केन्द्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण

विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board

Department of Water Resources, River Development and Ganga Rejuvenation,

Ministry of Jal Shakti

Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

Bargarh District
Odisha

दक्षिण पूर्वी क्षेत्र, भुवनेश्वर

South Eastern Region, Bhubaneswar

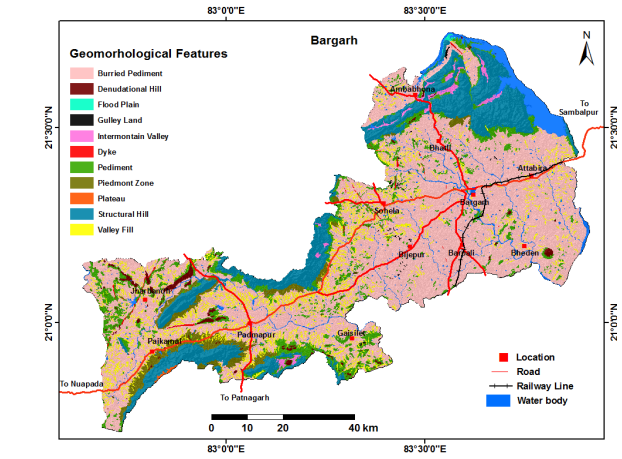
Government of India

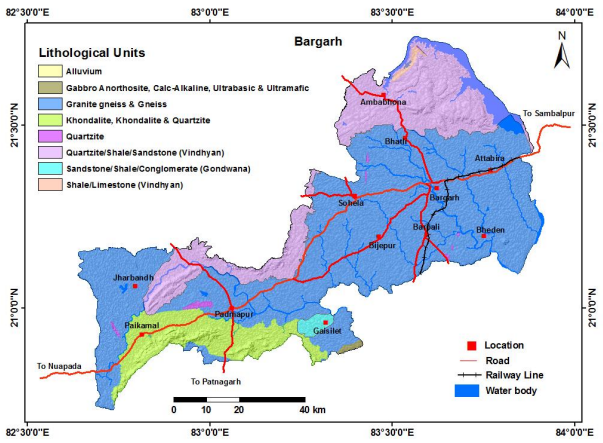
MINISTRY OF JAL SHAKTI,

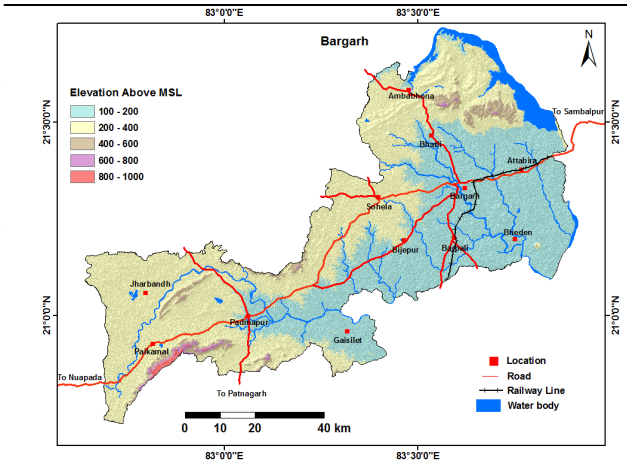
DEPARTMENT OF WATER RESOURCES, RIVER DEVELOPMENT & GANGA REJUVENATION

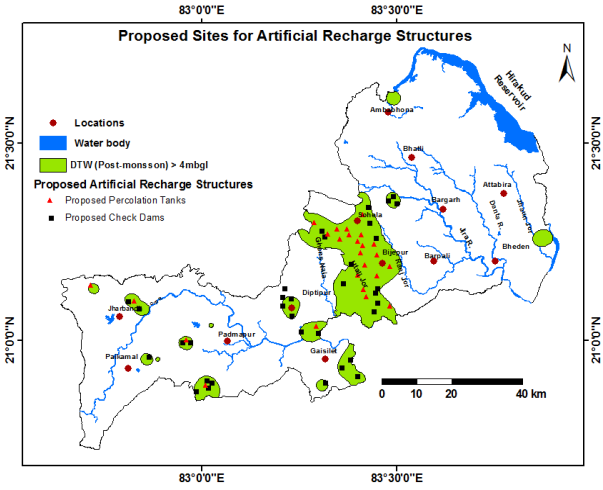
REPORT ON

AQUIFER MAPPING AND MANAGEMENT PLAN IN BARGARH DISTRICT, ODISHA









CENTRAL GROUND WATER BOARD

South Eastern Region, Bhubaneswar

July -2022

FORWARD

Bargarh district, located in the central parts of the Odisha state, bears an agrarian economy. The agriculture in the district is inevitably exposed to the vagaries of rainfall. Erratic rainfall is quite frequent and also the irrigation facilities are inadequate in the district, affecting the agriculture production from year to year. The agrarian development of the district can be boosted by tapping the groundwater 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. The common modes of groundwater exploitation in the district are dug well, dug-cum-bore well, shallow tube well etc. The hard crystalline rocks of the district form two distinct aquifer systems. The shallow aquifers formed by the weathered mantle, stores groundwater under phreatic condition. The deeper aquifer is formed by fracture zones, joints, etc holds groundwater in semi-confined/confined conditions. Aquifers in Granite Gneiss, Charnockite, Khondalite, Gondwanas formation have water yielding fracture zones and have average success rate with negl -22 lps of discharge. 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.

Groundwater irrigation is currently an underutilized resource that could mitigate the effects of drought such as surface water scarcity and crop failure. Groundwater 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 groundwater. The present stage of groundwater development is only 48.16%, leaving a vast scope for future groundwater development in the district. Groundwater irrigation practices can ensure increased agricultural production by enhancing the area irrigated and scope of irrigation.

Based on the available data and the earlier hydrogeological studies taken up in 12 blocks of the district viz. Ambabhona, Attabira, Bargarh, Barpali, Bhatli, Bheden, Bijepur, Gaisilet, Jharbandh, Padampur, Paikmal and Sohela covering 4637 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 R.K.Tripathy, Scientist-'B' has compiled and prepared the present report on "Aquifer Mapping and Management Plan in Bargarh 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 groundwater user agencies, administrators and planners in preparation of groundwater development plans and will be a handy tool in effective management of groundwater resources in the district.

(P. K. Mohapatra)
Regional Director

CONTRIBUTION

Prepared By	Sh. Rajeev Tripathy, Scientist- B
Technical Support	Sh. D.N Mandal, Scientist-D
Data Collection in Field	Sh. Rajeev Tripathy, Scientist- B
RODC data facilitations	Smt. Mausumi Sahoo, Scientist-B Smt. Purba Bera, Scientist-B
Chemical Data Analysis	Sh. B.B.Sahoo, Scientist -D Sh. B.N.Dehury,Assistant Chemist
Geophysical Data Analysis	Smt. Bindu Singh, Assistant Geophysicist Sh. Rajesh Babu, Assistant Geophysicist
Thematic Map Preparation	Sh. Satyabrata Sahu, Young Professional
Report Processing and Issuance	Sh. S.Samantray, Scientist-C Smt. Sumita Sarkar, Scientist-B
Overall Supervision	Shri P. K. Mohapatra, Regional Director

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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 XIIth 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 Bargarh district in Odisha covering an area of about 4637 sq. km. covering all twelve blocks of the district namely, Ambabhona, Attabira, Bargarh, Barpali, Bhatli, Bheden, Bijepur, Gaisilet, Jharbandh, Padampur, Paikmal and Sohela.

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 Bargarh district has been geologically mapped by the Geological Survey of India. The district has been covered through systematic hydrogeological surveys by S/shri. P. K. Das (1984-85), A. D. Rao (1986-87), K. J. Anandh Kumar (1986-87) of CGWB, SER on 1:50,000 scale. Reappraisal hydrogeological surveys were also carried out by S/Shri A. Subburaj (1991-92), G. K. Roy (1990-91), Sh. D. P. Pati (1993–94), Sh. Gulab Prasad (1993-94). So far 48 exploratory wells, 13 observation wells have been drilled under exploratory drilling programme of CGWB to delineate ground water potential of deeper aquifers.

1.3.1 Compilation of Existing Data,Identification of Data Gaps and Data Generation

Preliminary work consists of the collection and review of all existing data which relate to the area. This usually included the results of any 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

From the data analysis it is found that only 55 NHNS monitoring wells found in the District. So additional 57 key well established to fill the gap of water level monitoring. **(Table.2.3)**

In case of exploratory 49 EWs driiled in the distrct before NAQUIM study. So additional 12 EWs drilled during NAQUIM study to fill the gap. **(Table.2.2)**

Similarly for Geophysical analysis data availability was zero. So 26 VES carried out in Bargarh district during NAQUIM studty to fill the Gap. **(Table1.0)**

VES Data Generation

A total of 26 VES were carried out in Bargarh district. The VES locations are shown in figure 1.0

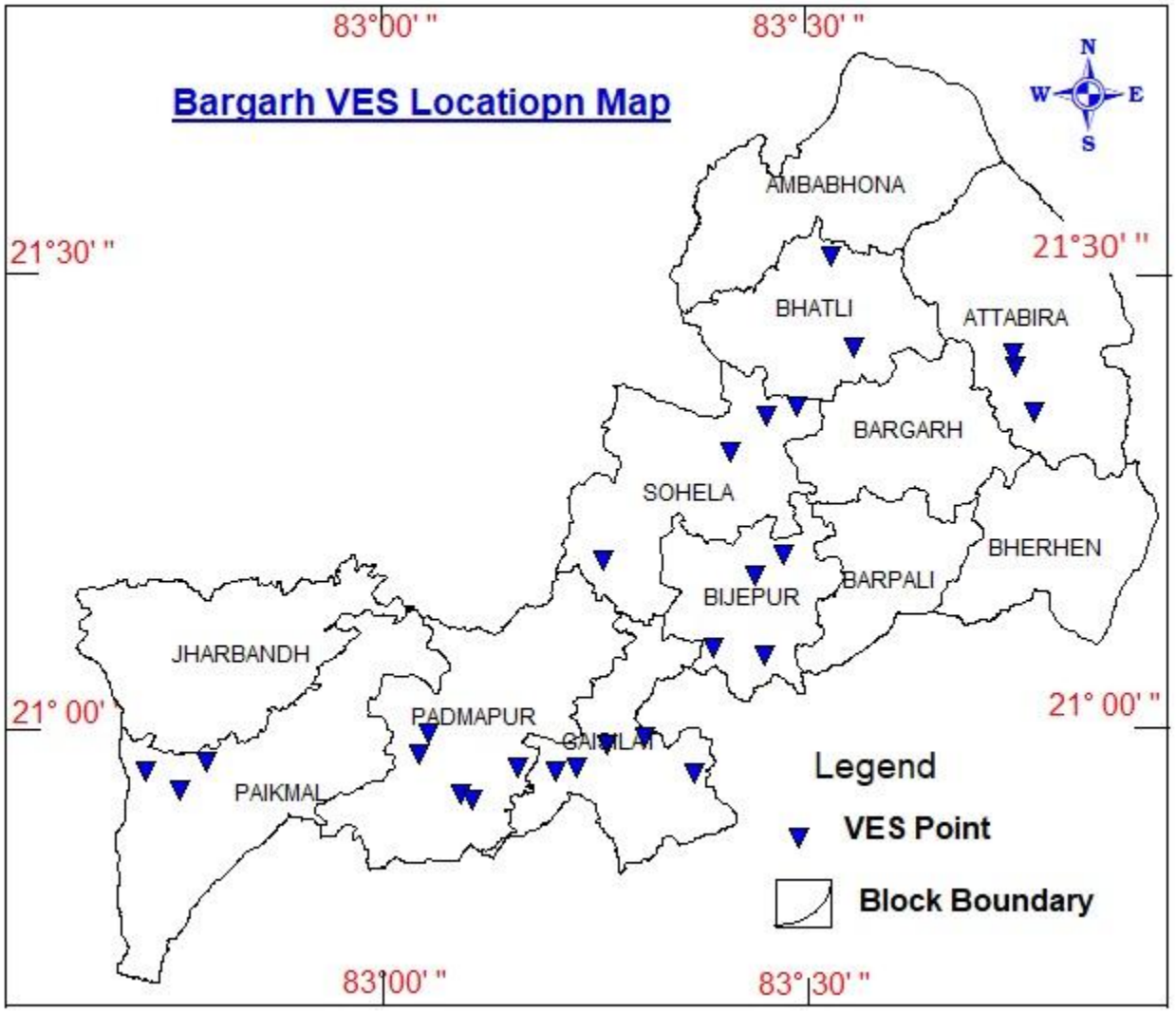

Figure 1.0: Location of VES Points in Bargarh District

1.3.1.1 Interpreted VES Results

The Interpreted results of VES are given in Table 1.0. VES results were compared with the lithologs of the nearby 4 borehole drilled by CGWB at Ruchida, Diptipur, Nuapara and Bijepur (table 5.1). After comparing the VES results with the lithologs of the nearby boreholes and local geology and hydrogeology, the resistivity characteristics of the near surface weathered rock and the underlying massive / fractured formation were presented in the table 5.2.

The top geoelectrical layer with resistivities in general varying from 14 to 106 Ohm m was inferred as top soil. Its thickness is varying from 0.5-2.1m. However, its resistivity extends up to 483 Ohm m and thickness to 2.6 m. The resistivity of weathered formation ranges from 6 to 53 Ohm m depending on type of

formation, its nature and saturation. Occasionally, it exceeds 145 Ohm m where poor weathering is there. In general, the weathered zone is extending down to a depth of 12.2 m bgl. Occasionally it extends up to 26.4 m depth. Weathered zone thickness is maximum in the north-eastern and western parts where as it is minimum in the eastern and southern parts of the study area. To understand the possibility of encountering thin fractured zones, the VES curves were analysed for 'current increase', 'curve break' and 'factor flat'. The depth zones with combination of all these three attributes, viz., increase in current, associated with reduced gradient in apparent resistivity trend (curve break) and horizontal flattening of factor curve were identified as indicators of the presence of fractured zones. The 3rd and /or 4th geoelectric layer (occasionally 2nd and / or 5th) with resistivities ranging from 18 and 330 Ohm m, occasionally exceeding up to 406 Ohm m was inferred as Less compact / fractured formation. The variations in the resistivity range may be due to the variations in the type and nature of the formation and degree of fracturing. The thickness of the geoelectric layer inferred as Less compact / fractured formation in general is varying between 10 and 151 m and occasionally exceeding up to 198 m. Several VES indicate the presence of Less compact / fractured formation beyond 100 m depth. On the basis of geoelectrical layer parameters and the fractured zone analysis a few sites are recommended for the construction of boreholes and shown in table 5.2.

1.3.1.2 Conclusions and Recommendations

The thickness of the Top Sol in general is varying from 0.5-2.1m. The weathered zone is extending down to a depth of 12.2 m bgl. Occasionally it extends up to 26.4 m depth. The weathered zone thickness is maximum in the north-eastern and western parts where as it is minimum in the eastern and southern parts of the study area. The depth zones with combination of increase in current, associated with reduced gradient in apparent resistivity trend (curve break) and horizontal flattening of factor curve were identified as indicators of the presence of fractured zones. The thickness of the geoelectric layer inferred as Less compact / fractured formation in general is varying between 10 and 151 m and occasionally exceeding up to 198 m. Several VES indicate the presence of Less compact / fractured formation beyond 100 m depth. On the basis of geoelectrical layer parameters and the fractured zone analysis a few sites are recommended for the construction of borehol

Table 1.0: Interpreted VES results in parts of Bargarh District

Bargarh District_HR			WAPCOS Ltd.		PROJECT: VERTICAL ELECTRICAL SOUNDING(VES) IN 12 STATES FOR DATA GENERATION								
S.No.	LOCATION	Block	VES NO.	EASTING/	NORTHING	Direct interpretion of VES layer parameters by software					Aquifer Charectristics		
				Longitude	Latitude	Layer	Resisitivity (ohm.m)	Thickness (m)	Depth (m)	Inferred lithology	Aquifer	Depth Range(m)	Inferred aquifer water quality
1	Badimal	Padmapur	348	44Q0713555	2323065	1	29	1.1	1.1	Top soil			
						2	10	4.1	5.2	Weathered Formation	Aquifer	1.1-5.2	Potable
						3	39	48	53.2	Less Compact Rock	Aquifer	5.2-53.2	Potable
						4	571			Compact Rock			
2	Singhanpur	Padmapur	349	44Q0712365	2320544	1	24	1.56	1.6	Top soil			
						2	8	1.96	3.5	Weathered Formation	Aquifer	1.6-3.5	Potable
						3	15232	2.24	5.8	Compact Rock			
						4	88	31.8	37.5	Less compact Rock	Aquifer	5.8-37.5	Potable
						5	vh			Compact Rock			
3	Dahigaon	Padmapur	350	44Q0717723	2315747	1	76	0.9	0.9	Top soil			
						2	53	7.8	8.7	Weathered Formation	Aquifer	0.9-8.7	Potable
						3	490	30.9	39.6	Compact Rock			
						4	131	43.6	83.2	Less compact Rock	Aquifer	39.6-83.2	Potable
						5	vh			Compact Rock			
4	Guthurli	Padampur	351	44Q0724710	2319133	1	8	5.1	5	Weathered Formation	Aquifer	0-5.1	Potable
						2	20	39.5	44.6	Less compact Rock	Aquifer	5.1-44.6	Potable

						3	301			Compact Rock				
5	Kantabahal	Padmapur	352	44Q0729263	2318531	1	90	1.6	1.6	Top soil				
						2	15.3	5.9	7.5	Weathered Formation	Aquifer	1.6-7.5	Potable	
						3	96.8	11.2	18.7	Semi- Weathered Rock				
						4	24.7	27.9	46.7	Less compact Rock	Aquifer	18.7-46.7	Potable	
						5	260			Compct Rock				
6	Antarla	Padampur	353	44Q0719011	2315094	1	17	1.7	1.7	Top soil				
						2	53	9.4	11.1	Weathered Formation	Aquifer	1.7-11.1	Potable	
						3	305	151	162	Less compact Rock	Aquifer	11.1-162	Potable	
						4	vh			Compact Rock				
7	Barihapalli	Gaisilet	354	44Q0731731	2319087	1	22.5	3.1	3.1	Weathered formation	Aquifer	0-3.1	Potable	
						2	371	1.9	5	Compact Rock				
						3	206	11.8	16.8	Compact Rock				
						4	vh			Compact Rock				
8	Kendubhata	Gaisilet	355	44Q0735427	2321885	1	54	1.2	1.2	Top soil				
						2	24	3.7	4.9	Weathered Formation	Aquifer	1.2-4.9	Potable	
						3	272	38.3	43.2	Less compact Rock	Aquifer	4.9-43.2	Potable	
						4	vh			Compact Rock				
9	Bardapali	Gaisilet	356	44Q0740148	2322872	1	9	3.8	3.8	Weathered Formation	Aquifer	0-3.8	Potable	
						2	VH			Compact Rock				
10	Sardhapali	Gaisilet	357	44Q0746180	2318647	1	14	0.5	0.5	Top Soil				
						2	6	1.1	1.6	Weathered Formation				
						3	24	8.7	10.3	Weathered Formation	Aquifer	1.6-10.3	Potable	

						4	86	105.2	115.5	Less compact Rock	Aquifer	10.3-115.5	Potable	
						5	vh			Compact Rock				
11	Banjipali	Attabira	358	44Q0787350	2363290	1	106	1.9	1.9	Top soil				
						2	35	16.5	18.4	Weathered Formation	Aquifer	1.9-18.4	Potable	
						3	160	64.7	83.1	Less compact Rock	Aquifer	18.4-83.1	Potable	
						4	vh			Compact Rock				
12	Bhurshipali	Attabira	359	44Q0784887	2368690	1	50	26.4	26.4	Weathered rock	Aquifer	0-26.4	Potable	
						2	vh			Compact rock				
13	Hirlipali	Attabira	360	44Q0784474	2370330	1	106	1.9	1.9	Top Soil				
						2	35	16.5	18.4	Weathered rock	Aquifer	1.9-18.4	Potable	
						3	160	64.7	83.1	Less compact Rock	Aquifer	18.4-83.1	Potable	
						4	vh			Compact rock				
14	Nuapali	Bhatli	361	44Q0765154	2370755	1	55.7	1.3	1.3	Top soil				
						2	20	4.5	5.8	Weathered Formation	Aquifer	1.3-5.8	Potable	
						3	330	114.3	120.1	Less compact Rock	Aquifer	5.8-120.1	Potable	
						4	vh			Compact Rock				
15	Nalichua	Bhatli	362	44Q0761981	2381752	1	32.1	0.96	0.96	Top soil				
						2	17.6	10.3	11.26	Weathered Formation	Aquifer	1.0-11.3	Potable	
						3	103.8	13.6	24.86	Less compact Rock	Aquifer	11.3-24.9	Potable	
						4	vh			Compact Rock				
16	Jaring	Bejapur	363	44Q0756909	2345501	1	157	2.1	2.1	Top soil				
						2	13	2.1	4.2	Weathered Formation	Aquifer	2.1-4.2	Potable	
						3	107	4.0	8.2	Semi Weathered Formation				

						4	18	10.0	18.2	Weathered Formation	Aquifer	8.2-18.2	Potable	
						5	222	59.3	77.5	Less compact Rock	Aquifer	18.2-77.5	Potable	
						6	vh			Compact Rock				
17	Bejapur	Bejapur	364	44Q0734710	2344307	1	70	0.7	0.7	Top soil				
						2	1110	0.4	1.1	Compact Rock				
						3	82	22.8	23.9	Weathered Formation	Aquifer	1.1-23.9	Potable	
						4	vh			Compact Rock				
18	Laumunda	Bejapur	365	44Q0748380	2333981	1	80	0.8	0.8	Top Soil				
						2	1104	0.7	1.4	Compact rock				
						3	33	4.2	5.6	Weathered Rock	Aquifer	1.4-5.6	Potable	
						4	790	117.0	122.6	Compact rock				
						5	vh			Compact rock				
19	Saipali	Bijapur	366	44Q0754674	2333207	1	23.7	4.01	4.01	Weathered Formation	Aquifer	0-4	Potable	
						2	330	16.6	20.61	Compact Rock				
						3	vh			Compact Rock				
20	pada	Bijapur	367	44Q0753318	2342820	1	182	0.9	0.9	Top soil				
						2	27	1.0	1.9	Top soil				
						3	442	2.2	4.1	Compact Rock				
						3	130	14.2	18.3	Less Compact Rock	Aquifer	4.1-18.3	Potrable	
						5	2259	20.5	38.8	Compact Rock				
						6	155	43.6	82.4	Less Compact Rock	Aquifer	38.8-82.4	Potrable	
						7	vh			Compact Rock				
21	Sohela	Sohela	368	44Q0750149	2357718	1	54	1.4	1.4	Top soil				
						2	15	4.4	5.8	Weathered Formation	Aquifer	1.4-5.8	Potable	

						3	142	31.2	37	Less Compact Rock	Aquifer	5.8-37	Potable	
						4	vh			Compact Rock				
22	Jatla	Sohela	369	44Q0758251	2363492	1	82	0.9	0.9	Top Soil				
						2	17	2.6	3.5	Top Soil				
						3	52	8.7	12.2	Weathered rock	Aquifer	3.5-12.2	Potable	
						4	380	104.2	116.4	Less compact Rock	Aquifer	12.2-116.4	Potable	
						5	vh			Compact Rock				
23	Sarkanda	Sohela	370	44Q0754510	2362334	1	483	0.7	0.7	Top soil				
						2	145	3.8	4.5	Semi- Weathered Formation				
						3	296	4.3	8.8	Semi- Weathered Formation				
						4	67	10.1	18.9	Less compact Rock	Aquifer	8.8-18.9	Potable	
						5	406	198.0	216.9	Less compact Rock	Aquifer	18.9-216.9	Potable	
						6	vh			Compact Rock				
24	Jhatiki	Jharbandh	371	44Q0683110	2315704	1	54	1.6	1.6	Top soil				
						2	26	9.9	11.5	Weathered Formation	Aquifer	1.6-11.5	Potable	
						3	VH			Compact Rock				
25	Brahmandhi	Jharbandh	372	44Q0686340	2319260	1	22	1.6	1.6	Top soil				
						2	9	3.3	4.9	Weathered Formation	Aquifer	1.6-4.9	Potable	
						3	23555	12.1	17	Compact Rock				
						4	64			Less compact Rock	Aquifer	below 17m	Potable	
26	Bhubaneswarpur	Jharbandh	373	44Q0678825	2317919	1	61	1.8	1.8	Top soil				
						2	113	1.7	3.5	Semi weathered Formation				
						3	56	12.4	15.9	Less compact Rock	Aquifer	3.5-15.9	Potable	
						5	vh			Compact Rock				

1.3.2 Hydrogeological Investigations

Review of background information will lead 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 to be carried out. Well inventory and collection of relevant data is to be carried out to strengthen the data base. The analysis of the data has to be carried out for preparation of thematic 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

- Drainage
- Soil
- Land use and land cover
- Geomorphology
- Geology
- Hydrogeological map
- Aquifer disposition
- Ground water quality

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.

1.3.6 Study area

During XII five year plan, the National Aquifer Mapping and Management (NAQUIM) programme were taken up under Annual Action Plan (AAP) 2019-20 for detailed hydrogeological investigation and Aquifer Mapping in Bargarh district. The district is bounded by 82°39’00” E and 83°55’00” E longitudes and 20°43’00” N and 21°49’00” N latitudes covering 5837 sq. Km. under the SOI Degree sheets No 64 K ,L, O and P . The mappable area under NAQUIM is 4637 sq. Km, which was taken up for the study after excluding the

hilly and recharge-unworthy areas. The administrative map of the study area is presented in **Fig.1.1** The District is divided into 2 sub divisions and 12 Administrative Blocks. It is bounded on the North by Raipur District of Chhattisgarh, on the east by Jharsuguda and Sambalpur District, on the south by Bolangir and Sonepur District and on the west by Nawapara district of Orissa. The district is well connected by Rails and Roads. The Kolkata-Mumbai National Highway No-6 passes through the District connecting important places like Attabira, Bargarh and Sohela. broad gauge lines of the South-eastern railway pass through Attabira, Bargarh and Barpali. The Block Headquarters are well connected by roads. Interior villages are also connected with the nearest town by fair weather and forest roads. The study area is part of Mahanadi basin.

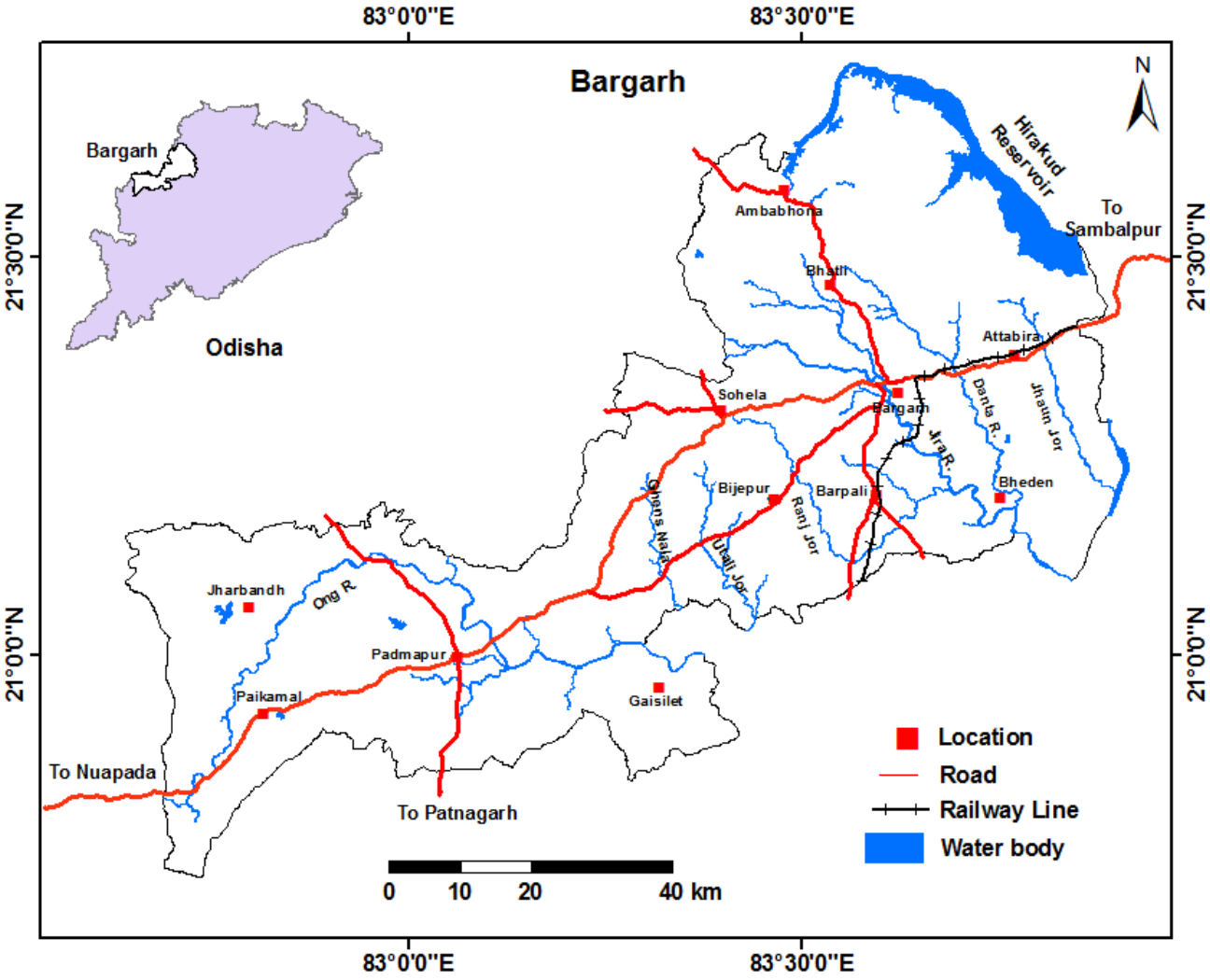

Fig. 1.1: Administrative Map of Bargarh District.

1.4 Demography:

The district is having a total population of 14, 81,255 with a rural population of 13, 31,145 (89.86 percent) and urban population of 1,50,110 (10.14 percent) and 749161 males and 732094 females. The Schedule Caste (SC) and Schedule Tribe (ST) household of the district counts to 78089 (21.08 %) & 70592 (19.06 %) respectively. So, the district is more rural in its character though the district is experiencing increasing rate of urbanisation in recent years. Number of households in the district is 370308. The district recorded a decadal change of 10.02 percent during the period 2001-2011 in its population. The population density of the district has increased from 231 (census 2001) to 254 (census 2011). A positive change is also observed in the sex composition of the district with increased sex ratio from 976 (census 2001) to 977(census2011).

The district comprises two subdivisions i.e. Bargarh and Padampur and 12 CD Blocks/Tahasils namely Ambabhona, Attabira, Bargarh, Barpali, Bhatli, Bheden, Bijepur, Gaisilet, Jharbandh, Padampur, Paikmal, Sohela. There are 248 Gram Panchayats with 1211 villages. The block-wise demographic details are shown in **Table-1.1**.

Table-1.1: Block-Wise Demographic Details in Bargarh District.

Sl No	Block	Area (Sq.km)	GPs	Villages	Population (2011)			Decadal growth rate		
					Rural	Urban	Total	Rural	Urban	Total
1	Jharbandha	422	14	83	103676	0	103676	14.77	0	14.77
2	Paikamal	487	22	128	91916	0	91916	16.40	0	16.40
3	Rajbarasambar	585	21	150	63634	17625	81259	15.51	14.14	15.21
4	Gaisilet	354	19	103	77443	0	77443	16.99	0	16.99
5	Bijepur	323	24	110	100452	6922	107374	4.81	0	12.03
6	sohela	514	26	129	97649	6917	104566	3.01	0	10.31
7	Bhatli	355	16	84	85456	4865	90321	0.64	0	6.37
8	Ambabhona	182	11	109	65715	0	65715	3.21	0	3.21
9	Attabira	404	26	81	157296	0	157296	2.68	0	2.68
10	Bargarh	374	25	62	71200	92931	164131	-0.02	34.80	17.11
11	Barpali	275	23	74	107421	20850	128271	4.98	8.84	5.59
12	Bheden	362	21	98	127400	0	127400	4.12	0	4.12
Total		**4637**	**248**	**1211**	**1331145**	**150110**	**1481255**	**7.11**	**44.98**	**10.02**

Source; Census data (2011) of Bargarh district

1.5 Rainfall and Climate

The rainfall in the district is mainly derived from the south west monsoon. The average annual rainfall is of

the order of 1679 mm, out of which 91% is received during monsoon (mid-June to mid-October). Based on the average annual rainfall for 10 yrs(2010 – 2019) it was observed that during the last 10 years, from 2010 to 2019, the highest rainfall amounting 2185 mm occurred in Paikmal block in 2012 and the lowest annual of 526.0 mm. in Bhatli block in 2015. It is also observed that the district is in general drought prone with mild and normal drought more or less of equal spread only. The rainfall map is given in Fig1.2

The climate of this district is characterized by a very hot dry summer and well distributed rains in the south-west monsoon season. The cold season commences from November and lasts till the end of February. The hot season follows thereafter and continues till about the second week of June. The south-west monsoon season is from mid-June to the mid of October.

During summer temperature varies from 35° to 45°C. May is the hottest month with the maximum mean daily temperature of 41°C. In winter temperature varies from 9 to 27°C. December is the coldest month of the year.

Humidity of the air is generally high during south west monsoon and decreases from the end of November due to cold wave. The relative humidity is varying from 14% to 92% during summer and monsoon. The average humidity during summer is 25% to 30% and in monsoon 75%.

Wind is generally light to moderate. During summer and south-west monsoon season, wind velocity increases. In the post-monsoon months and in winter, wind is mainly from the north and east. During summer wind direction is variable and in rainy season wind from south west direction is very common. Mean wind speed varies from 34 km/ hr. in January to 6.8 km. /hr. in June - July.

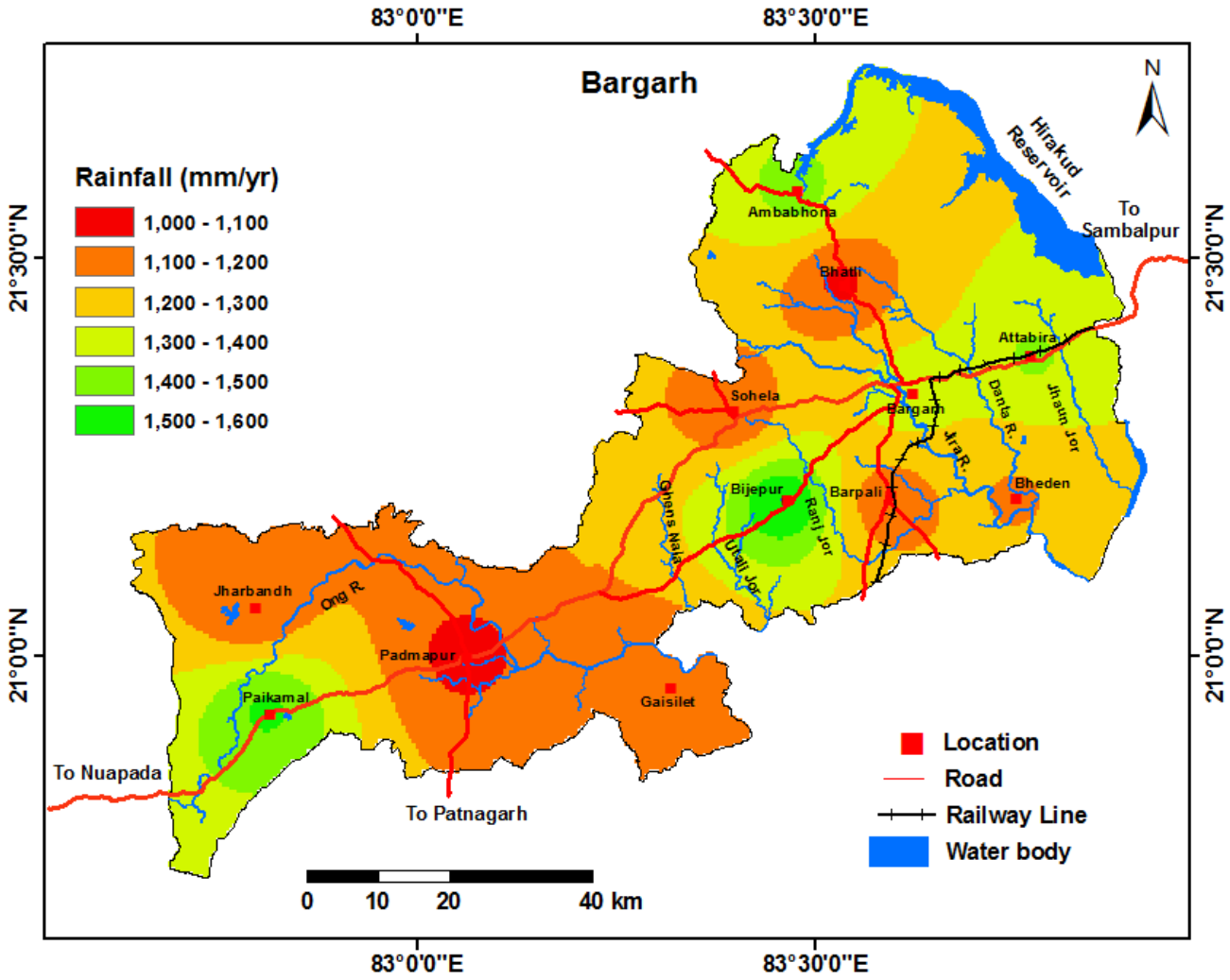

Fig. 1.2: Rainfall Map of Bargarh District.

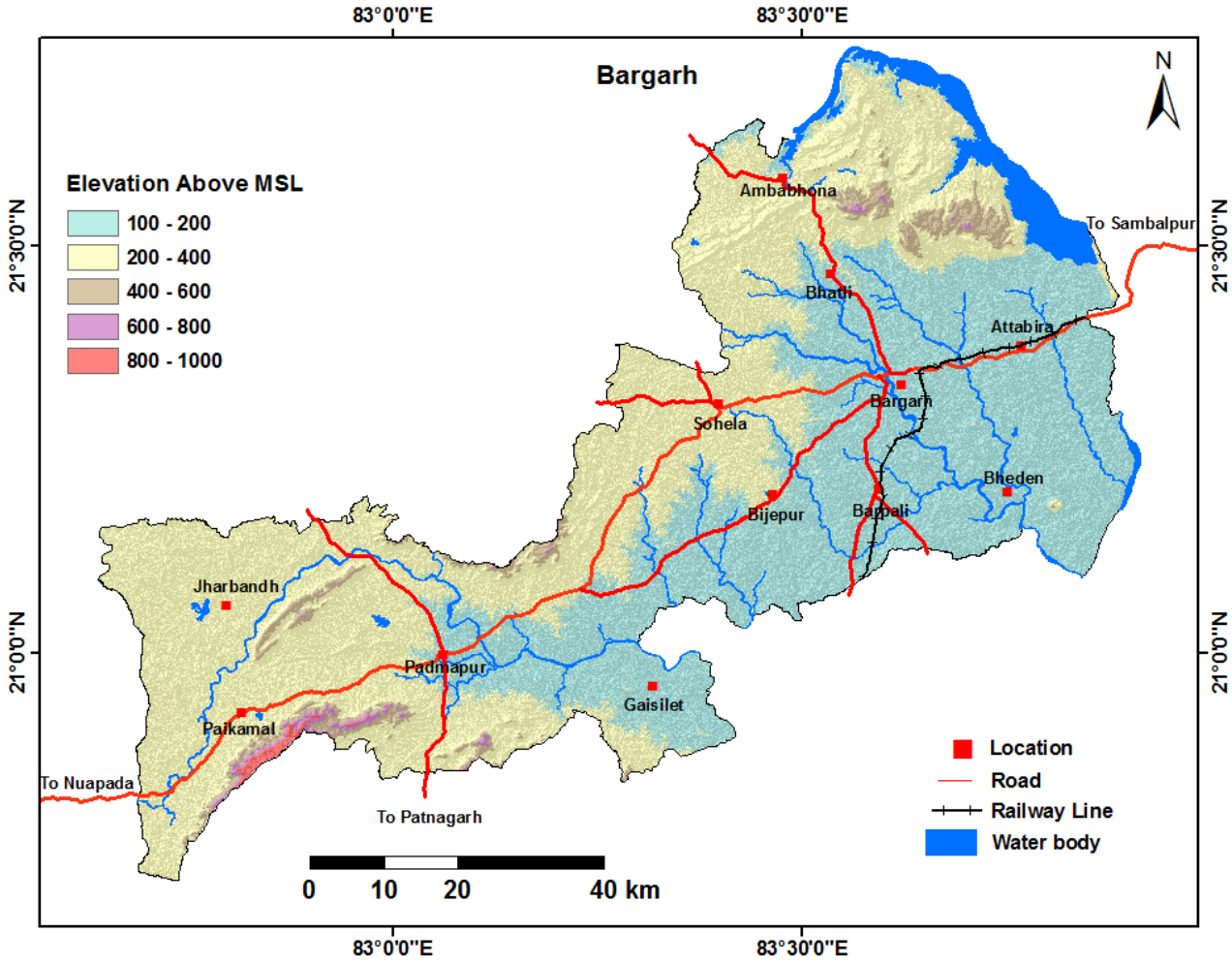

Fig. 1.3: Land Elevation Map of Bargarh District

1.6 Physiographic Setup

Physiographically the district can be broadly divided into two distinct geomorphic units - Gently undulating terrain in the south and south west and Undulating plains with isolated hills and mound in northern and western part of the district. The major parts of the district are characterised by a flat gently undulating terrain with a vast stretch of cultivable land. The general elevation of land surface ranges from 285 m to 120 m above mean sea level. The important hills are Gandha Mardan (980m), Burhadongar (801 m), Ashawal dongar (618m), Jhanjhi pahar (681m), Gosai parbat (356m.), Kala pahar (640m), Chhuria dongri (637 m). The various hydrogeomorphological units are Flood Plains, Deep Buried Pediplain, moderately Deep Buried Pediplain, Shallow Buried Pediplain, Pediment Inselberg Complex, Pediment, Intermontane Valleys, Linear Ridges, Residual Hills, Denudational Hills and Structural Hills. Fig. 1.3 shows the Elevation map of Bargarh District.

1.7 Geomorphology

Geomorphological mapping was done from visual interpretation of IRS LISS-II data of the year 1991 (February-April) on 1:50,000 scale. Drainage features, structures, lithology and weathering characteristics were considered for qualitative evaluation of hydrogeologic conditions. Fig.1.4 shows the Geomorphology of Bargarh District. The various hydrogeomorphological units are described below :

1.7.1 Flood Plains (FP): Youngest geomorphic unit, confined to the bank of the Mahanadi River, consists of recent alluvial deposits. Groundwater condition is very good. The yield of open wells varies from 39.09 to 53.7m^3/day.

1.7.2 Deep Buried Pediplain (BPPD) : This forms a major hydrogeological unit of Precambrian group of formations. It is gently undulating and encompasses a vast stretch of land with thick weathered residuum. The weathered thickness varies from 20 to 30m. Groundwater potential is very good. The yield of open wells varies from 18.4 to 579 m^3/day.

1.7.3 Moderately Deep Buried Pediplain (BPPM) : The thickness of the weathered residuum in this unit varies from 10 to 20 m. both in Sambalpur and Gondwana Super groups of formation. Infiltration is moderately good. Groundwater potential is moderately good. The yield of the open wells in this unit varies from 18.4 to 118.8m^3/day. Bore wells drilled in the vicinity of the lineaments, yield fairly good to moderate discharge.

1.7.4 Shallow Buried Pediplain (BPPS) : The thickness of the weathered residuum is less than 10m. The rate of infiltration is good. The yield of the open wells varies from 38m^3/day to 86m^3/day.

1.7.5 Pediment Inselberg Complex (PI) : This geomorphic unit occurs mostly in Khondalitic group of rocks. This is a vast stretch of pediplain, dotted with inselbergs. The thickness of the weathered zone varies between 5 to 10m. Groundwater potential is moderate in shallow aquifers. Bore well yield depends on the presence of deeper fractures.

1.7.6 Pediment (P) : The pediment zones are flat or undulating rocky surfaces with thin weathered residuum. These are restricted to the hilly tract and also occur in localized patches throughout the area. Groundwater potential is poor to moderate.

1.7.7 Intermontane Valley (IMV): These are mostly structure controlled and restricted to the northern sector of the district. Groundwater condition is very good.

1.7.8 Linear Ridges (LR): These ridges mostly act as run off zones and also as water divides at places. Groundwater potential is poor.

1.7.9 i Residual Hills (RH): These are residual masses left out after prolonged weathering and denudation. These are exposed throughout the district almost in all the geological units. These are mostly run off zones and the rate of infiltration is negligible. Groundwater potential is poor.

ii.Denudational Hills (DH): These geomorphic units consist of mostly Charnockites, Khondalites of Precambrian age. Drainage density is high and run off is also high due to high relief. Groundwater potential is poor.

iii.Structural Hills (SH): This geomorphic unit consists of Quartzites, Khondalites etc. These are structurally controlled hills with complex folding, faulting, and also traversed by numerous fractures, joints, etc. This unit acts as run off zone.

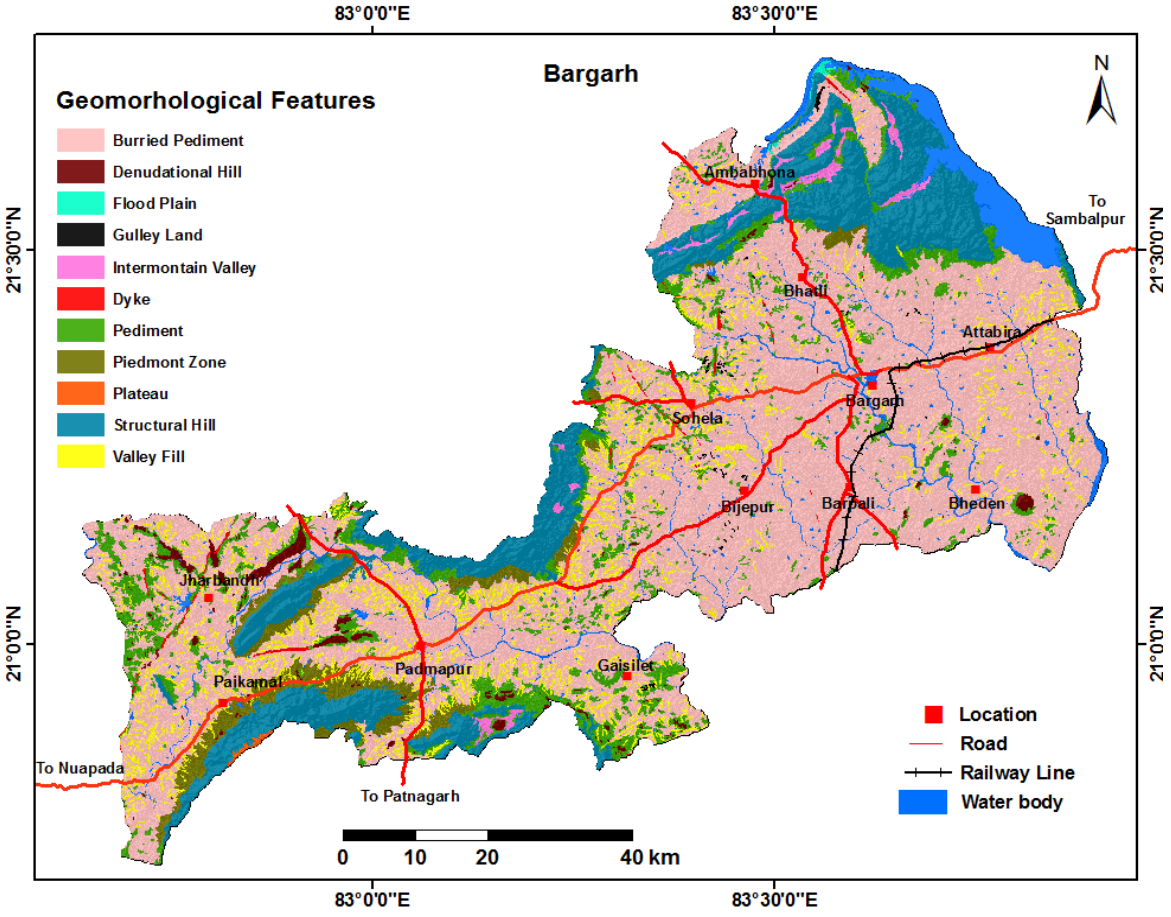

Fig. 1.4: Geomorphology of Bargarh District.

1.8 Soil characteristics;-

Soils of the district are generally having average to good fertility status. Based on the physical and chemical characteristics, mode of origin and occurrence, soils of the district can broadly be grouped into following types :-

Ultisols : The ultisols include laterirtic soils and red and yellow soils. These soils are poor in nitrogen, phosphate, pottasium and organic matter and slightly acidic in nature.

Alfisols : The Alfisols include red sandy soils, red loamy soils mixed red and black soils. The red soils are light textured and are usually devoid of lime concretion. These soils are neutral to slightly alkaline in nature. The soil map of the Bargarh districts is shown in **Fig. 1.5**

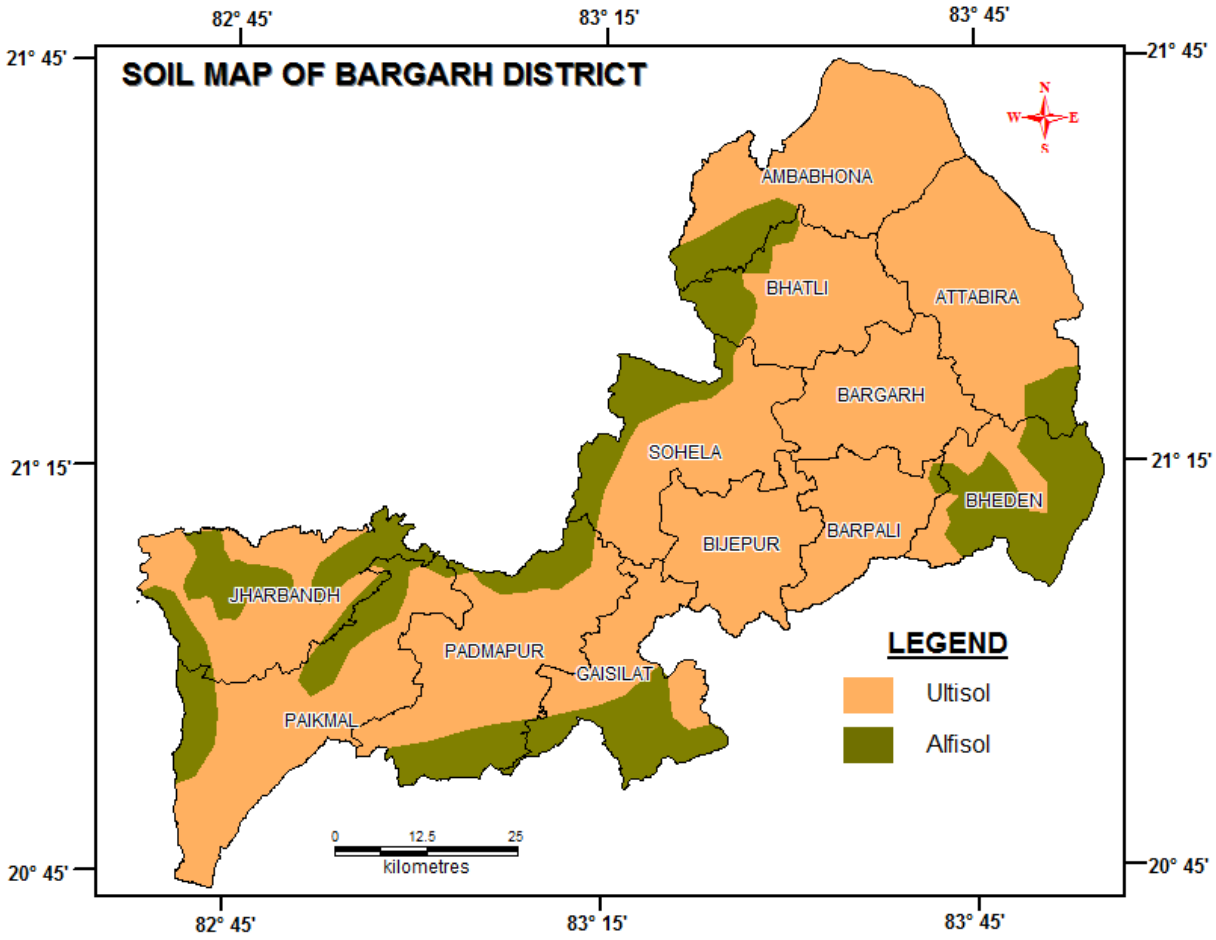

Fig. 1.5: Soil map of the Bargarh district

1.9 Landuse,Cropping Pattern and Irrigation Potential

The study area shows wide variation in the pattern of land utilization. The forest area is 12.33% of total geographical area. The net sown area of the district is 348747 ha .Agriculture is the main stay for the rural population of the district. The block-wise landuse pattern is shown in Table 1.2 and the thematic map on land use is shown in **Fig. 1.6**.

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 paddy, pulses (Arhar, Green and Black gram) and vegetables (potato, onion, garlic, turmeric, ginger and seasonal vegetables), fruits (mango, coconut, guava) etc. The major crop of the district is paddy. The paddy area in the district covers 252581 ha.

Land use, Cropping Pattern: Large percentage of the land in the district is kharif crop land which indicates that the land is used predominantly for agriculture. Crop land in Kharif is 3, 48,747 hectares where as in rabi it is 1, 22,949 hectares. The agriculture land is the major land use pattern having 70.4% of the total geographical area followed by forest land with 12.48%, pastures 3.4%. Agriculture land use includes Net Sown, Cultivable Waste, Land under miscellaneous tree crops & groves and Fallows Land. The average cropping intensity is 133%. and Net sown area constitute 86.10% of the total Agriculture area.Area sown more than once is higher in Attabira, Bheden, Bargarh and Barapli. On the contrary the area sown more than once is lesser Padampur, Gaisilet and Bijepur. This difference in coverage of area under double cropping can be attributed to availability of irrigation facilities. Thus irrigation is definitely going to increase the crop production and well being of farmers.

Irrigation Potential: Bargarh district is distinct in odisha because of some blocks having net irrigated area more than 60% and some block with less than less than 35%. Few blocks like Bargah, Bheden, Barapali being covered with Hirakud major irrigation project has higher percentage coverage on irrigation. Major irrigation system is controlled jointly by Canal Div., Bargarh and Sambalpur Irrigation Div. Major irrigation system is mainly by means of canal based irrigation. Canal div., have coverage in 6 blocks of Bargarh district and Sambalpur irrigation div. have coverage in three blocks. Nuapada Irrigation div. also provides canal based medium irrigation in two blocks.MI div. have control over 19464.66 ha. command area by means of check dam and other minor irrigation system. MI div. has so far constructed 600 check dam spreaded over entire district. Lift irrigation div., provides irrigation facilities by means of community RL project, Shallow T/W and energized bore well system. Presently lift irrigation have 625 nos. operable RL project covering 12736 ha. command area and 4800 energised bore well covering 28898 ha. command area.Maximum irrigated area is covered under cereal followed by Maize and Ground nut in kharif season. Similarly

maximum irrigated area is covered by paddy followed by vegetables, Onion and chilly during rabi season.Paddy cultivation is highest in Bheden block whereas it is lowest in Ambabhona block. Paddy is cultivated in total of 47123 ha. areas in two seasons in Bheden block and in Ambabhona, it is only 4191 ha. area. Paddy cultivated area in Ambabhona is lowest among blocks during kharif as well as Rabi season.VII

Table 1.2: Block wise land use pattern in Bargarh District (in Ha)

Block	Total Geographical Area	Forest Area	Khariff Culivated Area	Rabi cClivated Area	Gross Cropped Area	Net Sown Area	Area Sown More Than Once	Cropping Intensity (%)	Land Under Non-Agri use	Cultivable Waste	Permanent Pastures	Misc. Trees, Crops & Grooves	Current Fallows	Other Fallows	Culivable Area
Bargarh	38778	456	31643	23226	54869	31643	23226	173	4688	536	600	172	583	100	33034
Barpali	27955	564	23845	16008	39862	23854	16008	167	1485	124	398	206	836	434	25508
Bheden	35990	425	30150	24742	54892	30150	24742	182	2425	384	1500	60	1018	28	31640
Bhatli	44570	2899	26030	4274	30304	26030	4274	116	4917	724	981	643	7607	769	35773
Attabira	39439	3760	28776	29563	58339	28776	29563	203	2278	745	2113	598	238	931	31288
Ambabhona	57644	499	22373	2250	24623	22373	2401	110	21249	3642	39	8	7807	2027	35857
Sohela	51562	2873	37365	4383	41748	37865	3883	110	8452	1763	208	112	780	9	40529
Bijepur	34130	938	27400	3340	30740	29050	1690	106	3320	224	1305	570	20	353	30217
Gaisilet	35260	2588	23710	3077	26787	25364	1423	106	659	2150	2490	1708	1781	174	31177
Padampur	48052	2077	33979	3766	37745	34479	990	109	2326	3126	3299	167	1565	1513	40850
Paikamal	56734	8025	37897	4940	42837	38397	4440	112	325	1490	4417	454	3106	1020	44467
Jharbandh	40676	5402	25570	3381	28951	26070	2881	111	2705	2950	2205	191	461	1192	30864
District Total	**583700**	**30506**	**348747**	**122949**	**471696**	**354051**	**115520**	**1605**	**54829**	**17858**	**19555**	**4943**	**25802**	**8550**	**411204**

Source: CDAP 2016 Bargarh

Table 1.3: Pecentage of Irrigation Potential in different blocks of Bargarh District,Odisha

Block	Total Cultivable Area	Net sown Area(Ha)	Net irrigation potential (upto Dec 2015)	% of Irrigation to Net sown area (present)	Total Unirrigated Area
Bargarh	33034	31643	23584	75	8059
Barpali	25508	23854	15022	63	8832
Bheden	31640	30150	31330	104	0
Bhatli	35773	26030	12050	46	13980
Attabira	31288	28776	30003	104	0
Ambabhona	35857	22373	6235	28	16138
Sohela	40529	37865	13184	35	24681
Bijepur	30217	29050	7408	26	21642
Gaisilet	31177	25364	7290	29	18074
Padampur	40850	34479	12555	36	21924
Paikamal	44467	38397	15476	40	22921
Jharbandh	30864	26070	7759	30	18311
Bargarh District	411204	354051	181896	51	174562

Source; CDAP-2016 Bargarh District Odisha watershed Development Mission

(Area in Hectares)

Status of Water availability for irrigation purpose during seasons like kharif and rabi were computed from the available data for entire Bargarh district. Water from different surface and ground water sources are being used for irrigation purpose. Surface water and ground water potentiality utilized by different divisions for irrigation purpose are summarized in table below. However, water availability from perennial sources of water and various water bodies including RWH system are not included for determining water availability. Different departments like Bargarh Canal Division, Sambalpur Irrigation Division and Nuapada Irrigation Division, are providing canal based irrigation. Lift irrigation div., Bargarh provide irrigation by means of community RL project and energized bore well. Minor irrigation div., Padampur is providing irrigation by means of check dam and other minor irrigation project, where as watershed div., Bargarh also provide minor type irrigation.

Presently installed irrigation structure is using 0.88294 BCM surface water during kharif & 0.79130 BCM surface water during rabi. Total surface water requirement for 100 % utilization of presently installed irrigation structure is about 1.67424 BCM. Presently, installed irrigation facilities uses only 0.001452 BCM ground water during kharif and 0.0010948 BCM ground water during rabi season. Total ground water

requirement for 100% utilization of presently installed irrigation structure is about 0.0025468 BCM. However, all irrigation structures are not operating at their full potential through out the year, hence actual water utilization for irrigation purpose during Kharif & Rabi seasons is much less than design calculation.

Table.1.4: Water Availability for Irrigation purpose (Water in BCM)

Sl No	Source	Kharif	Rabi	Total
1	Surface Irrigation			
i	Canal (Major & Medium Irrigation)	0.781327	0.779327	1.560654
ii	Minor Irrigation tanks	0.101019	0.01145	0.112469
iii	Lift Irrigations/Diversions	0.000594816	0.000529482	0.001124298
	Sub total	0.882940816	0.791306482	1.67247298
2	Ground water			
i	Open Well	0.0003	0.000538	0.000838
ii	Deep Tube Well	0.001152	0.0005568	0.0017088
	Sub total	0.001452	0.0010948	0.0025468
	Grand Total	0.884392816	0.792401282	1.676794098

Source: Canal Div. Bargarh,Sambaipur & Padmpur irrigation div. Lift irrigation Div. Bargarh, MI irrigation Padampur,water shed Div,Bargarh

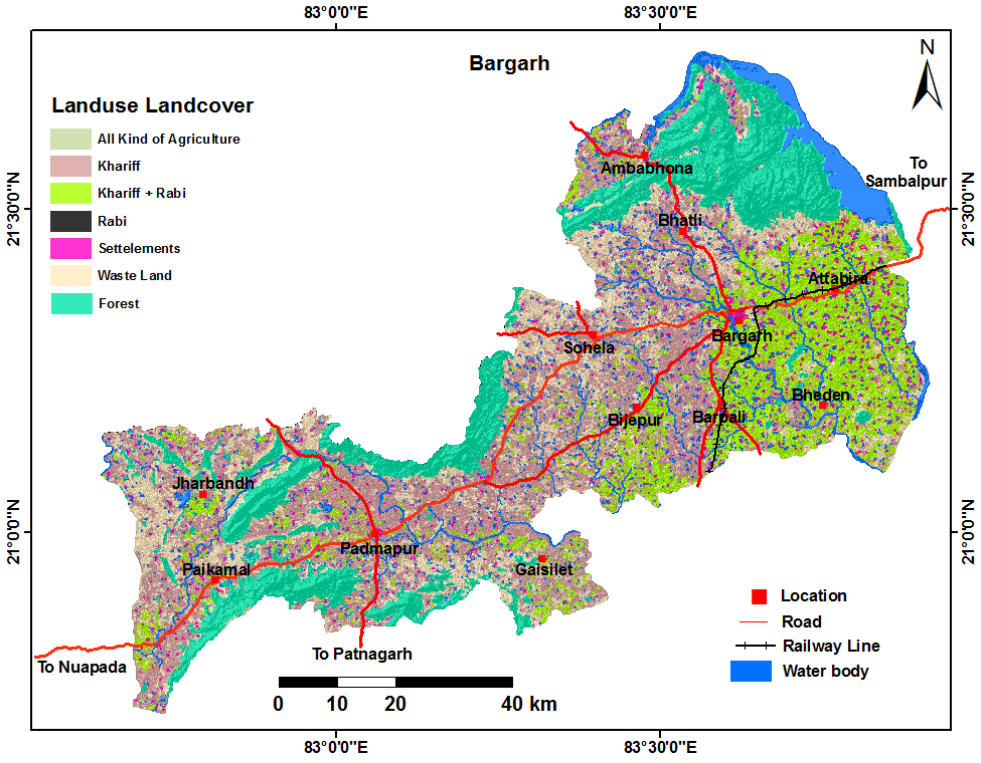

Fig. 1.6: Landuse in the NAQUIM Area in Bargarh District.

1.10 Drainage and Hydrology

The drainage of the area is controlled by the tributaries of Mahanadi river, like Ong river,Danta river and Jira river.These tributaries are ephimeral in natute and generally follow the master slope of the area. In the western part of the District the river Ong flows roughly towards east whereas in the north-western part the river Danta and Jira flows roughly towards southeast direction. The drainage is effluent in nature. **Fig. 1.7:** shows the drainage of Bargarh District.

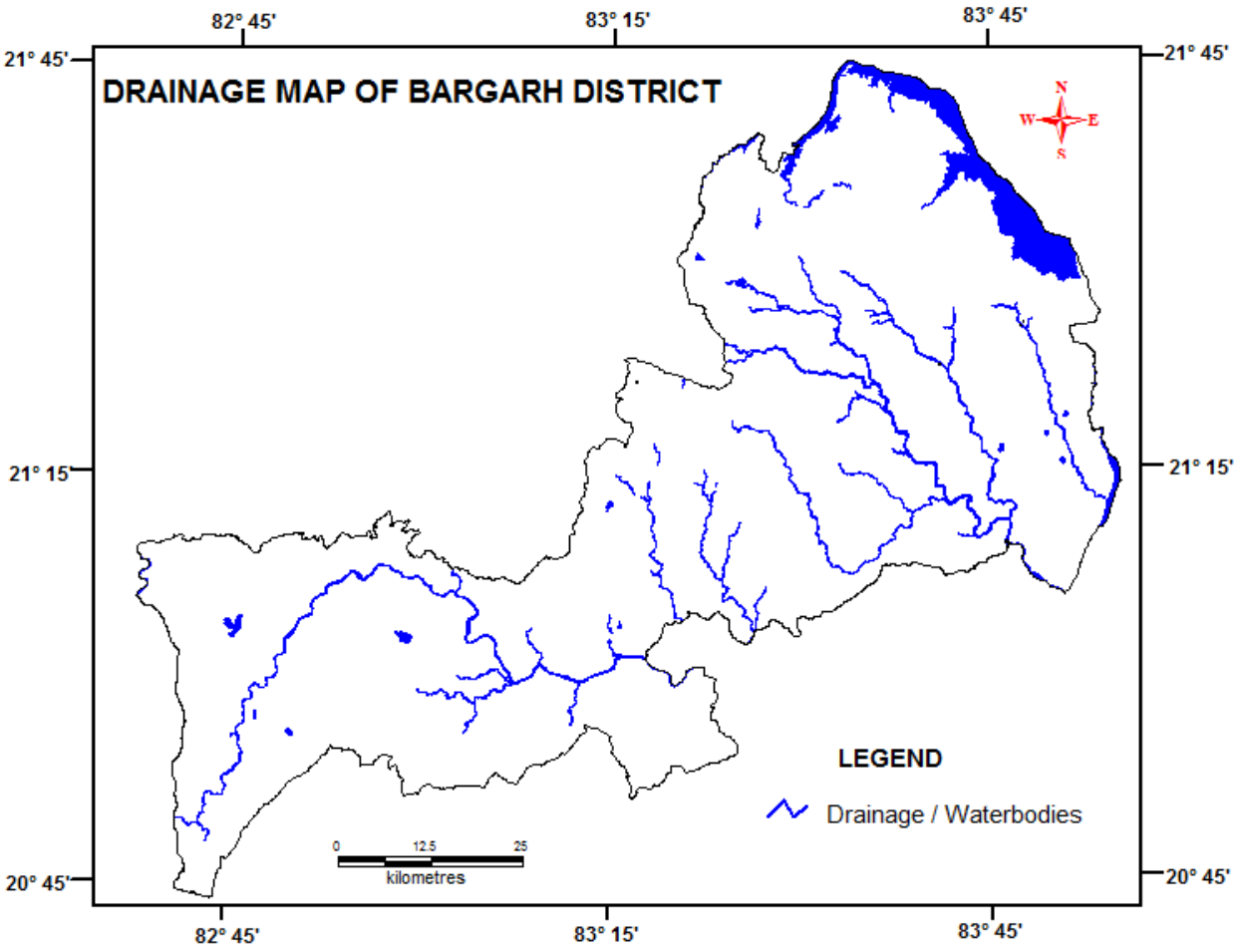

Fig. 1.7: The drainage Map of Bargarh District.

2 DATA COLLECTION AND GENERATION

2.1 Geology

The area is characterized by a complex geological set up with a variety of rock types belonging mainly to Archaean Precambrian and Permo-Carboniferous ages. A small patch of lower Gondwana's comprising of shale and sandstone also occurs in the Gaisilet area.

The hard rocks consist of granite and its variants, khondalites, charnockites and also fractured quartzites, shales and sandstones of Purana Group. Like in other districts the khondalities and charnockites generally forms forested hills and mounds. The shale and sandstone of Purana Group occurs in the north eastern part covering Ambhabona-Lakhanpur area.

Granite Gneiss and its variants: Granite gneisses are the predominant rock type, occurring in the major part of the district. These are medium to fine grained rocks exposed in the undulating plains and scattered in low hills. This suite of rocks comprise Biotite Gneiss, Porphyritic granite gneiss and pink granite. Megascopically the rocks are fine to medium grained, Leucocratic, well foliated. The gneisses are usually banded. The bands consist of this layers rich in quartz and feldspar. These rocks also are well foliated and jointed. The regional trend of foliation is Northeast- Southwest. In general five sets of joints have been observed in these rocks.

(i) Parallel to the strike of the rock

(ii) N 10° E – S 10° W with southern dip

(iii) N 36° W – S 36° E with 20^0 northeasterly dip

(iv) N 80° E – S 80° W with south westerly dip and

(v) N 55° W – S 55° E with northeasterly dip.

The opening(apertures) of the joints varies from 5 mm to 30 mm.

Charnockites : It forms massive outcrop near Papanga in toposheet no 64O-16. The rock is medium to coarse grained, dark green to gray in colour having greasing luster with feldspar and quartz. Crystals. The ferromagnesian mineral are hypersthenes and pyroxene.

Khondalites : The Khondalitic group of rocks consists of quartz garnet sillimanite-schist and gneiss and garnetiferous sillimanite, quartzite etc. These rocks usually form steep hills in the southwestern part of the district in 64 L/13 and 64 P/1. These rocks exhibit multiple sets of joints having steep dips.

Pegmatites, Dolerites, Quartz Reef : The country rocks are traversed by numerous veins of quartz and pegmatite. They are usually hard, coarse grained but highly jointed and fractured. The dolerites occur locally as dykes in the gneisses.

Quartzites : The quartzite belonging to Chandapur group are occurring as linear outcrops forming a linear hill range in the north and north western part of the district. Generally quartzite are well bedded, jointed and having fissile bedding planes. The quartzitic hill range in the north western part, acts as boundary between Orissa and Chhatisgarh and the trend is SSW-NNE. These formations are highly resistant to weathering and are traversed by closely spaced open joints striking N 60^0E – S60^0 W and N 48^0 W-S48^0 E with steep dips.

Raipur Group: This group of rocks comprise sandstones, shales, quartzites, limestone and dolomite and occupy a small area in the northern and western part of the district as an extension of the Chhatisgarh basin of the adjoining state. These rocks are folded into asymmetric anticline plunging towards northwest. The rock types are devoid of fossil and have not undergone deformations. Limestone and dolomite have limited occurrence around Dungri. It occurs as elongated bed (40 m thick) in the core of the anticline. The shale belonging to this group are gray to purple in colour, fine grained and well bedded and exposed around Jagdalpur in 64 K/16 around Bhukta in 64 O/6. It is striking E-W with steep dips. The shales occurring north of Lakhmara are striking N5I^{0}E-S51^{0}W with steep dips. This formation in traversed by closely spaced rectangular joints trending N65^{0}W-S65^{0}E and N70^{0}E-S70^{0}W are dipping incline. Because of well developed joints and bedding plains shales are fragmented.

Gondwana Sedimentary : Gondwana sedimentary comprising felspathic sandstones and shale, occupy a small area in Gaisilet block (toposheet No. 64 P/5). The rocks are friable in nature, generally trending NNE-SSW with steep dips. It is highly susceptible to weathering down to the depth of about 10 mbgl.

Alluvium and Laterites : Laterites occur as capping over the older formations. The best known occurrence of laterite with bauxite is found as capping over the khondalites of Gandhamardhan hill range in the toposheet No 64 L/13. Alluvium consisting mainly of sand and gravel occurs in the close vicinity of the major drainage channels like Ong river Danta river, Jira river etc.

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 Bargarh District.**

Age	Formation/Group	Lithology
Recent to Sub-Recent		Gravel,sand and silt in varying proportions,laterite
	Unconformity	
Permocarboniferous	Gondwana super Group	Feldspathicmicaceous sandstone,shale pebble bed
	Unconformity	
Precambrian	Raipur Group	Shale and calcareous shale(purple colour)quarzite, Limestone and Dolomite
	Chandrapur Group	Coarse quarzite sandstones,shale phyllite,Feldspathic grit,Conglomerate
	Unconformity	
Archeans	Intrusives	Dolerite dyke quatrz react vein,pegmatite
	Iron Ore Group	Amphibolite
	Sambalpur Group	Medium grainedbiotite and gneiss,Migmatitic gneiss
	Charnockite group	Undifferentiated charnockite
	Khondalite group	Garnet Sillimanite schist andgneiss,quartzite,Unclassified gneiss

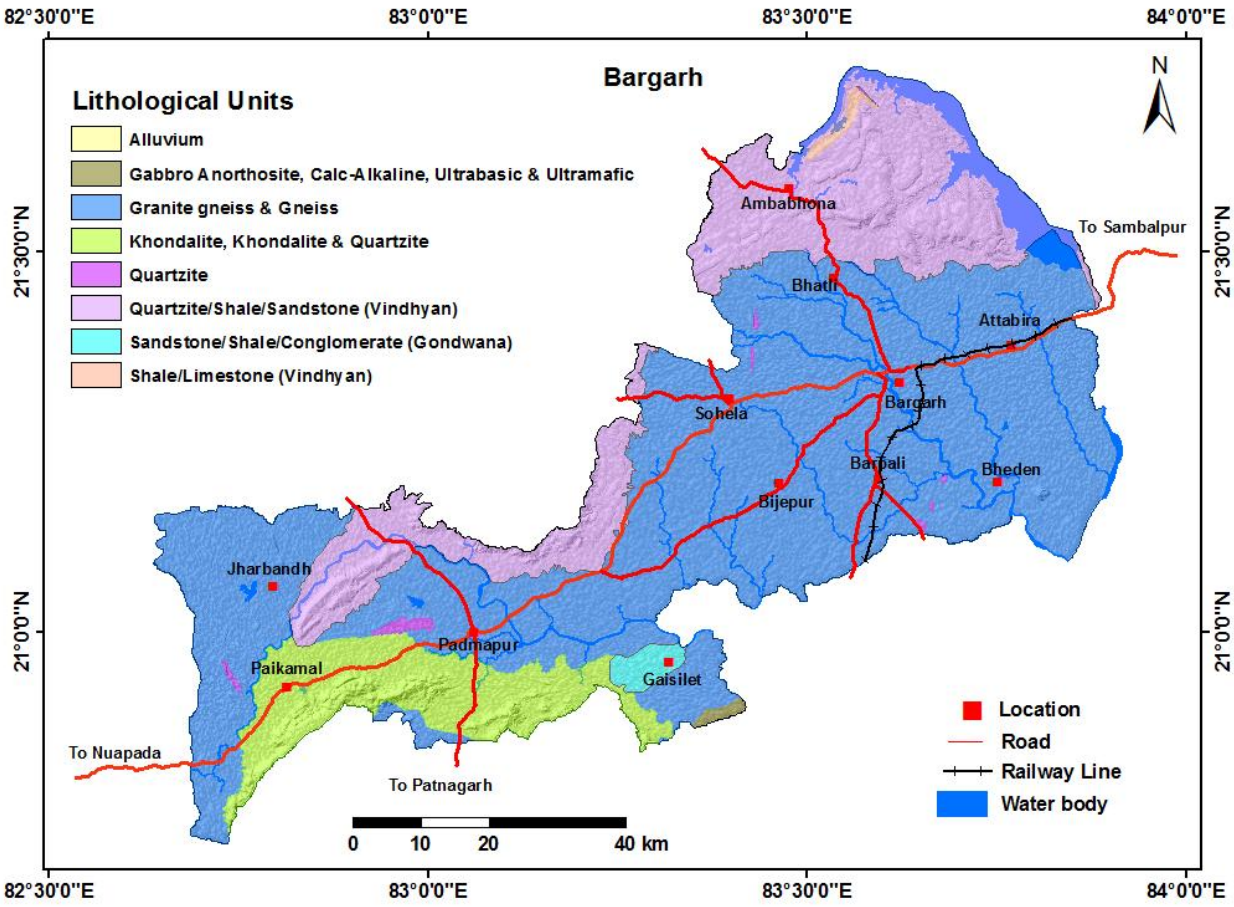

Fig. 2.1: Geological Map of Bargarh District.

2.2 Hydrogeology

The granites and its variants are most predominant rock type and occupy major parts of the district. Geological set up of the district primarily controls the Hydrogeological condition of the area.

Depending upon geology, water bearing and water yielding properties, three major Hydrogeological units have been identified in the district - Consolidated formations, Semi consolidated formations and Unconsolidated formations. Rainfall and climate, topography, soil conditions and land use are the other factors controlling ground water potentials of the area.

2.2.1 Consolidated Formations : Almost the entire district is occupied by the consolidated formations comprising granites, gneiss, and Khondalites, Metabasics and shale. These rocks are very hard and compact, and lack 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. The weathered residuum form the main repositories of ground

water, which occurs under water table conditions and circulates through deeper fractures and fissures. Ground water occurs under confined to semi-confined condition in the deeper fractured 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 into the near surface weathered zone.

Water Bearing Properties of Major Litho Units :

Granite and Granite Gneisses. These are most predominant rock types in the district occupying undulating terrain and low-lying areas. On weathering these rocks yield sandy residuum. The thickness of the weathered zone varies from 2.80 m to 32.70m depending on topography, and foliated and jointed nature of the rocks. Most of the shallow ground water structures (dug wells) are located in these formations. The depth to water table ranges from 0.89 to 10.80 m in the pre-monsoon period and 1.26m to 4.75m in the post monsoon period. The seasonal water table fluctuation is in the range of less than 1m to 7.40m.The specific capacity index of open wells varies from 0.38 to 10.26 LPM/m/m^2. The permeability of the formation varies from 0.29 to 20.9 m/day. The yield of open wells (having 5m diameter and minimum 2m of water column) tapping saturated weathered zone ranges from 18.40 to 579 m3/ day. Exploratory drilling by CGWB reveals existence of promising water bearing deeper fractures with a cumulative discharge of 22 LPS.

Khondalites : The khondalities are restricted to the western part of the district. These rocks occupy the hill and have limited ground water development potentials. Due to well-foliated nature of the rock, weathering is quite deep. The specific capacity index as computed in a representative open well is 1.50 LPM/m/m^2 and the well yield is 85 m^3/day.

Metabasic rocks: These rocks occur as bands and on weathering a brownish regolith is formed in the topographic lows. These rocks exhibit well developed joints and open wells located in these rocks may provide dependable source of water supply. The premonsoon and post monsoon depth to water table values ranged from 5.3m to 8.68 m. and 4.72m to 4.97 m respectively. The seasonal fluctuation is in the range of 0.66 m to 3.71m. The specific capacity index of wells varies from 0.39 to 4.61 LPM /m/M^2 and yield of the well varies from 22 to 260 m^3/day.The bore wells tapping deeper fracture 30 ha record discharge up to 4.3 LPS (371.5 m^3/day)

Shale : The undulating plains in the western and northern part of the district are underlain by shale. These shales are generally fractured and highly weathered. The thickness of the weathered residuum ranges from 1.97m to 15.27 m. The premonsoon and post monsoon depth to water table value ranges from 4.75 to

13.67 and water level 1.95m to 7.02m respectively. The seasonal fluctuation of water level in the range of 0.13m to 8.58m. The specific capacity index of the aquifer as computed in a representative open well varies from 0.16 to 1.90 LPM/m/m^2. The yield of dug wells varies from 9.20 to 107.0 m^3/day.

2.2.2 Semi-Consolidated Formations : These are represented by the rocks of Gondwana super group. Which occur as small patch in Gaisilet block of the district. Sandstone and shale are the main component of this group. Sandstone on weathering give rise to loose sandy products. Groundwater occurs under water table condition in the shallow aquifers and in semi confined to confined condition in deeper aquifer. The average depth of weathering is 10m. Depth of water level varies from 7.44 mbgl to 2.27 mbgl through out the year and the seasonal untreatable fluctuation is on overage 5.17 m. From the pumping test results of the sanitary open well, the specific capacity index has been computed as 0.76 LPM/m/m^2 while the yield of the well is 43 m^3/day.

2.2.3 Unconsolidated Formation : The alluvial deposit of recent origin occur as thin discontinuous patches along the prominent drainage channels. These mainly consist of silt, sand with gravel & pebble, which form potential shallow aquifers tapped through dug wells.

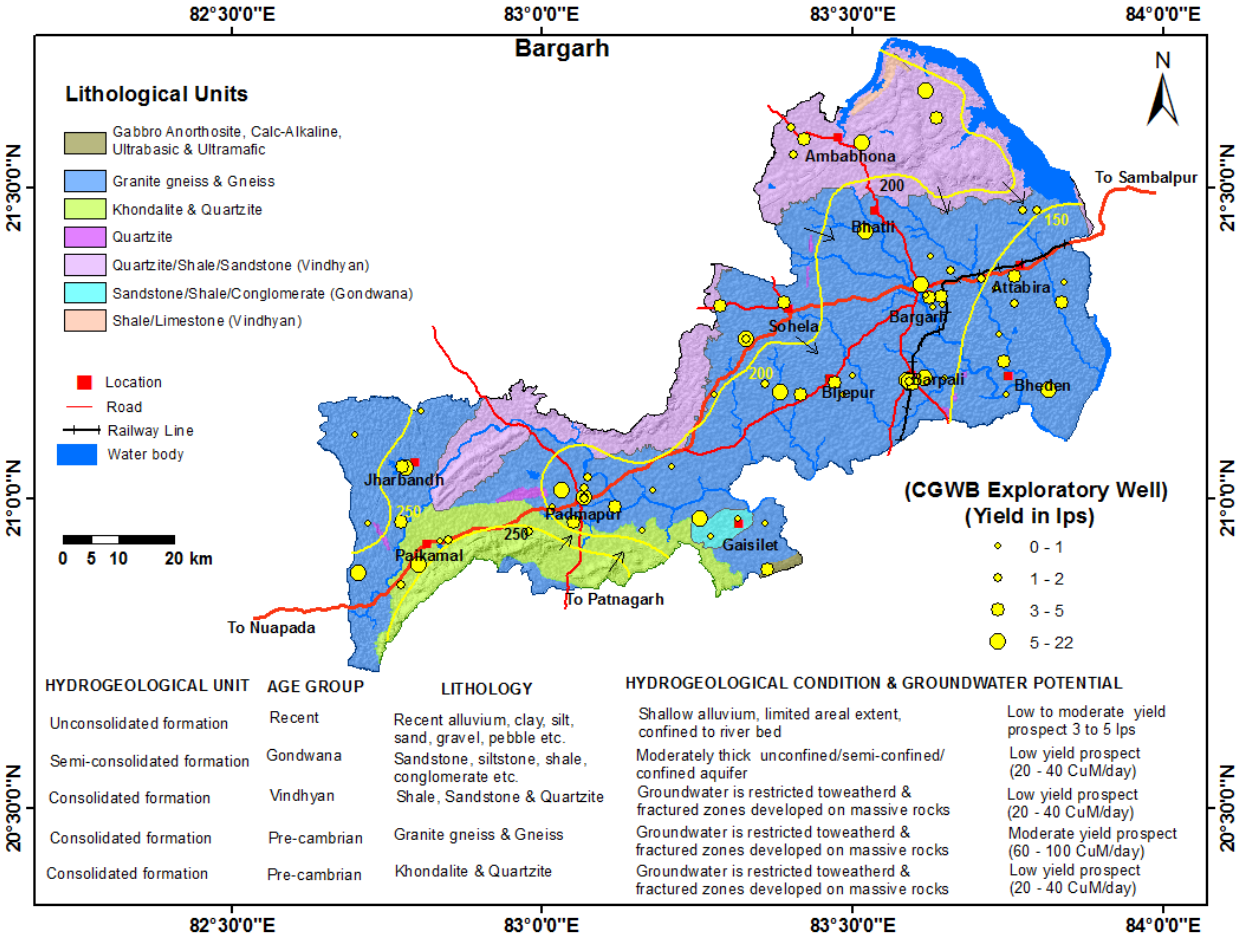

Fig. 2.2: Hydrogeological Map of Bargarh District.

2.3 Ground Water Exploration

In order to decipher the aquifer system of the area, CGWB has constructed numerous exploratory wells and observation wells which are shown in **Fig. 2.3**. The details of data generated from this exploration are given in **Table 2.2**.

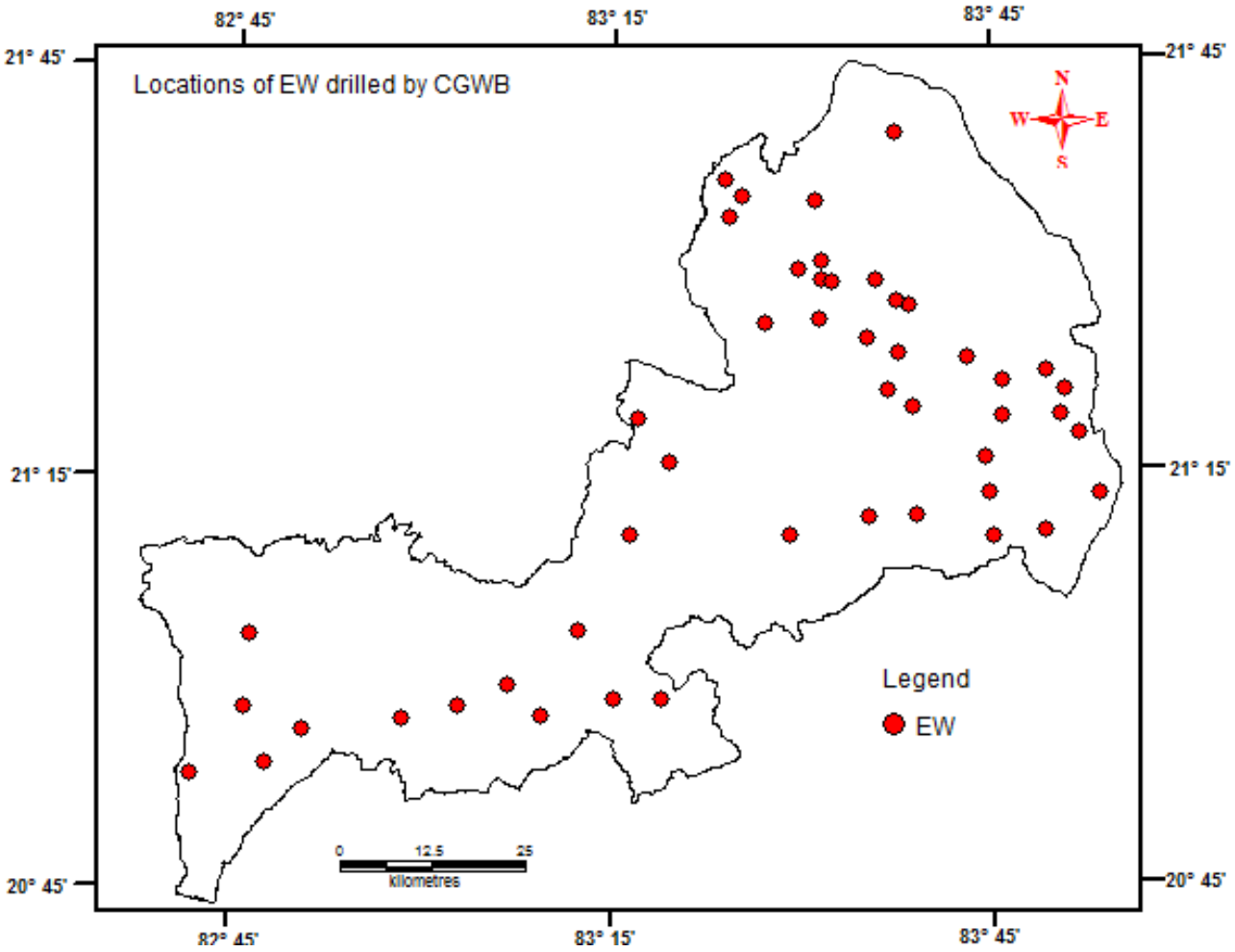

Fig. 2.3: Locations of Exploratory Wells Drilled by CGWB in Bargarh District.

2.4 Monitoring of Ground Water Regime

Under NAQUIM, the ground water regime of the phreatic aquifer was monitored during pre- and post-monsoon periods in 2019-20 in 56 National Hydrograph Network Stations (NHNS) and 56 Key Observation wells (dug wells). The details of the monitoring wells are shown in **Table 2.3** and the locations of the monitoring stations are shown in **Fig. 2.4**. The chemical quality of ground water in the district is monitored annually on a routine basis by CGWB through its National Hydrograph Network Stations. During the NAQUIM programme, 56 water samples were collected from the monitoring wells and results of their chemical analysis is given in **Table 2.4.** Quality of ground water from deeper aquifers is assessed during the drilling and pumping tests. The chemical data of water samples collected during the exploration is given in **Table 2.5**

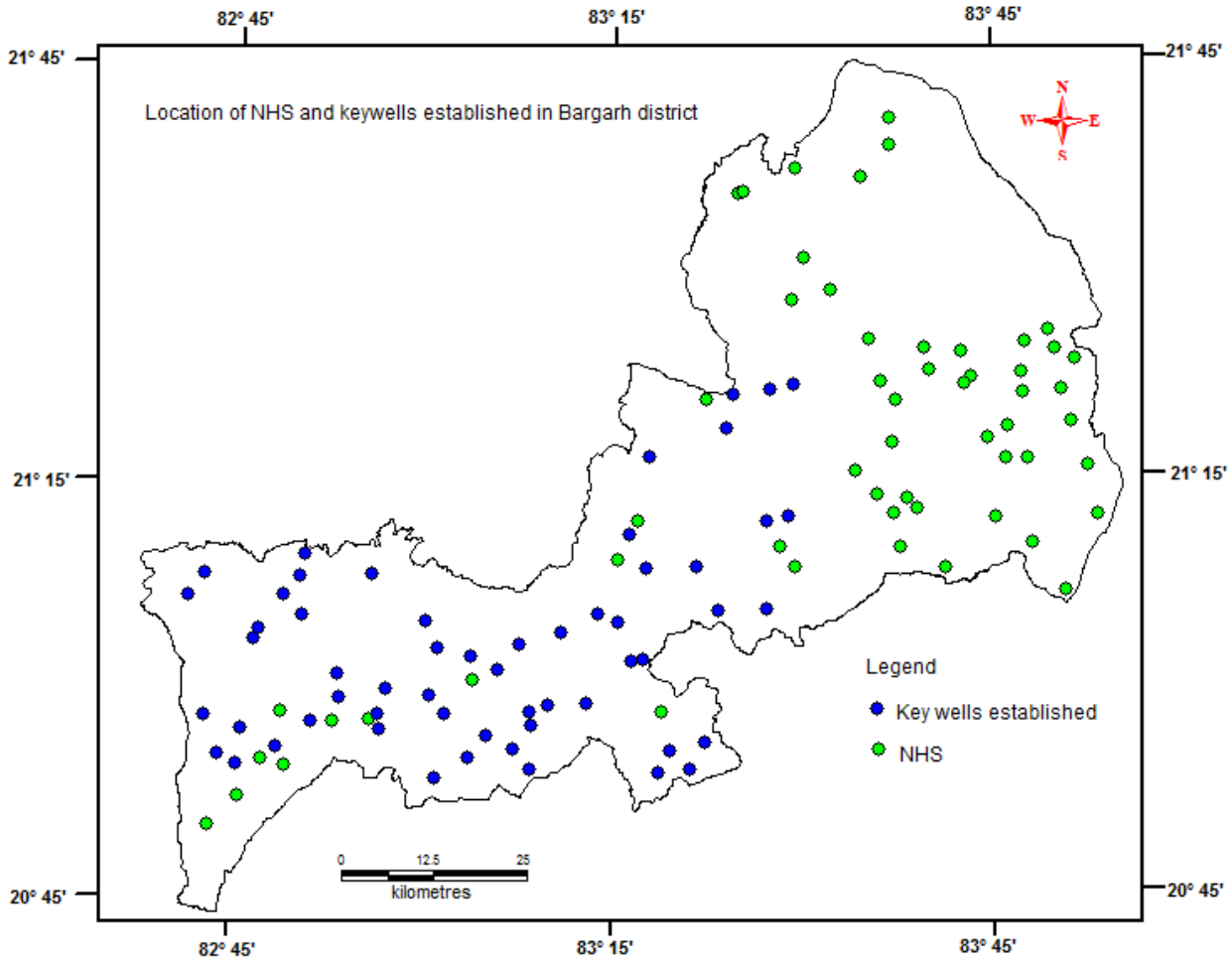

Fig. 2.4: Locations of NHS and Key wells in Bargarh District.

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

S. No	Block	Location	Latitude in decimal	Longitude in decimal	Type	Depth drilled (mbgl)	Lithology	Casing depth	Aquifer zones tapped (mbgl)	SWL (mbgl) / Date	Discharge (lps)	Drawdown/ RDD	Transmissivity(m2/day)	Storativity
1	Jharbandh	Jharbandh	21.0501	82.7802	EW	202.90	Granite Gneiss	11.00	7,13.6,21,53,66,80,106	2.738	5.78	20.18		
2	Paikmal	Paikmal	20.8928	82.8003	EW	200.00	Granite Gneiss	2.80	13.8,22.5,34.5,56.8,68,76.2	2.738	5.78	11.60		
3	Padampur	Padampur	20.9612	83.051	EW	190.90	Granite Gneiss	15.00	45,64,144.2,167.4,186.9,190.9	3.730	5.00	25.96		
4	Gaislet	Gaisilet	20.9684	83.3157	EW	101.00	Sandstone & Shale	-	30,38,43-59,91-98	4.150	0.60	25.40		
5	Padampur	Diptipur	21.0514	83.2086	EW	200.30	Pink Granite Gneiss	8.80	11.6,15.4,62.3,74.1,160.30	5.510	0.075	-		
6	Bijepur	Bijepur	21.1682	83.4846	EW	200.00	Granite Gneiss	17.60	37.2, 70.8, 82.1	2.185	1.000	32.54		
7	Sohela	Sohela	21.2571	83.3276	EW	99.20	Granite Gneiss	9.40	63.5, 96.70	7.400	2.820	27.21		
8	Sohela	Sohela	21.2571	83.3276	OW	129.00	Granite Gneiss	4.60	99.2	9.300	6.110	32.24		
9	Sohela	Laharchala	21.3096	83.2871	EW	149.90	Granite Gneiss	15.10	20.1,27.3,53.7,97.4,116.96,149.3	6.880	5.000	24.27		
10	Sohela	Laharchala	21.3096	83.2871	OW	133.80	Granite Gneiss	17.90	26,58.6,96.2,110.4,119.60,127.3	6.990	4.700	12.83		
11	Jharbandh	Amthi	20.9621	82.7718	EW	162.30	Basic Intrusive	12.00	23, 46.4, 90.1, 100.3, 148.0, 152.10	5.280	3.500	23.20		
12	Paikmal	Bhingrajpur	20.9333	82.849	EW	190.90	Garnetiferous Gr.Gneiss		21,25,29.1,40.3,75.9,93.1,117.5,160.3	3.450	3.000	21.25		
13	Padampur	Borikel	20.9469	82.9785	EW	178.50	Biotite Gr.Gneiss	10.80	12.8,68.6,122.6,150.1,165.3,176.5	7.560	1.350	30.60		
14	Gaislet	Talpali	20.9495	83.1597	EW	69.00	Granite Gneiss				.2			
15	Gaislet	Talpali	20.9495	83.1597	OW	200.00	Granite Gneiss	10.80	58.60		.2			
16	Bargarh	Bargarh	21.3442	83.6097	EW	178.00	Granite Gneiss	23.10	25.2,37.6,47.9	6.385	5.780	11.12		
17	Bargarh	Bargarh	21.3442	83.6097	OW	100.50	Granite Gneiss	28.00	28.3,33.4,40.5,43.6,59.6	3.050	5.600	27.00		
18	Barpali	Barpali	21.1896	83.5871	EW	148.40	Granite Gneiss	12.00	12.7,15.2,28.4,30.4,34.5,63.72	1.650	11.000	21.75		
19	Bhatli	Bhatli	21.4308	83.5203	EW	178.50	Granite Gneiss	32.75	39.7,58.4,100.1,151.70	4.323	5.780	17.45		

20	Ambhabana	Bhukta	21.5786	83.4221	EW	200.20	Shale (Pre combrian)	12.75	15.70,24.20,135	4.730	4.500	22.76		
21	Ambhabana	Bhukta	21.5786	83.4221	OW	136.20	Granite Gneiss	12.75	15.2,18.20,25.30	5.490	4.800	19.00		
22	Ambhabana	Ruchida	21.5981	83.4003	EW	197.20	Granite Gneiss	10.10	29.90,31.40,47.70	3.270	3.000	20.00		
23	Ambhabana	Kandelpali	21.5551	83.405	EW	200.20	Granite Gneiss	7.30	29.50	1.280	1.150	28.37		
24	Ambhabana	Ambabhana	21.5733	83.5147	EW	106.40	Sandstone (Precombrian)	17.20	33.40,60.62,70	2.270	14.000	19.62		
25	Ambhabana	Ambabhana	21.5733	83.5147	OW	79.70	SST, Basic Rock Quartzite	8.10	36.50,59.90,41.60, 53.80,79.20	1.800	20.000	11.12		
26	Ambhabana	Lakhanpur	21.6561	83.6174	EW	197.20	Shale (Pre-combrian)	20.30	37.5,50.8,111.6,80 .2	6.470	7.300	20.87		
27	Attabira	Attabira	21.358	83.7604	EW	172.40	Granite Gneiss	11.70	45.10,49.70,70.38, 80.20,91.65	4.740	5.000	40.90		
28	Attabira	Godbhaga	21.3705	83.817	EW	150.50	Granite Gneiss	19.70	47.8,35.8,43.50,55 .00	2.510	7.330	19.79		
29	Attabira	Lastala	21.3839	83.7135	EW	196.80	Granite Gneiss	15.93	16.9,28.4,48,58.3, 69,90,178,189.2	2.375	6.470	13.24		
30	Bijepur	Ghens	21.1668	83.2766	EW	202.90	Granite Gneiss	13.88	22.70,117.30	2.212	0.266	58.37		
31	Gaislet	Melchamun da	20.9684	83.2543	EW	93.10	Granite Gneiss	9.80	12.3,18.5,23.2,25. 3,34,38.7,43,68.4, 79.1	4.320	20.000	1.75		
32	Gaislet	Melchamun da	20.9684	83.2543	OW	82.00	Granite Gneiss	13.10	16.2,33,48,57.3,80 .60	4.680	22.000	3.918		
33	Bargarh	Rehunia	21.3248	83.6422	EW	105.30	Granite Gneiss	17.10	27.5,98.70	3.690	4.070	19.85		
34	Bargarh	Katapali	21.3908	83.6245	EW	160.00	Granite Gneiss	11.80			Ngl			
35	Bheden	Gondturum	21.2206	83.885	EW	147.75	Granite Gneiss	13.2	21, 35, 87	0.45	3.5	32.92		
36	Bheden	Bheden	21.1671	83.7477	EW	146.7	Granite Gneiss	10.7	11, 24	6.09	0.5	-		
37	Bheden	Soharatikra	21.2201	83.7428	EW	190.7	Granite Gneiss	17.4	17.9,26, 135.8, 147, 161.3	3.55	4.4	23.62		
38	Bargarh	Adgaon	21.2648	83.7363	EW	196.8	Granite Gneiss Basic intrusive	19.9	19.9, 120.7	2.67	0.4	30.52		
39	Bheden	Chichina	21.1748	83.8151	EW	148.0	Granite Gneiss	12.8	13, 25, 47,54, 76,126	2.72	10.0	11.15		
40	Bheden	Chichina	21.1748	83.8151	OW	165.3	Gr. Gneiss	15.2	17,18,26,126,132	2.57	7.0	3.98		
41	Attabira	Kadobahal	21.316	83.8362	EW	142.45	Granite & basic rock	16.9	17, 9, 82, 142.5	1.04	4.3	19.21		
42	Attabira	Kadobahal	21.316	83.8362	OW	111.5	Granite	21.0	26, 31.1, 62.6.	0.45	3.93	26.4		
43	Paikmal	Mandosil	20.8798	82.7029	EW	74.8	Gr. Gneiss & basic intrusive	14.0	11, 14, 17, 44	1.95	9.5	5.47		

44	Paikmal	Mandosil	20.8798	82.7029	OW	54.0	Gr. Gneiss	15.0	11, 18, 27, 31	2.27	22.0	3.33		
45	Padampur	Mahulpali	20.987	83.1161	EW	200	Gr. Gneiss	11.5	21,27,105,	4.67	3.44	13.76		
46	Barpali	Kumbhari	21.1938	83.6475	EW	200	Granite	15.0	8, 12	0.74	1.0	30.64		
47	Attabira	Laramdha	21.3476	83.8407	EW	200	Granite	-	107.5	-	Net	-		
48	Attabira	Patrapalli	21.3149	83.7598	EW	200	Granite	15.8	18, 24, 33	2.65	1.2	39.63		
49	Bheden	Salna	21.2948	83.8581	EW	200.7	Gr. Gneiss	18.3	19,45	1.5	1.5	-		
50	Bhatli	Mulbar	83.593	21.4772	EW	200	Granite Gneiss	26.5	171.8-172.8	6	0.25	4.85	210.73	
51	Bhatli	Tukula	83.584	21.4085	EW	175	Granite Gneiss	25	31.50-32.5,116.9-117.9	16	4.5		S=0.2711	0.2711
52	Bhatli	Tukula	83.584	21.4085	OW	159.6	Granite Gneiss	22	31.50-32.5,55.9-58.9	14	10			
53	Bhatli	Jampali	83.45	21.4247	EW	196	Granite Gneiss	25	162.6-163.7	11.5	0.5	5.70m, RDD	1.664	
54	Bhatli	Sukuda	83.524	21.5	EW	200	Granite Gneiss	33	132-133	27.9	1			
55	Bhatli	Kamgaon	83.6376	21.4482	EW	160	Granite Gneiss	27.5	35-36,45-46	7.2	10.12	1.70m, RDD	217.72	
56	Bhatli	Kamgaon	83.6376	21.4482	OW	170	Granite Gneiss	30	43-44	7.6	10			
57	Bhatli	Antapali	83.6222	21.4518	EW	196	Granite Gneiss	25	50-51,73-74	10.25	1.78	13.50m ,RDD	66.6	
58	Bhatli	Kesaipali	83.5251	21.478	EW	184	Granite Gneiss	21	24.40-25.40,136-137,183-184	18.6	8.4			
59	Bhatli	Kesaipali	83.5251	21.478	OW	170	Granite Gneiss	21.5	114-115,136-137	18.2	8.4			
60	Bhatli	Kelendapali	83.4934	21.4916	EW	200	Granite Gneiss	16	seepage		0.77			
61	Bhatli	Kusanpuri	83.5385	21.4762	EW	196	Granite Gneiss	44	78-79,101-102,180-181		1.78			

Table. 2.3: Ground Water Monitoring Stations in Bargarh district.

SlNo	Village	Block	Long	Latt	Type	Elevation	Depth	Pre-WL	Post_WL
1	Lakhanpur	Ambabhona	83.61056	21.64194	NHS	200	9.64	4.12	1.8
2	Shukutapali	Attabira	83.71667	21.36583	NHS	170	7.55	3.4	3.04
3	Resham	Bheden	83.68361	21.13611	NHS	150	6.75	6	2.35
4	Thuapali	Bheden	83.79111	21.26667	NHS	160	5.23	3.25	2.93
5	Kalapani	Bargarh	83.70861	21.35722	NHS	150	5.19	4.8	2.46
6	Bugbugi	Ambabhona	83.48917	21.61389	NHS	220	10.2	7.87	4.4
7	Karla	Ambabhona	83.57472	21.60306	NHS	240	9.85	7	3.2
8	Bhukta	Ambabhona	83.41528	21.58472	NHS	180	14.64	5.28	1.92
9	Remada	Barpali	83.61778	21.20083	NHS	160	6.86	2.9	2.45
10	Bheden	Bheden	83.75083	21.19611	NHS	135	7.25	5.2	3.78
11	Malada	Paikmal	82.93389	20.95417	NHS	260	8.5	7.2	3.15
12	Nrusingnath	Paikmal	82.8225	20.89889	NHS	300	7.02	2.17	1.7
13	Majhipali	Paikmal	82.88667	20.95194	NHS	250	9.2	6.54	4.1
14	Hirapur	Paikmal	82.81889	20.96389	NHS	260	8.5	7.8	3.64
15	Purena	Paikmal	82.76111	20.86306	NHS	250	8.27	7.64	2.33
16	Mithapali	Paikmal	82.79333	20.90583	NHS	250	5.85	4.11	1.17
17	Gaisilet	Gaisilet	83.315	20.96222	NHS	210	8.66	3.55	1.87
18	Jagalpet	Gaisilet	83.35139	20.89306	NHS	210	8.02	6.2	3.25
19	Burdapali	Bijepur	83.46917	21.15944	NHS	190	7.5	5.1	4.85
20	Kharmunda	Bijepur	83.48972	21.13528	NHS	180	9.04	8.13	2.75
21	Puturipali	Barapali	83.63472	21.21944	NHS	150	5.6	2.1	1.88
22	Kusanpur	Barapali	83.56778	21.25056	NHS	180	8.66	5.78	2.62
23	Lenda	Barapali	83.59444	21.22222	NHS	150	11	2.86	2.59
24	Khutlipalli	Bheden	83.87	21.25889	NHS	135	10	9.3	5.4
25	Boipur	Bheden	83.88194	21.20139	NHS	130	5	2.12	1.5

26	Sikirdi	Bheden	83.62639	21.15972	NHS	160	5.5	2.3	1.75
27	Kumbhari	Bheden	83.64778	21.20694	NHS	160	7.78	2.5	2.11
28	Baghapalli	Bheden	83.79861	21.16528	NHS	140	5.95	3.1	2.8
29	Remenda	Bheden	83.7625	21.26667	NHS	140	4.3	2.5	1.77
30	Gondtarum	Bheden	83.84167	21.10972	NHS	130	11.5	1.37	1.35
31	Dang	Bargarh	83.60056	21.35806	NHS	170	5.5	1.9	1.5
32	Jamurda	Bargarh	83.6625	21.37222	NHS	150	7.8	3.1	2.55
33	Khuntapali	Bargarh	83.61528	21.28528	NHS	150	8.4	3.4	2.85
34	Tora	Bargarh	83.62028	21.33722	NHS	170	7	3.47	2.65
35	Grinjal	Sohela	83.37417	21.33667	NHS	200	9.55	6.73	1.88
36	Dumalpali	Bhatli	83.5	21.50694	NHS	190	10.8	2	1.75
37	Sunajuri-Tukuria	Bhatli	83.58444	21.40861	NHS	170	10.48	8.58	2.88
38	Chaklifarm	Attabira	83.825	21.4	NHS	150	7.1	3.1	2.04
39	Top	Attabira	83.7875	21.40833	NHS	160	7.49	2.1	1.37
40	Kumelsingha	Attabira	83.85306	21.38778	NHS	155	5.41	2.5	2.12
41	Larambha	Attabira	83.83389	21.35139	NHS	145	4.07	3.5	3.31
42	Kulunda	Attabira	83.78389	21.34583	NHS	160	6.27	2.9	2.37
43	Lastala	Attabira	83.705	21.39583	NHS	170	7.35	4.35	3.8
44	Kodabahal	Attabira	83.8475	21.31278	NHS	130	7.9	2.2	2.19
45	Patrapalli	Attabira	83.705	21.39583	NHS	170	5.17	4.6	4.13
46	Uttam	Ambabhona	83.8475	21.31278	NHS	130	5.1	1.8	1.39
47	Padampur	Rajborasambar	83.06833	20.99917	NHS	180	9.4	5.98	3.28
48	Sarala	Bargarh	83.65556	21.39889	NHS	150	6	3.5	2.41
49	Katapali	Bhatli	83.42056	21.585	NHS	180	9	5.1	3.05
50	Batetarma	Sohela	83.25778	21.14417	NHS	210	7.25	5.73	3.4
51	Ghens	Sohela	83.28528	21.18972	NHS	210	8.53	5.79	3.01
52	Bhatli	Bhatli	83.53472	21.46722	NHS	190	12.26	2.28	1.93
53	Purrakhai	Bhatli	83.48389	21.45639	NHS	190	6.42	2.2	1.4
54	Godbhaga	Attabira	83.81667	21.42083	NHS	150	34	4.1	3.93

55	Bargarh	Bargarh	83.60972	21.34417	NHS	170	7.5	6.7	2.3
56	Jaring	Bijepur	83.4793	21.1972	KW	200	9.8	8.8	4.7
57	Bijepur	Bijepur	83.45203	21.18964	KW	200	9.2	8.7	4.4
58	Laumunda	Bijepur	83.3898	21.084	KW	150	10.1	6.8	4.65
59	Saipali	Bijepur	83.4514	21.0846	KW	160	8.4	6.3	4.6
60	Para	Bijepur	83.2732	21.1753	KW	210	10.4	9.1	3.3
61	Sanimal	Bijepur	83.2315	21.0783	KW	200	13.1	10.8	6.35
62	Badipali	Bijepur	83.3597	21.1356	KW	180	10.5	8.4	4.6
63	Birjam	Bijepur	83.2953	21.1344	KW	200	9.9	7.3	2.4
64	Paikmal	Paikmal	82.813	20.92053	KW	250	8.15	5.6	2.12
65	Kutna	Jharbandh	82.7843	21.0512	KW	230	12.3	5.4	2.7
66	Dobha	Jharbandh	82.698	21.1033	KW	310	9.85	8.2	3.7
67	Bhandarpuri	Jharbandh	82.7214	21.1288	KW	320	9.7	8.4	4.1
68	Kumir	Jharbandh	82.8464	21.0797	KW	240	7.3	5.3	4.35
69	Chandibhata	Jharbandh	82.8239	21.1033	KW	250	11.1	5.6	4.6
70	Dongripali	Jharbandh	82.8454	21.12494	KW	240	10.35	9.4	3.35
71	Laudidhara	Jharbandh	82.8504	21.1525	KW	250	10.07	4.8	1.55
72	Jharbandh	Jharbandh	82.7914	21.06192	KW	250	11.1	9.3	3.9
73	Jhenganadih	Jharbandh	82.8946	20.9793	KW	210	6.13	4.5	1.9
74	Temri	Jharbandh	82.8937	21.0089	KW	210	6.2	5.4	2.05
75	Barrikel	Padampur	83.0128	20.98267	KW	190	9.93	6.1	3.4
76	Borasambar	Paikamal	82.948	20.94061	KW	280	9.26	7.7	3.1
77	Palsada	Paikamal	82.9563	20.9891	KW	220	9.6	7.7	5.1
78	Garjori	Paikamal	82.9456	20.9601	KW	220	6	4.6	2.8
79	Jharmunda	Paikamal	82.8571	20.9513	KW	250	10.1	8	4.9
80	Munnikel	Jharbandh	82.7608	20.9013	KW	260	8.9	8.1	3.4
81	Jatki	Jharbandh	82.7355	20.9124	KW	250	8.6	7.6	3.55
82	Bamandih	Jharbandh	82.7656	20.9433	KW	250	9.03	7.5	4
83	Bhubaneswarpur	Jharbandh	82.7187	20.9593	KW	270	9.4	6.7	3.3

84	Deoli	Padampur	83.0658	21.0286	KW	180	9.4	5	2.19
85	Purena	Padampur	83.0226	21.0377	KW	190	11.05	8	4.1
86	Dhumabhata	Jharbandh	83.0076	21.0712	KW	190	9.8	6.7	1.9
87	Jagdalpur	Jharbandh	82.9393	21.1271	KW	210	12.1	10.9	4
88	Bajenmunda	Padampur	83.0326	20.9593	KW	200	6.72	5.2	3.37
89	Dahita	Padampur	83.0624	20.90711	KW	210	5.7	5	2.3
90	Buden	Padampur	83.0185	20.882	KW	210	8.9	8	5.4
91	Dahigaon	Padampur	83.0873	20.9328	KW	200	7.3	6.2	3.35
92	Beheratal	Padampur	83.1219	20.9167	KW	220	9.8	6.9	3.7
93	Luhakhani	Padampur	83.1445	20.9446	KW	200	8.5	5.7	2
94	Jamartala	Padampur	83.142	20.8936	KW	210	8.05	6.9	3.9
95	Mahulpali	Padampur	83.1009	21.0129	KW	180	8.9	7.8	3.65
96	Sargibahal	Padampur	83.1834	21.0577	KW	180	10.9	7.7	1.45
97	Karsingha	Padampur	83.1288	21.0422	KW	200	8.8	7.7	4
98	Budhamal	Padampur	83.1433	20.9609	KW	200	6.55	5.6	1.9
99	Khairapali	Padampur	83.1679	20.9692	KW	210	8.75	6.3	2.33
100	Talpali	Gaisilet	83.2161	20.9707	KW	210	9.8	5.9	3.3
101	Turcha	Gaisilet	83.3101	20.8894	KW	190	9.25	6.6	4.6
102	Kathaumal	Gaisilet	83.3251	20.9151	KW	210	6.8	4.4	1.15
103	Jagalpet	Gaisilet	83.3515	20.8933	KW	210	7.6	6.9	3.85
104	Kasdol	Gaisilet	83.3721	20.9247	KW	170	12.15	7.25	7.2
105	Chantipali	Gaisilet	83.2907	21.0236	KW	165	12.8	11	4.3
106	Telmahuli	Gaisilet	83.2586	21.0689	KW	220	8.9	8.1	1.9
107	Jhar	Sohela	83.2763	21.02303	KW	165	10.7	9.1	5.1
108	Tabra	Sohela	83.2989	21.26661	KW	230	10.4	9.1	4.8
109	Sohela	Sohela	83.3991	21.3023	KW	220	12.1	10.1	5.35
110	Jatla	Sohela	83.4857	21.3557	KW	180	9.7	8.9	4.8
111	Sarkanda	Sohela	83.4551	21.3483	KW	190	10.53	3	2.6
112	Beherapali	Sohela	83.4079	21.3435	KW	200	10.4	9.1	5.6

Table-2.4: Ground Water Quality Data of Monitoring Wells in Bargarh District.

SL NO.	DIST	VILLAGE	well	Lat	Long	pH	EC µS/cm	TDS	Hardness	Alkalinity	Ca++	Mg++	Na+	K+	CO3=	HCO3-	Cl-	SO4=	F	NO3-
1	Bargarh	Attabira	DW	83.7833	21.3708	8.18	3100	1704	604	139	83	96	416	30.9	0	169	993	1.9	0.38	31
2	Bargarh	Baghapalli	DW	83.7986	21.1653	7.42	2600	1294	842	456	131	125	206	4.7	0	556	410	145	0.59	45
3	Bargarh	Bargarh3	DW	83.6097	21.3442	7.35	980	512	371	158	89	36	49	6.2	0	193	211	26	0.28	9
4	Bargarh	Batetarma	DW	83.2578	21.1442	7.48	700	376	178	99	58	8	69	16.2	0	121	119	46	0.17	51
5	Bargarh	Bhatli 1	DW	83.5347	21.4672	7.79	720	350	243	158	48	30	49	5.3	0	193	87	36	0.25	34
6	Bargarh	Bheden 1	DW	83.7508	21.1961	7.34	1280	588	525	193	83	77	50	1.7	0	236	219	42	0.58	49
7	Bargarh	Bhukta	DW	83.4153	21.5847	7.63	690	349	248	203	42	35	40	5.7	0	248	68	37	0.51	3
8	Bargarh	Bijeur	DW	83.4636	21.1883	8.26	430	206	168	134	50	10	19	0.8	0	163	27	19	0.51	11
9	Bargarh	Boipur	DW	83.8819	21.2014	8.25	380	196	149	134	40	12	17	2.5	0	163	22	23	0.26	2
10	Bargarh	Bugbugi	DW	83.4892	21.6139	7.45	330	175	134	114	40	8	8	9.6	0	139	29	12	0.19	4.5
11	Bargarh	Burdapali	DW	83.4692	21.1594	7.77	1140	603	317	386	54	44	106	14.5	0	471	124	29	1.76	2.8
12	Bargarh	Chaklifarm	DW	83.8250	21.4000	7.72	370	189	153	129	34	17	12	3.4	0	157	29	17	0.47	1.8
13	Bargarh	Dang	DW	83.6006	21.3581	7.78	740	386	233	243	40	32	61	1.3	0	296	70	36	0.77	1.6
14	Bargarh	Dumalpali	DW	83.5000	21.5069	7.86	580	283	203	153	46	21	36	3.3	0	187	66	19	0.33	10
15	Bargarh	Dungri	DW	83.5652	21.6866	7.91	260	132	99	104	22	11	12	1.6	0	127	10	13	0.33	1
16	Bargarh	Gaisilet3	DW	83.3150	20.9622	7.92	2970	1472	832	262	63	164	297	3.9	0	320	658	129	0.72	97
17	Bargarh	Ghens 1	DW	83.2853	21.1897	7.52	1580	821	426	267	79	56	155	19.3	0	326	260	92	0.4	43
18	Bargarh	Gondtarum	DW	83.8417	21.1097	7.72	340	169	124	119	34	9	18	4.8	0	145	22	10	0.39	1
19	Bargarh	Godbhaga	DW	83.8167	21.4208	7.64	220	116	89	94	36	0	7	1.7	0	115	10	5	0.48	0.2
20	Bargarh	Grinjal	DW	83.3742	21.3367	7.35	2020	1081	426	252	79	56	160	183	0	308	374	78	0.6	200
21	Bargarh	Jagalpet	DW	83.3514	20.8931	7.3	1760	909	639	495	137	72	89	33.2	0	604	199	83	1.96	12
22	Bargarh	Jamurda	DW	83.6625	21.3722	7.54	370	200	129	134	38	8	20	6.9	0	163	24	23	0.31	1
23	Bargarh	Kalapani	DW	83.7086	21.3572	7.8	690	386	198	208	44	21	29	62.3	0	254	66	39	0.32	4
24	Bargarh	Karla	DW	83.5747	21.6031	7.65	230	109	94	59	18	12	9	0.8	0	72	27	7	0.21	8
25	Bargarh	Katapali	DW	83.4206	21.5850	7.81	910	466	272	257	54	33	82	1.6	0	314	100	41	0.77	8
26	Bargarh	Kharmunda	DW	83.4897	21.1353	7.3	1300	575	450	208	99	49	89	1.9	0	254	153	58	0.92	203
27	Bargarh	Khuntapali	DW	83.6153	21.2853	8	1080	588	233	238	65	17	87	90.3	0	290	138	48	0.66	107
28	Bargarh	Khutlipalli	DW	83.8700	21.2589	7.74	590	290	243	134	75	13	23	1.5	0	163	87	10	0.36	38

29	Bargarh	Kulunda	DW	83.7839	21.3458	7.71	480	259	134	153	20	20	31	28	0	187	46	22	0.3	14
30	Bargarh	Kumbhari	DW	83.6478	21.2069	7.86	890	426	322	168	34	58	54	2.8	0	205	124	53	0.56	53
31	Bargarh	Kuruan	DW	83.7397	21.2916	7.98	600	305	173	238	32	23	42	24.2	0	290	36	6	0.4	13
32	Bargarh	Kusanpur	DW	83.5678	21.2506	7.9	1530	812	416	198	85	49	157	4.5	0	242	323	74	0.59	47
33	Bargarh	Kumelsingha	DW	83.8531	21.3878	8.23	260	129	104	84	30	7	9	2.3	0	103	17	13	0.25	4
34	Bargarh	Kodabahal 2	DW	83.8475	21.3128	7.87	260	124	99	94	24	9	11	2	0	115	12	9	0.17	1
35	Bargarh	Lakhanpur	DW	83.6106	21.6419	7.58	400	197	149	139	26	20	19	6.6	0	169	34	8	0.26	1
36	Bargarh	Larambha	DW	83.8339	21.3514	8	260	126	94	89	18	12	12	3.9	0	109	12	15	0.17	1
37	Bargarh	Lastala	DW	83.7050	21.3958	7.27	250	133	59	54	16	5	28	1.9	0	66	44	6	0.33	1
38	Bargarh	Lenda	DW	83.5944	21.2222	8.09	820	391	213	292	34	31	90	1	0	356	46	14	1.1	1
39	Bargarh	Padampur2	DW	83.0683	20.9992	7.79	1990	1001	520	347	44	100	212	10	0	423	345	83	0.87	65
40	Bargarh	Patrapalli	DW	83.7050	21.3958	8.01	560	278	193	114	42	21	36	4.9	0	139	70	36	0.68	14
41	Bargarh	Purrakhai	DW	83.4839	21.4564	8.28	1100	655	203	218	26	34	84	127	0	266	189	65	0.23	37
42	Bargarh	Remada	DW	83.6178	21.2008	8.2	570	270	198	188	24	34	36	6	0	229	32	26	0.92	7
43	Bargarh	Remenda	DW	83.7625	21.2667	7.95	530	277	183	178	40	20	35	4.3	0	217	53	18	0.42	1
44	Bargarh	Rusuda	DW	83.8555	21.1722	8.05	620	295	193	228	24	32	51	2.4	0	278	29	20	1.6	1
45	Bargarh	Sarala	DW	83.6556	21.3989	7.7	270	126	89	59	26	6	20	1.5	0	72	24	13	0.28	24
46	Bargarh	Shukutapali	DW	83.7167	21.3658	7.77	1760	914	604	193	26	131	114	18.3	0	236	401	108	0.23	58
47	Bargarh	Sikirdi	DW	83.6264	21.1597	8.1	340	161	139	104	20	22	12	2.5	0	127	27	16	0.32	4
48	Bargarh	Sunajuri-Tukuria	DW	83.5844	21.4086	8.17	600	314	129	163	26	16	77	2	0	199	70	26	0.21	1
49	Bargarh	Sarandapali	DW	83.4933	21.2361	7.95	1210	579	495	178	42	95	45	5.8	0	217	233	52	0.7	110
50	Bargarh	Thuapali	DW	83.7911	21.2667	8.24	620	271	243	218	24	44	28	3.8	0	266	34	6	0.28	9
51	Bargarh	Top	DW	83.7875	21.4083	8.25	240	121	94	84	26	7	10	1	0	103	15	11	0.25	1
52	Bargarh	Tora	DW	83.6203	21.3372	8.26	870	405	262	193	20	52	75	5.7	0	236	100	37	1.14	35
53	Bargarh	Uttam	DW	83.8475	21.3128	8.12	770	420	228	267	24	41	42	48	0	326	70	35	0.42	6
54	Bargarh	Bargarh (New)	DW	83.6097	21.3442	8.13	960	492	248	248	24	46	103	5.9	0	302	131	34	1.35	8
55	Bargarh	Hirapur	DW	20.9638	82.8188	8.43	400	192	160	75	34	18.23	16	2.1	54	92	15	7	0.87	
56	Bargarh	Jamset	DW	20.8269	82.7233	8.17	600	313	235	190	44	30.38	36	2.2	0	232	57	30	0.98	
57	Bargarh	Majhipal	DW	20.9519	82.8866	8.18	260	124	105	100	18	14.58	11	1.2	0	122	17	3	0.14	
58	Bargarh	Mithapali	DW	20.9058	82.7933	7.89	380	187	155	135	36	15.8	14	1.2	0	165	32	7	0.31	
59	Bargarh	Purena	DW	20.8630	82.7611	7.99	700	351	295	215	82	21.87	27	2.1	0	262	72	18	0.32	

60	Bargarh	Nrusinghanath	DW	20.8988	82.8225	8.08	260	132	105	95	24	10.94	13	1.2	0	116	20	7	0.11	
61	Bargarh	Jaring	DW	21.1972	83.4793	7.64	2000	993	740	195	98	120	110	3.1	0	238	439	103	0.78	
62	Bargarh	Bijepur	DW	21.1896	83.4520	8.07	700	341	245	138	57	25	40	0.4	0	169	94	40	0.5	
63	Bargarh	Laumunda	DW	21.0840	83.3898	8.41	650	337	235	195	65	18	34	3.3	12	213	60	40	0.78	
64	Bargarh	Saipali	DW	21.0846	83.4514	7.79	1450	703	431	215	84	54	112	5.8	0	263	217	100	0.88	
65	Bargarh	Para	DW	21.1753	83.2732	7.98	1040	745	529	236	114	60	50	6	0	288	246	127	1.34	
66	Bargarh	Sanimal	DW	21.0783	83.2315	7.95	1400	780	480	231	151	25	76	36.9	0	281	265	88	1.23	
67	Bargarh	Badipali	DW	21.1356	83.3597	8.52	600	289	191	215	45	19	47	0.9	22	219	31	17	1.96	
68	Bargarh	Birjam	HP	21.1344	83.2953	8.28	450	222	142	164	37	12	30	1	0	200	27	17	0.82	
69	Bargarh	Paikmal	DW	20.9205	82.8130	8.08	850	422	279	185	47	39	60	4.5	0	225	154	6	0.67	
70	Bargarh	Kutna	DW	21.0512	82.7843	8.29	920	479	181	318	33	24	109	9.3	0	388	60	53	0.81	
71	Bargarh	Dobha	DW	21.1033	82.6980	7.88	1350	697	421	190	69	61	90	31	0	231	260	72	0.46	
72	Bargarh	Bhandarpuri	HP	21.1288	82.7214	8.06	1200	583	470	195	53	82	54	2.4	0	238	207	66	0.57	
73	Bargarh	Kumir	DW	21.0797	82.8464	8.47	610	305	196	169	25	32	36	19.3	15	175	63	28	0.39	
74	Bargarh	Chandibhata	DW	21.1033	82.8239	8.61	1240	690	289	338	78	23	89	103	25	363	157	37	0.34	
75	Bargarh	Dongripali	DW	21.1249	82.8454	8.3	860	445	260	185	61	26	52	11.6	9	206	133	51	0.77	
76	Bargarh	laudidhara	HP	21.1525	82.8504	8.14	800	425	167	190	37	18	96	0.9	0	231	113	46	1.36	
77	Bargarh	Jharbandh	DW	21.0619	82.7914	8	780	409	250	154	73	17	48	1.5	0	188	128	50	0.67	
78	Bargarh	Jhenganadih	DW	20.9793	82.8946	7.95	1050	559	323	205	61	42	76	15.3	0	250	176	65	0.47	
79	Bargarh	Temri	DW	21.0089	82.8937	8.46	580	282	142	185	25	19	65	1.5	12	200	36	25	1.07	
80	Bargarh	Barrikel	DW	20.9827	83.0128	8.01	1480	753	446	323	18	98	118	14.1	0	394	210	100	1.03	
81	Bargarh	Borasambar	DW	20.9406	82.9480	8.29	450	217	176	179	45	15	14	1.3	0	219	19	14	0.52	
82	Bargarh	Palsada	DW	20.9891	82.9563	7.75	2260	1124	760	313	94	127	99	101	0	381	458	56	0.62	
83	Bargarh	Garjori	DW	20.9601	82.9456	8.22	640	288	221	241	35	32	27	1.9	0	294	31	17	0.73	
84	Bargarh	Jharmunda	DW	20.9513	82.8571	8.07	970	503	319	164	63	39	56	31.7	0	200	159	55	0.39	
85	Bargarh	Munnikel	DW	20.9013	82.7608	7.96	900	448	319	205	71	35	52	6.2	0	250	137	24	0.74	
86	Bargarh	Jatki	HP	20.9124	82.7355	8.27	70	357	245	185	67	19	35	1.3	0	225	87	37	0.73	
87	Bargarh	Bamandih	DW	20.9433	82.7656	8.46	840	453	260	220	90	8	48	16	18	231	92	67	0.59	
88	Bargarh	Bubaneswar	DW	20.9593	82.7187	8.37	860	433	333	215	73	37	38	0.6	12	238	96	59	1.14	
89	Bargarh	Deoli	DW	21.0286	83.0658	8.53	1930	997	470	374	37	92	168	24.1	25	406	297	153	0.9	
90	Bargarh	Purena	DW	21.0377	83.0226	8.38	610	297	191	236	35	25	40	1.4	18	250	29	25	1.06	

91	Bargarh	Dhumabhata	DW	21.0712	83.0076	8.53	550	276	186	210	45	18	31	4	12	231	22	31	1.53	
92	Bargarh	Jagdalpur	DW	21.1271	82.9393	8.4	780	409	279	169	61	31	31	11.2	12	181	99	74	0.72	
93	Bargarh	Bajenmunda	DW	20.9593	83.0326	8.87	1150	585	142	487	31	15	176	2	22	550	34	35	2.34	
94	Bargarh	Dahita	DW	20.9071	83.0624	8.37	420	206	137	144	35	12	25	1.4	12	150	27	20	0.56	
95	Bargarh	Buden	DW	20.8820	83.0185	8.26	840	444	201	195	33	29	60	41.5	0	238	99	65	0.57	
96	Bargarh	Dahigaon	HP	20.9328	83.0873	7.97	1180	599	348	231	55	51	81	41.1	0	281	174	58	0.74	
97	Bargarh	Beheratal	DW	20.9167	83.1219	8.16	1000	512	338	226	69	40	54	7.7	0	275	137	68	0.74	
98	Bargarh	Luhakhani	DW	20.9446	83.1445	8.44	710	360	289	190	53	38	21	7.1	12	206	94	33	0.66	
99	Bargarh	Jamartala	DW	20.8936	83.1420	8.42	560	256	230	154	55	23	12	2.4	12	163	39	33	0.67	
100	Bargarh	Mahulpali	HP	21.0129	83.1009	7.89	1690	819	662	179	104	98	70	5.5	0	219	352	80	0.5	
101	Bargarh	Sargibahal	DW	21.0577	83.1834	8.31	1240	645	284	292	43	43	82	66.3	18	319	147	89	0.71	
102	Bargarh	Karsingha	DW	21.0422	83.1288	8.52	720	405	294	190	47	43	51	3.3	22	188	101	44	0.88	
103	Bargarh	Budhamal	DW	20.9609	83.1433	7.98	1390	723	363	318	49	58	116	22.9	0	388	190	95	0.88	
104	Bargarh	Khairapali	DW	20.9692	83.1679	7.89	1160	631	299	154	88	19	109	2.9	0	188	258	61	2.08	
105	Bargarh	Talpali	DW	20.9707	83.2161	8.46	620	308	211	190	29	33	40	2.6	12	206	75	14	0.86	
106	Bargarh	Turcha	DW	20.8894	83.3101	8.34	2320	1145	353	513	29	68	294	2.8	31	563	325	118	2.53	
107	Bargarh	Kathaumal	HP	20.9151	83.3251	8	1430	691	451	231	61	73	72	4.3	0	281	217	125	2.5	
108	Bargarh	Jagalpet	DW	20.8933	83.3515	7.83	1580	780	544	246	69	90	86	25.3	0	300	236	125	3.3	
109	Bargarh	Kasdol	HP	20.9247	83.3721	8.16	1650	813	549	384	39	110	90	3	0	469	231	107	1.12	
110	Bargarh	Chantipali	DW	21.0236	83.2907	8.31	1180	565	441	261	61	70	59	5.9	15	288	145	67	0.94	
111	Bargarh	Telmahuli	DW	21.0689	83.2586	8.17	1170	598	358	256	51	56	86	1.9	0	313	176	74	0.93	
112	Bargarh	Jhar	HP	21.0230	83.2763	8.05	760	389	294	215	69	30	31	0.4	0	263	77	53	0.88	
113	Bargarh	Tabra	HP	21.2666	83.2989	8.06	930	468	279	210	39	44	65	0.5	0	256	128	65	0.91	
114	Bargarh	Sohela	DW	21.3023	83.3991	7.8	1660	874	412	256	135	17.861	148	1.4	0	313	301	117	0.49	
115	Bargarh	Jatla	HP	21.3557	83.4857	7.8	2250	1183	701	205	145	82.158	162	2.6	0	250	571	96	0.96	
116	Bargarh	Sarkanda	HP	21.3483	83.4551	8.18	1180	647	181	277	37	21.433	115	76.2	0	338	164	67	0.53	
117	Bargarh	Beherapali	DW	21.3435	83.4079	7.94	1800	967	470	226	106	50.009	165	44.9	0	275	369	96	0.71	

Table-2.5: Ground Water Quality Data of Exploratory Wells in Bargarh District.

Sl No	Location	Block	Latitude	Longitude	pH	EC	TDS	Hardness	Ca++	Mg	Na+	K+	CO3=	HCO3-	Cl-	SO4=	NO_3^-	F^-	Fe	SAR
						µS/cm	mg/L	as CaCO3 mg/L	mg/L											
1	Antapali	Bhatli	21.4518	83.6222	8.28	360	170	129	36	9	20	3.5	0	169	10	8		0.43	0	
2	Jampali	Bhatli	21.4247	83.45	7.72	740	356	307	65	35	26	1.2	0	308	49	29		0.756	0	
3	Kamgaon EW	Bhatli	21.4482	83.6376	7.3	260		87	14	12	20	2	0	96	25	0		0.89	0	
4	Kamgaon OW	Bhatli	21.4482	83.6376	7.48	220		66	18	5	18	1	0	89	20	0		0.1	0	
5	Kelendapali	Bhatli	21.4916	83.4934	8.15	690	353	173	32	23	75	6	0	242	66	0		1.66	0	
6	Kesaipali EW	Bhatli	21.478	83.5251	7.81	1340		406	83	48	117	5	0	193	253	0		1.11	0	
7	Kesaipali OW	Bhatli	21.478	83.5251	7.56	1520		406	79	51	157	6.5	0	374	221	0		1.69	0	
8	Mulbar	Bhatli	21.4772	83.539	7.6	560	279	233	58	21	19	1.8	0	193	53	31		0.257	0	
9	Sukuda	Bhatli	21.5	83.524	7.66	520	276	124	34	9	60	2.3	0	290	19	9		0.84	0	
10	Tukurla	Bhatli	21.4085	83.584	7.84	360		129	32	12	21	1.3	0	199	15	0		0.427	0	
11	Bargarh	Bargarh	21.3442	83.6097	7.7	487	306	165	30	22	30	1.6	0	92	92	0	17	0.26	0.03	
12	Bargarh OW	Bargarh	21.3442	83.6097	7.65	589	348	210	66	9.7	30	1.2	0	116	113	1	6	0.27	0.24	
13	Rehunia	Bargarh	21.3248	83.6422	6.58	143	120	35	12	1.2	15	0.8	0	37	14	8.1	11	0.75	0.01	
14	Adagaon EW	Bargarh	21.2648	83.7363	8.23	254	199	95	32	3.6	17	0.6	0	140	11	2.2	1.1	0.51	0.54	
15	Barpali	Barpali	21.1896	83.5871	7.14	987	542	320	98	18	69	3.1	0	201	188	14	27	0.98	0.03	
16	Kumbhari	Barpali	21.1938	83.6475	7.14	987	209	105	98	18	19	2.9	0	134	21	12	3.5	0.9	0.22	
17	Kadabahal EW	Attabira	21.316	83.8362	8.09	257	190	75	24	3.6	34	2.5	0	146	14	5	0.4	0.63	0.16	
18	Kadabahal OW	Attabira	21.316	83.8362	8.23	190	145	60	20	2.4	19	1.4	0	110	8.9	2.4	0	0.56	0.23	
19	Patrapali EW	Attabira	21.3149	83.7598	7.82	117	116	35	10	2.4	13	1.2	0	61	11	1	0.8	0.68	0.2	
20	Janhapada EW	Attabira	21.3486	83.8347	7.13	159	137	45	16	1.2	12	1.6	0	73	7.1	6.5	6	0.42	0.28	
21	Saharatikra	Bheden	21.2201	83.7428	8.12	390	257	135	42	7.3	24	1.4	0	220	14	8.9	0.9	1.05	0.06	
22	Chichinda	Bheden	21.1748	83.8151	7.32	283	227	115	30	9.7	16	1.8	0	128	21	1	12	0.13	0.07	

	EW																			
23	Chichinda OW	Bheden	21.1748	83.8151	8.25	245	198	90	26	6.1	15	2	0	122	14	7.1	8.4	0.65	0.01	
24	Padampur	Padampur	20.9612	83.051	8.19	962		160	32	19	143	8.6	0	476	43	14	< 1	1.32	< 0.1	
25	Jharbandh	Jharbandh	21.0501	82.7802	7.98	727		275	66	27	25	1.6	0	262	71	13	< 1	0.55	0.26	
26	Paikamal	Paikmal	20.8928	82.8003	7.85	881		335	110	44	15	4.7	0	366	89	25	< 1	0.99	8.26	
27	Gaisilet	Gaisilet	20.9684	83.3157	8.26	758		255	42	36	36	59	0	360	53	20	4.5	0.76	0.01	
28	Sohela EW	Sohela	21.2571	83.3276	8.13	470		125	36	8.5	8.5	22	0	214	28	12	3	2	0.01	
29	Sohela OW	Sohela	21.2571	83.3276	7.19	641		150	48	7.3	79	1.4	0	293	43	18	0.05	1.18	0.06	
30	Bhatli	Bhatli	21.4308	83.5203	7.51	303		75	22	4.8	38	1	0	140	21	15	5.8	0.4	0.12	
31	Bhukta EW	Ambabhona	21.5786	83.4221	6.98	563		265	66	24	12	0.78	0	281	25	3.8	23	0.31	0.09	
32	Bhukta OW	Ambabhona	21.5786	83.4221	7.06	592		265	82	15	11	0.4	0	329	23	7.2	2.1	0.37	0.39	
33	Ruchida	Ambabhona	21.5981	83.4003	7.93	484		180	38	21	25	1.4	0	268	7.1	4.1	11	0.17	0.08	
34	Kandapala	Ambabhona	21.55	83.4	6.94	565		253	86	9.1	20	0.6	0	250	60	11	0.8	0.46	0.08	
35	Bijepur	Bijepur	21.1682	83.4846	8.12	703	406	190		15	98	3.3	0	360	28	0				
36	Bijepur	Bijepur	21.1682	83.4846	8.12	703	406	190		15	98	3.3	0	360	28	0				

3 DATA INTERPRETATION, INTEGRATION 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 5.7 to 13.1 mbgl and their diameter ranges from 1.0 m to 6.5 m. The wells are generally lined to the total depth.

3.1.1 Pre-monsoon Depth to Water Level

The Depth to water level in pre-monsoon period (May 2019) varies from 1.37 mbgl (Gondturum) to 11.0 mbgl (Chantipali) the average being 5.8mbgl. In general, the study area has the depth to water level in between 6 to8 mbgl during the pre-monsoon. Water logging condition (<3 mbgl) is found in Northern portion in Hirakud Area during the pre-monsoon. Shallower water level of 2-4 mbgl is observed in parts of Bhatli,Bargarh,Attabira,Bheden blocks. They are mainly due to adequate irrigation facility through the Hirakud Main Branch canal and its distributaries. Deeper water levels (> 8 mbgl) are found mostly in Sohela block and in patches of Bargarh, Bheden, Gaisilat, Padampur and Jharbandh blocks. The locations where the depth to water level more than 8 m bgl are Kharmunda (8.18), Jaring (8.8), Bijepur (8.7), Para (9.1), Sanimal (10.8) in Bijepur Block, Dobha (8.2), Bhandarpuri (8.4), Dongripali (9.4), Jharbandh (9.3) in Jharbandh Block, Telmahuli (8.1), Jhar (9.1), Tabra (9.10), in Gaisilet block, sohela (10.1), Jatla (8.9), Beherapali (9.1) in Sohela block, and Sanjari Tukurla (8.58), in Bhatli block. 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 (Nov 2019) varies from 1.15 mbgl (Kathaumal) to 7.20 mbgl (Kasdol) the average being 3.13 mbgl. The depth to water level of the study area during Nov 2019 is in general within 2-4 mbgl. The areas around Bhatli,Bargarh,Barpali and pats of Attabira ,Bheden,and isolated patches of in all blocks show shallow water level of less than 3.0 mbgl. The locations where the depth to water level is more than 5.0 m bgl are Khutlipali(5.4)in Bheden block,Buden(5.4)in Padampur block,Jhar(5.1)in Gaisilet block and Sohela(5.35),Beherapali(5.6) in sohela block. (4.66).The village Kasdol in Gaisilet Block depth to water level is 7.2) The post-monsoon depth to water level map is shown below in **Fig. 3.2**.

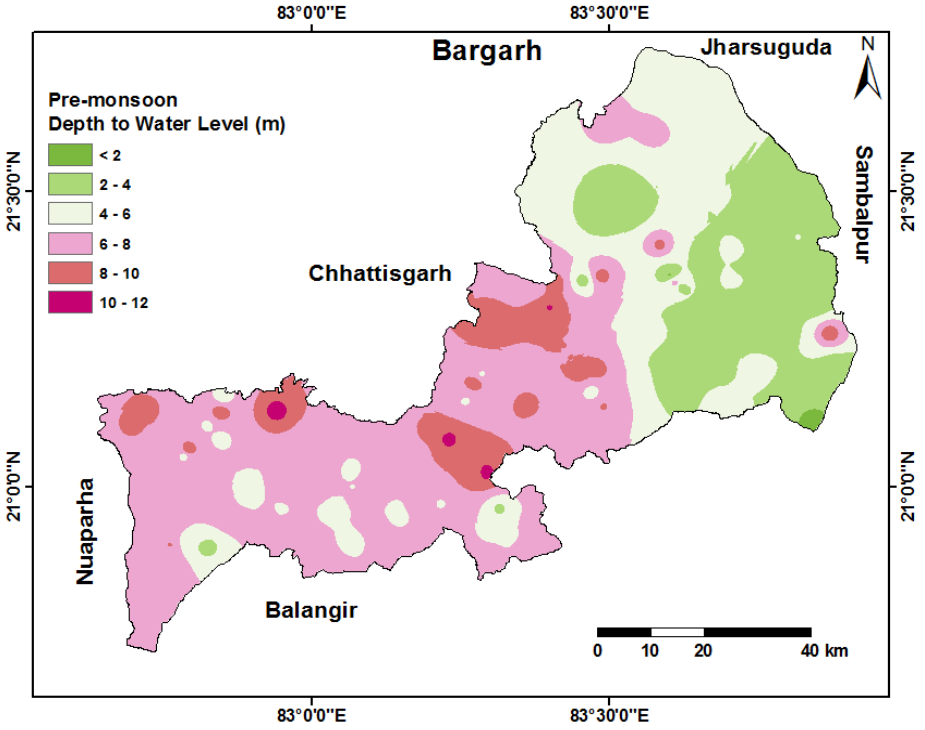

Fig. 3.1: Depth to Water Level in Phreatic Aquifer During Pre-monsoon.

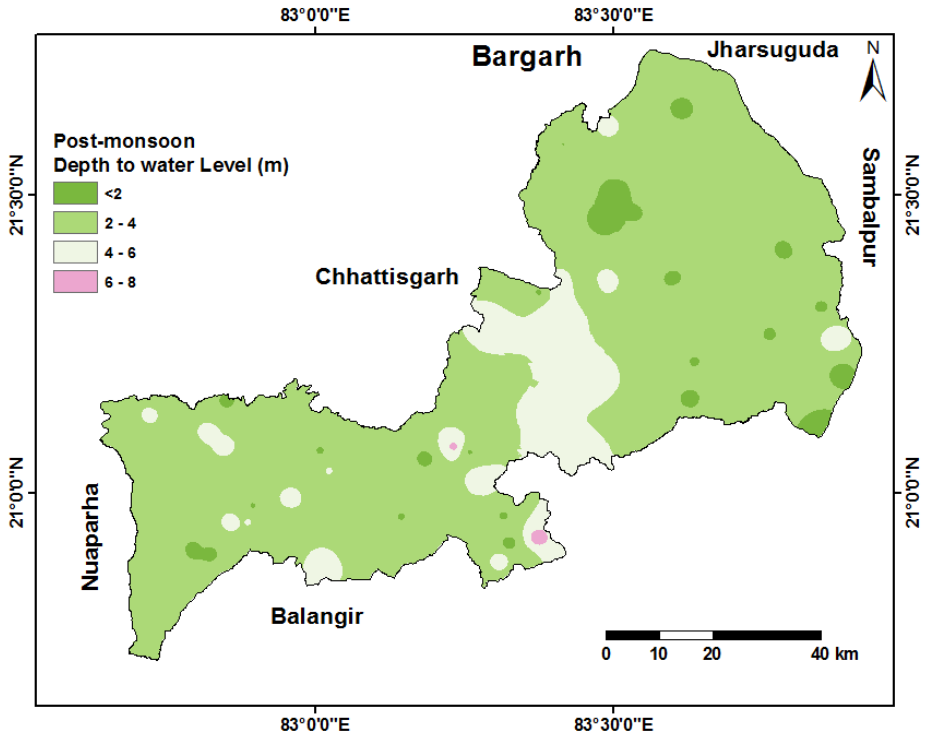

Fig. 3.2: Depth to Water Level in Phreatic Aquifer During Post-monsoon.

3.1.3 Seasonal Fluctuation of Water Level

The water level flctuation varies from 0.01 mbgl (Kadobahal) to 6.90 mbgl (Jagdalpur) the average being 2.67 mbgl. The general range of fluctuation in water level in the study area is between 2-4m. The locations where the fluctuation of water level is more than 5 m bgl and 6mbgl are Purena(5.3), Sargibahal(6.25) in Padampur block, Kharmunda(5.38),Para(5.8)in Bijepur block andDongripali(6.05), Jagdalpur(6.9) in Jharbandh block. The shallow post-monsoon water level along with fluctuation pattern indicates that the annual replenishment of phreatic aquifer due to monsoon rainfall is adequate in the district but deeper summer level is due to rapid dewatering of the phreatic aquifer due to steep gradient towards the Mahanadi. The seasonal fluctuation of water level of Aquifer-I is shown in **Fig. 3.3**.

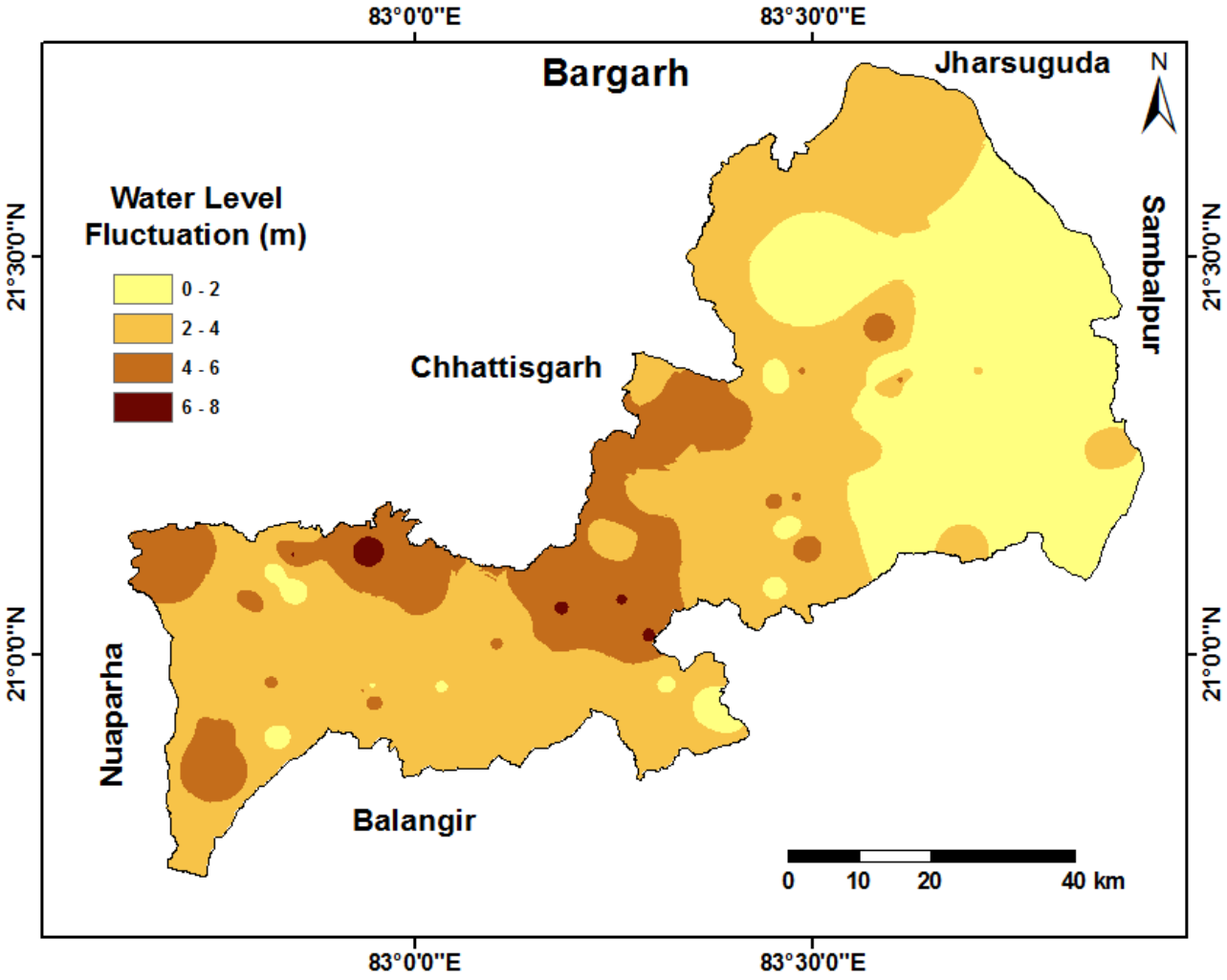

Fig. 3.3: Seasonal Fluctuation in Water Level in Phreatic Aquifer.

3.1.4 Decadal Water Level Trend

There are 56 National Hydrograph Station (NHS) in the district, the data from which are considered for analysis of long-term decadal trend for the period 2010-2019. The decadal trend of water level for both pre-monsoon and post-monsoon periods were analyzed. The results of trend analysis have been shown in **Table-3.1**. The long term trend analysis indicates that out of 56 stations, 24(42.85%) show falling trend and 9 stations (16.07%) show rising trend in both the seasons. The area around Rusuda in Bheden block has significant falling trend of about 06-75 cm/year. In all other stations with falling trend, the extent of fall is not significant.

Table-3.1: Decadal Water Level Trend Analysis of CGWB NHS (period 2010-2019) in Bargarh District.

	Block	Location	**Pre-monsoon**		**Post-monsoon**	
Sl No			Trend (m/Yr)	Remark	Trend (m/Yr)	Remark
1	GAISILET	Gaisilet3	0.4779	Rise	0.0769	Rise
2	BHATLI	Sunajuri-Tukuria	-0.263	Fall	0.5880	Rise
3	BHEDEN	Bheden 1	-0.597	Fall	-0.0797	Fall
4	BHATLI	Bhatli 1	0.0065	Rise	0.0704	Rise
5	SOHELA	Batetarma	0.0715	Rise	-0.1656	Fall
6	SOHELA	Ghens 1	-0.0836	Fall	-0.034	Fall
7	BARAPALI	Remada	-0.2230	Fall	-0.2394	Fall
8	GAISILET	Kantabahal	0.0314	Rise	-0.127	Fall
9	BARAPALI	Kusanpur	-0.0624	Fall	-0.0764	Fall
10	BARGARH	Tora	-0.0006	Fall	-0.0051	Fall
11	BARGARH	Rengalpali	0.0977	Rise	-0.0520	Fall
12	BARGARH	Dang	0.3031	Rise	0.0658	Rise
13	PAIKMAL	Jamset	-0.0053	Fall	0.3166	Rise
14	PAIKMAL	Purena	-0.1915	Fall	-0.0757	Fall
15	PAIKMAL	Mithapali	-0.044	Fall	-0.0866	Fall
16	PAIKMAL	Hirapur	-0.0882	Fall	-0.2122	Fall
17	PAIKMAL	Majhipali	-0.025	Fall	0.0669	Rise
18	PAIKMAL	Malada	-0.0996	Fall	-0.0764	Fall
19	BIJEPUR	Kharmunda 1	-0.3492	Fall	0.0117	Rise
20	BIJEPUR	Burdapali	-0.2784	Fall	-0.2781	Fall
21	ATTABIRA	Puturipali	-0.0373	Fall	-0.0373	Fall
22	BARGARH	Khuntapali	-0.0433	Fall	-0.0869	Fall
23	BHATLI	Dumalpali	0.8621	Rise	0.0201	Rise
24	AMBABHONA	Uttam	0.0165	Rise	0.0444	Rise
25	BHATLI	Sulsulia	-0.1363	Fall	-0.2228	Fall
26	BHEDEN	Rusuda	-0.7598	Fall	-0.0693	Fall
27	BHEDEN	Baghapalli	-0.1457	Fall	-0.3587	Fall
28	BHEDEN	Remenda	-0.0901	Fall	-0.1109	Fall
29	BARGARH	Sarala	-0.1904	Fall	-0.2035	Fall

30	BHATLI	Katapali	-0.1102	Fall	0.0090	Rise
31	ATTABIRA	Gorbhaga	0.1624	Rise	-0.0510	Fall
32	BHEDEN	Chichinda	0.0302	Rise	-0.0249	Fall
33	BHEDEN	Burda	0.024	Rise	-0.2760	Fall
34	BHEDEN	Gondtarum	0.3776	Rise	0.0486	Rise
35	BHEDEN	Boipur	0.0892	Rise	-0.0019	Fall
36	BHEDEN	Lupursinga	0.1038	Rise	-0.1162	Fall
37	BHEDEN	Kumbhari	0.0458	Rise	-0.0385	Fall
38	BARAPALI	Lenda	0.2978	Rise	-0.0255	Fall
39	BHEDEN	Satlama	-0.195	Fall	-0.0830	Fall
40	BHEDEN	Mahada	0.2475	Rise	0.1227	Rise
41	BHEDEN	Sikirdi	0.0679	Rise	-0.0168	Fall
42	BIJEPUR	Bijepur1	-0.1855	Fall	-0.1786	Fall
43	PADAMPUR	Mahulpali	-0.1592	Fall	0.0358	Rise
44	ATTABIRA	Patrapalli	-0.0882	Fall	0.2900	Rise
45	ATTABIRA	Attabira1	--0.2084	Fall	0.3191	Rise
46	ATTABIRA	Top	0.059	Rise	-0.0139	Fall
47	ATTABIRA	Kulunda	0.0046	Rise	-0.0331	Fall
48	ATTABIRA	Chaklifarm	0.1161	Rise	-0.1123	Fall
49	BHEDEN	Khutlipalli	-0.0126	Fall	-0.3143	Fall
50	ATTABIRA	Larambha	-0.1018	Fall	-0.2203	Fall
51	ATTABIRA	Lastala	-0.0785	Fall	-0.1806	Fall
52	BARGARH	Bargarh1	0.0473	Rise	-0.0248	Fall
53	BARGARH	Jamurda	0.4515	Rise	0.1458	Rise
54	AMBABHONA	Dungri	2168	Rise	0.2306	Rise
55	AMBABHONA	Bhukta	-0.1522	Fall	-0.1076	Fall
56	ATTABIRA	Godbhaga	-0.056	Fall	-0.2391	Fall

3.1.5 Aquifer Characteristics of Phreatic Aquifer

The pumping tests were conducted on selected dugwells representing different hydrogeological units and the aquifer characteristics was evaluated in terms of Specific Capacity Index i.e. flow of ground water per metre depression of head over unit cross sectional area of inflow offered by the aquifer. The **Table-3.2** summarises the aquifer characteristics of the phreatic aquifers. The wide range of yield and specific capacity is due to very much heterogeneous nature of the weathered zone in lateral extension as well as variation of thickness of this zone.

Table-3.2: Aquifer Characteristics of Major Hydrogeological Units in Bargarh District,

Sl. No	Hydrogeological Unit	Specific Capacity Index (lpm/m/m^2)
1	Weathered Granite Gneiss	0.50 to 4
2	Weathered Charnockite	1 to 3
3	Khondalites	0.80 to 4
4	Lower Gondwana (Sandstone)	2.3
5	Valley Fills	3.0 to 40.0
6	Alluvium	4 to 9

3.2 Deeper Aquifer

Unlike phreatic aquifer, ground water occurs under confined to semi-confined condition in the deeper aquifer. The deeper aquifer comprises of the jointed and fractured consolidated or crystalline formations as well as the semi-consolidated formations such as Gondwanas. In general it's confined on top by weathered formations and bottom by massive rocks.

CGWB has constructed 48 EW and 13 OW in Bargarh district through its Ground Water Exploration Programme, whose depths range from 54.0 m bgl (Jharbandh) to 202.90 m bgl (Mandosil). The static water level varies from 0.74 m bgl (Kumbhari) to 27.9 m bgl (Sukuda). The discharge of successful borewells varies from 0.40 lps (Adgaon) to a maximum of 22 lps (Melchhamunda). The drawdown varies from 1.70 m (Kamgaon) to 58.37 m (Ghens). The transmissivity (T) of the aquifers ranges from 1.664 m^2/day (Jampali) to 217.72 m^2/day (Kamgaon). 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 35 m., which is just below the zone of weathering. The depth range of prime importance is from 40 to 100 m. Normally, the fracture zones in this depth range 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 40-65, 70-90, 95-115, 130-140 and 180-190 mbgl. Granite suites rocks have more promising aquifers in comparison to other rocks like Charnockites and Khondalites. 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 3.3

Table 3.3: Aquifer-Wise Ranges of Chemical Constituents in Bargarh District.

Parameter	Unit	Shallow (Aquifer-I)		Deep (Aquifer-II)	
		Minimum	Maximum	Minimum	Maximum
pH	-	7.27	8.87	6.58	8.28
EC	µS/cm	70	3100	117	1520
TDS	mg/L	109	1704	116	542
TH	mg/L	59	842	35	406
TA	mg/L	54	513	-	-
Ca^{++}	mg/L	16	151	10	110
Mg^{++}	mg/L	0	164	1.2	51
Na^{+}	mg/L	7	416	8.5	157
K^{+}	mg/L	0.4	183	0.4	59
$CO_3^{=}$	mg/L	0	54	0	0
HCO_3^{-}	mg/L	66	604	37	476
NO_3^{-}	mg/L	0.2	203	< 1	27
Cl^{-}	mg/L	10	993	7.1	253
$SO_4^{=}$	mg/L	1.9	153	0	31
F^{-}	mg/L	0.1	3.3	0.1	2
Fe	mg/L	-	-	-	-
SAR	-	-	-	-	-

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. For example, fluoride in excess of permissible limit has been found certain villages, which is discussed in detail in Chapter-5. The iso-conductivity map of phreatic aquifers of the district has been prepared and presented as **Fig. 3.4** . The quality of ground water is generally good with EC ranging from 70 to 3100µs/cm. The suitability of the ground water for the purpose of irrigation analysed in the US-Salinity diagram as shown in **Fig. 3.7**.in which EC is taken as salinity hazard and SAR as alkalinity hazard. The predominant USSL classes of the water samples fall within C2S1and C3S1 classes. C3S1 class indicating high salinity and low alkali water which cannot be used on soil with restricted drainage and requires special arrangement for salinity control.The soil must be permeable and the drainage must be adequate,irriagation water must be added in excess to provide considerable leaching and tolerant crops and plants should be selected for such regions.The water samples represent Ca-HCO_3 type to mixed facies of Ca-Mg-Na-HCO_3-SO_4 types as shown in the Piper diagram in **Fig. 3.8**. This indicates a transitional or mixing environment between the younger water and resident water.

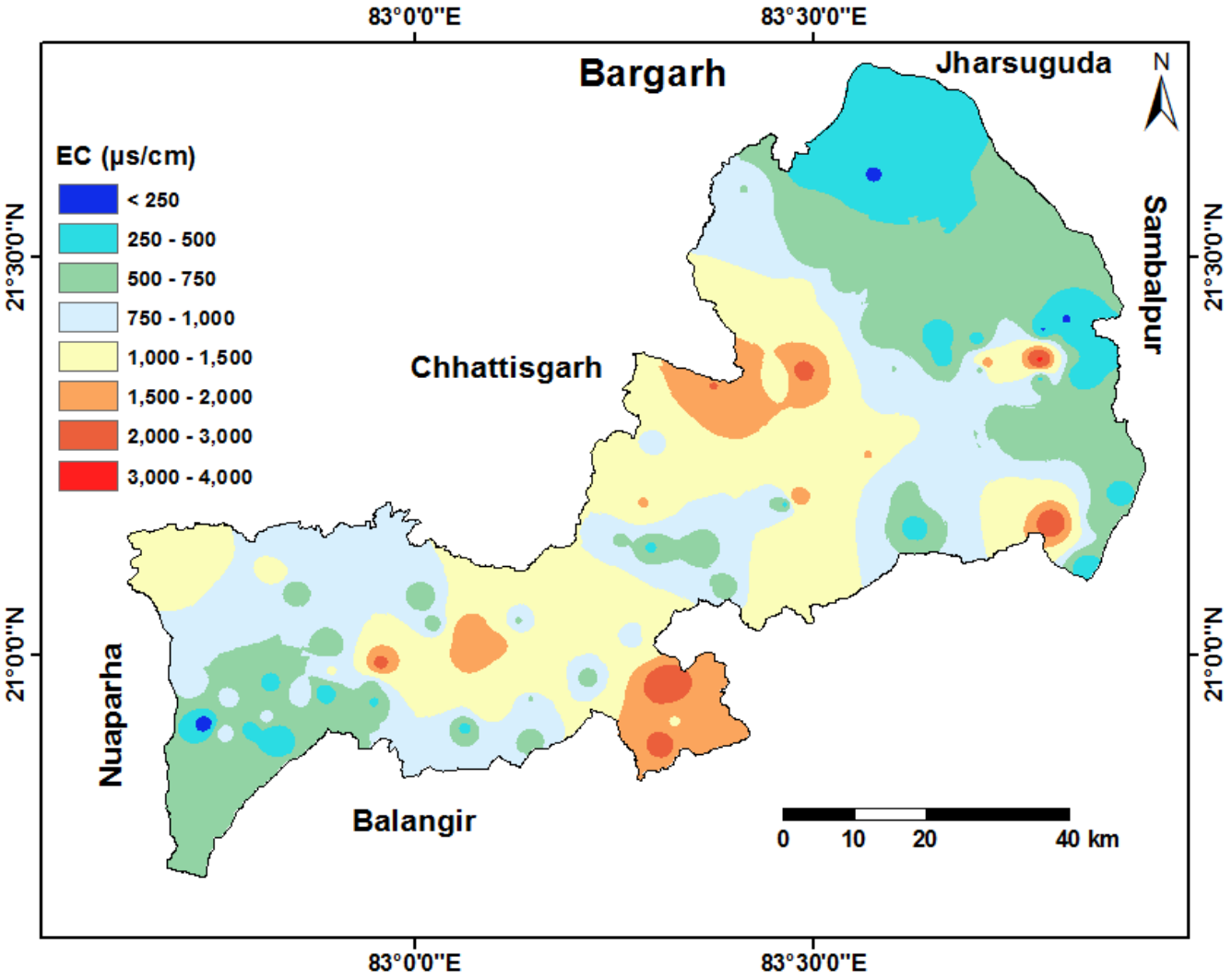

Fig. 3.4: Iso-conductivity Map of Phreatic Aquifer.

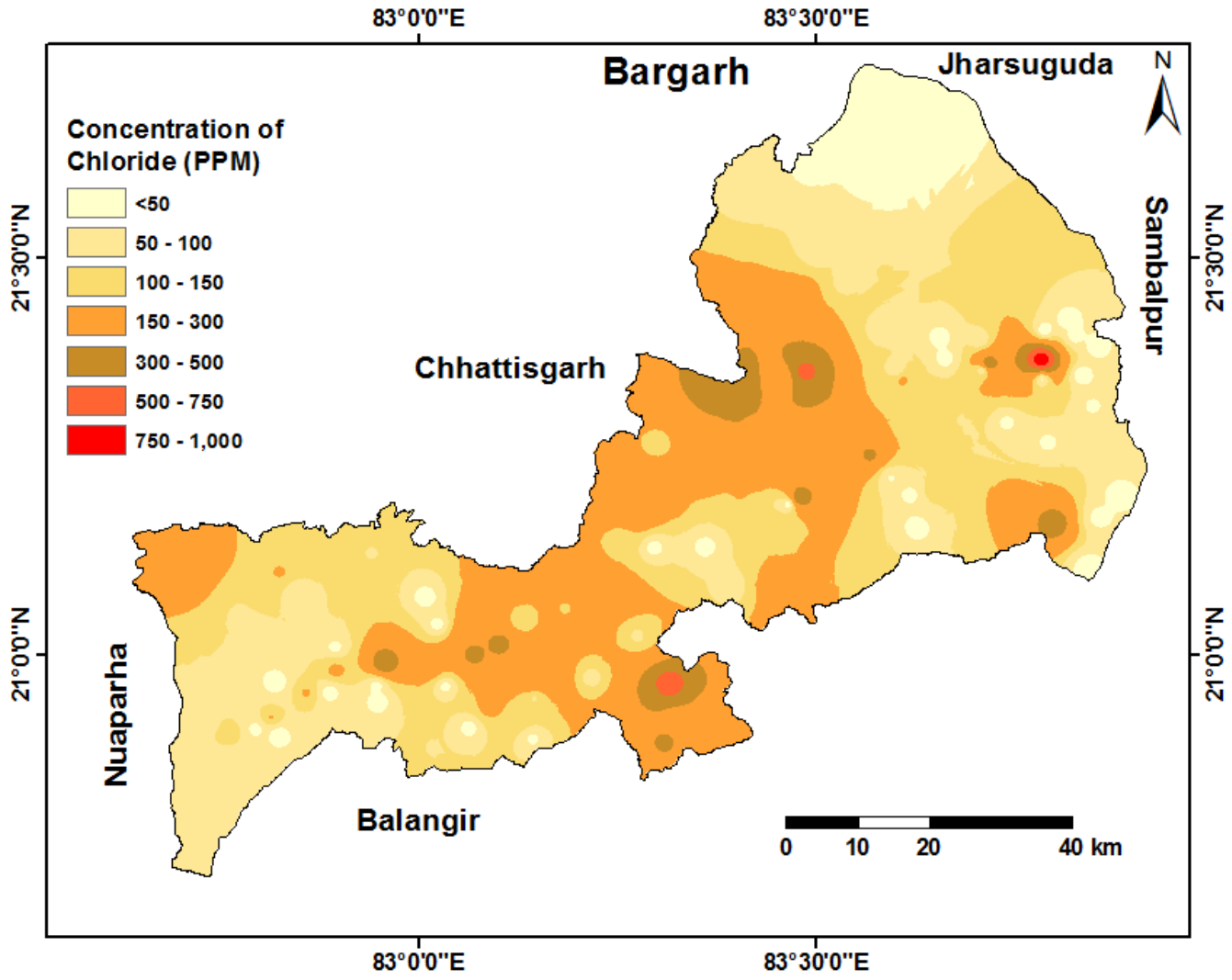

Fig. 3.5: Chloride Map of Phreatic Aquifer.

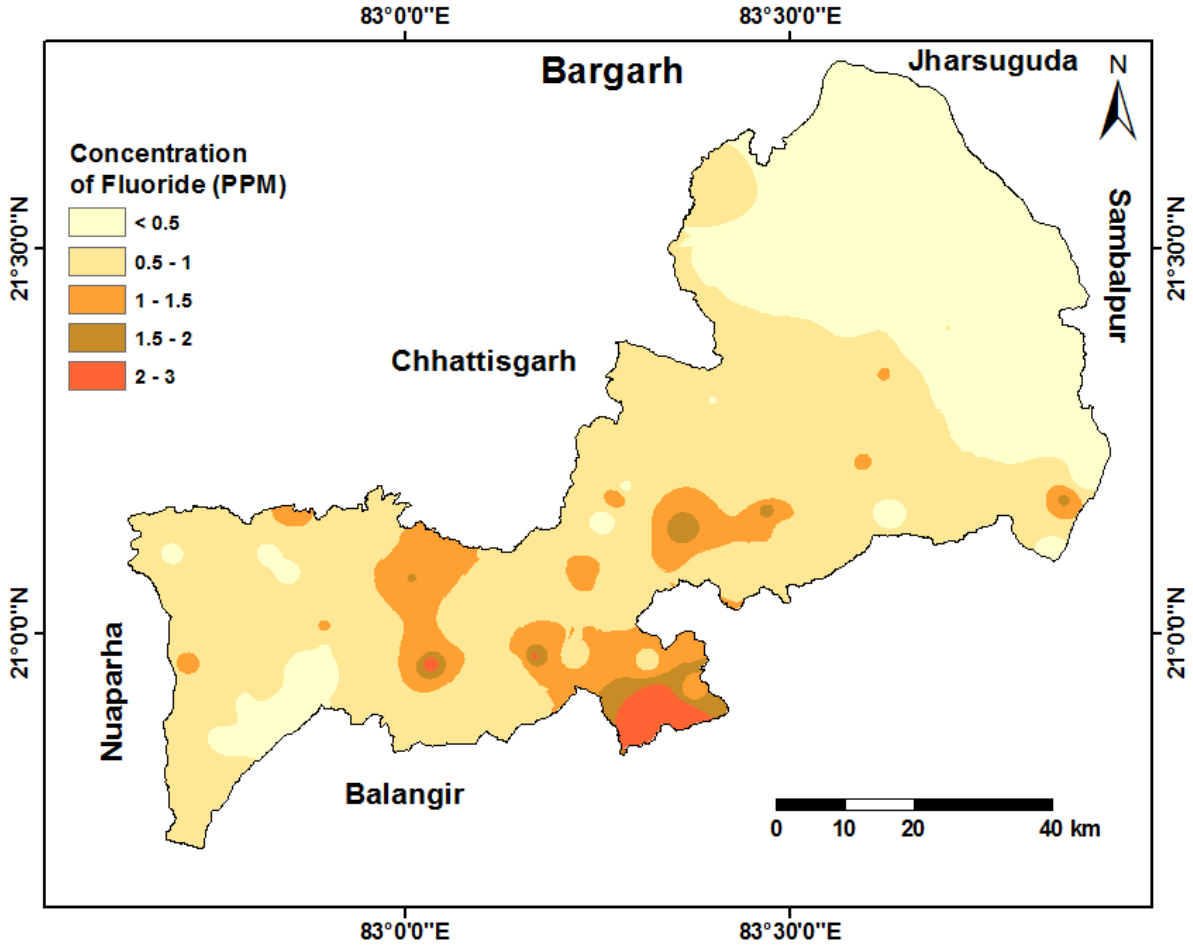

Fig. 3.6: Fluoride Map of Phreatic Aquifer.

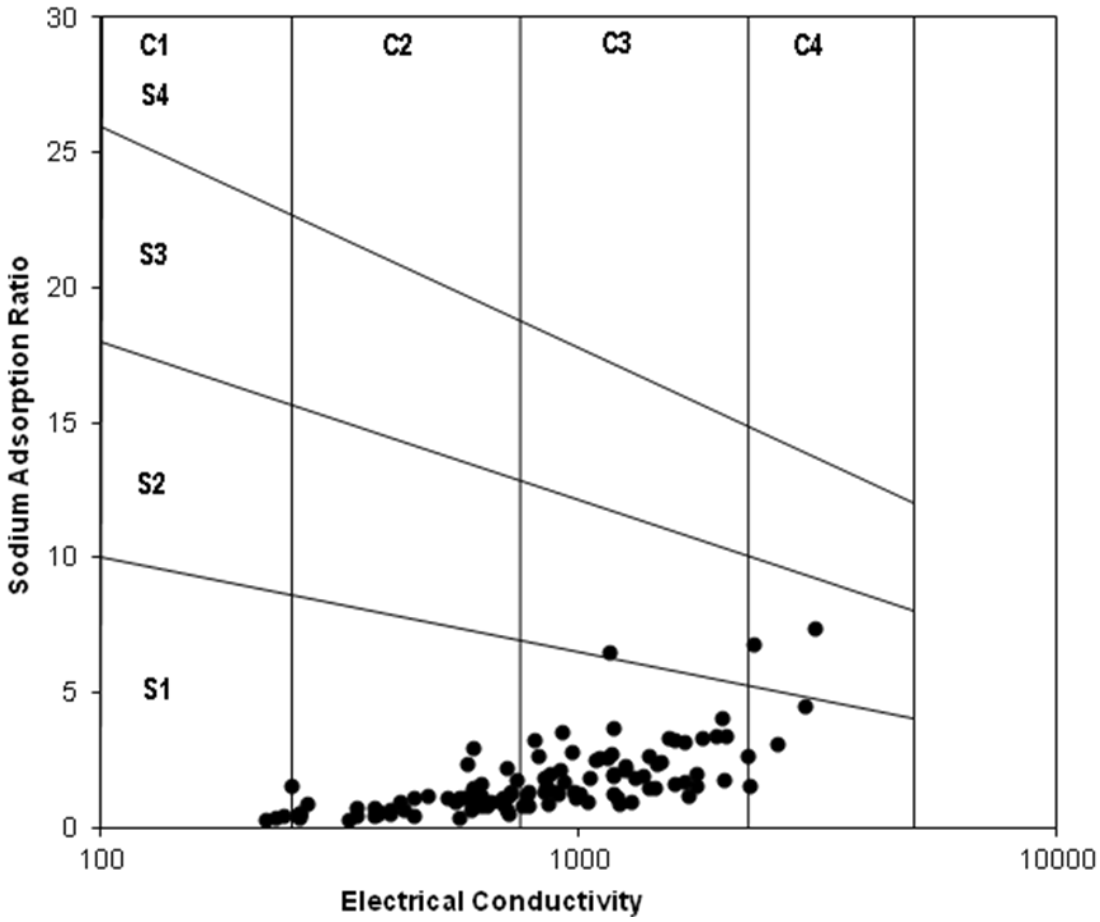

Fig. 3.7: US-Salinity Diagram, Phreatic Aquifer in Bargarh District.

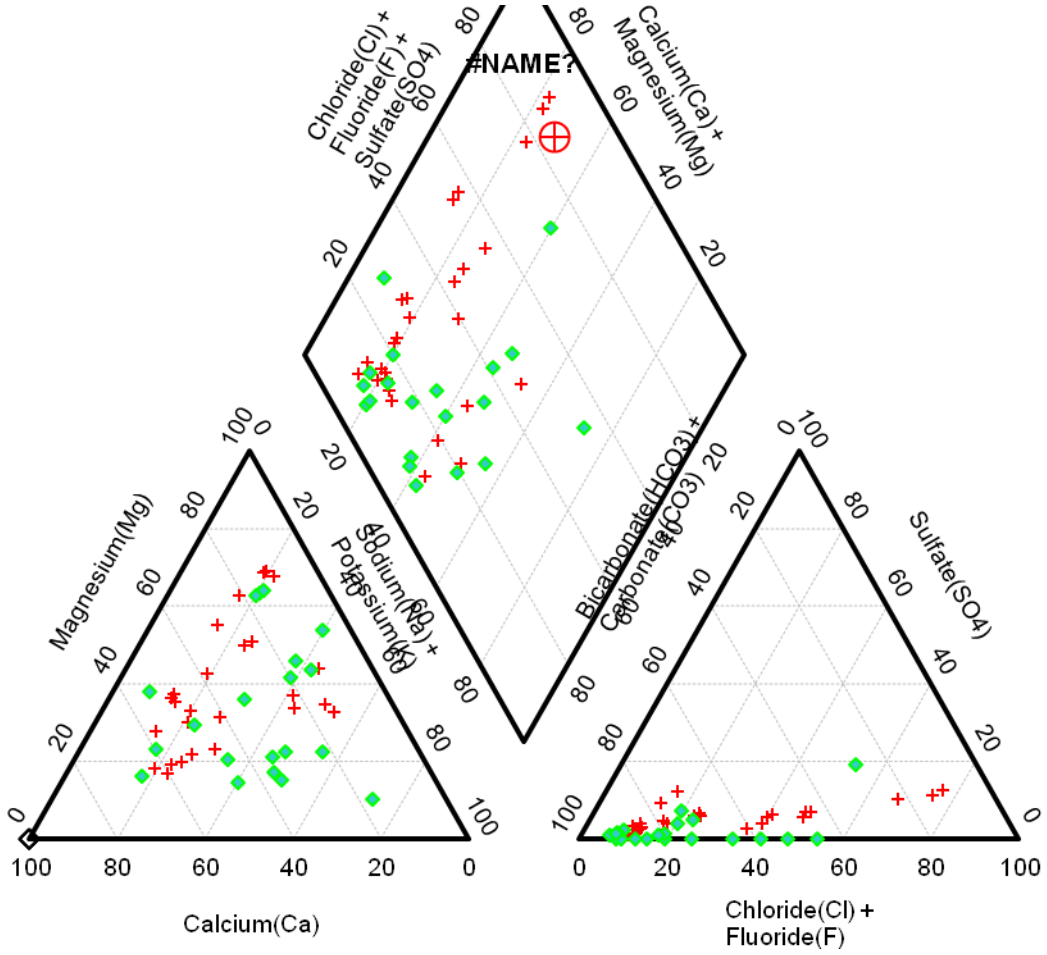

Fig. 3.8: Piper Diagram of Water Samples, Bargarh District

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 rocky outcrops, formed by the weathered mantle atop all crystalline as well as Gondwana formations and discontinuous alluvial

tracts along major river channels. This aquifer generally occurs down to maximum depth of 30m bgl. Based on field observations, isopach map of Aquifer–I is generated and shown in **Fig. 3.9.**

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. Aquifer-II in Granitic rocks has better yield in comparison to Gondwanas, Charnockites and Khondalites. In general, most of the fracture zones are encountered within 30 to 180 mbgl and seldom beyond that. Thus the maximum depth for the Aquifer-II has been taken as 200 mbgl.

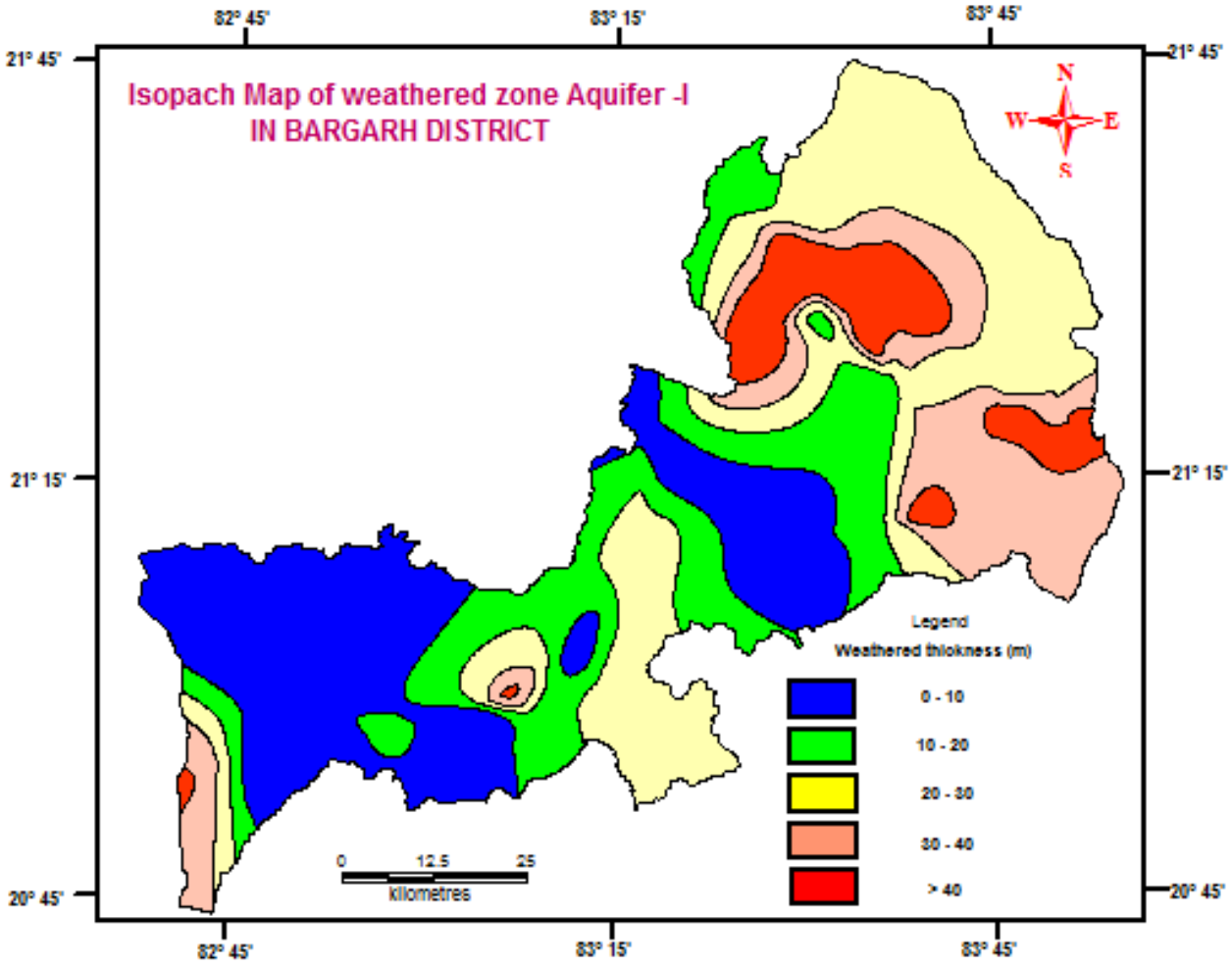

Fig. 3.9: Isopach of Weathered Zone (Aquifer-I) in Bargarh District.

The characteristics of the aquifer groups are summarized in **Table 3.4**.

Table 3.4: Characteristics of Aquifer Groups in Bargarh District.

Type of Aquifer Group	Formation	Depth range (mbgl)	Yield	Aquifer parameter	Suitability for drinking/ irrigation
Aquifer-I (Phreatic)	**Unconsolidated and Weathered** **Recent**: Soil,sand, Alluvium & Laterite **Pre-cambrian**: Granite Gneiss, Charnockite, Khondalite,	0-30	12-580 m^3/day	Specific Capacity Index: 0.5-10.26 lpm/m/m^2	Yes for both
Aquifer-II (Semi-confined to Confined)	**Fractured** Granite Gneiss, Charnockite, Khondalite, Gondwanas	30-200	Negl.-22 lps	Transmissivity: 1.66-217.72	Yes for both

3.5 Aquifer Disposition

The ground water exploration data has been used to generate the 3D disposition of the aquifer system. It comprises of all existing litho-units and the zones tapped during the ground water exploration, forming an aquifer. Five 2D schematic sections were drawn along lines A-B, C-D, E-F, G-H and I-J, which are shown in plan view in Fig.3.10 and the corresponding 2D schematic sections are shown in Fig. 3.11 ,3.12, 3.13,3.14 and 3.15. The 3D disposition of the aquifer system and Fence Diagram in Bargarh District are shown in Fig.3.16 and 3.17

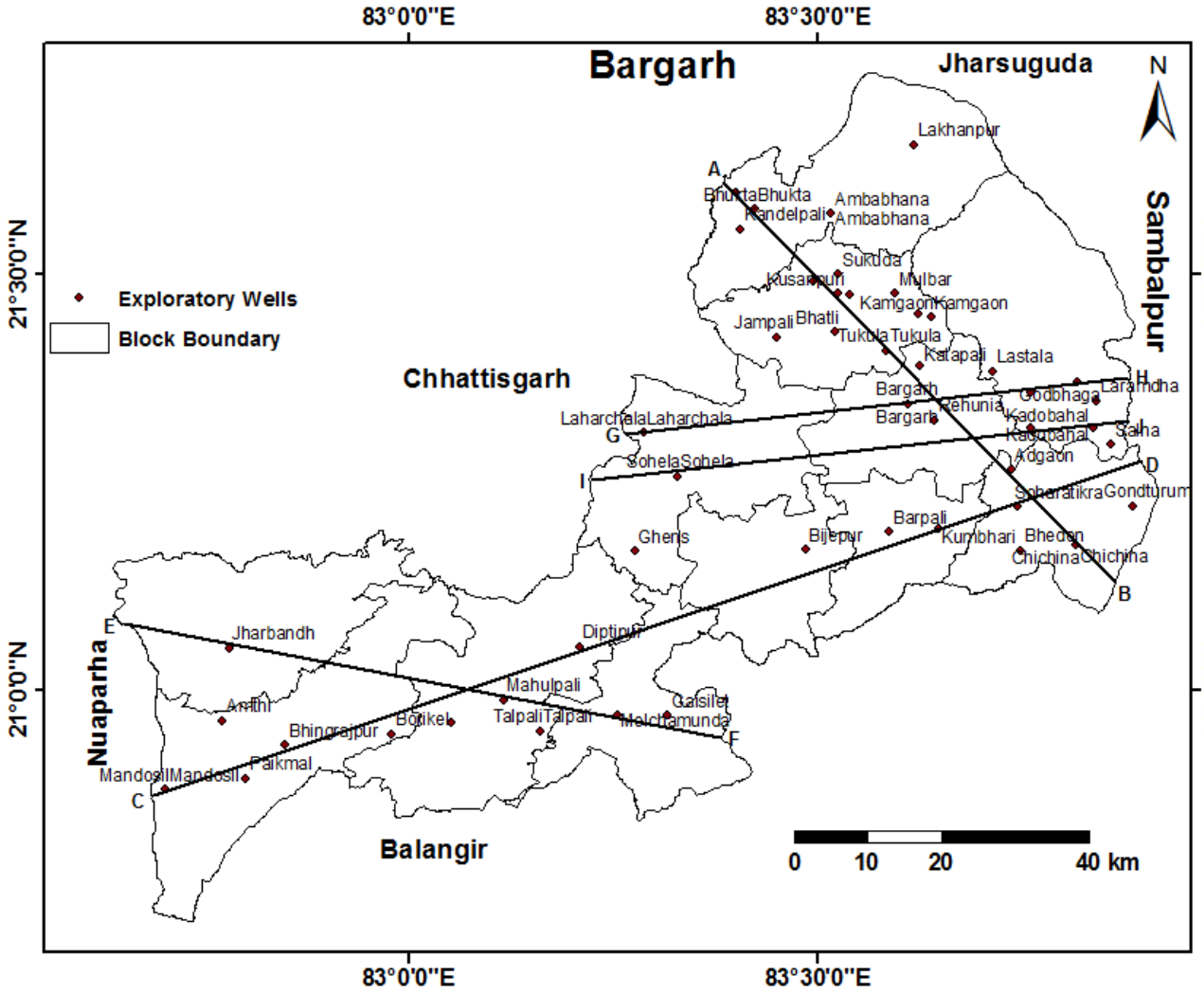

Fig. 3.10: Aquifer 2D Section Lines along A-B, C-D, E-F, G-H and I-J.

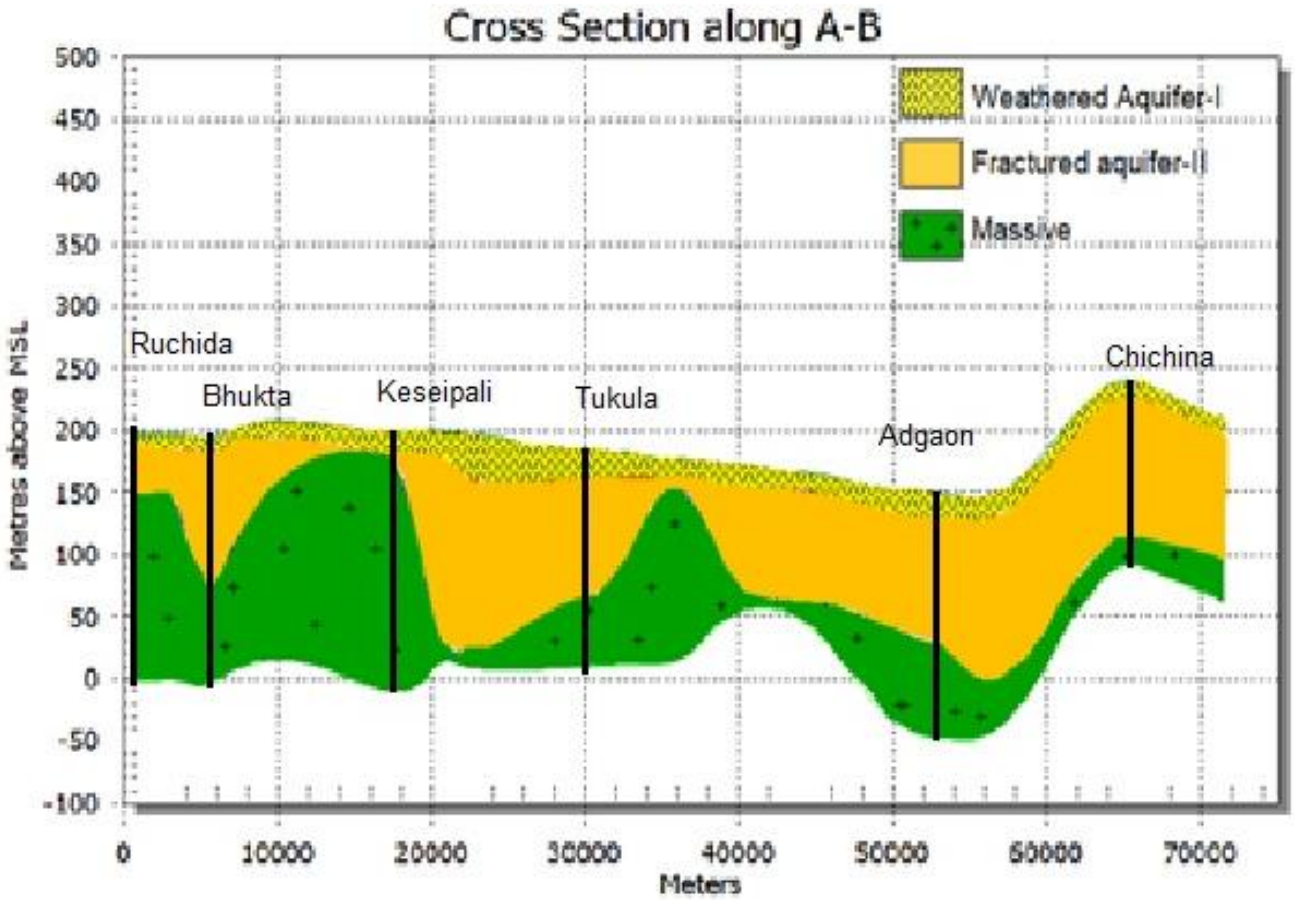

Fig. 3.11: Schematic Aquifer Cross-Section Along A-B in Bargarh District.

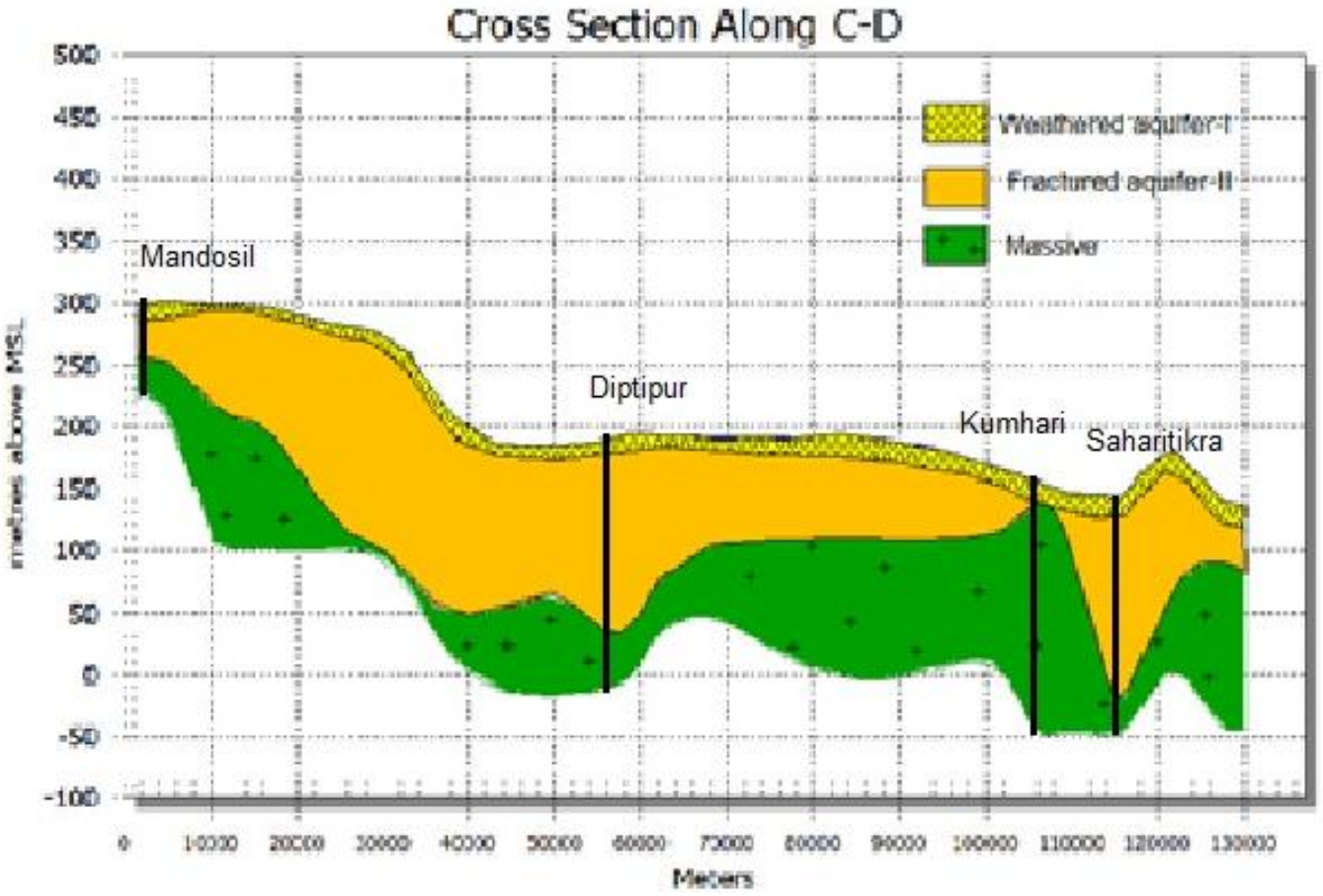

Fig. 3.12: Schematic Aquifer Cross-Section Along C-D in Bargarh District.

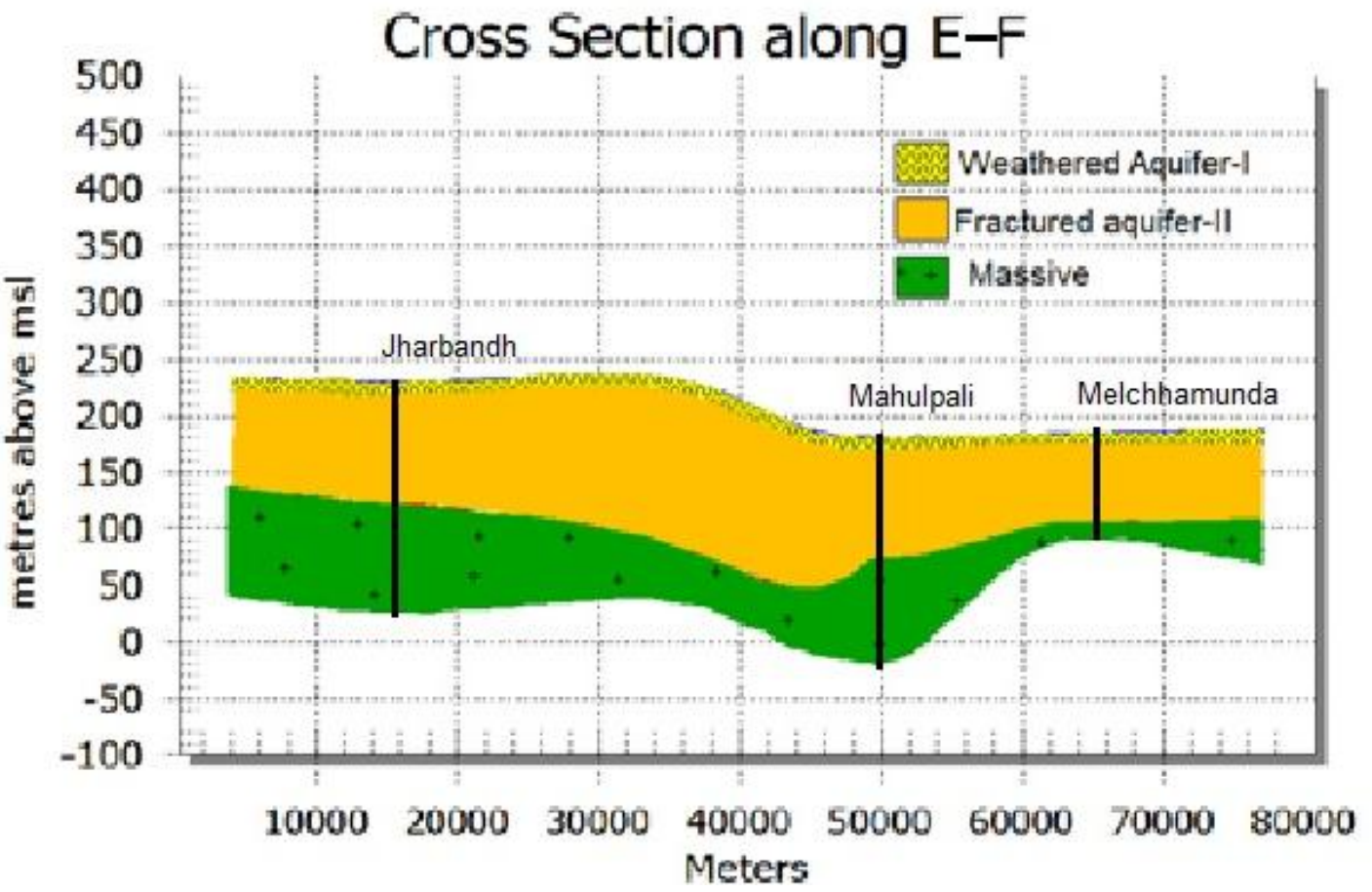

Fig. 3.13: Schematic Aquifer Cross-Section Along E-F in Bargarh District.

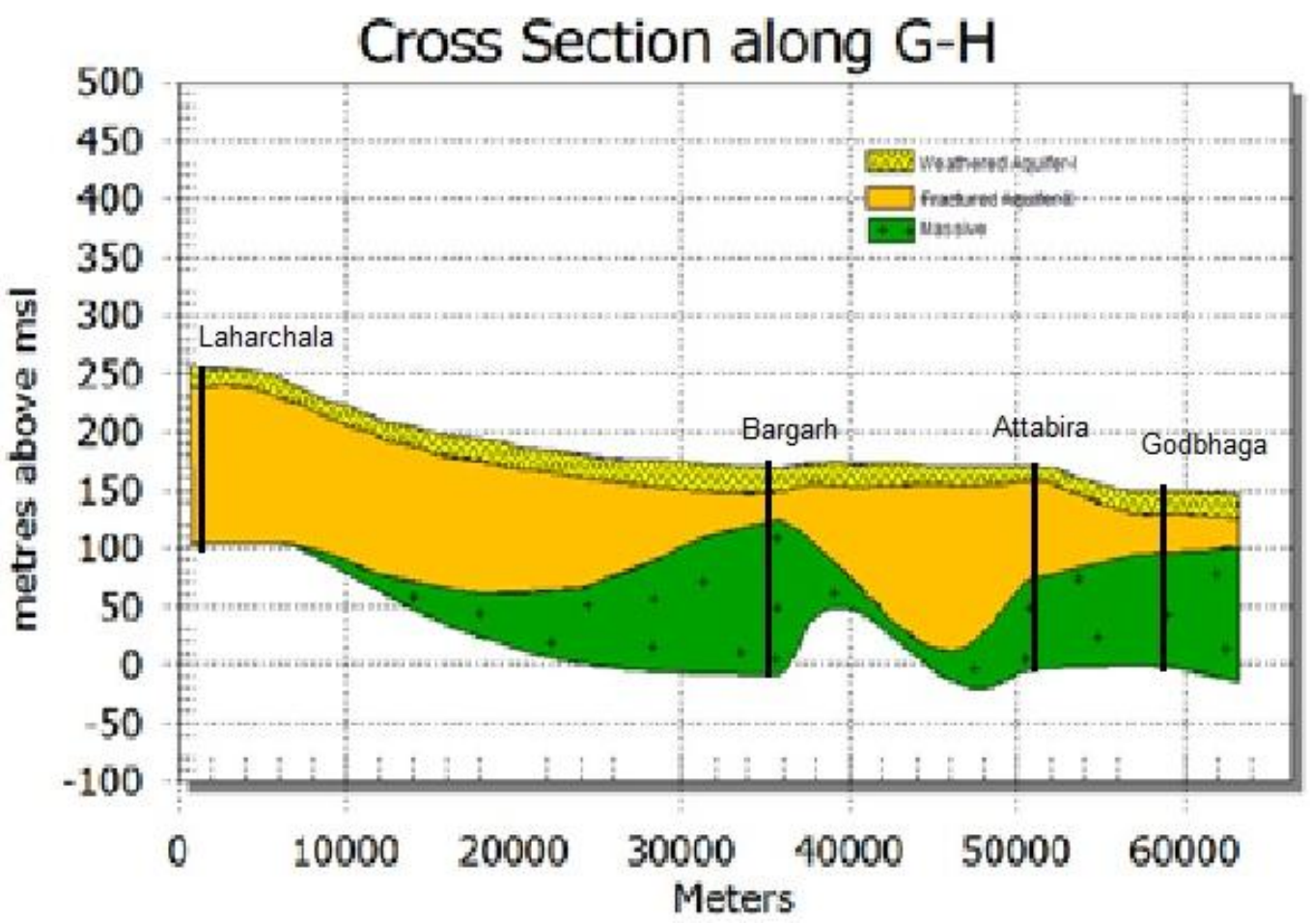

Fig. 3.14: Schematic Aquifer Cross-Section Along G-H in Bargarh District.

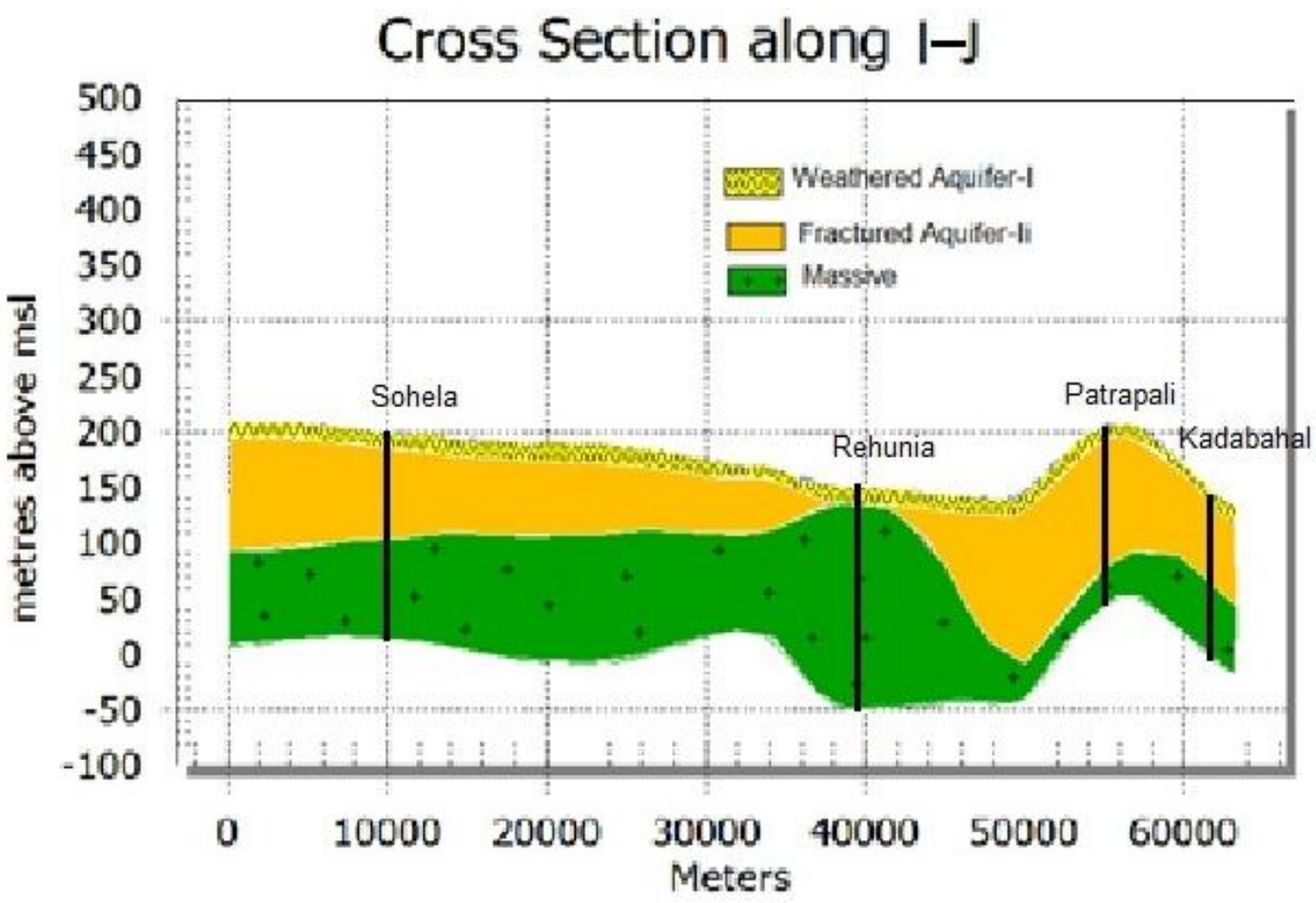

Fig. 3.15: Schematic Aquifer Cross-Section Along I-J in Bargarh District.

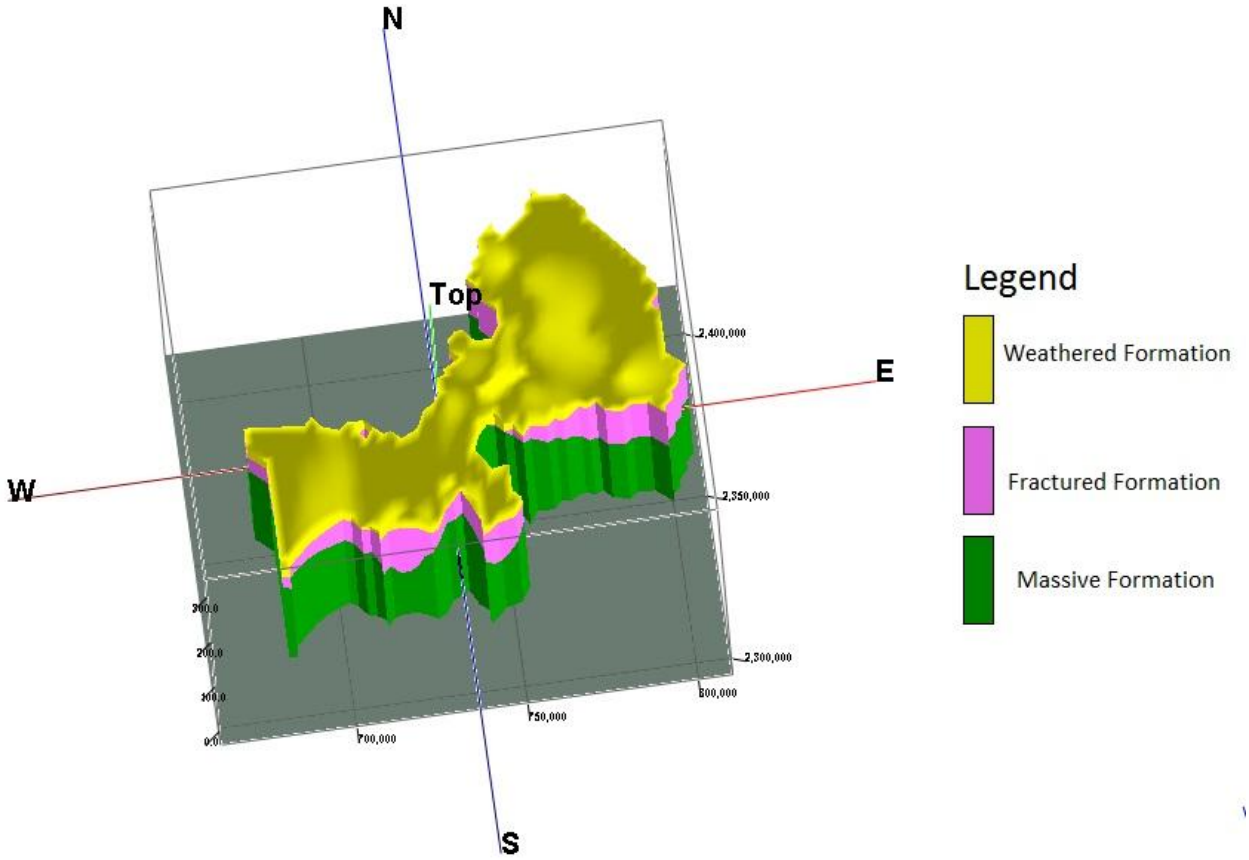

Fig. 3.16: 3D disposition of the aquifer system **in Bargarh District.**

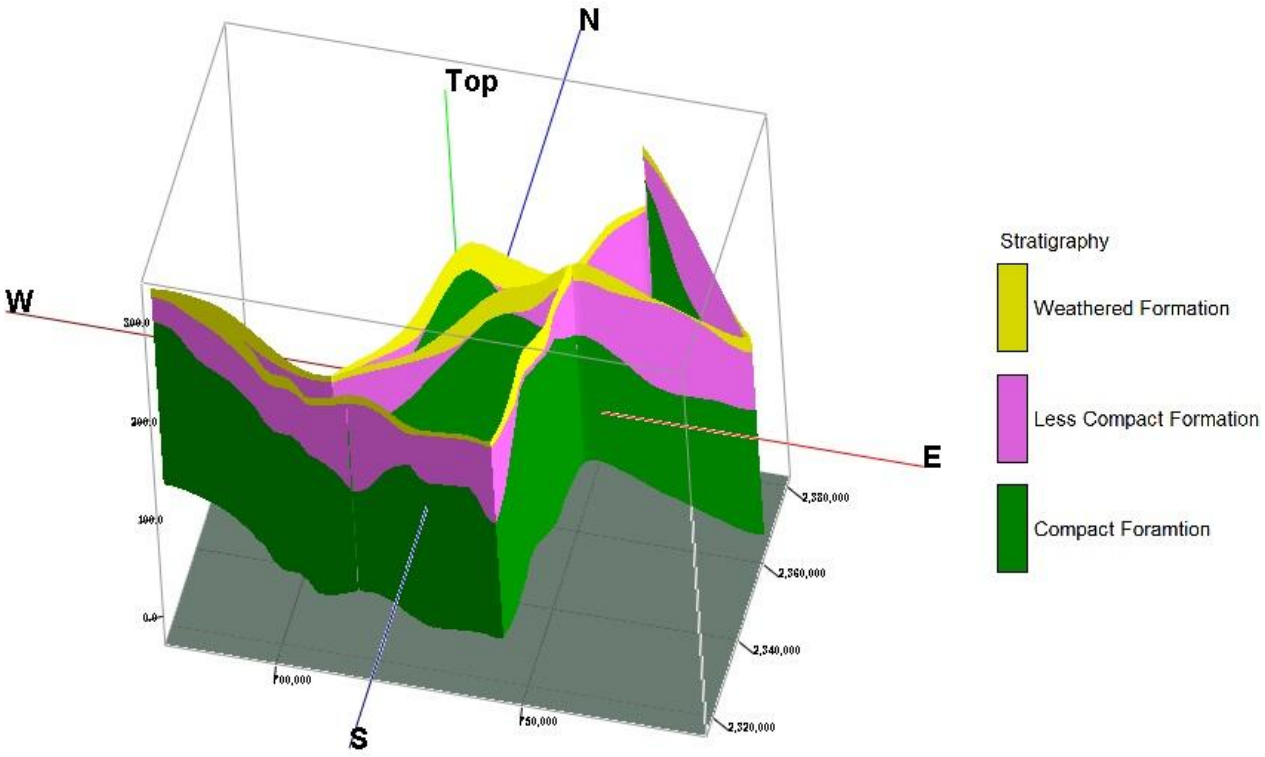

Fig. 3.17: Fence Diagram of EWs **in Bargarh District.**

4 GROUND WATER RESOURCES

The dynamic ground water resource of the district was jointly carried out in 2017 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 2017 is given below in **Table 4.1.**

Table 4.1: Dynamic Ground Water Resources of Aquifer-I in Bargarh District. (2017)

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 Development
		(Ham)	(Ham)	(Ham)	(Ham)	(Ham)	(Ham)	(%)
1	Ambabhona	5449.13	1569.93	173.26	1743.19	175.45	3701.9	31.99
2	Attabira	4358.62	761.34	472.22	1233.56	416.96	3115.36	28.3
3	Barpali	3872.91	1215.53	404.42	1619.95	409.06	2232.48	41.83
4	Bargarh	5291.43	2323.95	1019.18	3343.13	1074.82	1797.42	63.18
5	Bhatli	4988.85	3206.2	247.7	3453.9	246.42	1532.31	69.23
6	Bheden	3888.34	461.18	348.21	809.39	344.27	3066.89	20.82
7	Bijepur	4995.6	1811.57	314.98	2126.55	313.79	2854.24	42.57
8	Gaisilet	4106.19	1562.6	260.29	1822.89	294.17	2246.78	44.39
9	Jharbandha	4872.39	3030.06	223.74	3253.8	236.71	1595.06	66.78
10	Padampur	5801.73	2681.16	449.17	3310.33	474.61	2434.28	57.06
11	Paikamal	6939.87	2132.77	333.38	2466.15	371.94	4427.24	35.54
12	Sohela	7501.67	4293.03	413.33	4706.36	402.91	2775.57	62.74
	Total	**62066.73**	**4293.03**	**4659.88**	**29889.2**	**4761.11**	**31778.72**	**48.16**

The combined net ground water available is 31778.72 Ham and gross annual draft is 29889.2 Ham. The stage of ground water development is minimum for Bheden block which is 20.82 %. The highest ground water development is in Bhatli block that is 69.23 % 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 linkage 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 Bargarh District.

Sl No	Block	Assessment Area	Bottom Depth of Aquifer	Average Pre-monsoon Water Level	Total Effective Saturated Thickness 5% of (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	Ambabhona	50547	30.00	4.46	1.277	0.03	1936.456
2	Attabira	51476	30.00	8.24	1.088	0.03	1680.177
3	Barpali	27850	30.00	8.3	1.085	0.03	906.5175
4	Bargarh	37768	30.00	4.56	1.272	0.03	1441.227
5	Bhatli	38206	30.00	7.72	1.114	0.03	1276.845
6	Bheden	38927	30.00	6	1.2	0.03	1401.372
7	Bijepur	34220	30.00	7.24	1.138	0.03	1168.271
8	Gaisilet	38608	30.00	5.96	1.202	0.03	1392.204
9	Jharbandha	48769	30.00	8.46	1.077	0.02	1050.484
10	Padampur	52371	30.00	6.92	1.154	0.02	1208.723
11	Paikamal	54313	30.00	5.68	1.216	0.02	1320.892
12	Sohela	52122	30.00	5.66	1.217	0.03	1902.974
	Total	**525177**					**16686.1425**

Table 4.3: Total Ground Water Resources of Aquifer-I in Bargarh District. (2017)

Sl No	Block	Dynamic Resource	In Storage Resource	Total Ground Water
1	Ambabhona	5449.13	1936.456	7385.586
2	Attabira	4358.62	1680.177	6038.797
3	Barpali	3872.91	906.5175	4779.428
4	Bargarh	5291.43	1441.227	6732.657
5	Bhatli	4988.85	1276.845	6265.695
6	Bheden	3888.34	1401.372	5289.712
7	Bijepur	4995.6	1168.271	6163.871
8	Gaisilet	4106.19	1392.204	5498.394
9	Jharbandha	4872.39	1050.484	5922.874
10	Padampur	5801.73	1208.723	7010.453
11	Paikamal	6939.87	1320.892	8260.762
12	Sohela	7501.67	1902.974	9404.644
	Total	**62066.73**	**16686.1425**	78752.87

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 Bargarh District. (2017)

Sl No	Block	Assessment Area	Bottom Depth of Aquifer	Average Pre-monsoon Water Level	Total Effective Saturated Thickness 5% of (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	Ambabhona	50547	200.00	4.46	9.777	0.03	14825.94
2	Attabira	51476	200.00	8.24	9.588	0.03	14806.56
3	Barpali	27850	200.00	8.3	9.585	0.03	8008.268
4	Bargarh	37768	200.00	4.56	9.772	0.03	11072.07
5	Bhatli	38206	200.00	7.72	9.614	0.03	11019.37
6	Bheden	38927	200.00	6	9.7	0.03	11327.76
7	Bijepur	34220	200.00	7.24	9.638	0.03	9894.371
8	Gaisilet	38608	200.00	5.96	9.702	0.03	11237.24
9	Jharbandha	48769	200.00	8.46	9.577	0.02	9341.214
10	Padampur	52371	200.00	6.92	9.654	0.02	10111.79
11	Paikamal	54313	200.00	5.68	9.716	0.02	10554.1
12	Sohela	52122	200.00	5.66	9.717	0.03	15194.08
	Total	**525177**					**137392.763**

5 GROUND WATER RELATED ISSUES

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 Fluoride in Ground Water

Incidence of high concentration of fluoride in ground water of Bargarh district has been detected in the following areas as shown in Table 5.1 and depicted in **Fig. 3.6**

Table 5.1: Fluoride Point Sourced Villages in Bargarh District.

Sl No	Village	Source	Block	Longitude	Latitude	Fluoride
1	Burdapali	DW	Bijepur	83.4692	21.1594	1.76
2	Jagalpet	DW	Gaisilet	83.3514	20.8931	1.96
3	Rusuda	DW	Bheden	83.8555	21.1722	1.6
4	Badipali	DW	Bijepur	83.3597	21.1356	1.96
5	Dhumabhata	DW	Paikamal	83.0076	21.0712	1.53
6	Bejenmunda	DW	Padampur	83.0326	20.9593	2.34
7	Khairapali	DW	Padampur	83.1679	20.9692	2.08
8	Turcha	DW	Gaisilet	83.3101	20.8894	2.53
9	Kathaumal	BW	Gaisilet	83.3251	20.9151	2.5
10	Jagalpet	DW	Gaisilet	83.3515	20.8933	3.3
11	Kelendapali	EW	Bhatli	83.4934	21.4916	1.66
12	Keasipali	EW	Bhatli	83.5251	21.478	1.69
Note: DW- Dug Well, EW- CGWB Exploratory Well, BW- Bore Well						

Hydrochemically ground water in the area is of $Ca(HCO_3)_2$ type,$CaSO_4$ type , $NaHCO_3$ type and Mixed type. $Ca(HCO_3)_2$ type waters are mainly associated with DWs in granite gneiss and rarely in Charnockite. Fluoride in this type of ground water is generally low and less than 1 mg/L. Ground water in dugwells tapping weathered residuum with charnockite is generally of $NaHCO_3$ type which plays an important role in presence of high F^- in this type of water. The Mixed type water resemble both $Ca(HCO_3)_2$ type and $NaHCO_3$ type. The studies also reveal that the high bicarbonate concentrations are indicative of surface water recharge to the aquifers which while percolating down through the subsurface materials, extract F^- from the fluoride bearing minerals, exchange Ca^{++} with Na^+ ions and finally appear as $NaHCO_3$ type water with high fluoride content.

5.2 Under Utilisation of Ground Water Resources

As per the ground water resource estimated jointly by CGWB and State Govt. in 2017, all the Blocks in Bargarh District comes under safe category. Thus there is ample scope exists for further ground water development in Blocks like Ambabhona,Attabira,Barpali,Bheden,Bijepur Gaisilet,Padampur and Paikamal. The Stages of ground water development in these Blocks are 31.99, 28.3, 41.83, 20.82, 42.57, 44.39, 57.06, and 35.54 % respectively. There is scope for extraction of water available from the phreatic aquifer keeping the percentage of ground water development within 60%.

5.3 Water logging: Water logging conditions have developed in parts of Hirakud Command, in the eastern part of the area, where water table is within 2m from surface. Low topography, unlined canals indiscriminate use of canal water and the prevailing paddy cultivation in both Kharif and Rabi seasons are mainly responsible for excessive seepage of water and water table rise. Water logging condition is prevalent in Chaklifarm-Kumelsingha-Larambha-Kadobahal areas of Godbhaga block, Top, Babebira – Jafartikra of Attabira block, Lastala, Tora-Debgarh, Rengalipalli-Khuntapali-Kanbar areas of Bargarh block, Kumbhari-Kainsir areas of Barpali block and this depicts the response of water level to canal irrigation.

5.4 Ground Water Problem in Hilly Areas

Bargarh district receives adequate rainfall and the normal annual rainfall is 1304 mm. The northen eastern and south-western parts of the district are mainly of of hilly terrain and thus high run off zone. They act as recharge zones as well as good reservoir of ground water. Once they get saturated, during monsoon the excess water flows as run off and base flow. During the post-monsoon period, the thin weathered zones soon loose the entire storage water due to base flow. So there is scarcity of water in these areas in lean and summer season.

5.5 Depleted Water Level in Phreatic Aquifer

Ground water level in the phreatic aquifer is found to be deep in many parts of Bargarh district. The Depth to water level in pre-monsoon period (May 2019) varies from 5.7 mbgl (Dahita) to 12.8 mbgl (Chantipali). In the study area Depth to water level in post-monsoon period (Nov 2019) varies from 1.15 mbgl (Kathaumal) to 6.35 mbgl (Sanimal). The areas where post-monsoon water level varies from 4m to more than 6 m are are Bijepur,Gaisilet,Sohela,Padampur,Paikamal and Jharbandh blocks. The water level fluctuation varies from 0.4 mbgl (Sarkanda) to 6.90 mbgl (Jagdalpur).

6.0 MANAGEMENT STRATEGIES

6.1 Management Plan for Higher Concentration of Fluoride

Though there are fluoride in many of the villages as discussed earlier, they are mostly found in shallow aquifers (dugwells) and medium deep borewells mostly drilled by the state govt. agencies. The occurrence of fluoride are point specific and there are alternate sources available. Hence deeper aquifers form a better alternative source for the domestic use in this area.

6.2 Management Plan for Under-Utilisation of Ground Water

Demand and Supply Scenario: The water demand and supply scenario of the district is depicted in **Table 5.2** where the demand figures were projected for year 2020, 2025 and 2035 and the supply represents the existing water supply status.

Table 6.1: Water Demand and Supply Scenario in Bargarh District.

Block	Existing Water Availability (BCM)			Water Demand (BCM)			Remarks
	Surface Water	Ground Water	Total	Projected (2020)	Projected (2025)	Projected (2035)	
Bargarh	0.15	0.03813	0.19	0.225481	0.227262	0.228653	
Barpali	0.11	0.03307	0.14	0.184825	0.186275	0.477035	
Bheden	0.15	0.03309	0.18	0.342694	0.344315	0.345626	
Bhatli	0.18	0.03776	0.22	0.111648	0.113599	0.115097	
Attabira	0.25	0.0285	0.27	0.27124	0.27214	0.27315	
Ambabhona	0.22	0.01832	0.24	0.026633	0.027848	0.028882	
Sohela	0.23	0.05806	0.29	0.071406	0.073584	0.075392	
Bijepur	0.13	0.03505	0.16	0.054485	0.056124	0.057508	
Gaisilet	0.15	0.03228	0.18	0.053942	0.05548	0.056695	
Padampur	0.23	0.0495	0.28	0.054454	0.056214	0.057631	
Paikamal	0.28	0.05857	0.33	0.077144	0.079334	0.081058	
Jharbandha	0.21	0.03821	0.24	0.071106	0.072908	0.0744	Adequate water is available for meeting the projected demand for all Blocks
Bargarh District	2.27	0.46	2.73	1.55	1.57	1.87	

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

Proposed Interventions: There is very little scope for the demand side interventions as the district experiences acute shortage of water during the lean seasons. However to meet the irrigation requirement in relatively water deficient areas, efficient irrigation techniques such as drip and sprinkler should be practised. No other demand side intervention is feasible.

For the supply side intervention, further development of ground water resource is possible as there is sufficient scope for this is available in the district as the present ground water development ranges from 20.82 % to 69.23 % in the district. 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 5.3**.

Table 6.2: Ground Water Development Potential of Bargarh District.

Block	Net Ground Water Availability (Ham)	Stage of Ground Water Development (% in 2017)	Present Ground Water Draft (Ham)	Ground Water draft at 60% Stage of development (Ham) (1)*0.6	Surplus Ground Water at Present Stage of development (Ham) (4)-(3)	Number of BW/ STW Recommended in Each block (assuming unit draft as 2.21 ham per structure per year) 50%	Number of DW Recommended in Each block(assuming unit draft as 0.26 ham per structure per year) 50%
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Ambabhona	5449.13	31.99	1743.19	3269.478	1526.288	345	1328
Attabira	4358.62	28.3	1233.56	2615.172	1381.612	312	1202
Barpali	3872.91	41.83	1619.95	2323.746	703.796	159	612
Bheden	3888.34	20.82	809.39	2333.004	1523.614	345	1326
Bijepur	4995.6	42.57	2126.55	2997.36	870.81	197	758
Gaisilet	4106.19	44.39	1822.89	2463.714	640.824	145	558
Padampur	5801.73	57.06	3310.33	3481.038	170.708	38	148
Paikamal	4427.24	35.54	2466.15	2656.344	190.194	43	165

Structures Feasible: The feasible ground water structures and probable yield in different geological units in Bargarh district is given below:

Granite and Granite Gneiss: Ground water occurs in weathered horizon in unconfined condition, yield of dug well upto 50 m3/day; Deeper fracture zones - yield of bore wells within 2.0 lps, occasionally upto 5 lps.

Charnockites: Ground water in weathered zone in unconfined condition, yield of dug wells upto 30 m^3/day; Deeper fracture zones- yield of bore wells less than 1 lps

Khondalites: Ground water in weathered zone in unconfined condition, yield of dug wells upto 50 m^3/day; Deeper fracture zones- yield of bore wells less than 1 lps

Lower Gondwana: The semi-consolidated sandstones are friable and exhibit well developed bedding planes and open joints. The yield potentials of dugwells up to 20 m^3/day. Shallow tube wells yield less than 1 lps.

6.3 Management Plan for water logging Areas

Water logging conditions have developed in parts of Hirakud Command, in the eastern part of the area, where water table is within 2m from surface. The problem of water logging needs to be rectified through

conjunctive use of surface water and Ground water. The demand of water for 200% cropping intensity can be made from surface water 90% and ground water 10% for both the seasons. The existing cropping pattern needs modification. Diversification of crops from paddy to non paddy crops like oil seed, pulses, vegetables during rabi season at least in the high land and part of medium land areas is essential. The conjunctive use of surface water and ground water is necessary to rectify water logging and to augment irrigation potentials and to ensure agriculture in period of delayed rainfall. In Hirakud command area, development of ground water is feasible through dug wells and bore wells. Dug well is the most suitable ground water structures in the area.

6.4 Management Plan for Scarcity of Water in Hilly Areas

Due to uneven and hilly terrain and lower ground water recharge and storage capacity, there are many areas where the phreatic aquifer quickly desaturates causing water scarcity during non-monsoon periods. To enhance the ground water availability, suitable measures for augmentation of monsoon recharge, should be taken up. In the foot hill regions, contour trenching alongwith gabian structures should be constructed to arrest the surface runoff and improve rainfall recharge.

6.5 Management Plan for Depleted Water Level in Phreatic Aquifer

The areas where post-monsoon water level varies from 4m to more than 6 m are are Bijepur, Gaisilet, Sohela, Padampur, Paikamal and Jharbandh blocks. These areas are suitable for artificial recharge.

The problem of water level depletion in the phreatic aquifers can be addressed through artificial recharge and through various water conservation structures. Construction of 25 percolation tanks and 34 check dams has been proposed in these areas for artificial recharge.

In these areas surface spreading techniques will be useful. Similarly 2^{nd} and 3^{rd} order drainages are suitable for the construction of check dams. For the mitigation of deeper water level areas in the district, the following measures can be taken up:

1. Contour trenching, staggered trenching and gully plugging in foot-hill areas.

2. Construction of farm ponds and renovation of existing water bodies.

3. Construction of 25 percolation tanks, 34 check dams can be done.

The proposed sites for these structures are shown in Fig. 5.1.

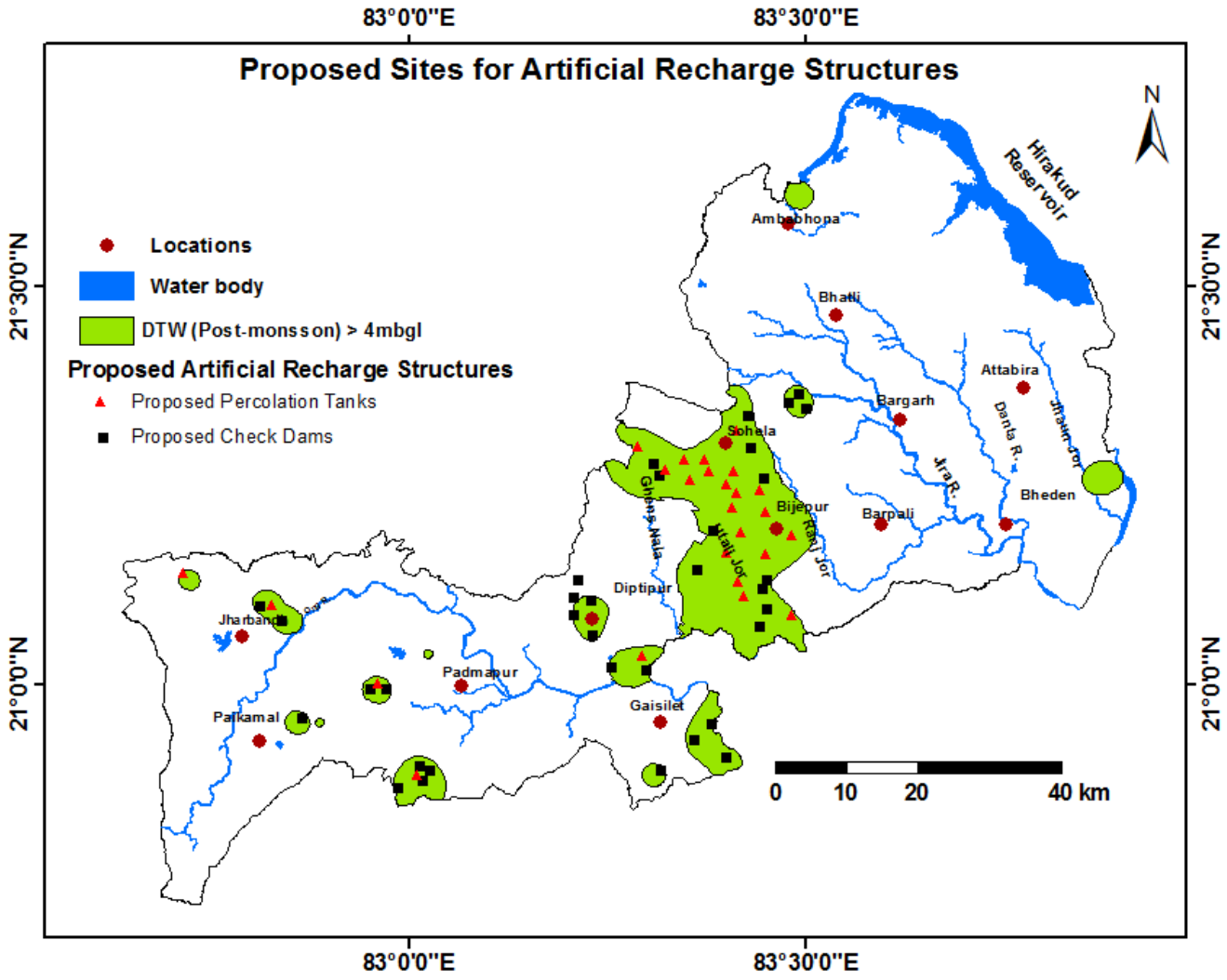

Fig. 6.1. Proposed sites for Artificial Recharge Structures in Bargarh District.

6.6 Organising Out-reach and Public interaction programmes (PIPs)

To create awareness among local public, farmers and various stake holders of Ground water CGWB has organized various PIPs and mass awareness programmes in the state of Odisha .In this context four public interaction programmes has been organized in Bargarh,Bhatli and Sohela blocks of Bargarh District to discuss about local issues, sustainable Ground water development and management ,water conservation, Rain water Harvesting and Artificial Recharge techniques . One outreach programme has been organized in Bhatli boys high school to teach students regarding Water conservation, Rain water Harvesting and Artificial Recharge.

7 SUMMARY AND RECOMMENDATIONS

7.1 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 Bargarh, covering twelve blocks namely Ambabhona, Attabira, Bargarh, Barpali, Bhatli, Bheden, Bijepur, Gaisilet, Jharbandh, Padampur, Paikmal and Sohela covering an area of 4637 sq. km., during the period 2019-2020. The following are the summarised details.

1 The district is bounded by 82°39'00" E and 83°55'00" E longitudes and 20°43'00" N and 21°49'00" N latitudes covering 5837 sq. Km. under the SOI Degree sheets No 64 K ,L, O and P . The mappable area under NAQUIM is 5837 sq. Km, The mappable area under NAQUIM is 4637 sq. Km. This study area was taken up after excluding the hilly areas.

2 The average annual rainfall for 10 yrs(2010 – 2019)is 1679mm. it was observed that during the last 10 years, from 2010 to 2019, the highest rainfall amounting 2185 mm occurred in Paikmal block in 2012 and the lowest annual of 526.0 mm. in Bhatli block in 2015.

3 The forest area is 12.33% of total geographical area of 5837 km^2. The net area sown is 86.10% with cropping intensity of 133.0 %.

4 Two types of soil are found in the district viz. Ultisols and Alfisols.

5 The total cropped area is 354051 Ha out of which 51% (181896 Ha) is irrigated and rest 49% area are rainfed.

6 Bargarh district is distinct in odisha because of some blocks having net irrigated area more than 60% and some block with less than less than 35%. Few blocks like Bargah, Bheden, Barapali being covered with Hirakud major irrigation project has higher percentage coverage on irrigation. Major irrigation system is mainly by means of canal based irrigation. MI div. has so far constructed 600 check dam spreaded over entire district. Lift irrigation div., provides irrigation facilities by means of community RL project, Shallow T/W and energized bore well system. Presently lift irrigation have 625 nos. operable RL project covering 12736 ha. command area and 4800 energised bore well covering 28898 ha. command area.

7 The district is underlain by Granite-gneiss and its variants,Raipur Group of rocks and a small patch of Lower Gondwana formations, Alluvium and laterites.

8 The crystalline formations like Granite Gneiss, Khondalite and metabasics like shale are classified under Consolidated water bearing formations. The weathered residum of these rocks form the main repositories of ground water, which occurs under water table conditions and circulates through deeper fractures and fissures. Ground water occurs under confined to semi-confined condition in the deeper fractured zones. The Gondwana, sandstone and shale constitute the Semi-consolidated water bearing formations Groundwater occurs under water table condition in the shallow aquifers and in semi confined to confined condition in deeper aquifer. The alluvium deposits,silt,sand and gravels are classified under Unconsolidated formations.

9 CGWB has constructed 48 EWs and 13 OWs during the ground water exploration programme. For the monitoring of ground water level and quality CGWB has established 56 National Hydrograph Network Stations in the district.

10 The Depth to water level in pre-monsoon period (May 2019) varies from 1.37 mbgl (Gondturum) to 11.0 mbgl (Chantipali) the average being 5.8mbgl. Depth to water level in post-monsoon period (Nov 2019) varies from 1.15 mbgl (Kathaumal) to 7.20 mbgl (Kasdol) the average being 3.13 mbgl. The water level flctuation varies from 0.01 mbgl (Kadobahal) to 6.90 mbgl (Jagdalpur) the average being 2.67 mbgl. The long term trend analysis indicates that out of 56 stations, 24(42.85%) show falling trend and 9 stations (16.07%) show rising trend in both the seasons.

11 The chemical quality of ground water both from shallow and deeper aquifers are good and can be suitably utilised for all purposes. Fluoride contamination has been detected in isolated patches of Bijepur ,Gaisilet, Bheden, Paikmal,Padampur and Bhatli Blocks of the District.The higher fluoride concentration is restricted to shallow aquifers tapped by dugwells and shallow bore/tubewells. Deeper aquifer can provide alternative fluoride free sources of water.

12 The estimated dynamic ground water resource is 62066.73 Ham and the stages of development of ground water range from 20.82 to 69.23 %.The ground water development is most in the Bhatli block.

7.2 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 As there is large scope for development of ground water, suitable schemes may be launched for development to boost agricultural production in the district. The financial institutions should generously finance such schemes.

2 In water logged areas like Hirakud command areas conjunctive use of surface and ground water should be done. . Diversification of crops from paddy to non paddy crops like oil seed, pulses and vegetables during rabi season at least in the high land and part of medium land areas is essential.

3 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.

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

5 The occurrence of fluoride are point specific and there are alternate sources available. Deeper aquifers form a better alternative source for the domestic use in this area.

6 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

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

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

9 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.

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

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