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Ministry of Jal Shakti

Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

JAJPUR DISTRICT, ODISHA

दक्षिण पूर्वी क्षेत्र, भुवनेश्वर

South Eastern Region, Bhubaneswar

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1 INTRODUCTION

1.1 Objective

Central Ground Water Board (CGWB) has taken up National Aquifer Mappingand Management (NAQUIM) programme during the 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 the coastal alluvial tract of Jajpur district in Odisha covering full or part of eight blocks of the district namely, Badachana, Bari, Binjharpur, Dasrathpur, Dharmasala, Jajpur, Korei and Rasulpur.

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 300 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.

1.3.1 Compilation of Existing Data and Identification of Data Gaps: Preliminary work will consist of the collection and review of all existing data which relate to the area. This usually included the results of 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.

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 will be established and monitoring will 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 will be carried out for prepare maps.

1.3.3 Geo -hydrochemical Investigations: Water Samples will 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 characteristicsare essential for their effective management and sustainable development. Local ground water related issues should be identified and studied in detail to make plans to solve them.

1.4 Study area

During XII five year plan, the National Aquifer Mapping and Management (NAQUIM) programme were taken up under Annual Action Plan (AAP) 2016-17 for detailed hydrogeological investigation, data-gap analysis and Aquifer Mapping in the coastal alluvial area covered in eight blocks of Jajpur district. The study area is bounded by 85°57'07" E and 86°37'35" E longitudes and 20°34'41" N and 21°04'32" N latitudes covering 1934 sq. Km under the SOI Sheet Numbers 73G, 73H, 73K and 73L. The index map of the study area is presented in **Fig.1.1** while an administrative map is presented as **Fig. 1.2.**The area is well connected to road and rail network. The National Highway No. 16 and the East-Coast railway line connecting Kolkata to Chennaipasses through the area.The district comprises of 10 CD Blocks/Tahasils with the district headquarter at Jajpur. Jajpur town and Vyasanagar (Jajpur Road) are the two Municipality towns along with other small urban agglomerates like Singhpur, Kuakhia, Panikoili, Mangalpur and Binjharpur. The demographic details of the NAQUIM blocks is shown in **Table-1.1**.

1.5 Data Adequacy and Data Gap Analysis:

The available data of the Exploratory wells drilled by Central Ground Water Board, Southeastern Region, Bhubaneswar, Geophysical Survey carried out in the area, Ground water monitoring stations and ground water quality stations monitored by Central Ground Water Board were compiled and analysed for adequacy of the same for the aquifer mapping studies. The data adequacy and data gap analysis was carried out for each of the quadrant of falling in the study area mainly in respect of following primary and essential data requirements: **Exploratory Wells** **GeophysicalSurveys** **Ground Water Monitoring** **Ground Water Quality**

After taking into consideration, the available data of Ground Water Exploration, Geophysical survey, GroundWater Monitoring and Ground Water Quality, the data adequacy and datagap analysis was carried out initially for five blocks the details of which are given in **Table-1.2**.

1.5.1 Exploratory Wells

The information in respect of un-confined/Phreatic aquifer has been generated from the dug wells present in the area. Data from CGWB Exploratory wells (EW), Observation Wells (OW) and Piezometers are necessary for establishing aquifer geometry and determining aquifer parameters.CGWB during its explration programme had constructed 8 DW, 16 EW, 2 OW, 3 PZ and 2 Slimholes previously in this area.

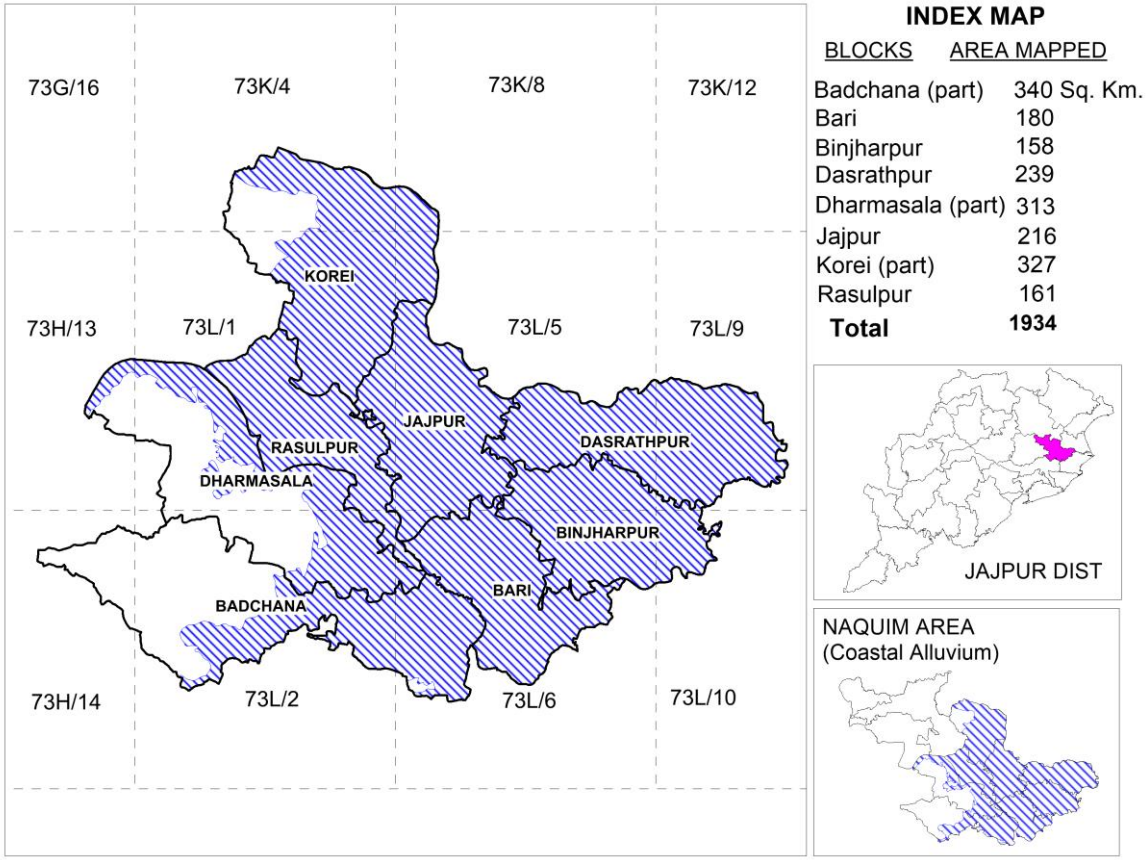

Fig. 1.1: Index Map of Study Area under NAQUIM in Jajpur District

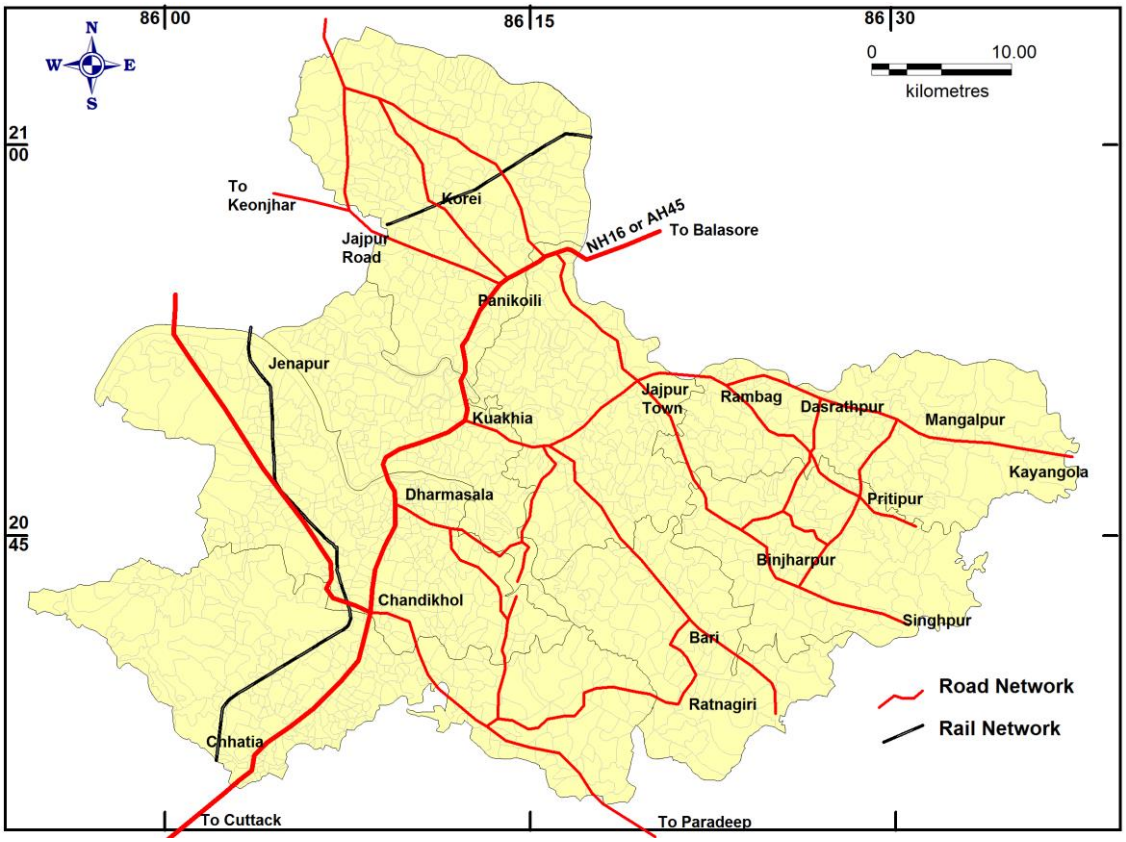

Fig. 1.2: Administrative Map of Study Area in Jajpur District

Table-1.1: Demographic Details of Blocks under NAQUIMinJajpur District.

Sl No	Block	GPs	Villages	Towns	Population (2011)			Sex Ratio	Decadal growth rate			Projected population as on 2025		
					Rural	Urban	Total		Rural	Urban	Total	Rural	Urban	Total
1	Badachana	37	260		234541		234541	959	13.78		13.78	279800	0	279800
2	Bari	29	109		152239		152239	1002	8.56		8.56	170475	0	170475
3	Binjharpur	26	113	1 (Sayedpur)	159699	8798	168497	1017	2.86		8.52	166084	9848	175932
4	Dasarathpur	28	156		195414		195414	1011	7.54		7.54	216051	0	216051
5	Dharmasala	39	316	1 (Kabatabandha)	212357	10641	222998	965	8.60		14.04	237917	12732	250649
6	Jajpur	24	190	1 (Jajpur Town)	168063	37458	205521	955	9.79	16.19	10.91	191106	45947	237053
7	Rasulpur	28	172	1 (Brahmabarada)	162138	10721	172859	959	4.91		11.85	173286	12499	185785
8	Korei	22	229	1 (Vyasanagar)	156437	56946	213383	962	12.95	39.78	19.05	184794	88657	273451
Total		**233**	**1545**	**5**	**1440888**	**115766**	**1565452**	**870**	**8.62**	**26.37**	**11.78**	**1619513**	**169683**	**1789196**

Table-1.2: Data Gap Analysis for Aquifer Mapping in Parts of Jajpur District.

Block with area in sq. km	No. of Additional EW required					No. of Additional VES/TEM required	Nos of Additional water level monitoring stations required						Nos of additional water quality stations required						Remarks
	Total Reqd.	Present Status	Aq-I	Aq-II	Aq-III	Total Reqd	Total Reqd	Present Status	Phreatic	Aq-I	Aq-II	Aq-III	Total Reqd	Present Status	Phreatic	Aq -I	Aq- II	Aq-III	
Bari	2	Total= 0 Aq-I= Aq-II= Aq-III= Aq (cum)= T (value)=	1	1	1	7	7	Total= 0 DW= Pz (Aq-I)= Pz (Aq-II)= Pz (Aq-III)= Pz (cum)=	4	1	1	1	7	Total= 0 DW= Aq-I= Aq-II= Aq-III= Aq(cum)=	4	1	1	1	

Binjharpur	3	Total= 2 Aq-I= 1 Aq-II= Aq-III= Aq (cum)= 1 T (value)= 1		1	1	9	9	Total= 1 DW= 1 Pz (Aq-I)= Pz (Aq-II)= Pz (Aq-III)= Pz (cum)=			1	1	9	Total= 3 DW= 1 Aq-I= 1 Aq-II= Aq-III= Aq(cum)= 1	4		1	1	
Dasarathpur	3	Total= 5 Aq-I= Aq-II= 2 Aq-III= Aq (cum)= 3 T (value)= 3	1		1	10	10	Total= 1 DW= 1 Pz (Aq-I)= Pz (Aq-II)= Pz (Aq-III)= Pz (cum)=	8	1		1	10	Total= 6 DW= 1 Aq-I= Aq-II= 2 Aq-III= Aq(cum)= 3	2	1		1	
Jajpur	3	Total= 4 Aq-I= 1 Aq-II= Aq-III= Aq (cum)= 3 T (value)= 3		1	1	10	10	Total= 2 DW= 2 Pz (Aq-I)= Pz (Aq-II)= Pz (Aq-III)= Pz (cum)=	6		1	1	10	Total= 6 DW= 2 Aq-I= 1 Aq-II= Aq-III= Aq(cum)= 3	2		1	1	
Rasulpur	2	Total= 1 Aq-I= Aq-II= Aq-III= Aq (cum)= 1 T (value)= 1	1	1	1	6	6	Total= 1 DW= 1 Pz (Aq-I)= Pz (Aq-II)= Pz (Aq-III)= Pz (cum)=	3	1	1	1	6	Total= 2 DW= 1 Aq-I= Aq-II= Aq-III= Aq(cum)= 1	1	1	1	1	
Total Additional no. Required		12	3	4	5	42		29	21	3	4	5		25	13	3	4	5	

N.B.: **Aq-I**: 75 m depth **Aq-II**:- 150 m depth **Aq-III**: up to 300 m depth, T(value)= No of wells having T value

1.5.2 Geophysical Surveys

Ground water geophysical survey data (VES) is required for filling gaps while establishing aquifer geometry. However no geophysical survey has been carried out in the area.

1.5.3 Ground Water Monitoring

For ground water regime monitoring, open/dugwells were considered for phreatic aquifer and piezometers for monitoring deeper aquifers.CGWB has 7 no of National Hydrograph Network Stations (NHNS) in the area for monitoring the ground water regime in the phreatic aquifer. The frequency of monitoring is four times annually during the months of May, Aug., Nov. & Jan.

1.5.4 Ground Water Quality

For the assessment of ground water quality, the existing water quality data includes quality data from hydrograph network stations and quality data from ground water exploration.

1.6 Rainfall and Climate

The district enjoys a humid sub-tropical climatic condition characterized by three distinct seasons viz. summer, rainy and winter. The maximum temperature rises to 46°C in summer and falls to a minimum of 14°C during Winter. The industrial belt of Kalinga Nagar area towards west experiences hotter condition compared to the irrigated and cultivated tract on-the south-east part of the district. The relative humidity is high and varies between 40 to 90% during the year. Humidity is very high during monsoon season. The potential evapotranspiration ranges from a low of 50mm in January to as high as 275mm in May.

The South-west monsoon is the principal source of rainfall in the area. The normal rainfall of the district is 1610.2 mm out of which monsoon rainfall is 1207.6 mm and non-monsoon rainfall is 402.6 mm. About 87% of the annual rainfall occurs during monsoon period between June to October. Generally the monsoon breaks in the middle of June and continues till the end of October, which forms the rainy season. Maximum rainfall generally occurs during August followed by Julyand September.The result of long term analysis of rainfall is presented in **Table 1.3.**

Table 1.3: Long-term Rainfall Analysis of NAQUIM Blocks of JajpurDistrict.

Sl No	Station	Years	No of Years	Avg. Annual Rainfall (mm)	Coefficient of Variation (%)	Droughts (No of yrs / % of Tot. Yrs)	Rainfall Received (No of yrs/ % of Tot. Yrs)		Rainfall Trend mm/yr
							Normal	Excess	
1	Badachana	1988-2017	30	1520.5	23	3/10	23/77	4/13	-5.38
2	Bari	1988-2017	30	1814	33	6/20	20/67	4/13	-33.22
3	Binjharpur	1988-2017	30	1463.1	32	7/23	19/64	4/13	-21.19
4	Dasrathpur	1988-2017	30	1544.3	25	7/23	20/67	3/10	+9.99
5	Dharmasala	1988-2017	30	1495.9	23	3/10	25/83	2/7	-5.05
6	Jajpur	1988-2017	30	1337.9	23	5/17	18/60	7/23	+0.95
7	Korei	1988-2017	30	1315.8	25	4/13	21/70	5/17	-2.26
8	Rasulpur	1988-2017	30	1370.2	27	7/23	17/57	6/20	-17.73

Perusal of **Table 1.3**shows that

1. The coefficient of variation in rainfall is mostly within 23 to 27 % except Bari and Binjharpur blocks where variation is slightly higher i.e 32-33 %.
2. Normal rainfall has been received in 60% to 80 % of the years.
3. The rainfall data indicates that in all the blocks except Dasrathpur and Jajpur, the rainfall is on a declining trend.

1.7 Physiographic Setup

Physiographically, the district is composed of three distinct physiographic units, i.e.

1) High hill ranges in the north-westem part in the form of Mahagiri and Daitari Ranges which are not part of the study area
2) Gentle sloping plain with isolated hills and mounds with a general land elevation ranges from 25 to 100 meter above mean sea level.
3) Deltaic alluvial plain that occurs on the eastern part of the study area forms the most fertile land. The general slope is towards south-east with 0.5 to 1 m per Km. However the north-western part is steeper as compared to the south-eastem part.

The variation in land elevations above MSL is shown in **Fig. 1.3**.

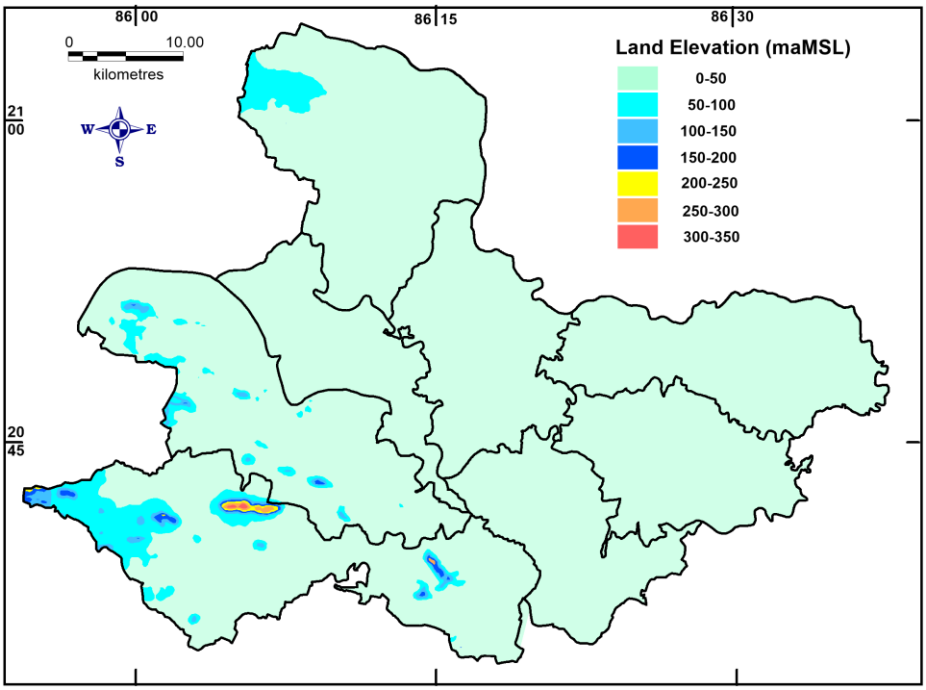

Fig. 1.3: Land Elevations in the NAQUIM Area in Jajpur District

1.8 Geomorphology

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

1.8.1 Residual and DenudationalHills: These are small made up of khondalites and quartzitic rocks and granite gneiss. The altitude of the hillocks range up to 300 m. above msl.

1.8.2 Shallow to Moderate Buried Pediments : This unit mostly occurs in the west and in a small patch around the small hilly tract near balichandrapur in the south. The area exhibits shallow to moderate deep buried pediments developed due to weathering of the country rocks. The area is highly undulating and rugged and thealtitud varies from 48 to 140 m. above msl.

1.8.3 Alluvial Plains: The eastern, north-eastern and southern part of the district is covered by thick alluvium deposits formed by the river system of Brahmani and the Bitarani. The slope of the tract is towards south-east and the altitude of the plain varies from 4 to 25 m. above msl. The small dotted hills within the alluvial plain represents monadnocks. The meanderig river s form ox-bow lakes at places Bogs and swampy are developed in low lying area.

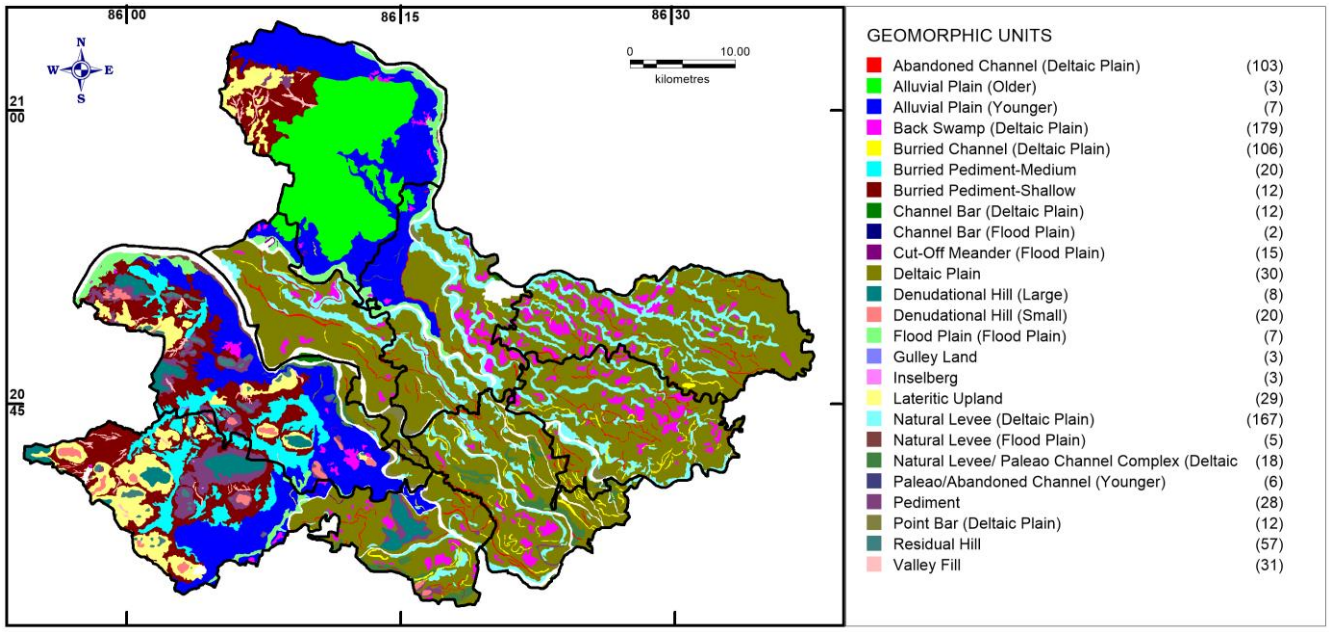

Fig. 1.4: Geomorphology of the NAQUIM Area in, Jajpur District

1.9 Landuse and Cropping Pattern

Being surrounded by rivers, Jajpur has good potentials for agricultural development. At this juncture, it is essential to understand the potentials of the district in terms of land utilization pattern. Out of the total geographical area of the district, 46% is net sown, 25% is covered by forest and land under non agricultural use is 17%. The cropping intensity of Jajpur is 186%, which is higher than the state average of 158%.

The block level analysis of the pattern of land utilization shows that Korei has the highest hectares of net sown area with the lowest cropping intensity (140.8%) in the district whereas, Bari has lowest share of net sown area in the district, i.e. is 11,420 ha but with a highest cropping intensity of 205.8%. Gross cropped area is highest in Jajpur district owing to maximum irrigated area of65,581 ha (38.2%).The landuse pattern of the blocks under the study area is shown in **Table 1.4**and the thematic map on land use is shown in **Fig. 1.5**.

The major field crops of the district during Kharif are paddy, maize, biri andarhor. Area under paddy is highest among other field crops i.e. 1,10,000 ha. Similarly, area under maize varied more or less around 3,000 haover the years. Vegetables like sweet potato, spices and condiments like chilli, ginger etc.are major crops grown in Kharif season. Area under pulses varied widely

overyears.Though the area under arhor varied in and around 2,500 ha but there was wide variationin area under biri (greengram) and other pulses over years.

Table 1.4: Land Use Pattern inDifferent Blocks of JajpurDistrict

(Area in hectares)

Sl No	Block	Geogr. Area	Forest Area	Land Non-Agri Use	Cultivable Waste	Permanent Pasture	Land under miscellaneous tree crops and groves	Current Fallow	Other	Net sown Area	Gross Cropped Area
										2013-14	2013-14
1	Badachana	42087	16819	6443	32	779	1022	349	750	15089	28128
2	Bari	15611	16	2851	178	64	48	477	246	12147	22389
3	Binjharpur	17894	0	2067	139	179	964	47	229	14272	27700
4	Dasarathapur	22524	0	6013	14	275	194	13	210	15503	29374
5	Dharmasala	28783	4945	4893	525	524	394	410	208	16785	31757
6	Jajpur	17685	0	3932	382	133	39	450	604	12416	24408
7	Rasulpur	13129	49	868	12	436	395	338	401	10818	21170
8	Korei	27426	175	253	305	928	717	16	1873	22070	24828
	Total	**185139**	**22004**	**27320**	**1587**	**3318**	**3773**	**2100**	**4521**	**119100**	**209754**

Source: District Irrigation Planof Jajpur, DLICJajpur, March 2016

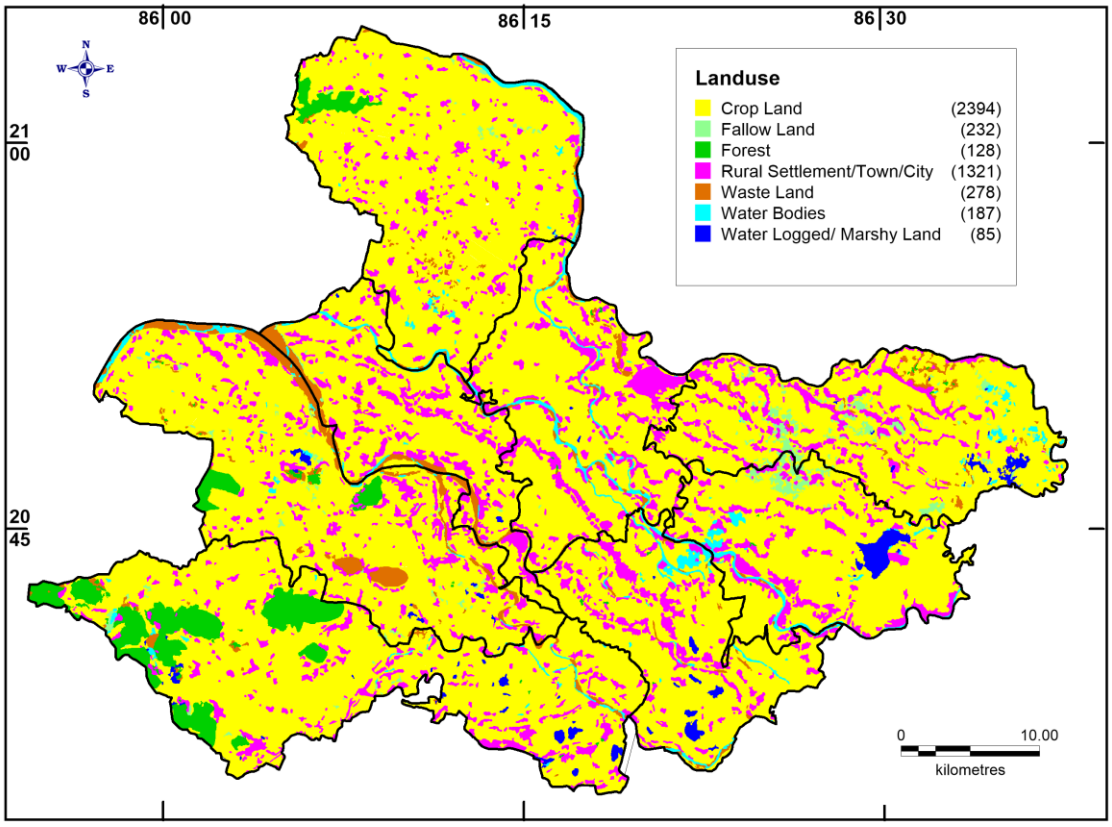

Fig. 1.5: Landuse in the NAQUIM Area in JajpurDistrict.

The major cereal crops of the district during Rabi season are paddy, wheat.Among pulses, green gram, black gram, kulthi and in oilseeds, groundnut and mustards are the main crops grown. Important vegetablesduring Rabi season are potato, onion, garlic, coriander, sweet potato, chilli and cash crop like sugarcane.

Horticulture has emerged as an important sector for diversification of agriculture.It has established its capability in improving the income through increased productivity,generating employment besides providing household nutritionalsecurity. The climatic conditions and soil type are more conducive for the cultivation ofhorticulture crops in Jajpur district. The important horticulture crops are coconut, cashewnut, mango, papaya, banana, guava & pineapple etc. Out of the total croppedarea of the district, nearly 7,920 ha (5.46%) has been devoted for the production of fruits.

1.9.1 Crop Water Requirement: The water requirement of different crops grown in the district as worked out by Dept. of Agricuture and Food Production, Govt. of Odisha are enumerated in **Table 1.5**.

Table 1.5: Crop Water Requirement in Jajpur District.

Sl.No	Name of the Crop	Growing Season	Total Water Requirement (in cm)
1	Paddy	Kharif & Rabi	100-125
2	Sugarcane	Kharif & Rabi	150-160
3	Jute	Kharif	50-65
4	Vegetables	Kharif & Rabi	120-150
5	Wheat	Rabi	35-40
6	Groundnut	Kharif & Rabi	30-35
7	Pulses	Kharif & Rabi	15-20

Source: DAO, Jajpur.

1.10. Soil

The district is underlain by good fertile soil with four major soil types as follows.

1.10.1 Alfisols: These include deltaic and old alluvial soils and red sandy soils. The old alluvial soils are always found in the river valleys and form main soil type of Jajpur, Bari, Binjharpur and Dasarathpur blocks. These soils are deficient in P_2O_5 and Nitrogen. K_2O is fairly adequate and pH varies between 6.5 and 7.3. The red sandy soils are lightly textured and are usually devoid of lime

concretions. The reddish colour is due to the oxidation of ferruginous materials of the underlying hard crystalline formations.

1.10.2 Ultisols: These include the lateritic soils found in the western upland areas and form most part of Sukinda and Danagadi block. These soils are poor in nitrogen, phosphate, potassium and organic materials withpH ranges from 4.5 to 6.0.

1.10.3 Vertisols: These are medium black soils occurring in the northern parts of the district in parts of Danagadi, Sukinda and Korei blocks. These are rich in iron, calcium, magnesium, potash and lime and poor in nitrogen, phosphorus and organic matters. The pH of the soil is neutral to alkaline with loamy to clayey loam in nature. These soils are fertile.

1.10.4 Entisols: These consist of younger alluvial soils covering most part of Badachana and Dharmasala block. These soils are fertile in nature and rich in potash but deficient in nitrogen, phosphorus and humus. The soil map of the NAQUIM blocks is shown in **Fig. 1.6**.

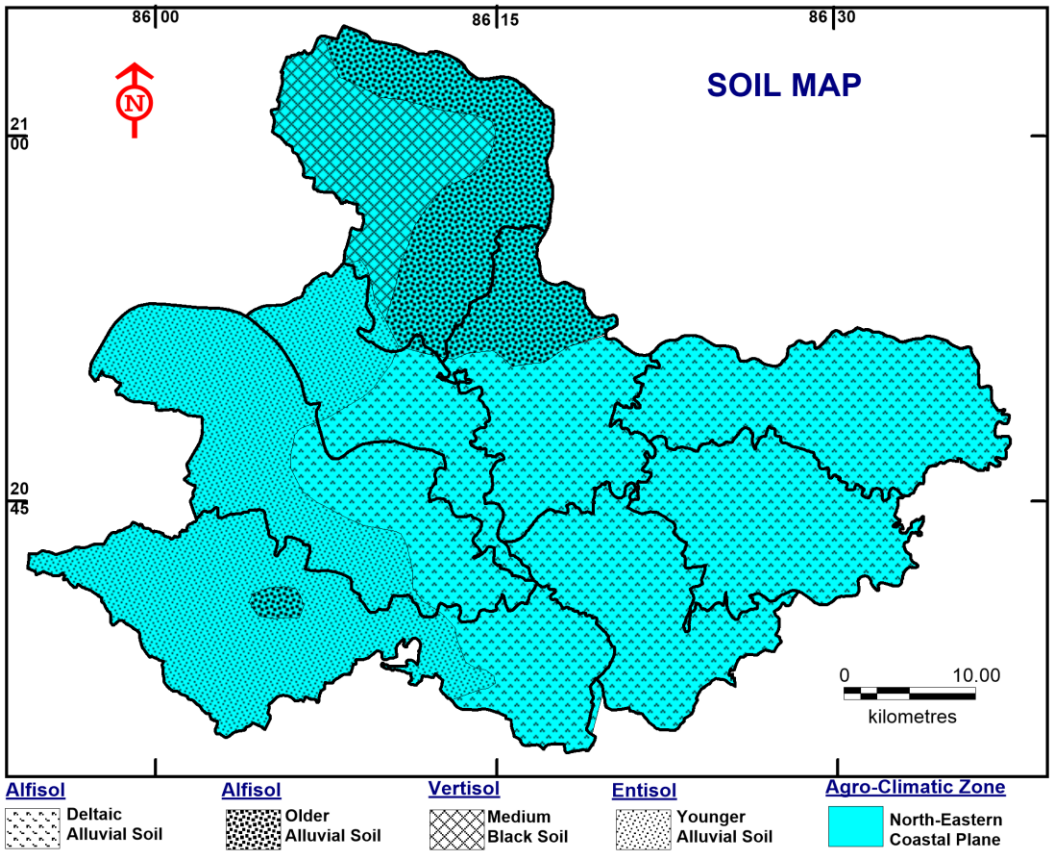

Fig. 1.6: The Soil Map of the NAQUIM Area in Jajpur District.

1.11 Drainage and Hydrology

Brahmani and Baitarini rivers along with their tributaries and distributaries form the main drainage system of the district. Near Jenapur Brahmani river is bifurcated to give rise to Kharasua river. The same river at Dharmasala bifurcates into another distributary known as Kelua river. At downstream, Birupa and its distributary Bada Genguty joins with Kelua river which ultimately sheds water to the Brahmani river further downstream. At Sathipur, Baitarini river bifurcates to to Budha river which ultimately joins with Kharasua river. The major rivers follow a south-eastern flow direction. The rivers often meanders and give rise to Ox-bow lakes along their courses. Abandoned river courses in the form of palaeo-channels are commonlyseen in the regionspecially between Kharsua and Baitarani river. The drainage pattern is braided and anastomosing in the alluvial plain while it is dendritic near the foothills.Due to flat topography and anastomosing drainage pattern, flood is a common phenomena in the region. The major drainage in the mapping area has been shown in **Fig. 1.7**.

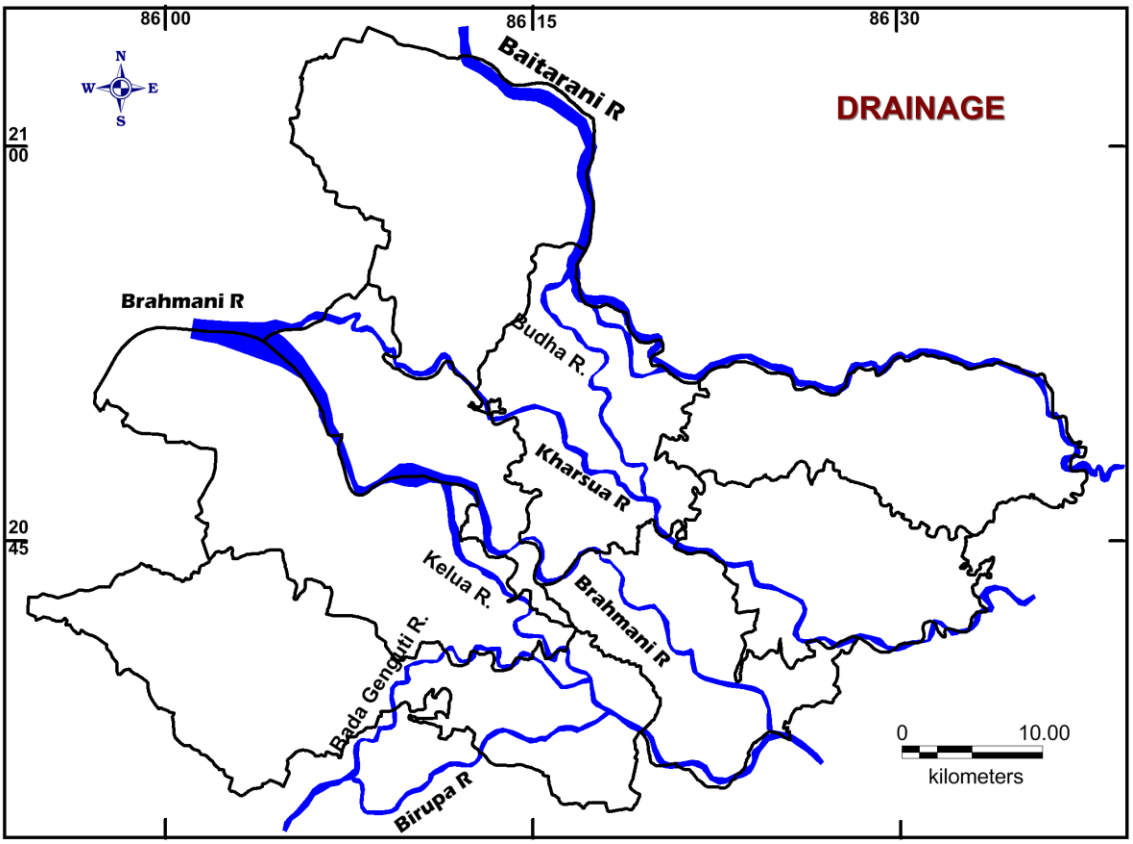

Fig. 1.7: Major Rivers in the NAQUIM Area in Jajpur District.

Though agriculture in this district mainly depends on rain, irrigation facilities are provided through major/medium irrigation, minor irrigation and lift irrigation projects both for Kharif and Rabi crops.The district has about 49.8% land are irrigated. The total water available from different sources during kharif season is around 1.346 BCM, in which the share of surface and ground water are 1.048 and 0.298 BCM, respectively, while during rabi& summer it is 0.783 BCM.The total irrigation potential is 212900 Ha the source wise details of which are given in **Table 1.6**. The block-wise irrigation area under different sources has been shown in **Table 1.7.**

Table 1.6: Source-wiseIrrigation Potentialin Jajpur District.

Sl. No.	Source	Kharif(ham)		Rabi & Summer(ham)		Total (ham)	
		Utilisable	Utilised	Utilisable	Utilised	Utilisable	Utilised
	Surface Water						
1	Surface Irrigation						
i.	Canal (major & Medium irrigation	61530	24837	32920		94450	24837
ii.	Minor Irrigation (Flow)	7875	18844	1457		9332	18844
iii.	Minor Irrigation (Lift)	35434	8043	20750		56184	8043
	Sub Total	**104839**	**51724**	**55127**		**159966**	**51724**
	Ground Water						
i.	Dug well		800				800
ii.	Deep Tubewell	4275		1200		5475	
iii.	Medium deep/Shallow tubewell/borewell		17100				17100
iii.	Other Sources	23584		21866		45450	
iv.	Other Sources Jalanidhi I & II	1925	1906	84		2009	1906
	Sub Total	**29784**	**19806**	**23150**		**52934**	**19806**
	Total	**134623**	**71530**	**78277**	**63840**	**212900**	**135370**

Source: District Irrigation Plan of Jajpur, DLICJajpur, March 2016

Table 1.7: Area Irrigated by Different Sources in Ha

Sl. No.	Name of the Block	Canal Irrigation	LIP	STW & BW	MI	Dugwells	Others	Total Irrigated Area	
								Kharif	Rabi
1	Badachana	7372	2902	1000	2314	112	136	13836	12675
2	Bari	0	1882	2150	62	23	150	4267	3401
3	Binjharpur	3697	2727	1250	460	30	350	8514	7136
4	Dasarathapur	5970	2033	1500	285	35	380	10203	8992
5	Dharmasala	4365	1965	2100	542	58	150	9180	8476
6	Jajpur	3433	2296	2100	337	100	230	8496	7201
7	Korei	0	2608	2800	415	34	150	6007	4855
8	Rasulpur	0	1383	2700	30	40	130	4283	3462
TOTAL		**24837**	**17796**	**15600**	**4445**	**432**	**1676**	**64786**	**56198**

Source:Jajpur District Gazeteer 2015

1.11.1 Major and Medium Irrigation Projects: Presently there are two major irrigation projects existing in the area i.e. (a) Baitarani System (b) High Level Canal (Mahanadi-Birupa Barrage). The Jajpur Canal System which includes the Jajpur Main Canal, its Distributaries and Minors. Jajpur Main Canal offtakes from Budha Anicut to Malanandpur having 10.144 Km with its 15 nos. distributaries and 14 Nos. minors. The total ayacut of this canal is 13,099 Ha. Jajpur Canal system supplies Khariff Irrigation of 13,099 Ha & Rabi Irrigation of 3238 Ha covering three Blocks i.e. Jajpur, Dashrathpur & Binjharpur Block in Jajpur District. The high level canal system is originated at cuttack and it's irrigating areas falling in Cuttack, Jajpur and Kendrapara districts. Besides there is one medium irrigation project viz. Birupa Genguti IIP with irrigation potential of 2590Ha which irrigates parts of of Rasulpur and Jajpur blocks.The block-wise details of Minor Irrigation Projects in the study area are given in**Table 1.8.**

Table 1.8: Block-wise MIPs in the Study Area in JajpurDistrict.

(As on 31.12.2013)

Sl. No.	Block	No of	Ayacut Area (Ha)
1	Badachana	26	2314
2	Bari	2	87
3	Binjharpur	13	880
4	Dasarathapur	8	875
5	Dharmasala	12	1854
6	Jajpur	18	1364
7	Korei	10	1909
8	Rasulpur	3	230
	Total	**92**	**9513**

Source: Dept. of Water Resources, Minor Irrigation Projects, Odisha 2014

2 DATA COLLECTION AND GENERATION

2.1 Geology

The disrict is underlain by geological formations varying in age from Archaean to Recent. The Quaternary and Recent alluvial formation covers nearly two third of the geographical area of the district while the Archaean meta-sedimentaries and crystalline formations are confined to the western and north-westem part of the district. 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 JajpurDistrict.**

Era	Age	Group	Formation
Quarternary	Pleistocene to Recent		Newer Alluvium Older Alluvium Laterite
----------Unconformity----------			
Archean to Middle-Upper Proterozoic	1000 to 3000 Ma	Iron Ore SuperGroup	Granite
			Ultramafic complex with Dunite, Peridotite and Pyroxenite Conglomerate, Grits and Quartzites
			----------Unconformity----------
		Eastern Ghat SuperGroup	Schists and Quartzites Banded Cherty Quartzites Khondalites

2.1.1. Archeans: Khondalites,quartzites, ultramafics mainly dunite, peridotite & pyroxenites, schists & phyliites and younger granites are the major Achaean formations in the district. Khondalite belonging to Eastern Ghat Super Group is constituted by garnet-quartz-sillimanite mineral assemblages. The hills of western part of the district as well as the residual isolated ones, mainly comprise of khondalites. These archaean crystallines have latter invaded by granitic plutons of Upper Proterozoic age and occur as small patches in the district.

2.1.2. Quaternaries: Almost-two third of the districtis underlain by quartenary formations. The sand, gravel, silt and clays deposited under fluvial condition in the Brahmani- Baitarani delta constitute the major part of it. They are white, grey to brown in colour. The older alluvium is characterized by plenty of calcareous concretions. In Korei block, these older alluvial formations have been extensively lateritized. Thick lateritic capping is seen over ultramafics of Sukinda valley and over the schistose rocks found in the northern part of the distict. Khondalites are also not been spared from large scale lateriization.

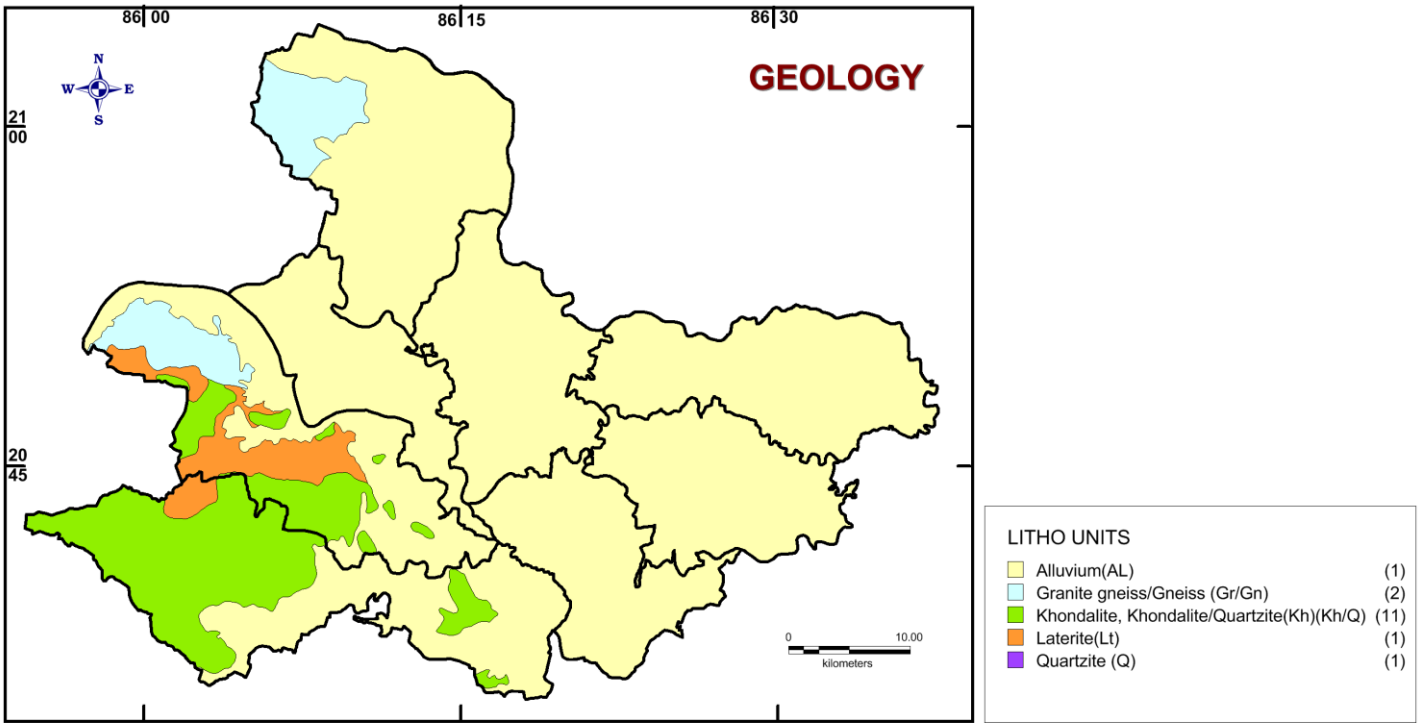

Fig. 2.1: Geological Map of the NAQUIM Area, Jajpur District

2.2.3. **Structures:**The crystalline and meta-sedimentary formations have undergone multiple phases of orogenic movements and consequently several structural features are developed in them. The khondalites are well foliated and schistose with a NE-SW trend. The granites are having good joints having trends varying from N-S to NW-SE with sub-vertical joints having dip from 60° to 75°.

2.2 Hydrogeology

The geological set up of the district controls the occurrence and movement of ground water. Based on the rock types and their diverse hydrogeological properties, the hydrogeological formations can be grouped into two broad hydrogeological units i.e. consolidated formations and unconsolidated formations. The hydrogeological map of the area is presented in **Fig. 2.2**.

2.2.1 Consolidated Formation

The crystalline archaean formations comprising of khondaltes and granites are predominant consolidated formations in the study area. They are devoid of primary porosity and the secondary porosity present in the weathered and fracture mantle developed on them serves as good repository of ground water. Ground water occurs under water table condition in shallow phreatic aquifer, where as in semi-confined to confined condition in deeper aquifers. Since the water bearing properties of different litho-units vary, they have been described separately below.

2.2.1.1 Khondalites: They are well foliated but moderately fractured. The thickness of the weathered zone may extend down to a depth of 15 to 20 meters. Generally the weathered zone is clayey which renders it to form moderate to low water yielding phreatic aquifer. The weathered mantle is lateritised in most places and is being tapped byunlined or partially lined dug wells. The yield of dug wells varies from 5 to 20 m^3/day. The deeper moderately developed fractures are encountered in bore wells and are highly site specific. However the elastic properties of the rock prohibit the formation of well defined joints and fractures as seen in granitic rocks. Generally yield of the bore wells varies between 1 to 5 lps. Most of the drinking water supply systems in these areas get water from these fracture systems. Drilling by CGWB has revealed that there is good ground water potential of the deeper fractures in and around Chatia and Jaraka. A deep bore well constructed in Jaraka College campus is high yielding in nature with 8 lps discharge.

2.2.1.2 Schists and quartzites: They are moderately weathered and the thickness of weathered zone varies between 1 to 5 meters. The quartzites are generally resistant to weathering but the presence of argillaceous impurity enhances its weathering ability. The yield of dugwells in such formation varies fiom 6 to 20 m^3/day. Specific Capacity of the dug wells varies from 0.004 to 0.008 m^3/minute per meter drawdown. The brittleness of the rock is responsible for well developed joints and fractures in the rock and are likely to be encountered in the bore wells. The yield of

bore wells again are highly site specific, but having very good yield. One drinking water well and one irrigationtube well drilled by RWSS and OLIC shows perennial auto-flowing condition. The wells produce free flow of 1.5 to 2 lps with piezometric head of 0.7 to 1.1 meter above ground level.

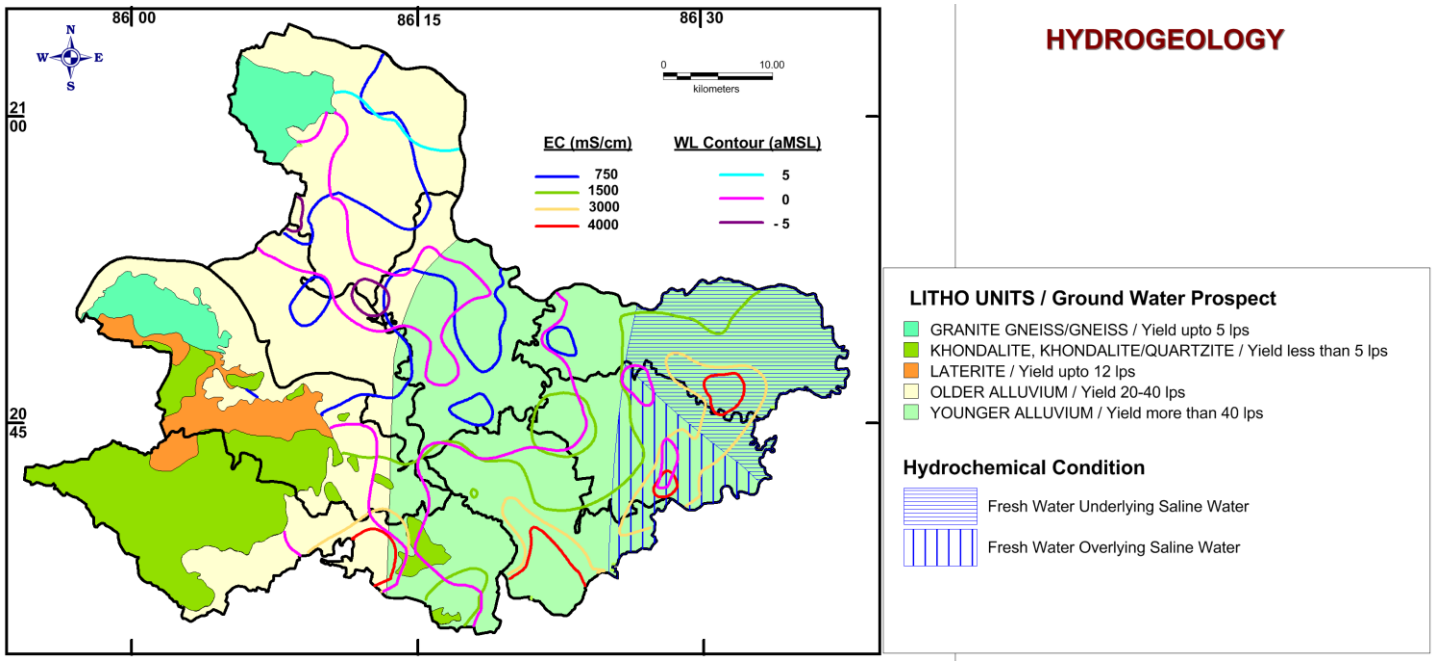

Fig. 2.2: Hydrogeology of NAQUIM Area in Jajpur District

2.2.1.3 Granites: In comparison to the rock types described earlier, granites are more prone to weathering. Depth of weathering ranges from 15 to 20 meters except near to hills and exposures. The yield of dug wells in the weathered residuum varies from 6 to 15 m^3/day. The specific capacity of the dug wells varies from 0.0037 to 0.007 m^3/minute per meter of drawdown. The bore wells if located properly can yield ground water upto 5 lps.

2.2.2 Unconsolidated Formation

Two third of the district and the entire NAQUIM area is covered by alluvial formations comprising of sand, gravel, silt and clay deposited in a prograding deltaic environment. The sand and gravel formations are highly porous and permeable and form very good repository of ground

water. Extensive shallow aquifers are present within 25 to 60 meter which has been tapped by means of dug wells, shallow tube wells and filter points. The phreatic aquifer is sandy and thus has good yield ranging between25 and 70 m^3/day. The shallow tube wells have moderate yield between 5 to 15 lps.

2.2.3 Ground Water Exploration

In order to decipher the aquifer system of the area, CGWB has constructed numerous deposit wells, exploratory wells, observation wells, slim holes and piezometers of different depths which is shown in **Fig. 2.3**. The detail data generated from this exploration is given in **Table 2.2**.

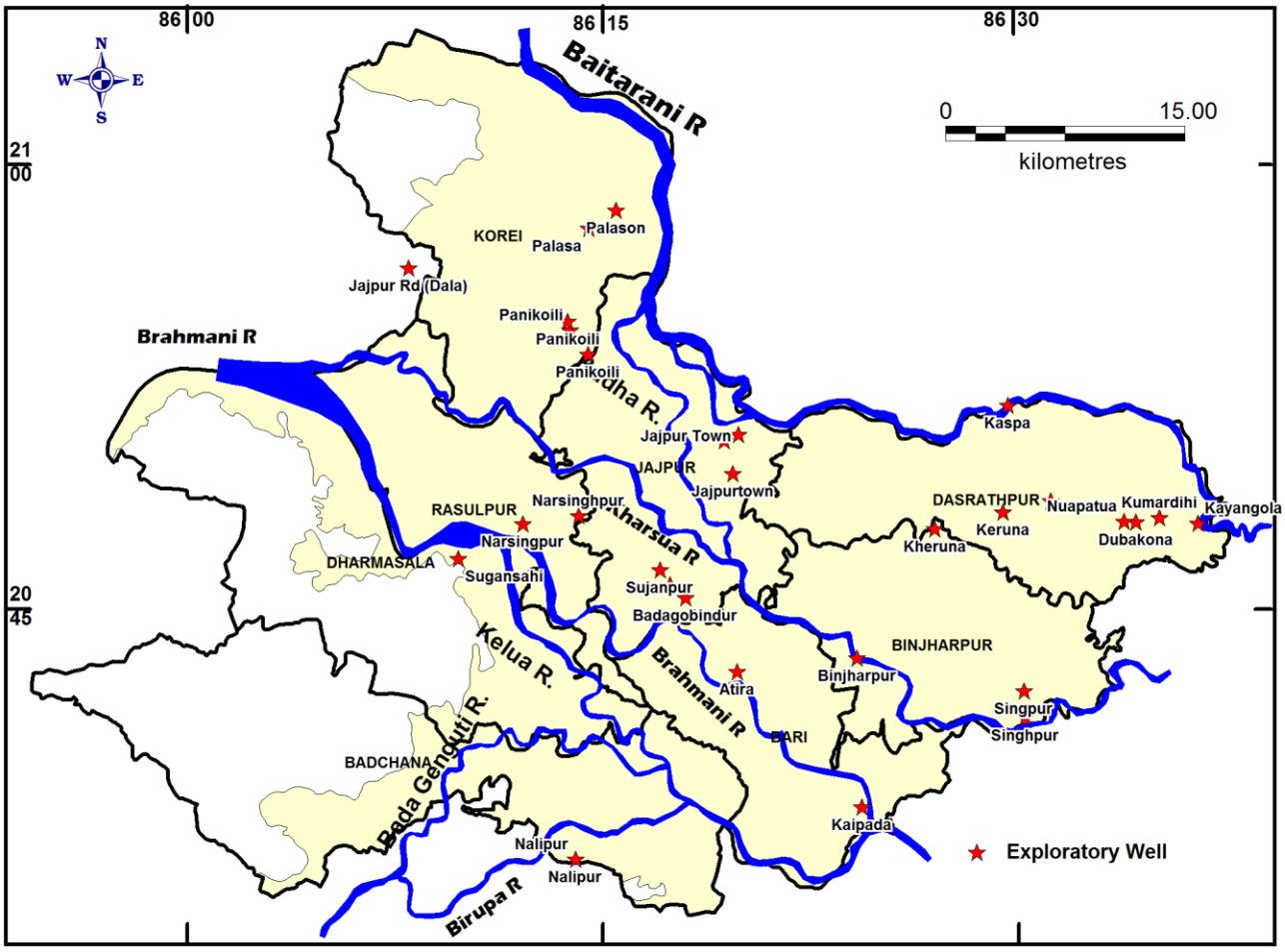

Fig. 2.3: Locations of ExploratoryWells Drilled by CGWB in the Study Area in Jajpur District.

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

Sl. No	Location	Type	Lati-tude	Longi-tude	Depth drilled (mbgl)	Constr. Depth (mbgl)	Zone Tapped	Cum. Thickness (m)	Discharge (lps)	Drawdown (m)	T (m² / day)	S	EC	Hydrochemical Profile
Block: Barachana														
1	Nalipur	EW	20.61	86.233	127.2	31	16-28	12	9.86					All Fresh
2	Nalipur	OW	20.61	86.233	32.5	31	16-28	12	7.73					All Fresh
Block: Bari														
3	Badagobindur	EW	20.757	86.299	150			37.8	95.3	5.3			684	21-50 Fresh 50-111 Saline
4	Atira	EW	20.715	86.331	186	52	33-39,43-49	12						20-69 Saline 75-100 Saline 120-147 Marginal 147-155 Fresh 155-173 Marginal 173-194 Fresh
5	Kaipada	EW	20.639	86.405	195	184	171-180	9	2.37	8.06	57.6 / 83.25			
Block: Binjharpur														
6	Singpur	EW	20.704	86.503	319.93									
8	Singhpur	Slim hole	20.689	86.504	319.93									0-28.5 Fresh 28.5-95.5 Saline 95.5-319.93 Fresh
7	Binjharpur	DW	20.723	86.403	89.74		17.4-47.4	40	65.13	9.09	2630			0-48 Fresh 52-84 Brackish
Block: Dasrathpur														
9	Kheruna	EW	20.795	86.449	136.44									
13	Kheruna	Slim hole	20.805	86.49	163.44		61-69.5, 71.5-81, 96-109, 113-119, 140-151	47						0-48 Brackish to Saline 52-160 Fresh
10	Dubakona	DW	20.799	86.57	176.63		94-108, 112-119, 123-142, 148-156	46	44.58	17.91	393			0-75 Brackish 92-176 Fresh
11	Nuapatna	DW	20.8	86.563	190.47		140-164, 176-185	33	49.83	22.3	376			376 (Autoflow)
12	Kumardihi	DW	20.802	86.584	221.1		134-153, 162-192	39	57.88	16.52	965			0-100 Brackish 120-160 Fresh, 965 (Autoflow)

14	Mangalpur	PZ	20.811	86.519	179.6		105-120	15						0-76 Saline 90-179 Fresh
15	Kayangola	EW	20.798	86.608	167.95	152	130-139, 142-148	15	9.16	18.5	225.6			25-60 Saline 60-113 Brackish 119-155 Fresh
16	Kaspa	DW	20.865	86.493	185		89-97, 107-110, 112-115, 118-122, 132-141, 143-149, 156-161	38						All Fresh
Block: Dharmasala														
17	Sugansahi	EW	20.778	86.163	150		34-43, 67-70	12	30					All Fresh
18	Sugansahi	OW	20.778	86.163	78.5									All Fresh
Block: Jajpur														
20	Erbank	DW	20.764	86.29	170.32		36-68, 85-107	54	68.71	7.22	2180			All Fresh
21	Sujanpur	DW	20.772	86.284	164		29.3-35.5, 38.4-61.5	28.3	61.75	4.22	4650			All Fresh
19	Jajpurtown	EW	20.826	86.328	104.85		59-61, 64-72, 77-78, 92-107	33	138	14.12				All Fresh
22	Jajpur Town	EW	20.848	86.331	104.85		59-61, 64.5-72, 77-87	19.5	38.5	14.12	1087			All Fresh
23	Jajpur Town	PZ	20.845	86.323	159.5		71-80, 92-107	24						All Fresh
Block: Korei														
24	Palason	EW	20.975	86.258	110.94			32.2	134.6	9.5				All Fresh
25	Panikoili	EW	20.894	86.241	136.55			27.05	77.07	5.37				All Fresh
26	Panikoili	PZ	20.907	86.23	120.95		106-118	12						All Fresh
27	Panikoili	EW	20.912	86.229	136.55			27.05	21.4	5.37				
28	Jajpur Rd (Dala)	DW	20.942	86.133	100.85		19-30, 43-51, 85-95	29	44.67	10.48	989.7			All Fresh
29	Palasa	EW	20.964	86.241	110.94			32.2	37.38	9.5				All Fresh
Block: Rasulpur														
30	Narsingpur	EW	20.798	86.202	152.4		65		79.33	6.01			684	
31	Narsinghpur	EW	20.803	86.235	152.4			39.21	22.03	6.01	74.5	$4.1x10^{-4}$		

Under NAQUIM, 70 tubewells/handpumps were monitored during pre and post monsoonperiods in 2016-17 andthe piezometric levels in deeper aquifer were recorded. The water level data of the phreatic aquifer monitored in 48 dug wells during 2009-10 were taken for the analysis. The details of the monitoring tubewells/handpumps and dugwellsareshown in **Table 2.3** and **Table 2.4**respectively and the locations of the monitoring stations are shown if **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. Quality of ground water from deeper aquifers is assessed during the drilling and pumping tests. During the NAQUIM programme, 70 water samples from deeper aquifer were collected during pre-monsoon period and results of their chemical analysis is given in **Table 2.5.**

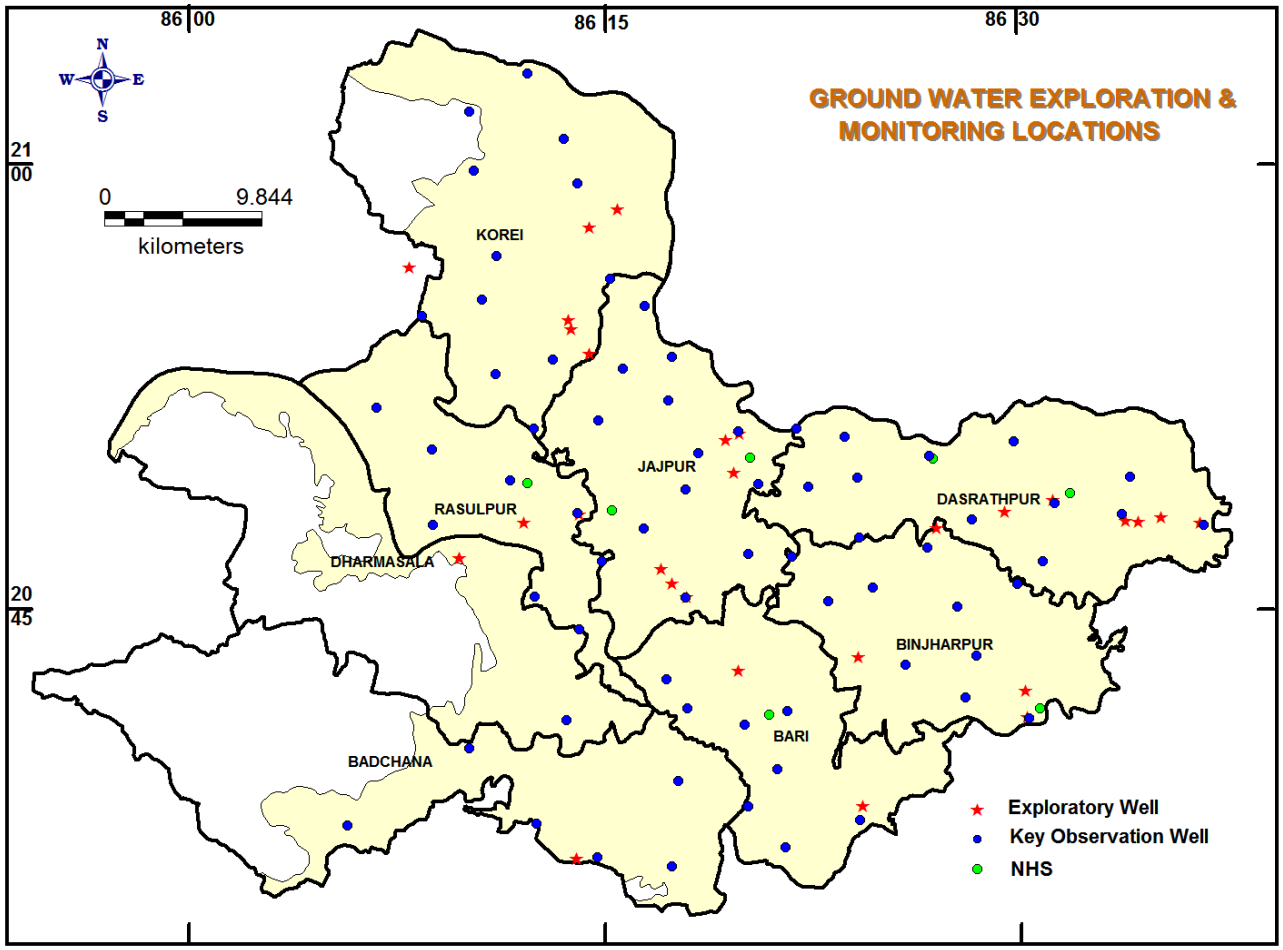

Fig. 2.4: Locations of MonitoringStations in the Study Area in Jajpur district.

Table 2.3: Details of Observation Tubewells/Handpumps in NAQUIM Area in Jajpur District.

Sl No	Location	Block	Latitude	Longitude	Elevation (maMSL)	MP (m)	Pre-Monsoon DTWL (mbgl)	Pre-Monsoon DTWL (mbgl)
1	Sinduraimuha	Dasrathpur	20.8515	86.36498	8.8	0.70	6.9	5.55
2	Taliha	Dasrathpur	20.84695	86.39401	3.6	0.65	5.2	3.70
3	Dasrathpur	Dasrathpur	20.83617	86.44433	3.8	0.75	6.65	5.45
4	Patri	Dasrathpur	20.84426	86.49509	2.5	0.60	4.5	3.70
5	Mangalpur	Dasrathpur	20.80963	86.5201	1.9	1.35	5.66	4.10
6	Radanga	Dasrathpur	20.8242	86.56519	1.6	0.55	5.61	5.60
7	Lalbag	Dasrathpur	20.80345	86.56015	1.2	0.80	5.63	5.00
8	Kayangola	Dasrathpur	20.79724	86.60949	1.1	0.70	5.58	4.80
9	Narigan	Dasrathpur	20.77676	86.51264	3.0	1.50	3.1	2.30
10	Dihakula	Binjharpur	20.76417	86.49738	3.0	0.65	6.75	5.75
11	Alkund	Binjharpur	20.7515	86.4616	3.0	0.60	3.15	2.30
12	Kantabania	Dasrathpur	20.80051	86.47008	4.4	1.15	6.09	4.50
13	Barikul	Binjharpur	20.7847	86.44338	4.5	0.45	4.1	3.20
14	Palda	Dasrathpur	20.82387	86.40146	4.1	0.60	5.35	4.05
15	Sridharpur	Dasrathpur	20.81893	86.37221	4.0	0.50	4.58	3.55
16	Brundabanpur	Dasrathpur	20.79025	86.40267	3.0	0.85	4.25	3.15
17	Chikana	Binjharpur	20.76217	86.41054	2.2	1.35	3.75	2.95
18	Gaudsahi	Binjharpur	20.71882	86.43062	2.0	0.40	4.3	4.00
19	Rasguhali	Binjharpur	20.72376	86.47273	3.0	0.50	2.83	1.90
20	Malia (Dandisahi)	Binjharpur	20.70034	86.46636	2.7	0.65	2.59	2.15
21	Singhpur	Binjharpur	20.68888	86.50483	4.1	0.75	8.9	8.00
22	Mainda	Binjharpur	20.75469	86.38387	4.8	0.65	4.1	3.35
23	Tauntara Chhak	Binjharpur	20.77945	86.36196	6.3	0.45	3.99	3.45
24	Markandapur	Jajpur	20.78109	86.3359	6.6	0.65	6.2	4.70
25	Padini-Mirchandpur	Jajpur	20.82009	86.34207	6.5	0.80	5.97	4.80
26	Ganeswarpur	Jajpur	20.8915	86.29007	7.9	0.65	5.65	4.60
27	Rudhia	Jajpur	20.92053	86.27397	7.9	0.50	5.13	4.95
28	Bhagatpur	Jajpur	20.88534	86.26083	5.8	0.70	6.2	4.90
29	Suninda	Jajpur	20.86743	86.28788	4.1	0.50	7	5.30
30	Gaukhana	Jajpur	20.83743	86.30618	8.8	0.50	5.95	4.65
31	Olaipada	Jajpur	20.81721	86.29802	6.5	1.40	5.01	4.90
32	Sibachhak	Jajpur	20.75652	86.29838	5.6	0.75	4.3	3.85
33	Arangabad	Bari	20.69249	86.35958	4.1	0.90	4.8	3.60
34	Upar Kaipada	Bari	20.63129	86.40304	4.2	1.20	7.65	6.45
35	Samdaspur	Jajpur	20.79524	86.27297	4.4	0.45	5.05	4.65
36	Haripurhata	Rasulpur	20.80379	86.23318	6.3	0.55	4.15	4.00
37	Chandipur	Rasulpur	20.82229	86.19264	6.8	0.60	4.36	4.30
38	Gopinathpur	Rasulpur	20.83983	86.14604	7.6	0.75	5	4.00
39	Nathuabar	Rasulpur	20.8629	86.11248	7.7	0.80	4.2	3.30

40	Barabati	Rasulpur	20.79741	86.14666	6.9	0.50	5.6	5.60
41	Nilakanthapur	Rasulpur	20.7572	86.20784	6.1	0.50	6	5.10
42	Brahmabarada	Rasulpur	20.73849	86.23417	6.0	0.40	5.75	4.90
43	Sankhamatha	Rasulpur	20.77667	86.24791	5.3	0.65	4.85	3.83
44	Jajpur town-2	Jajpur	20.85008	86.3301	5.4	0.70	5.1	3.95
45	Karada	Jajpur	20.93559	86.25309	4.9	0.50	4.44	4.20
46	Barundei	Korei	20.98924	86.23307	8.0	0.60	3.73	3.70
47	Ichhapur	Korei	21.01413	86.22516	9.9	0.50	2.62	3.85
48	Ranapur	Korei	21.05115	86.20312	11.2	1.20	4.4	3.95
49	Kantor	Korei	21.02958	86.16836	12.1	0.65	5.07	4.65
50	Tulati	Korei	20.9964	86.17093	10.7	0.70	11.56	5.60
51	Pandula	Korei	20.94827	86.18478	8.9	0.45	7.63	3.00
52	Chhotaraipur	Korei	20.91462	86.14007	7.6	0.40	12.95	6.20
53	Badabiruan	Korei	20.88194	86.1841	6.2	0.95	6.88	4.85
54	Taluri (Talunga)	Korei	20.92404	86.17577	9.6	0.50	10.32	6.65
55	Kandarapur	Korei	20.8904	86.21843	7.9	0.80	5.17	4.10
56	Malparha	Korei	20.85131	86.20711	0.1	0.60	8.05	6.95
57	Biruda	Jajpur	20.85594	86.24583	6.3	0.50	7.24	7.30
58	Udayanagar	Dharmasala	20.68741	86.2269	4.7	0.75	4.2	3.30
59	Krushnadaspur	Badachana	20.62937	86.20863	4.9	0.80	6.05	5.65
60	Santipur	Badachana	20.67204	86.16809	4.5	1.20	5.95	5.25
61	Dihakaranda	Badachana	20.62826	86.09515	6.6	1.00	5	6.50
62	Palai	Badachana	20.60523	86.29025	4.1	0.60	3.94	3.15
63	Nalipur	Badachana	20.61048	86.24511	5.0	0.70	4.52	3.90
64	Balikuda	Badachana	20.65363	86.29387	4.4	1.05	5.67	5.15
65	Ratnagiri	Bari	20.63896	86.33611	3.4	0.60	5.54	3.85
66	Kharimunda	Bari	20.61641	86.35855	3.6	1.20	5.25	4.05
67	Sukal	Bari	20.66028	86.35334	4.7	0.95	5.45	4.30
68	Haladibasanta	Bari	20.68502	86.33389	5.2	0.80	6.62	5.50
69	Balia	Bari	20.69401	86.29918	4.1	0.40	5.46	4.60
70	Nahana	Bari	20.7105	86.28697	3.9	0.90	4.64	3.50

Table 2.4: Depth to Water Level Data of Monitoring Dug Wells in NAQUIM Area of Jajpur District.

Slno	Village	Block	Latitude	Longitude	Location	MP (m)	Depth (mbmp)	Diameter (m)	Pre-Monsoon DTWL (mbgl)	Pre-Monsoon DTWL (mbgl)	EC µS/cm
1	Chhatia	Badachana	20.606	86.067	Vet. Hospital	0.4	11.8	2	8.5	4.1	200
2	Bairi	Badachana	20.633	85.039	Mahadevsahi, Hrusikesh	0.2	7.8	1.2	4.3	2.74	3200
3	Sakuntalapur	Badachana	20.629	86.128	Natabar Pradhan house	0.2	9.2	0.8	5.14	3.9	4200
4	Kantigadia	Dharmasala	20.699	86.168	Kailash Ch. Jena, Kumbharasahi	0.8	10	1	5.1	3.88	3500
5	Narsinghpur	Badachana	20.672	86.199	Front of Tarini Temple	0.4	7	1	3.25	3.76	220
6	Bhagabanpur	Dharmasala	20.704	86.236	Madhabananda Samal house	0.85	6.5	0.85	4.55	2.45	900
7	Arelkana	Rasulpur	20.669	86.228	Gayadhar ray house	0.7	8.1	0.8	5.12	4.13	720
8	Anaka	Badachana	20.650	86.222	Village entrance	0.4	4.4	0.75	2.73	1.72	200
9	Dhaurlapada	Badachana	20.635	86.269	Babaji das house	0.4	8	0.8	7.6	6.4	220
10	Ramdaspur	Badachana	20.653	86.303	Baira Mahakali Peetha	0.5	5.3	0.8	2.8	1.35	2200
11	Ratnagiri	Bari	20.639	86.338	on the way to Museum	0	7.7	1	5.55	3.72	1320
12	Kharimunda	Bari	20.615	86.358	Dhaneswar Palai premises	0.6	7.2	0.7	6.45	3.56	1440
13	Balichandrapur	Badachana	20.610	86.228	Kartik Parida shop	0.75	5.4	0.8	2.9	2.54	460
14	Bikrama Tirana	Badachana	20.607	86.296	Murali Prusty house	0.55	5.9	0.6	4.55	3.53	440
15	Kaduamagra	Rasulpur	20.756	86.061	Adj. Rajshri Devi temple	0.3	6.6	0.4	3.88	2.95	600
16	Antia	Dharmasala	20.821	86.093	Naear Anganwadi, Talasahi	0.2	7.5	1.5	6.2	3.1	1430
17	Jenapur	Dharmasala	20.857	86.072	Maa Hingula temple	0.35	5	1.1	3.44	1.49	560
18	Raghupur	Korei	21.049	86.193	Dolamadhab Das premises	0.1	8.6	1.3	7.9	6.66	580
19	Gaurapur	Korei	21.024	86.218	Sani temple premises	0.5	5.6	0.9	4.4	1.92	480
20	Baitarani Road	Korei	20.988	86.236	Adj. Sub-Post office	0.45	5.3	1.2	2.95	1.21	
21	Tarakot	Korei	20.996	86.204	Premananda Pati, Sahanta Sahi	0.4	11	0.55	4.93	1.38	1600
22	Korei	Korei	20.957	86.182	Batira harijan Sahi, Near vet.	0.5	9	0.85	6.24	2.3	620
23	Rambag	Dasrathpur	20.846	86.390	High School premises	0.85	6.5	0.8	1.99	1.6	280
24	Dasrathpur	Dasrathpur	20.835	86.444	Weekly market	0.55	6.2	0.85	2.65	1.65	1150
25	Ahias	Dasrathpur	20.846	86.511	Entrance of High School	0.5	5	0.6	3.25	2.2	840
26	Balspan	Dasrathpur	20.842	86.533	UGME School backside	0.7	6.7	0.6	2.63	1.4	660
27	Mangalpur	Dasrathpur	20.811	86.521	PHC near	0.76	7.3	0.7	1.49	1.09	1140

28	Chatrapada	Dasrathpur	20.796	86.478	Mangaraj Sahoo premises	0.6	5	0.65	3.37	1.9	440
29	Biripatha	Dasrathpur	20.765	86.503	Haragauri Chhak	0.6	4.9	0.6	2.73	1.11	2400
30	Sana Kuani	Dasrathpur	20.776	86.536	Braja Kishore Pandav premises	0.8	5	0.55	2.8	1.8	1300
31	Sighpur	Binjharpur	20.690	86.510	SBI side	0.7	6.3	0.8	4.74	4.33	640
32	Fatehpur	Binjharpur	20.701	86.463	Tarakanta sahoo	0.7	5.85	0.65	4.14	3.1	1930
33	Binjharpur	Binjharpur	20.721	86.410	Jagannath Sahoo, Treasury	0.7	6.9	0.65	2.5	1.8	1360
34	Alkund	Binjharpur	20.753	86.461	near Mosque	0.7	7.8	0.7	2.54	1.85	3100
35	Uttangada	Binjharpur	20.786	86.431	Muralidhar bhadra house	0.6	5.1	0.6	2.74	1.96	630
36	Jajpur Town	Jajpur	20.835	86.340	Dakhin Dwar of Biraja temple	0.6	7.4	0.65	6.07	3.75	750
37	Chitala	Dasrathpur	20.808	86.369	Mahakala temple premises	0.6	6.5	0.6	2.05	1.65	420
38	Kamagarh	Jajpur	20.879	86.308	vet. Hospital	1.15	10	0.6	3.05	1.73	410
39	Rudhia	Jajpur	20.919	86.275	Kanhucharan Nanda premises	0.45	5.3	0.9	3.95	3	400
40	Uchinda	Korei	20.942	86.217	Gopabandhu satpathy house	0.35	5.2	0.9	4.67	3.01	940
41	Panikoili	Korei	20.907	86.228	Sharma Dhaba	0.4	15.6	1.2	2.15	2.42	640
42	Sankhachilo	Korei	20.900	86.158	Radhagovinda Jiu temple	0.8	8.6	0.9	2.18	1.35	1240
43	Ambtala	Korei	20.878	86.189	Chakradhar sahoo premises	0.1	11.4	0.6	3.22	1.26	2000
44	Badakaincha	Rasulpur	20.839	86.150	Malhasahi chhaka	0.3	5.7	1	3.7	2.4	380
45	Kuakhia	Rasulpur	20.819	86.203	Saw mill	0.5	6	0.8	4.63	3.06	1120
46	Kabirpur	Jajpur	20.804	86.256	Post office front	0.25	5.5	0.86	3.87	2.78	810
47	Sujanpur	Jajpur	20.772	86.286	Market	0.85	5.2	0.9	2.98	1.67	
48	Bari	Bari	20.701	86.349	Revenue IB	0.7		1.2	3.5	2.88	

Table-2.5: Ground Water Quality Data of Monitoring Wells in NAQUIM Area of Jajpur District.

Sl No	Location	Block	Latitude	Longitude	pH	EC	TDS	Hardness	Alkalinity	Ca++	Mg	Na+	K+	CO3=	HCO3-	Cl-	SO4=	F-
						µS/cm	mg/L	as CaCO3 mg/L		mg/L								
1	Jajpur town-1	Jajpur	20.851	86.328	6.66	560	267	180	222	12	41	24	21.4	0	271	24	12	0.98
2	Sinduraimuha	Dasrathpur	20.852	86.365	7.16	670	318	194	237	12	45	45	3.5	0	290	62	9	0.66
3	Taliha	Dasrathpur	20.847	86.394	7.24	490	212	167	187	19	33	22	1.4	0	228	19	6	0.84
4	Dasrathpur	Dasrathpur	20.836	86.444	7.25	1090	541	383	242	48	73	54	1.6	0	296	189	31	0.73
5	Patri	Dasrathpur	20.844	86.495	7.45	760	383	189	298	18	40	71	2.9	0	363	41	31	0.66
6	Mangalpur	Dasrathpur	20.810	86.520	7.34	1050	526	238	313	16	55	105	4.5	0	382	112	47	0.44
7	Radanga	Dasrathpur	20.824	86.565	7.48	1100	556	282	333	26	60	97	5.1	0	407	110	59	0.21
8	Lalbag	Dasrathpur	20.803	86.560	7.42	1310	665	339	253	39	67	111	4.8	0	308	227	66	0.24
9	Kayangola	Dasrathpur	20.797	86.609	7.47	1010	512	273	253	49	41	77	4.9	0	308	127	62	0.20
10	Narigan	Dasrathpur	20.777	86.513	7.53	3000	1677	392	263	53	72	450	19.2	0	320	847	79	0.57
11	Dihakula	Binjharpur	20.764	86.497	7.58	980	485	238	298	23	50	88	5.0	0	363	93	49	0.32
12	Alkund	Binjharpur	20.751	86.462	7.54	1210	644	185	273	23	35	159	25.9	0	333	201	37	0.45
13	Kantabania	Dasrathpur	20.801	86.470	7.13	2220	1188	585	278	76	109	224	6.6	0	339	541	65	0.26
14	Barikul	Binjharpur	20.785	86.443	7.42	760	379	167	263	32	24	80	1.0	0	320	60	26	0.47
15	Palda	Dasrathpur	20.824	86.401	7.4	590	265	202	232	30	35	24	0.9	0	283	29	7	0.63
16	sridharpur	Dasrathpur	20.819	86.372	7.44	390	181	136	157	21	23	23	1.6	0	191	19	0	0.86
17	Brundabanpur	Dasrathpur	20.790	86.403	7.4	460	228	110	182	23	15	46	4.6	0	222	29	2	0.88
18	Chikana	Binjharpur	20.762	86.411	7.41	620	301	106	247	19	16	73	4.6	0	302	36	5	0.68
19	Gaudsahi	Binjharpur	20.719	86.431	7.43	260	121	97	96	11	19	9	4.7	0	117	19	1	0.24
20	Rasguhali	Binjharpur	20.724	86.473	7.79	2600	1380	154	409	14	33	450	11.8	0	499	553	73	0.47
21	Malia (Dandisahi)	Binjharpur	20.700	86.466	7.67	1890	979	141	601	18	27	320	10.8	0	733	237	7	0.86
22	Singhpur	Binjharpur	20.689	86.505	7.33	3280	2015	625	268	72	123	484	9.4	0	327	1084	82	0.19
23	Mainda	Binjharpur	20.755	86.384	7.42	870	446	172	263	26	29	99	2.6	0	320	89	43	0.56
24	Tauntara Chhak	Binjharpur	20.779	86.362	7.24	630	299	176	268	21	34	46	1.5	0	327	24	12	0.28
25	Markandapur	Jajpur	20.781	86.336	7.31	630	287	220	283	25	44	25	1.1	0	345	19	4	0.45

26	Padini-Mirchandpur	Jajpur	20.820	86.342	7.36	600	276	167	268	21	32	42	2.1	0	327	14	5	0.63
27	Ganeswarpur	Jajpur	20.891	86.290	6.89	210	84	66	61	14	9	6	0.7	0	74	14	4	0.23
28	Rudhia	Jajpur	20.921	86.274	7.13	310	146	119	131	26	15	10	1.0	0	160	14	1	0.80
29	Bhagatpur	Jajpur	20.885	86.261	6.91	500	258	172	131	44	17	23	6.0	0	160	65	25	0.27
30	Suninda	Jajpur	20.867	86.288	7.13	460	213	158	192	28	24	21	0.7	0	234	19	6	0.55
31	Jajpur town-3	Jajpur	20.837	86.306	7.24	390	189	145	136	37	15	13	1.2	0	166	31	10	0.57
32	Olaipada	Jajpur	20.817	86.298	7.25	450	205	185	182	32	29	11	1.3	0	222	19	4	0.86
33	Sibachhak	Jajpur	20.757	86.298	7.47	580	285	145	253	19	27	55	0.9	0	308	12	20	0.46
34	Arangabad	Bari	20.692	86.360	7.57	500	252	70	192	9	13	70	4.0	0	234	38	3	0.86
35	Upar Kaipada	Bari	20.631	86.403	7.49	2250	1200	194	460	28	34	380	14.0	0	561	459	10	0.57
36	Samdaspur	Jajpur	20.795	86.273	7.5	460	220	172	187	44	17	17	1.0	0	228	24	5	0.49
37	Haripurhata	Rasulpur	20.804	86.233	7.19	320	149	123	111	26	16	9	1.7	0	136	24	5	0.19
38	Chandipur	Rasulpur	20.822	86.193	7.76	380	181	145	141	28	21	13	4.2	0	173	24	6	0.57
39	Gopinathpur	Rasulpur	20.840	86.146	7.59	640	296	211	293	26	40	37	0.5	0	357	14	4	0.58
40	Nathuabar	Rasulpur	20.863	86.112	7.03	300	136	119	111	21	18	8	1.8	0	136	19	1	0.10
41	Barabati	Rasulpur	20.797	86.147	6.99	240	114	79	101	19	9	13	1.3	0	123	12	0	0.19
42	Nilakanthapur	Rasulpur	20.757	86.208	7.05	600	298	132	253	19	23	67	3.7	0	308	34	0	0.33
43	Brahmabarada	Rasulpur	20.738	86.234	7	430	213	101	177	16	17	46	4.5	0	216	24	0	0.42
44	Sankhamatha	Rasulpur	20.777	86.248	7.22	500	236	136	212	28	18	40	0.9	0	259	19	3	0.63
45	Jajpur town-2	Jajpur	20.850	86.330	6.89	420	213	128	131	26	17	26	7.6	0	160	43	15	0.26
46	Karada	Jajpur	20.936	86.253	7.13	450	207	194	187	40	26	7	0.6	0	228	19	3	0.45
47	Barundei	Korei	20.989	86.233	7.23	460	224	167	177	42	17	17	2.2	0	216	29	10	0.45
48	Ichhapur	Korei	21.014	86.225	7.08	370	177	163	167	42	16	6	0.3	0	203	10	3	0.37
49	Ranapur	Korei	21.051	86.203	7.56	1250	592	321	384	28	69	95	0.6	0	468	151	19	1.15
50	Kantor	Korei	21.030	86.168	7.29	780	257	163	198	17	29.1	31	10.5	0	241	38	13	0.54
51	Tulati	Korei	20.996	86.171	7.23	390	181	154	147	38	15.2	8	0.9	0	180	31	0	0.32
52	Pandula	Korei	20.948	86.185	7.22	420	199	158	184	48	10.3	13	0.6	0	224	17	0	0.44
53	Chhotaraipur	Korei	20.915	86.140	7.08	550	281	192	133	52	15.1	29	0.3	0	163	79	26	0.16
54	Badabiruan	Korei	20.882	86.184	7.01	340	163	134	138	38	9.2	10	0.6	0	168	22	1	0.26

55	Taluri(Talunga)	Korei	20.924	86.176	7.05	380	172	144	161	33	15.1	10	0.4	0	196	17	0	0.37
56	Kandarapur	Korei	20.890	86.218	7.03	380	185	158	170	40	13.8	10	0.6	0	208	19	0	0.42
57	Malparha	Korei	20.851	86.207	7.25	350	169	125	147	35	9.3	16	0.4	0	180	17	3	0.55
58	Biruda	Jajpur	20.856	86.246	7.14	710	365	192	244	48	17.4	35	40.2	0	297	57	22	0.25
59	Udayanagar	Dharmasala	20.687	86.227	7.2	1840	838	288	474	36	47.8	247	7.8	0	578	196	21	0.28
60	Krushnadaspur	Badachana	20.629	86.209	7.18	3570	1844	451	294	92	53.5	500	6.8	0	359	967	49	0.28
61	Santipur	Badachana	20.672	86.168	7.16	560	221	125	170	31	11.7	35	2.4	0	208	31	8	0.36
62	Dihakaranda	Badachana	20.628	86.095	7.3	820	410	197	276	35	26.8	78	2.9	0	337	67	35	0.68
63	Palai	Badachana	20.605	86.290	6.87	260	122	106	87	25	10.6	8	1.9	0	107	17	8	0.14
64	Nalipur	Badachana	20.610	86.245	6.8	1280	629	336	405	42	55.9	119	10.0	0	494	160	0	0.15
65	Balikuda	Badachana	20.654	86.294	7.09	1310	648	326	354	46	51.2	120	8.4	0	432	208	3	0.41
66	Ratnagiri	Bari	20.639	86.336	7.13	1230	700	336	336	77	34.9	88	82.0	0	410	148	69	0.29
67	Kharimunda	Bari	20.616	86.359	7.06	5500	3085	494	262	63	81.5	1023	8.0	0	320	1670	82	0.26
68	Sukal	Bari	20.660	86.353	7.21	1640	881	336	202	44	54.8	200	29.7	0	247	400	31	0.10
69	Haladibasanta	Bari	20.685	86.334	7.68	1930	1019	91	437	10	16.3	391	5.0	0	533	313	24	0.76
70	Balia	Bari	20.694	86.299	7.08	680	340	182	170	38	20.8	58	1.1	0	208	101	18	0.11
71	Nahana	Bari	20.711	86.287	7.25	470	234	110	110	12	19.7	45	4.4	0	135	86	0	0.20

3 DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

3.1 Shallow Aquifer (Aquifer-I)

Ground water occurs in phreatic condition in shallow aquifers and is utilized by means of dug wells or shallow tube wells. Generally the depth of the dug wells vary from 4 to 12 m below ground level with average depth of around 7 mbgl. The shallow aquifer is commonly overlain by 3 to 6 meter of silt to clay layer, which necessitates the need for deep dug wells. The diameter of the dug wells varies from 0.5 to 2m. The wells are generally lined to the total depth except in the lateritic aquifer, which is present in the western part of the district. The average depth to water level during pre-monsoon period ranges from 3 to 5 meter. However deep water level condition is found in two pockets: (a)Northern part in Korei block (Raghupur-8 mbgl)

(b) Southern part of study area in Badachana and Bari block along Chhatia-Dhaurlapada-Kharimunda tract.

The pre-monsoon depth to water level map is given in **Fig. 3.1**.Very shallow and water logging condition was observed in the eastern-most part of the area east of Mangalpur to KayanGola on Bitarani floodplain in Dasrathpur block.

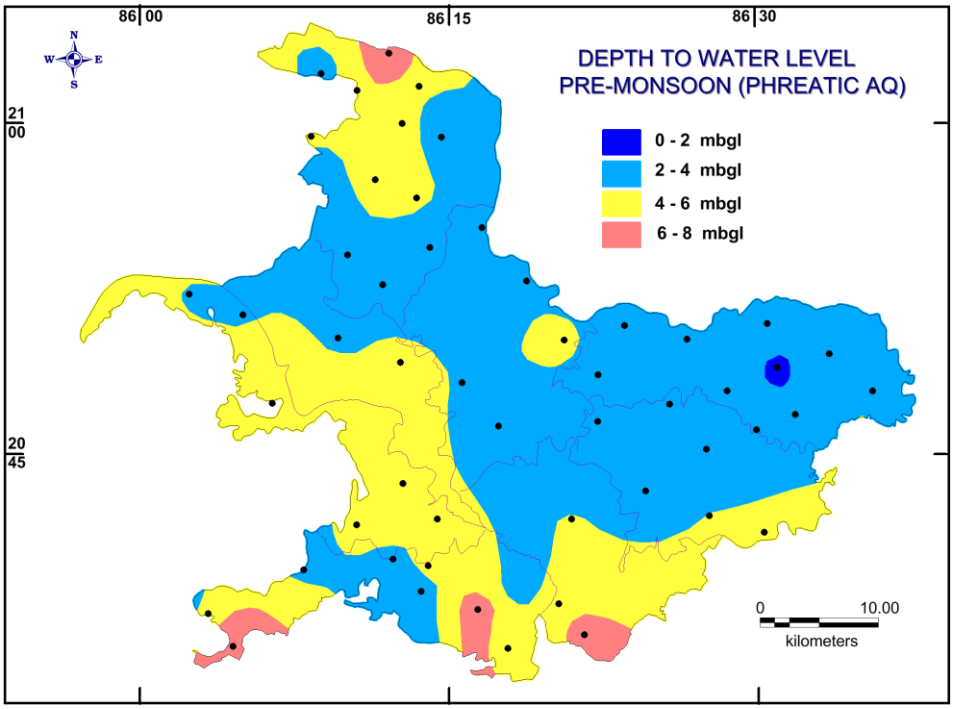

Fig. 3.1: Depth to Water Level in Phreatic Aquifer DuringPre-monsoon

The post monsoon water level remains shallow within 3 m below ground level in most part

of the district. Again Raghupurwell is an exception with depth to water level at 6.5 mbgl. The post-monsoon depth to water level map is given in **Fig. 3.2**.

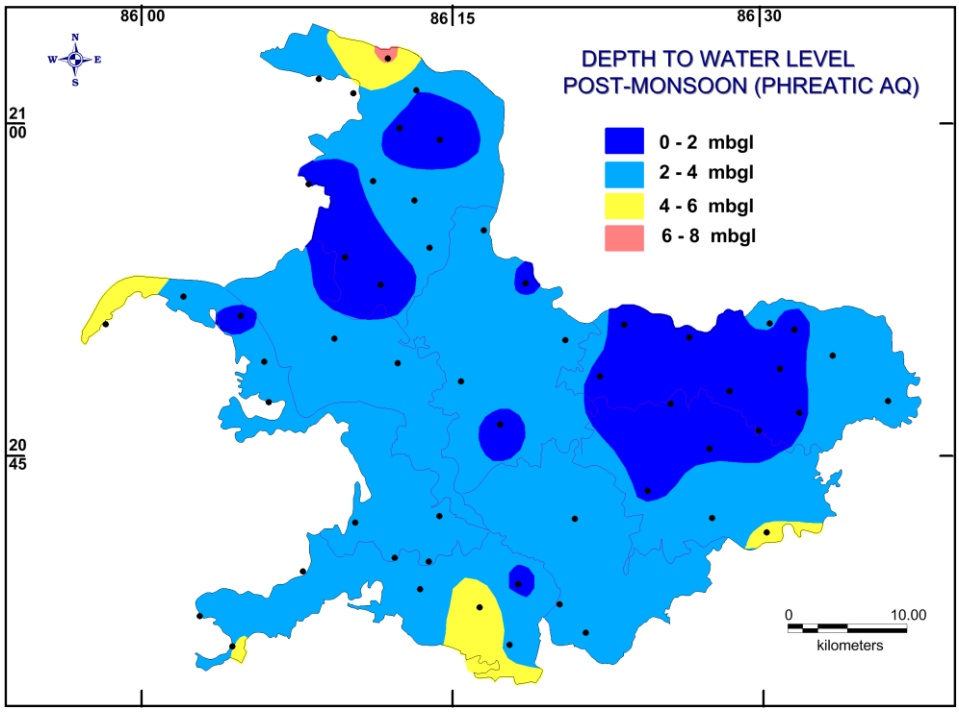

Fig. 3.2: Depth to Water Level in Phreatic Aquifer During Post-monsoon

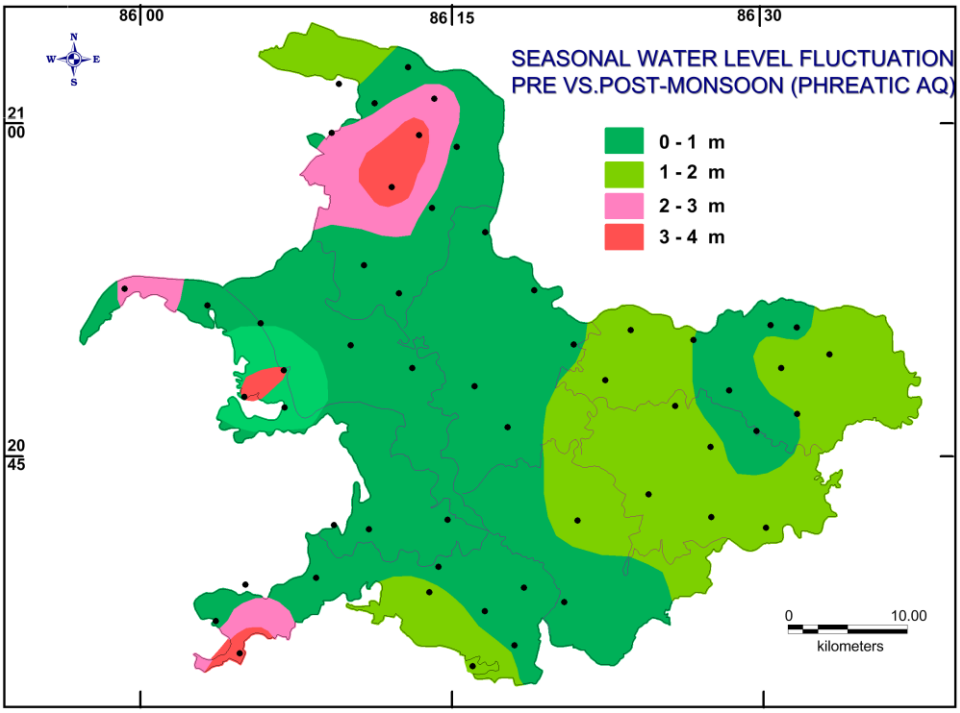

Fig. 3.3: Seasonal Fluctuation in Water Level in Phreatic Aquifer

The seasonal fluctuation in water level was obtained from difference in water level during pre and post monsoon water level. Generally the water level fluctuation between Pre & Post Monsoon seasons varies from 1 to 2m. However higher fluctuation of around 3 to 4 meters is observed in and around Kalinga Nagar area in Korei block, Chhatia area in Badachana block and Antia, Badakaicha in Rasulpur block.The seasonal fluctuation of water level of Aquifer-I is shown in **Fig. 3.3**.

3.2 Deeper Aquifer (Aquifer-II/ III)

Unlike phreatic aquifer, ground water occurs under confined to semi-confined condition in deeper aquifer. The presence of coarse sand and gravels of terrestrial deposit form numerous prolific aquifer system in the study area. Alternate layers of clay and granular formations are the characteristic feature of the coastal aquifer system. To know the disposition of the deeper aquifers the analysis of exploration data, mainly the lithologs, available electrical logs was carried out. CGWB has drilled 16 exploratory wells, 2 observation wells, 3 piezometers and 2 slimholes under exploratory drilling programme till date. In addition to these, it has also drilled 8 tube wells under deposit well drilling programme.

In the alluvial areas, exploratory tube wells were drilled upto a depth of 200 meters tapping multiple sand and gravel horizons. At Singhpur a slim hole was drilled to a depth of319.9 meter which shows the presence of numerous aquifer zones beyond 200 meters which can be tapped as on when required. Crystalline basement was touched at diferent depths in many tube wells constructed in the district. The basement is encountered in Binjharpur, Erbank, Mangalpur, Keruna, Sujanpur, Panikoili and Nalipur at a depth of 84m, 168m, 179m, 163m, 164m, 121m and 127m respectively. Hence the thickness of the sedimentary sequence increases towards south-east. Lithological logs indicate the presence of alternate clayey and sandy layers. The sand and gravel layers are fine to very coarse in texture, more often graded, sub-angular to sub-rounded and grayish white to light yellow in colour. These are mostly quartzo-feldspathic in composition with ferruginous concretions at shallow depths. These granular formations, whose cumulative thickness ranges from 15 to 50 meters, form prolific aquifer in the district. The yield of the tube

wells varies from 2.37 lps to69 lps for a drawdown of 4.2 to 22.3m. The transmissivity value varies from 57.6 m^2/day to as high as 4650 m^2/day.

The district possesses a narrow saline tract in the south-eastern part confined to Binjharpur, Dasarathpur and Bari blocks. Recent drilling at Ruktipat near to Balichandrapur in Badachana block indicated the presence of saline formation in patches much inland. In the Mangalpur-Keruna-Kumardihi tract, the top aquifers down to 90 meter are saline to brackish while the aquifers beyond this depth are fresh. In Binjharpur area the top aquifers upto 48 meters are fresh while the lower aquifers are saline. In Singhpur, the top aquifer upto 20 meter is fresh followed by saline formations upto 90 meters, beyond which again fresh aquifers are existing. The yield of aquifers in the saline tract is very high with more than 40 lps discharge. As the land elevation is 4 to 6 meter above mean sea level, most of the deeper aquifers are in auto-flowing conditions. The deposit wells drilled at Nuapatna and Kumardihi were of auto-flowing in nature. The disposition of deeper aquifers and their hydrochemical profile is the eastern saline tract of the study area is shown in **Table 3.1**.

The piezometric head levels of the deeper aquifer were monitored in 70 tubewells during the pre-monsoon (May/June 2016) and post monsoon (Nov./Dec. 2016) periods in the aquifer mapping area.

During the pre-monsoon period the piezometric levels were in the range of 2.59 to 12.95 mbgl. Most of the area exhibit a water level within 2 to 6 mbgl. Deeper piezometric surface was observed in two distinct patches.

(a) The Kalinganagar area near Jajpur Road in Korei block and and the patch joining Kalinganagar-Panikoili-Jajpur Town three major urbanised area in the district.

(b) The south-eastern extreme of the district connecting Bari-Kaipada-Singhpur covering eastern most parts of Bari and Binjharpur blocks.

The map depicting the depth to piezometric surface of deeper aquifer during pre-monsoon is shown in **Fig 3.4**.

Table 3.1: Disposition of Aquifers and Their Hydrochemical Profile in the Saline Tract in the NAQUIM Area in Jajpur District.

Place	Block	Hydrochemical Profile	Zones Tapped (mbgl)	SWL (mbgl)	Yield (lps)	EC (µS/cm)	Chloride (ppm)
Binjharpur	Binjharpur	0-48 Fresh 52-84 Saline Basement at 89 m	17.4-37.4	0.2	65	640	132
Singhpur	Binjharpur	0-28.5 Fresh 28.5-95.5 Saline 95.5-320 Fresh	126-186				
Kumardihi	Dasrathpur	0-100 Brackish 120-221 Fresh	134-153, 162-190	0.74 magl	57.9	1171	195
Dubakona	Dasrathpur	0-75 Brackish 92-176 Fresh	94-108, 112-119, 123-142, 148-156	0.25	44.6	1038	206
Nuapatna	Dasrathpur	0-75 Brackish 92-176 Fresh	140-164, 176-185	0.4 magl	50	1024	142
Mangalpur	Dasrathpur	0-76 Saline 92-179 Fresh Basement at 179 m	105-120		37	755	82
Keruna	Dasrathpur	0-48 Saline 52-160 Fresh Basement at 163 m					
Kayan Gola	Dasrathpur	20-60 Saline 60-113 Brackish 119-155 Fresh	130-139, 142-148	2.7	9.16		
Atira	Bari	21-50 Fresh 50-111 Saline	33-39, 43-49				
Kaipada	Bari	20-100 Saline 120-147 Marginal 147-155 Fresh 155-173 Marginal 173-194 Fresh	171-180	7.18	2.37	584	112

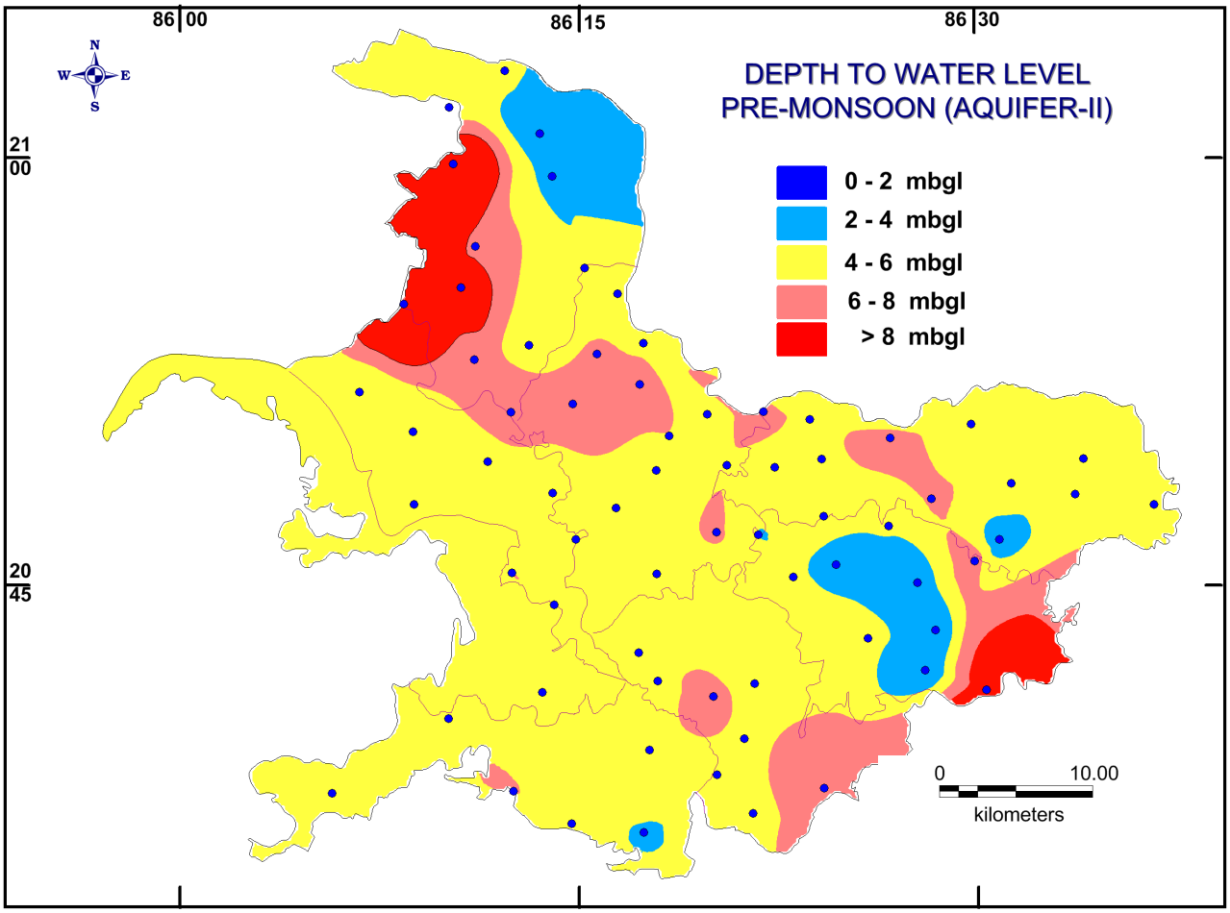

Fig. 3.4: Depth to Piezometric Level in Deeper Aquifer During Pre-monsoon in NAQUIM Area.

During the post-monsoon period the piezometric levels were in the range of 1.9 to 8.0 mbgl. Most of the area exhibit a water level within 2 to 6 mbgl indicating not much fluctuation in the piezometric surface. Deeper piezometric surface was observed in some small patches. The near elimination of deeper patch in the Kalinganagar-Panikoili-Jajpur tract indicates good recovery of piezometric head of the deeper aquifer afterrecharge from monsoon. The map depicting the depth to piezometric surface of deeper aquifer during post-monsoon is shown in **Fig 3.5**.

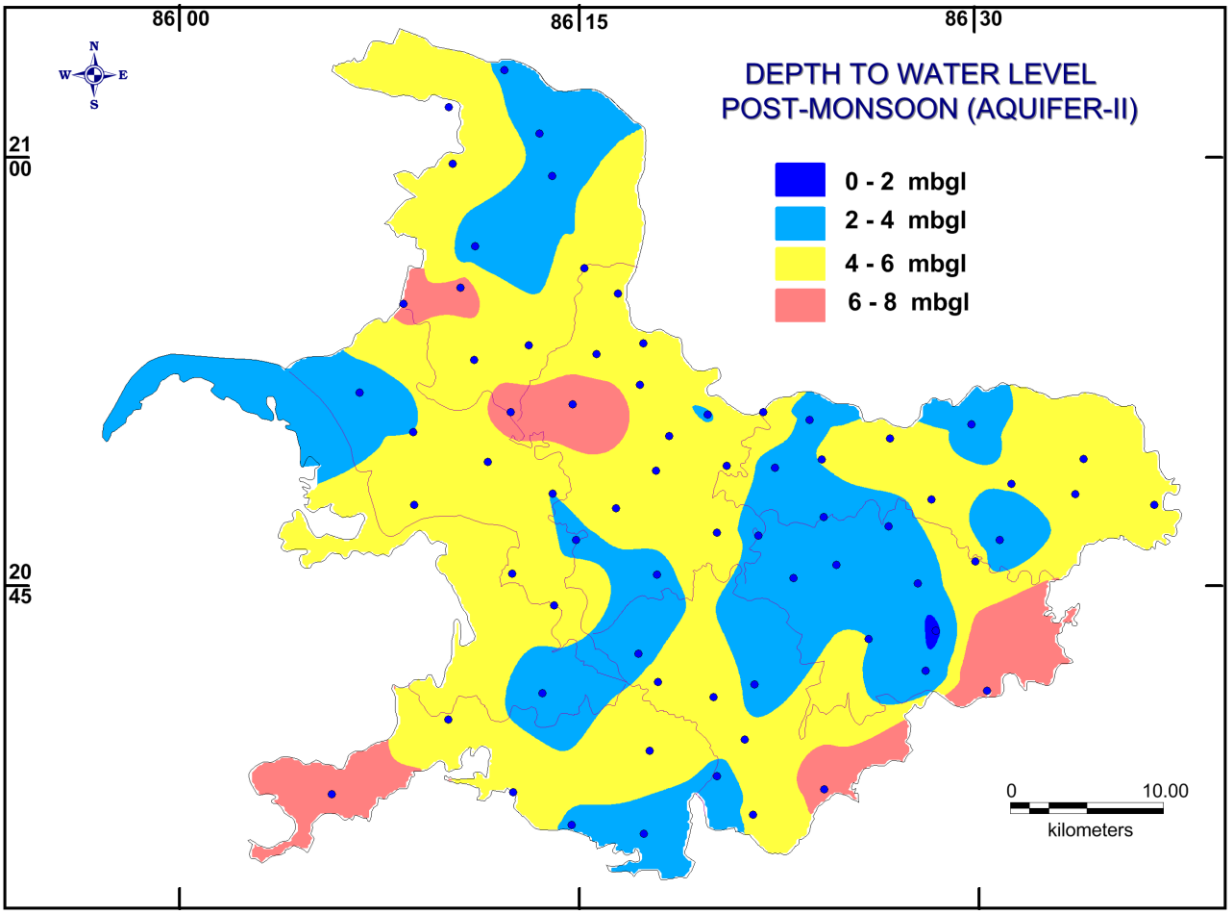

Fig. 3.5: Depth to Piezometric Level in Deeper Aquifer During Post-monsoon in NAQUIM Area.

The seasonal fluctuation in piezometric surface was obtained from difference in depth to water level during pre and post monsoon water level which is shown in the map in **Fig. 3.6**. Out of the 70 tube wells monitored, 63 wells show rise of piezometric surface by around 2m, 4 wells show rise of 3.67 to 6.75 m. Three wells show anomalous fall in water level by 0.06 to 1.5 m. The very low fluctuation of water level is the typical characteristic of coastal alluvial aquifer of odisha state. The higher fluctuation is confined to the western part of Korei block which is in general deeper water level area, where head of deeper aquifer is recover well due to monsoon recharge.

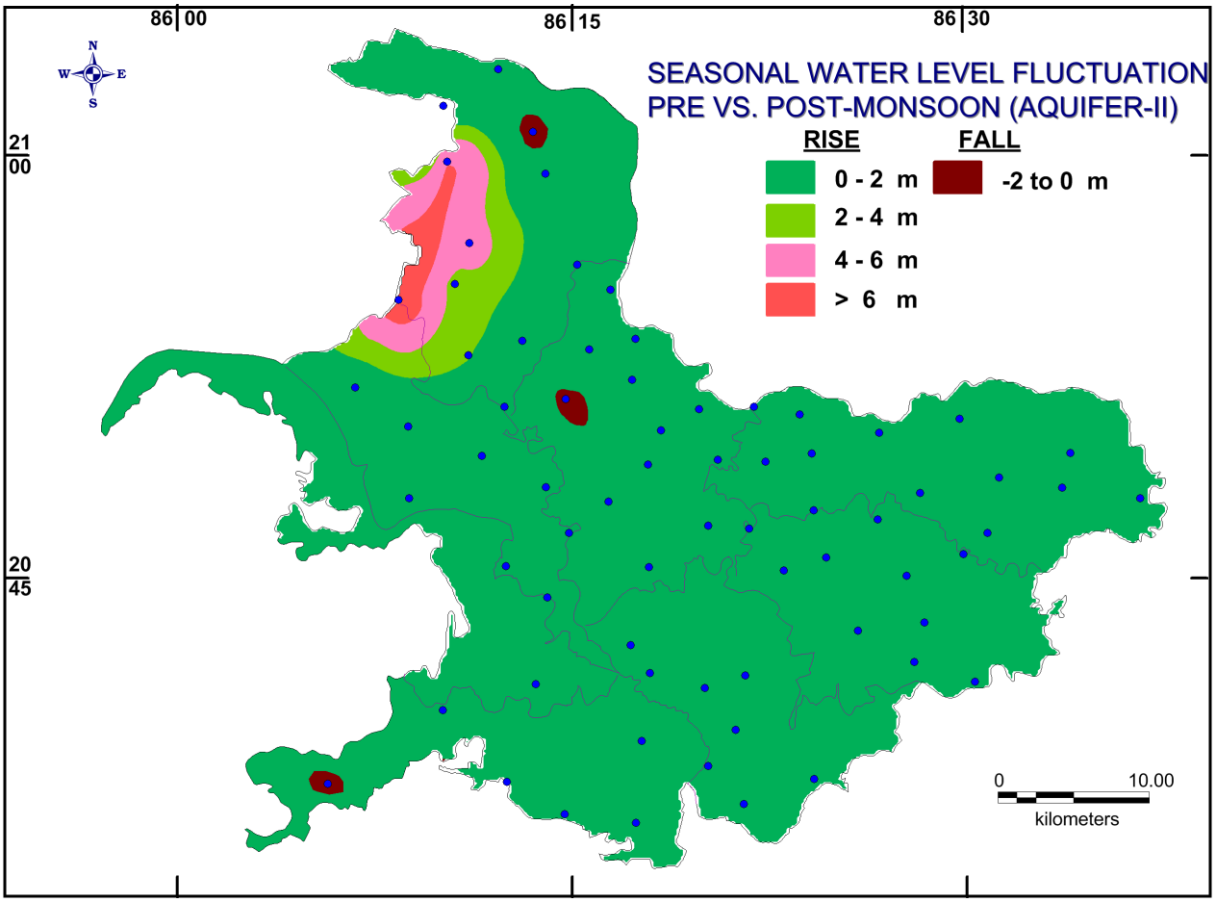

Fig. 3.6: Seasonal Fluctuation of Piezometric Surface of Deeper Aquifer

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, he aquifer wise ranges of different chemical constituents present in ground water, are determined andgiven in **Table 3.2.**

Table 3.2: Aquifer-wise Ranges of Chemical Constituents in NAQUIM Area, JajpurDistrict.

Parameter	Unit	Shallow (Aquifer-I)		Deep (Aquifer-II)	
		Minimum	Maximum	Minimum	Maximum
pH	-	7.01	7.88	6.6	7.79
EC	µS/cm	200	4200	210	5500
TDS	mg/L	169	340	84	3085
TH	mg/L	127	216	66	625
TA	mg/L	90	125	61	601
Ca	mg/L	26	60	9	92
Mg	mg/L	15	23	9	123
Na	mg/L	19	46	6	1023
K	mg/L	1	1.3	0.3	82
CO_3	mg/L	0	0	15	40
HCO_3	mg/L	110	153	74	733
NO3	mg/L	0.23	120	1.1	1.6
Cl	mg/L	43	138	10	1670
SO_4	mg/L	4	30	0	82
F	mg/L	0.6	1.4	.1	1.15 (Ranapur)
SAR	-	0.8	2	0.2	27.5

Based on the chemical analysis of water samples from different sources, it was observed that, almost all chemical parameters lie within permissible limit for drinking and irrigation purpose except few samples of some isolated pockets. The iso-conductivity map of Aquifer I and II has been prepared and presented as **Fig.3.7**and **Fig. 3.8**respectively. The quality of ground water is generally good with EC ranging from 200 to 4200 µs/cm in shallow and 210 to 5500 µs/cm in deeper aquifers. Poor ground water quality with higher EC was observed as an elongated patch covering the eastern parts of Dasarathpur, Binjharpur, Bari&Danagadi blocks which are underlain by thick alluvial formation. The higher value of EC in these areas and their extent is more prominent in **Fig. 3.8**, that is in the deeper aquifers, which indicates that the higher salinity is mostly in the deeper aquifer.

The SAR value of the samples of Aquifer-I ranges from 0 to 12.7. The suitability of the ground water for the purpose of irrigation analysed in the US-Salinity diagram as shown in **Fig. 3.9**. the predominant USSL classes of the water samples fall within C2S1 and C3S1 classes. The water samples represent mixed facies of water, the predominant type being the Na-Ca-Mg-HCO_3-Cl-SO_4 type as shown in the Piper diagram in **Fig. 3.10**. This indicates a transitional or mixing environment between the younger water and resident water.

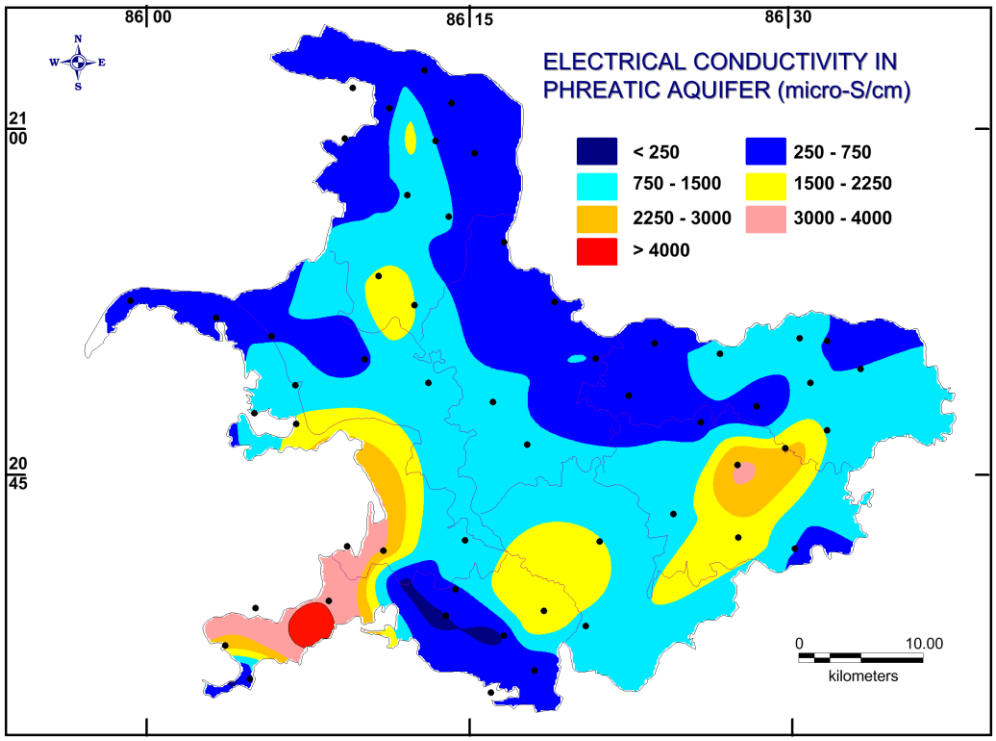

Fig. 3.7: Iso-conductivity Map of Phreatic Aquifer (Aquifer-I) in NAQUIM Area.

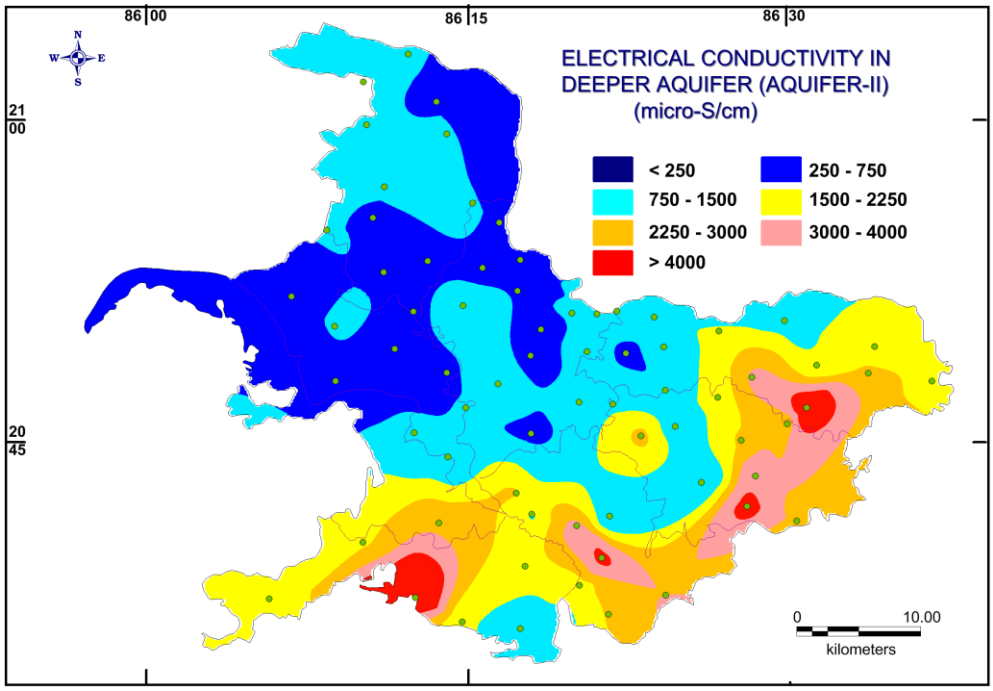

Fig. 3.8: Iso-conductivity Map of Deeper Aquifer (Aquifer-II) in NAQUIM Area

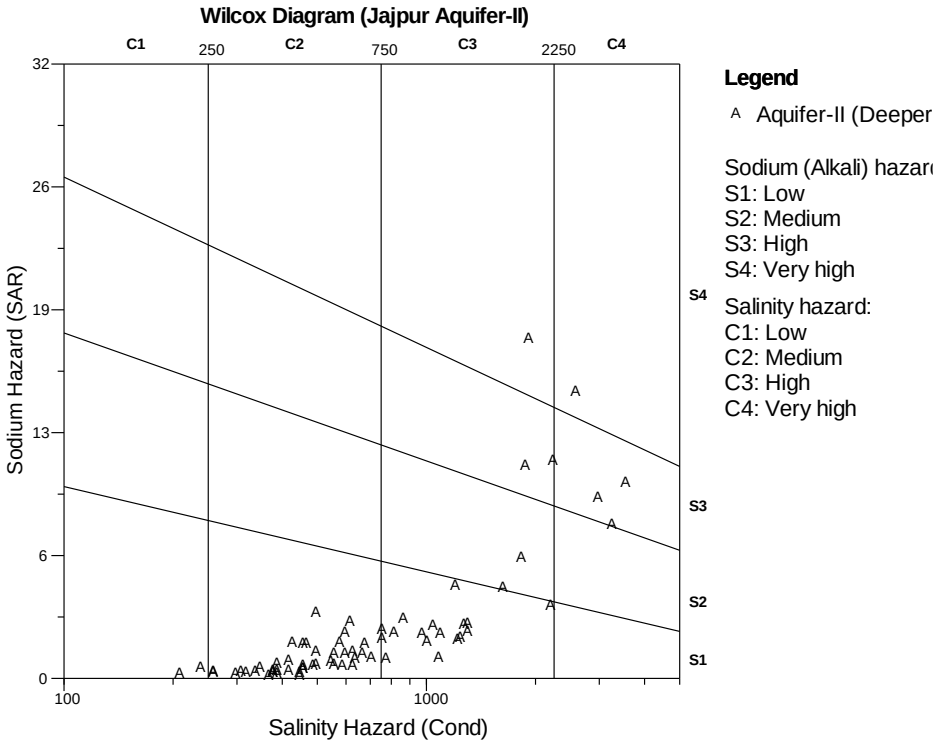

Fig. 3.9: US-SalinityDiagram, Aquifer-II in the NAQUIM Area, JajpurDistrict.

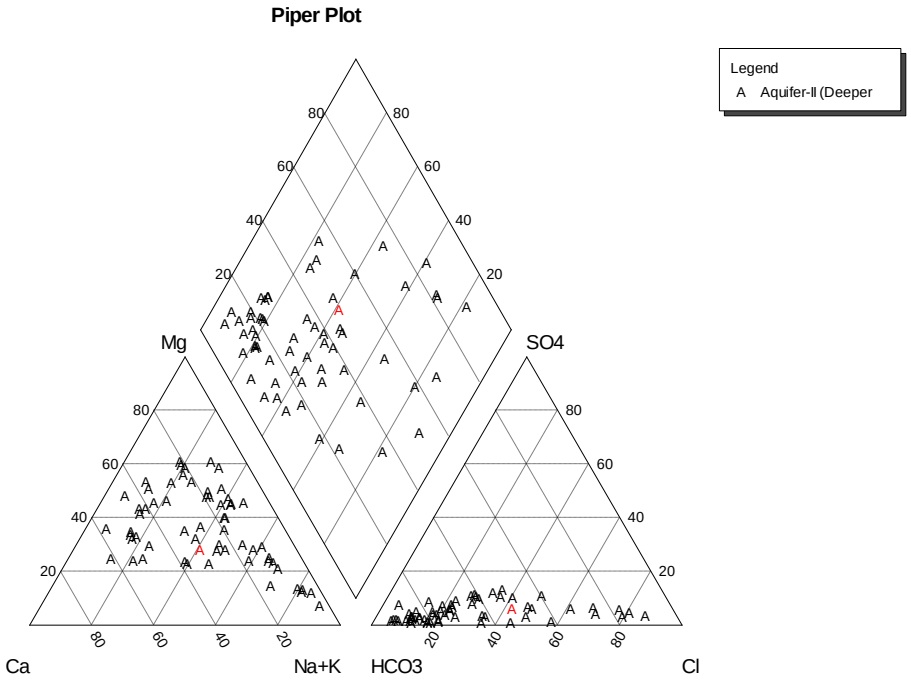

Fig. 3.10: Piper Diagram, Samples of Aquifer-II, NAQUIM Area, Jajpur District

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): occurs in entire area except rocky outcrops. In the alluvial areas covering most part of the NAQUIM blocks, formed by the top few meters of sandy formations.The depth of the top aquifer varies in thickness from 10 m to above 40 m. For the aquifer mapping data gap analysis the unconfined aquifer was classified as **Aquifer Group-I** or **Aquifer-I**and the extent this aquifer groupwas taken down to50 mbgl.

Aquifer-II(Semi-confined to confined aquifer):In the areas of coastal alluvium, multi layered aquifer with alternate sand/gravel and clay zones forms the deeper semi-confined to confined aquifers classified as **Aquifer Group-II** or **Aquifer- II**and the extent this aquifer groupwas taken from depth50 -150 mbgl.

Aquifer-III (Semi-confined to confined aquifer):The deeper alluvial aquifer in semi-confined to confined conditions in the depth range of 150-300 mbgl or more were classified as **Aquifer Group-III** or **Aquifer- III.**

However, as the data on zone-wise yield and aquifer parameters were not available, except for the different depth ranges the Aquifer-II and Aquifer-III are the parts of the same aquifer. The characteristics of the aquifer groups are summarized in **Table 3.3**.

Table 3.3: Characteristics of Aquifer Groups intheNAQUIMArea, JajpurDistrict.

Type of Aquifer	Formation	Depth range (mbgl)	Yield	Aquifer parameter (T : m^2/day)	Suitability for drinking/ irrigation
Phreatic					
Aquifer-I	Alluvial Deposits (Sand/Gravel)	0-50	DW: 25-70 m^3/day Filter Points: 5-15 lps	-	Yes for both (except Salinity affected villages)
Semi-Confined /Confined					
Aquifer-II	Alluvial Deposits (Sand/Gravel)	50-150	2.37-95.3 lps	57.6-4650	Yes for both
Aquifer-III	Alluvial Deposits (Sand/Gravel)	150-300 or more			

3.5 Aquifer Disposition

The ground water exploration data has been used to generate the 3D disposition of deeper alluvial aquifers. It comprises of all existing litho-units and the zones tapped during the ground water exploration, forming an aquifer. Based on the ground water exploration and micro-level hydrogeological survey data and aquifer delineation method,a schematic 3-D aquifer disposition has been prepared and shown in **Fig. 3.11** and three 2D schematic sections were drawn along section lines A-B, C-B and D-E are shown in plan view in **Fig.3. 12** and the 2D sections are shown in **Fig. 3.13**, **Fig. 3.14** and Fig. **3.15**.

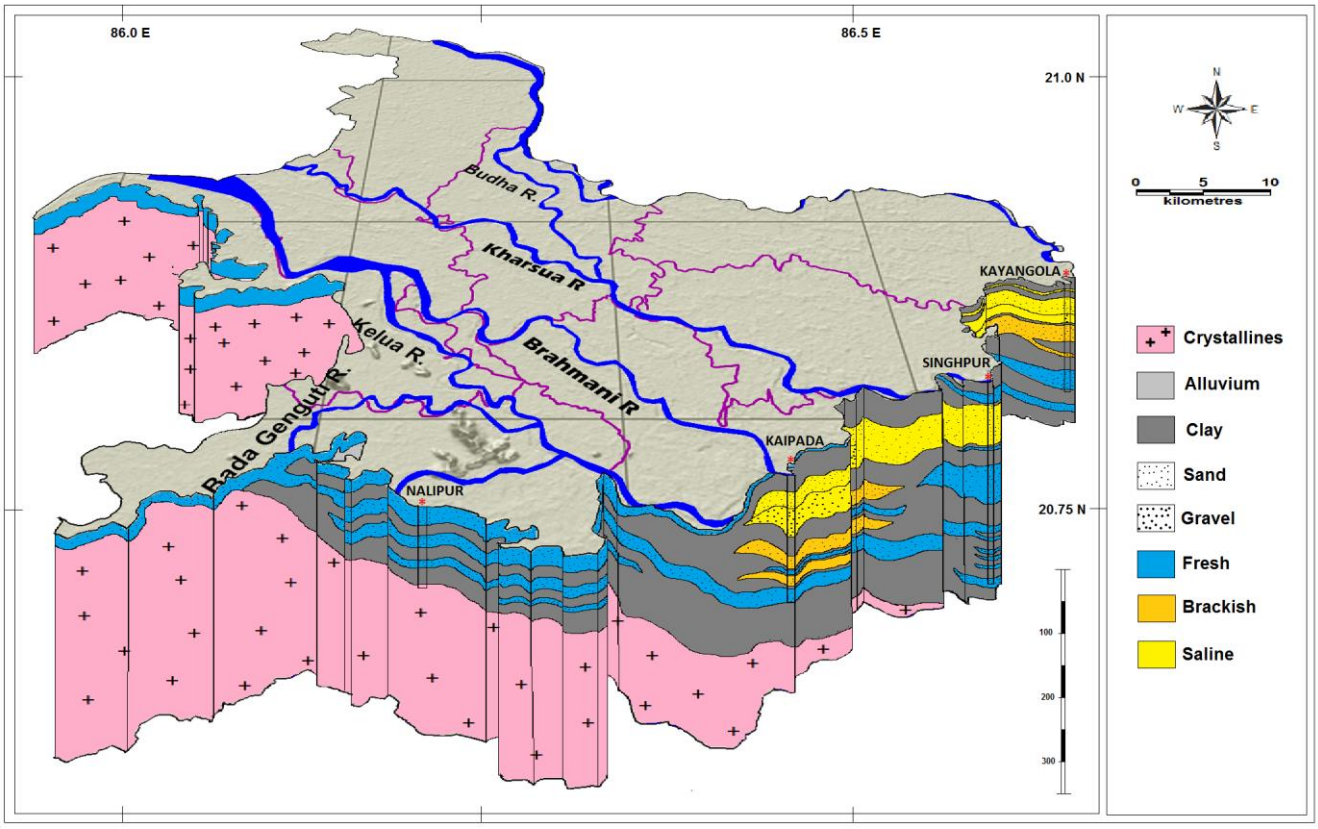

Fig. 3.11: Schematic 3D Aquifer Disposition in NAQUIM Area, Jajpur District.

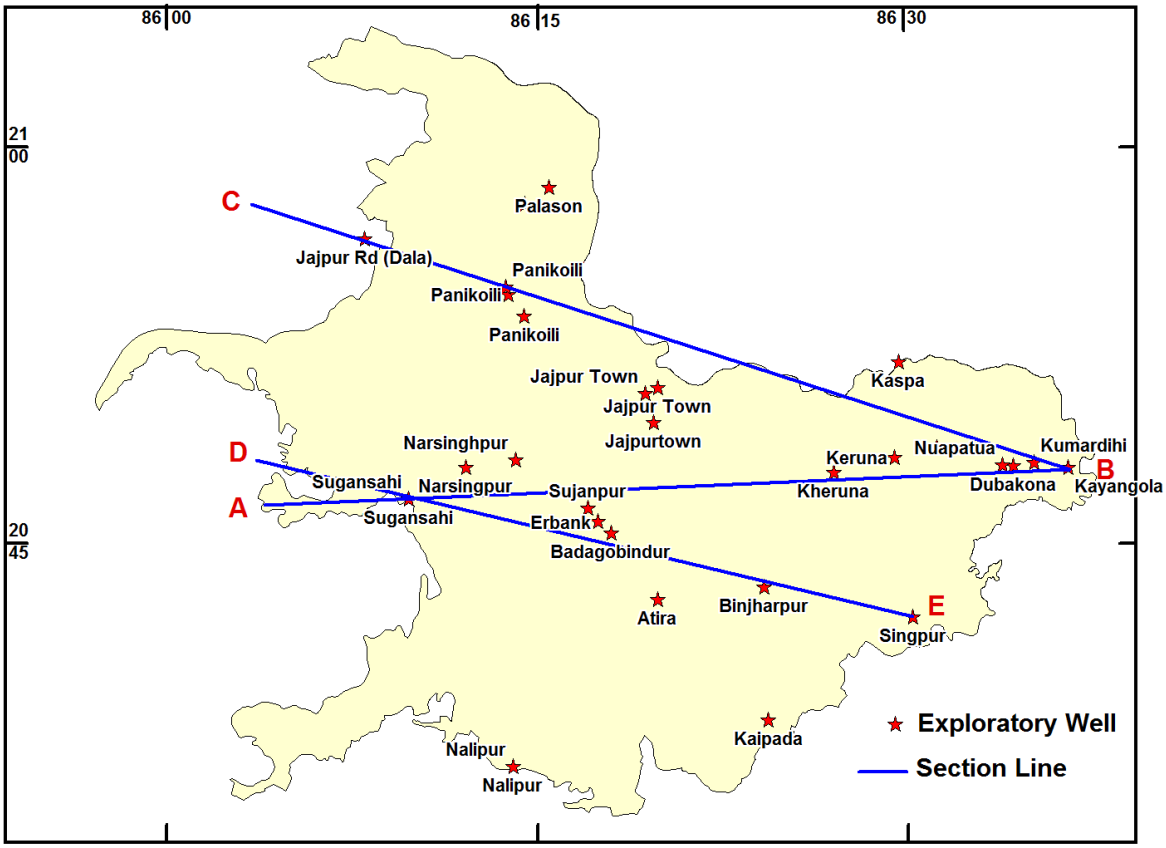

Fig. 3.12: Aquier Section Along Lines A-B, C-B and D-E in Plan View.

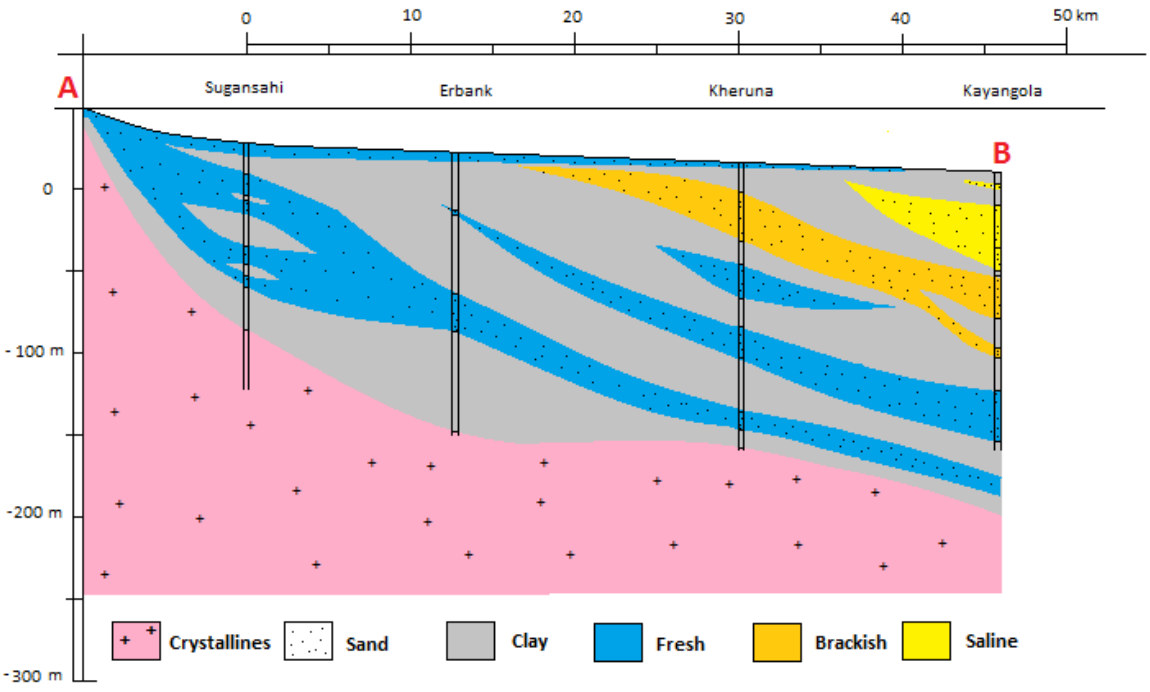

Fig. 3.13: Schematic Aquifer Cross-Section Along A-B in NAQUIM Area in Jajpur District.

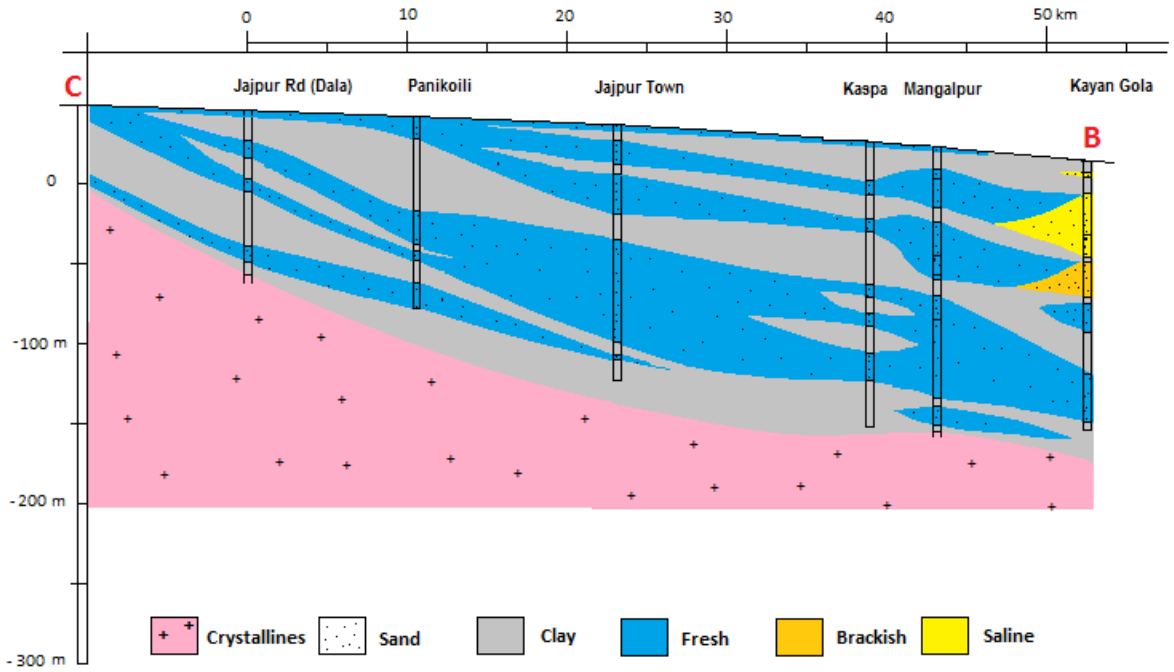

Fig. 3.13: Schematic Aquifer Cross-Section Along C-B in NAQUIM Area in Jajpur District.

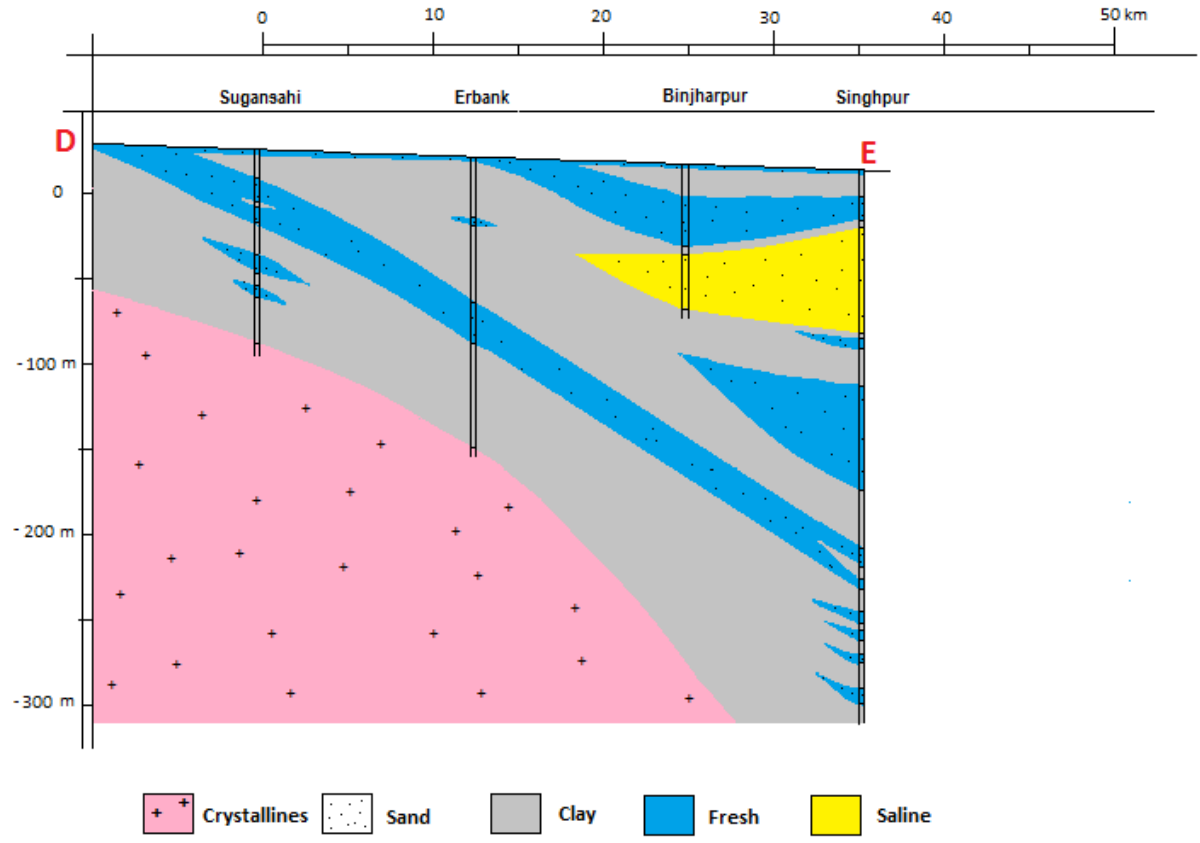

Fig. 3.14: Schematic Aquifer Cross-Section Along D-E in NAQUIM Area in Jajpur District.

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.**

Table4.1: Dynamic Ground Water Resources of Aquifer-I, NAQUIM Area, JajpurDistrict (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	Provision for domestic & industrial requirement supply for next 25 years	Net Ground Water Availability for future irrigation development	Stage of Ground Water Development
		(Ham)	(Ham)	(Ham)	(Ham)	(Ham)	(Ham)	(%)
1	Badachana	7926.61	3464.5	690.42	4154.92	714.89	3697.36	52.42
2	Bari	4973.79	1932.35	427.58	2359.93	435.57	2583.91	47.45
3	Binjharpur	5139.37	2300.29	493.05	3037.74	472.87	2332.22	54.35
4	Dasrathpur	5087.54	2234.64	547.55	2782.19	552.01	2271.46	54.69
5	Dharmasala	5933.67	2798.92	622.01	3420.93	670.62	2464.13	57.65
6	Jajpur	6892.39	3795.51	584.82	4380.33	601.48	2460.78	63.55
7	Korei	8593.3	6599	638.02	7237.02	690.58	1259.47	84.22
8	Rasulpur	3753.81	2128.32	480.39	2608.71	504.33	1121.16	69.49
	Total	**48300.48**	**25253.53**	**4483.84**	**29981.77**	**4642.35**	**18190.49**	**62.07**

Among the NAQUIM blocks, Bari, Binjharpur and Dasrathpur blocks have partly poor ground water quality areas with occurrence of brackish to saline aquifers. As per the resource

estimation methodology calculation for fresh and poor water quality areas were computed separately and then the combined resource is shown in the table above. The combined net ground water available is 48300.48 Ham and gross annual draft is 29981.77 Ham. The stage of ground water development is minimum for Bari which is 47.45%. The highest ground water development is in Korei block that is 84.22 % which is in Semi-Critical category. All other blocks are under Safe category. The average depth of phreatic or unconfined aquifer was taken as 11 mbgl for all eastern blocks except for Badachana blocks towards the west which are partly covered with hard rock aquifers and river born sediments. The thickness here was taken as 100 mbgl. 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 mostly in the western parts of the coastal alluvium 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.

Table4.2: In-Storage Ground Water Resources of Aquifer-I, NAQUIM Area, Jajpur 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	Badachana	36234	100	4.36	4.78	0.04	6930.84
2	Bari	18102	11	4.58	6.42	0.08	9297.18
3	Binjharpur	19382	11	4.48	6.52	0.08	10109.65
4	Dasrathpur	19382	11	2.95	8.05	0.09	14042.26
5	Dharmasala	32411	11	5.26	5.74	0.04	7441.57
6	Jajpur	21704	11	5	6	0.08	10417.92
7	Korei	32818	11	6.21	4.79	0.05	7859.91
8	Rasulpur	16156	11	4.32	6.68	0.08	8633.77
	Total	**196189**					**74733.1**

Table4.3: Total Ground Water Resources of Aquifer-I, NAQUIM Area, Jajpur District (2017)

Sl No	Block	Dynamic Resource	In Storage Resource	Total Ground Water
1	Badachana	7926.61	6930.84	14857.45
2	Bari	4973.79	9297.18	14270.97
3	Binjharpur	5139.37	10109.65	15249.02
4	Dasrathpur	5087.54	14042.26	19129.8
5	Dharmasala	5933.67	7441.57	13375.24
6	Jajpur	6892.39	10417.92	17310.31
7	Korei	8593.3	7859.91	16453.21
8	Rasulpur	3753.81	8633.77	12387.58
	Total	**48300.48**	**74733.1**	**123033.58**

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

Table4.4: In-Storage Ground Water Resources of Aquifer-II, NAQUIM Area, Jajpur District (2017)

Sl No	Block	Assessment Area	Storativity	Pre-monsoon PZ Head	Bottom of top confining layer	Difference(4-3)	In StorageGW Resources (1)*(2)*(5)
		(Ha) (1)	(mbgl) (2)	(mbgl) (3)	(m) (4)	(m) (5)	(Ham) (6)
1	Badachana	0				0	0
2	Bari	18102	0.00024	4.58	80	75.42	327.66
3	Binjharpur	19382	0.0002	4.48	80	75.52	292.75
4	Dasrathpur	19382	0.00016	2.95	120	117.05	362.99
5	Dharmasala	32411	0.0001	5.26	40	34.74	112.6
6	Jajpur	21704	0.0002	5	40	35	151.93
7	Korei	32818	0.00016	6.21	40	33.79	177.43
8	Rasulpur	16156	0.00016	4.32	40	35.68	92.23
	Total	**159955**					**1517.59**

5 AQUIFER MANAGEMENT PLAN

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

5.1 Ground Water Related Issues

5.1.1 Water Logging Problem

The alluvial area in the eastern half of the district is drained by network of rivers and their distributaries like Baitarani, Brahmani, Kharsua and Birupa etc. The district is flood prone and during the rainy season low lying areas are frequently flooded. But there are certain areas which are under water logging conditions throughout the year. The area in the eastern part of Dasrathpur block spreading from east of Nizampur to Kayan Golais always water logged. There are also other patches in the river flood plains where due to inadequate surface drainage, water logging frequently happens.

5.1.2 Salinity in Deeper Aquifer

The district possesses a narrow saline tract in the south-eastern part confined to Binjharpur, Dasarathpur and Bari blocks. Presence of saline formation has been traced much inland near Balichandrapur in Badachana block. In the northern part of district along Mangalpur-Keruna-Kumardihi tract, the saline to brackish aquifer is the thickest and lying above fresh water aquifer. Towards south the thickness of brackish aquifer reduces and is both over- and underlained by fresh water aquifers.

5.1.3 Excessive Ground Water development in Korei, Rasulpur and Jajpur Blocks

The ground water development has been significantly higher in these three blocks as compared to the other blocks. The percentages of ground water development are Korei 84.22% (semi-critical), Rasulpur 69.49% and Jajpur 64%. The impact of excessive ground water pumping

has already been reflected in water level depletion in the areas. The decline in water level in phreatic aquifer is not quite noticeable. But the piezometric level in deeper aquifers was found to be deeper in these areas in comparison to the entire district. The urban and semi-urban cetres are located in these block viz. Jajpur-Town, Jajpur-Road (Korei) and Kuakhia. The water requirement in thse areas are mainly met through ground water pumping.

5.2 Aquifer Management Plan

A through study was carried out based on data gap analysis, data generated in-house, data acquired from State Govt. departments and maps procured from GSI and other sources, an integrated approach was adopted while preparing aquifer management plan of the NAQUIM area of Jajpur district. Based on this, geomorphology, soil, land use, field data, lithological information and ground water related issues, aquifer management plan was prepared.

5.2.1 Management Plan for Water Logging

There are areas where due to excessive canal seepages and return flow water logging occurs. To prevent the same the canal water should be controlled or restricted in such areas, which will help in minimizing the water logging and at the same time tail end parts of command get adequate irrigation water. In the areas under water logging ground water development should be accelerated or conjuctive water use should be promoted so that water level goes down and irrigation requirement also met. There are certain areas in the district, water logging is caused by the trapped rain and flood water can not be easily drained due to low topographic gradient. The existing surface drainage network in such areas, should be improved substantially. The contribution of canal commands to water logging problem should be studied in detail. This will help not only to minimize the menace of water logging but also to avoid accumulation of salinity in the ground water regime.

5.2.2 Management Plan for Salinity in Deeper Aquifer

The eastern parts of the alluvial area in the district exhibit the salinity problem. There are three distinct patterns of hydrogeochemical regime observed in the deeper aquifers viz. (a) top saline/brackish followed by fresh, (b) top fresh followed by saline/brackish and (c) alternate fresh and saline/brackish multi-aquifer system. These different aquifer layers are separated by

intermediate clay zones. In the water samples collected from the govt Mark-II handpumps in the area, the highest EC has been observed in excess of 5000 µS/cm. The higher EC in these tubewells are due to faulty well assembly or due to improper cement sealing causing leakage of saline water from top or bottom. Thus while constructing a tubewell tapping the deeper aquifer, the well bore should be properly cased and cemented, while tapping fresh aquifer adequate margin should be given at top and bottom of the slotted pipe and fresh aquifer should be totally insulated from brackish aquifer through quality cement sealing. For accurately inferring the formation water quality, electrical logging should be essentially done after drilling.

5.2.3 Management Plan for Excess Ground Development in Korei, Rasulpur and Jajpur Blocks

The percentages of ground water development are Korei 84.22% (semi-critical), Rasulpur 69.49% and Jajpur 64%. It was observed that the contribution of irrigation to the total ground water draft is 91.18%, 81.69% and 86.65% respectively in these blocks. From this it is obvious that the major ground water utilization is for irrigation in the area. Hence to reduce the load on ground water utilization. Secondly except Jajpur block there is no canal irrigation in the other two blocks. The following management plan has been suggested:

1. No demand side intervation is required.
2. Further development of ground water for irrigation should be immediately stopped.
3. Surface water sources should be utilized for irrigation through lift water irrigation schemes from rivers Brahmani and Baitarani.
4. Schemes of artificial recharge and water conservation structures should be prioritized.
5. Construction of 11 percolation tanks, 36 check dams and 120 farm ponds can be done.
6. Contour trenching can be done in the topographically higher areas in the adjacent blocks which are the catchment areas.

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

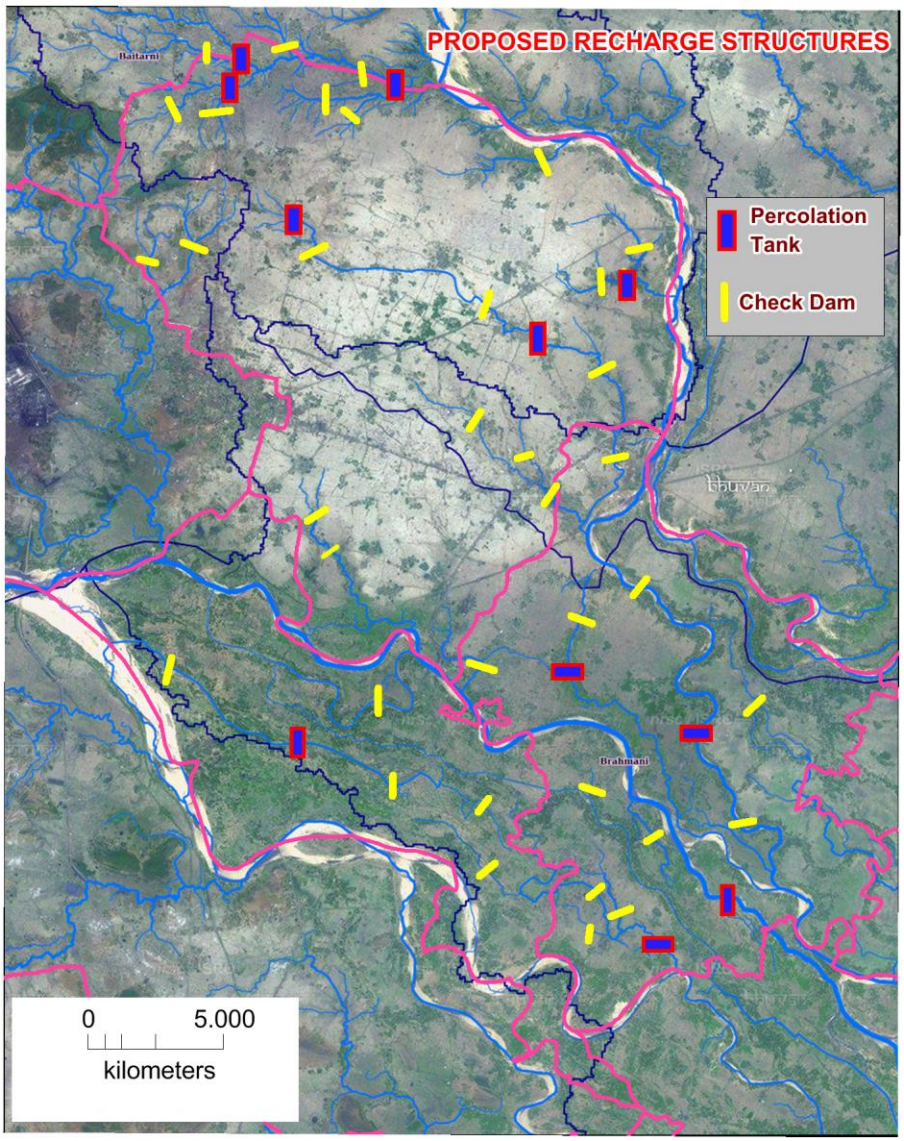

Fig. 5.1: Proposed sites for Artificial Recharge Structures.

5.2.4 Ground Water Development Possibilities in Paleochannels

There are a lot of paleochannels in the study area which are formed due to shifting of river channels in the past. These paleochannels include cut off river channels and ox-bow lakes which consist of sandy and gravelly river sediments. These are ideal source of fresh water which can be tapped through dug wells and shallow tube wells or filter points. A map of the existing paleochannels has been prepared and shown in **Fig. 5.2.**

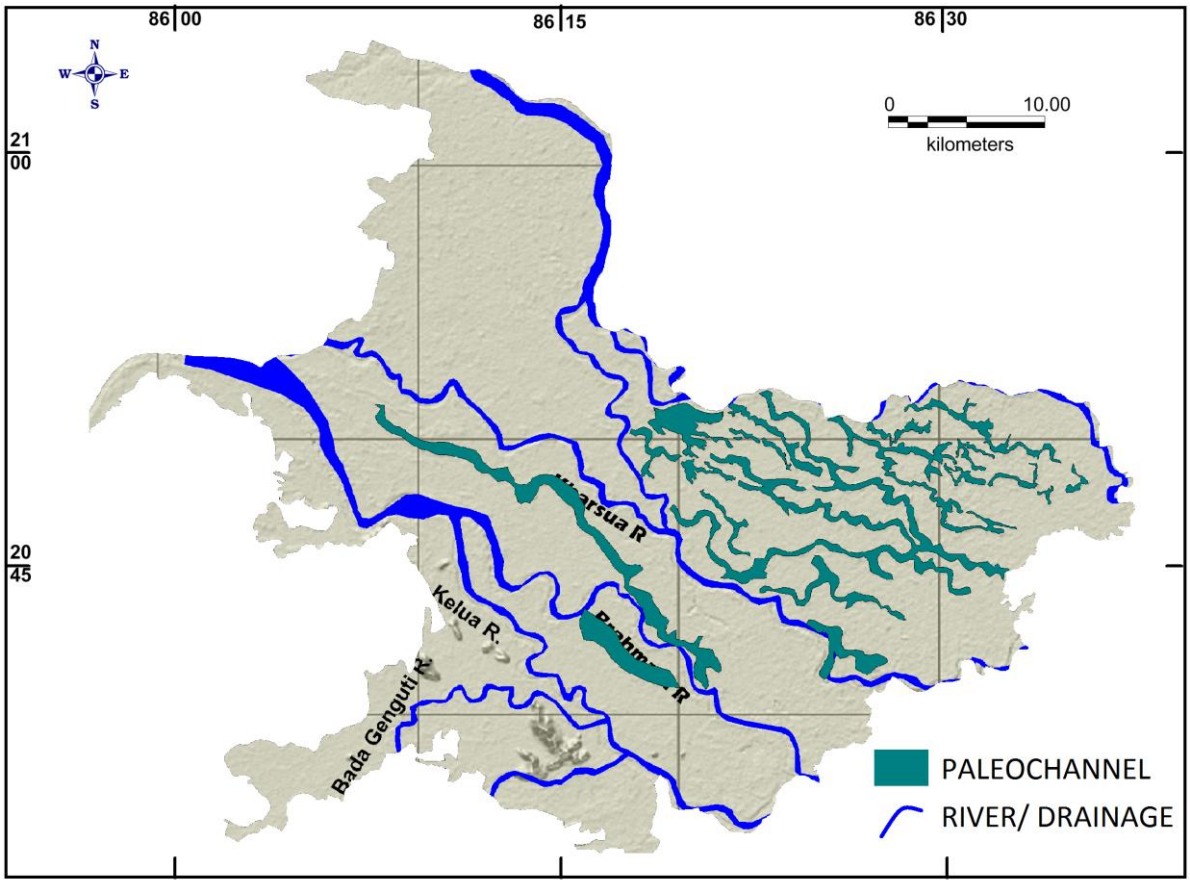

Fig. 5.2: Paleochannels in NAQUIM Area in Jajpur District.

6 SUMMARY AND RECOMMENDATIONS

6.1 Summary

National Aquifer Mapping Programme (NAQUIM)were taken up for detailed hydrogeological investigation, data-gap analysis and Aquifer Mapping in the coastal alluvial tract covering full or part of eight blocks of Jajpur districtnamely Badachana, Bari, Binjharpur, Dasrathpur, Dharmasala, Jajpur, Korei and Rasulpur covering an area of 1934 sq. km., during the period 2016-2017. The following are the summarised details.

1 The study area lies between 85°57'07" E and 86°37'35" E longitudes and 20°34'41" N and 21°04'32" N latitudes under the SOI Sheet Numbers 73G, 73H, 73K and 73L.

2 Data gap analysis was carried out in the area and further data acquisition is planned accordingly.

3 The average rainfall of the district is 1610.2 mm out of which monsoon rainfall is 1207.6 mm and non-monsoon rainfall is 402.6 mm.Normal rainfall has been received in 60% to 80 % of the years during the period 1988-2017.

4 The district is composed of three geomorphic units viz. residual and denudational hills, shallow to medium buried pediments and alluvial plains.

5 The area covered by forest in the district is 25% of total geographical area of 3205.8 km^2. The net area sown is 46% with croppiong intensity of 186%.

6 Four types of soil are found in the district viz. Alfisols, Ultisols, Vertisols and Entisols.

7 The irrigation potential in the district is met through both surface and ground water. Total utilisable irrigation potential is 2.129 BCM out of which surface water potential is 1.599 BCM and ground water potential is 0.529 BCM. There are two major irrigation projects viz. High level canal (Mahanadi-Birupa barrage) and Baitarani system. Total irrigated area in the eight NAQUIM blocks is 64786 Ha during kharif and 56198 Ha during Rabi.

8 The district is underlain by various rocks of Iron-Ore Super Group, Easternghat Super Group and Quarternary alluvium and laterites.

9 The older alluvium consisting of sand and gravel with calcareous concretions occupies the western portion of the alluvial tract. The younger alluvium towards the east consists of sand, clay, gravel, pebble etc.

10 The alluvial formations form the most prolific aquifers and ground water occurs in pheatic condition in shallow sandy aquifers and in semi-confined to confined condition at greater depth. Alternate layers of sand/gravel and clay forms multi-aquifer system in the area.

11 In alluvium, the yield of shallow and filter point tube wells varies from 5 to 15 lps. Transmissivity of the shallow aquifers varies from 234 to 3112 m^2/day. The yield of medium deep tube wells in older alluvium varies from 20 to 40 lps whereas in younger alluvium the yield of medium to deep tubewells may go beyond 40 lps to upto 90 lps or more. The transmissivity of deeper alluvial aquifers varies from 393 to 4650 m^2/day.

12 In the south eastern part saline aquifers are seen. In Kumardihi-Mangalpur-Keruna-Kayangola tract saline ground water overlies fresh ground water and extends till 90 to 118 mbgl. At Binjharpur the fresh aquifers exist upto 48m followed by saline aquifers. At Singhpur fresh water is seen upto 20m and again beyond 90m with saline water in between. At Kaipada fresh water aquifer is tapped from 147-155 mbgl and then from 173-194 mbgl.

13 The average pre-monsoon water level in the shallow aquifer is between 3-5 mbgl and the pre-monsoon piezometric level of the deeper aquifer ranges between 2.5 to 12.6 mbgl with average of 4-6 mbgl. During the post-monsoon period the piezometric levels were in the range of 1.9 to 8.0 mbgl. The water table rises at most 2 m during the post monsoon in shallow aquifers.

14 The chemical quality of ground water both from shallow and deeper aquifers are good and can be suitably utilised for all purposes.

15 The estimated dynamic ground water resource is 52048 Ham and the stages of development of ground water range from 47.45 to 84.22 %.The ground water development is most inthe blocks Korei, Rasulpur and jajpur blocks.

6.2 RECOMMENDATIONS

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

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

2 Piezometric nests should be constructed at various pockets in the district to closely monitor the level of development of different alluvial aquifers regularly.

3 Aquifer Performance test for each prolific aquifer should be carried out to deduce the safe spacing of tubewells to avoid interference.

4 In the town and industrial areas ground water development to be restricted and conjuctive use of ground and surface water should be planned. Surface water sourcing from rivers and irrigation canals should be explored.

5 An intensive network of ground water monitoring stations should be established in the command areas to monitor the changes in ground water regime consequent to application of surface water and to assess the extent of areas under water logging.

6 The surface drainage system should be improved in the water logging areas and ground water utilization enhanced.

7 Paleochannels to be mapped and explored in detail and their ground water potential to be utilized.

8 Artificial recharge projects may be taken up in the district especially in hard rock areas for augmentation of ground eater resources throughconstruction of percolation tanks, check dams, contour bundings and farm ponds.

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

10 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.

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