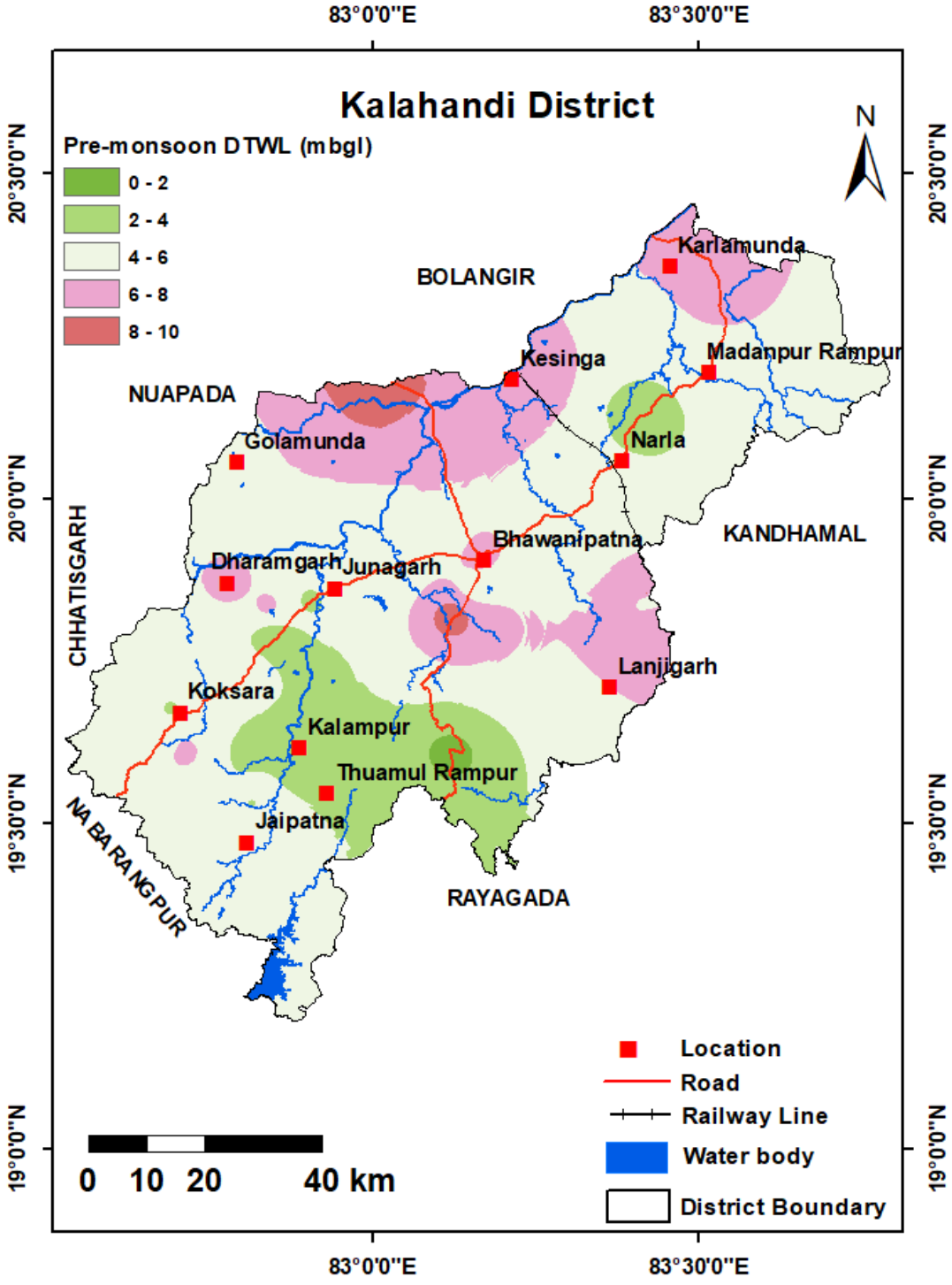

Fig. 3.1: Depth to Water Level in Phreatic Aquifer during Pre-Monsoon(2019).

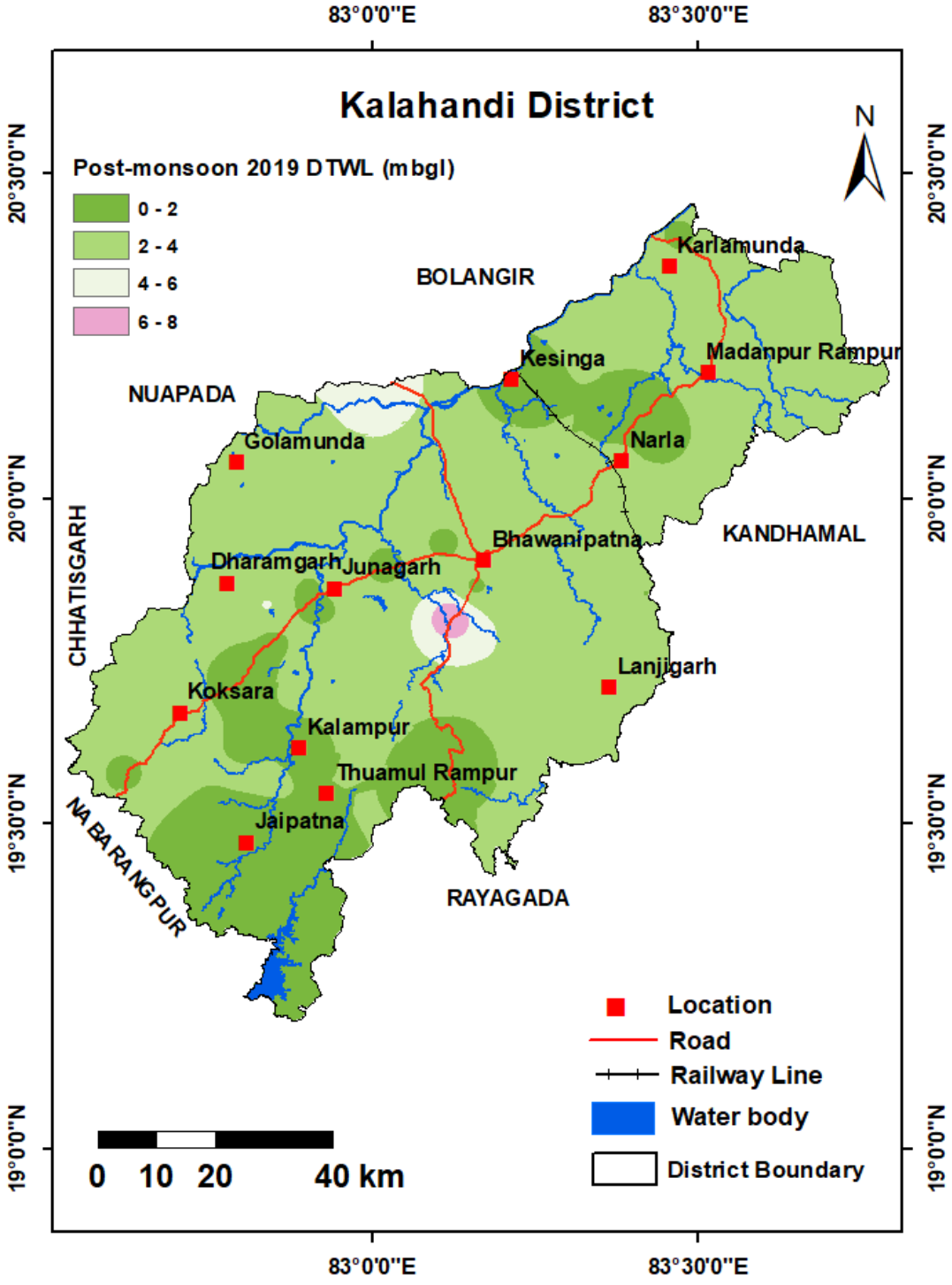

Fig. 3.2a: Depth to Water Level in Phreatic Aquifer during Post-Monsoon(2019).

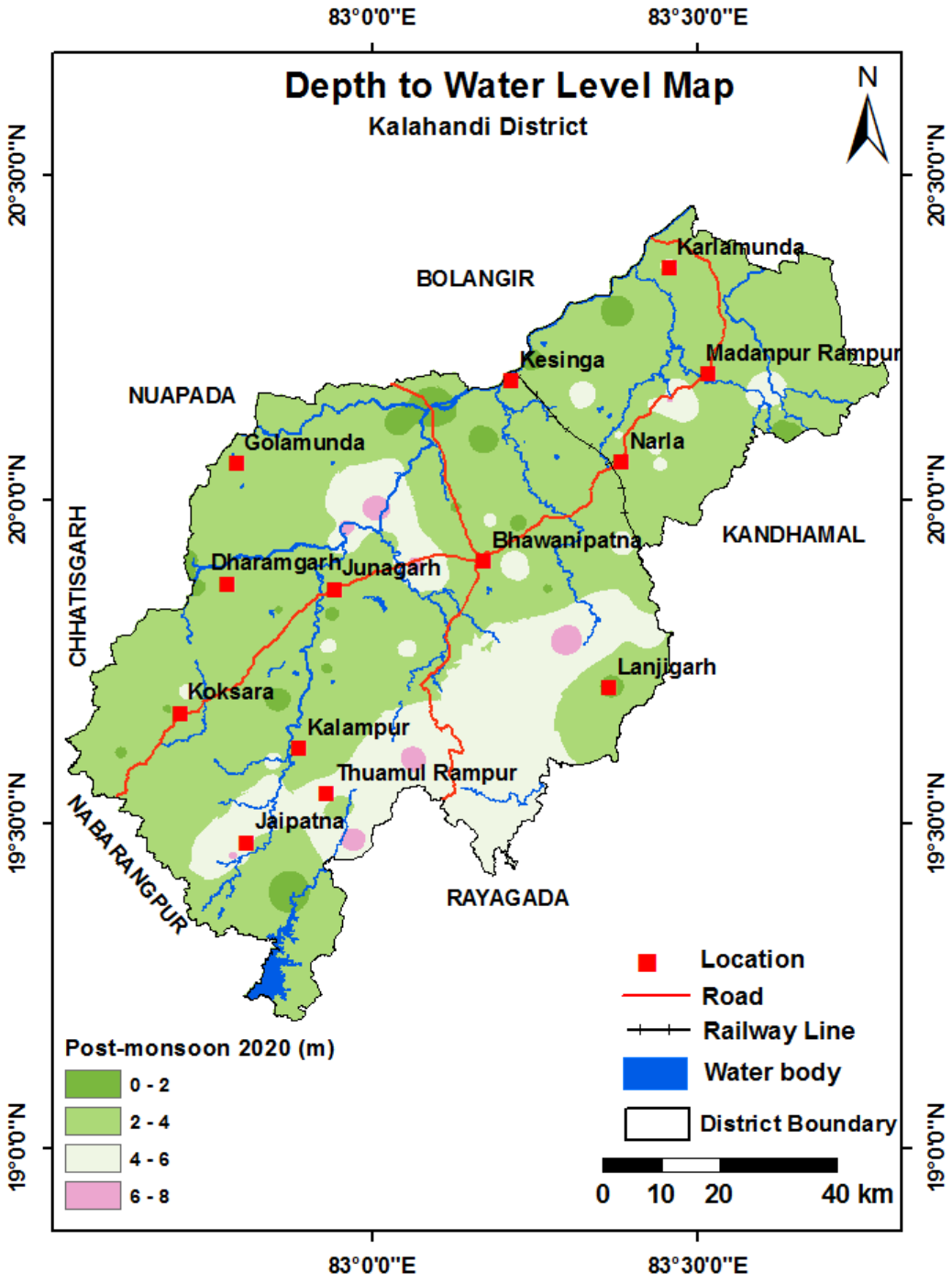

Fig. 3.2b: Depth to Water Level in Phreatic Aquifer during Post-Monsoon (2020).

3.1.3 Seasonal Fluctuation of Water Level

The seasonal fluctuation of water level of Aquifer-I is shown in **Fig. 3.3**. Fluctuation of ground water table between pre and post monsoon periods in the study area varies from 0.21 m (Baktapur in Lanjigarh block) to 6.32 m (Pokharibandhin Lanjigarh block) with average water level rise of 2.50 m. All the 32 stations show rise in water level.

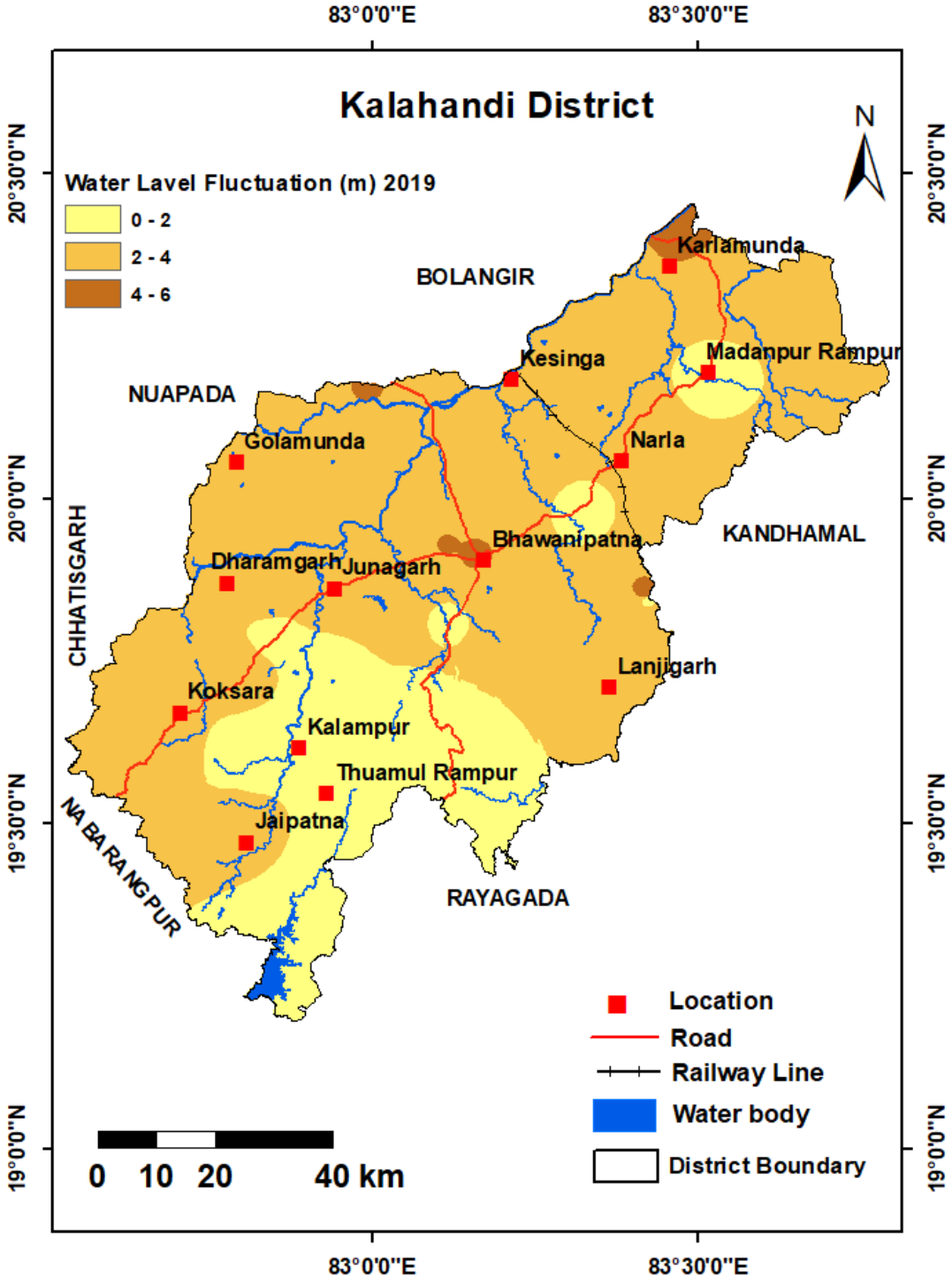

Fig. 3.3: Seasonal Fluctuation in Water Level in Phreatic Aquifer.

3.1.4 Decadal Water Level Trend

There are 55 National Hydrograph Station (NHS) in the district, the data 33 stations having long term data availablewere considered for analysis of decadal trend for the period 2010-2019. 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 (2010-2019) in Kalahandi District.

Block	Location	Pre-monsoon		Post-monsoon	
		Trend (m/Yr)	Remark	Trend (m/Yr)	Remark
Bhawanipatna	Malgaon	-0.1654	**Fall**	-0.3992	**Fall**
Bhawanipatna	Attanguda	-0.0169	**Fall**	0.0197	Rise
Bhawanipatna	Karlapada	0.0698	Rise	0.1459	**Fall**
Bhawanipatna	Bhawanipatna	0.0230	Rise	0.2037	Rise
Bhawanipatna	Dalguma	0.1799	Rise	-0.3441	**Fall**
Bhawanipatna	Bawanipatna	-0.1687	**Fall**	-0.0551	**Fall**
Dharamgarh	Dharamgarh	0.2190	Rise	-0.1142	**Fall**
Golamunda	Kegaon	-0.1377	**Fall**	-0.0431	**Fall**
Golamunda	Golamunda	0.0634	Rise	-0.1147	**Fall**
Golamunda	Daspur	0.1250	Rise	-0.1710	**Fall**
Jaipatna	Mukhiguda	-0.2556	**Fall**	0.1065	Rise
Jaipatna	Jaipatna	-0.3606	**Fall**	-0.0166	**Fall**
Jaipatna	Baner	-0.1203	**Fall**	-0.0468	**Fall**
Jaipatna	Bijamara	-0.1896	**Fall**	-0.0296	**Fall**
Junagarh	Badbasul	-0.2245	**Fall**	0.0129	Rise
Junagarh	Baldiamal	-0.1278	**Fall**	0.0974	Rise
Junagarh	Mahichala	-0.0018	**Fall**	0.0632	Rise
Junagarh	Junagarh 1	-0.0324	**Fall**	-0.0099	**Fall**
Junagarh	Charbahal	0.1380	Rise	0.2563	Rise
Junagarh	Chiliguda1	0.1144	Rise	0.0045	Rise
Junagarh	Tal Jaring	-0.6843	**Fall**	-0.1243	**Fall**
Kalampur	Kalampur	-0.2676	**Fall**	0.0556	Rise
Kalampur	Bandigaon	-0.2589	**Fall**	0.0811	Rise
Karlamunda	Risida	-0.0799	**Fall**	-0.0537	**Fall**
Kesinga	Tundala	-0.1725	**Fall**	-0.2038	**Fall**
Kesinga	Pastikudi1	0.1163	Rise	0.0427	Rise
Kesinga	Pastikudi	-0.1476	**Fall**	-0.1853	**Fall**
Koksara	Sunamala	0.0598	Rise	0.0116	Rise
Koksara	Moter	-0.2852	**Fall**	0.1048	Rise
Koksara	Sargigora	-0.3309	**Fall**	-0.5377	**Fall**
Koksara	Ladugaon	-0.2477	**Fall**	-0.4305	**Fall**
Koksara	Ampani	-0.0306	**Fall**	0.0288	Rise
Koksara	Koksara	0.0376	Rise	-0.0668	**Fall**
Lanjigarh	Pokaribandh	-0.2812	**Fall**	-0.2644	**Fall**
Lanjigarh	Biswanathppur	-0.3169	**Fall**	-0.3028	**Fall**
M Rampur	Madanpur1	0.1500	Rise	0.2351	Rise

M Rampur	Jurakhaman	-0.4596	**Fall**	-0.8460	**Fall**
M Rampur	M-rampur	-0.0475	**Fall**	0.0210	Rise
Narla	Santapur	-0.2650	**Fall**	-0.1536	**Fall**
Narla	Tulapada	-0.1246	**Fall**	-0.1179	**Fall**
Narla	Narla	-0.2278	**Fall**	0.0009	Rise
T Rampur	Gunupur	0.1849	Rise	0.1690	Rise
Total	**42**		**Rise-13** **Fall-29**		**Rise-18** **Fall-24**

The long term trend analysis indicates that out of 42 stations, during the pre-monsoon 13 (30.95%) show rising trend and the rest 29 stations (69.05%) show falling trend. Similarly during the post-monsoon, 18 (42.85%) show rising trend and the rest 24 stations (57.15%) show falling trend. During the pre-monsoon, the range of fall is from -0.0018 to -0.6843m/yr, whereas the range of rising trend is from 0.0230to 0.2190m/yr. Similarly during the post-monsoon, the range of fall is from -0.0099to -0.8460m/yr and the range of rise is from 0.0009to 0.2563m/yr. The pre- and post-monsoon decadal trend maps for the period 2010-2019 in the district are shown in **Fig. 3.4** and **Fig. 3.5**.

3.1.5 Hydrograph Analysis

The hydrographs of 13 ground water monitoring stations were analysed for the period from 2010 to 2019. 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. 3.6a** to **3.6m**. 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.

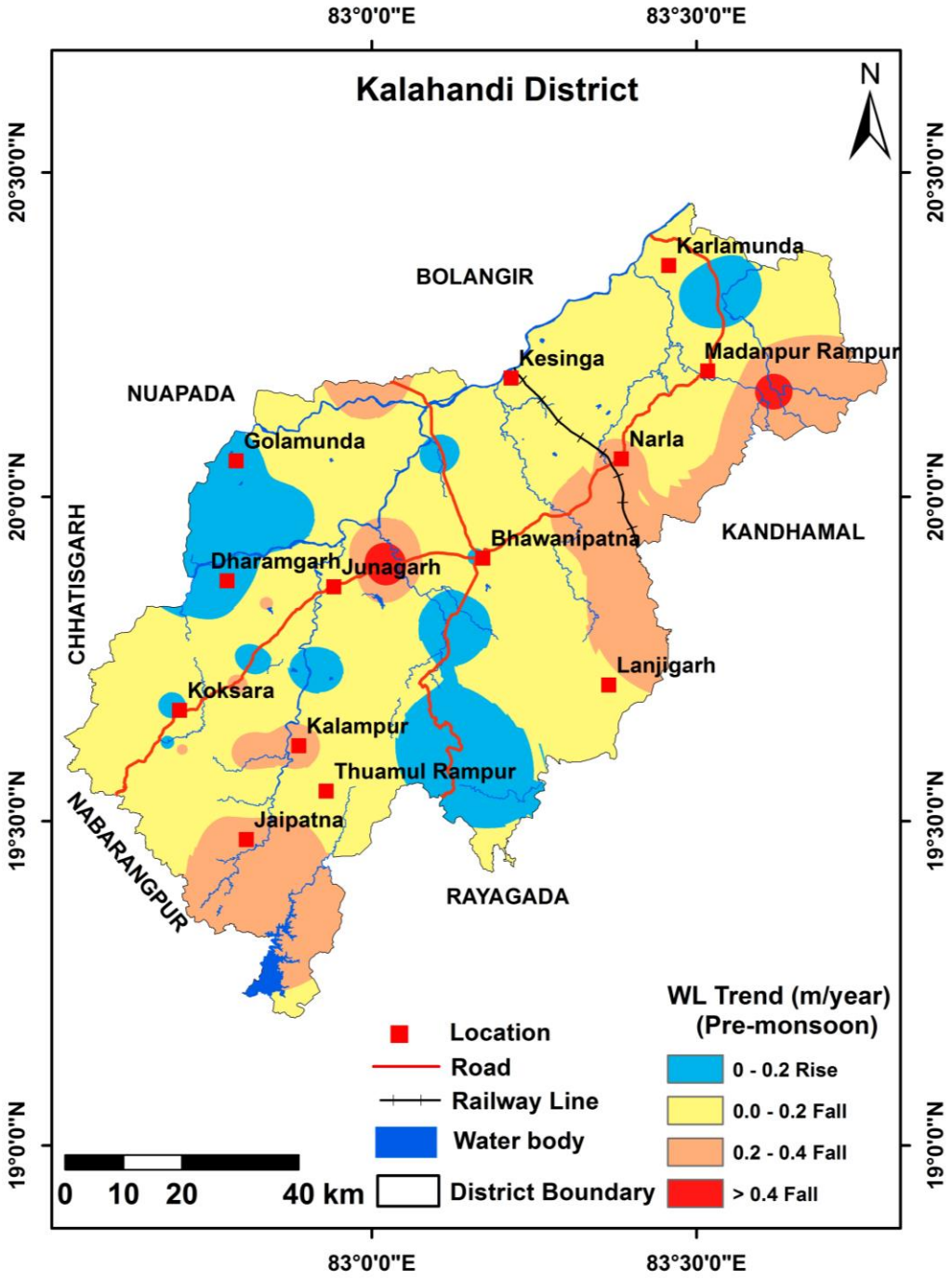

Fig. 3.4: Decadal Trend of Water Level for Pre-Monsoon Period (2010-19), in Kalahandi District.

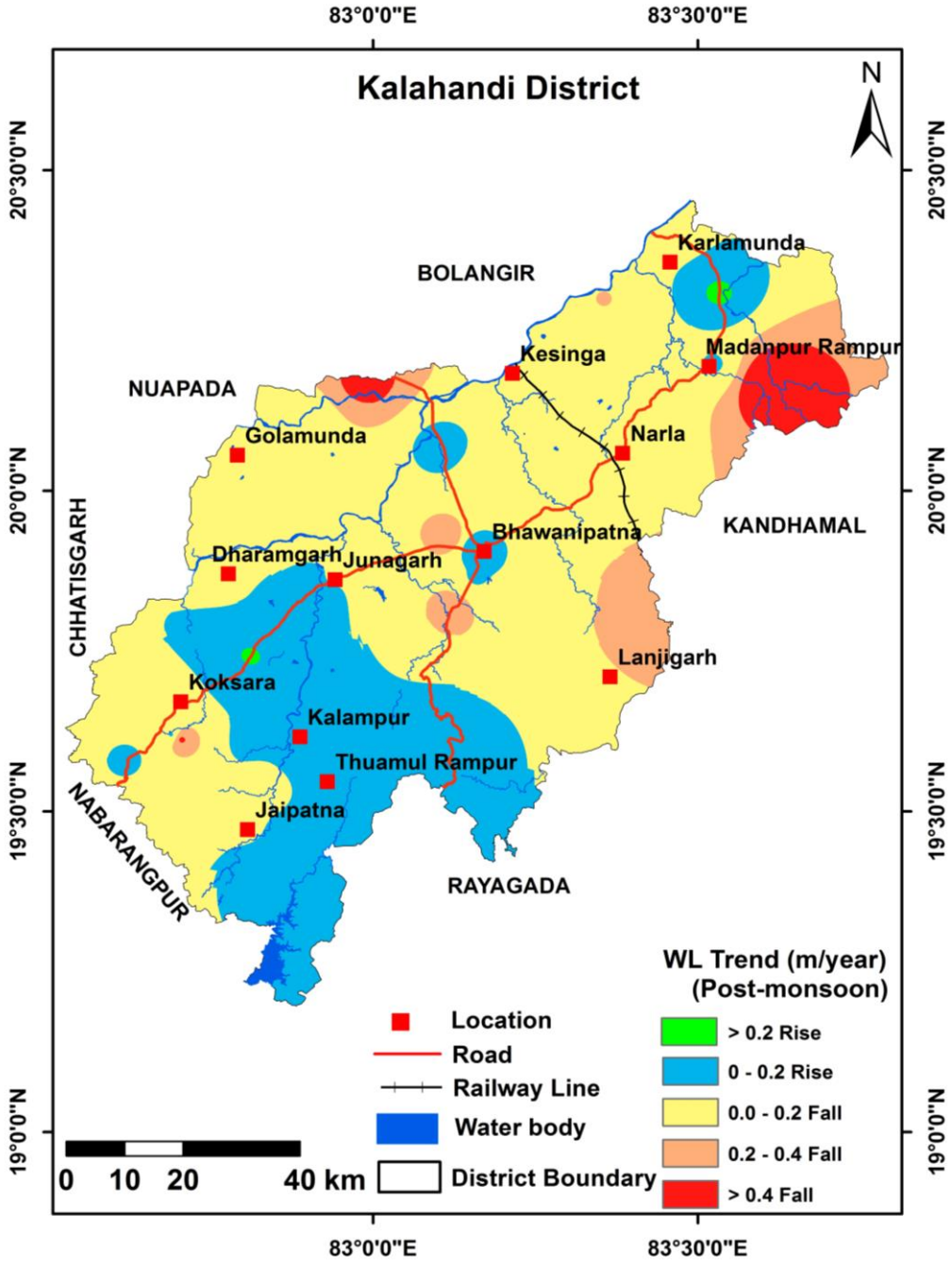

Fig. 3.5: Decadal Trend of Water Level for Post-Monsoon Period (2010-19), in Kalahandi District.

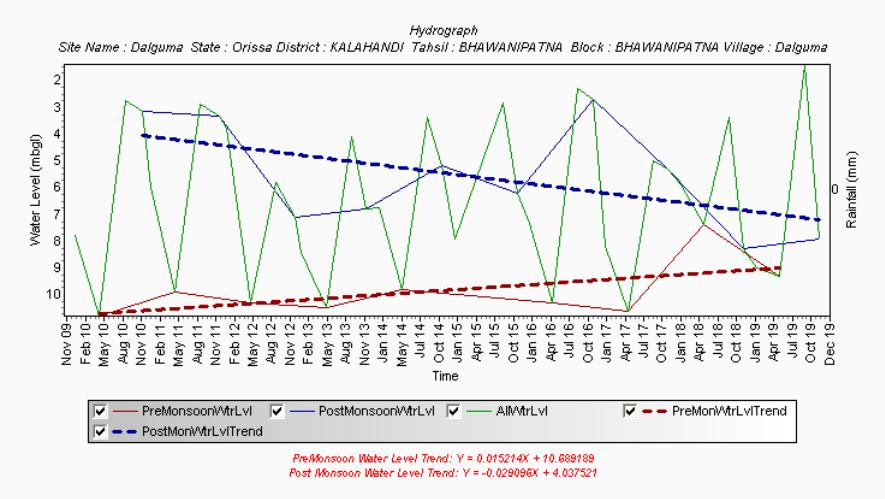

Fig. 3.6a: Hydrograph (2010-19), Dalguma, Bhawanipatna Block.

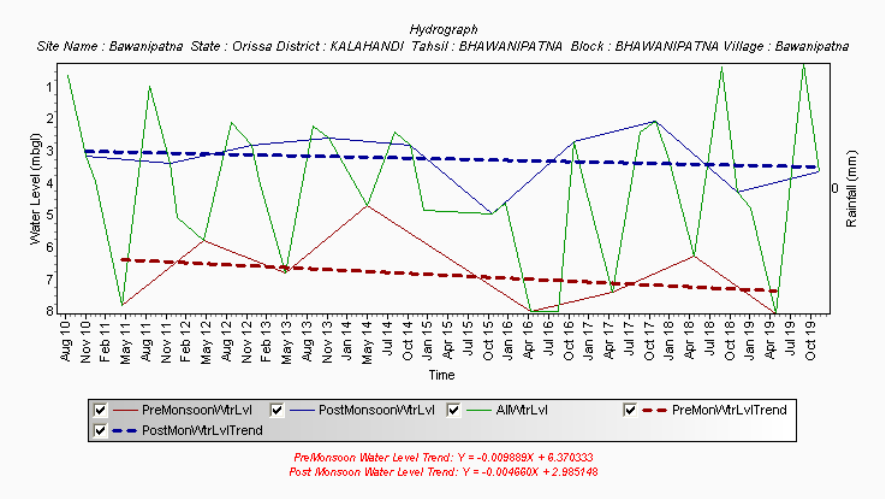

Fig.3.6b: Hydrograph (2010-19), Bhawanipatna, Bhawanipatna Block.

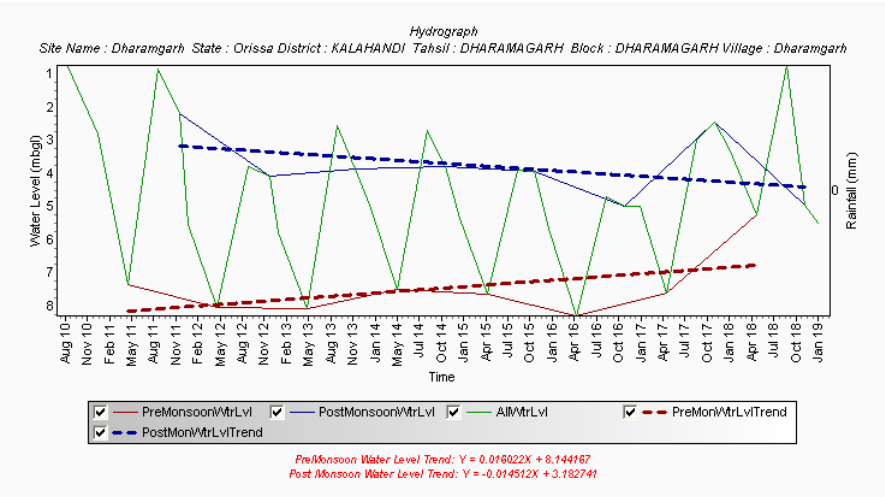

Fig.3.6c: Hydrograph (2010-19), Dharamgarh, Dharamgarh Block.

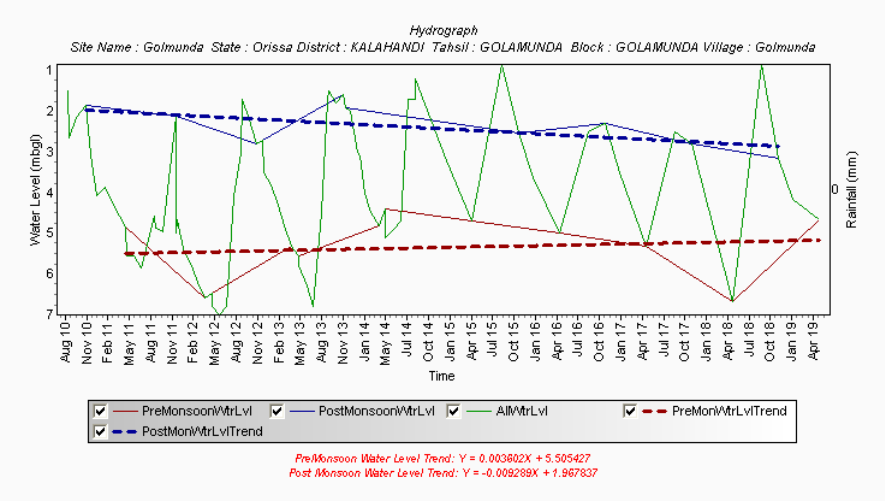

Fig.3.6d: Hydrograph (2010-19), Golamunda, Golamunda Block.

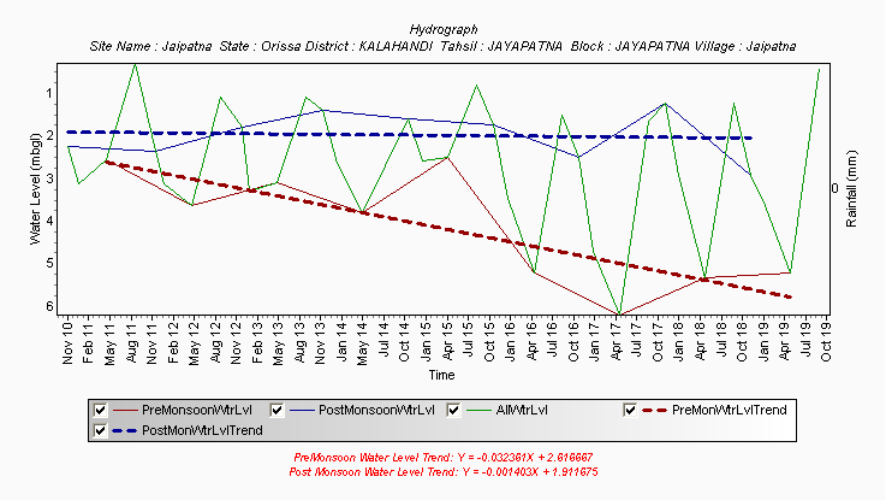

Fig.3.6e: Hydrograph (2010-19), Jaipatna, Jaipatna Block.

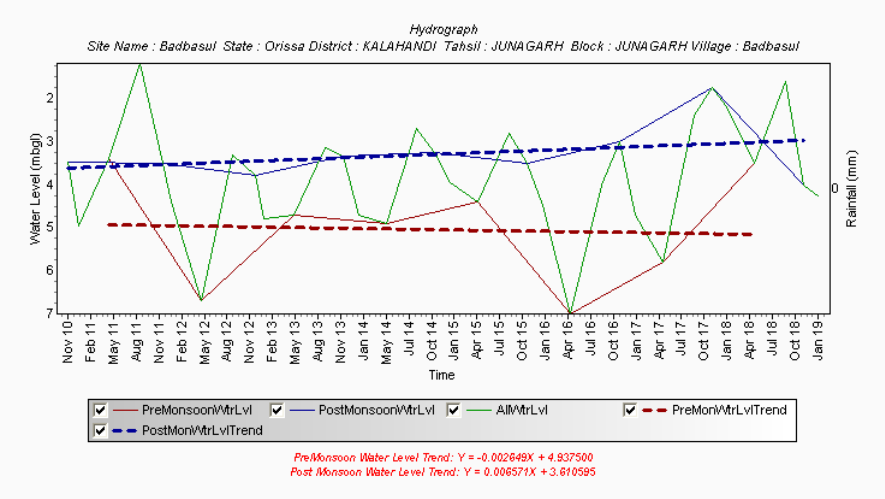

Fig.3.6f: Hydrograph (2010-19), Badbasul, Junagarh Block.

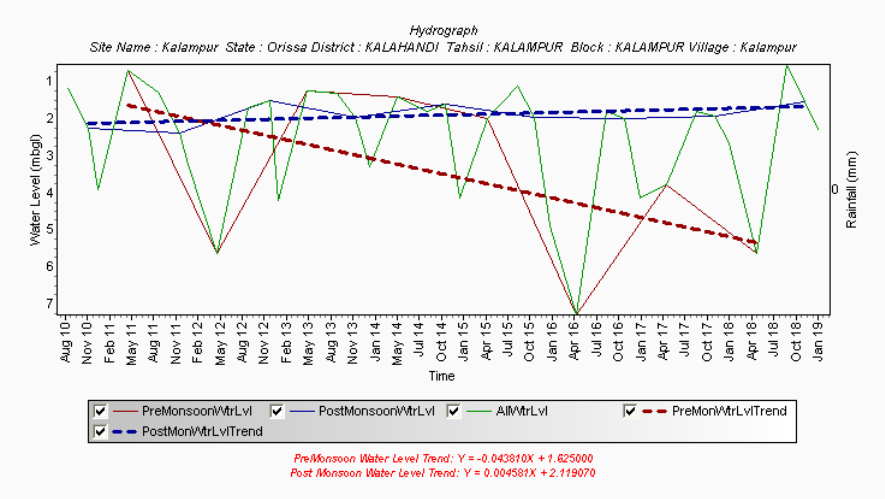

Fig.3.6g: Hydrograph (2010-19), Kalampur, Kalampur Block.

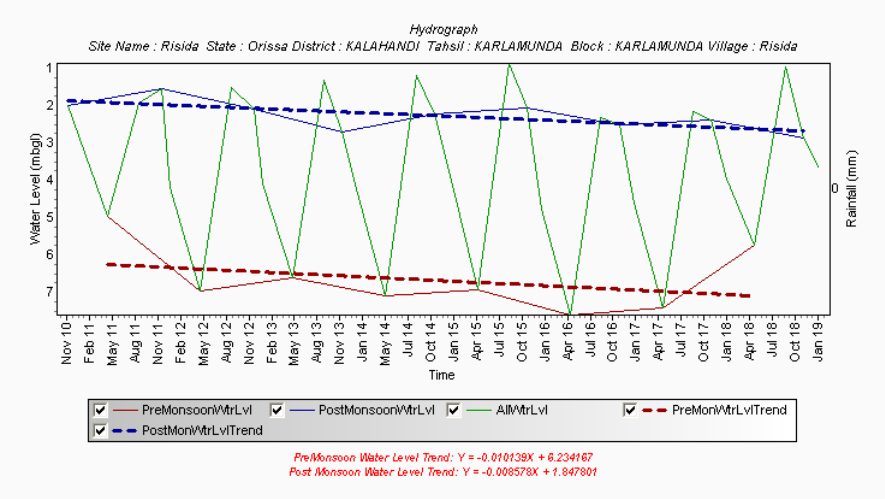

Fig.3.6h: Hydrograph (2010-19), Risida, Karlamunda Block.

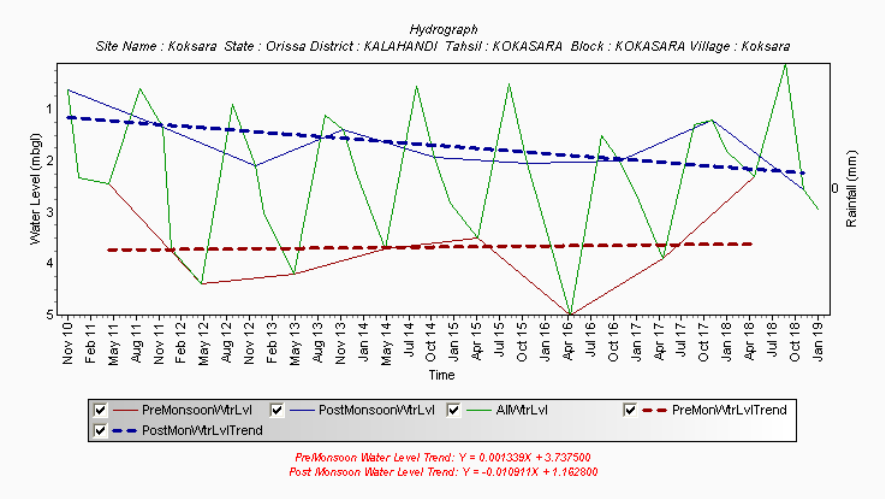

Fig.3.6i: Hydrograph (2010-19), Koksara, Koksara Block.

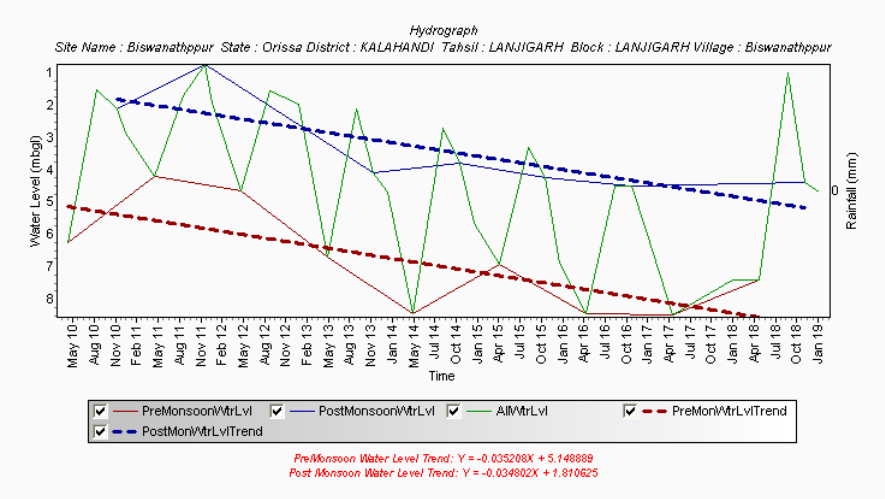

Fig.3.6j: Hydrograph (2010-19), Biswanathpur, Lanjigarh Block.

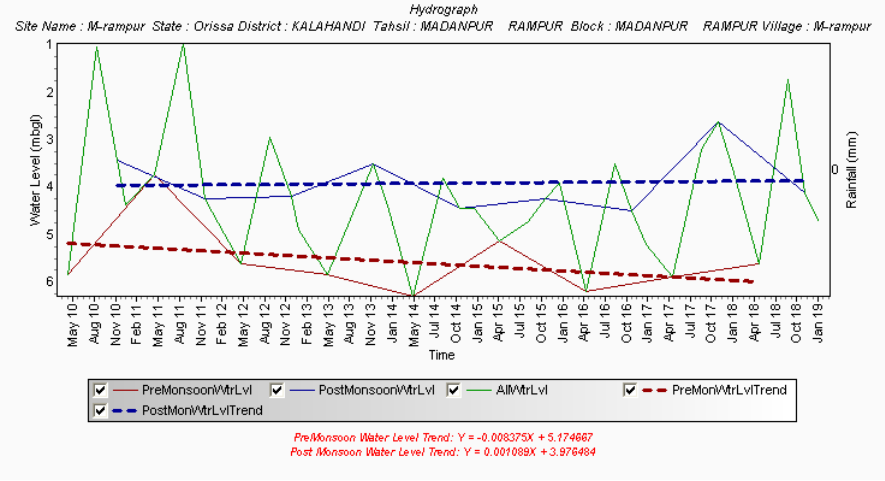

Fig.3.6k: Hydrograph (2010-19), M Rampur, M Rampur Block.

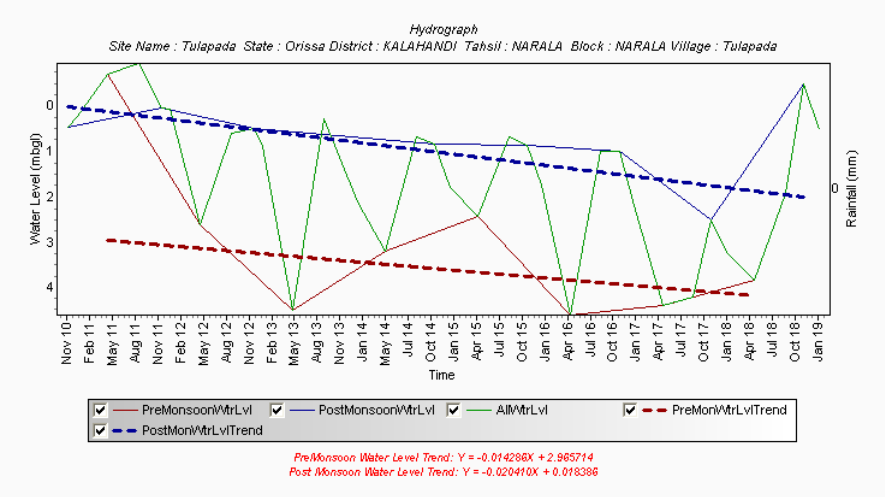

Fig.3.6l: Hydrograph (2010-19), Tulapada, Narla Block.

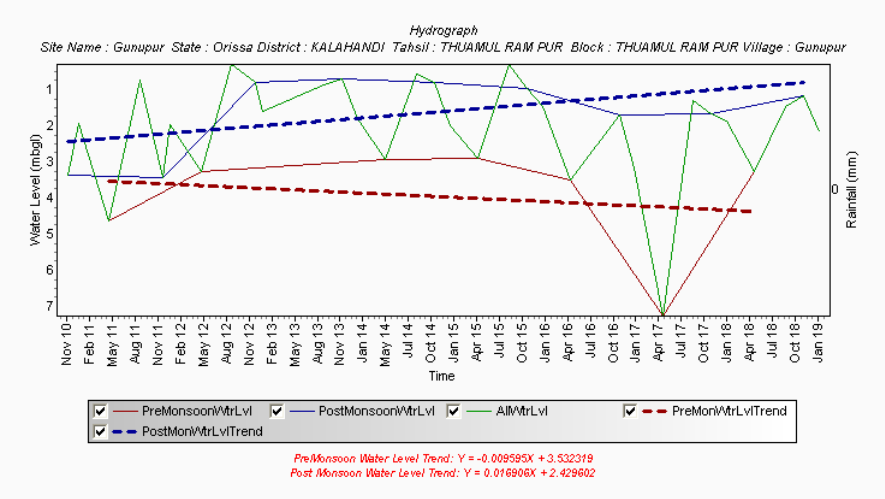

Fig.3.6m: Hydrograph (2010-19), Gunupur, T Rampur Block.

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 122 EWs (Exploratory Well) and 20 OWs (Observation Wells) in Kalahandi district through its Ground Water Exploration Programme and AEDP programme,whose depths range from 84.87 m bgl (Duarsuni) to 200.20 m bgl (Boria, Kashibahal etc). The static water level varies from 1.0 m bgl (Jamunabahal) to 11.95 m bgl (Gopalpur). The discharge of successful borewells varies from 0.5lps to a maximum of 18 lps (Bishwanathpur). The maximum drawdown recorded during PYT/APT varies from 3.37 m (Singhjharni) to 33.74 m (Kalampur). The transmissivity (T) of the aquifers ranges from 0.23 m^2/day (Golamunda) to 86.5 m^2/day (Badli). 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 15 to 50 m, which is just below the zone of weathering. The second depth range of prime importance is from 70 to 110 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 Kalahandi District.

Parameter	Unit	Shallow (Aquifer-I)		Deep (Aquifer-II)	
		Minimum	Maximum	Minimum	Maximum
pH	-	7.42	8.66	6.68	8.26
EC	µS/cm	100	4360	48	1739
TDS	mg/L	48	2549	38	990
TH	mg/L	35	980	3	720
TA	mg/L	30	610	-	-
Ca^{++}	mg/L	10	137	6	194
Mg^{++}	mg/L	1	177	1.2	85
Na^{+}	mg/L	1	678	2	152
K^{+}	mg/L	0.4	241	0.4	62
$CO_3^{=}$	mg/L	0	84	0	0
HCO_3^{-}	mg/L	37	718	12	628
NO_3^{-}	mg/L	0	594	0	192
Cl^{-}	mg/L	4	893	7.1	216
$SO_4^{=}$	mg/L	0	434	0.6	152
F^{-}	mg/L	0	7.2	0.03	2.6
Fe	mg/L	-	-	0.02	5.8

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 100 to 4360 µs/cm in shallow and 48 to 1739 µs/cm in deeper aquifers. The EC map is given in **Figure 3.5.**

The fluoride concentration is within permissible limit in all location except few samples of some isolated pockets. The Fluoride concentration map is given in **Figure 3.6**. The chloride map is given in **Figure 3.7.**

***Salinity hazard*:** For the determination of salinity hazard and suitability of the ground water for the purpose of irrigation analysed in the *US-Salinity diagram* as shown in **Fig. 3.8**. The predominant USSL classes of the water samples fall within C2S1 and C3S1 classes.

***Ground water facies*:**The water samples represent Ca-Mg-HCO3to Ca-Mg-Cl- SO_4type as shown in the *Piper diagram* in **Fig. 3.9**. This indicates a transitional or mixing environment between the younger water and resident water.

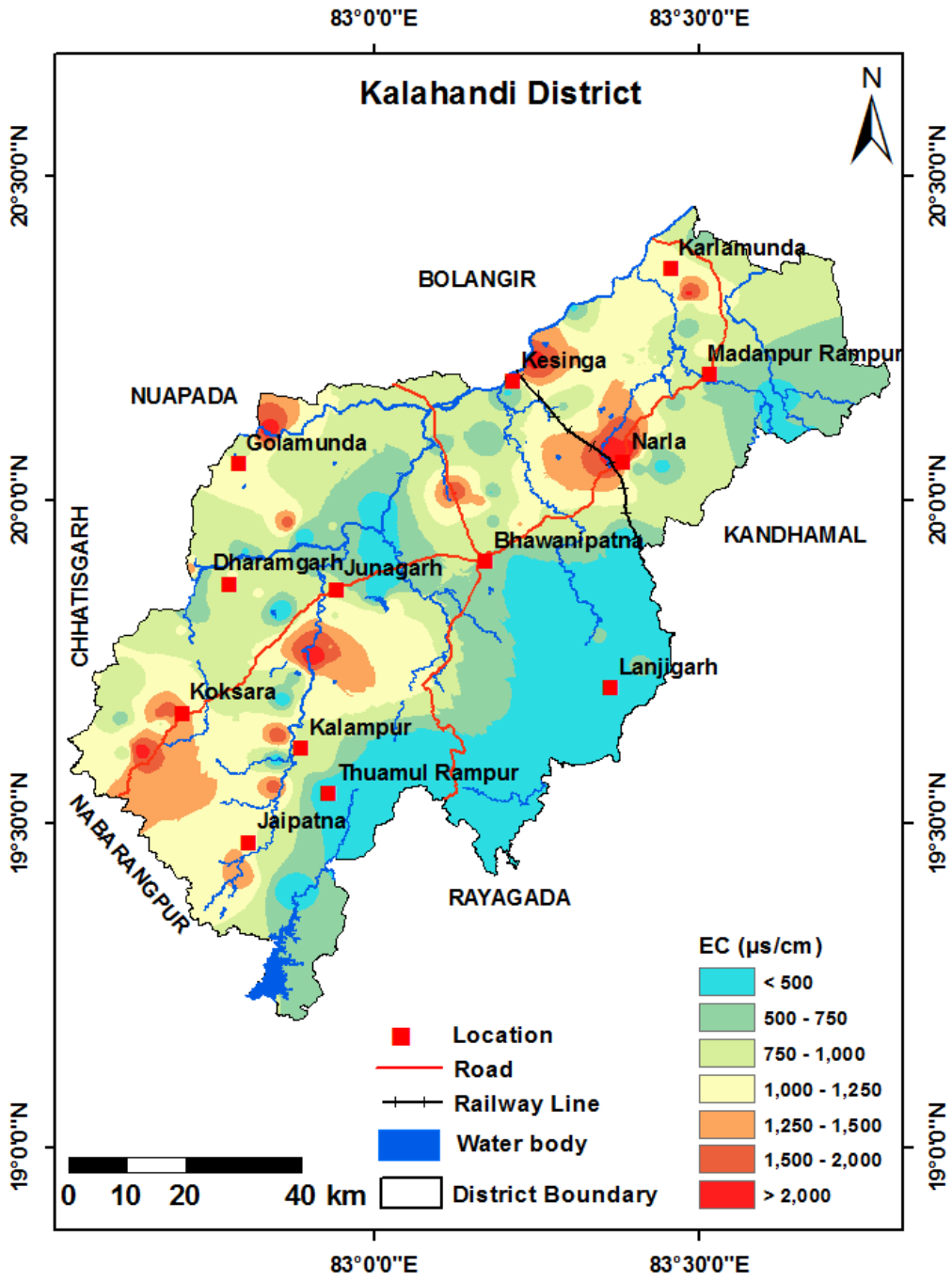

Fig. 3.7: Electrical Conductivity Map, Phreatic Aquifer in Kalahandi District.

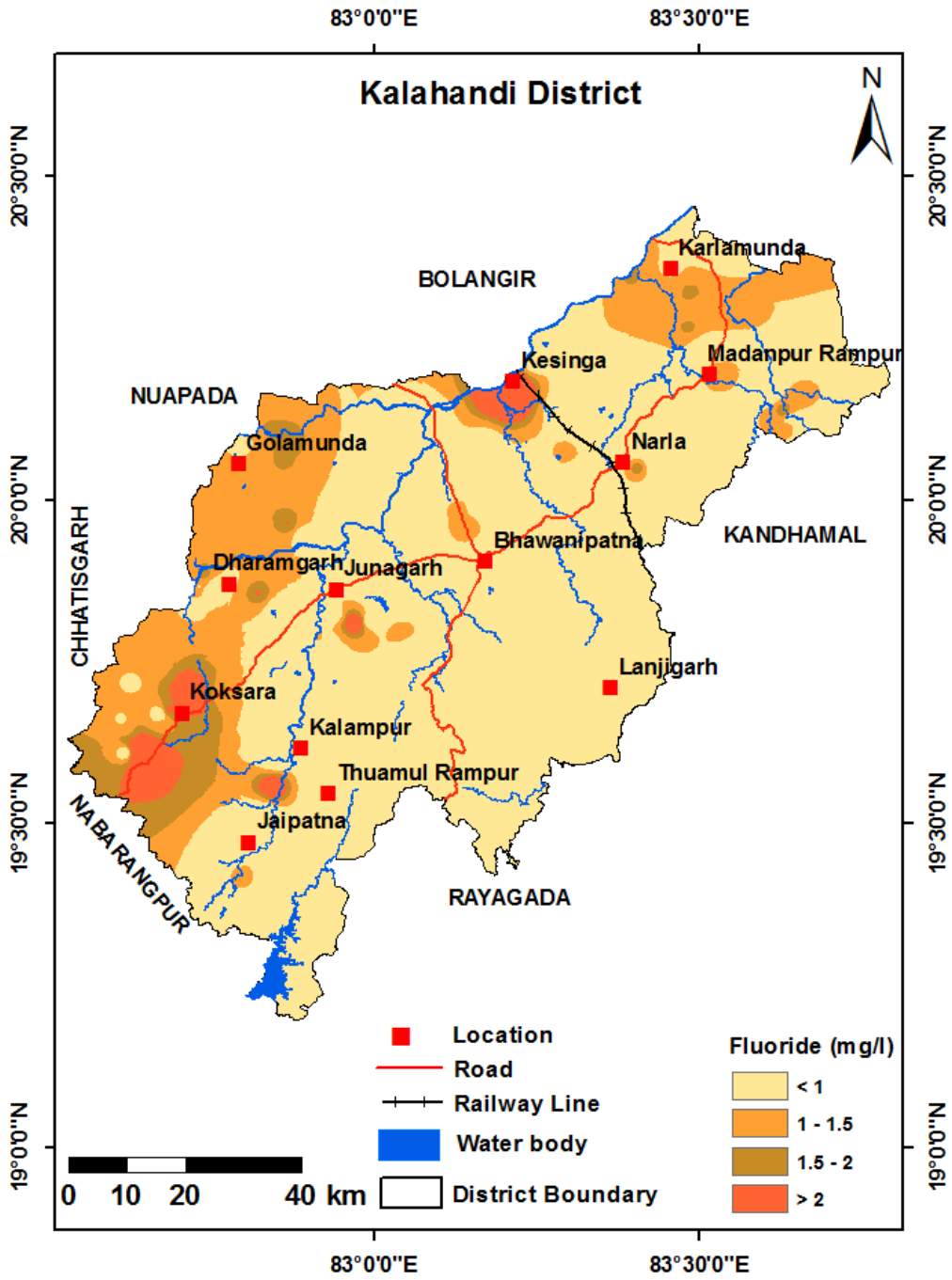

Figure 3.8: Fluoride Concentration Map, Phreatic Aquifer in Kalahandi District.

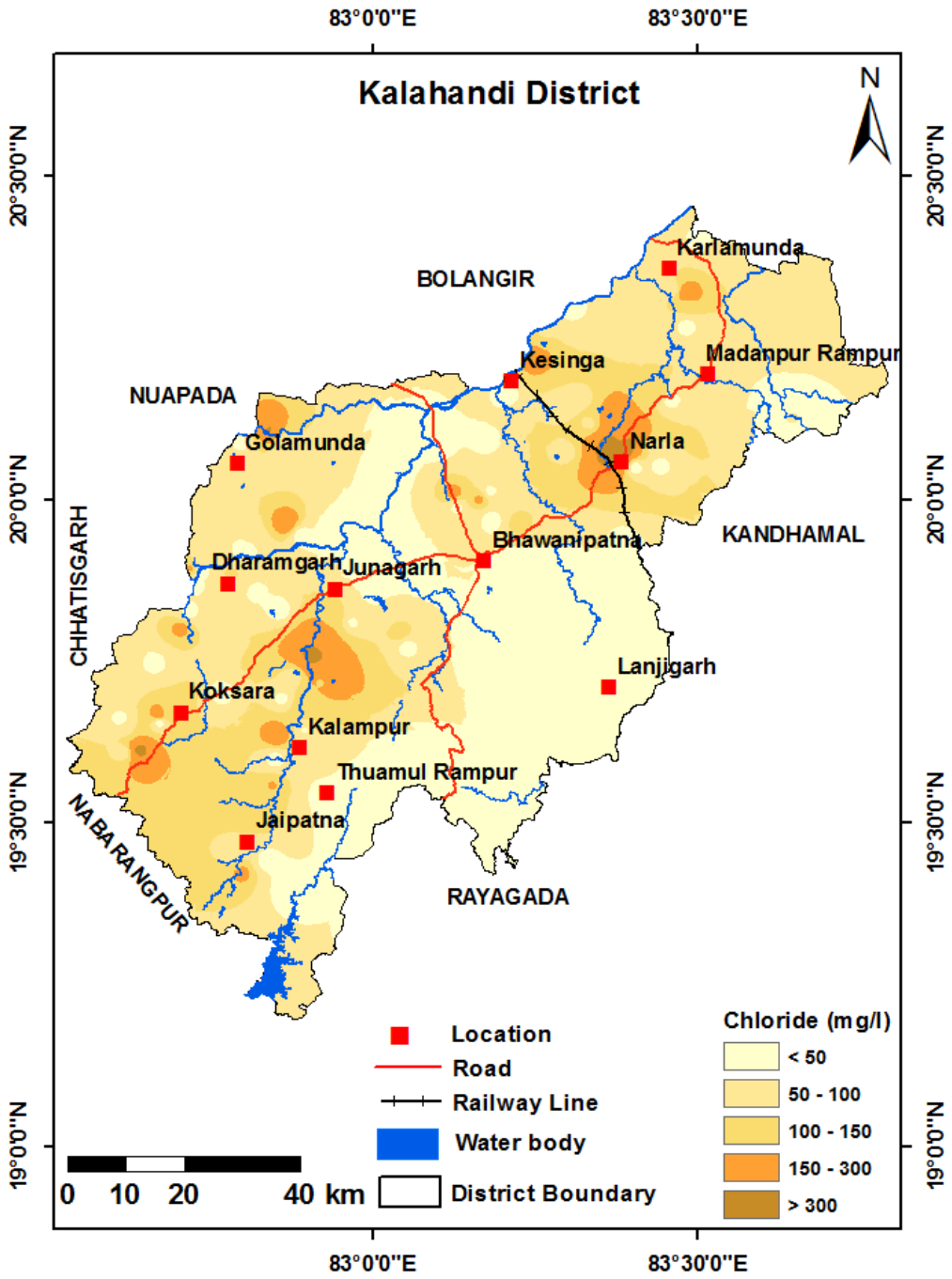

Figure 3.9: Chloride Concentration Map, Phreatic Aquifer in Kalahandi District.

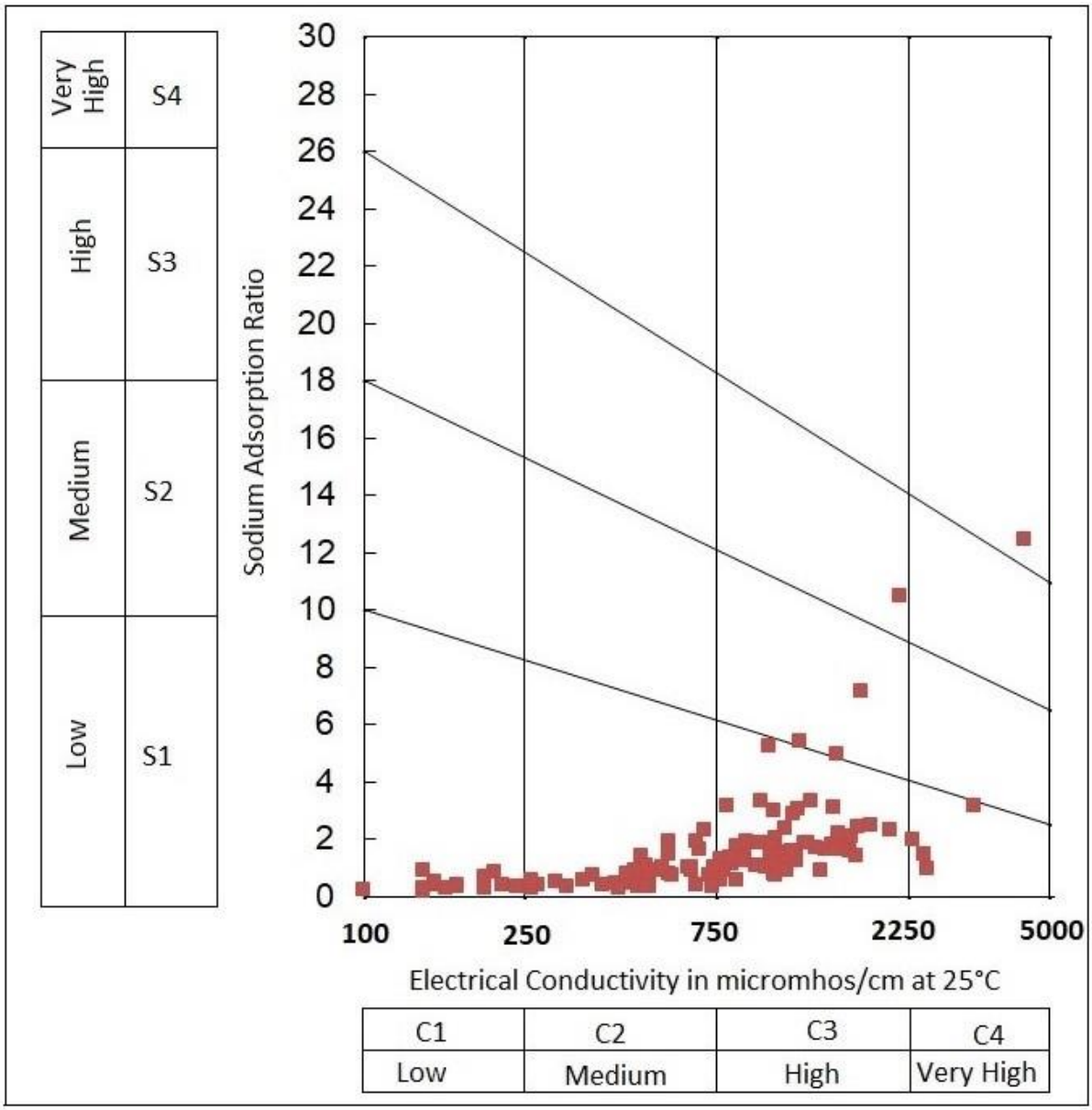

Fig. 3.10: US-Salinity Diagram, Phreatic Aquifer in Kalahandi District.

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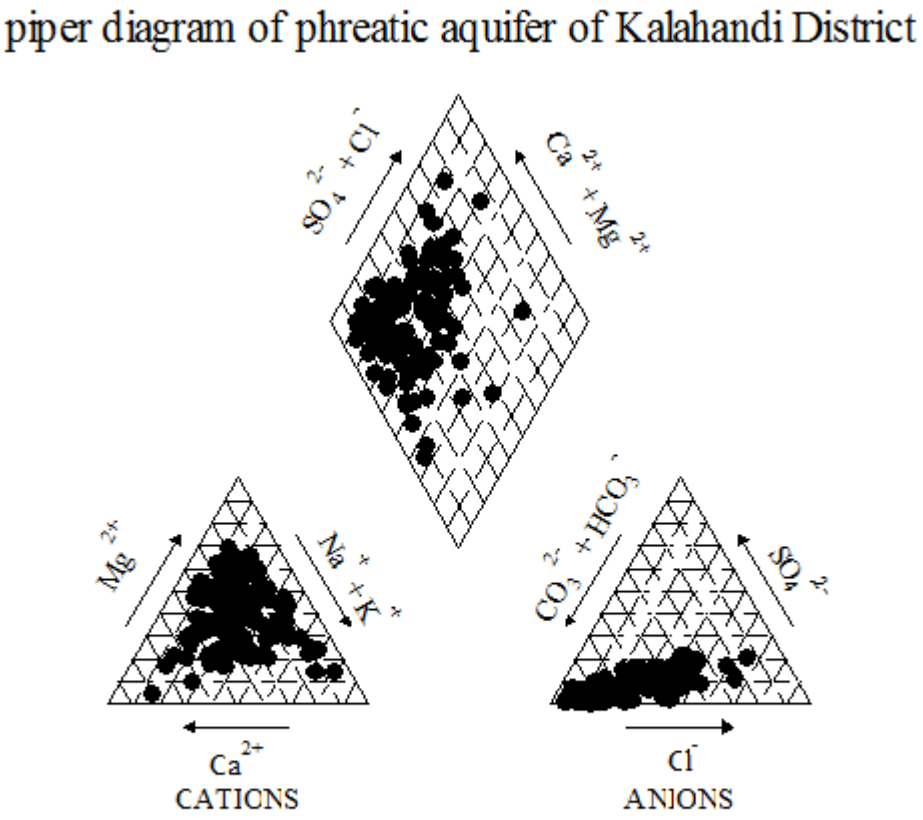

Fig. 3.11: Piper Diagram of Water Samples in Phreatic Aquifer, Kalahandi District.

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): Unconfined aquifer 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.

The characteristics of the aquifer groups are summarized in **Table 3.3**.

Table 3.3: Characteristics of Aquifer Groups in Kalahandi District.

Type of Aquifer Group	Formation	Depth range (mbgl)	Yield	Suitability for drinking/ irrigation
Aquifer-I (Phreatic)	**Unconsolidated and Weathered** **Recent**: Soil, Alluvium & Laterite **Pre-cambrian**: Granite Gneiss, Charnockite, Khondalite,	0-50	5-10 lps	Yes for both
Aquifer-II (Semi-confined to Confined)	**Fractured** Granite Gneiss, Charnockite, Khondalite, Anorthosites,	50-200	Negl.-18 lps	Yes for both

3.5 Aquifer Disposition

The ground water exploration data has been used to generate the 3D 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, C-D and E-F, which are shown in plan view in **Fig.3.12** and the 2D sections are shown in **Figure 3.13, Figure 3.14** and **Figure 3.15.** Based on the ground water exploration and micro-level hydrogeological survey data and aquifer delineation method, a schematic 3-D aquifer disposition is prepared and shown in **Fig. 3.16.** A 3D Fence diagram is shown in **Fig. 3.17**. As per VES data four 2D schematic sections were drawn along lines A-A', B-B' , C-C' and D-D', which are shown in plan view in **Fig.3.18** and the corresponding 2D schematic sections are shown in **Fig. 3.19**, **3.20, 3.21** and **3.22.**

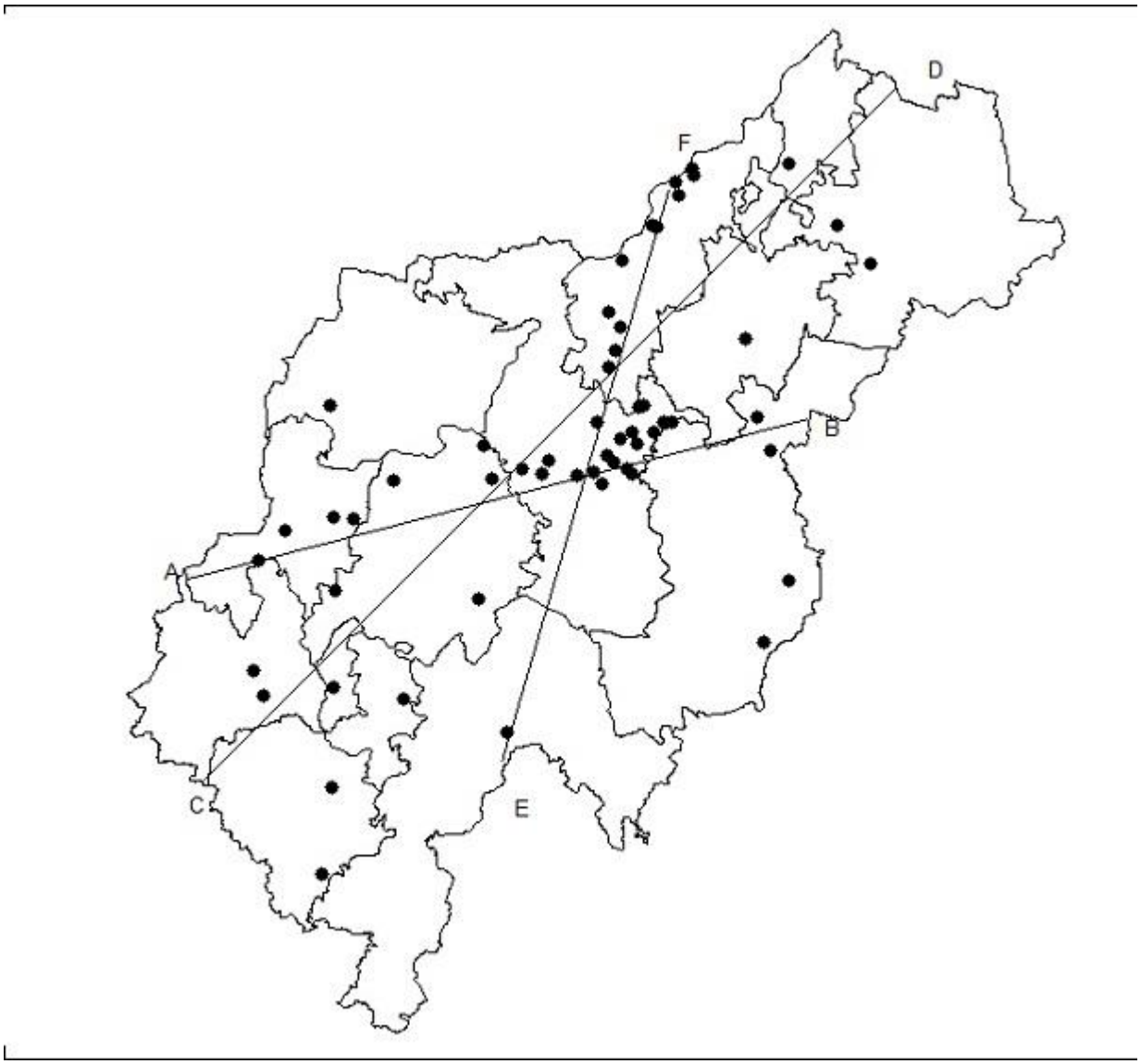

Fig. 3.12: Aquifer 2D Section Lines along A-B, C-D and E-F.

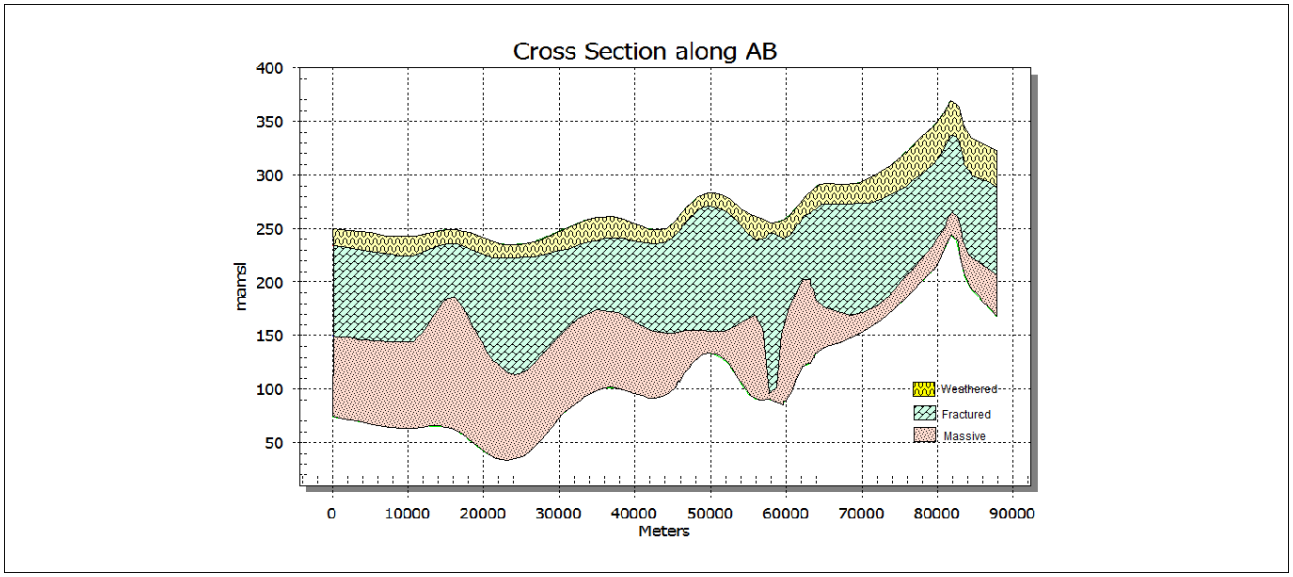

Fig. 3.13: Schematic Aquifer Cross-Section along A-B in KalahandiDistrict.

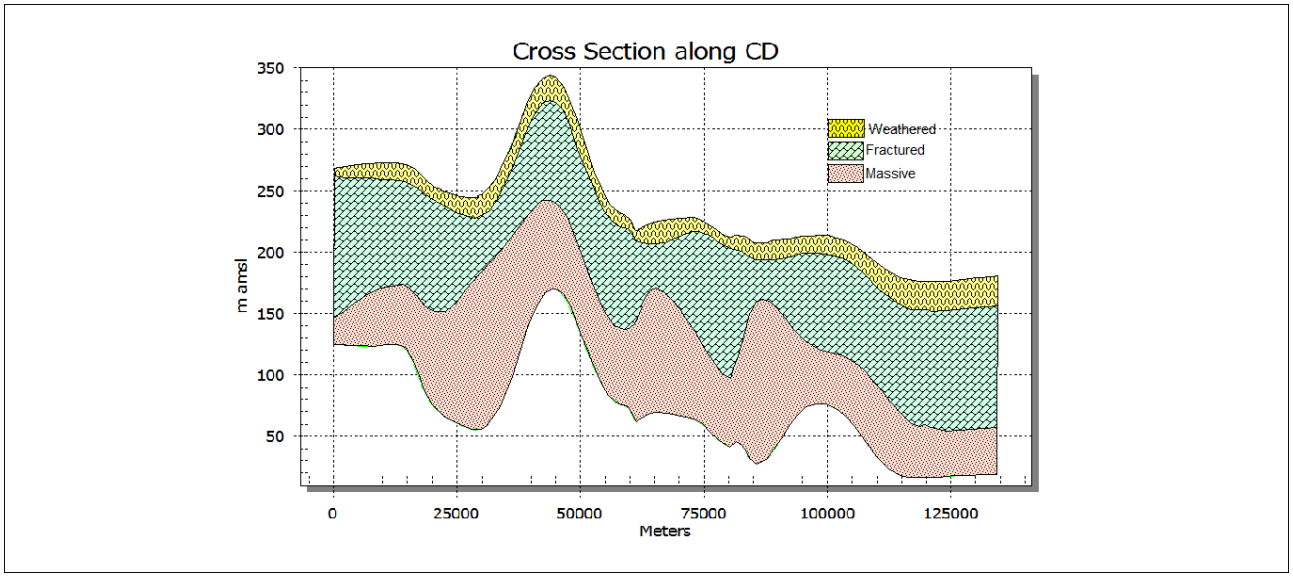

Fig. 3.14: Schematic Aquifer Cross-Section along C-D in KalahandiDistrict.

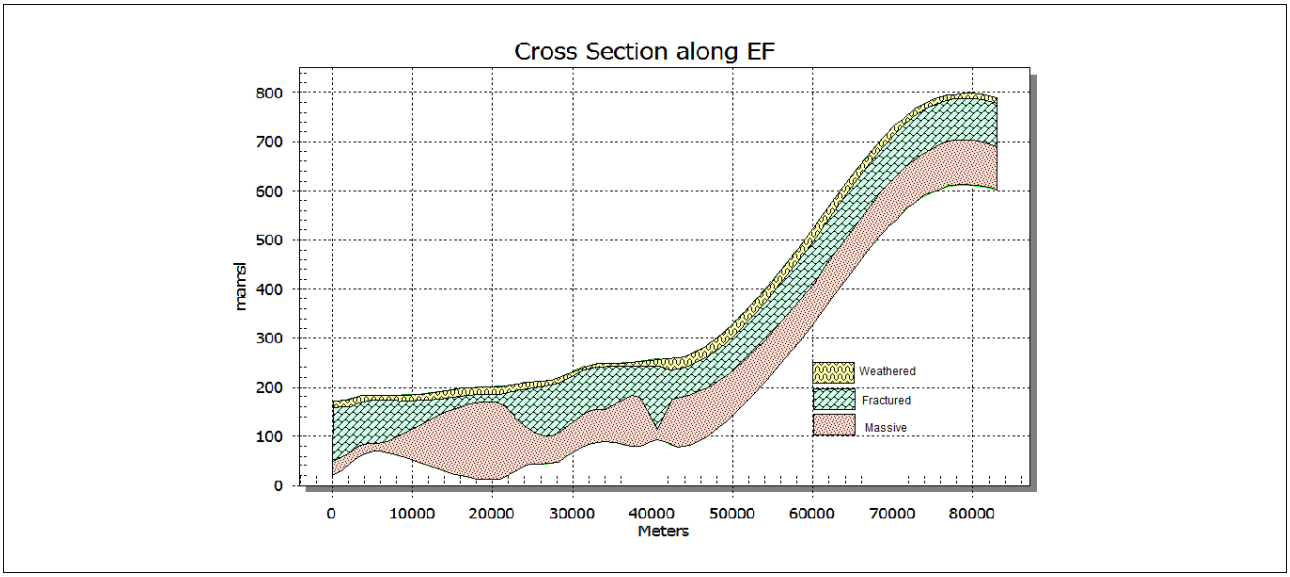

Fig. 3.15: Schematic Aquifer Cross-Section along E-F in KalahandiDistrict.

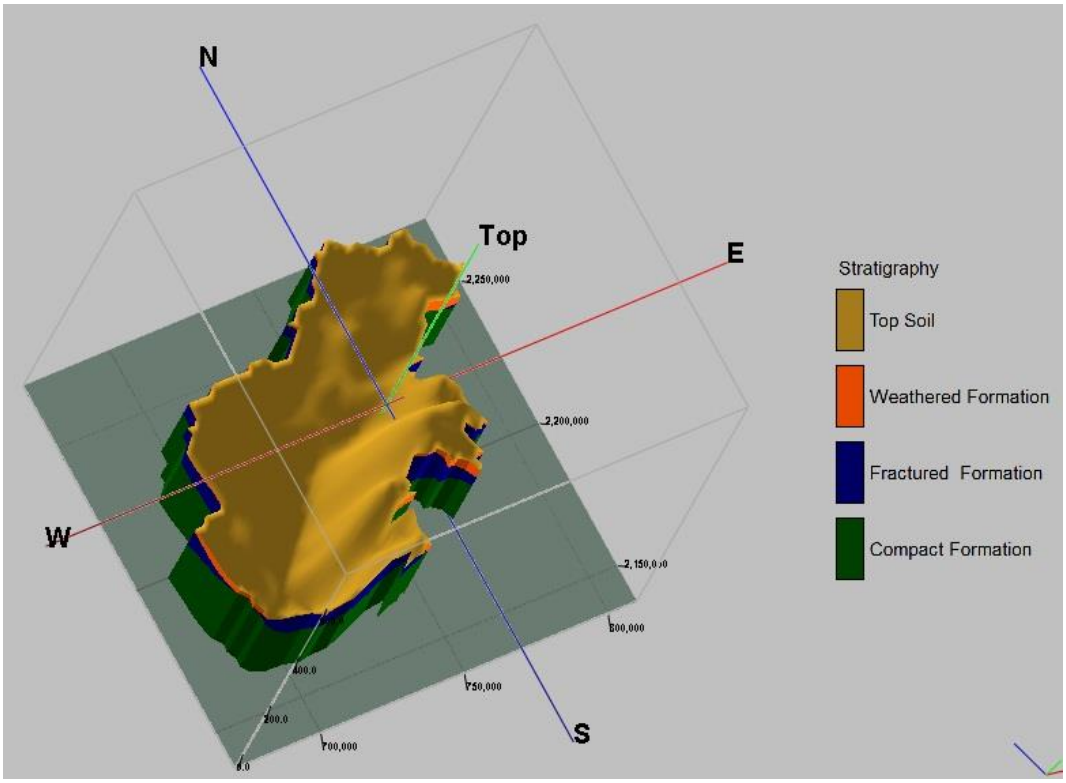

Fig. 3.16: Schematic 3D Aquifer Disposition in Kalahandi District.

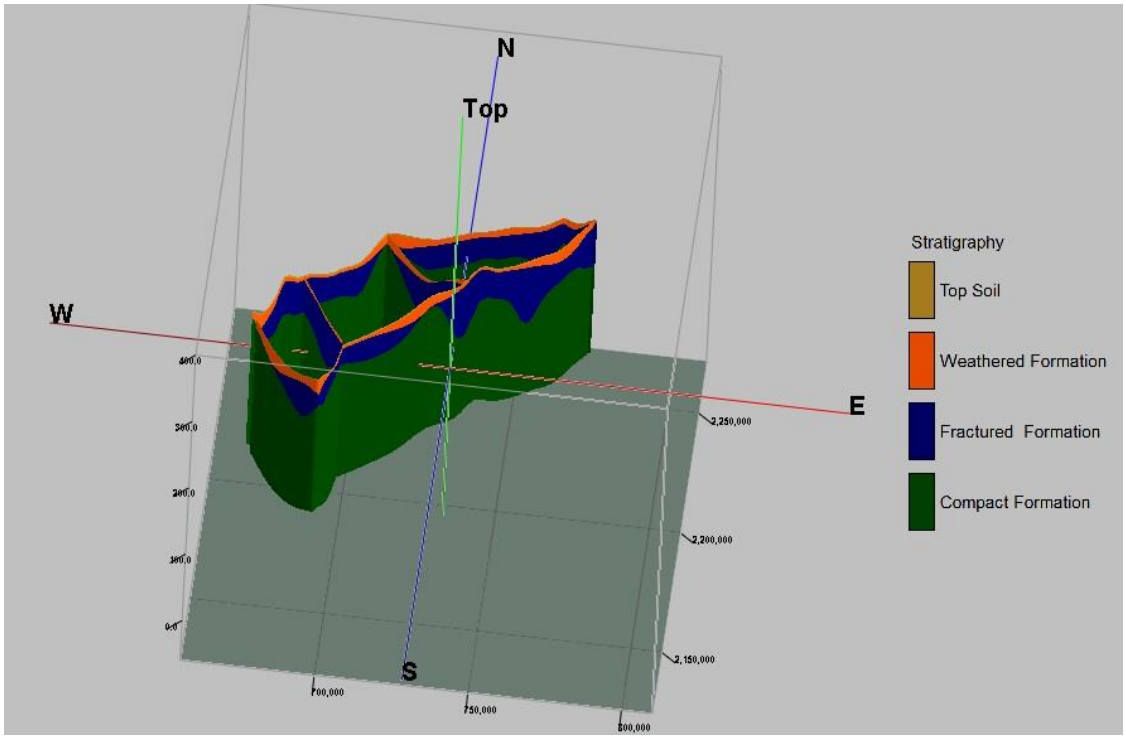

Fig. 3.17: Schematic 3D-Fence Diagram in Kalahandi District.

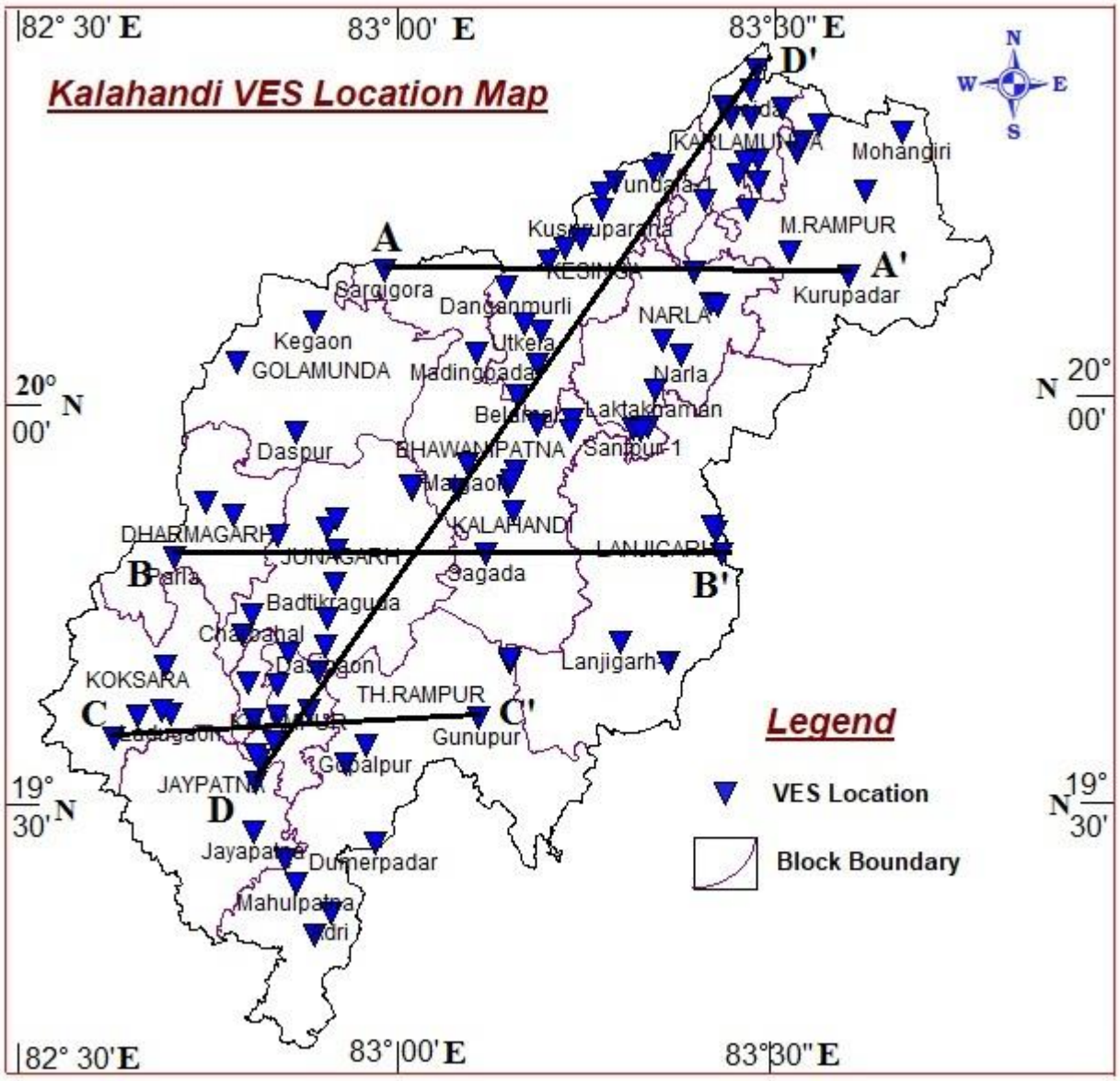

Fig. 3.18: Aquifer 2D Section(VES DATA) Lines along A-A', B-B', C-C' and D-D' Kalahandi District.

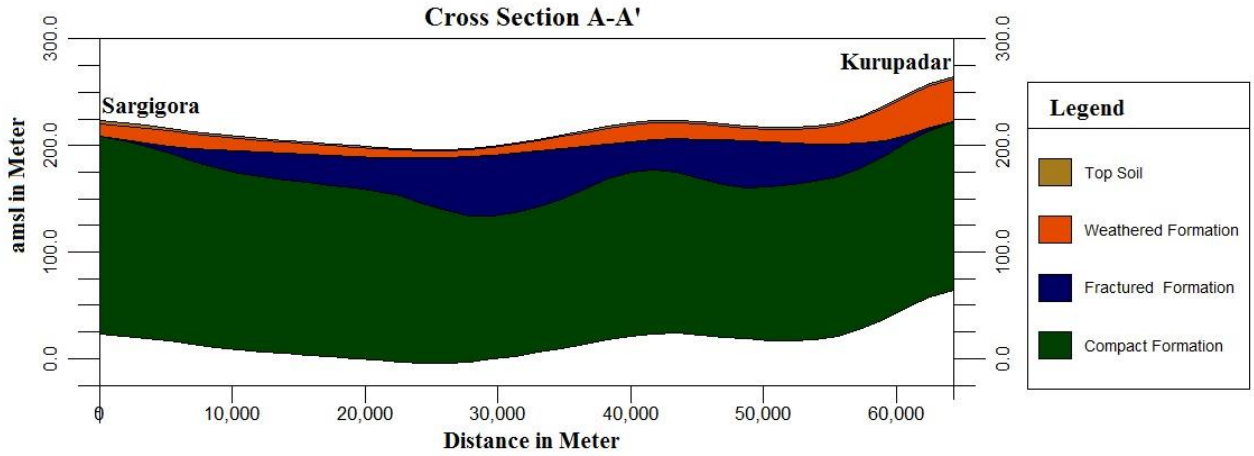

Fig. 3.19: Schematic Aquifer(VES DATA) Cross-Section Along A-A' in Kalahand District.

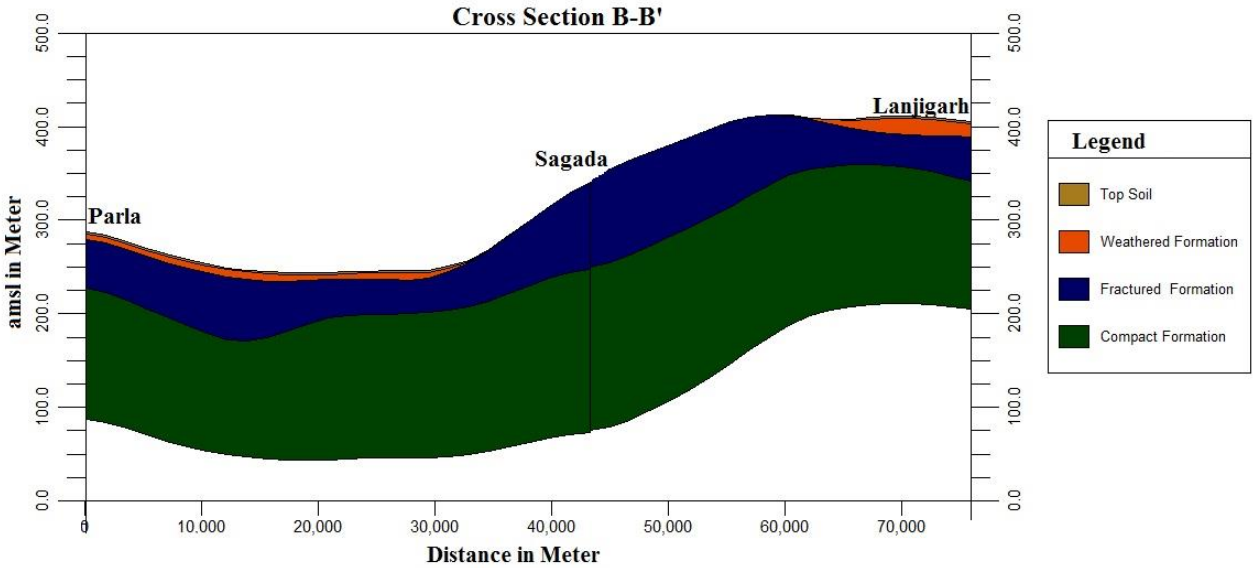

Fig. 3.20: Schematic Aquifer(VES DATA) Cross-Section Along B-B' in Kalahand District.

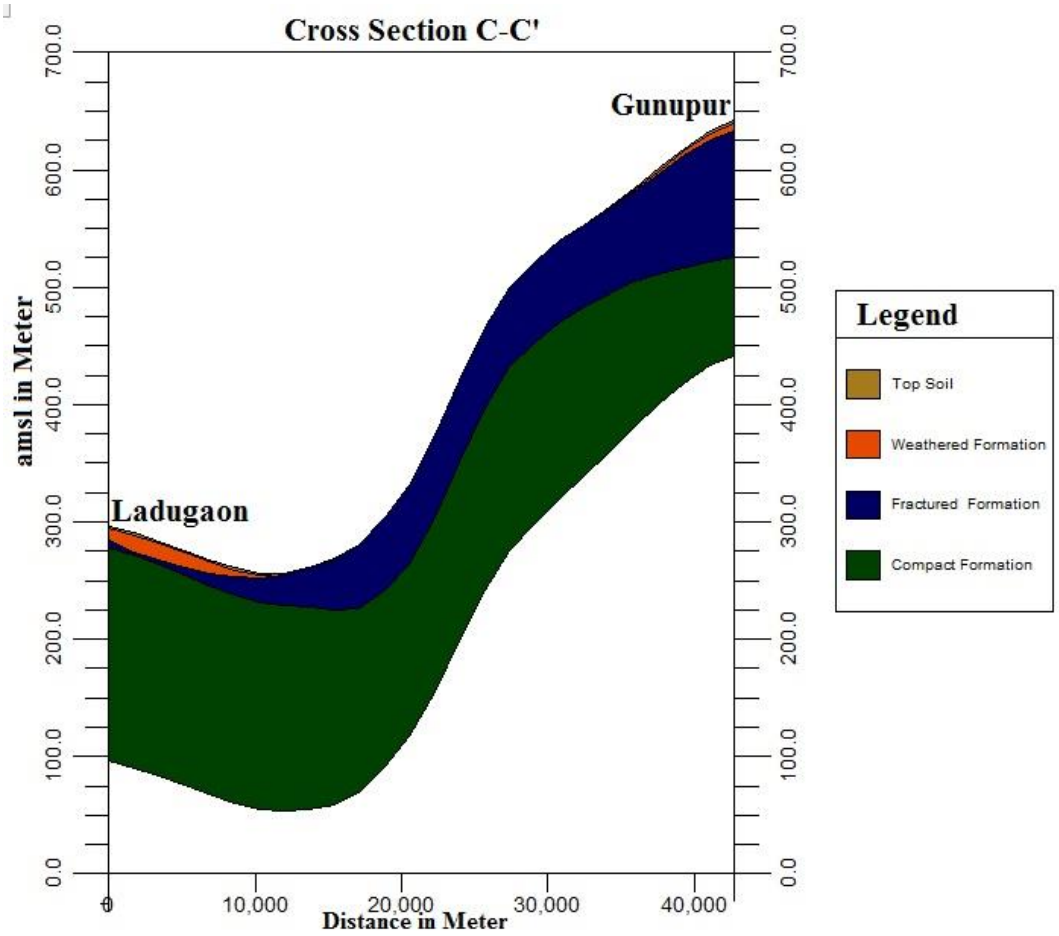

Fig. 3.21: Schematic Aquifer(VES DATA) Cross-Section Along C-C' in Kalahand District.

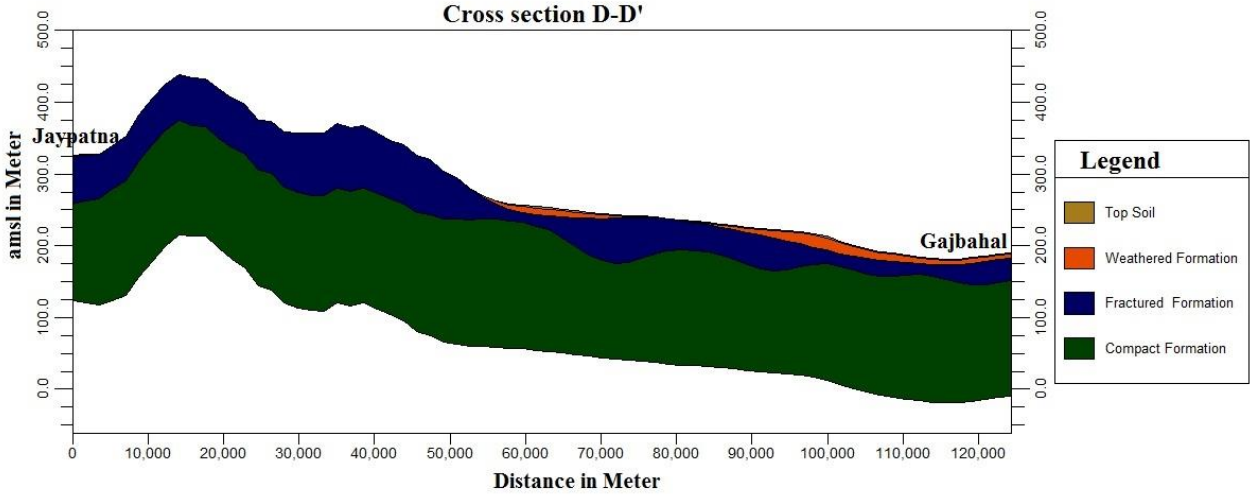

Fig. 3.22: Schematic Aquifer(VES DATA) Cross-Section Along D-D' in Kalahand District.

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 Kalahandi 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	Bhawanipatna	6975.49	3266.56	799.04	4065.61	795.39	2825.13	58.28
2	Dharmagarh	4200.97	1087.78	438.51	1526.29	468.86	2624.44	36.33
3	Golamunda	6518.4	2473.96	403.02	2876.97	442.21	3591.44	44.14
4	Jaipatna	4618.73	748.75	404.25	1153	392.62	3433.71	24.96
5	Junagarh	7047.47	2050.04	672.33	2722.37	705.01	4251.97	38.63
6	Kalampur	2704.83	410.88	179.95	590.84	188.24	2099.07	21.84
7	Karlamunda	3298.35	511.45	186.27	697.72	187.49	2582.75	21.15
8	Kesinga	5863.66	2609.99	716.40	3326.39	498.79	2489.83	56.73
9	Koksara	4275.58	1346.86	439.52	1786.38	374.37	2459.32	41.78
10	Lanjigarh	3357.67	510.95	324.85	835.82	333.34	2478	24.89
11	M. Rampur	4198.65	1408.28	240.98	1649.27	245.31	2540.63	39.28
12	Narla	4533.91	2217.88	377.62	2595.5	400.09	1898.26	57.25
13	Th. Rampur	3457.34	305.72	264.50	570.22	292.22	2859.4	16.49

	Total	**61051.05**	**18949.10**	**5447.25**	**24396.38**	**5323.94**	**36133.95**	**39.96**

The combined net ground water available is 61051.05 Ham and gross annual draft is 24396.38 Ham. The stage of ground water extraction is minimum in Karlamunda block which is 21.15%. The highest ground water extraction is in Bhawanipatna block that is 58.28 % 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 Kalahandi 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	Bhawanipatna	92090	50	7.63	42.37	0.03	117055.60
2	Dharmagarh	37792	50	6.94	43.06	0.03	48819.71
3	Golamunda	63920	50	5.82	44.18	0.02	56479.71
4	Jaipatna	50859	50	4.19	45.81	0.02	46597.02
5	Junagarh	67401	50	4.32	45.68	0.02	61577.55
6	Kalampur	16001	50	2.86	47.14	0.02	15085.74
7	Karlamunda	20891	50	6.57	43.43	0.02	18145.92
8	Kesinga	48239	50	5.6	44.40	0.02	42836.23
9	Koksara	46564	50	4.37	45.63	0.02	42494.31
10	Lanjigarh	104237	50	6.41	43.59	0.02	90873.82
11	M. Rampur	85818	50	5.81	44.19	0.02	75845.95
12	Narla	49842	50	3.37	46.63	0.02	46482.65
13	Th. Rampur	107781	50	1.56	48.44	0.02	104418.23

	Total	**791435**					**766712.44**

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

Sl No	Block	Dynamic Resource	In Storage Resource	Total Ground Water
1	Bhawanipatna	6975.49	117055.60	124031.1
2	Dharmagarh	4200.97	48819.71	53020.68
3	Golamunda	6518.4	56479.71	62998.11
4	Jaipatna	4618.73	46597.02	51215.75
5	Junagarh	7047.47	61577.55	68625.02
6	Kalampur	2704.83	15085.74	17790.57
7	Karlamunda	3298.35	18145.92	21444.27
8	Kesinga	5863.66	42836.23	48699.89
9	Koksara	4275.58	42494.31	46769.89
10	Lanjigarh	3357.67	90873.82	94231.49
11	M. Rampur	4198.65	75845.95	80044.6
12	Narla	4533.91	46482.65	51016.56
13	Th. Rampur	3457.34	104418.23	107875.6
	Total	**61051.1**	**766712.4**	**827763.5**

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 Kalahandi 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	Bhawanipatna	92090	50	200	150	7.5	0.03	20720.3
2	Dharmagarh	37792	50	200	150	7.5	0.03	8503.2
3	Golamunda	63920	50	200	150	7.5	0.02	9588.0

4	Jaipatna	50859	50	200	150	7.5	0.02	7628.9
5	Junagarh	67401	50	200	150	7.5	0.02	10110.2
6	Kalampur	16001	50	200	150	7.5	0.02	2400.2
7	Karlamunda	20891	50	200	150	7.5	0.02	3133.7
8	Kesinga	48239	50	200	150	7.5	0.02	7235.9
9	Koksara	46564	50	200	150	7.5	0.02	6984.6
10	Lanjigarh	104237	50	200	150	7.5	0.02	15635.6
11	M. Rampur	85818	50	200	150	7.5	0.02	12872.7
12	Narla	49842	50	200	150	7.5	0.02	7476.3
13	Th. Rampur	107781	50	200	150	7.5	0.02	16167.2
	Total	**791435**						**128456.4**

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 Dharmagarh, Golamunda, Jaipatna, Kalampur, Karlamunda, Koksara, Lanjigarh, M. Rampur and Thuamul Rampur4200.97, 6518.4, 4618.73, 7047.47, 2704.83, 3298.35, 4275.58, 3357.67, 4198.65and 3457.34ham respectively. The stages of ground water development are 36.33, 44.14, 24.96, 38.63, 21.84, 21.15, 41.78, 24.89, 39.28 and 16.49%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 Water Logging Problem

Water logging conditions have been observed in parts of Jaipatna, Thuamul Rampur, Kalampur and Koksara blocks which form a part of Indravati Command area, where water level is within 2m below from ground surface. Low topography, unlined canals, indiscriminate application of canal water and the prevailing paddy cultivation in both Kharif and Rabi seasons are mainly responsible for the water logging.

5.1.4 Depleted Water Level in Phreatic Aquifer

Ground water level in the phreatic aquifer is found to be deep in many parts of Kalahandi district. Depth to water level during pre-monsoon periods is deeper (4-8mbgl) in most of Bhawanipatna, Golamunda, Karlamunda, Kesinga and Lanjigarh blocks. However, during the post-monsoon water level rises in most of the districts and remain within 2-4 mbgl excluding small patches. The decadal trend of water level is negative in eastern and southern part of Lanjigarh and Jaipatna blocks respectively and in the western and northern part of the district covering parts of Golamunda, Kesinga and Karlamunda blocks.Thus long-term change in water level is not so significant. The deeper level during the pre-monsoon indicates ground water scarcity in the areas during the summer months. But shallow post-monsoon water level in most parts of the district indicates that, the natural replenishment of phreatic aquifer during rainy season is adequate.

5.2 Aquifer Management Plan

5.2.1 Demand Vs Supply Scenario of 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 Kalahandi District.

Block	Existing Water Demand for 2011 (MCM)					Water Demand for 2025 (MCM)	Existing Water Availability(MCM)			Demand-SupplyGap (MCM)		Further Ground Water Development Potential (MCM)
	Domestic	Livestock	Irrigation	Industrial	Total	Total	Surface Water	Ground Water	Total	2011	2025	
Bhawanipatna	3.73	1.42	57.29	0.56	63	307.44	48.57	18.87	67.44	-4.44	240.01	1.20
Dharmagarh	3.05	0.44	47.53	0.46	51.48	863.4	110.64	10.03	120.67	-69.19	742.73	9.94
Golamunda	2.84	0.92	47.53	0.43	51.71	309.99	41.81	13.26	55.07	-3.36	254.92	10.34
Jaipatna	2.91	0.65	94.22	0.44	98.21	1024.4	95.02	6.63	101.65	-3.44	922.74	16.18
Junagarh	3.8	0.85	256.11	0.57	261.34	1600.83	252.23	13.6	265.83	-4.49	1335	15.06
Kalampur	1.32	0.26	75.37	0.2	77.14	598.56	72.58	6.11	78.69	-1.55	519.87	10.32
Karlamunda	1.26	0.53	64.71	0.19	66.69	239.45	63.07	5.12	68.19	-1.5	171.27	12.81
Kesinga	2.54	0.9	58.59	0.38	62.4	292.87	49.67	15.74	65.41	-3.01	227.46	1.92
Koksara	2.61	0.87	60.74	0.39	64.61	340.58	55.9	11.81	67.71	-3.1	272.87	7.79
Lanjigarh	2.04	0.85	38.91	0.31	42.1	133.41	36.5	8.03	44.53	-2.43	88.88	11.79
M. Rampur	1.82	0.69	38.89	0.27	41.67	155.96	34.68	9.16	43.84	-2.17	112.11	8.70
Narla	2.65	0.82	63.24	0.4	67.11	287.63	56.03	14.22	70.25	-3.14	217.38	1.25
Th. Rampur	1.7	1.24	5.92	0.26	9.12	97.39	5.24	5.94	11.18	-2.06	86.21	15.04
Total	**26.54**	**8.4**	**742.2**	**3.98**	**781.12**	**5568.87**	**768.16**	**110.02**	**878.18**	**-97.06**	**4690.69**	**122.34**

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

The water demand domestic and livestock use is 34.94 MCM, calculated for the year 2011, which is about 4% of the total water demand. At present, crop water demand is highest i.e. 95% of total water demand, followed by domestic demand (3%). During 2025, the crop water demand will increase to nearly 99 % of total water demand.Further ground water potential is calculated and taken from **Table 5.2**. Thus, about 8% 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 Dharmagarh, Golamunda, Jaipatna, Kalampur, Karlamunda, Koksara, Lanjigarh, M. Rampur and Thuamul Rampura 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-Utilisationof Ground Water

For the supply side intervention, further development of ground water resource is possible as there is sufficient scope for this is available in ten blocks of the district viz. Dharmagarh, Golamunda, Jaipatna, Kalampur, Karlamunda, Koksara, Lanjigarh, M. Rampur and Thuamul Rampur. The present ground water extraction rate in these blocks ranges from 21.15 % to 39.28 %. 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 12744 structures are feasible with irrigation potential of 25488 Ha in these blocks.

Table-5.2: Ground Water Development Potential of Kalahandi 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)
Bhawanipatna	6975.49	58.28	4065.61	4185.29	119.68	125	250
Dharmagarh	4200.97	36.33	1526.29	2520.58	994.29	1036	2072
Golamunda	6518.4	44.14	2876.97	3911.04	1034.07	1077	2154
Jaipatna	4618.73	24.96	1153	2771.24	1618.24	1686	3372
Junagarh	7047.47	38.63	2722.37	4228.48	1506.11	1569	3138
Kalampur	2704.83	21.84	590.84	1622.90	1032.06	1075	2150
Karlamunda	3298.35	21.15	697.72	1979.01	1281.29	1335	2670
Kesinga	5863.66	56.73	3326.39	3518.20	191.81	200	400
Koksara	4275.58	41.78	1786.38	2565.35	778.97	811	1622
Lanjigarh	3357.67	24.89	835.82	2014.60	1178.78	1228	2456
M. Rampur	4198.65	39.28	1649.27	2519.19	869.92	906	1812
Narla	4533.91	57.25	2595.5	2720.35	124.85	130	260
Th. Rampur	3457.34	16.49	570.22	2074.40	1504.18	1567	3134
Total	**61051.05**	**39.96**	**24396.38**	**36630.63**	**12234.25**	**12744**	**25488**

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 to be 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 Water Logging

Some parts in the canal command areas of Indravati irrigation project and Uttai irrigation project show a rising trend of water level over the year. Low topography, unlined canals, indiscriminate use of canal water and prevailing paddy culitivation in both seasons are mainly responsible for excessive seepage of water and water level rise. In these command areas, development of ground water is feasible through dug wells and bore wells. Dug wells are more suitable ground water structure in the area. For better management of surface and ground water and rectifying water logging problem, their conjuctive use is needed. Diversification of crops from paddy to non-paddy crops like oil seed, pulses, vegetables during rabi season, at least in high and medium land areas is essential. Conjunctive use of surface water and ground water can rectify waterlogging condition, augment irrigation potentials and ensure safe agricultural practices in periods of delayed monsoon rainfall.

5.2.5 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 42 percolation tanks, 30 checkdams can be done.

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

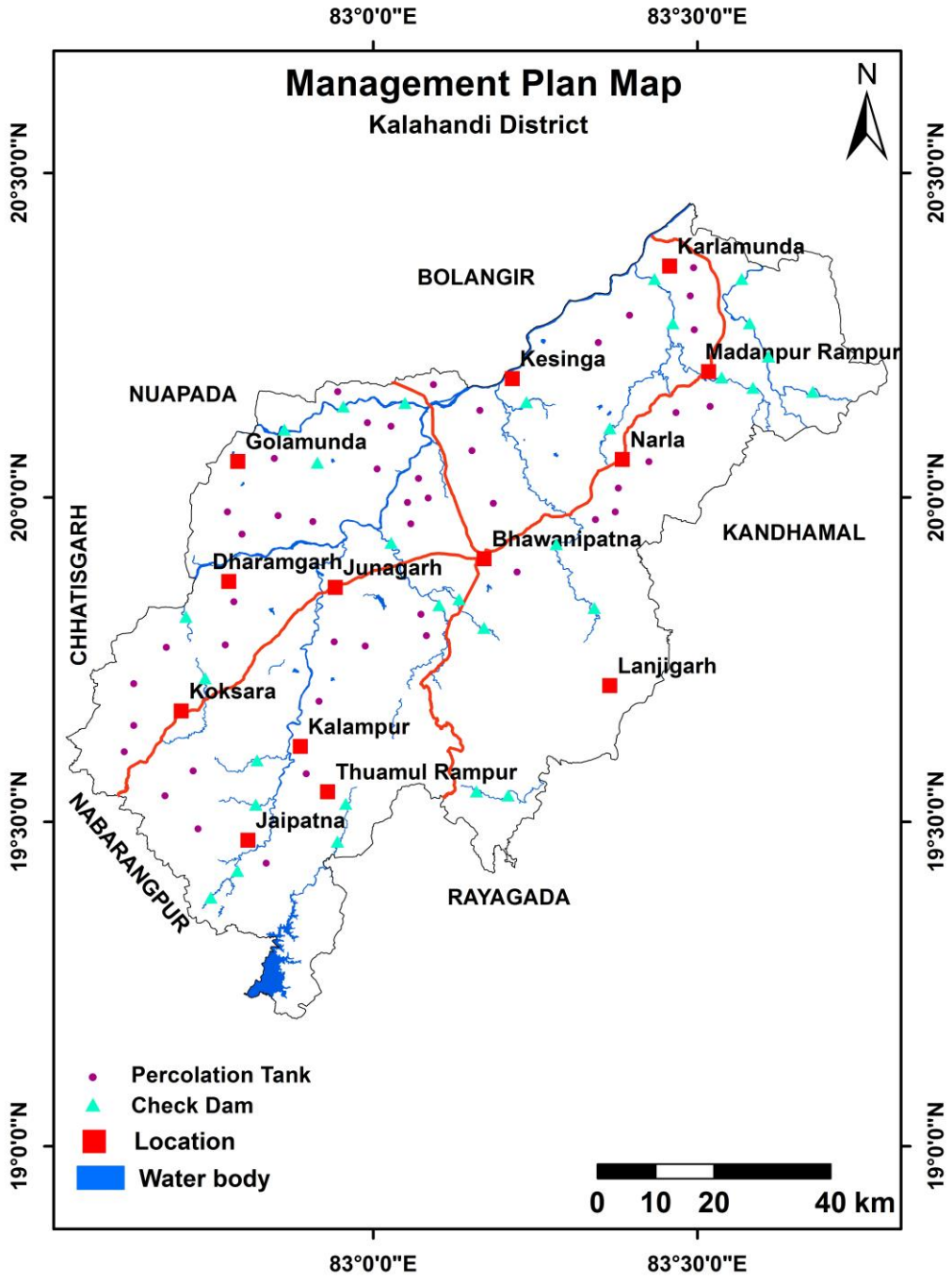

Fig. 5.1: Tentative sites for Artificial Recharge Structures Proposed in Kalahandi District.

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 Kalahandi, covering 13 blocks of Bhawanipatna, Dharmagarh, Golamunda, Jaipatna, Junagarh, Kalampur, Karlamunda, Kesinga, Koksara, Lanjigarh, M. Rampur, Narla and Thuamul Rampur during the period 2020-2021. The following are the summarised details.

1 Kalahandi districtis bounded by 82°18'E and 83°48' E longitudes and 19°03' N and 21°45' N latitudes covering 7920 Sq. Km under the SOI Toposheet Numbers 64 L, 64 P, 65 I and 65 M.The total mappable area under NAQUIM is 6160 sq. Km, which was taken up for the study after excluding the hilly areas.

2 The district is having 2 Subdivisions (Bhawanipatna and Dharmagarh), 13 administrative blocks (Bhawanipatna, Karlamunda, Kesinga, Lanjigarh, Madanpur-Rampur, Narla, Thuamul-Rampur, Dharamgarh, Golamunda, Jaipatna, Junagarh, Kalampur and Koksara),3 towns (Bhawanipatna Municipality, Junagarh NAC and Kesinga NAC),310 Gram Panchayats and 2255 villages including two Census towns (Mukhiguda and Madanpur-Rampur).

3 The normal annual rainfall in the district in 2020 was 1482 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 Tel and its tributaries constitute the main drainage system of the district. Some important rivers like Indravati, Nagavalli and Vansadhara owe their origin to the hill ranges in the southeastern parts of the district.

5 The area covered by forest in the district is 31%. The net area sown is highest in Bhawanipatna block with cropping intensity of 175%.

6 Five types of soil are found in the district viz. Inceptisol, Alfisol, Histosol,Vertisolsand Entisol.

7 The Upper Indravati and Uttei are the main irrigation projects providing irrigation facilities in the district.

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

9 The crystalline formations like charnockite, khondalite, anorthosite and granite gneiss are classified as consolidated 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 90 EWs and 29 OWs during the departmental ground water exploration programme. Apart from that, 32 Nos. EWs were drilled under Accelerated Exploratory Drilling Programme (AEDP), on contractual basis in two phases. For the monitoring of ground water level and quality CGWB has established 32 National Hydrograph Network Stations (NHNS) in the district.

11 The discharge of successful borewells varies from 0.5 lps to a maximum of 18 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 1.56 mbgl (Gunupur in Thuamul Rampur block) to 10.10 mbgl (Sargigora in Bhawanipatna block), the average being 5.17 m bgl. Depth to water level in post-monsoon period varies from 0.45 mbgl (Tulapada in Narla block) to 7.92 (Dalguma in Bhawanipatna block) mbgl, the average being 2.66 mbgl. The seasonal fluctuation of ground water table between pre and post monsoon period in the study area varies from 0.21 m (Baktapur in Lanjigarh block) to 6.32 m (Pokharibandhin Lanjigarh block) with average water level rise of 2.50 m. The decadal water level trend analysis indicates that out of 42 stations, 13 show rising and 29show falling trend during pre-monsoon and 18 show rising and 24 show falling trend during post-monsoon seasons.

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 61051.05 Ham and the stages of extraction of ground water range from 21.15 to 58.28 %.The ground water development is minimum in Karlamunda block and maximum inthe Bhawanipatna 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.