केन्द्रीय भूमि जल बोर्ड

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विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board

Department of Water Resources, River Development and Ganga Rejuvenation,

Ministry of Jal Shakti

Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

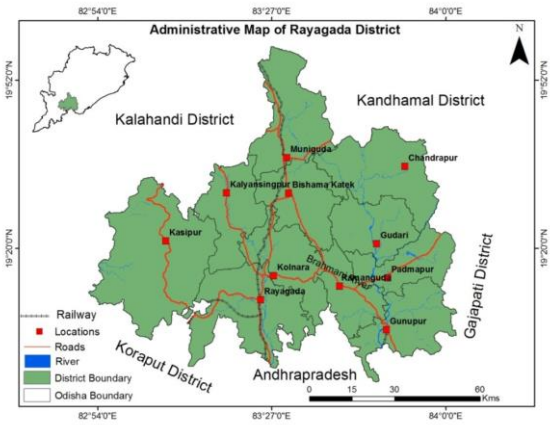
Rayagada District
Odisha State

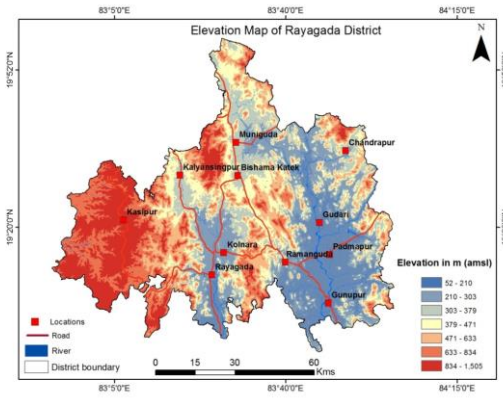
दक्षिण पूर्वी क्षेत्र, भुवनेश्वर

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 RAYGADA DISTRICT, ODISHA





CENTRAL GROUND WATER BOARD
South Eastern Region, Bhubaneswar
JUNE -2022

FORWARD

Rayagada is the 8th district in terms of size and also 21st in terms of population in the State of Odisha. The district has very low density of human population. Among them Schedule Tribe constitutes about 56% of the total population. The important tribal communities are Kondhas and Souras. The district is having 7073 sq. kms of geographical area (4.54% of state area) with 11 developmental blocks. The average literacy rate of the district is very poor and is about 49 %. Nearly 94% of the inhabitants are rural based and depends on agriculture for livelihood. The district receives good amount of rainfall of about 1030 to 1570 mm. The district is underlain by consolidated hard rock formation of the Eastern-ghat group of rocks, mostly Khondalite, Charnockite and Granites. Managing the existing groundwater resource is the prime challenge especially in the highly elevated areas before the authority. The agrarian development of the district can be boosted by tapping these enormous groundwater resources through dug wells, medium-deep bore wells.

The present stage of groundwater development is only 29.57%, leaving a vast scope for future groundwater development in the district. Judicious utilization of groundwater can ensure increased agricultural production, decreased drinking water scarcity, and enhancement of the industrial sector.

The study area includes eleven blocks of Rayagada district viz. Bisam- Cuttack, Chandrapur, Gudari, Gunupur, Kalyansinghpur, Kashipur, Kolnara, Muniguda, Padampur, Ramnaguda, Rayagada covering total geographical area of 7073 sq. km. 4301 sq. km of the mappable area of the district has been studied under National Aquifer Mapping and Management Plan (NAQUIM) during AAP 2021-22. An attempt has been made in this report to compile all relevant information collected through field investigation and earlier hydro geological studies taken up in the district. **Smt. Sumita Sarkar, Scientist- 'B' & Miss Purba Bera, Scientist- 'B'**, jointly have compiled and prepared the present report on **"Aquifer Mapping and Management Plan of Rayagada District, Odisha."** Their sincere efforts in the execution of this report will no doubt be very useful and beneficial for the district. It is hoped that it will be of immense help to different groundwater user agencies, administrators, and planners in preparation for groundwater development plans and will be a handy tool in the effective management of groundwater resources in the district.

Place: Bhubaneswar
Date: 06/06/2022

6/6/2022

(P K Mohapatra)
Regional Director

CONTRIBUTION

1.	**Data Generation**		
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	b.	Exploration	Outsourcing
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2.	**Map Preparation**		Sh. Litan Mohanty, Young Professional
3.	**Report Writing**		Smt. Sumita Sarkar (Sc B) Miss Purba Bera (Sc B)
4.	**Supervision**		Dr. B K Sahoo (Sc E)
5.	**Overall Supervision**		Sh. P K Mohapatra (Regional Director)

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1. INTRODUCTION

1.1 Objectives

Aquifer mapping can be defined as a scientific process, wherein a combination of geologic, geophysical, hydrologic and chemical field and laboratory analyses are applied to characterize the quantity, quality and sustainability of ground water in aquifers. Systematic aquifer mapping is expected to improve our understanding of the geologic framework of aquifers, their hydrologic characteristics, water levels in the aquifers and how they change over time, and the occurrence of natural and anthropogenic contaminants that affect the potability of ground water. Results of these studies will contribute significantly to resource management tools such as long-term aquifer monitoring networks and conceptual and quantitative regional ground-water-flow models used planners, policy makers and other stakeholders. Aquifer mapping at the appropriate scale can help prepare, implement and monitor the efficacy of various management interventions aimed at long-term sustainability of our precious ground water resources, which, in turn, will help achieve drinking water security, improved irrigation facilities and sustainability in water resources development in the country as a whole. Various on-going activities of Central Ground Water Board, such as ground water monitoring, ground water resource assessment, artificial recharge and ground water exploration in drought, water scarcity and vulnerable areas can also be also integrated in the aquifer mapping project.

1.2 Scope of the study

Various development activities over the years have adversely affected the ground water regime in many parts of the country. There is a need for scientific planning in development of ground water under different hydro geological situations and to evolve effective management practices with involvement of community for better ground water governance. Though a vast amount of hydrological and hydro geological data has been generated through scientific investigations by Central Ground Water Board and other Central/State agencies, these mostly pertain to administrative units and have addressed the issues of the whole aquifer systems in very few cases. In view of the emergent challenges in the ground water sector in the country, there is an urgent need for comprehensive and realistic information pertaining to various aspects of ground water resources available in different hydro-geological settings through a process of systematic data collection, compilation, data generation, analysis and synthesis.

National Aquifer Mapping Programme (NAQUIM) is the thrust area of CGWB activities in the 12^{th} and 13^{th} plan period, there has been lot of deliberations and Concept note / implementation strategies are being finalized by CGWB. In view of the challenging work ahead, involvement of State Ground Water Department being the implementing agency in the area of ground water development and management is of prime importance to achieve the objectives envisaged under NAQUIM.

Aquifer mapping is a multidisciplinary study wherein a combination of geological, geophysical, hydrological, hydro geological, meteorological and hydro-chemical information is integrated to characterize the spatial and temporal variation of quantity and quality of the aquifer system. This involves in depth studies of the Aquifer Disposition in the Rayagada District (Administrative

Block wise) in respect of availability, potential, quality & quantity, identification of problems and finding solutions which require immediate interventions. The following were the broad objectives for the same:

- To define the aquifer geometry with precise lateral and vertical demarcation.
- To define Ground water regime behavior in time and space.
- To study the hydraulic characteristics of both shallow and deeper aquifer.
- To study the Geochemistry of aquifer systems down to the depth of 200 m in Hard Rock areas and up to a depth of 300 m (or up to Bed Rock) in alluvial areas.
- To prepare Aquifer Maps indicating dispositions of aquifers along with their characterization.
- To formulate the Aquifer Management Plans for sustainable development and management of ground water resources.

1.3 Approach and methodology: Geologically, the major parts of the district are underlain by Precambrian crystalline rocks viz. granite, granite gneiss also khondalite and charnokite. It is worthwhile to mention upfront, that aquifer mapping is not simply creation of aquifer maps. It is a process for visioning how India's groundwater resources will be managed not just in the next 5-10 years, but for the next 50 years, primarily through the active participation of its citizens. Aquifer mapping will lead to strategic plans for ensuring sustainable, equitable and efficient use of India's groundwater resources for many years to come. It will not only help understand aquifers but will use aquifers as units of measuring, monitoring, legislating and governing India's groundwater resources. Major reforms in data management, groundwater governance including the legislative framework and drinking water security will derive benefits from aquifer mapping through the development of strategic groundwater management plans. Hence, aquifers will form the units on which decisions are taken and actions performed with regard to groundwater resources. The methodology proposed is an amalgamation of both top-down and bottoms-up approach which suggests the use of latest technology as well as the process of participatory data collection and management of ground water.

Central Ground Water Board has implemented the Pilot Project on Aquifer Mapping under the World Bank funded Hydrology Project (HP-II). CGWB carried out advanced geophysical investigations and their interpretation for the Pilot Project under HP-II for aquifer delineation and its characterization through National Geophysical Research Institute (NGRI), which is a premier research organization under CSIR (Ministry of Science and Technology, Govt. of India). This information, in turn, lead to an effective ground water management in a participatory approach involving various stake holders. The outcome established the efficacy of various geophysical techniques under different hydro geological conditions and established a protocol for geophysical investigations when aquifer mapping shall be up-scaled for the entire country. The action plan adopted for Aquifer mapping is as given below:

Five major steps have been identified for Aquifer mapping, namely

1. Compilation of existing ground water data and data gap analysis

2. Generation of additional ground water data

3. Preparation of Aquifer Maps

4. Preparation of Aquifer Management Plans

5. Participatory ground water management

NAQUIM is planned to address the following issues in respect of each of the above-mentioned steps as given below:

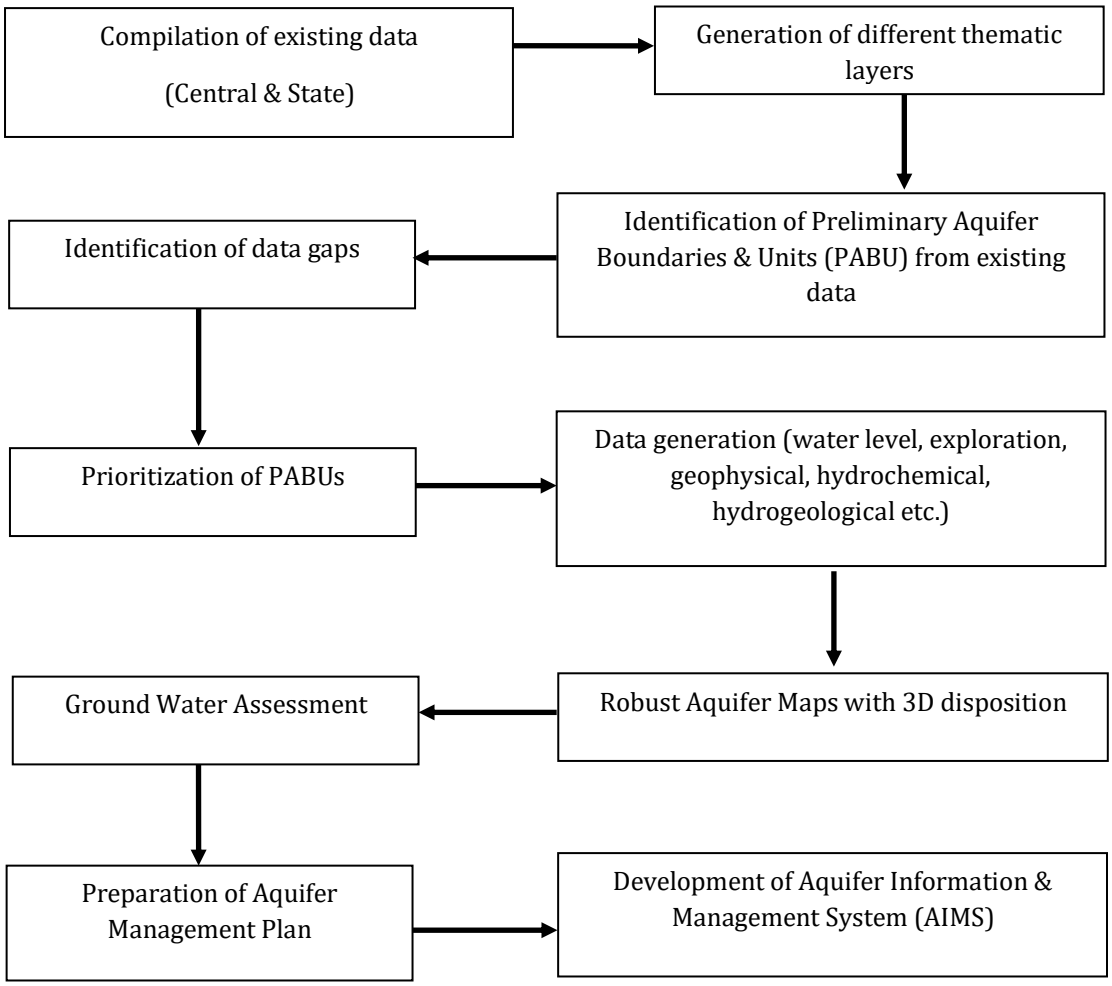


Figure – 1.1: Approach Methodology

1.3.1 Compilation of existing ground water data and data gap analysis: The existing data from all state and central agencies will be collected and processed to make a validated ground water data base. The specific parameters missing in the secondary data like co-ordinates and reduced ground elevation etc will be collected and standard data base in GIS platform will be made.

1.3.2 Generation of additional ground water data: The data generation to bring out validated ground information on aquifer geometry, its characteristics, status of development and stress acting in localized aquifer system like quality and scarcity, need for augmentation with suitable

site and design and other factors controlling the ground water occurrence and movement in surface and sub-surface will be optimized. Specific scientific data required will be generated and used for better understanding of the total ground water system including the interaction with surface water

1.3.3 Preparation of Aquifer Maps:

a) Institutional and project management support – SPV, CGWB, State, District and Block level organizations.
b) Identification of Aquifer Management Units (AMU) and operationalisation at appropriate scales.
c) Prioritization and work programme on the basis of quantity, quality and stage of development of ground water and criticality of groundwater quality issues.
d) Investigation and data compilation for each / cluster of AMUs through participation of para-hydrogeologists, block and district level support and State Groundwater Co-ordination Committees.

1.3.4 Preparation of Aquifer Management Plans:

a) Facilitate State Government Organizations and other stakeholders in the Preparation of Aquifer Management Plan and supporting tools while taking into consideration the quantity and quality aspects of ground water.
b) Development of Aquifer Information and Management System (AIMS).
c) Articulate and share information across hydrological units for crop planning, drinking water security and urban water security, as the case may be. It is important to consider these three because some aquifers might transect rural-urban divides and may require an integrated management plan that includes both types of requirements.

1.3.5 Implementation of Aquifer management plan by Participatory ground water management:

a) Demystify the science of ground water hydrology through capacity building and community level participation in real time data collection planning and development.
b) Establishment of protocols for participatory ground water management through
    i. Suggesting mechanism for collection of required data / parameters for seasonal assessment of ground water resources and their regular updating at local level involving the end users.
    ii. Formulating appropriate strategies and methodology for strengthening local institutions and end users for ground water management and capacity building of stakeholders (staff / officials/PRIs/NGOs/CSOs etc.).
c) Strengthen local institutions to address emerging ground water issues in respect of quantity and quality of ground water resources.
d) Transform the perception of groundwater from private property to that of a “common good”, where individual farmers take decisions for collective good.

1.4 Study area: Central Ground Water Board has initiated the National Aquifer Mapping Programme (NAQUIM) in India during XIIth five-year plan. All the 11 blocks of Rayagada District viz. Bisam- Cuttack, Chandrapur, Gudari, Gunupur, Kalyansinghpur,Kashipur, Kolnara, Muniguda, Padampur, Ramnaguda, Rayagada covering an area of 7073 sq. km. were taken up for detailed hydrogeological investigation, data-gap analysis and Aquifer Mapping during the period 2021-2022. The administrative map presented in **Plate 1.1**.

1.4.1 Administrative Setup: The district is divided into 11 Community Development Blocks, which in turn are further subdivided into 1820 Gram Panchayats comprising of 2665 villages in the rural front and on the urban side it comprises of 1 Municipal Corporation of Rayagada and 2 Notified Area Councils

Table – 1.1: Administrative Setup of Rayagada District

Sl No	Block	Geographical Area (Km^2)	Gram Panchayats	Total Villages	Municipality	NAC
1	Bisam-cuttack	620.38	21	307		
2	Chandrapur	433.31	9	219		
3	Gudari	766.89	9	159		1
4	Gunupur	968.06	19	127		1
5	Kalyansinghpur	418.21	14	253		
6	Kashipur	484.82	22	449		
7	Kolnara	366.56	17	199		
8	Muniguda	648.39	17	415		
9	Padampur	856.23	13	125		
10	Ramanguda	642.30	11	119		
11	Rayagada	530.70	28	293	1	
	TOTAL	**7073**	**180**	**2665**	**1**	**2**

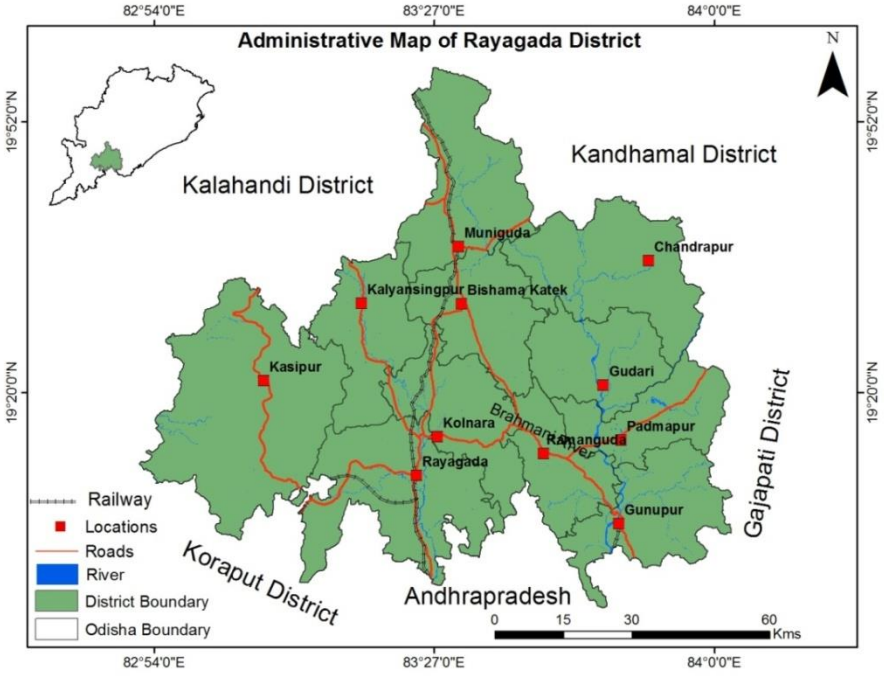


Plate 1.1: Administrative Map of Rayagada district

1.4.2. Demographic Setup: As per the Census Data of 2011, the total population of the district is 967911. Of this the Male population is 471960 and the female population is 495951. 820,945 is rural population and 146,966 is urban population. Sex Ration (female per 1000) is 1051. The decadal growth rate is pegged at 16%.

Table – 1.2: Demographic Setup of Rayagada District.

Sl No	Block	Total Population		
		Rural	Urban	Total
1	Bishamakatak	84091	8399	92490
2	Chandrapur	41129		41129
3	Gudari	42737	6931	49668
4	Gunupur	76333	28870	105203
5	Kalyanasingpur	59093	4660	63753
6	Kashipur	140633		140633
7	Kolnara	73839		73839
8	Muniguda	85218	8346	93564
9	Padmapur	56459		56459
10	Ramanguda	52632		52632
11	Rayagada	108781	89760	198541
	TOTAL	**820945**	**146966**	**967911**

1.5. Data Adequacy and Data Gap Analysis: The available data of the Exploratory wells drilled by Central Ground Water Board, South Eastern 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 were 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**
- **Geophysical Surveys**
- **Ground Water Monitoring and**
- **Ground Water Quality**

After taking into consideration, the available data of Ground Water Exploration, Geophysical survey, Ground Water Monitoring and Ground Water Quality, the data adequacy and datagap analysis was carried out.

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), OW and Piezometers are necessary for establishing aquifer geometry and determining aquifer parameters. There were 11 existing exploratory wells drilled in the area under Ground Water Exploration programme of CGWB is mapped and the adequacy of Exploration data is determined to demarcate the Aquifers .The adequacy of exploration data is given in Annexure. The data gap analysis indicates that, 42 additional wells are required to drill in entire district.

1.5.2 Monitoring wells: Present status of monitoring station is 26. From Data Gap analysis it is observed that 75 no. additional well required to monitor the Ground Water regime of the aquifers.

1.5.3. Water Quality monitoring stations: 21 wells are there for monitoring the quality of Ground Water in different Aquifers. From the data Gap analysis, it is found that 75 no. of wells are required more to get a clear picture of hydrochemical regime.

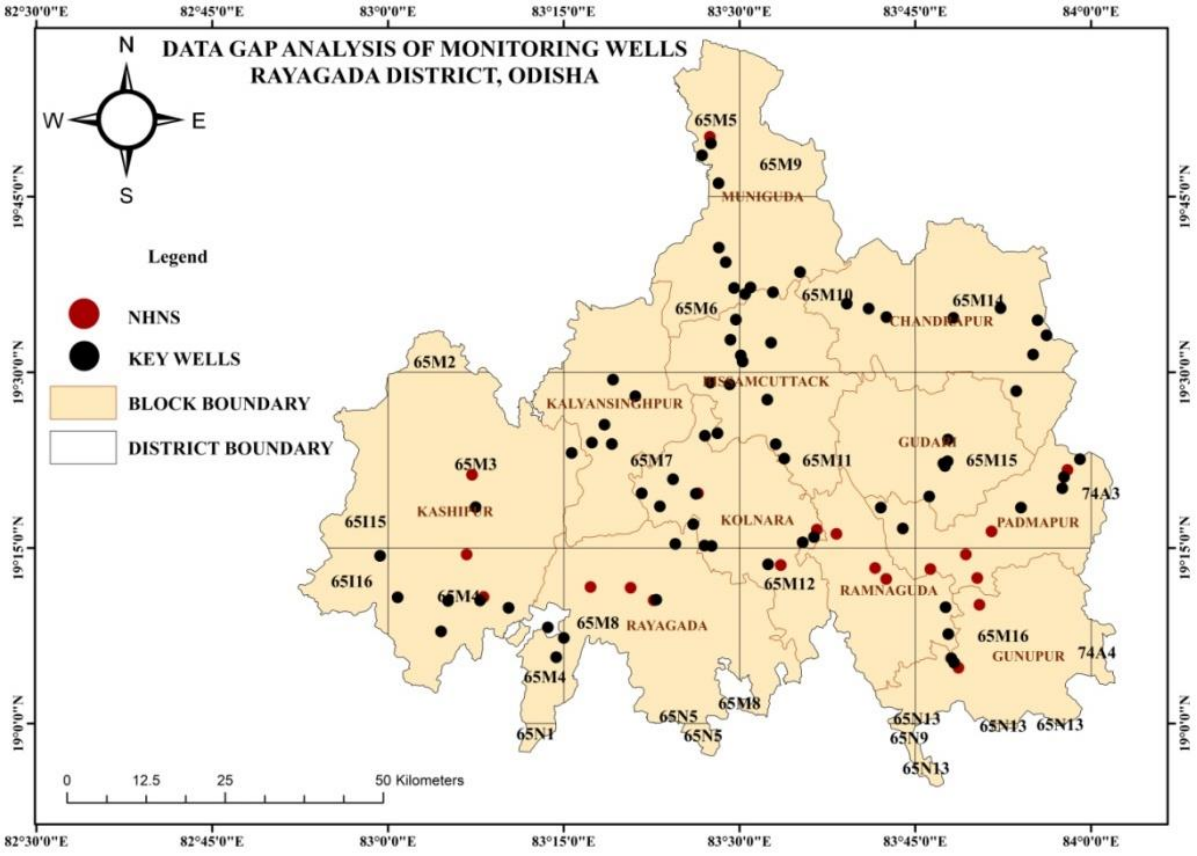


Plate 1.2: Base Map of Rayagada district

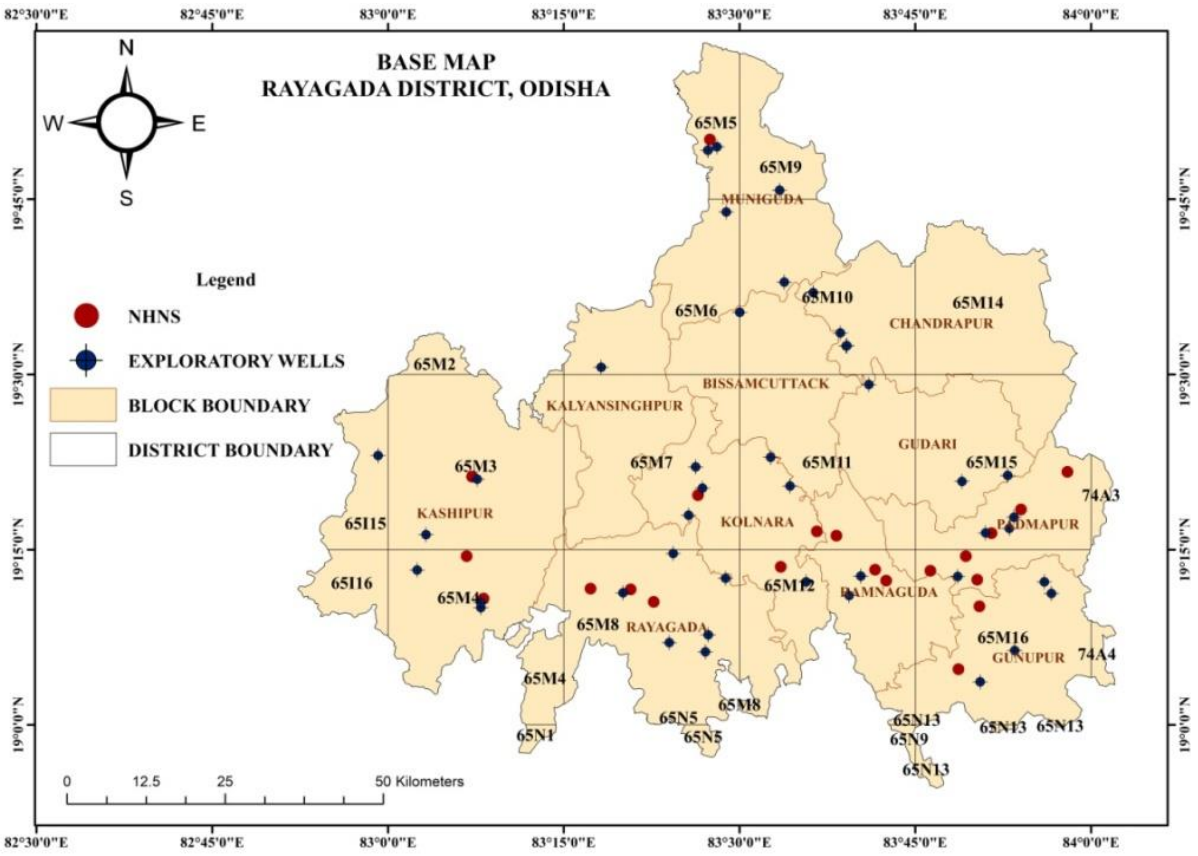


Plate 1.3: Data gap Map of monitoring wells of Rayagada district

1.6 Climate: The study area is characterized by tropical monsoon climate having three distinct seasons in a year i.e winter, summer and rainy seasons. Winter in this area commences from late November and continues till end of February. Winter is followed by summer season which continues up to mid June. In the period from April to May, three to four cyclonic rains generally occur, which causes a drop in the temperature and bring some relief during summer. The rainy season sets in the study area at the advent of southwest monsoon, generally commences from middle of June and continues till the end of September. Vast stretch of high hills and Green forests control the climate to a great extent. December is the coldest month with mean daily average temperature of 20^0C which reaches a maximum of 42^0C in May.

1.6.1 Rainfall: The area enjoys tropical to sub-tropical climate and is therefore subjected to high temperature and rainfall. June to September is the rainy season. The rain fall in the area is mostly from the south west monsoon lasts from middle of June to October. The average annual rainfall varies from 1030.21 mm to 1569.50 mm.

The block – wise analysis of rainfall data from 2009 to 2018 (10 years) of the study area (block-wise) is given in Annexure-1.

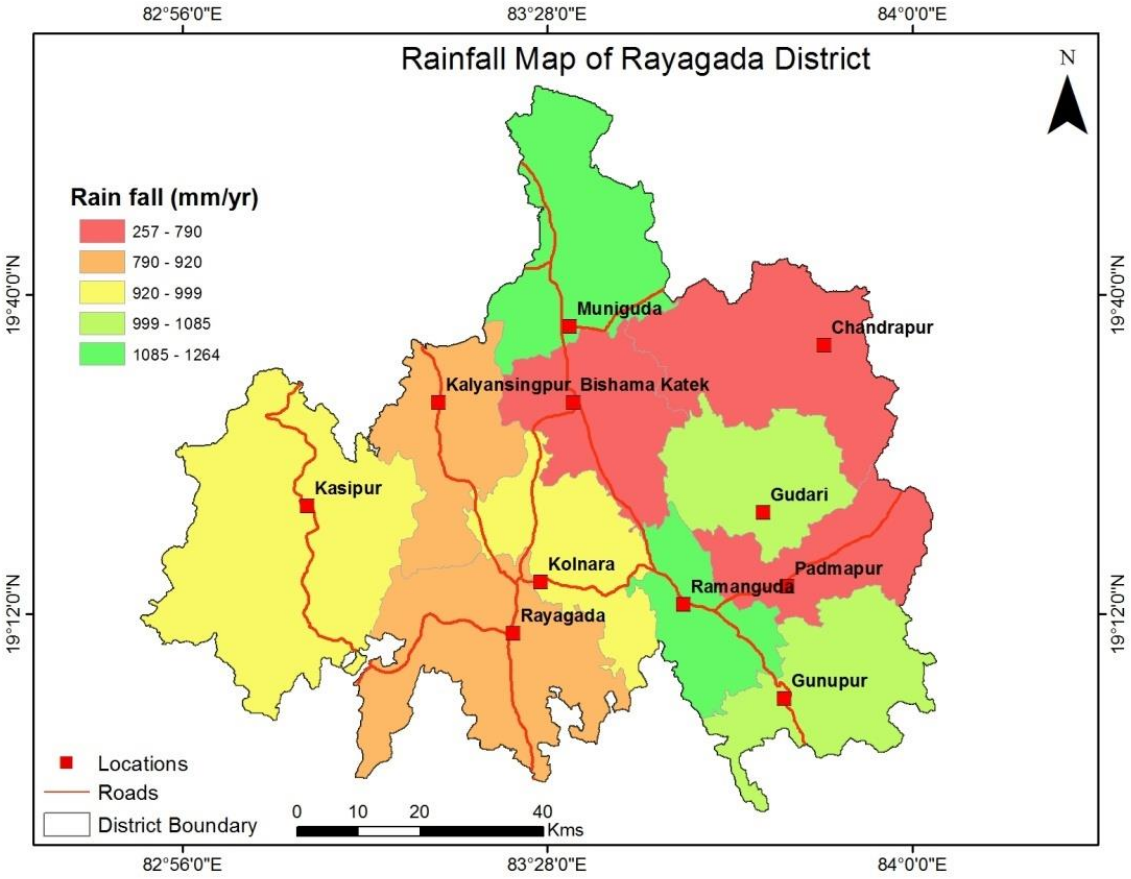


Plate 1.4: Isohyets Map of Rayagada district

1.6.2 Temperature, Humidity and wind: The month of May/June is usually the hottest month when the maximum temperature in day time is about 44.6 ^{0} C. Monsoon season is between June to September. Relative humidity is around 55 to 81 % throughout the year. South-West monsoon is the principal source of rainfall in the study area and wind is active in this period. The wind speed is fairly strong during summer and monsoon months and major direction is between southwest and south. Mean wind speed is 14.3 km/hr at Bhubaneswar. The mean monthly potential evapotranspiration values range from 57 mm in January to 284 mm in May.

1.7 Physiographic setup

1.7.1 Slope of the area: The average slope of Rayagada district is less than 10^0. Slope is as high as 70^0 in some parts of the district in scatter manner.

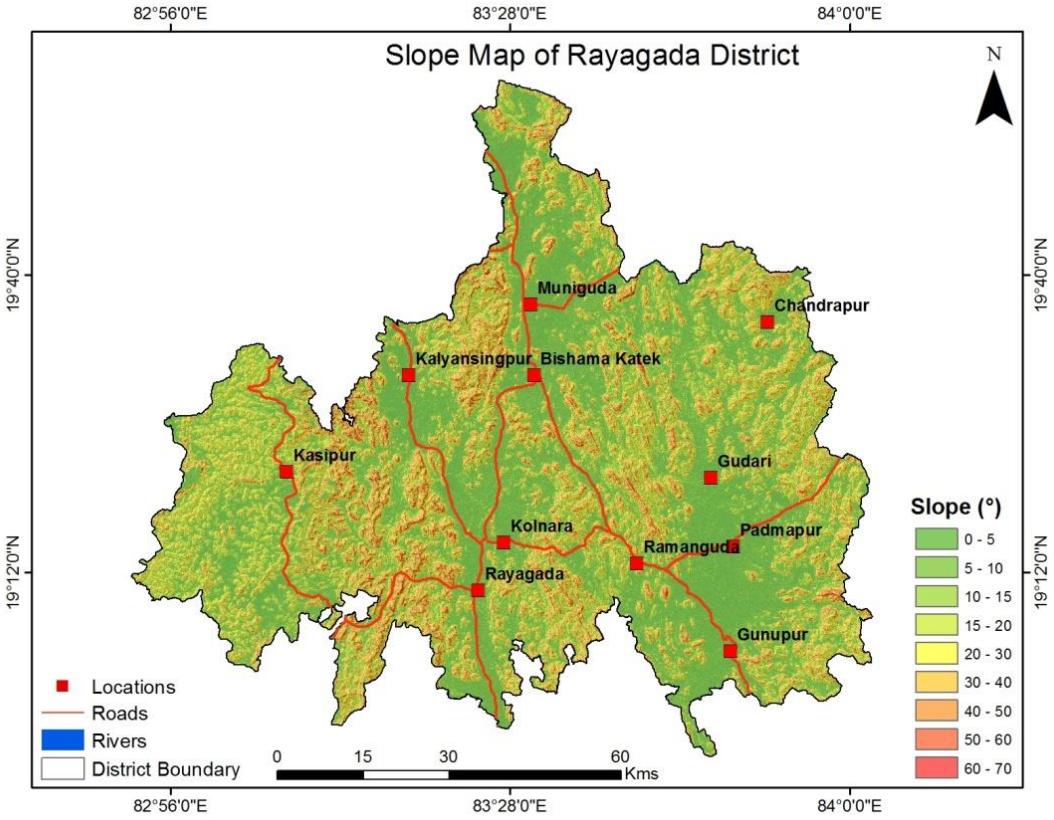


Plate 1.5: Slope Map of Rayagada district

1.7.2 Elevation: The Digital elevation map is prepared and presented in Plate no-1.6

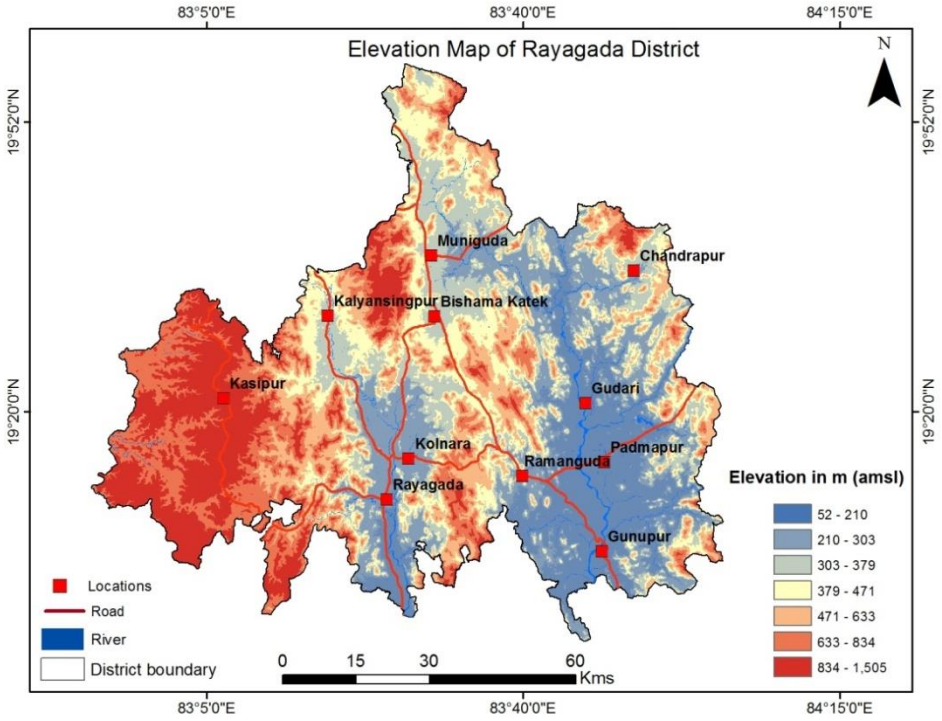


Plate 1.6: Elevation Map of Rayagada district

1.8 Geomorphology

1.8.1. Geomorphologic features

Major proportion of the district is occupied by rolling hills. The average altitude in hilly region ranges between 600 m to 800 m above mean sea level with highest of 1550 m. The plains of the district are represented by low lying flood plain of Vamsadhara and Nagavalli rivers and intermontane valleys. The average altitude of the flood plains and intermontane valleys range between 100 m to 300 m above mean sea level. The district has varied geomorphological features. The geomorphic units are (i) Lateritic Upland, (ii) Pediplane, (iii) Denudational Hills, (iv) Flood Plain, (v) Structural Hills, (vi) Inselberg, (vii) Mesa & Butte, (viii) Residual Hills, (ix) Intermontane Valleys, (x) Bazada.

1. Structural Hills: It is the most predominant geomorphic unit in the district. It is characterized by structurally controlled hills with complex folding and faulting. Thses hills act as recharge zone for intermontane valleys and for the surrounding area. The occurrence of springs are common in this hydromorphic unit.

2. Denudational Hills: Denudational hills occupy the western part of the district. It is represented by a group of massive hills interspersed with narrow intermontane valley. These hills have either no structural control or structures are obliterated by denudation. The drainage density in this type of unit is medium and run –off is high. The ground water prospect is poor.

3. Intermontane Valleys: This lies in between mountain ranges. Intermontane valleys are found in Muniguda, Bissam Cuttack, Padampur, Gunupur, Gudari, Kalyansinghpur and Rayagada block. Ground water potential in this type of unit is moderately good.

4. Structural Valleys: A narrow patch of structural valleys occurs in the southern part of Rayagada district. It is a narrow linear valley within the structural hills formed along the structurally weak planes. The overall ground water potential varies from moderate to good.

5. Inselbergs: These are isolated hillocks of limited areal extent, surrounded by plains all around. This unit also acts as run off zones and not favourable for ground water occurrence.

6. Flood Plain: Flood plains of the Vamsadhara and Nagavalli rivers constitute an important hydro geomorphic unit of the district. It is formed by late Pleistocene and recent alluvium deposited along the rivers. Buried channel, meander point bars are common features in the flood plains, the flood plains form potential groundwater storage.

7. Mesa/Butte: It is characterized by flat topped hills/plateau of laterites/bauxite with escarpment on all sides. Mesa is larger in areal extent than Butte. Perched water bodies of limited extent may occur in Mesa dependiong on their areal extent/widh of the plateau.

8. Linear Ridge: Narrow linear ridges occur in the Muniguda block in the northern part of the district. These are formed by resistant rock units. These act as barrier for ground water movement. Upstream side of the ridge is favourable for ground water occurrence.

9. Residual Hill: These are isolated hills of limited areal extent surrounded by plains all around. This unit acts as run off zone and not favourable for groundwater occurrence.

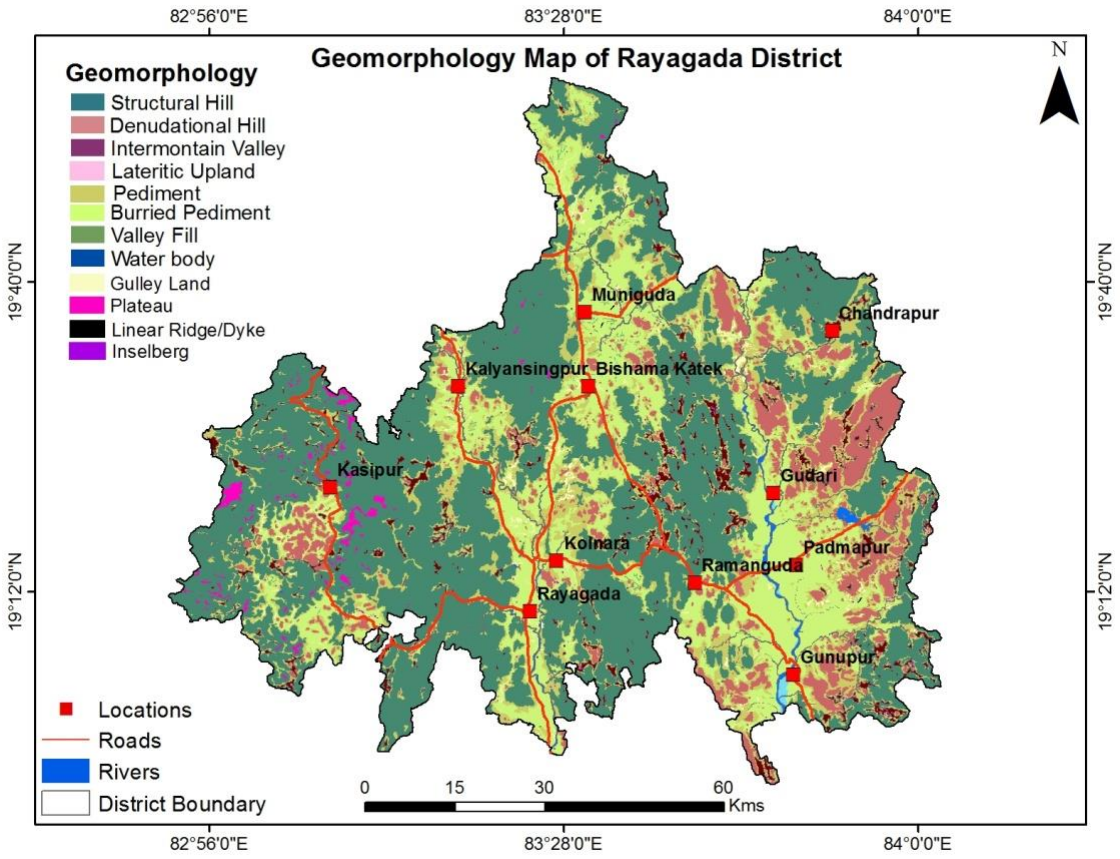


Plate 1.7: Geomorphology Map of Rayagada district

1.8.2 Drainage: The area is mainly drained by the Vamsadhara and Nagavalli river which are effluent in nature. The Vamsadhara river originates in the extreme northern parts of the BissamCuttack flows southwards through Gudari and Gunupur and enter Andhra Pradesh. The length of the river in Rayagada district is approximately 140 kms. The Nagavalli river which originates from the Kalahandi district, flows southwards through Kalyansinghpur of Rayagada district and enters Andhra Pradesh below Rayagada town. In Rayagada, the Nagavalli river descends below Rayagada town. In Rayagada the Nagavalli river descends into a gorge with occasional waterfalls. The length of the Nagavalli river in the district is about 101 km. The general drainage pattern of the district is dendritic to subparallel. (Plate -1.8)

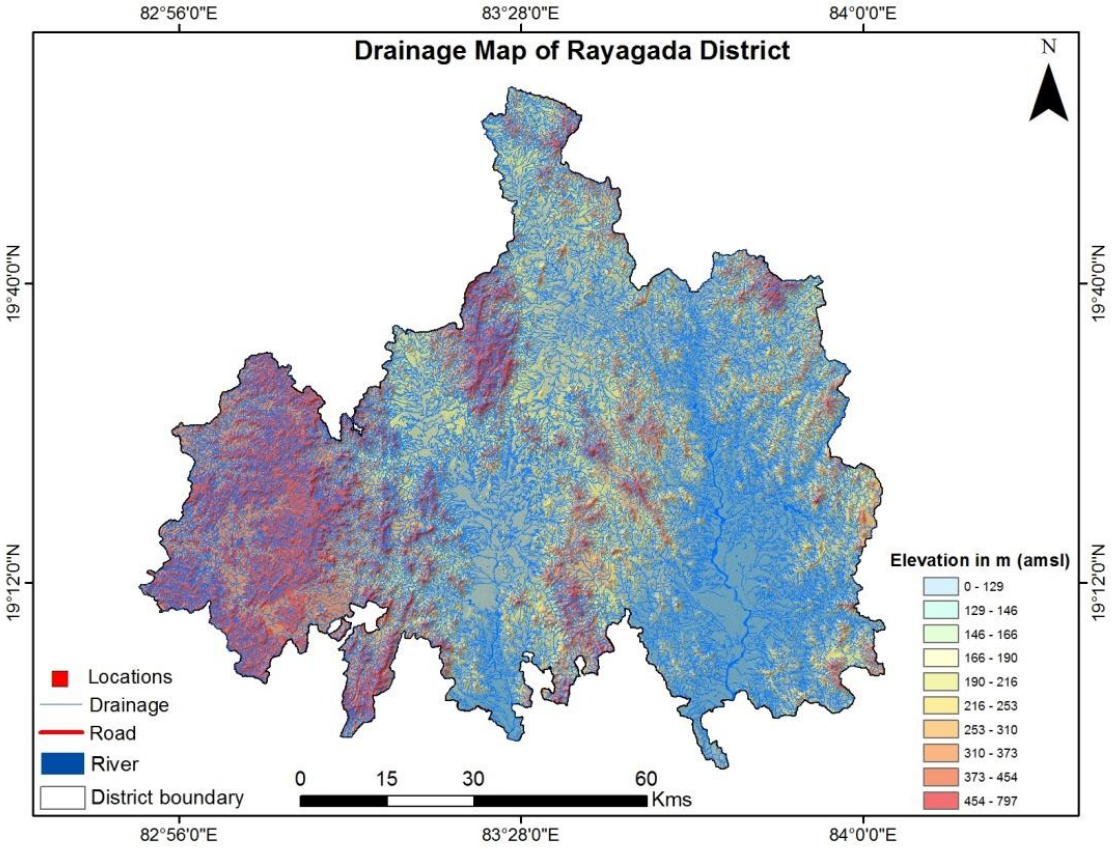


Plate 1.8: Drainage Map of Rayagada district

1.9 Landuse: Rayagada district showed wide variation in land use pattern. The land utilization pattern indicates that out of total geographical area, the forest area constitute 175790 ha. (24.96 percent) and the net sown area is 182907 ha.
Land use pattern shows that it has 5.65 percent geographical area of the state with 2.60 percent gross cropped area, 2.63 percent net sown area, 1.46 percent forest area, 0.53 percent wasteland area of the state.

Average cropping intensity of the district is 129 percent. The blocks namely Muniguda, Kashipur, Gudari, Kolnara and K. singhpur have lower cropping intensity than the other blocks and below the district average cropping intensity. There is a scope to increase cropping intensity by increasing area under irrigation thus provides water source for growing second crops.

Area under wasteland is low (3.17 percent) and maximum is in the blocks of Chandrapur block. Block also having highest area under forest.

Presentation of land use/ land cover map of the district mentioned in Plate 1.9

Table. 1.3 Land use pattern of Rayagada district

S. No	Block	No. of G.P	Villages	Geographical Area	Area under Agriculture				Area under Forest	Area under Waste Land	Area under other uses
					Gross Cropped Area	Net Sown Area	Area sown more than once (1-2)	Cropping Intensity			
		No	No	ha				%	ha		
1	Rayagada	28	294	55857.65	22716	17536	5180	130	4160	540	510
2	Kolnara	15	199	39425	17785	15224	2561	117	17140	160	810
3	K.Singpur	13	254	44590	17533	14228	3305	123	8470	2020	1040
4	Kasipur	20	449	51251	45545	37000	8545	123	7700	1110	1850
5	Gunupur	18	129	99586.65	22616	16464	6152	137	0	900	3580
6	Padmapur	13	125	88390	20008	13190	6818	152	24530	210	940
7	Ramanaguda	12	119	66999	23543	16506	7037	143	28340	1050	760
8	Gudari	9	159	79460	15439	12784	2655	121	2670	600	1220
9	Bissam Cuttack	20	308	64807	23000	18085	4915	127	31770	850	2820
10	Muniguda	16	416	67608	18806	15428	3378	122	16280	1170	3340
11	Chandrapur	7	219	46100	8521	6462	2059	132	34730	13760	4110
Total		**171**	**2671**	**704074.3**	**235512**	**182907**	**52605**	**1427**	**175790**	**22370**	**20980**

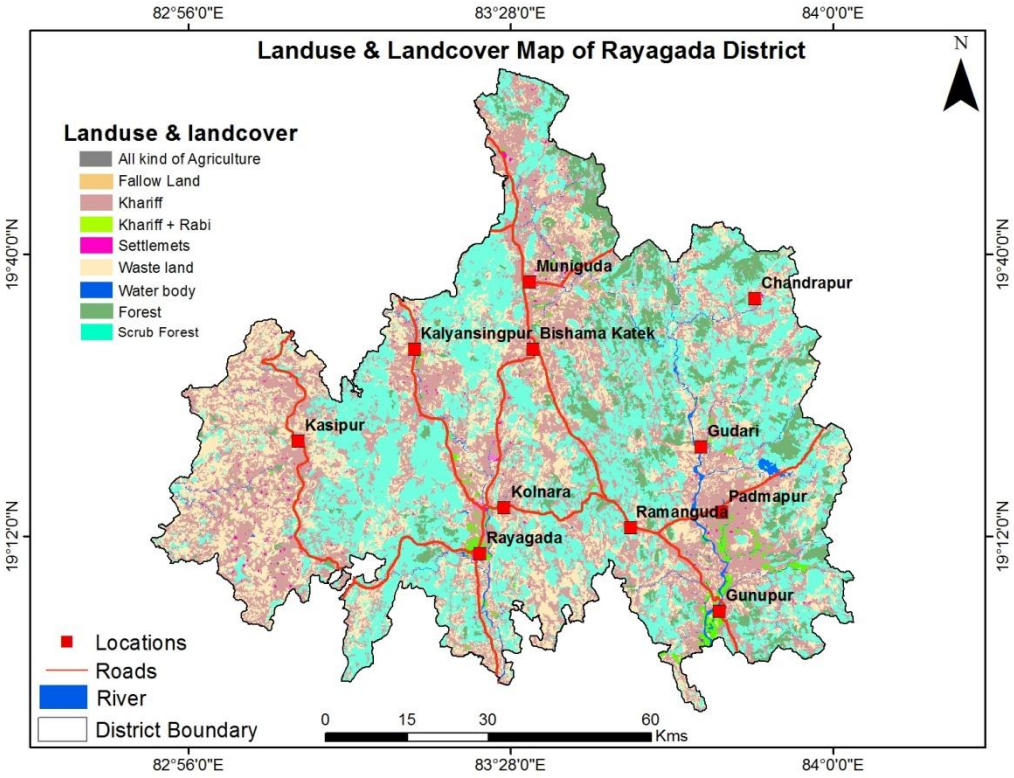


Plate 1.9: Land use and Land cover Map of Rayagada district

1.10 Soil Types: Based on the physical and chemical characteristics, mode of origin and occurrence, the soils of the district can be broadly grouped into following types:

i) Alfisols (Red soil)
ii) Entisols (Alluvial soils)

i) Alfisols: This is the most predominant soil in the higher land area spreading almost all the blocks of Rayagada district. These types of soil are porous and acidic in nature and poor in organic matter. As a result its fertility is low. Two types of red soils are encountered in the district, red loamy soil and red sandy soil.

ii) Entisols: These are restricted to the flood plains of Vamsadhara and Nagavalli rivers in the blocks of Ramanguda, Gudari, Padampur,Rayagada and Kolnara and consists of sand,silt and clay. This type of soil is alkaline in nature and deficient in Nitrogen and humus material. The district belongs to the North Eastern Ghat agro climatic zone. Various types of soils in the district have been shown in plate 1.10.

Table 1.4 Block wise Soil type and slope wise area of Rayagada district

Name of the Block	Geographical Area of the Block (ha)	Soil Type		Slope wise area (ha.)			
		Major Soil Class	Area (ha)	0-3%	3-8%	8-25%	>25%
Rayagada	55857.65	Inceptisols	50271.89	17315.89	14522.98	13964.41	10054.37
		Entisols	5585.76				
Kasipur	51251.00	Alfisols	19475.38	10.00	20750.00	29465.98	1025.02
		Inceptisols	30750.42				
		Entisols	1025.02				
K.Singpur	44590.00	Alfisols	27645.80	5350.80	25862.20	13377.00	
		Inceptisols	16944.20				
Bissam Cuttack	64807.00	Alfisols	39534.27		39532.27	24626.66	648.07
		Inceptisols	25272.73				
Muniguda	67608.00	Alfisols	22986.72	2014.00	45987.68	16225.92	3380.40
		Inceptisols	44621.28				
Chandrapur	46100.00	Alfisols	19362.00		26738.00	18440.00	922.00
		Inceptisols	25816.00				
		Entisols	922.00				
Gudari	79460.28	Alfisols	21686.88		62773.40	15892.00	794.88
		Inceptisols	57773.40				
Padmapur	88390.00	Alfisols	883.90		34472.00	53034.00	883.90
		Inceptisols	87506.10				
Gunupur	99586.65	Alfisols	71702.38		81661.00	15933.86	1991.73
		Inceptisols	27884.27				
Ramanaguda	66999.00	Alfisols	43549.35		26799.60	40199.40	
		Inceptisols	23449.65				
Kolnara	39425.00	Alfisols	27203.25		22078.00	16558.50	788.50
		Inceptisols	11433.25				
		Entisols	788.50				
Total	**704074**		**704074**				

Source: DIP, Rayagada

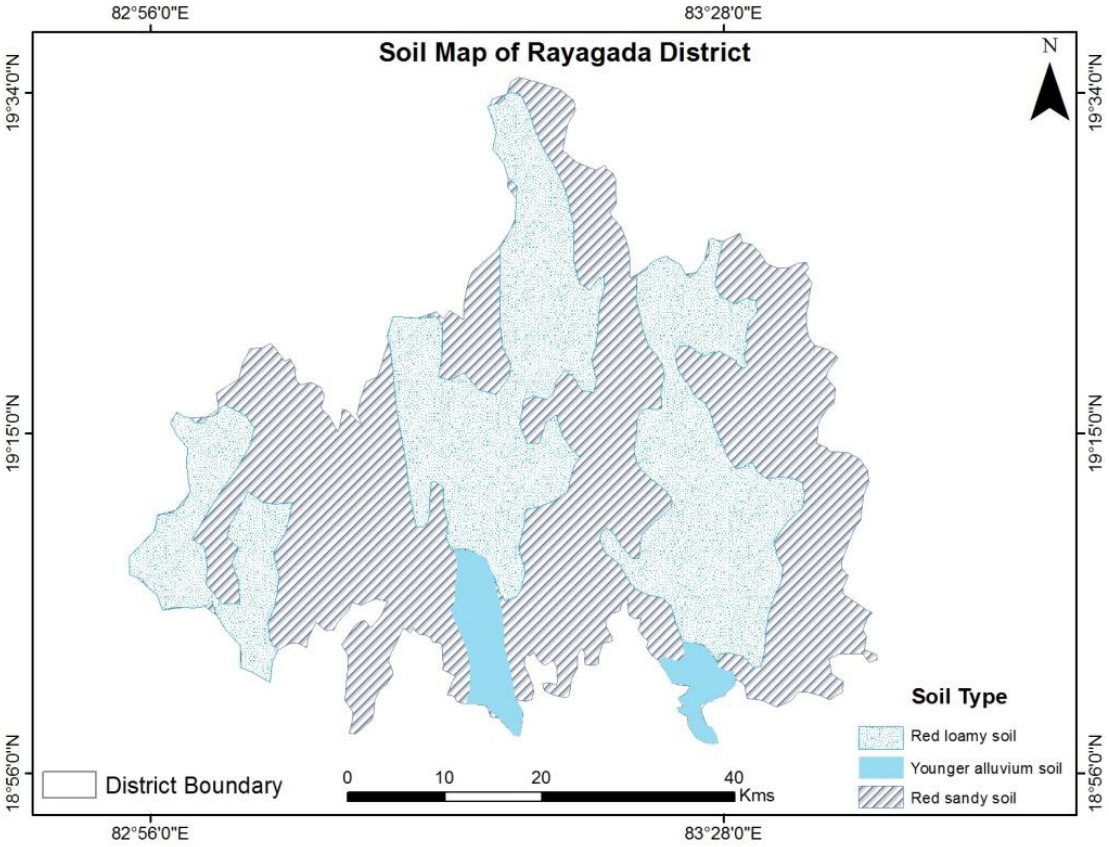


Plate 1.10: Soil Map of Rayagada district

1.11 Agriculture: Most of the tribal people are engage with agriculture. Paddy, pulse crops, some oil seed crops along with brinjal, tomato, pumpkin, cabbage are grown in a small scale. There are no Major Irrigation Projects in the District. One Medium Irrigation Project namely Badanalla situated in Padampur Block designed to cater irrigation to an ayacut of 9874 ha is in Padmapur, Gunupur, Gudari and Ramanaguda Block. 78 Nos. of Minor Irrigation Projects, situated in different Blocks designed to cater irrigation to an ayacut of 24621 ha. Similarly 1010 Nos. of Lift Irrigation Points in all the Blocks designed to cater irrigation to an ayacut of 19243 ha. Further to supply irrigation to designed ayacut of 2870 ha in Gunupur Blocks Mega Lift Irrigation Project is taken up. As such Irrigation to a total Designed Ayacut of 56.608 ha of the cultivable area is be provided through Irrigation Department. Block wise agro-ecology, climate, hydrology and topography features of Rayagada district (Annexure-2)

1.12 **Crops and Block-wise Irrigated and Rainfed area:** The crop wise and block wise irrigated and rainfed area in Rayagada district is presented in Annexure.

The total cropped area (TCA) is about 2.49 lakh ha out of which 0.69 lakh ha (27.4% of TCA) is irrigated and 1.80 lakh ha (72.6% of TCA) is under rainfed area (Annexure 3).

- The blocks like Gunupur, K. Singhpur, Padmapur, Ramangada, and Rayagada having higher percent of irrigated as compared to other blocks .
- Among the different crop groups, cereals accounts for 47.0% of the irrigated area followed horticulture & plantation (18.9%), pulses (9.5%), oil seed crops (8.8%), fibers (8.0%) and coarse cereals (7.0%). This indicates that major source of water in agriculture is being used for cultivation of cereals like paddy and maize .

- In the district as a whole, total cereals account for 14.8% of the TCA is under irrigated and 25.1% of the total TCA is under rainfed. Among the blocks, Padmapur (24.6%) and K. Singhpur (19.3%) having higher percent of the GCA is under irrigated and followed by Gunupur (17.9%). Other hand, Chandapur (39.1%), Kashipur (37.2%), and B. Cuttack (35.5%) are the blocks, where higher percent of GCA is under rainfed cereals.
- Total pulses accounts nearly 2.6% of the TCA are under irrigated and 22.2 % is under rainfedin the district. The blocks like Padmapur (6.0%), Rayagada (5.1%), and K. Singhpur (4.8%) are the blocks having higher percent of the total pulses under irrigated.
- Total pulses accounts nearly 2.6% of the TCA are under irrigated and 22.2 % is under rainfedin the district. The blocks like Padmapur (6.0%), Rayagada (5.1%), and K. Singhpur (4.8%) are the blocks having higher percent of the total pulses under irrigated.
- It's very interesting to know that, only 17.9% the TCA is under irrigated food crops and nearly 47.3% of the TCA is under rainfed food crops (Fig.2.1.4). The blocks like Padmapur (30.6%), K. Singhpur (24.1%), Rayagada (22.4%) and Gunupur (21.1%) are having higher per cent of TCA under irrigated food crops. This suggests that other blocks having greater potential to convert rainfed area into irrigated.
- Oil seeds accounts for hardly 2.4% of the TCA is irrigated and 9.3% of the GCA is under rainfed, which shows majority of the oilseeds is under rainfed areas. In the district Gunupur (5.6%), Padmapur (4.6%) and Gudari (3.7%) blocks are having maximum higher per cent of TCA under irrigated oil seeds (Fig 2.1.5).

- Other crops including fiber accounts about 2.4% of the TCA is irrigated but percent area under rainfed is 11.9% (Fig.2.1.6)
- In the district only 5.2% of the TCA is irrigated horticulture and plantation crops whereas 4.4% of the TCA is under rainfed horticulture & plantation (Fig.2.1.7). Particularly blocks like Kolnara, Gudari, K. Singhpur, Kashipur, and Ramangada are having lesser horticulture and plantation cropped area in the district.

2. DATA GENERATION:

For National Aquifer Mapping & Management, the primal objective is to collect, generate and collate various types of data - Rainfall, Drainage, Soil, Lithology, Structure, Lineament Mapping, Microlevel hydrogeological data collection, establishment of well inventory, setting up of a monitoring network for effective ground water regime monitoring (level, Quantity & Quality) over space and time, sub-surface information through geophysical investigations and exploratory drilling programme etc., use of remote sensing studies for geomorphological mapping, change analysis interpretation to name a few :

Table – 2.1 NAQUIM Data Collection Status

Sl No		Item	Sub Item	CGWB	Data generated during NAQUIM
1	a	Ground Water Level Data	NHNS - Phreatic	22	
	b		NHNS - Piezometric	0	
	c		Additional Observation Wells (Phreatic)	67	Established during field
	d		Additional Observation Wells (Piezometric)	8	Established during field
2	a	Ground Water Quality Data	Phreatic	67	
	b		Deeper	42	
3		Exploratory Well Data		11	42
4		Vertical Electrical Sounding		0	75
5		Bore Hole Geophysical Logging			0
6		Water Harvesting Structures		0	0

2.1 Water Level Measurements: Water level measurements were carried out using the existing National Hydrographs Network stations as well as by establishing a dedicated network of Key Wells (67Dug wells and 8 Pz). This involved measurement of water levels of both the phreatic aquifer through dug wells and measurement of Piezometric surface through the existing piezometers as well as through established dug wells and tube wells (97 Nos).

Measurement of monitoring wells: Total nos of 22 wells are there as NHS in Rayagada district. Those wells are measured 4 times in a year. For the NAQUIM of Rayagada, pre and post monsoon (2021) data are utilized which are tabularised in Annexure – 4.

Data Generation done during the field work done in AAP-2021-22.

The highly uneven and rugged topography has restricted the occurrence of ground water in discontinuous patches mainly in topographic lows, intermontene valleys and adjacent to nala and stream courses.

Monitoring wells: 75 nos. of key wells established during the NAQUIM field study. The key wells are measured during Premonsoon (May, 2021) and Post monsoon (Nov, 2021). The details of the Key wells with the water level measurement are given in tabularised and given in Annexure-5. Location details of monitoring wells represented in Plate-2.1.

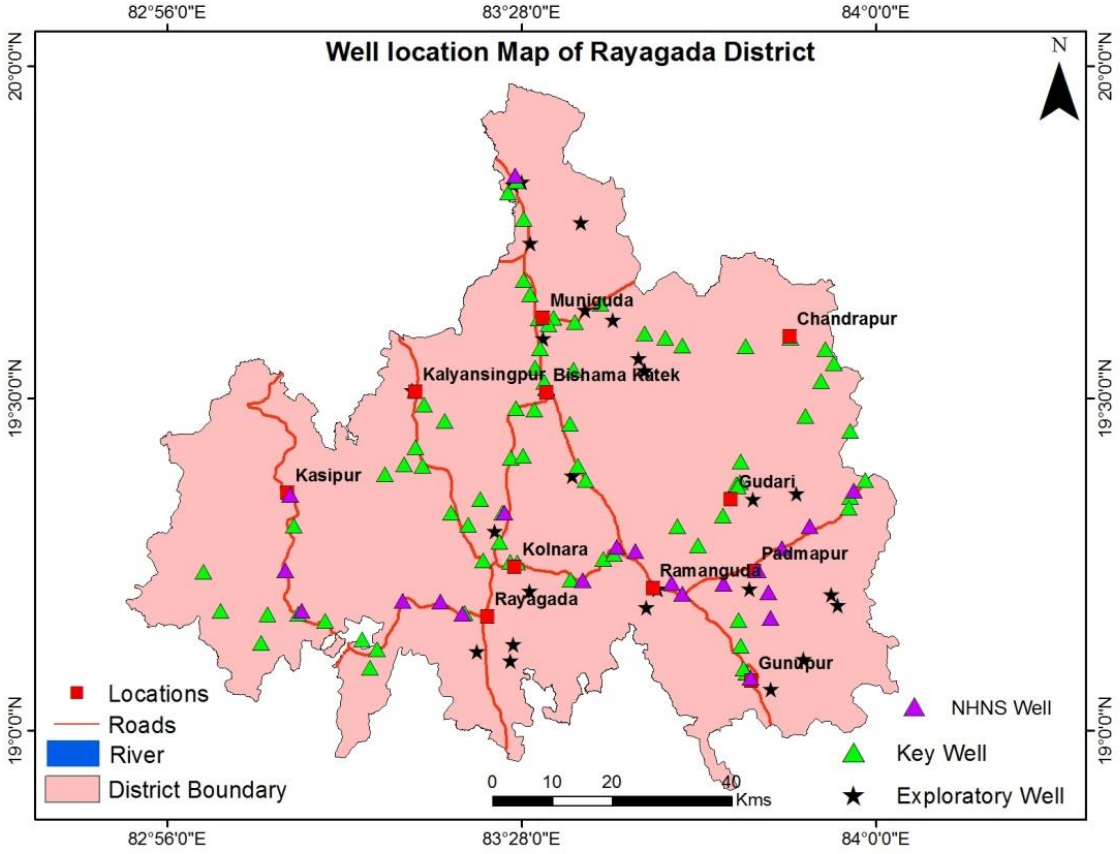


Plate 2.1: Well location Map of Rayagada district

2.1.1 Pre-monsoon depth to water level (May 2021): Depth to water level in pre-monsoon period varies from 1 m bgl (Matuguda in Padampur block) to 11.55 m. bgl (Kumbhikota in Rayagada block); the average being 5.4 m bgl (Annexure). The western parts area in hard rock crystalline rocks many areas in patches are having depth to water level more than 6m below ground level in pre-monsoon period (May 2021). These areas form part of Kashipur and Rayagada blocks of the study area. There are 20 locations where the depth to water level is observed more than 6 mbgl.The places having depth to water level more than 6 m bgl during pre-monsoon period

are Dumulupadar(10.9), Nuagada(9.15), Kenduguda NHS(6.45), Dhepagaon(7.35), Kailaspur(6.2), Purna Baliguda(11.35), Sirikana(6.55), Kumbhikota(11.55), Keskapadi(7.35), Sankarada(6.85), Kaliapada(9.15), Podapadi(7.25), Dongasil(11.25), Renga(8.65), Getipada(6.8), Thunpadi(7.6), Kutragarh(6.03), Bandhuguda(7.45), Badamajusikopa(9.3), Hukumtoda(7.4). The pre-monsoon depth to water level map is given in Plate 6.4. It has observed that the depth to water level is deeper in most of the wells in Kashipur block during premonsoon. This are is mostly comprises of Easterghat Group of rocks, Granite gneiss, Khondalite and Charnokite.

The depth to water level (April, 2021) map is presented in plate-2.2

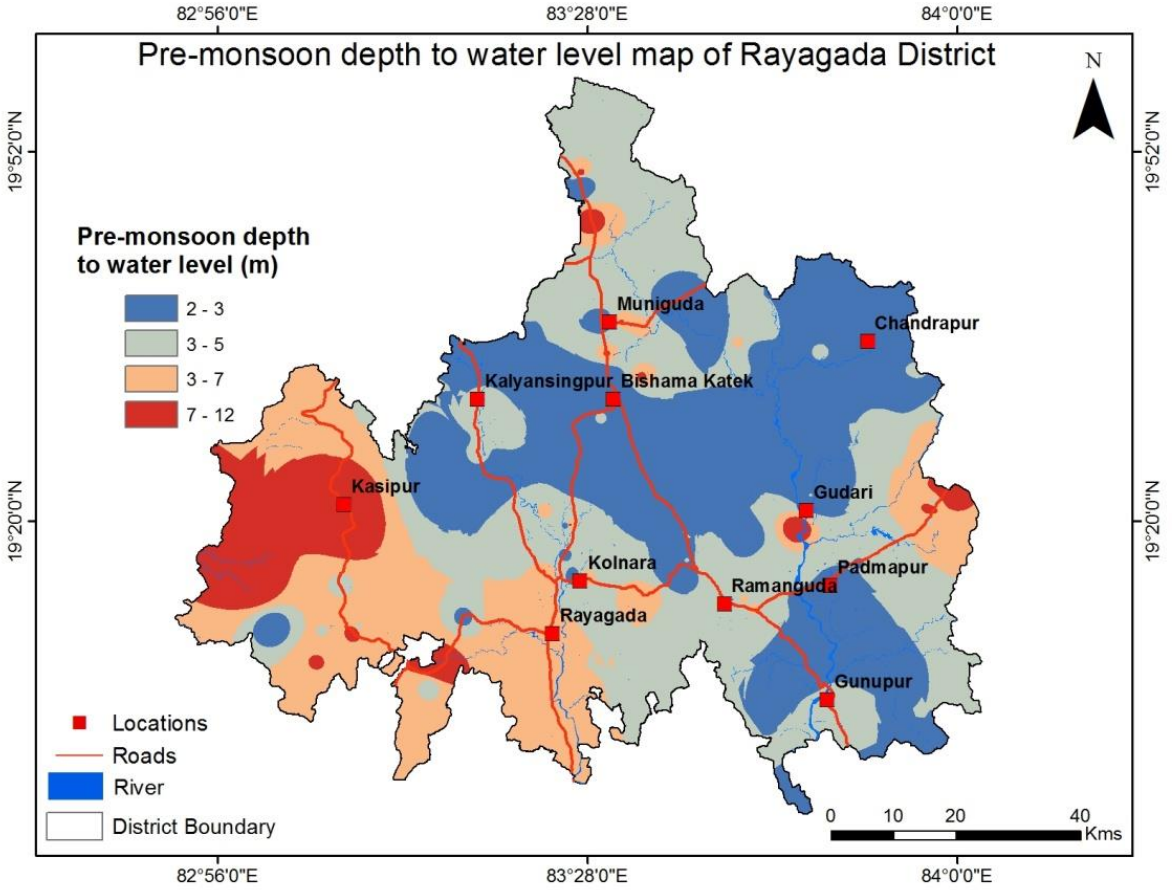


Plate 2.2: Pre-monsoon depth to water level Map of Rayagada district

2.1.2 Post-monsoon depth to water level: Post-monsoon depth to water level: Depth to water level in post-monsoon period varies from0.05 m below ground level (Matuguda, Padampur block) to 15.25 m below ground level(Nuagaon, Bissam cuttack block); the average being 3.78 m bgl (annexure 5). Majority area is having depth to water level within 0 to 5 m below ground level. In western and northern parts,many areas in patches are having depth to water level more than 5 m below ground level in post-monsoon period (Nov 2021). These areas form part of Bissamcuttack, Gudari, Kolnara,Padampur, Kashipur, Rayagada and Muniguda blocks of the study area. The places having depthto water level more than 5 m bgl during post-monsoon period are Podapadi, Renga, Sankarada,D.Karol, Kaliapada, Dongasil in Kashipur block; Banadurga, Ambadola, Badamajusikopa inMuniguda block; Sirikana and Kumbhikota in Rayagada block; Dhepagaon,

Badachampua,Therubali in Kolnara block; Silimi, Purna Baliguda in Gudari block. The depth to water level (Nov, 2021) map is presented in plate-2.3

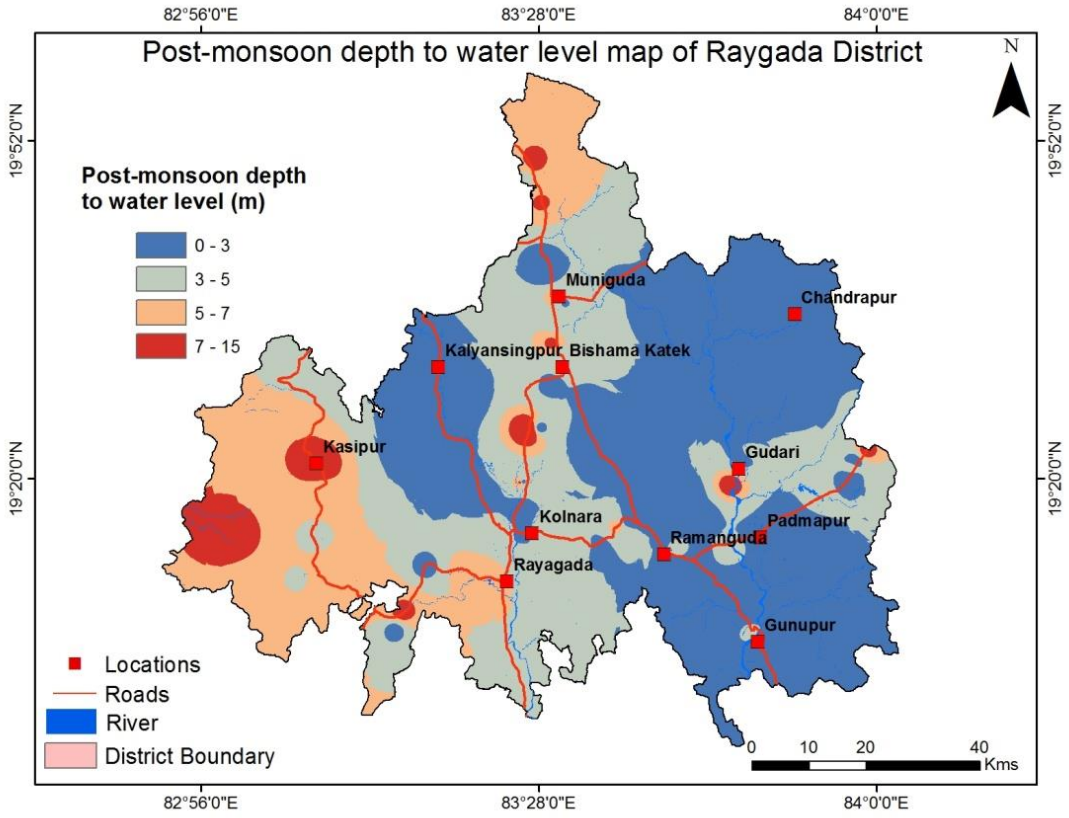


Plate 2.3: Post-monsoon depth to water level Map of Rayagada district

2.1.3 Fluctuation of water level: The seasonal fluctuations in the water level between pre monsoon and postmonsoon periods indicate accretion to the ground water storage from rainfall recharge. The fluctuation in water level between pre monsoon and winter periods range between 0.16 m to 8.16 m in Granite Gneiss, 1.20 m to 4.14 m in Khondalite, 0.07 m to 3.09 m in charnockite, 0.05 m to 5.33 m in alluvium. The seasonal fluctuation is shown in the annexure. The fluctuation map is shown in plate no-2.4.

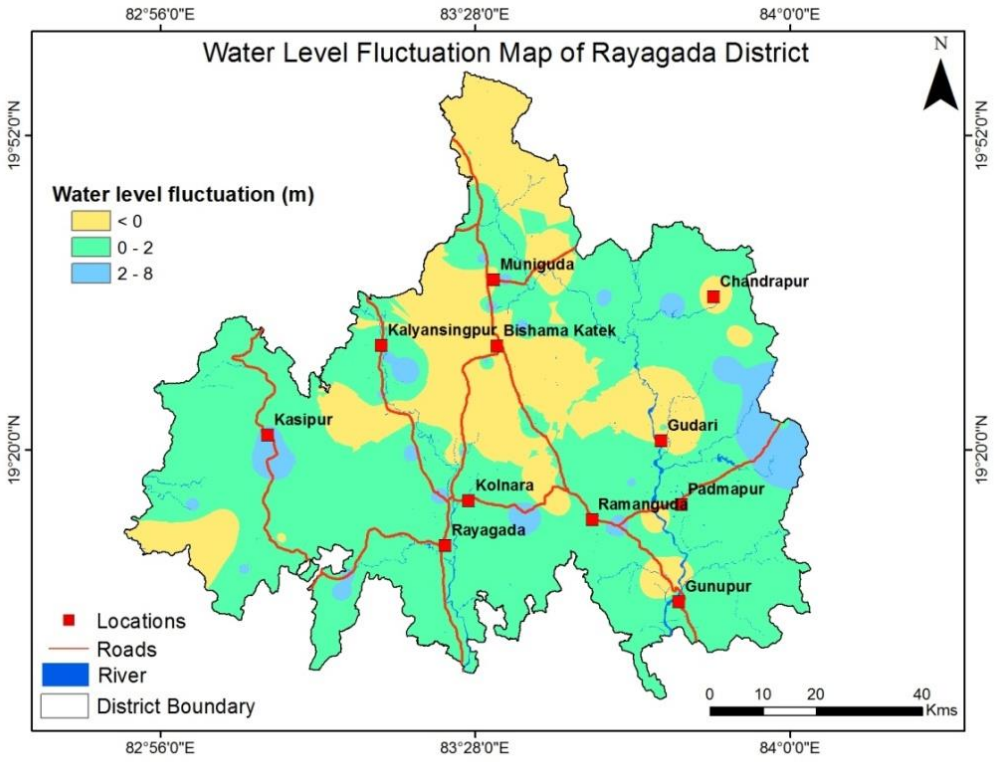


Plate 2.4: Water level fluctuation Map of Rayagada district

2.1.4 Decadal Mean depth to water level (2011-20): Mean water level varies from 1.47 mbgl (Dambasara, Gunupur block) to 9.19 mbgl (Kashipur, Kashipur block). Average of decadal meanwater level is 3.07 mbgl. The map showing decadal mean water level is show in Plate 2.5

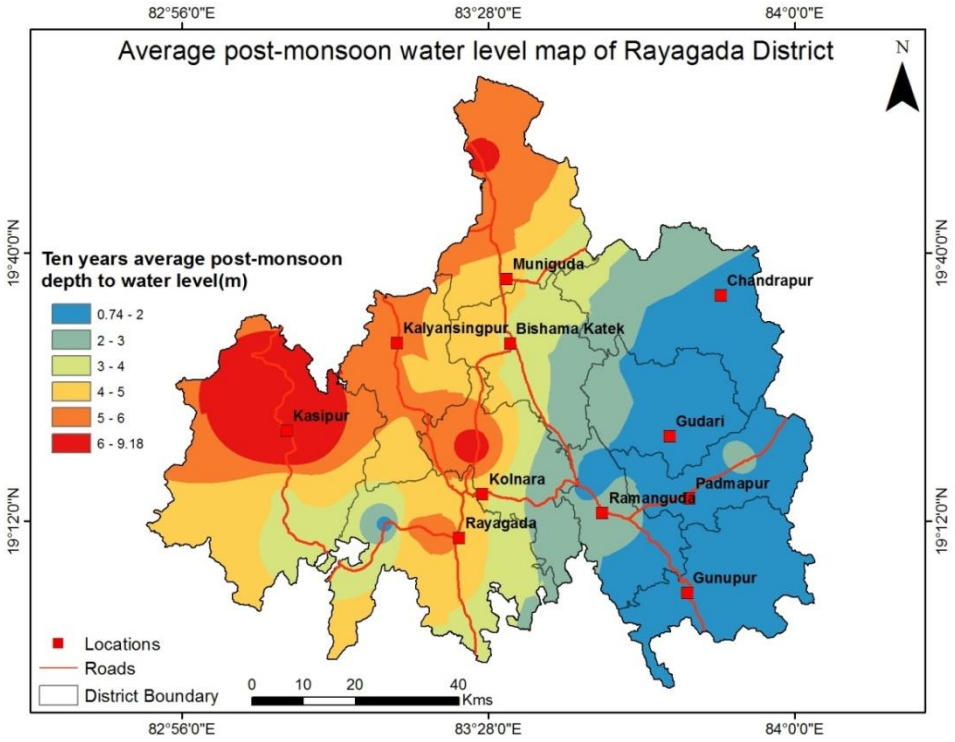


Plate 2.5: Average post-monsoon water level Map of Rayagada district

2.1.5 Decadal Trend: The Decadal trend of water level for premonsoon which is presented in a table 2.2 shows that 31% stations shows rise in the water level where as 42% of stations depicts fall in the water level.

Similarly, the post monsoon trend of water level represents rise in 46% of the stations and 31% of the total stations shows falling trend. (Table 2.3)

Table 2.2: Decadal Trend of Water Level-Pre monsoon of Rayagada District

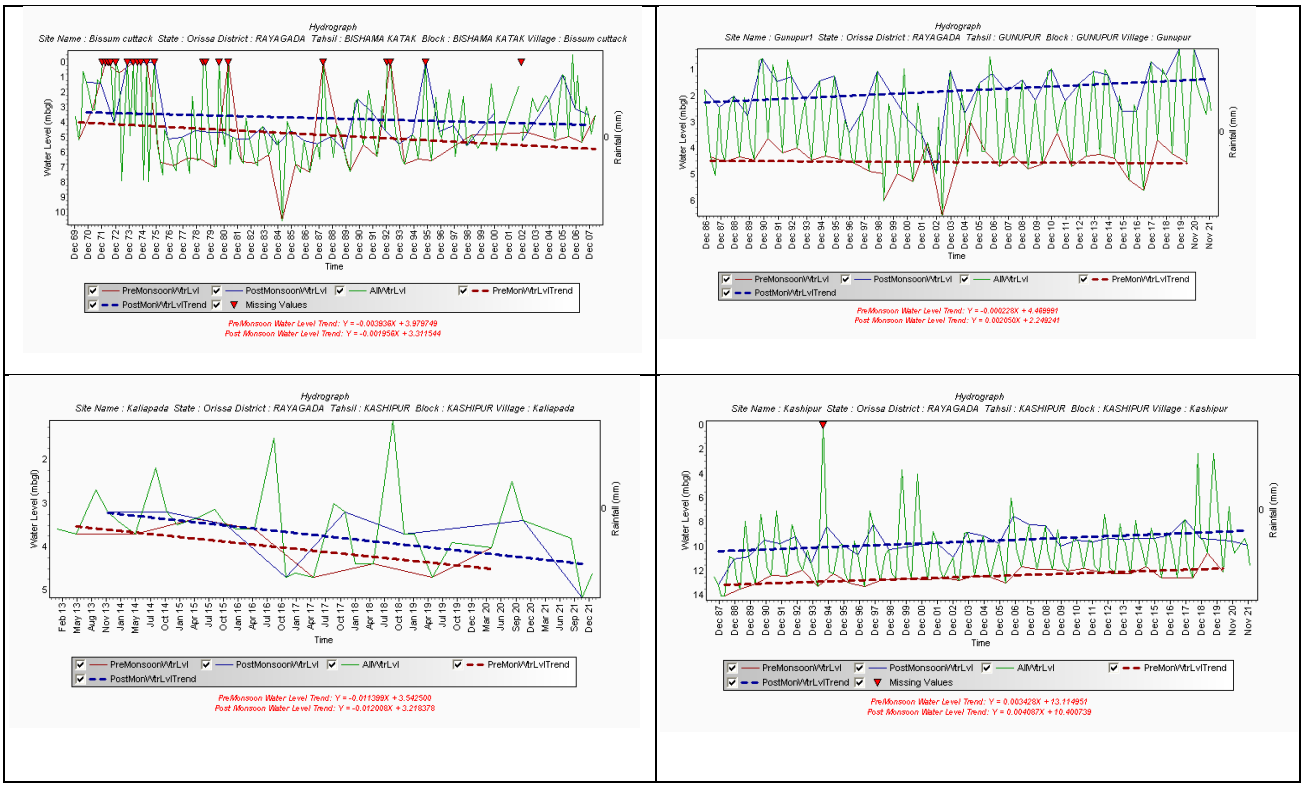
Trend of Water Level – Pre Monsoon (From 2011-21)					
Sl No.	**Location**	**Data Points**	**Rise(m/year)**	**Fall(m/year)**	**Intercept**
1	Akhusingi	8		0.1138	2.3342
2	Ambadola	10		0.2802	6.4883
3	Bangi Chowk	7	0.0398		5.4268
4	Chakunda	5			0.0000
5	Dambasara	8	0.0387		2.3285
6	Durgi	1			0.0000
7	Gorakhpur	9		0.0806	3.8449
8	Gumda	10	0.1263		3.7736
9	Gumma	10		0.0468	1.8980
10	Gunupur1	10		0.0514	4.1772
11	Kaliapada	8		0.1348	3.2255
12	Kashipur	10	0.0296		12.1811
13	Kenduguda	8	0.0361		4.5530
14	Kodapadu	7	0.0535		6.7752
15	Minajhola	5			0.0000
16	Mukundpur	10	0.1403		6.6560
17	Narainpur	10		0.0068	4.2127
18	Nua Dakasikula	7	0.0246		2.7458
19	Padampur2	10		0.0416	1.8504
20	Paikranipinda	0			0.0000
21	Ramnaguda1	4			0.0000
22	Ramnaguda2	6			0.0000
23	Rebatiguda	0			0.0000
24	Shirikona	10		0.0315	6.9676
25	Tandikana	7		0.2408	2.2579
26	Therabali	10		0.1754	7.7140

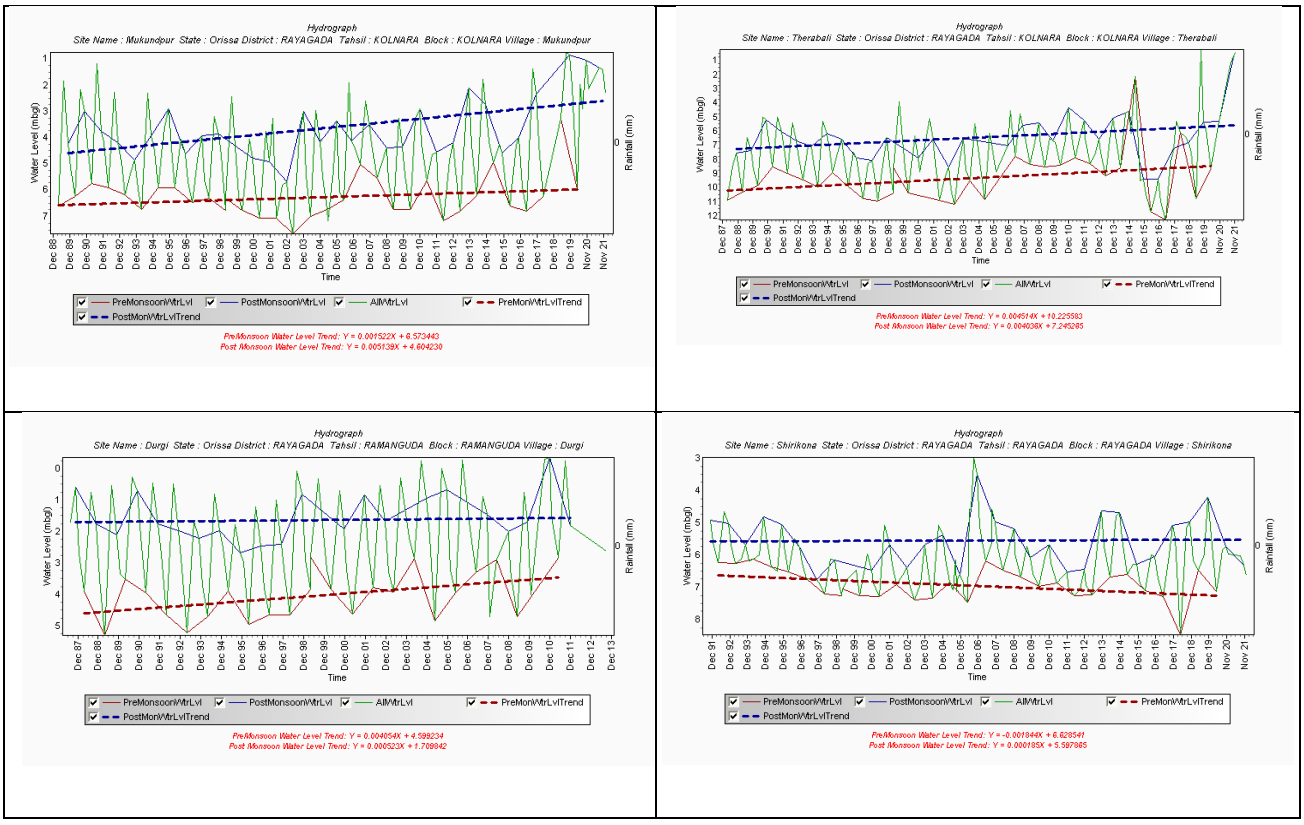
Table 2.3: Decadal Trend of Water Level-Post monsoon of Rayagada District

Trend of Water Level – Post Monsoon (From 2011-21)					
Sl No.	**Location**	**Data Points**	**Rise(m/year)**	**Fall(m/year)**	**Intercept**
1	Akhusingi	9	0.0810		1.7931
2	Ambadola	11		0.1555	5.2696
3	Bangi Chowk	8	0.0790		2.6628

4	Chakunda	5			0.0000
5	Dambasara	9	0.0176		1.5831
6	Durgi	1			0.0000
7	Gorakhpur	11	0.0252		4.0500
8	Gumda	9		0.2012	1.0287
9	Gumma	11	0.0104		1.7071
10	Gunupur1	11	0.1017		1.9970
11	Kaliapada	8		0.1420	2.8095
12	Kashipur	10		0.0027	9.2430
13	Kenduguda	9		0.1216	1.8098
14	Kodapadu	8		0.0261	5.2339
15	Minajhola	6			0.0000
16	Mukundpur	10	0.3190		4.6237
17	Narainpur	11	0.0505		1.4621
18	Nua Dakasikula	7		0.0142	0.6840
19	Padampur2	10	0.0473		1.5856
20	Paikranipinda	1			0.0000
21	Ramnaguda1	3			0.0000
22	Ramnaguda2	7	0.2190		2.8099
23	Rebatiguda	1			0.0000
24	Shirikona	11	0.0523		5.8572
25	Tandikana	8		0.0618	1.0288
26	Therabali	11	0.2291		7.3337

Fig 2.1 Hydrographs of representative area





2.1.6 Groundwater Movement: Major parts of the district present an uneven and rugged topography characterized by high run off and low infiltration. The aquifers are highly discontinuous. Water table contour could not be drawn in those hilly and rugged terrains. Efforts have been made to draw the water table contours in discontinuous patches which are relatively very much plains; to draw these contours surface elevation has been estimated w.r.t. spot heights/bench marks and even studying the successive contours and ultimately a very limited number of water table could been drawn. The water table is continuous mainly in the valley fills and/or flood plains of the Vamsadhara and Nagavalli rivers. The water table gradient varies from 1/20 to 1/200. The rivers are generally effluent excepting downstream of Rayagadain Nagavalli valley where influent condition may exist. The groundwater flow direction has been shown on hydrogeological map.

2.2 Hydrochemistry (Annexure 9)

The quality of water is significant to the mankind, because it has a direct link with human welfare. In an agrarian country like India, groundwater quality is of paramount importance in assessing its suitability for irrigation purpose. A study on geochemical characterization of groundwater and its suitability for irrigation purpose was carried out in the mineral rich Rayagada District, Odisha State. Altogether 75 groundwater samples were collected during May 2021. The quality assessment is made through the estimation of Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Cl^{-}, SO_4^{2-}, CO_3^{2-}, HCO_3^{-} and total hardness as $CaCO_3$, TDS, EC and pH. Based on these analyses, the irrigational parameters like sodium absorption ratio, sodium%, residual sodium carbonate, potential salinity,

magnesium ratio, Kelley's ratio and permeability index were calculated to determine the suitability of groundwater for irrigational purpose. The groundwater falling under (Doneen's) class-II is almost good for irrigation purpose whereas groundwater falling under class-III indicates poor water quality. The groundwater samples are excellent to good as per Wilcox diagram.

Various classifications show that present status of groundwater is suitable for irrigation purpose, except few locations, with a caution that it may deteriorate in near future.

2.2.1 Groundwater Chemistry: The hydro-chemical parameters were analyzed to assess the suitability of groundwater of the study area for agricultural purpose. The analytical results and computed values of water samples of the study area are given in Annexure. The groundwater quality data interpretation for irrigation has been carried out as per guidelines given by Ayers (1977) and Christiansen et al. (1977). The suitability of water for irrigation depends upon TDS (salinity) and the sodium content in relation to the amounts of calcium and magnesium or Sodium Absorption Ratio (Alagbe, 2006).

2.2.2 Piper Diagram: Piper Trilinear Diagram: The Piper diagram (Piper, 1953) is analysed to interpret hydro-geochemical facies. This diagram includes two triangles (one for cations and one for anions). This tri-linear diagram is useful in bringing out chemical relationships among groundwater samples in more definite terms. Thus, groundwater samples are plotted in the Piper Trilinear Diagram (Fig. 2). Facies are recognizable parts of different characters belonging to any genetically related system. Hydrochemical facies are distinct zones that possess cation and anion concentrations. For anion concentration, the plot shows that most of the groundwater samples fall in the field of Chloride and Bicarbonate type. The groundwater samples fall in the fields 5 and 9 of the diamond shaped field.

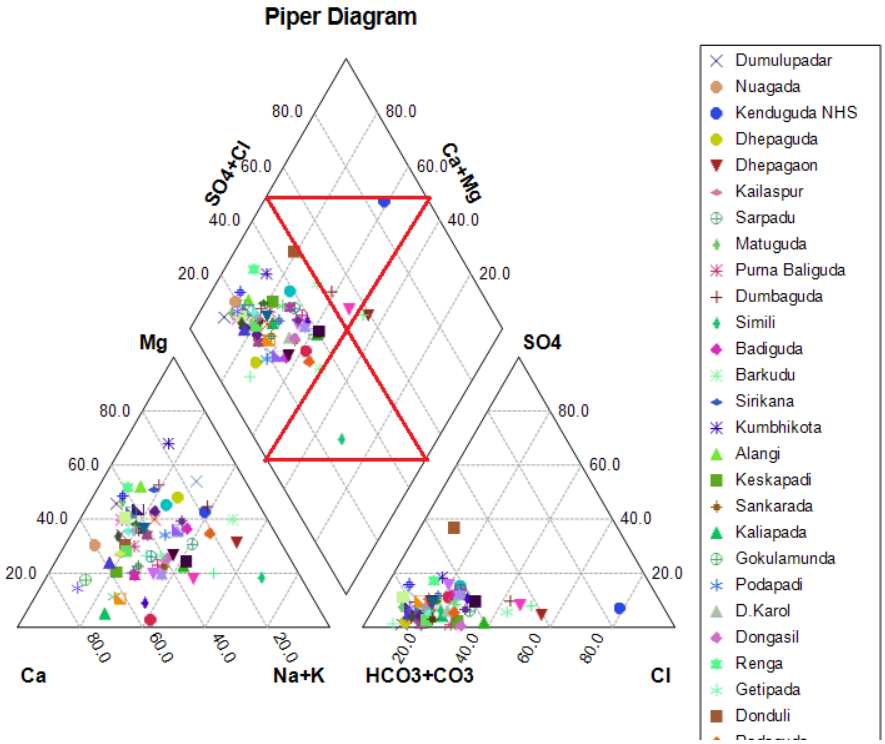


Fig. 2.2 Piper Trilinear Diagram

2.2.3 Salinity: The salinity (usually recorded as Electrical Conductance/EC) affects the availability of water to crops. The EC varies from 76 µS/cm (Gorakhpur, Kashipur block) to 2900 µS/cm (Kenduguda NHS). The EC values of all samples are excellent to good and good to permissible limit according to the classification of Wilcox (1967).

2.2.4 Bicarbonate: Bicarbonate concentrations of all the samples come under no problem except one that falls under increasing category. Bicarbonate ranges from 0.92 epm (Gorakhpur, Kashipur block) to 11epm (Dhepgaon) in the study area. Bicarbonate content more than 1epm in the water is necessarily attributed from the biological activities of plant roots, from the oxidation of organic matter included in the soils and in the rock, and from various chemical reactions.

2.2.5 Sodium Absorption Ratio (SAR): The sodium or alkali hazard in groundwater for irrigation is determined by the absolute and relative concentration of cations and is expressed in terms of Sodium Absorption Ratio (SAR). There is a significant relationship between SAR values of irrigation water and the extent to which sodium is absorbed by the soil. If groundwater used for irrigation is high in sodium and low in calcium, the cation-exchange complex may become saturated with sodium.

$$SAR = \frac{Na+}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}}$$

A simple method of evaluating the high sodium in water is the Sodium Absorption Ratio. Calculation of SAR value for a given groundwater provides a useful index of the sodium hazard of that water for soil and crops. A low SAR of 2 to 10 indicates little danger from sodium; medium hazard is in between 10 to 18; high hazard is in between 18 to 26 and very high hazard is above 26. The lower the ionic strength of solution, the greater sodium hazards for a given SAR value of groundwater sample. The values of SAR in the groundwater samples of the study area range from 0.0595 epm (Nuagada) to 6.234 (Simili) (Annexure).

2.2.6 Residual Sodium Carbonate: Residual Sodium Carbonate (RSC) is defined as (CO_3^{+} HCO_3^{-}) – (Ca^{++} + Mg^{++}), where all concentrations are expressed in epm. Water having excess of carbonate and bicarbonate concentration over the alkaline earth mainly of calcium and magnesium (beyond the permissible limit) affects agriculture unfavorably. The values ranges between -13.75 epm (Kendugura) to 4.76 (Simili). The values < 1.25 epm are safe for irrigation purpose. The values 1.25-2.5 are marginally safe.

2.2.7 Doneen's Permeability Index: Permeability of the soil is influenced by the sodium content of the irrigation water. The permeability index (PI) is obtained by considering the ions (epm), which influence permeability. Permeability Index is defined as:

$$\text{Permiability Index(PI)} = \frac{Na+\sqrt{HCO_3^-} \times 100}{Ca^{++} + Mg^{++} + Na+}$$

The concentration of cations and anions are in epm. The groundwater samples of the study area fall in class-II. It is inferred on the basis of the permeability index that the groundwater of the study area is almost suitable for irrigation purpose. The increased percentage of groundwater samples under class-II is due to dilution and subsequent lower values of permeability index.

2.2.8 Potential Soil Salinity (PS): Doneen (1962) proposed a criterion based on the salinity of the irrigation water, which is an improvement over the U.S soil salinity. The potential soil salinity (PS) is given by the concentration of chloride of half of the sulphate ions.

$$PS=Cl\ (epm) +1/2\ SO^{4}\ (epm)$$

The potential soil salinity varies between 0.178 epm(Gorakhpur, Kashipur block) to 22.627 epm (Kendugua). From the PS classification, it is clearly evident that the groundwater of the study area comes under excellent to good category for irrigation.

2.2.9 Wilcox Diagram : Percentage of sodium content in natural water is an imperative parameter to assess its suitability for agricultural use. A maximum of 60% sodium in groundwater is allotted for agricultural purposes . Sodium percentage can be defined in terms of epm of the common cations. The concentrations of cations are in epm.

$$Na\% = \frac{(Na^{+}+K^{+})100}{Ca^{++}+Mg^{++}+Na^{+}+K^{+}}$$

+

The sodium percentage (Na %) in the study area ranges from 9.21 epm (Dumlapda) to 69.18(Simili, Gudari Block). The highest percentage of sodium is found in the dug well water sample of Simili. The minimum value of Na% is located in the water sample of Dumplapada. Plotting the data of the study area on Wilcox diagram relating to electrical conductivity and sodium percentage (Fig. 2) show different water classes for irrigation on the basis of Na% value. Figure 2 explicitly reveals that all samples fall in excellent to good zone. Excellent to good and good to permissible water can be used for the purpose of irrigation.

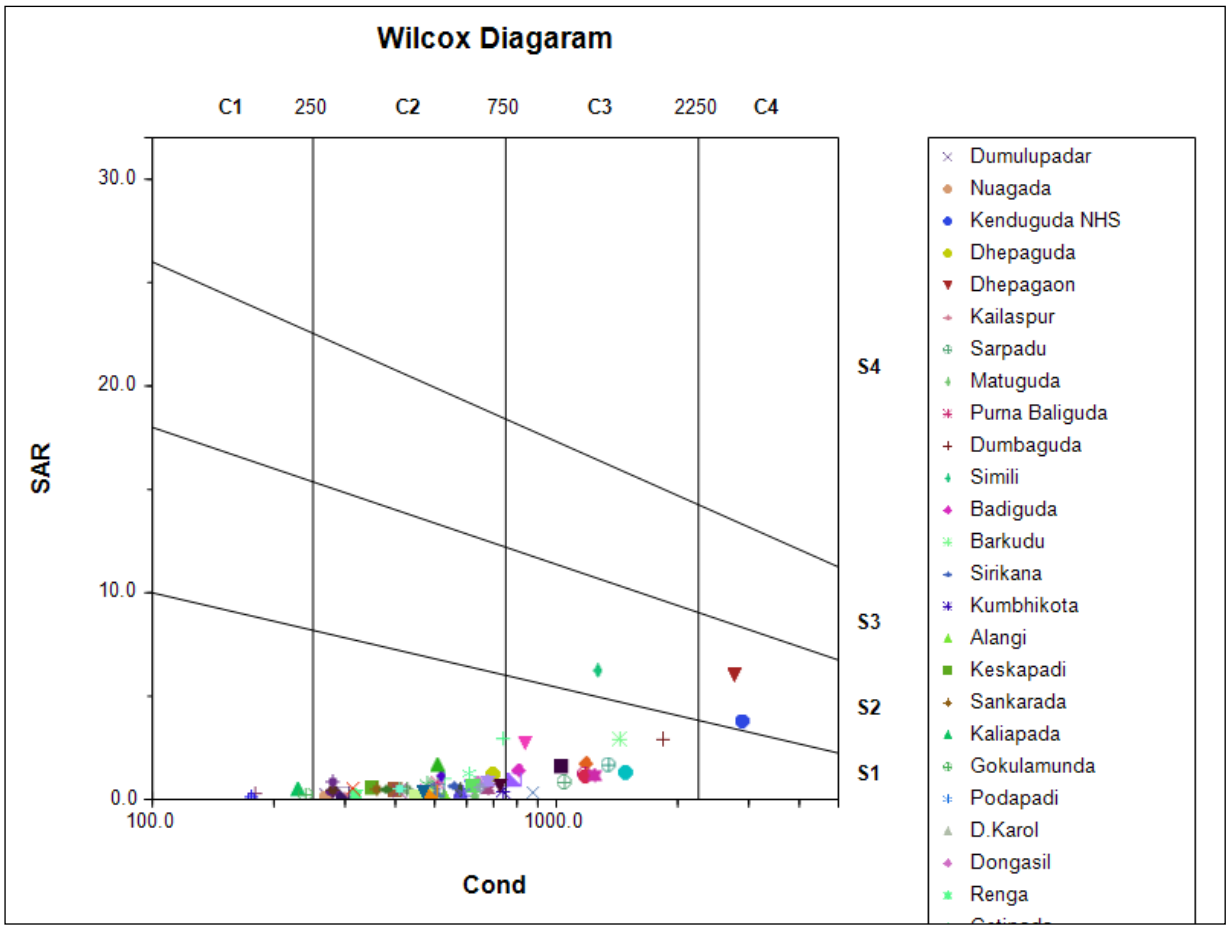


Fig. 2.3 Wilcox Diagram

2.2.10 USSL Diagram : In the U.S. Salinity Laboratory diagram based on Sodium Absorption Ratio (SAR) vis-a-vis specific conductance values, the two most significant parameters namely sodium and salinity hazards determine the suitability of water for agricultural purpose. Out of 16 water samples, 15 samples are plotted in C_1S_1, which indicate low salinity and lower alkali water and only one sample plotted in C_2S_1 reveals medium salinity and lower sodium water.

2.2.11 Kelley's Ratio: Kelley et al. (1940) have suggested that the sodium problem in irrigational water could very conveniently be worked out on the basis of the values of Kelley's ratio. Groundwater having Kelley's ratio more than one is generally considered as unfit for irrigation. Kellys ration is calculated for the samples of the study area (Annexure). It varies from 0.027 (Nuagada) to 0.41 epm (Simili) The formula used in the estimation of this ratio is expressed as:

$$\text{Kelly's ratio} = \frac{Na^{+}}{Ca^{++}+Mg^{++}}$$

2.2.12 Magnesium Ratio: The magnesium ratio can be expressed as:

++++

$$MR = \frac{Mg^{++} \times 100}{Ca^{++}+Mg^{++}}$$

++
+
×

(All ions are expressed in epm). Excess of magnesium affects the quality of soils, which is the cause of poor yield of crops. The magnesium ratio of groundwater varies from 4.279 (Thumpadi, Bissamcuttack block) to 79.29 epm (Kumbhikota). More magnesium present in water will adversely affect the soil quality, converting it to alkaline and decreases crop yields. The high magnesium ratio in the area depicts that the water cannot be used for agricultural purpose.

2.2.13 Conclusion: The study is based on the quality assessment of the groundwater system to identify the suitability of water for irrigation purpose. Various parameters such as salinity, sodium absorption ratio (SAR), Sodium percentage (Na%), Residual Sodium Carbonate (RSC), sodium carbonate values show that most of the water class-II for most of the sites as per classification of good for irrigation.

The increased percentage of groundwater samples under class-II is due to dilution and subsequent lower values of permeability index. The Wilcox classification shows most of the samples come under excellent to good zone. Graphical representation of the chemical data on the irrigation suitability diagram shows that the region contains low salinity and lower alkali water (C1S1) in almost all areas except one which shows medium salinity and lower sodium water quality and needs adequate drainage to overcome the salinity problem. As a whole, the water of the study area is safe for irrigation purposes except few locations, with a caution that it may deteriorate in near future. Preferably, the soil must be permeable with adequate drainage facilities for satisfactory crop growth. However, remedial measures should be taken to monitor the quality of groundwater. In zones that have high sodium content in groundwater; one can go for sodium/ salinity resistant crops.

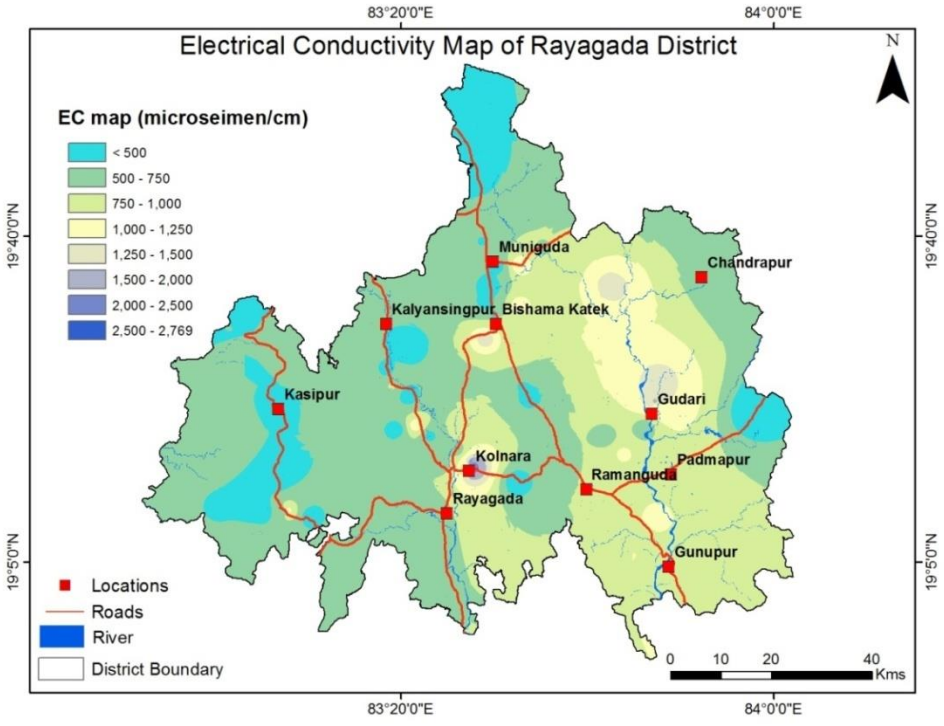


Plate 2.6: Electric Conductivity Map of Rayagada district

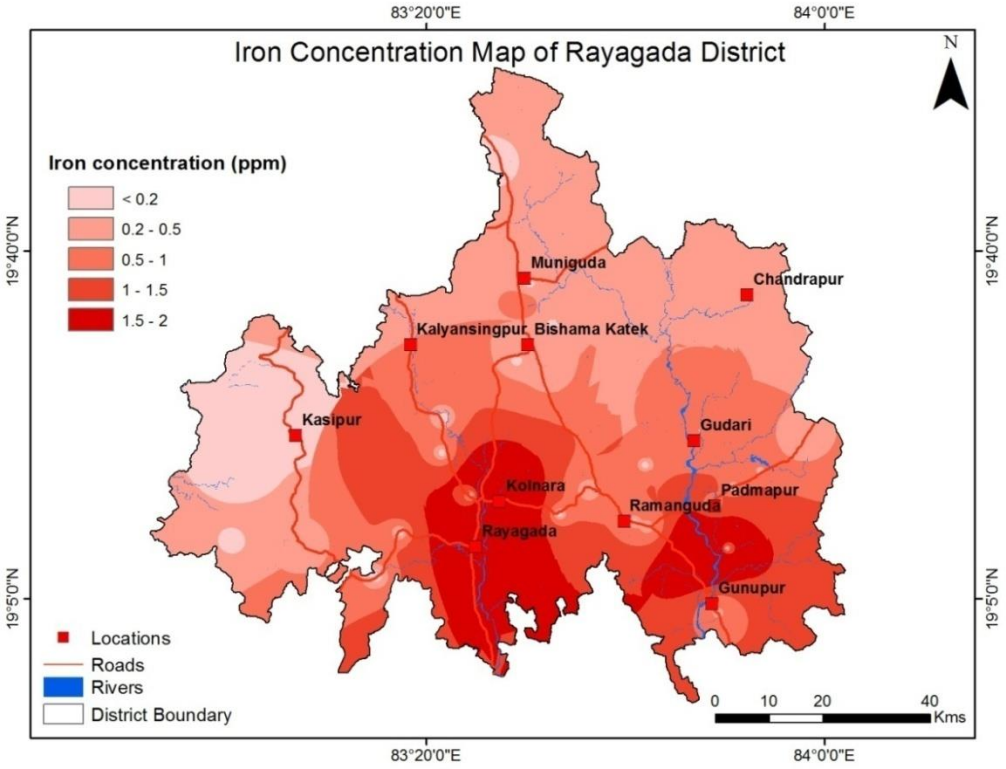


Plate 2.7: Iron concentration Map of Rayagada district

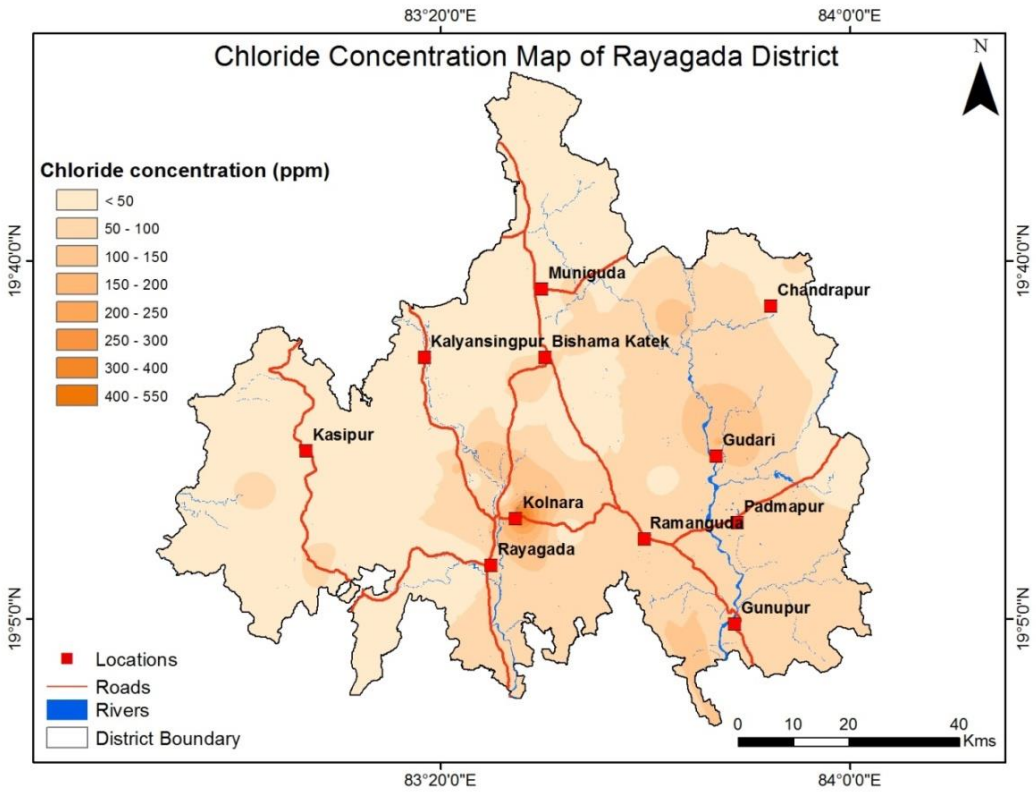


Plate 2.8: Chloride concentration Map of Rayagada district

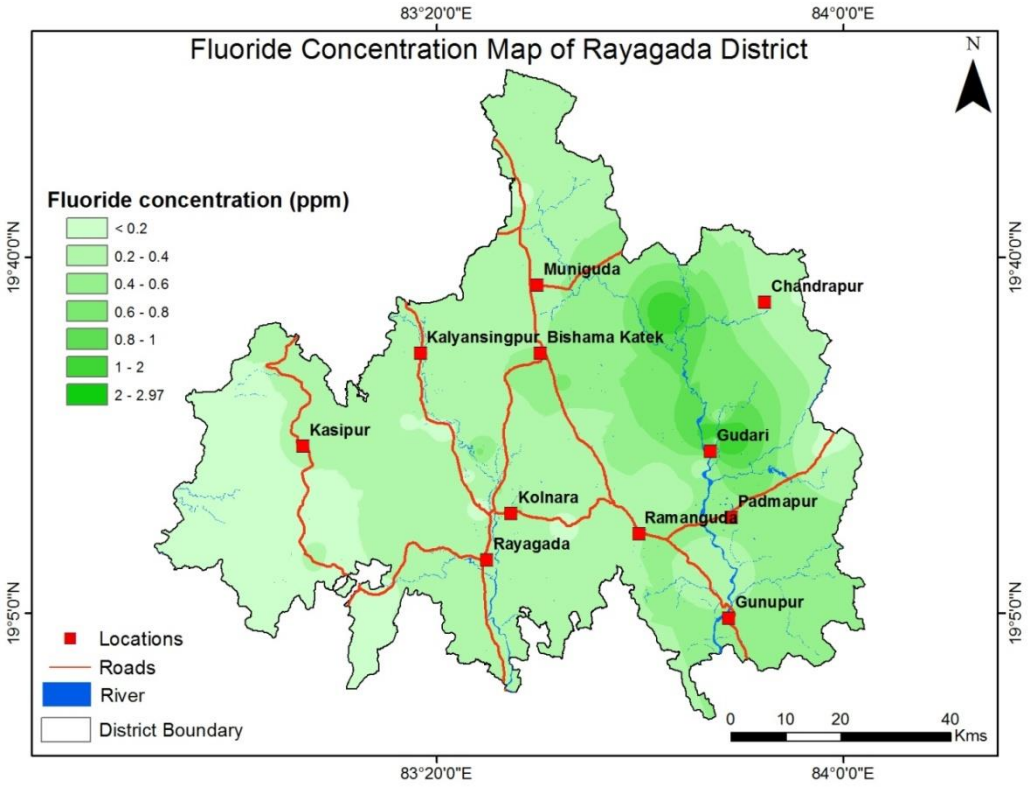


Plate 2.9: Fluoride concentration Map of Rayagada district

2.3 Geophysical

2.3.1 Survey Area, Geology and Hydro geological Conditions: Raygada districts situated in the south western part of Orissa lying between the north latitudes 180 54/ and 200 00/ N and east longitudes 820 54/ and 82002' E. It is bordered by Kalahandi Phulbani district of Orissa in North and Gajapati district of Orissa in the South. The Vamsadhara and Nagavally rivers river is the most prominent river in the district.

The climate of the district is typically tropical to subtropical with three distinct seasons e.g. summer, winter, and monsoon. The average annual rainfall varies from 1030.21 mm to 1569.50 mm. The district has varied geomorphological features. Major Physiographic Units are 1. Undulating plains dotted with residual hills and 2. Scattered hills are present with high relief.

Predominant geological formations are Eastern Ghat Supergroup of Rocks (Precambrian Crystalline Rocks) and Quaternaries. Major water bearing formations are weathered & fractured crystalline rocks. EC and F value higher in limited patches.

The hydrogeological conditions vary from place to place depending upon the aquifer characteristics of the litho units, sources of groundwater recharge and the structural setting of the area. The hydrogeological units of the area are broadly categorized into three groups namely: Consolidated formations, Semi Consolidated formations and Unconsolidated formations.

The weathered and fractured granites, granite gneisses and their variants, khondalites, charnockites etc. are the most predominant rock types in the district. These are characterized by development of secondary porosity. The secondary porosity in the consolidated formations developed as a result of weathering and fracturing due to major and minor tectonic movements from the conduits for movement of groundwater as also act as reservoir of groundwater. Generally, the secondary porosity developed in the crystallines is non uniform in distribution. This fractured and jointed rocks when interconnected form potential aquifers, which sustain limited to moderate yield.
Semi consolidated porous laterites are occurring as discontinuous capping over older formations. These have both primary and secondary porosities. Recent alluvium (unconsolidated formation) occurring as valley fills of the rivers, Vamsadhara & Nagavalli are characterized by primary porosity.

The granite and granite gneisses with leaching out of kaolinised clay on weathering reduce to porous granular materials. The weathered as also fractured and fissures intersecting system of granite gneisses in topographic lows form potential aquifers. The yield of the wells depends upon the thickness of the saturated zone as also number of fractures tapped. Khondalites are actually metasediments and occupy mainly ridges and hills, covered with thick forests and profuse vegetation. Khondalites have undergone high degree of weathering down to a depth of more than 20 meters. Although the interlacing joints and sheared surfaces, from potential receptacles of groundwater, preponderance of clayey material reduces the permeability of the formation. The Charnockitic rocks in the area are generally devoid of significant ground water storage due to lack of well-connected joints and fractures.

Porous laterites are formed as capping over the crystalline hard rocks in the upland areas like the Raygada-Kolnara uplands, Kailashkota, Ramanguda, Gudari section etc. Due to restricted areal extent these rocks do not contribute as potential aquifers.

The alluvial deposits in the flood plains of the Vamsadhara and Nagavali rivers form the most potential aquifer system of the district. The borehole data reveals that there is a sub surface disposition of aquifers in parts of the Vamsadhara basin. The colluviums in the intermontane valleys also form rich aquifers. The alluvium comprises an admixture of gravel, sand and clay derived from eroded and weathered country rocks. Groundwater occurs in these deposits under both unconfined as well as semi confined conditions.

In the saprolite/regolith horizon ground water generally occurs under unconfined condition where as is the fractured bedrock aquifers it occurs under semi-confined to confined conditions. The ground water potentials of various zones i.e. saprolite (tapped by dug wells), weathered basement rock and shallow fractured basement rock horizon (tapped by the hand pumps) and deeper fractured basement rock (tapped by the deep boreholes by CGWB) vary considerably depending upon their lithological and structural characteristics.

2.3.2 Electrical Resistivity Survey: A total of 74 VES were carried out in Rayagada district (Phase II). The VES locations are shown in Plate.

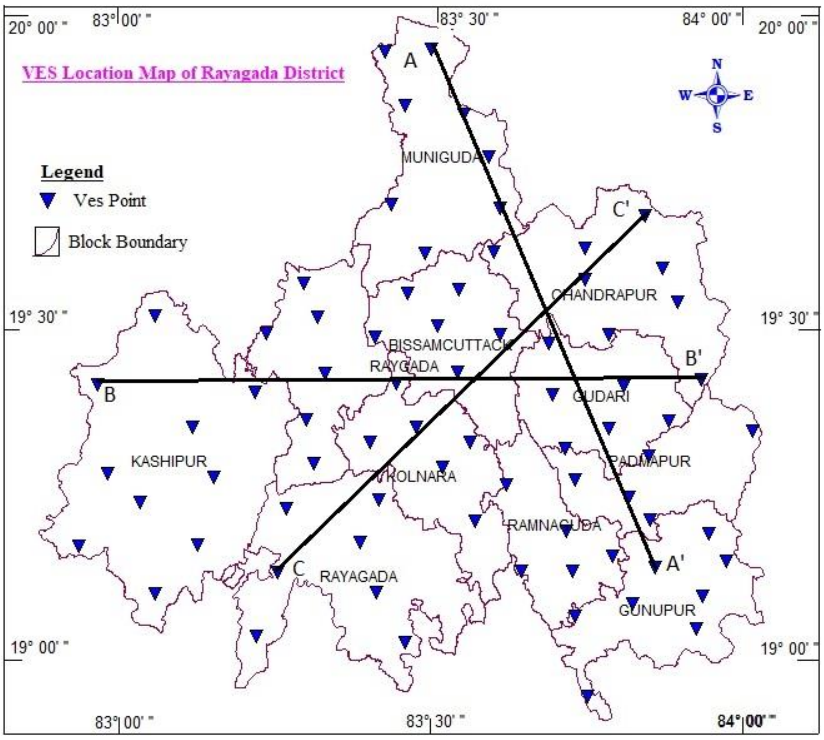


Plate 2.10: VES Location Map of Rayagada district

2.3.3 Interpreted VES Results: The Interpreted results of VES are given in Annexure I. There are only three boreholes drilled by CGWB in the study area, one at Muniguda, which is about 1.2 km from the nearest VES point 467 and the another two are at Therubali and Rayagada, which are more than 2 km from the nearest VES points. After comparing the VES results with the nearest borehole lithology (Annexure), local geology and hydrogeology, the resistivity characteristics of the near surface weathered rock and the underlying massive / fractured formation were established and are presented in (Annexure).

The resistivity of the top geoelectric layer inferred as soil varies between 5 and 322 Ohm m depending on its nature and saturation and the thickness varies between 0.3 and 3.8 m. At few places, the 2nd and / or 3rd geoelectric layer, occasionally 4th one with resistivities ranging from 3 to 30 Ohm m, occasionally exceeds to 50 Ohm m has been inferred as Alluvium. Its thickness is varying between 0.9 to 11 m, occasionally exceeds to 32 m, while depth ranges varying between 1.5 and 18.3 m, occasionally exceeds to 38.2m.

Mostly the 2nd or 3rd geoelectric layer, occasionally, the 1st or 4th one with resistivities ranging from 6 to 76 Ohm m has been inferred as weathered layer. Its thickness is ranging from 2.2 to 23.6m. The 2nd or 3rd geoelectric layer, occasionally, the 1st one with resistivities ranging from 66 to 317 Ohm m has been inferred as semi weathered layer. Its thickness is ranging from 3.8 to 25m. in general, the weathered / semi-weathered layer extends down to a depth of 28.6m. The wide range of resistivities may be due to its nature and saturation. 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. Mostly the 3rd or 4th geoelectric layer, occasionally, the 2nd or 5th one with resistivities ranging from 14 to 683 Ohm m, occasionally exceeding up to 1130 Ohm m has been inferred as Less compact formation / formation with fractures. Wide range of the resistivities may be due to the variations in the degree of fracturing, nature of the formation, etc. The thickness of the geoelectric layer inferred as less compact / formation with fractures, in general varies between 8.5 and 200 m. The depth to bottom of this layer is, in general, varying from 18.5 to 200 m. The layer with resistivities more than 632 Ohm m occasionally more than 1839 Ohm m may be inferred as compact depending on the nature and type of the formation.
On the basis of geoelectrical layer parameters and the fractured zone analysis a few sites are recommended for borehole drilling or Shallow borehole or Dug well (Annexure 6).

2.3.4 Conclusions and Recommendations: In the surveyed area of Rayagada district, in general, the weathered / semi weathered zone extends down to a depth of 28.6 m bgl. Thin fractured zones were identified by 'current increase', 'curve break' and 'factor flat'. Mostly the 3rd or 4th geoelectric layer, occasionally, the 2nd or 5th one with resistivities ranging from 14 to 683 Ohm m, occasionally exceeding up to 1130 Ohm m has been inferred as Less compact formation / formation with fractures. Wide range of the resistivities may be due to the variations in the degree of fracturing, nature of the formation, etc. The thickness of the geoelectric layer inferred as less compact / formation with fractures, in general varies between 8.5 and 200 m. The depth to bottom of this layer is, in general, varying from 18.5 to 200 m. The layer with resistivities more than 632 Ohm m, occasionally more than 1839 Ohm m may be inferred as compact depending on the nature and type of the formation.

At few places, the thickness of alluvium is varying between 1.6 to 32.4m, while depth ranges varying between 0.9 and 11m, occasionally exceeds to 32 m, while depth ranges varying between 1.5 and 18.3 m, occasionally exceeds to 38.2m.

On the basis of geoelectrical layer parameters and the fractured zone analysis a few sites were recommended for borehole drilling.

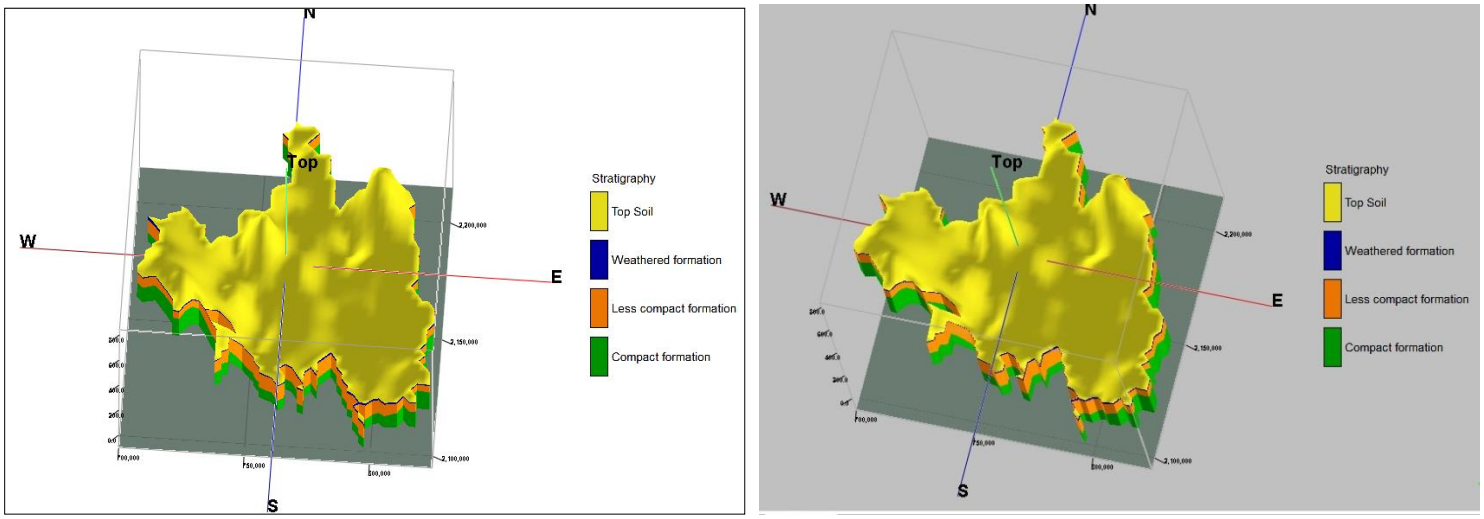


Fig.2.4 3D from Geophysical interpretation

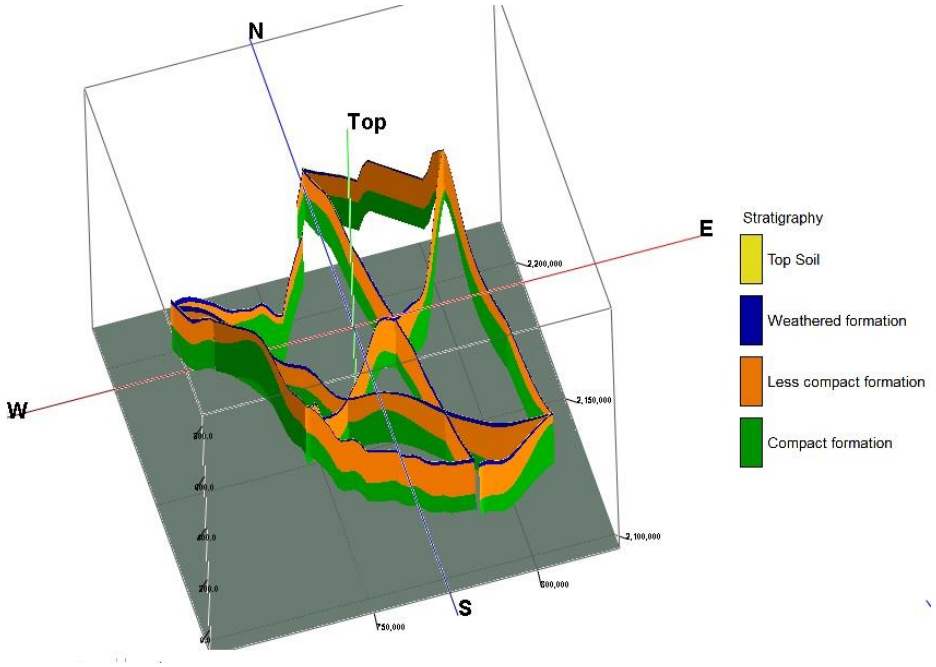


Fig.2.5 Fence diagram from Geophysical interpretation

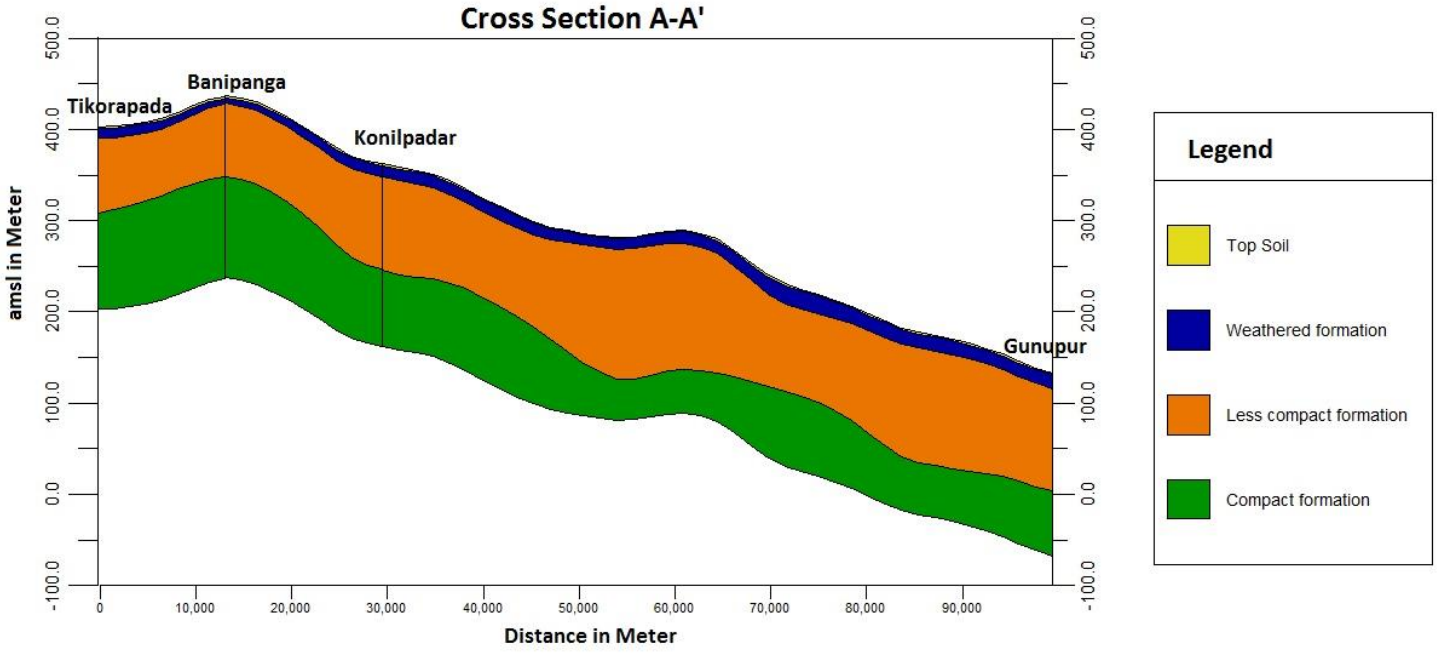


Fig.2.6 Cross section along A-A’

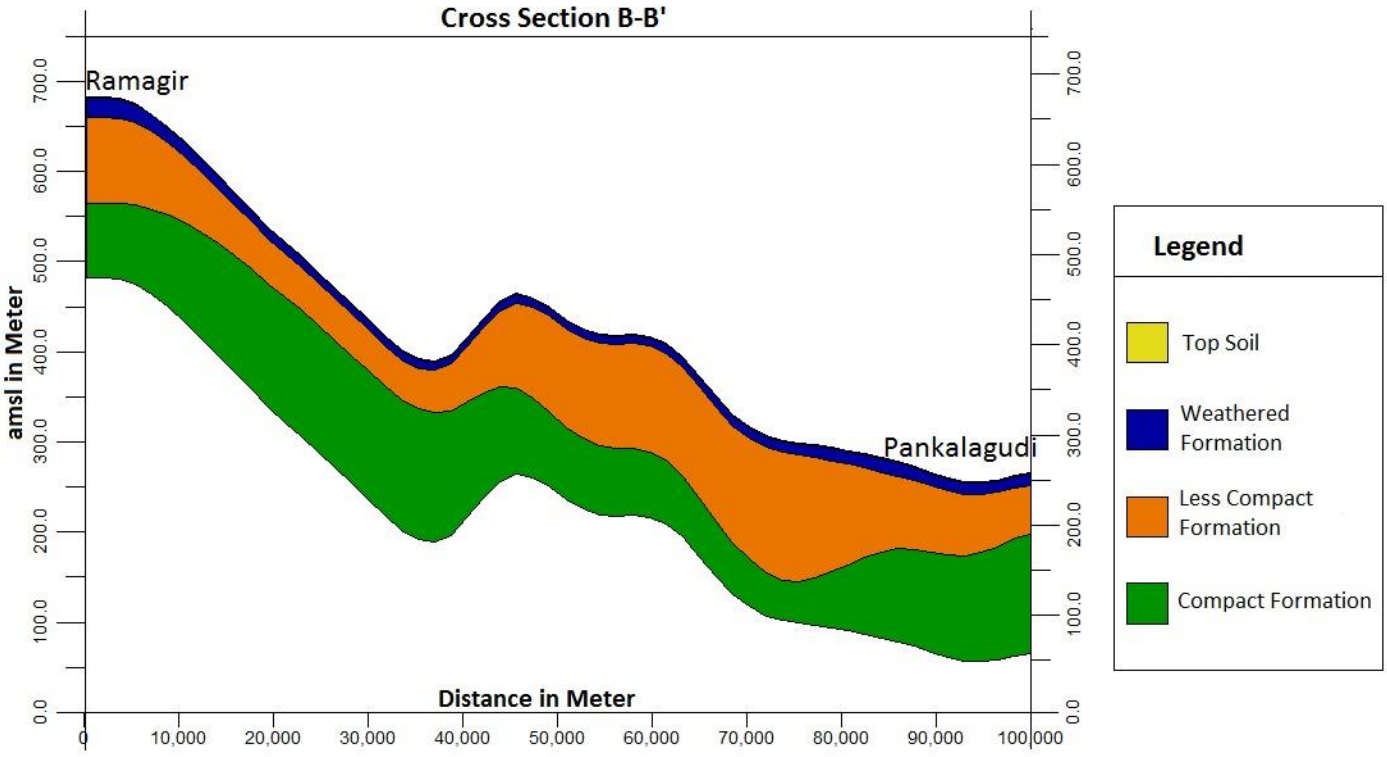


Fig.2.7 Cross section along B-B’

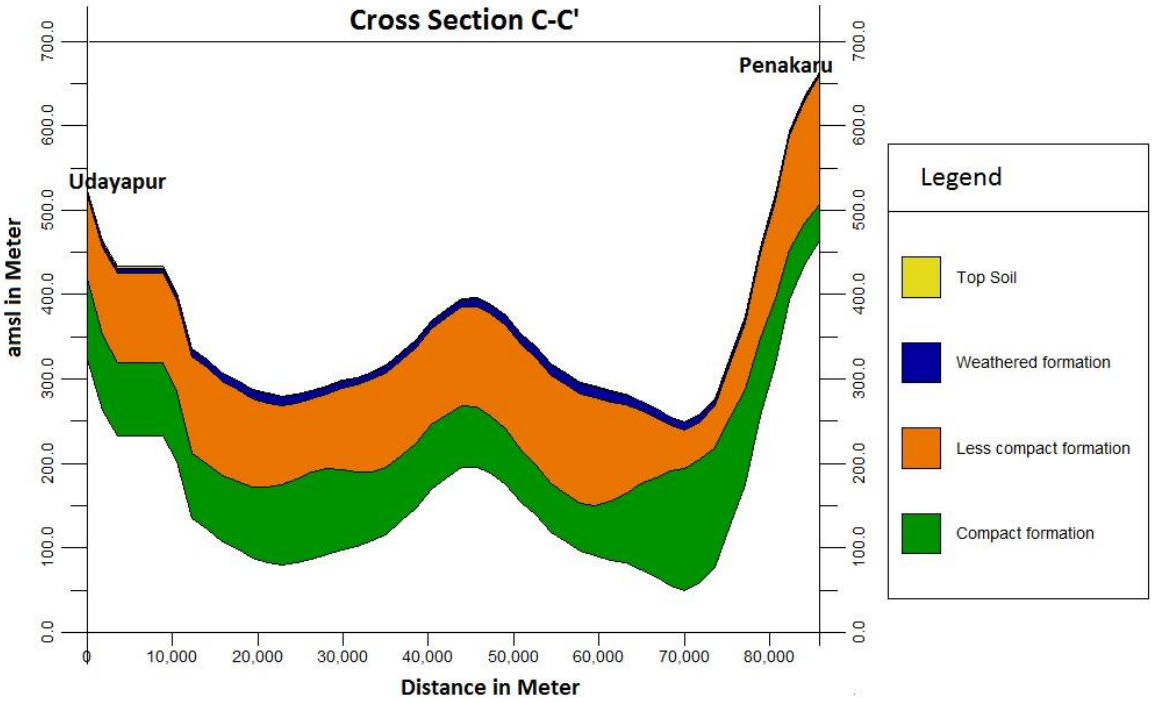


Fig.2.8 Cross section along C-C’

2.4 Exploratory drilling

2.4.1 Previous study: Initially 11 exploratory drilling carried out by CGWB during 1989-92 and has yielded good results. The bore hole drilled by CGWB ranged from 25.60 to 200.60 m depth, which recorded maximum discharge of 23.50 lps wells tapping granite gneiss at a depth of 43, 82, 87 and 105 mbgl. The wells constructed in granite gneiss having depth ranges of 91.80 to 185.00 mbgl with discharge ranges from 0.5 lps to 23.50 lps. The wells constructed in khondalites having depth ranges of 198 to 200.60 mbgl with discharge ranges from 1.35 lps. The wells constructed in fractured charnockites having depth ranges of 63 to 75 mbgl with discharge ranges from 7.50 to 10.50 lps. The wells constructed in alluvium having depth ranges of 25.60 to 50.5 mbgl with discharge ranges from 1 to 1.33 lps. The wells constructed in granite having depth ranges of 132 to 138.20 mbgl with discharge ranges from 4.5 to 4.70 lps. (Annexure- 7)

2.4.2 Present Study: During AAP 2020-21 a total number of 42 exploratory wells have been constructed within a depth ranges from 101 – 207 mbgl depth and discharge varying from negligible 0.1 lps to 18.5 lps. Lithologs data, discharge data, chemical quality data etc. are also collected from the Basic data reports of 42 Exploratory wells constructed in Rayagada District. The details of the exploratory drilling are presented in Annexure -8.

3. DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

3.1 Geology of the Study area: Rayagada district is mainly occupied by the crystalline of Precambrian Eastern Ghats. In the narrow elongated valleys of the Vamsadhara and Nagavalli rivers and their tributaries which are occupied by thick alluvium.

The Precambrians in the area are represented mainly by the Granite gneiss and its variants, Khondalites and Charnokites. Alluvium consists mainly sand, silt and clay. The general geology of Rayagada district is as follows:

Alluvium

Quarternary---------- ------unconformity----------

Laterite

---------- Unconformity ----------

Precambrian ---------- Charnockites

Khondalite

Granite gneiss and its Variants

Geology Map is shown in Plate No.3.1

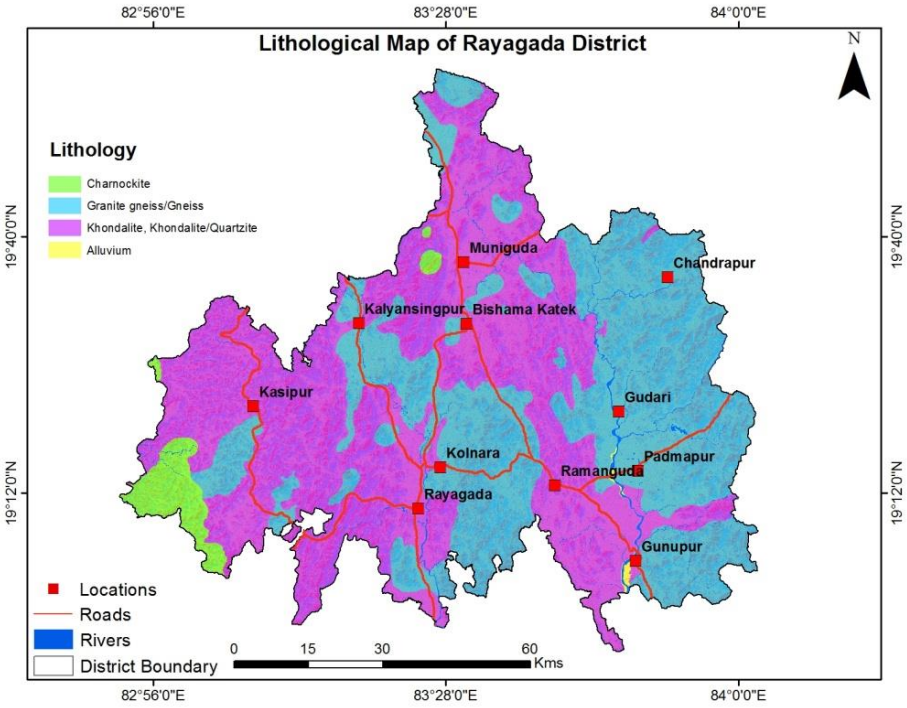


Plate 3.1: Lithological Map of Rayagada district

I. **Precambrians:** The Precambrians of Rayagada District belongs to Eastern Ghats Mobile Belt. The structural elements developed in these rock types is attributed to the mobile belt tectonism. Among all the rock types encountered granite gneiss is predominant.

II. **Granite Gneiss and its variants:** Granite gneiss is the common rock type in the area. The hilly as well as flat terrains are generally occupied by granitic rocks, the older granite gneiss, at places are intruded by younger granitic rocks, which are harder in nature and texturally they are also different. The later generally occurs as isolated hills. At places, gneissosity in the Granite gneiss obliterated. Gneissosity trend ranges from NNE-NSW to SE-NW. NE joints in the granitic rocks are:

(i) NE-SW/steeply dipping northwesternly.

(ii) ENE-WSW to E-W /Subvertical.

These granitic rocks are generally leucocratic, coarse to very coarse grained and sometimes contain garnet as accessory. The common texture is porphyroblastic. Typical Augen gneisses have been encountered northeast of Ambadola.

III. **Khondalites:** In the present area the khondalitic suits of rocks occur mainly as linear to curvilinear patches.Th trend of these bodies is generally NNW-SSE to N-S, this trend is very characteristic feature in the eastern sector of Rayagada district of Nagavalli river.Khondalites are essentially garnetiferous quartz schist, containing graphite as accessory and reddish in colour. They are prone to weathering and secondary porosity is well developed in these rocks. Gneissosity in khondalites like Granite Gneiss is varying in orientation and ranges between NE-SW to NNW-SE with medium dips towards varying direction. Generally, three sets of joints are well developed in these rocks.Khondalites are often intruded by Charnockites.

IV. **Charnockites:** These rocks occur as isolated bodies and are intrusive in the older gneisses and khondalies. At places, they occur as dome shapd outcrops viz. Kalyansinghpur area and are massive in nature. Charnockite are melanocratic and essentially hypersthenes-granite containing smokey quartz and blue feldspar. The prominent joints in charnokites are NNW-SSE to NW-SE with medium to steep dips.

V. **Laterites:** In Rayagada district, laterites occur as capping on the older country rocks i.e. khondalites and Granite Gneisses in medium to high altitude areas viz. Rayagada, Kulnara, Kailaskota, Ramnaguda.

VI. **Alluvium:** Quaternary alluvial deposits generally occur as valley fill and/or flood plain dposits long the courses of the two main rivers viz Vamsadhara and Nagavalli.

In the Nagavalli river valley areas, alluvium occurs as narrow linear body, 40 kms long to 9 km wide lithologs of vtubewells around Rayagada-Kotapetta-Khulliguda area reveal alluvial thickness of more than even 45m.

In the Vamsadhara river valley areas, alluvium occurs as relatively wider patch, Padampur-Gunupur sector is the prime area of alluvial deposits, having width of 10 to 14kms. Lithologs of tubewells reveal the maximum thickness of alluvium of the order of 40m.

Alluvium also occurs in and around Bhairagarh, north of Muniguda and Kalyansinghpur and in the upper reaches of the Vamsadhara and Nagavalli rivers respectively. In thses areas, alluvium occurs as local pockets. At Kalyansinghpur, exploratory drilling by CGWB encountered an alluvial thickness of about 28m and around Bhairagarh its more than 20m. (Plate -3.1)

3.2 Hydrogology: The hydrogeological conditions vary from place to place depending upon the aquifer characteristics of the litho units, sources of groundwater recharge and the structural setting of the area. The hydrogeological units of the area are broadly categorized into three groups namely:

A. Consolidated formations.

B. Semi Consolidated formations

C. Unconsolidated formations

A. **Consolidated Formations:-** The weathered and fractured granites, granite gneisses and their variants, khondalites, charnockites etc. are the most predominant rock types in the district. These are characterized by development of secondary porosity. The secondary porosity in the consolidated formations developed as a result of weathering and fracturing due to major and minor tectonic movements from the conduits for movement of groundwater as also act as reservoir of groundwater. Generally the secondary porosity in the consolidated formations developed as a result of weathering and fracturing due to major and minor tectonic movements form conduits for movement of groundwater as also act as reservoir of ground water. Generally the secondary porosity developed in the crystallines is non uniform in distribution. This fractured and jointed rocks when interconnected form potential aquifers, which sustain limited to moderate yield.

B. **Semi-consolidated formations:-** Porous laterites occurring as discontinuous capping over older formations. These posses both primary and secondary porosities.

C. **Unconsolidated formations: -** Recent alluvium occurring as valley fills of the rivers; Vamsadhara & Nagavalli are characterized by primary porosity. Recent alluvial deposits formed in the river valleys of Vamsadhara and Nagavalli, are the most potential. The occurrence and movement of ground water in the alluvium are characerised by more or less homogenous hydrogeological properties.

Water bearing properties of the consolidated formations:

Granites and Granite Gneisses: The granite and granite gneisses with leaching out of kaolinised clay these rocks on weathering reduce to porous granular materials. The thickness of weathered mantle is an average 10 m. The weathered as also fractured and fissures intersecting system of granite gneisses in topographic lows form potential aquifers. It is in these hydrogeologically favourable locales that groundwater structures are successful and well yields are relatively high. The yield of the wells depends upon the thickness of the saturated zone as also number of fractures tapped. The open wells generally range from 7.3m to 8.5m. The depth to water table during premonsoon season is between 1.72 m to 11.70 m below ground level and during post monsoon season between 0.50 m to 9.80 m below ground level. The seasonal

fluctuation of water level is between 0.67 m to 7.28 m. Specific capacity index of wells in this formation ranges from 1 lpm/m/m^2 to 14 lpm/m/m^2 , the transmissivity values of the formation range from 0.5 m^2/day to 116 m^2/day. The yield of the open wells in Granitic Gneissic terrain is generally upto 3 lps. However generally the bore wells in this formation yield upto 10 lps.

Khondalites: Khondalites are actually metasediments and occupy mainly ridges and hills, covered with thick forests and profuse vegetation. Khondalites have undergone high degree of weathering down to a depth of more than 20 meters. Although the interlacing joints and sheared surfaces, from potential receptacles of groundwater, preponderance of clayey material reduces the permeability of the formation. The depth of open wells in this formation generally varies between 7 m to 8 m. The depth to water level during premonsoon period varies between 2.62 to 9.13 m below ground level and during post monsoon period between 0.86 m to 6.96 m below ground level. The seasonal water table fluctuation is between 1.20 m to 4.14m.The pumping test analysis in the open wells indicate that specific capacity index of the formation varies between 1.00 to 13 lpm/m/m^2 . The yield of the dugwells is upto 3 lps.

Charnockites: The Charnockitic rocks in the area are generally devoid of significant ground water storage due to lack of well connected joints and fractures. Very few wells exist in this formation. The average depths of open wells vary between 4 to 20m. The depth to water level during premonsoon period varies between 3.34 to 16.39 m below ground level and during post monsoon period it ranges between 0.64 to 16.39 m below ground level. The water level fluctuation between premonsoon and post monsoon period varies from 0.07 to 3.09 m. The aquifer characteristics of the formatuion could not be ascertained for want of facilities for conducting hydraulic tests on wells tapping charnockites.

Semi-Consolidated Formation:

Laterites : Porous laterites are formed as capping over the crystalline hardrocks in the upland areas like the Raygada-Kolnara uplands, Kailashkota, Ramanguda, Gudari section etc. Due to restricted areal extent these rocks do not contribute as potential aquifers.

Unconsolidated Formation:

Alluvium: The alluvial deposits in the flood plains of the Vamsadhara and Nagavali rivers form the most potential aquifer system of the district. The borehole data reveals that there is a sub surface disposition of aquifers in parts of the Vamsadhara basin. The colluviums in the intermontane valleys also form rich aquifers. The alluvium comprises an admixture of gravel, sand and clay derived from eroded and weathered country rocks. Groundwater occurs in these deposits under both unconfined as well as semi confined conditions. A number of openwells and shallow tubewells vary between 0.90m to 13.05 m below ground level with an average depth of 5.5 m to 7.5 m below ground level.

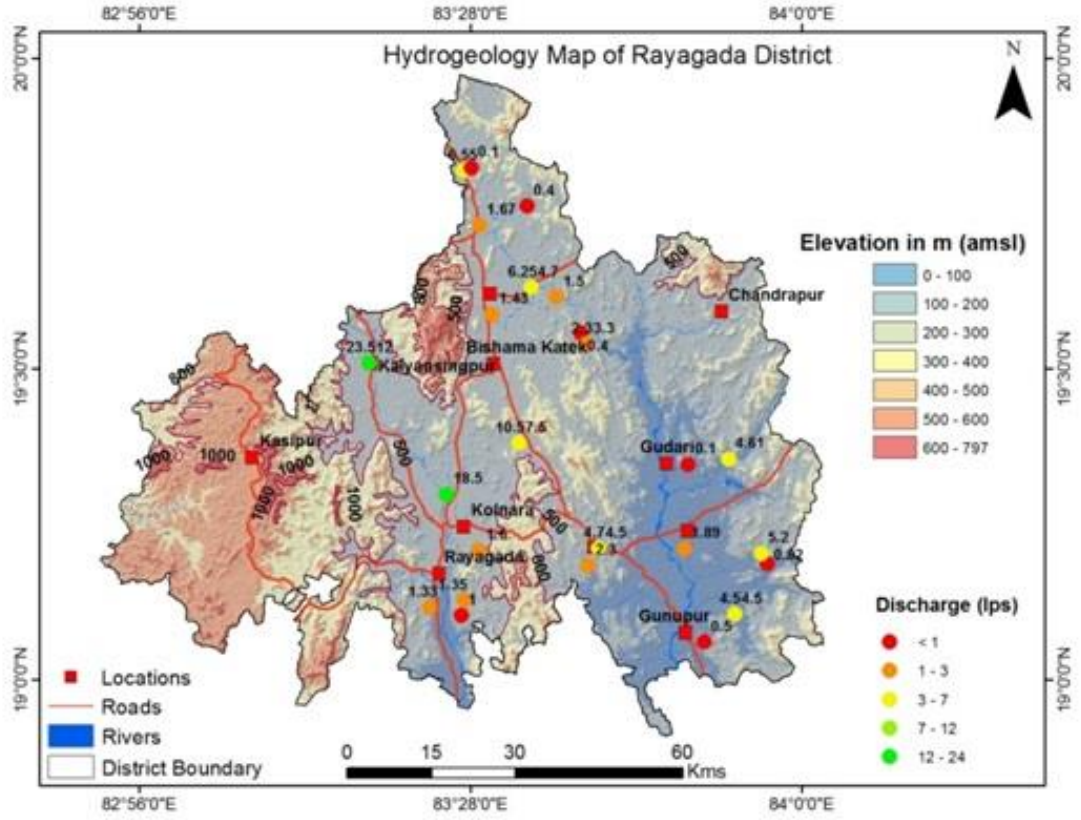


Plate 3.2: Hydrogeology Map of Rayagada district

3.2 Aquifer Disposition and Demarcation

Based on extensive analysis of historical data, microlevel hydrogeological survey, data generation and ground water exploration carried out in the area, the following two types of aquifers are demarcated in consolidated and semi consolidated area.

Aquifer -I (Phreatic /unconfined/shallow aquifer)- This type of aquifer is mostly occur throughout entire area except in the rocky outcrops. It is mostly occur within the depth range of 40m. In the granitic terrain the depth often reaches upto 66 m.

Aquifer –II (Fissured Aquifer/ Fractured Aquifer/ Unconfined to Semiconfined) - In case Khondalite and Granite and granite Gneiss the ground water is available in the fracture zones. The fracture zone lies between 24 m to 160m depth. The saturated fractures at shallow depth often contribute ground water to upper phreatic aquifer. In granitic and khondalitic terrain there are maximum 6 sets of fractures are encountered

The wells yield varies from 0.1 to 18.5 lps. Plate 3.3

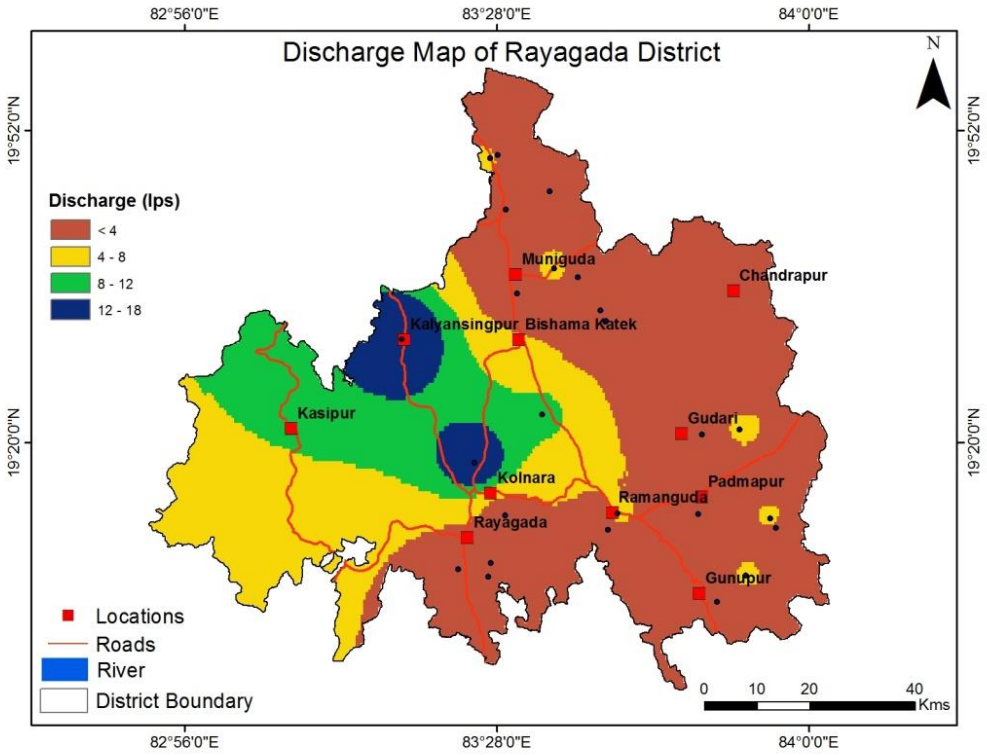


Plate 3.3: Discharge Map of Rayagada district

3.6.1 Aquifer Disposition - The ground water exploration data has been used to prepare the lithological 2 D sections and 3D disposition of the aquifers to better depict the aquifer patter subsurface. The figure 3.2 shows the directions in which the 2D sections are prepared. Fig. 3.3 shows how the aquifer extends laterally from NNE-SSW direction of the district whereas Fig. 3.3 shows how it extends N-S direction. Fig 3.4 and Fig 3.5 depict the extension of various types of aquifer (depending on the lithological variation) in E-W directiron.

The alluvial deposits in the flood plains of the Vamsadhara and Nagavali rivers form the most potential aquifer system of the district. The borehole data reveals that there is a sub surface disposition of aquifers in parts of the Vamsadhara basin. The colluviums in the intermontane valleys also form rich aquifers. The alluvium comprises an admixture of gravel, sand and clay derived from eroded and weathered country rocks. Due to the lack of drilling data in the alluvium area, the disposition and demarcation of the aquifer was not fruitful.

Table 3.4 Characteristics of Aquifer Group

Aquifer	Khondalite	Granite-Granite Gneiss
I (Phreatic)	**Depth-12- 60 m** **Yield-(1 -3 lps)**	**9- 60m** **Y= 1- 3lps**

II (Fissured)	**20-150 m** **Y= 1.5 -18.5 lps** **T= 1.72 – 70.15m^2/day**	**12-100m** **Y= 0.1-6.5** **T= 0.22 – 102.87m^2/day**

Fig . 3.1 2-D Sections directions of Rayagada district map.

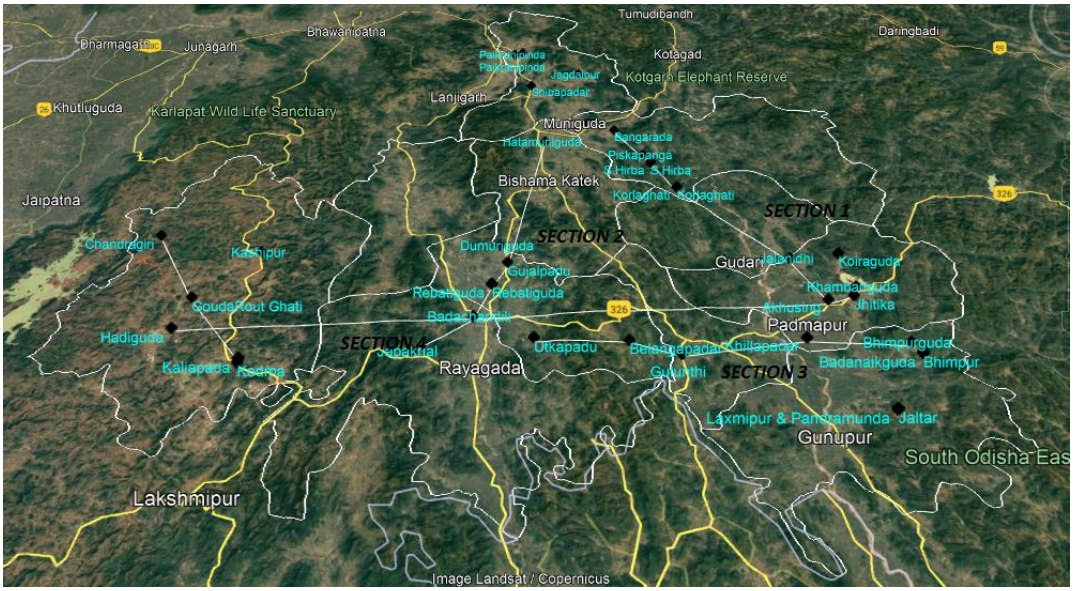


Fig. 3.2 Section-1 (NNW-SSE)

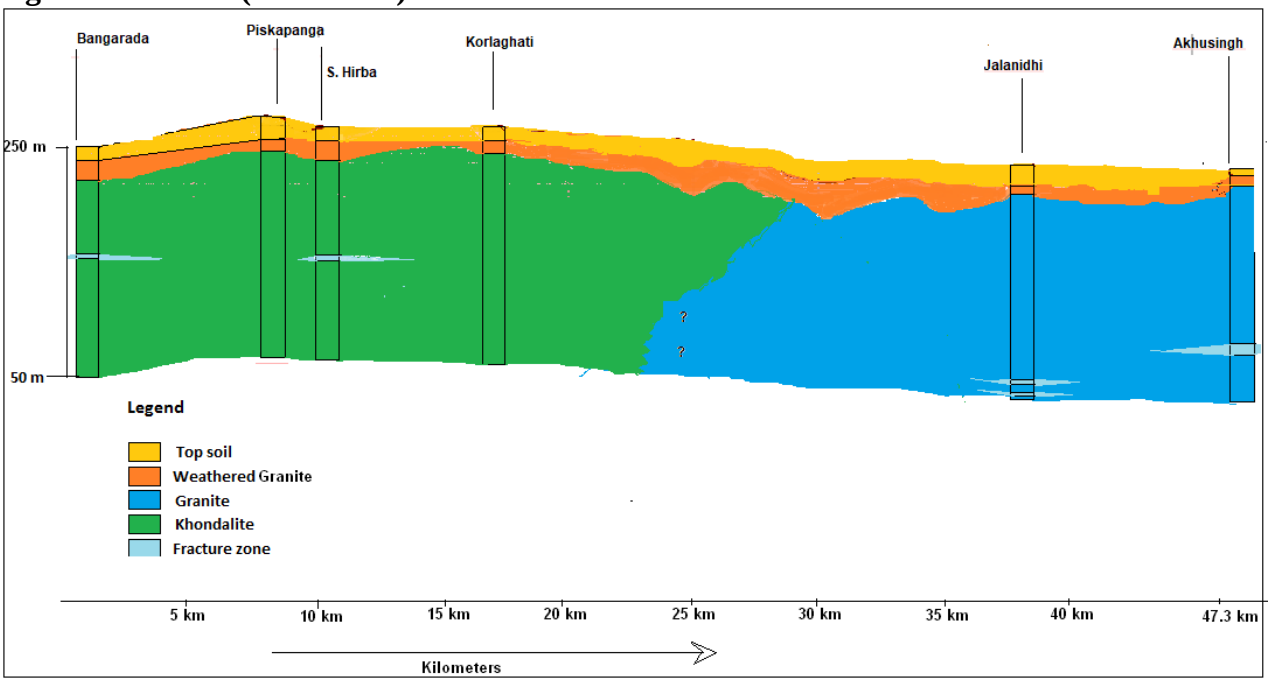


Fig. 3.3 Section-2 (N-S)

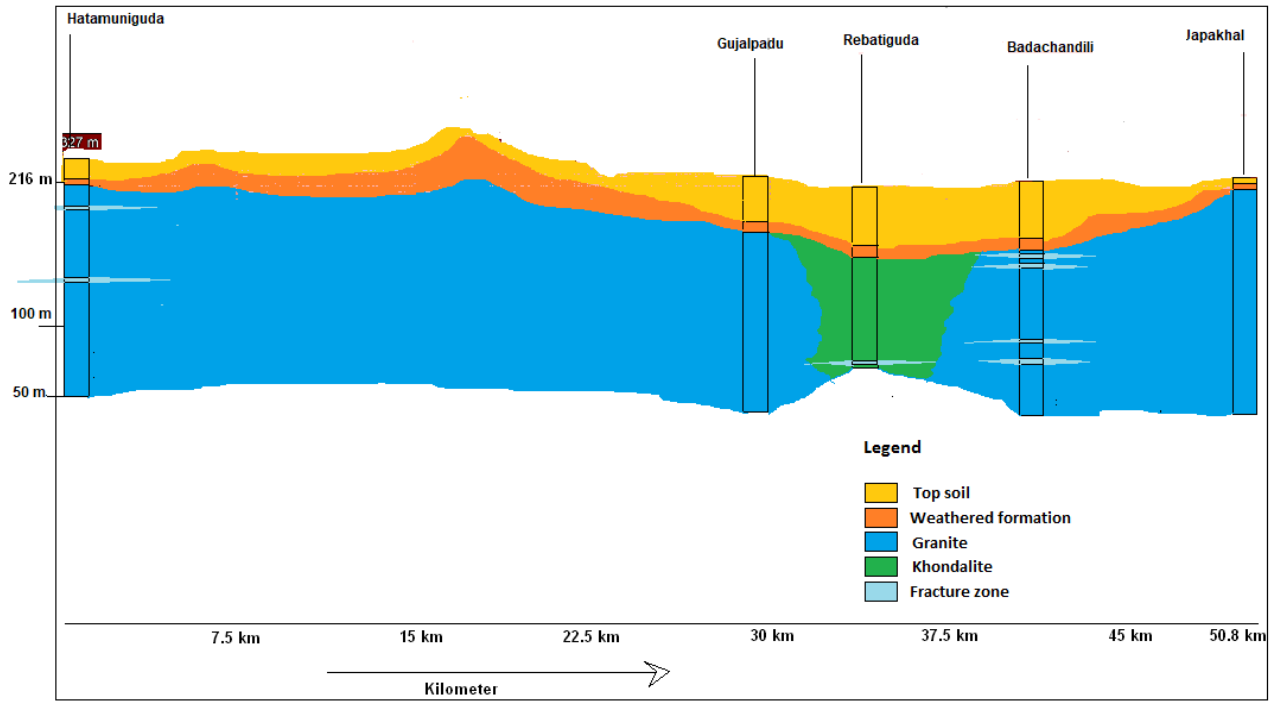


Fig. 3.4 Section 3 (E-W)

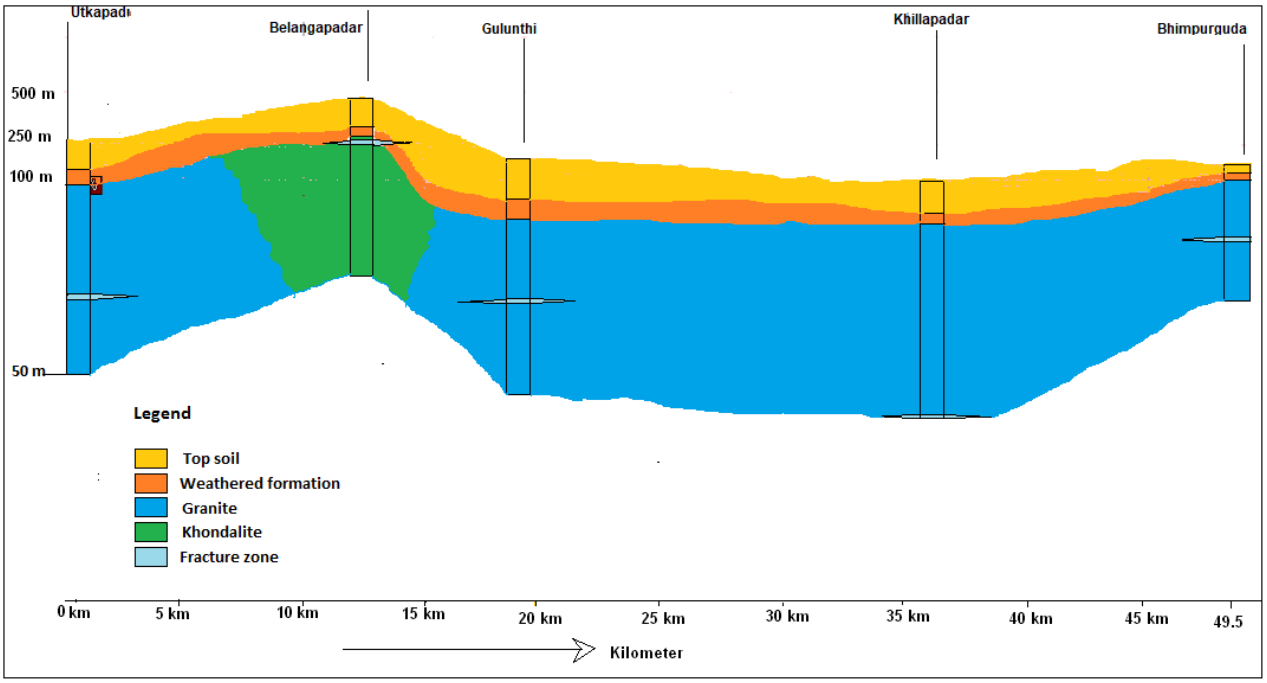
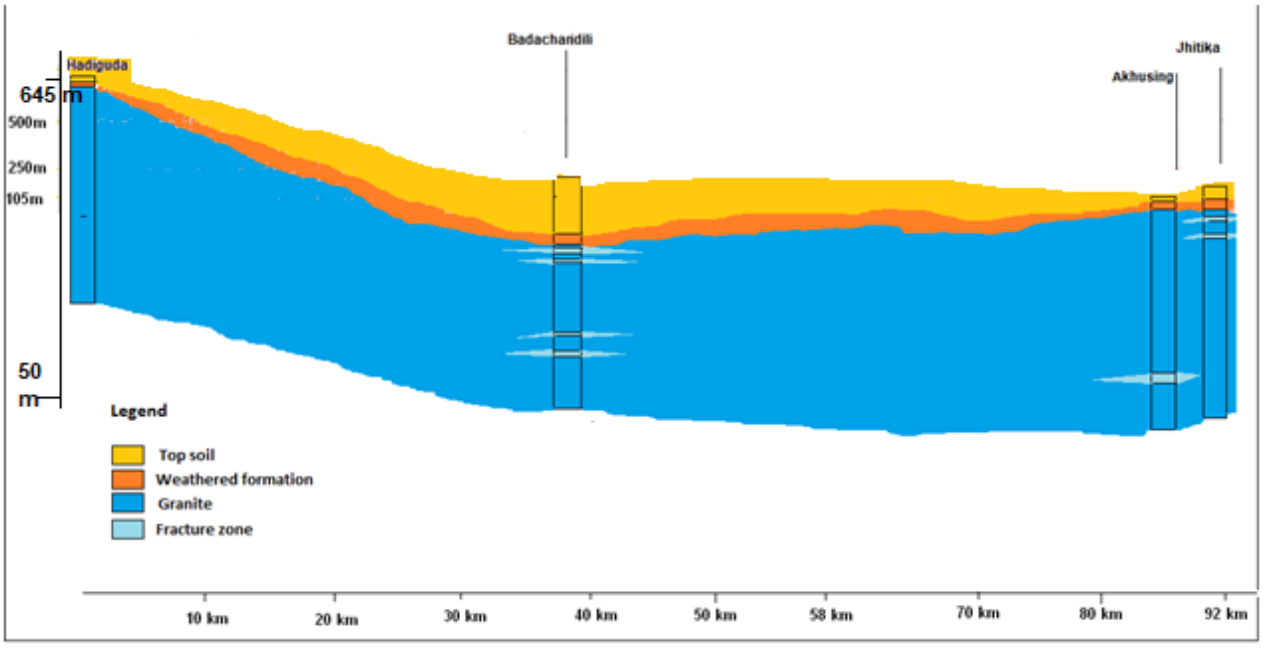


Fig. 3.5 Section-4 (E-W)



4. GROUND WATER RESOURCES:

The Ground Water Resources of the district has been assessed adopting the methodology recommended by the Groundwater Estimation Committee (2015), constituted by Govt. of India. The task was jointly carried out by the Central Ground Water Board and Ground water Survey & Investigation, Department of Water Resources, Govt. of Orissa.

4.1 Ground Water Resource and Draft: The study area is having considerable amount of ground water resource out of which a small part is being utilized. The estimation of the ground water resource indicates that the total annual extractable ground water resource is 32448.08 Ham. The Ground Water Draft for irrigation is 5993.67 Ham, for domestic is eastimated as 2932 Ham and for industrial extraction is 672 Ham. The ground water draft for irrigation is through dug wells and shallow tube wells. A large number of hand pumps fitted in PHED bore wells and tube wells also cater to the rural and urban water supply needs. On the basis of the estimated ground water potentials a detailed scheme for ground water development may be launched in the district. So far ground water development in the district has been meager, and all the blocks fall under the safe category. The stage of ground water development varies from 10.58% to 52.91% in differ ıt blocks. The overall Stage of Groundwater development of the district is 29.57%. There is ample scope for stepping up ground water development in the district.Net ground water available for future use is 20925.24 Ham, out of which 8000.14 Ham is allocated for Domestic use.

The block-wise ground water resource of study area is presented in Table 4.1.

Table. 4.1 Annual Extractable Ground Water Resource Estimation, 2020

Sr.No	District/Assessment Unit	Ground Water Recharge (Ham)				Total Annual Ground Water Recharge (Ham)	Total Natural Discharges (Ham)	Annual Extractable Ground Water Resource (Ham)
		Monsoon Season		Non Monsoon Season				
		Recharge from Rainfall	Recharge from Other Sources	Recharge from Rainfall	Recharge from Other Sources			
1	BISAMCUTTACK	2009.14	154.38	417.05	158.02	2738.59	136.93	2601.66
2	CHANDRAPUR	2091.17	62.9	330.73	64.18	2548.98	127.45	2421.53
3	GUDARI	1190.54	301.2	361.52	226.25	2079.51	207.95	1871.56
4	GUNUPUR	1664.63	1297.94	630.7	897.97	4491.24	271.63	4219.61
5	KALAYANSINGHPUR	868.02	51.79	151.35	47.55	1118.71	111.87	1006.84
6	KASHIPUR	6833.36	47.33	542.3	75.45	7498.44	749.85	6748.59
7	KOLNARA	1718.86	104.6	308.12	130.68	2262.26	226.23	2036.03
8	MUNIGUDA	3027.25	180.53	377.27	225.75	3810.8	190.54	3620.26
9	PADMAPUR	1323.55	936.16	411.34	329.3	3000.35	300.04	2700.31
10	RAMANAGUDA	1932.5	166.35	509.78	280.15	2888.78	157.56	2731.22
11	RAYAGADA	1975.65	44.04	525.12	76.73	2621.54	131.07	2490.47
	TOTAL	**24634.67**	**3347.22**	**4565.28**	**2512.03**	**35059.2**	**2611.12**	**32448.08**

The block-wise ground water draft of study area is presented in Table 4.2. It is worth mentioning that the resource is calculated based on the May and November depth to water level data, most of which is usually drained as base flow during post monsoon periods.

Table. 4.2 Total Extracted Ground Water Resource and Stage of GW Extraction, 2020.

Sr. No	Block	Annual Extractable Ground Water Resource (Ham)	Ground Water Extraction for Irrigation Use (Ham)	Ground Water Extraction for Industrial Use (Ham)	Ground Water Extraction for Domestic Use (Ham)	Total Extraction (Ham)	Annual GW Allocation for for Domestic Use as on 2025 (Ham)	Net Ground Water Availability for future use (Ham)	Stage of Ground Water Extraction (%)	Categorization (Over-ExploitedE/Critical/Semicritical/Safe/Saline)
1	BISAMCUTTACK	2601.66	474.92	30.5	283.61	789.03	303.65	1792.59	30.33	safe
2	CHANDRAPUR	2421.53	125.58	0	130.75	256.34	153.58	2142.36	10.59	safe
3	GUDARI	1871.56	826.3	0	164.10	990.41	181.11	864.14	52.92	safe
4	GUNUPUR	4219.61	1632.46	39.1	282.90	1954.45	320.09	2227.97	46.32	safe
5	KALAYANSINGHPUR	1006.84	91.08	0	178.45	269.53	181.94	733.82	26.77	safe
6	KASHIPUR	6748.59	225.42	138.8	411.52	775.74	451.67	5932.7	11.49	safe
7	KOLNARA	2036.03	299.65	92.85	206.92	599.42	220.13	1423.4	29.44	safe
8	MUNIGUDA	3620.26	548.08	241	282.15	1071.23	299.38	2531.8	29.59	safe
9	PADMAPUR	2700.31	662.14	14.44	162.22	838.8	175.66	1848.07	31.06	safe
10	RAMANAGUDA	2731.22	729.25	14.34	152.83	896.43	166.79	1820.83	32.82	safe
11	RAYAGADA	2490.47	378.79	101.1	676.51	1156.39	745.55	1265.04	46.43	safe
	TOTAL	**32448.08**	**5993.67**	**672.13**	**2931.97**	**9597.77**	**3199.55**	**22582.72**	**29.57**	

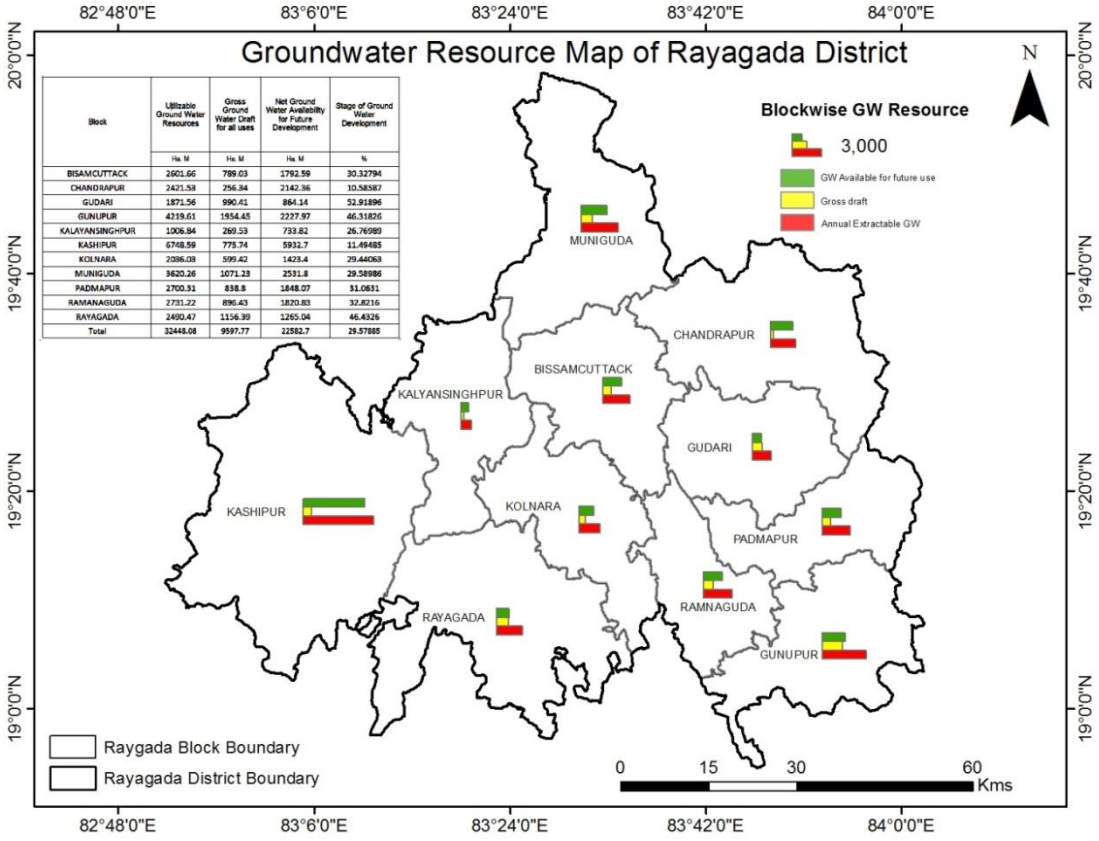


Plate 4.1: Resource Map of Rayagada district

4.2. Ground water related issues

4.2.1 Identification of issues: While surveying the whole district, it has been noticed that in Kashipur Block there is scarcity of water. The people are suffering a lot for drop of water. There are very few tubewells and most of them are even dry. Even the exploration carried out by CGWB also found the wells are dry in this part of the area. The terrain in this block mostly comprise of Granite and granite gneiss. In this area mostly Bauxite formation is visible.

4.2.2 Ground water quality/contamination: Two locations are showing high iron content in Kolnara and Ramnaguda block. Fluoride content is higher than permissible limit in Simili (2.980 ppm). Higher value of conductivity, TDS and hardness is observed in Kenduguda.

4.2.3 Future demand (for 2025 and 2030) scenario

i) **Domestic Water Demand:** Domestic water demand was assessed based on the rural and urban population water needs for drinking and other domestic purposes. The projected estimate for 2025 is made by considering the water demand @ 100 and 135 lpd for rural and urban population, respectively. The population at 2025 and 2030 is estimated by considering the cumulative growth of 14% from the base year of 2011.

As per the ground water resource estimation 2020, there is allocation of GW in domestic use which is estimated as **0.0319955 BCM.** The future demand in case of domestic use is calculated and presented below in the Table.

Table.5.1 Projected Domestic Ground Water Demand in 2025 and 2030.

District	Block	Census 2011			Projected population as on 2025			Projected population as on 2030			GW Demand 2025 (BCM)	GW Demand 2030 (BCM)
		Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total		
RAYAGADA	Bishamakatak	84091	8399	92490	97720	9972	107692	102588	10534	113122	0.00405815	0.004263525
	Chandrapur	41129		41129	56757	0	56757	62339	0	62339	0.002071631	0.002275374
	Gudari	42737	6931	49668	55150	7047	62197	59583	7089	66672	0.002360216	0.00252409
	Gunupur	76333	28870	105203	99906	35682	135588	108325	38115	146440	0.0054048	0.005831979
	Kalyanasingpur	59093	4660	63753	61838	5408	67246	62819	5675	68494	0.002523566	0.002572529
	Kashipur	140633		140633	172416	0	172416	183768	0	183768	0.006293184	0.006707532
	Kolnara	73839		73839	84955	0	84955	88925	0	88925	0.003100858	0.003245763
	Muniguda	85218	8346	93564	99397	11015	110412	104461	11968	116429	0.004170755	0.00440255
	Padmapur	56459		56459	67400	0	67400	71308	0	71308	0.0024601	0.002602742
	Ramanguda	52632		52632	63811	0	63811	67803	0	67803	0.002329102	0.00247481
	Rayagada	108781	89760	198541	133396	111650	245046	142188	1E+05	261656	0.010370508	0.011076648
	TOTAL	**820945**	**146966**	**967911**	**992746**	**180774**	**1173520**	**1E+06**	**####**	**1246956**	**0.0451429**	**0.04797754**

ii) **5.3.2 Crop Water Demand:** Crop water demand was calculated based on the average water requirement of major cereals, pulses, oilseeds, vegetables, spices & condiments and sugarcane crops multiplied by the present and future irrigated area for that particular crop. Existing crop water potential required is estimated after meeting domestic + livestock and industrial water demand. Ultimate water potential to be created is estimated at different scenario of 10 to 90% of the crop sown area to be brought under irrigation and assuming average 40% field application efficiency of irrigation water. Water potential to be created at different scenario is arrived by subtracting existing water potential from the ultimate crop water potential to be created at different scenarios.

- The current crop water demand is estimated to be 0.439 BCM and major crop groups are cereals and vegetables.
- The existing water potential is 2.774 BCM and the existing water potential available for crops after meeting the demand of domestic, livestock and industries comes down to 2.714 BCM.
- Present crop water demand is highest for cereals (45%) followed by spices (15%), other crops (15%) and oilseeds (12%).
- Ultimate crop water potential (UCWP) to be created under different scenario varied from 0.33 to 2.99 BCM from 10 to 90% of the crop sown area to be irrigated.
- Similarly, water potential to be created at different scenario varied from -2.38 to 0.28 BCM.
- Crop water demand for different blocks of Rayagada district will be in the following order: Ramnaguda > Padampur > Gunpur > Gudari > Rayagada > Kashipur > Bisam Cuttack > Kalyansinghpur > Muniguda > Kolnora > Chandrapur (Figure 4.1).

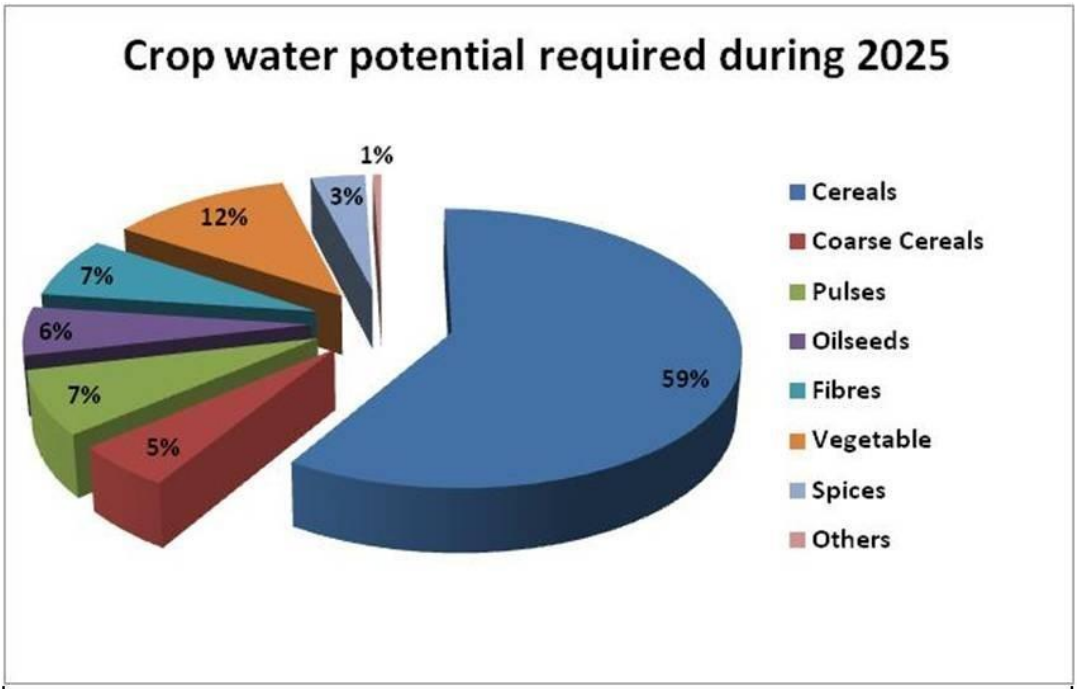


Fig. 4.2.4: Crop water potential to be created for Rayagada district

5. AQUIFER MANAGEMENT PLAN

The Key technical interventions for groundwater management include control of groundwater pumping to sustainable levels, control of discharges to groundwater and in some areas managing aquifer recharge.
Ground water is often neglected in planning, being an essentially invisible resource. However, it is also a shared resource that is high in demand, especially for irrigation and human consumption. That makes it vulnerable to stakeholders who act based on their short-term individual interests instead of long-term communal requirements. Ground water is also particularly vulnerable to pollution. Contaminants from the surface can move through the soil and into the aquifer below such as pesticides and fertilizers from agriculture, toxic substances from mining sites and used motor oil and so on. Since ground eater can move great distance through underground aquifers, ground water pollution is particularly hard to clan up. In practice, ground water is often managed seperately from 1) surface water though it is part of the overall hydrological cycle, both in quality and quantity, 2) Urban Wastewater though it simultaneously represents an additional resource and a potential pollution threat to ground water, 3) land management, though aquifers are threatened by pollution from urbanization, industrial development, agricultural activity and mining enterprises.

In the present scenario, groundwater plays a significant role in the food supply and the national economy. Unscientific and rampant exploitation of the available aquifers for irrigation at several places in the country has created serious conditions of groundwater decline, which has become very difficult to revive. Judicious and scientific exploitation of aquifers, keeping in mind the aquifer sustainability, has been of paramount significance. In order to give justice to both the aquifer sustainability and the growing demand for groundwater for different needs, the aquifer management plan is the need of the hour. With the help of the studies carried out in this aquifer mapping programme, integrating all the available information from the older studies, data available with the state governments, the aquifer management plan for the district has been prepared. To formulate the aquifer management plan, the need was to delineate the aquifer/groundwater related issues in the district.

The major issues identified in the district are as below:

1. Low yield of aquifers and groundwater scarcity
2. Vulnerable Urban agglomeration.

5.1 WATER DEMAND, AVAILABILITY AND GAP ANALYSIS:

The major demand side of ground water is in the sector of i) domestic use and ii) irrigation. The population projection till 2025 and 2030 is calculated and the domestic demand for 2025 is also calculated taking per capita demand for domestic use in urban as 135 lpcd and rural area as 100.

Table 5.1 Population Projection till 2025 and 2030 for different blocks of RayagadaDistrict

District	Block	Census 2011			Projected population as on 2025			Projected population as on 2030		
		Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Rayagada	Bishamakatak	84091	8399	92490	97720	9972	107692	102588	10534	113122
Rayagada	Chandrapur	41129		41129	56757	0	56757	62339	0	62339
Rayagada	Gudari	42737	6931	49668	55150	7047	62197	59583	7089	66672
Rayagada	Gunupur	76333	28870	105203	99906	35682	135588	108325	38115	146440
Rayagada	Kalyanasingpur	59093	4660	63753	61838	5408	67246	62819	5675	68494
Rayagada	Kashipur	140633		140633	172416	0	172416	183768	0	183768
Rayagada	Kolnara	73839		73839	84955	0	84955	88925	0	88925
Rayagada	Muniguda	85218	8346	93564	99397	11015	110412	104461	11968	116429
Rayagada	Padmapur	56459		56459	67400	0	67400	71308	0	71308
Rayagada	Ramanguda	52632		52632	63811	0	63811	67803	0	67803
Rayagada	Rayagada	108781	89760	198541	133396	111650	245046	142188	1E+05	261656
	TOTAL	**820945**	**146966**	**967911**	**992746**	**180774**	**1173520**	**1E+06**	**####**	**1246956**

Table 5.2 Domestic demand projected during 2025 & 2030 for different blocks of Rayagada district (Ham)

District	Block	Census 2011			Projected population as on 2025			Projected population as on 2030			GW Demand 2025 (BCM)	GW Demand 2030 (BCM)
		Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total		
RAYAGADA	Bishamakatak	84091	8399	92490	97720	9972	107692	102588	10534	113122	0.00405815	0.004263525
	Chandrapur	41129		41129	56757	0	56757	62339	0	62339	0.002071631	0.002275374
	Gudari	42737	6931	49668	55150	7047	62197	59583	7089	66672	0.002360216	0.00252409
	Gunupur	76333	28870	105203	99906	35682	135588	108325	38115	146440	0.0054048	0.005831979
	Kalyanasingpur	59093	4660	63753	61838	5408	67246	62819	5675	68494	0.002523566	0.002572529
	Kashipur	140633		140633	172416	0	172416	183768	0	183768	0.006293184	0.006707532
	Kolnara	73839		73839	84955	0	84955	88925	0	88925	0.003100858	0.003245763
	Muniguda	85218	8346	93564	99397	11015	110412	104461	11968	116429	0.004170755	0.00440255
	Padmapur	56459		56459	67400	0	67400	71308	0	71308	0.0024601	0.002602742
	Ramanguda	52632		52632	63811	0	63811	67803	0	67803	0.002329102	0.00247481
	Rayagada	108781	89760	198541	133396	111650	245046	142188	1E+05	261656	0.010370508	0.011076648
	TOTAL	**820945**	**146966**	**967911**	**992746**	**180774**	**1173520**	**1E+06**	**####**	**1246956**	**0.0451429**	**0.04797754**

If we compare the domestic demand projected and the allocated ground water for dometic use for 2025 as per estimation done in 2020.it has been observed that the Rayagada and Kashpur blocks are most vulnerable one.

Enhancing groundwater utilization (supply side management)

Ground water in Rayagada district is the main source of drinking in both the rural and urban areas. The existing groundwater draft in the district goes to meet the irrigation needs. Industrial use of groundwater in the district is very limited. The need of the hour is for the sustainable development of the available groundwater resources to meet the present and other emerging needs. The groundwater in the district is mainly developed by the means of dug wells, hand pumps, dug-cum-bore wells, bore wells and some tube wells.
The main constraints of canal irrigation in the command areas are:

i) Frequency of erratic monsoon and draught conditions in the area.

ii) Non supply of irrigation water for summer cultivation restricting the crop intensity

iii) The per hectare low yield, which is probably due to inadequate and untimely supply of irrigation water mostly in the tail end areas of canal command.

For augmenting the irrigation facilities and to boost food grain production optimal utilization of both surface and groundwater is a must. In the present scenario, the average stage of groundwater development in the district is only 29.57% with the minimum of 10.59% in Chandrapur block and the maximum of 52.9% in Gudari block. There is ample scope to enhance the groundwater utilization up to 60% to meet the challenges during the drought situations and in areas without the scope of canal water irrigation.

The available surplus groundwater resources in the district can help in mitigating the vagaries in the rain-fed agriculture and can assure the food grain production. Although, major parts of the district is underlain by crystalline rocks, favorable hydro geological conditions for construction of suitable groundwater abstraction structures exist in the undulating plains and intermontane valleys, where the weathered residuum is moderately thick and the rocks are intensely fractured.

Table 5.3 presents the additional number of groundwater abstraction structures feasible in the districts and in various blocks of it. Three kinds of structures have been suggested; dug wells (DWs), dug-cum-bore wells (DBWs) and bore wells (BWs). But while constructing additional groundwater abstraction structures, one should take into consideration of the safe spacing criteria between any two structures. The distance between any two DWs/DBWs fitted with pump set should be kept at least 100 m, while that between two BWs may be kept between 150-200 m.

Dug wells: The wells may be sited in the topographic lows and should tap the maximum saturated thickness of the weathered zone. The depth of the dug wells may vary from 9 to 12m with 4.5m to 6m diameter. The wells may be fitted with 1.5 to 2 H.P. centrifugal pumps. The wells may sustain yield maximum up to 3 lps.

Dug-cum-bore wells: Dug-cum-bore wells may drill down to a depth of 25 to 30m below ground level, tapping the saturated shallow fracture below the regolith and in top portion of the hard basement. The wells should be fitted with 2 H.P. centrifugal / submersible pumps may sustain yield up to 3 lps.

Bore wells: Borewells may tap the deeper saturated fractures found to occur in the depth range of 100 to 120m. The borewells should be 100 to 150mm. diameter and may be flitted with submersible pumps of 2 to 2.5H.P. capacities. The wells drilled in the vicinity of NNW-SSE and NE-SW trending lineaments are likely to be successful which has been established based on exploratory drilling by CGWB in the Western and Southern tracts of the district. The suitable sites for drilling may be selected in the district with the aid of Remote Sensing studies, Surface Geological, hydrogeological and Geophysical surveys.

Shallow tube well: These structures are feasible in the blocks of Gudari, Gunupur, Padampur, Kolnara, Ramanguda and Rayagada in the flood plain deposits of the Vamsadhara and Nagavalli rivers. The depth of the tube well will be within 50 m.

Creating additional irrigation potential

The existing irrigation facility in the district covers 68292 Ha constituting 27% of the total cropped area. Expanding the infrastructural facilities to enhance the groundwater deleopment up to 60% in the district can help in creating additional groundwater based irrigation potential. Table presents block-wise additional irrigation potential which can be developed for various crops like paddy, ground-nuts, oil seeds and vegetables. For paddy, resource between 36-909 (Min:Gudari, Max: Kashipur)has been allocated for different block depending on their cropping pattern. Similarly, 127- 3174 ham of the resource has been allocated for the ground-nut and oil seed crops in different blocks (min.: Gudari block; max.: Kashipur block). For the vegetable crops, resource allocation varies between 147- 3637 Ham (min.: Gudari block; max.: Kashipur block). The crop water requirements have been taken as 1.0 m for paddy and 0.4 m for ground-nuts/oil seeds and vegetables.
The total projected area to be irrigated utilizing the surplus groundwater resource stands at 23201 Ha including 2742 Ha for paddy, 9491 Ha for ground-nuts/oil seeds and 10968 Ha for vegetables. This projected area if irrigated can enhance the average irrigation in the district from the existing 27% to 33% (Table 6.4). The table also shows the block-wise irrigation status which can be achieved by creating additional irrigation potential.

Dealing with low yield of aquifers and water scarcity

In Rayagada district, several areas comprising khondalite, charnockite, granitic rocks the yield of the bore wells remains low, even less than 1.0 lps, which can seldom meet the requirements. In such water scarcity areas, large diameter dug wells (5-10 m wide) tapping the entire weathered residuum can give ample water for the needs of irrigation and drinking.

Augmenting groundwater resources (supply side management)

Depletion of phreatic aquifer in the foot-hills and piedmont zones of mountain belts is a common phenomenon during summer seasons in Odisha. The phreatic zone gets replenished through rainfall recharge and accounts for the dynamic groundwater resources. The weathered zone developed on massive crystallines is shallow and serves as the phreatic aquifer system for

groundwater storage and movement. Rapid decline in water level during the post-monsoon period renders most of the shallow dug wells drying up or unproductive. However, this lowering of groundwater level is due to out-flow from the basin in the form of base-flows through perennial and ephemeral streams in the area.

Though, there are patches in the district, where long term (decadal) decline in water level >0.1 m has been observed, those patches are very limited and some of them possess water level within 5.0 m bgl. Thus, the areas which show post-monsoon water levels beyond 5.0 m bgl have only been demarcated where artificial recharge to groundwater has been suggested. The block-wise distribution of area of such patches has been produced in Table. The areas have been grouped into a class with areas with DTW >5.0m bgl, Total area suitable for artificial recharge to the groundwater comes as 1689.109 km^2 with maximum of 761.44 km^2 area falling in the Kashipur block followed by 409.06 km^2 in the Muniguda block, 297.8 km^2 in the Kalyansinghpur block, 159.789 km^2 in Kolnara block and 61.02 km^2 in Rayagada block. In Table 5.7, total thickness of the aquifer, aquifer volume and total volume of water required to recharge the aquifers have been worked out for different blocks in the district (considering raising the water level up to 3.0 m bgl). The volume of aquifer that is proposed to be recharged has been calculated by using the following equation:

V in MCM = (Area in km2) x (Average post-monsoon DTWL in m - 3m)

Total volume of water required has been worked out to be 15.93745 MCM. A specific yield value of 0.35% (depending on area hydrogeology) has been considered while estimating the volume of water to be recharge.

Table 5.3: Number of additional feasible groundwater abstraction structures in Rayagada district, Odisha (as on 31st Mar 2020) by enhancing the stage of groundwater development up to 60%.

Block	Net Ground Water availability (Ham)	Stage of Ground Water development (%)	Present Ground Water Draft (Ham)	Ground Water draft at 60% Stage of development (Ham)	Surplus Ground Water at Present Stage of development (Ham)	Number of BW/ STW Recommended in Each block(assuming unit draft as 2.21/ ham/structure/ year) 50%	Number of DW Recommended in Each block(assuming unit draft as 0.26/ ham/structure/ year) 50%
BISAMCUTTACK	1792.59	30.33	789.03	1561.00	771.97	175	1485
CHANDRAPUR	2142.36	10.59	256.34	1452.92	1196.58	271	2301
GUDARI	864.14	52.92	990.41	1122.94	132.53	30	255
GUNUPUR	2227.97	46.32	1954.45	2531.77	577.32	131	1110
KALAYANSINGHPUR	733.82	26.77	269.53	604.10	334.57	76	643
KASHIPUR	5932.7	11.49	775.74	4049.15	3273.41	741	6295
KOLNARA	1423.4	29.44	599.42	1221.62	622.20	141	1197
MUNIGUDA	2531.8	29.59	1071.23	2172.16	1100.93	249	2117
PADMAPUR	1848.07	31.06	838.8	1620.19	781.39	177	1503
RAMANAGUDA	1820.83	32.82	896.43	1638.73	742.30	168	1428
RAYAGADA	1265.04	46.43	1156.39	1494.28	337.89	76	650

Table 5.4: Irrigation potential likely to be created in Rayagada district, Odisha (as on 31st Mar 2020) by enhancing the stage of groundwater development up to 60%.

Block	Present Stage of Ground Water Development (%)	Surplus Ground Water Available for 60% stage of Development (Ham)	Irrigation Potential likely to be created for Paddy (Ha)	Irrigation Potential likely to be created for Ground Nut, Oil seed (Ha)	Irrigation Potential likely to be created for vegetables (Ha)	Projected Area to be Irrigated (ha)
BISAMCUTTACK	30.33	771.97	214.44	742.28	857.74	1814.45
CHANDRAPUR	10.59	1196.58	332.38	1150.56	1329.53	2812.47
GUDARI	52.92	132.53	36.81	127.43	147.25	311.49
GUNUPUR	46.32	577.32	160.37	555.11	641.46	1356.94
KALAYANSINGHPUR	26.77	334.57	92.94	321.71	371.75	786.39
KASHIPUR	11.49	3273.41	909.28	3147.51	3637.13	7693.92
KOLNARA	29.44	622.20	172.83	598.27	691.33	1462.43
MUNIGUDA	29.59	1100.93	305.81	1058.58	1223.25	2587.65
PADMAPUR	31.06	781.39	217.05	751.33	868.21	1836.59
RAMANAGUDA	32.82	742.30	206.20	713.75	824.78	1744.73
RAYAGADA	46.43	337.89	93.86	324.90	375.44	794.19

Table 5.5: Block-wise Irrigation status in Rayagada district which can be achieved by creating additional groundwater based irrigation potential.

Sl. No.	Block	Existing status of Agriculture		Irrigation Use (GW)	GW based addi Irri. Pot. to be created
		Irrigated	Rainfed		
1	BISAMCUTTACK	5755	18531	474.92	857.74
2	CHANDRAPUR	975	8122	125.58	1329.53
3	GUDARI	4476	11979	826.3	147.25
4	GUNUPUR	8662	15087	1632.46	641.46
5	KALAYANSINGHPUR	5730	12607	91.08	371.75
6	KASHIPUR	6728	41829	225.42	3637.13
7	KOLNARA	4945	13833	299.65	691.33
8	MUNIGUDA	5483	14329	548.08	1223.25
9	PADMAPUR	8295	12642	662.14	868.21
10	RAMANAGUDA	8641	16609	729.25	824.78
11	RAYAGADA	8602	15163	378.79	375.44
District	**total/avergae**	**68292**	**180731**	**5993.67**	**10967.86**

Table 5. 6: Areas in each block with depth to water level (DTW) >5.0 m bgl

Sl. No.	Block	Areas >5 mbgl (sq.km)
1	BISAMCUTTACK	0
2	CHANDRAPUR	0
3	GUDARI	0
4	GUNUPUR	0
5	KALAYANSINGHPUR	297.8
6	KASHIPUR	761.44
7	KOLNARA	159.789
8	MUNIGUDA	409.06
9	PADMAPUR	0
10	RAMANAGUDA	0
11	RAYAGADA	61.02
	Total	1689.109

Artificial recharge structures and cost estimates

The most feasible artificial recharge and rain water harvesting structures are percolation tanks, sub-surface dykes, nala/contour bunding, small check dams/weirs, renovation of old tanks to percolation tanks, water spreading, gully plugging, gabion structures etc. Table 6.8 shows the estimated feasible numbers of some artificial recharge structures in the district. Allocation of different types of artificial recharge structures, presented in Table 6.8 have been done based on the topography. The area is a kind of mid- land area with rolling topography (300-600 m asl elevation). Thus, as per the state artificial recharge plan depending on the suitability of space and litholgy as well as terrain 50% or 40% have been considered for percolation ponds, and check dams/weirs. The number of structures to be constructed is worked out taking average gross capacity of one percolation tank as 200 TCM, for Nala bund/contour bunding/check dam as 150 TCM in multiple fillings.

The total number of recharge structure has been estimated as 43, 35 and 18 for the percolation ponds, nala/contour bunding and check dams/weirs respectively. The maximum numbers of such structures have been worked out for the blocks of Kashipur (38), Muniguda Block (30) Costing of the recharge structures have been produced in Table 5.9. It is estimated at 1655 lakh with the maximum share for the percolation ponds at 860 lakh.

Table 5.7: Estimation of volume of water required for artificial recharge to groundwater

Block	Total area of the block (sq km)	Area identified for Artificial Recharge (sq km)	Average DTW (mbgl)	Total thickness of aquifer to be saturated (m)	Aquifer volume to raise water level to 3 m bgl (MCM)	Total volume of water required to recharge (MCM)
BISAMCUTTACK	512.51	0	0	0	0	0
CHANDRAPUR	394.25	0	0	0	0	0
GUDARI	445.9	0	0	0	0	0
GUNUPUR	461	0	0	0	0	0
KALAYANSINGHPUR	995.87	297.8	5.5	2.5	744.5	2.60575
KASHIPUR	883.9	761.44	5.54	2.54	1934.06	6.7692
KOLNARA	794.6	159.789	6.51	3.51	560.859	1.68258
MUNIGUDA	558.58	409.06	6.04	3.04	1243.54	4.3524
PADMAPUR	676.08	0	0	0	0	0
RAMANAGUDA	648.07	0	0	0	0	0
RAYAGADA	669.99	61.02	5.47	2.47	150.719	0.52752
Total	7040.75	1689.109			4633.679	15.93745

Table 5.8: Number of feasible structures for artificial recharge to groundwater

Sr. No.	Block	Total volume of water required to recharge (MCM)	Percolation tank @0.2 MCM	Sub-surface dyke @0.15 MCM	Nala bund/contour bunding @0.15 MCM	Check dams & weirs@0.15
1	BISAMCUTTACK	0	0		0	0
2	CHANDRAPUR	0	0		0	0
3	GUDARI	0	0		0	0
4	GUNUPUR	0	0		0	0
5	KALAYANSINGHPUR	2.60575	10		4	0
6	KASHIPUR	6.7692	20		15	3
7	KOLNARA	1.68258	5		3	2
8	MUNIGUDA	4.3524	8		10	12
9	PADMAPUR	0				
10	RAMANAGUDA	0				
11	RAYAGADA	0.52752			3	1
	TOTAL	**15.93745**	**43**		**35**	**18**

Table 5.9: Estimation of cost of artificial recharge structures, Rayagada district

	Block	Percolation tank @20 lakh	Sub-surface dyke @10 lakh	Nala bund/contour bunding @5 lakh	Check dams & weirs@5 Lakh	Total Cost(in lakhs
1	BISAMCUTTACK					
2	CHANDRAPUR					
3	GUDARI					
4	GUNUPUR					
5	KALAYANSINGHPUR	200		20	0	220
6	KASHIPUR	400		75	15	490
7	KOLNARA	100		15	10	125
8	MUNIGUDA	160		50	60	270
9	PADMAPUR					
10	RAMANAGUDA					530
11	RAYAGADA			15	5	20
	Total	860		175	90	1655

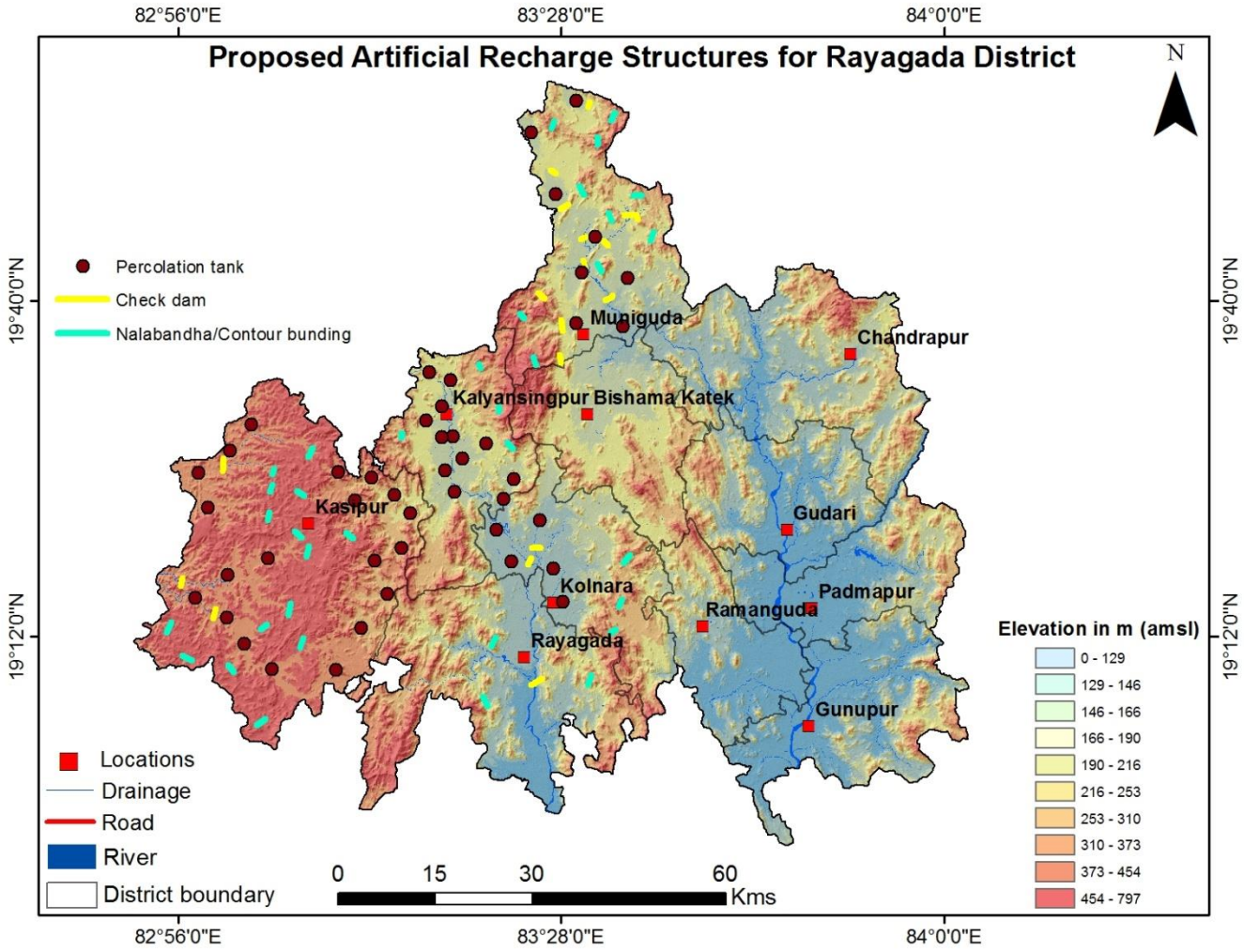


Plate 5.1: Proposed artificial recharge structure of Rayagada district

6. CONCLUSION:

1. The district covers an area of 7073 sq. km. and is divided into 11 administrative blocks. In terms of geographical area K. Singpur block having 14.14 percent of total district area followed by Kashipur (12.55 percent) and Kolnara (11.28 percent) with lowest area in Chandrapur (5.59 percent).

2. The district is characterized by a rugged terrain with hills and thick forests. The Predominent geomorphic features of the district are structural and denudational hills, intermontane valleys and flood plains of Vamsadhara and Nagavalli rivers.

3. The drainage of the district is controlled by the rivers Vamsadhara and Nagavalli and its tributeries.

1. The southwest monsoon is the principal source of rainfall and the average annual precipitation varies from 1030.21 mm to 1569.50 mm.

2. Only 30% of te total geographical area of the district is available for cultivation. The cultivation is generally confined to the Kharif season and depends upon rainfall.

3. Based on the physical and chemical characteristics, mode of origin and occurrence, soils of the district may be classified into two groups namely Alfisols and Entisols.

4. Rayagada district is mainly occupied by the crystallines of Precambrian Eastern Ghats, in the narrow elongated valleys of the Vamsadhara and Nagavalli rivers and their tributaries which are occupied by thick alluvium.The Precambrians in the area are represented mainly by the granite gneiss and its variants, khondalite and charnockites. Alluvium consists mainly sand, silt and clay.

5. Hydrogeologically the weathered and fractured zones of crystallines constitute the predominant hydrogeological units with limited to moderate yield potentials. The alluvial deposits in the flood plains of the Vamsadhara & Nagavalli form the repository of ground water in the district. The open wells in crystalline formation yields generally less than 3 lps. The borewells in granite and granite gneiss yields upto 18 lps.

6. The quality of groundwater from the shallow as well as deeper aquifers is fresh and suitable for drinking and irrigation purpose.

7. Depending upon the distribution of major lithounits, extent of weathering and intensity of fracturing ground water development potential varies widely from areas to areas. The principal source of groundwater recharge is the rainfall.

8. The annual extractable ground water 32448.08 HAM, out of which the existing Ground Water Draft for irrigation is 5993.67 HAM. The ground water draft for irrigation is through dug wells and shallow tube wells. A large number of hand pumps fitted in PHED bore wells and tube wells also cater to the rural and urban water supply needs. So far ground water development in the district has been meager, and all the blocks fall under the safe category. On the basis of the estimated ground water potentials a detailed scheme for ground water development may be launched in the district. The stage of ground water development varies from 10.58% to 52.91% in different blocks. The overall Stage of Groundwater development of the district is 29.57%. The is ample scope for stepping up ground water development in the district.

7. RECOMMENDATION

1. Large scale planning for Ground Water Resources development should be preceded by intensive hydrogeological and geophysical survey aided by Remote Sensing studies and ground truth data.

2. Bore wells/dug wells should be located in the vicinity of NNW-SSE and NE-SW trending lineaments which have been proved to be high yielding & productive and in thickly buried pediment areas.

3. Existing dug wells should be deepened to tap the maximum saturated thickness of the weathered mantle or vertical bores maybe drilled to enhance the yield of the well where normally the dug wells get dried up.

4. Energisation of wells should be stepped up to ensure optimal utilisation of the ground water resources to create additional irrigation potential.

5. The State Ground Water Organization should render expert guidance for siting ground water structures in favourable hydrogeological settings.

6. The farmers should be educated through agricultural extension services, Mass Awareness and water management training programme to adopt suitable cropping pattern, conservation of ground water and irrigation practices especially for drought tolerant crops for optimal utilisation of available ground water resources.

7. Programme for artificial recharge may also be taken up in areas where deeper water table condition coupled with high fluctuation is observed for augmentation of ground water resources through construction of percolation tanks, subsurface dykes, check dams, nala bunding and contour bunding and other site specific favourable artificial recharge structures.

In areas of shallow water table lying with in 0 to 5 m bgl during post monsoon period, surface water bodies like local ponds, farm ponds and small earthen dam along small streams may be constructed to hold water for long duration and for replenishment of soil moisture.

8. For augmentation of drinking water supply to the major towns and villages near the major rivers, infiltration galleries or collector wells may be constructed in suitable locales to fruitfully harness the base flow /subsurface flow which otherwise goes as waste.

Growing of sugarcane and cash crops may be encouraged along the thin linear alluvial patches lying adjacent to major rivers where prolific ground water is available throughout the year.

REFERENCE:

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ii) District Irrigation Plan, DoWR, Govt.of Odisha.

iii) Ground Water Information Booklet of Raygada District CGWB,SER, Bhubaneswar, 2007.

iv) District Report of Raygada District, CGWB,SER, Bhubaneswar, March,1996.

(v) "Hydochemistry and ground water quality assessment for irrigation purpose in and around Rayagada town, Odisha, India" by S.K.Sahu, Rosalin Das, Mira Das, Madhumita Das and S.Goswami, 'International Journal of Earth Science and Engineering' pp. 611-616, 2015

Annexure -1 Rainfall Distribution through the blocks of Odisha

Blocks	Jan-21	Feb-21	Mar-21	Apr-21	May-21	Jun-21	Jul-21	Aug-21	Sep-21	Oct-21	Nov-21	Dec-21
Rayagada	0	10.2	0.0	0.0	51.9	193.0	163.5	243.3	175.2	28.6	49.6	5.4
Kolnara	0	1.4	0.0	56.6	118.8	249.0	173.5	187.8	116.1	51.2	45.2	0.0
Kalyansingpur	0	0	0.0	20.8	49.3	61.6	182.2	193.0	250.8	60.6	59.9	32.8
Kashipur	0	0	0.0	0.0	29.6	220.2	241.7	182.3	179.0	82.1	34.0	8.2
Gunupur	0	0	0.0	0.0	15.2	68.2	122.6	350.5	296.1	99.8	63.0	9.0
Padmapur	0	0	0.0	0.0	0.0	108.5	197.0	190.1	175.5	65.0	49.9	4.0
Gudari	0	0	0.0	0.0	0.0	67.0	392.0	258.4	253.9	50.6	57.2	6.8
Ramanaguda	0	0	0.0	23.0	55.4	130.2	276.9	314.0	277.9	141.0	33.0	12.8
Bissam Cuttack	0	0	0.0	0.0	0.0	103.6	94.9	196.0	390.0	87.0	44.4	41.9
Muniguda	0	0	0.0	1.0	215.8	134.4	155.8	150.4	386.3	65.6	63.4	33.1
Chandrapur	0	0	0.0	63.0	22.8	70.6	72.3	129.6	314.0	49.7	34.7	10.4
Total	**0**	**11.6**	**0.0**	**164.4**	**558.8**	**1406.3**	**2072.4**	**2395.4**	**2814.8**	**781.2**	**534.3**	**164.4**
Average	**0**	**1.1**	**0.0**	**14.9**	**50.8**	**127.8**	**188.4**	**217.8**	**255.9**	**71.0**	**48.6**	**14.9**

Annexure -2 Block wise agro-ecology, climate, hydrology and topography features of Rayagada district

S. No	Name of the Blocks	Agro.Ecologyical Zone Type	Type of Terrain	Block Area in (Ha)	Average monthly rain fall (mm)	No.of rainy day's	Maximum Rain Fall Intensity =(Rain fall in m/Hr)			Average Weekly Temperature (c)									PET				Elevation		
										Period									Period						
										Summer			Winter			Rainy (June-									
							Up to 15min.	Beyond 15 but up to 30 min	Beyond 30 but up to 60 min	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Summer	Winter	Rainy Season	Cumulatiu e	Min	Max	Mean
1	Rayagada	Eastern Plateau and eastern ghats, hot sub humid eco-region with red & Lateritic soils	Very gently to moderatly sloping with hills, steeply sloping hills and nearly levelled inter hills.	55858	1438	68	25	52	98	25	42	34	8	30	19	22	38	30							
2	Kolnara	do	Moderatly sloping hills, gently sloping inter hills with undulated disserted Plateau.	39425	9226	55	18	40	80	26	40	33	8	29	19	23	38	31							
3	K.Singpur	do	Undulating disserted Plaeau with moderatly sloping Low hill range	44590	1199	69	20	42	85	27	42	35	9	30	20	21	36	29							
4	Kasipur	do	Undulated disserted Plateau & moderatly slopoping Low hill range	51251	1311	75	27	50	100	22	34	28	5	25	15	18	30	24							
5	Gunupur	do	Undulated disserted Plateau & gently slopoping Low hill range	99587	1161	64	20	40	80	26	39	33	8	28	18	22	35	29							
6	Padmapur	do	Undulated disserted Plateau and gently sloping inter hill range	88390	852	53	21	40	80	25	38	32	9	30	20	22	36	29	665	673	823.8	2161			
7	Ramnaguda	do	Gently sloping inter hills, moderatly sloping low hills & undulated disserted plateau.	66999	986	56	20	38	75	27	40	34	8	29	19	22	36	29							
8	Gudari	do	Moderatly sloping hills, gently sloping inter hills with undulated disserted Plateau.	79460	1202	67	22	42	85	26	39	33	8	29	19	22	37	30							
9	Bissam Cuttack	do	Moderatly sloping hills very gently sloping inter hills vally.	64807	1237	66	23	45	88	27	40	34	9	30	20	22	36	29							
10	Muniguda	do	Moderatly sloping hills some portion cover with steeply sloping hills and undulated plateau.	67608	1166	63	22	44	82	27	41	34	8	27	18	23	37	30							
11	Chandrapur	do	Undulated disserted plateau moderatly sloping low hill range.	46100	930	61	25	50	90	26	40	33	8	27	18	22	35	29							

S. No	Block	Cereals		Coarse Cereals		Pulses		Oil seed		Fibre		Any other		Hort&Plantation		Total		TCA
		IR	RF	IR	RF	IR	RF	IR	RF	IR	RF	IR	RF	IR	RF	IR	RF	
1	B.Cuttack	3968	2460	140	5178	154	3875	286	2305	0	2482	61	114	1146	2117	5755	18531	24285
2	Chandrapur	394	2066	25	1487	84	2382	78	1390	0	27	10	0	384	770	975	8122	9097
3	Gudari	1782	2903	745	1189	547	4577	613	585	419	1503	4	210	366	1012	4476	11979	16454
4	Gunupur	3703	1647	555	1042	758	3980	1334	481	843	6464	84	86	1384	1388	8662	15087	23748
5	K.Singpur	3069	2159	471	2625	873	3130	491	1084	0	2738	30	38	797	834	5730	12607	18337
6	Kashipur	2608	4706	845	13377	403	11741	188	10230	0	32	99	82	2586	1659	6728	41829	48557
7	Kolnara	2626	1689	411	2860	183	4487	263	1235	476	3062	111	0	874	500	4945	13833	18779
8	Muniguda	2664	3398	250	3628	256	4698	258	1870	0	424	23	11	2033	300	5483	14329	19812
9	Padmapur	4764	1701	394	907	1259	5946	936	852	218	2237	0	89	724	910	8295	12642	20937
10	Ramnaguda	3179	1246	150	1403	793	5370	914	1223	2540	5527	57	1052	1008	788	8641	16609	25249
11	Rayagada	3325	1368	793	3473	1206	5122	649	1895	967	2597	40	43	1622	663	8602	15163	23765
	Total	**32081**	**25343**	**4778**	**37170**	**6516**	**55308**	**6009**	**23151**	**5463**	**27093**	**519**	**1725**	**12924**	**10941**	**68290**	**180730**	**249020**

Source: DIP, Rayagada

Annexure 4: Details of NHNS monitoring network stations and depth to water level during Pre&Post Monsoon

Sl. No.	DISTRICT_NAME	BLOCK_NAME	VILLAGE	Source	Lat Decimal	Long decimal	DEPTH (m)	dia (m)	MP(m)	Pre_wl (mbgl)	Post_wl (mbgl)	Fluctuation (mbgl)
1	RAYAGADA	PADMAPUR	Akhusingi	DW	19.27361	83.85861	8	3	0.84	2.95	1.4	1.55
2	RAYAGADA	MUNIGUDA	Ambadola	DW	19.83528	83.45806	11.57	1.59	0.8	8.39	7.76	0.63
3	RAYAGADA	RAMANGUDA	Bangi Chowk	DW	19.20583	83.70889	7.5	2	0.7	5.19	2.1	3.09
4	RAYAGADA	RAMANGUDA	Chakunda	DW	19.22139	83.69306	7.9	2	0.8	5.08	3.3	1.78
5	RAYAGADA	GUNUPUR	Dambasara	DW	19.16917	83.84139	3.9	2.85	0.8	2.1	1.42	0.68
6	RAYAGADA	KASHIPUR	Gorakhpur	DW	19.24083	83.11194	7	2.2	0.85	4.29	4.08	0.21
7	RAYAGADA	RAMANGUDA	Gumda	DW	19.22	83.77167	9.5	1.98	0.8	2.68	4.6	-1.92
8	RAYAGADA	RAYAGADA	Gumma	DW	19.19444	83.28833	6.8	1.26	0.76	2.17	1.65	0.52
9	RAYAGADA	GUNUPUR	Gunupur1	DW	19.07944	83.81167	6.4	2.65	0.9	4.54	1.87	2.67
10	RAYAGADA	KASHIPUR	Kaliapada	DW	19.18028	83.13611	6.3	1	0.36	4.02	5.17	-1.15
11	RAYAGADA	KASHIPUR	Kashipur	DW	19.35417	83.11972	13.58	2.17	0.8	12.06	9.9	2.16
12	RAYAGADA	PADMAPUR	Kenduguda	DW	19.3075	83.90056	8.1	2.65	1	4.36	3.72	0.64
13	RAYAGADA	RAMANGUDA	Kodapadu	DW	19.19333	83.34528	8	0.8	1	6.46	5.93	0.53
14	RAYAGADA	KOLNARA	Minajhola	DW	19.27611	83.61028	4.6	0.8	1.2	3.06	2.49	0.57
15	RAYAGADA	KOLNARA	Mukundpur	DW	19.22556	83.55889	7.76	1.75	1.3	6	1.43	4.57
16	RAYAGADA	PADMAPUR	Narainpur	DW	19.36111	83.96667	8.75	1.88	1.1	4.26	0.79	3.47
17	RAYAGADA	PADMAPUR	Nua Dakasikula	DW	19.20722	83.83833	5.9	0.8	1	2.6	1	1.6
18	RAYAGADA	PADMAPUR	Padampur2	DW	19.24083	83.82222	5.6	2.49	0.83	2.14	1.17	0.97
19	RAYAGADA	RAYAGADA	Shirikona	DW	19.17556	83.37806	9.5	1	0.95	7.15	6.31	0.84
20	RAYAGADA	RAMANGUDA	Tandikana	DW	19.27	83.63806	8.1	3	0.73	3.68	2.67	1.01
21	RAYAGADA	KOLNARA	Therabali	DW	19.32778	83.44111	14.5	1.87	0.7	8.65	0.64	8.01

Annexure 5 : Details of established key wells and depth to water level during Pre&Post Monsoon

Sl No	Dist.	Block	Village	Source	Lat Decimal	Long Decimal	Depth (mbmp)	Dia (m)	MP (m)	premonsoon WL (mbgl)	postmonsoon WL (mbgl)	Fluctuation
1	Raygada	Padampur	Dumulupadar	DW	19.37639	83.98444	13.6	2.2	0.8	10.9	9.4	1.5
2	Raygada	Padampur	Nuagada	DW	19.35111	83.96167	11	2.1	0.85	9.15	4.3	4.85
3	Raygada	Padampur	Kenduguda NHS	DW	19.3075	83.90056	7.8	2.65	1.05	6.45	3.4	3.05
4	Raygada	Kolnara	Dhepaguda	PZ	19.25333	83.45028						0
5	Raygada	Kolnara	Dhepagaon	DW	19.25278	83.46056	11.3	0.8	0.5	7.35	5.85	1.5
6	Raygada	Kolnara	Kailaspur	DW	19.22667	83.54083	8.2	2	0.8	6.2	4	2.2
7	Raygada	Kolnara	Badachampua	DW	19.25806	83.59	9.4	2.1	0.7		6.6	-6.6
8	Raygada	Padampur	Sarpadu	DW	19.27778	83.7325	6.4	1.85	1.15	4.25	2.1	2.15
9	Raygada	Padampur	Matuguda	DW	19.3075	83.70111	3.8	1.8	1.5	1	0.05	0.95
10	Raygada	Gudari	Purna Baliguda	DW	19.32333	83.77	12.93	1.15	1	11.35	10.35	1
11	Raygada	Gudari	Dumbaguda	DW	19.37028	83.79028	6.8	1.8	0.9	4.15	0.6	3.55
12	Raygada	Gudari	Silimi	DW	19.37333	83.79611	6.7	1.95	0.85		5.5	-5.5
13	Raygada	Gudari	Badiguda	DW	19.36667	83.7925	4.1	1.2	0.9		2.23	-2.23
14	Raygada	Gudari	Barkudu	DW	19.40444	83.79667	4.75	2	1.05		2.05	-2.05
15	Raygada	Rayagada	Sirikana	DW	19.17639	83.38167	8.34	1.05	0.95	6.55	6.25	0.3
16	Raygada	Rayagada	Kumbhikota	DW	19.12194	83.25028	13.4	0.9	0.85	11.55	9.35	2.2
17	Raygada	Rayagada	Alangi	DW	19.09444	83.23944	8.15	1.9	1.15	3.5	1.25	2.25
18	Raygada	Laxmipur	Keskapadi	DW	19.13694	83.2275	9.1	2.15	1.15	7.35	6.35	1
19	Raygada	Kashipur	Sankarada	DW	19.16472	83.17167	7.8	1.5	0.65	6.85	5.3	1.55
20	Raygada	Kashipur	Kaliapada	DW	19.17528	83.13111	10.2	2.1	0.35	9.15	6.95	2.2
21	Raygada	Kashipur	Gokulamunda	DW	19.17472	83.08556	6.85	1.25	0.55	4.8	4.35	0.45
22	Raygada	Kashipur	Podapadi	DW	19.13111	83.07556	9.35	1.7	0.6	7.25	5.05	2.2
23	Raygada	Kashipur	D.Karol	DW	19.17972	83.01389	11.2	1.1	0.6		6.55	-6.55
24	Raygada	Kashipur	Dongasil	DW	19.23889	82.98889	12.9	1.12	0.75	11.25	8.97	2.28
25	Raygada	Kashipur	Renga	DW	19.30806	83.12472	10.7	1.9	0.85	8.65	5.25	3.4

26	Raygada	Raygada	Getipada	DW	19.25583	83.40889	9.18	2.7	0.7	6.8	4.2	2.6
27	Raygada	Kolnara	Donduli	DW	19.30917	83.38694	6.16	2.65	0.8	3.2	1.35	1.85
28	Raygada	Kolnara	Padaguda	DW	19.32778	83.36111	11.05	1.95	0.9	4.1	1.4	2.7
29	Raygada	Kalyansinghpur	Sikarpai	DW	19.39806	83.31861	5.25	0.78	1.1		2.25	-2.25
30	Raygada	Kalyansinghpur	Ghurtuli	PZ	19.4	83.29028						0
31	Raygada	Kashipur	Bandhamandi	PZ	19.38528	83.26139					2.44	-2.44
32	Raygada	Kalyansinghpur	Budaguda	DW	19.42556	83.30806	6.2	0.9	0.75	4.25	1.9	2.35
33	Raygada	Kalyansinghpur	Lataguda	DW	19.48972	83.32028	6.58	2.02	1	4	1.85	2.15
34	Raygada	Kalyansinghpur	Manaiguda	DW	19.46611	83.35194	7.9	1.15	0.75	4.25	0.25	4
35	Raygada	Kolnara	Paikpara	DW	19.34778	83.40556	7.9	1.85	0.75	5.65	3.6	2.05
36	Raygada	Bissumcuttack	Badagotiguda	DW	19.48278	83.48611	8.34	2.3	0.75	3.75	1.4	2.35
37	Raygada	Bissumcuttack	Tahsil office	DW	19.51528	83.50472	7.8	2	0.75		3.85	-3.85
38	Raygada	Bissumcuttack	Bissumcuttack	DW	19.51583	83.50444	8.25	1.7	0.95		2.75	-2.75
39	Raygada	Bissumcuttack	Thunpadi	DW	19.54222	83.545	9.5	0.82	0.9	7.6	4.22	3.38
40	Raygada	Bissumcuttack	Kutragarh	DW	19.61389	83.54778	8.5	0.85	0.97	6.03	4.48	1.55
41	Raygada	Muniguda	Angulapadar	DW	19.64278	83.58639	8.25	1.92	1		2.55	-2.55
42	Raygada	Chandrapur	Ghughupadar	DW	19.59778	83.65278	3.8	2	0.95	1.05	0.9	0.15
43	Raygada	Chandrapur	Gumkudi	DW	19.59083	83.68389	7.52	1.1	0.95	5.55	2.9	2.65
44	Raygada	Chandrapur	Kutudukupa	DW	19.57861	83.70917	4.17	1.35	1.05	2.45	0.85	1.6
45	Raygada	Chandrapur	Barchiguda	DW	19.5775	83.80444	4.65	1.45	0.85	3.15	0.47	2.68
46	Raygada	Chandrapur	Chichipanga	DW	19.59139	83.87139	5.5	1.95	1.2		0.9	-0.9
47	Raygada	Chandrapur	Kirama	DW	19.57417	83.92417	5.6	3.2	1			0
48	Raygada	Chandrapur	Khilundisahi	DW	19.55278	83.93694	5.9	0.6	0.3	4.1	2.82	1.28
49	Raygada	Chandrapur	Bijapur	DW	19.52528	83.91778	9.9	2	1.1		1.1	-1.1
50	Raygada	Chandrapur	Murchiguda	DW	19.47333	83.89389	5.65	2.7	1.2	3.8	0.8	3
51	Raygada	Chandrapur	T.Budoni	DW	19.28389	83.43444	4.3	1.15	0.95	2.55	0.6	1.95
52	Raygada	Kolnara	Therubali	DW	19.32722	83.43806	13.87	1.9	0.75		9	-9
53	Raygada	Bissumcuttack	Nuagaon	PZ	19.40972	83.45083	45	0.17	0.45		15.25	-15.25
54	Raygada	Bissumcuttack	Badisahi	DW	19.41333	83.46889	3.2	3	1.1		1.35	-1.35

55	Raygada	Bissumcuttack	Chatikona	PZ	19.48528	83.45861	45	0.17	0.6		3.1	-3.1
56	Raygada	Bissumcuttack	Kiribiri	DW	19.46111	83.53972	9.25	1.95	1.15		2.1	-2.1
57	Raygada	Bissumcuttack	Minahala Colony	DW	19.39778	83.55167	3.05	1.25	1.1	0.3		0.3
58	Raygada	Bissumcuttack	Pandaguruda	DW	19.37722	83.56389	5.2	2.4	1.25	1.75	1.05	0.7
59	Raygada	Bissumcuttack	Bissamcuttack-Pz	PZ	19.52417	83.50194	85	0.1	0.5		4.7	-4.7
60	Raygada	Bissumcuttack	Chintalguda	PZ	19.54639	83.48722		0.6	0.95		8.71	-8.71
61	Raygada	Bissumcuttack	Bandhuguda	DW	19.575	83.495	9.3	1.25	0.85	7.45	3.7	3.75
62	Raygada	Muniguda	Banadurga	DW	19.62	83.4925	12.8	0.9	0.15		7.25	-7.25
63	Raygada	Muniguda	Cheliana	DW	19.65667	83.48056	4.5	1.7	0.75	3.25	0.5	2.75
64	Raygada	Muniguda	Patharguda	DW	19.6775	83.47083	6.1	1.85	0.85	3.15	1.75	1.4
65	Raygada	Muniguda	Badamajusikopa	DW	19.76917	83.47028	12.4	1.9	0.7	9.3	7.5	1.8
66	Raygada	Muniguda	Kutrupalli	DW	19.80889	83.44694	5.95	2.15	1.01		3.84	-3.84
67	Raygada	Muniguda	Ambadola	DW	19.82583	83.45944	10.95	1.8	0.9		7.4	-7.4
68	Raygada	Muniguda	Hukumtoda	DW	19.62083	83.51583	8.55	1	0.6	7.4	3.4	4
69	Raygada	Muniguda	Gobardhan	DW	19.61139	83.50806	5.6	1.2	1	4	2.3	1.7
70	Raygada	Kolnara	Minajhola	DW	19.26556	83.60611	4.6	1.75	1	2.25	2.25	0
71	Raygada	Ramnaguda	Ukkamba	DW	19.16556	83.79333	7.56	0.8	0.63	1.37	0.89	0.48
72	Raygada	Ramnaguda	Bandhuguda	DW	19.1275	83.79722	6.8	2.05	0.75		1.9	-1.9
73	Raygada	Gunupur	Bikrampur	DW	19.08667	83.80556	7	2.1	0.75	5.75	4.05	1.7
74	Raygada	Gunupur	Gunupur	PZ	19.09306	83.80139		0.17	0.6		3.1	-3.1
75	Raygada	Padampur	Goibandha	DW	19.335	83.95944	7	2.1	0.95	4.55	1.85	2.7

Annexure – 6 INTERPRETED VES RESULTS IN PARTS OF RAYAGADA DISTRICT (PHASE II)

Rayagada District_HR					PROJECT: VERTICAL ELECTRICAL SOUNDING(VES) IN 10 STATES FOR DATA GENERATION (PMC Works)								
S.No.	LOCATION	Block	VES NO.	EASTING/	NORTHING	Direct interpretion of VES layer parameters by software				Inferred lithology	Aquifer Charectristics		
				Longitude	Latitude	Layer	Resisitivity (ohm.m)	Thickness (m)	Depth (m)		Aquifer	Depth Range (m)	Inferred aquifer water quality
1	Muniguda (Granite/Granite Gneiss)	Muniguda	467	44Q0761371	2170897	1	64	2.2	2.2	Top Soil			
						2	27	20.3	22.5	Weathered formaton	Aquifer	2.2-22.5	Potable
						3	83	54.9	77.4	Less compact formation	Aquifer	22.5-77.4	Potable
						4	VH			Compact formation			
2	Ambodala (Charnockite)	Muniguda	468	44Q0757721	2195403	1	102	1.92	1.9	Top Soil			
						2	76	6.7	8.6	Weathered formaton	Aquifer	1.9-8.6	Potable
						3	119	9.67	18.3	Semi Weathered formaton			
						4	20	20.5	38.8	Less compact formation	Aquifer	18.3-38.8	Potable
						5	VH			Compact formation			
3	Baatudi (Charnokite)	Muniguda	469	44Q0755484	2178885	1	52	1.4	1.4	Top Soil			
						2	83	10.0	11.4	Semi Weathered formaton	Aquifer	1.4-11.4	Potable
						3	45	55.6	67.0	Less compact formation	Aquifer	11.4-67	Potable

						4	VH			Compact formation			
4	**Konilpadar (Charnokite)**	**Muniguda**	470	**44Q0773930**	**2178666**	1	180	1.9	1.9	Top Soil			
						2	37	11.8	13.7	Weathered formaton	Aquifer	1.9-13.7	Potable
						3	202	110.0	123.7	Less compact formation	Aquifer	13.7-123.7	Potable
						4	VH			Compact formation			
5	**Banipanga (Charnokite)**	**Muniguda**	471	**44Q0767585**	**2194194**	1	502	2.8	2.8	Top Soil			
						2	119	4.4	7.1	Semi Weathered formaton			
						3	209	85.5	92.6	Less compact formation	Aquifer	7.1-92.6	Potable
						4	VH			Compact formation			
6	**Bamandeo (Khondalite)**	**Muniguda**	472	**44Q0754157**	**2204380**	1	78	1.3	1.3	Top Soil			
						2	15	5.7	7.0	Weathered formaton	Aquifer	1.3-7	Potable
						3	41	46.7	53.7	Less compact formation	Aquifer	7-53.7	Potable
						4	VH			Compact formation			
7	**Tikorapada (Charnokite)**	**Muniguda**	473	**44Q0762966**	**2206739**	1	42	0.8	0.8	Top Soil			
						2	22	1.1	1.9	Top Soil			
						3	51	11.5	13.4	Weathered formaton	Aquifer	1.9-13.4	Potable
						4	131	89.2	102.6	Less compact formation	Aquifer	13.4-102.6	Potable
						5	VH			Compact formation			
8	**Majhiguda (Granite / Granite Gneiss)**	**Chandrapur**	474	**44Q0788263**	**2172140**	1	197	1.4	1.4	Top Soil			
						2	41	11.9	13.3	Weathered formaton	Aquifer	1.4-13.3	Potable
						3	VH	5.7	18.9	Compact formation	Aquifer	13.3-18.9	Potable
						4	187			Less Compact formation			

9	**Chandrapur (Granite / Granite Gneiss)**	**Chandrapur**	475	**44Q0801395**	**2168873**	1	106	1.4	1.4	Top Soil			
						2	43	6.3	7.7	Weathered Formation	Aquifer	1.4-7.7	Potable
						3	VH			Compat firmation			
10	**Raibiji (Granite / Granite Gneiss)**	**Chandrapur**	476	**44Q0788310**	**2166830**	1	35	0.8	0.8	Top Soil			
						2	7	6.6	7.4	Weathered Formation			
						3	20	19.6	27.0	Weathered / Less Compact Formation	Aquifer	7.4-27	Potable
						4	VH			Compact Formation			
11	**Kurumajodi (Charnokite)**	**Chandrapur**	477	**44Q0772879**	**2171292**	1	313	18.3	18.3	Semi Weathered formation			
						2	683	157	175.3	Less compact formation	Aquifer	18.3-175.3	Potable
						3	VH			Compat firmation			
12	**Penakaru (Granite / Granite Gneiss)**	**Chandrapur**	478	**44Q0798218**	**2177729**	1	96	0.8	0.8	Top Soil			
						2	52	2.5	3.2	Weathered Formation	Aquifer	0.8-3.2	Potable
						3	1023	166.0	169.2	Less compact formation	Aquifer	3.2-169	Potable
						4	VH			Compat firmation			
13	**Bandhagam (Khondalite)**	**Chandrapur**	479	**44Q0792425**	**2157796**	1	172	1.3	1.3	Top Soil			
						2	17	0.6	1.9	Top Soil			
						3	66	21.5	23.4	Semi Weathered Formation	Aquifer	1.9-23.4	Potable
						4	28	20.1	43.5	Less compact formation	Aquifer	23.4-43.5	Potable
						5	VH			Compat firmation			
14	**Patotali (Granite / Granite Gneiss)**	**Chandrapur**	480	**44Q0803909**	**2163439**	1	74	5.4	5.4	Weathered Formation			
						2	277	26.7	32.1	Less compact formation	Aquifer	5.4-32.1	Potable

						3	VH			Compact formation			
15	**Pankalagudi (Granite / Granite Gneiss)**	**Chandrapur**	**481**	**44Q0808104**	**2150481**	1	170	0.9	0.9	Top Soil			
						2	46	0.8	1.8	Top Soil			
						3	108	11.6	13.4	Semi Weathered Formation			
						4	476	45.8	59.2	Less compact formation	Aquifer	13.4-59.2	Potable
						5	VH			Compat firmation			
16	**Gudari (Granite / Granite Gneiss)**	**Gudari**	**482**	**44Q0792691**	**2142066**	1	16	2.6	2.6	Top Soil			
						2	6	2.3	5.0	Weathered Formation			
						3	12	23.6	28.6	Weathered Formation	Aquifer	5-28.6	Potable
						4	VH			Compat firmation			
17	**Siriguda (Khondalite)**	**Gudari**	**483**	**44Q0795079**	**2149103**	1	18	0.8	0.8	Top Soil			
						2	5	0.8	1.6	Top Soil			
						3	11	19.5	21.1	Weathered Formation	Aquifer	1.6-21.1	Potable
						4	VH			Compat firmation			
18	**Atakabadi (Granite / Granite Gneiss)**	**Gudari**	**484**	**44Q0782313**	**2156182**	1	106	1	1.1	Top Soil			
						2	38	10.3	11.4	Weathered Formation	Aquifer	1.1-11.4	Potable
						3	593	164	175.4	Less Compat firmation	Aquifer	11.4-175.4	Potable
						4	VH			Compat firmation			
19	**Khatiguda (Khondalite/Granite Contact)**	**Gudari**	**485**	**44Q0783090**	**2147562**	1	141	1.4	1.4	Top Soil			
						2	44	11.1	12.5	Weathered Formation	Aquifer	1.4-12.5	Potable
						3	447	158	170.5	Less Compat firmation	Aquifer	12.5-170.5	Potable

						4	vh			Compat firmation			
20	**Khaira guda (Granite / Granite Gneiss)**	**Gudari**	**486**	**44Q0802934**	**2143536**	1	132	0.6	0.6	Top Soil			
						2	71	10.7	11.3	Weathered Formation	Aquifer	0.6-11.3	Potable
						3	463	75.4	86.7	Less Compat firmation	Aquifer	11.3-86.7	Potable
						4	VH			Compat firmation			
21	**Badigan (Granite / Granite Gneiss)**	**Gudari**	**487**	**44Q0785397**	**2138461**	1	431	0.3	0.3	Top Soil			
						2	54	2.2	2.5	Top Soil			
						3	61	22.9	25.4	Weathered / Less Compat firmation	Aquifer	2.5-25.4	Potable
						4	449	84.1	110	Less Compat firmation	Aquifer	25.4-110	Potable
						5	VH			Compat firmation			
22	**Padmapur (Granite / Granite Gneiss)**	**Padmapur**	**488**	**44Q0796261**	**2130604**	1	34	1.8	1.8	Top Soil			
						2	11	11.1	12.9	Weathered Formation	Aquifer	1.8-12.9	Potable
						3	32	52.2	65.1	Less Compat firmation	Aquifer	12.9-65.1	Potable
						4	VH			Compat firmation			
23	**Biripadar (Granite / Granite Gneiss)**	**Padmapur**	**489**	**44Q0799930**	**2126895**	1	42	1.5	1.5	Top Soil			
						2	30	17.3	18.8	Weathered Formation	Aquifer	1.5-18.8	Potable
						3	400	175	193.8	Less Compat firmation	Aquifer	18.8-194	Potable
						4	VH			Compat firmation			
24	**Sarupadu (Alluvium/Granite / Granite Gneiss)**	**Padmapur**	**490**	**44Q0787120**	**2133345**	1	49	0.9	0.9	Top Soil			
						2	21	3.2	4.1	Alluvium	Aquifer	0.9-18.3	Potable
						3	50	4.6	8.7	Alluvium			

						4	11	9.7	18.3	Alluvium/Weathered formaton			
						5	207	68.7	87.0	Less Compat firmation	Aquifer	18.3-87	Potable
						6	VH			Compat firmation			
25	**Soura Singipur (Granite / Granite Gneiss)**	**Padmapur**	**491**	**44Q0799665**	**2137435**	1	69	3.5	3.5	Top Soil			
						2	28	4.5	8.0	Weathered Formation	Aquifer	3.5-8	Potable
						3	1437	8.5	16.5	Compat firmation			
						4	199	62.8	79.3	Less Compat firmation	Aquifer	16.5-79.3	Potable
						5	VH			Compat firmation			
26	**Asaragudi**	**Padmapur**	**492**	**44Q0186673**	**2142053**	1	164	2	2.1	Top Soil			
						2	83	8.8	11.0	Semi Weathered Formation			
						3	23	11	22.0	Weathered Formation	Aquifer	11-22	Potable
						4	967			Less Compat firmation	Aquifer	22- ? (200)	Potable
27	**Bhimpurguda (Granite / Granite Gneiss)**	**Gunupur**	**493**	**44Q0809833**	**2124633**	1	63	1.7	1.7	Top Soil			
						2	6	2.4	4.1	Weathered Formation			
						3	239	3.8	7.9	Semi Weathered Formation			
						4	18	19.0	26.9	Less compact formation	Aquifer	7.9-26.9	Potable
						5	VH			Compact formation			
28	**Gunupur (Granite / Granite Gneiss)**	**Gunupur**	**494**	**44Q0797276**	**2112836**	1	89	1.5	1.5	Top Soil			
						2	23	15.4	16.9	Weathered Formation	Aquifer	1.5-16.9	Potable
						3	371	114	130.9	Less compact formation	Aquifer	16.9-131	Potable
						4	VH			Compact formation			

29	**Tolana (Granite / Granite Gneiss)**	**Gunupur**	**495**	**44Q0809055**	**2114180**	1	30	1.9	1.9	Top Soil			
						2	13	17.9	19.8	Weathered Formation	Aquifer	1.9-19.8	Potable
						3	VH			Compact formation			
30	**Kadasi (Granite / Granite Gneiss)**	**Gunupur**	496	**44Q0808098**	**2108798**	1	117	1.4	1.4	Top Soil			
						2	193	1.3	2.7	Top Soil			
						3	89	6.9	9.6	SemiWeathered Formation			
						4	24	8.3	18.0	Weathered Formation	Aquifer	9.6-18	Potable
						5	VH			Compact formation			
31	**Marama (Granite / Granite Gneiss)**	**Gunupur**	497	**44Q0789922**	**2097193**	1	26	1.6	1.6	Top Soil			
						2	37	14.1	15.7	Weathered Formation	Aquifer	1.6-15.7	Potable
						3	VH			Compact formation			
32	**Kebidi (Granite / Granite Gneiss)**	**Gunupur**	498	**44Q0787461**	**2110496**	1	104	2.5	2.5	Top Soil			
						2	36	15.2	17.7	Weathered Formation	Aquifer	2.5-17.7	Potable
						3	285	137	154.7	Less Compact formation	Aquifer	17.7-155	Potable
						4	VH			Compact formation			
33	**Ghanatri (Granite / Granite Gneiss)**	**Gunupur**	**499**	**44Q0800884**	**2118901**	1	30	1.9	1.9	Top Soil			
						2	13	17.9	19.8	Weathered Formation	Aquifer	1.9-19.8	Potable
						3	VH			Compact formation			
34	**Lingapur (Granite / Granite Gneiss)**	**Gunupur**	500	**44Q0812990**	**2120238**	1	105	3.8	3.8	Top Soil			
						2	544	5.0	8.8	Semi Weathered Formation			
						3	30	24.3	33.1	Less Compact formation	Aquifer	8.8-33.1	Potable

						4	VH			Compact formation			
35	**Ukkamba (Alluvium/(Granite / Granite Gneiss)**	**Ramanguda**	501	**44Q0793790**	**2120722**	1	18	1.2	1.2	Top Soil			
						2	9	4.5	5.7	Alluvium	Aquifer	1.2-29.6	Potable
						3	12	23.9	29.6	Alluvium			
						4	VH			Compact formation			
36	**Tandikona (Khondalite/ Charnockite/ Granite/Granite Gneiss contact)**	**Ramanguda**	**502**	**44Q0775665**	**2132355**	1	38	3.0	3.0	Top Soil			
						2	50	6.9	9.8	Weathered Formation	Aquifer	3-9.8	Potable
						3	1814			Compact Formation			
37	**Badabangi (Alluvium)**	**Ramanguda**	503	**44Q0785893**	**2124724**	1	46	0.7	0.7	Top Soil			
						2	6	0.9	1.5	Alluvium	Aquifer	0.7-32.4	Potable
						3	47	1.7	3.2	Alluvium			
						4	11	29.2	32.4	Alluvium			
						5	VH			Compact Formation			
38	**Katiki (Granite/Granite Gneiss)**	**Ramanguda**	504	**44Q0778277**	**2118015**	1	85	0.3	0.3	Top Soil			
						2	14	42.2	42.5	Less compact formation	Aquifer	3-9.8	Potable
						3	VH			Compact Formation			
39	**Dumuri (Alluvium)**	**Ramanguda**	505	**44Q0786991**	**2118152**	1	11	2.7	2.7	Top Soil			
						2	3	3.3	5.9	Alluvium			
						3	18	32.3	38.2	Alluvium	Aquifer	5.9-38.2	Potable
						4	VH			Compact Formation			
40	**Brundabadi (Khondalite)**	**Kolnara**	**506**	**44Q0756832**	**2149066**	1	103	0.9	0.9	Top Soil			

						2	20	3.2	4.1	Weathered Formaton	Aquifer	0.9-8.6	Potable
						3	14	4.6	8.6	Weathered Formaton			
						4	646	9.67	18.3	Compact Formation			
						5	45	20.5	38.8	Less Compact Formation	Aquifer	18.3-38.8	Potable
						6	VH			Compact Formation			
41	**Pujariguda (Khondalite)**	**Kolnara**	**507**	**44Q00752646**	**2139087**	1	42	0.8	0.8	Top Soil			
						2	17	7.0	7.8	Weathered Formaton	Aquifer	0.8-7.8	Potable
						3	138	49.7	58	Less Compact Formation	Aquifer	7.8-58	Potable
						4	VH			Compact Formation			
42	**Kachapai (Khondalite_Granite/Granite Gneiss contact)**	**Kolnara**	508	**44Q0769375**	**2139353**	1	129	1.2	1.2	Top Sol			
						2	180	13.5	14.7	Semi Weathered Formaton	---	---	---
						3	VH			Compact Formation			
43	**Badagumuda (Khondalite) Close to the NE-SW Lineament**	**Kolnara**	509	**44Q0764866**	**2135208**	1	79	0.5	0.5	Top Sol			
						2	9	6.3	6.8	Weathered Formaton	Aquifer	0.5-6.8	Potable
						3	41	37.3	44.1	Less Compact Formation	Aquifer	6.8-44.1	Potable
						4	VH			Compact Formation			
44	**Silingipadu (Charnockite)**	**Kolnara**	510	**44Q0770376**	**2126168**	1	281	1.9	1.9	Top Sol			
						2	632	7.9	9.8	Compact Formation			
						3	100	77.6	87.4	Less Compact Formation	Aquifer	9.8-87.4	Potable
						4	VH			Compact Formation			

45	**Banapur (Granite)**	**Kolnara**	511	**44Q0760227**	**2141782**	1	105	0.7	0.7	Top Sol			
						2	11	0.7	1.4	Top Sol			
						3	40	6.6	8.0	Weathered Formation	Aquifer	1.4-8	Potable
						4	196	137.0	145.0	Less Compact Formation	Aquifer	8-145	Potable
						5	VH			Compact Formation			
46	**Chandili (Khondalte)**	**Rayagada**	512	**44Q0754192**	**2129521**	1	322	0.4	0.4	Top Sol			
						2	35	13.2	13.6	Weathered Formation	Aquifer	0.4-13.6	Potable
						3	164	118.0	132.0	Less Compact Formation	Aquifer	13.6-132	Potable
						4	VH			Compact Formation			
47	**Seriguda (Khondalte)**	**Rayagada**	513	**44Q0751061**	**2122426**	1	56	1.2	1.2	Top Sol			
						2	15	3.2	4.3	Weathered Formation	Aquifer	1.2-4.3	Potable
						3	256	157.8	162.1	Less Compact Formation	Aquifer	4.3-162	Potable
						4	VH			Compact Formation			
48	**Ledda (Alluvium/(Granite/Granite Gneiss) contact)**	**Rayagada**	514	**44Q0753871**	**2113959**	1	69	0.9	0.9	Top Sol			
						2	29	7.8	8.7	Alluvium	Aquifer	0.9-18.3	Potable
						3	10	9.7	18.3	Alluvium / Weathered Formation			
						4	204	167	185.3	Less Compact Formation	Aquifer	18.3-185.3	Potable
						5	VH			Compact Formation			
49	**Udayapur (Khondalite)**	**Rayagada**	515	**44Q0737279**	**2117093**	1	65	2.6	2.6	Top Sol			
						2	26	3.1	5.7	Weathered Formation	Aquifer	2.6-5.7	Potable
						3	271	101.0	106.7	Less Compact Formation	Aquifer	5.7-107	Potable
						4	VH			Compact Formation			

50	**Kiyapadu (Khondalte)**	**Rayagada**	516	**44Q0738566**	**2127875**	1	28	6.0	6.0	Weathered Formation	Aquifer	0-6	Potable
						2	VH	16.6	22.6	Compact formation			
						3	44	20.3	42.9	Less Compact formation	Aquifer	22.6-42.9	Potable
						4	VH			Compact formation			
51	**Badachak (Khondalte)**	**Rayagada**	517	**44Q0733838**	**2106463**	1	78	2.6	2.6	Top Soil			
						2	656	3.1	5.7	Compact formation			
						3	49	73.0	78.7	Less compact formation	Aquifer	5.7-78.7	Potable
						4	VH			compact formation			
52	**Junjamani (Granite/Granite Gneiss)**	**Rayagada**	518	**44Q0759010**	**2105621**	1	234	2.2	2.2	Top Soil			
						2	632	14.2	16.5	Compact formation			
						3	VH	205.1	221.6	Compact formation			
						4	VH			Compact formation			
53	**Kasipur (Charnockite, Close to NE-SW Lineament)**	**Kasipur**	519	**44Q0722548**	**2141158**	1	151	1.6	1.6	Top Soil			
						2	1839	0.9	2.5	Compact formation			
						3	494	25.3	27.8	Less Compact formation	Aquifer	2.5-27.8	Potable
						4	1484	292	319.8	Compact formation			
						5	VH			Compact formation			
54	**Ambiligada tunda (Khondalte)**	**Kasipur**	520	**44Q0713817**	**2128512**	1	71	3.1	3.1	Top Soil			
						2	36	4.9	8.1	Weathered Formation	Aquifer	3.1-8.1	Potable
						3	266	84.2	92.3	Less Compact formation	Aquifer	8.1-92.3	Potable
						4	VH			Compact formation			
55	**Kaliapada (Khondalte)**	**Kashipur**	521	**44Q0723749**	**2121607**	1	314	0.4	0.4	Top Soil			

						2	110	10.6	11.0	Semi Weathered Formation			
						3	71	11.0	22.0	Less Compact formation	Aquifer	11-22	Potable
						4	VH			Compact formation			
56	**Manditunesa (Precambrian Limestone/Shale/Quartzites)**	**Kasipur**	522	**44Q0716066**	**2159785**	1	183	0.7	0.7	Top Soil			
						2	111	2.0	2.7	Top Soil			
						3	247	8.7	11.4	Semi Weathered Formation			
						4	1130	247.3	258.7	Less Compact formation	Aquifer	11.4-259	Potable
						5	VH			Compact formation			
57	**Ramagir (Khondalites)**	**Kasipur**	523	**44Q0706537**	**2148196**	1	267	0.9	0.9	Top Soil			
						2	131	25.2	26.1	Semi Weathered Formation			
						3	383	113.1	139.2	Less Compact formation	Aquifer	26.1-139.2	Potable
						4	VH			Compact formation			
58	**Pushughati (Khondalites)**	**Kashipur**	524	**44Q0732991**	**2147214**	1	25	1.4	1.4	Top Soil			
						2	40	10.4	11.8	Weathered Formation	Aquifer	1.4-11.8	Potable
						3	891			Compact formation			
59	**Silapas (Khondalites)**	**Kasipur**	525	**44Q0708266**	**2133277**	1	78	1.1	1.1	Top Soil			
						2	174	5.9	7.0	Semi Weathered Formation			
						3	809	193.4	200.4	Less Compact formation	Aquifer	7-200	Potable
						4	VH			Compact formation			
60	**Bhitaraduluki (Khondalites)**	**Kasipur**	526	**44Q0726186**	**2132914**	1	107	0.4	0.4	Top Soil			
						2	274	6.3	6.7	Semi Weathered Formation			
						3	736	3.2	10.0	Compact formation			

						4	110	8.5	18.5	Less Compact formation	Aquifer	10-18.5	Potable
						5	1165	296.0	314.5	Compact formation			
						6	VH			Compact formation			
61	**Mankadajhola (Khondalites)**	**Kasipur**	527	**44Q0716698**	**2113261**	1	292	0.8	0.8	Top Soil			
						2	114	0.5	1.3	Top Soil			
						3	317	4.2	5.5	Semi weathered formation			
						4	482	43.8	49.3	Less Compact formation	Aquifer	5.5-49.3	Potable
						5	1010	183.3	232.6	Compact formation			
						6	VH			Compact formation			
62	**Tureighati (Charnockites)**	**Kasipur**	528	**44Q0703757**	**2121202**	1	144	5.2	5.2	Semi Weathered Formation			
						2	245	49.3	54.5	Less Compact formaton	Aquifer	5.2-54.5	Potable
						3	VH			Compact formaton			
63	**Kalyansinghpur (Khondalites)**	**Kalyansinghpur**	529	**44Q0742592**	**2159444**	1	42	0.6	0.6	Top Soil			
						2	7.05	0.6	1.2	Top Soil			
						3	34	10.8	12.0	Weathered formaton	Aquifer	1.2-12	Potable
						4	14.8	11.8	23.8	Less Compact formaton	Aquifer	12-23.8	Potable
						5	VH			Compact formaton			
64	**Kasakadanga (Granite/Charnockite Contact)**	**Kalyansinghpur**	530	**44Q0743049**	**2135470**	1	154	0.4	0.4	Top Soil			
						2	45	3.6	4.0	Weathered formation	Aquifer	0.4-18.5	Potable
						3	24	14.5	18.5	Weathered formation			
						4	129	80.5	99.0	Less Compact formation	Aquifer	18.5-99	Potable
						5	VH			Compact formation			

65	**Kanipai (Khondalite)**	**Kalyansinghpur**	531	**44Q0741691**	**2142781**	1	68	1.5	1.5	Top Soil			
						2	177	13.3	14.8	Semi Weathered formation	---	---	---
						3	VH			Compact formation			
66	**Majhiguda (Kondalite/Granite Contact)**	**Kalyansinghpur**	532	**44Q0744874**	**2150494**	1	75	1.2	1.2	Top Soil			
						2	26	8.6	9.8	Weathered formation	Aquifer	1.2-9.8	Potable
						3	149	30.5	40.3	Less Compact formation	Aquifer	9.8-40.3	Potable
						4	VH			Compact formation			
67	**Mutekoni (Khondalites)**	**Kalyansinghpur**	533	**44Q0734744**	**2157131**	1	45	2.3	2.3	Top Soil			
						2	16	2.2	4.5	Weathered formation	Aquifer	2.3-11.7	Potable
						3	40	7.2	11.7	Weathered formation			
						4	17	23.8	35.5	Less Compact formation	Aquifer	11.7-35.5	Potable
						5	VH			Compact formation			
68	**Chatapadar (Khondalites)**	**Kalyansinghpur**	534	**44Q0740995**	**2165517**	1	43	2.0	2.0	Top Soil			
						2	20	8.5	10.5	Weathered formation	Aquifer	2-10.5	Potable
						3	VH			Compact formation			
69	**Bisamacuttack (Alluvium/Granite)**	**Bisamacuttack**	535	**44Q0763634**	**2158788**	1	77	1.4	1.4	Top Soil			
						2	27	11.1	12.5	Alluvium	Aquifer	1.4-12.5	Potable
						3	159	71.2	83.7	Less compact formation	Aquifer	12.5-83.7	Potable
						4	VH			Compact formation			
70	**Jangojodi (Khondalite)**	**Bisamcuttack**	537	**44Q0753041**	**2156699**	1	232	1.6	1.6	Top Soil			

						2	109	11.1	12.7	Semi weathered formation			
						3	403	162.0	174.7	Less Compact formation	Aquifer	12.7-175	Potable
						4	VH			Compact formation			
71	**Kodiguma (Khondalite/Granite contact)**	**Bisamacuttack**	538	**44Q0758538**	**2164073**	1	109	2.5	2.5	Top Soil			
						2	24	29.7	32.1	Weathered formation	Aquifer	2.5-32.1	Potable
						3	113	172	204.0	Less Compact formation	Aquifer	32.1-204	Potable
						4	VH			Compact formation			
72	**Sindhupanga (Granite/Granite Gneiss)**	**Bisamcuttack**	539	**44Q0767196**	**2164954**	1	81	2.0	2.0	Top Soil			
						2	105	23.7	25.7	Semi weathered / Less Compact formationformation			
						3	334	121.0	146.7	Less Compact formation	Aquifer	25.7-147	Potable
						4	VH			Compact formation			
73	**Hazaridanga (Charnockite/(Granite/Granite Gneiss) Contact)**	**Bisamacuttack**	540	**44Q0767052**	**2151100**	1	55	1.3	1.3	Top Soil			
						2	13	8.1	9.4	Weathered formaton	Aquifer	1.3-9.4	Potable
						3	279	118	127.4	Less Compact formation	Aquifer	9.4-127.4	Potable
						4	VH			Compact formation			
74	**Jugapadar (Granite/Granite Gneiss)**	**Bisamcuttack**	541	**44Q0774185**	**2157354**	1	28	8.2	8.2	Weathered formaton	Aquifer	0-8.2	Potable
						2	752	140.0	148.2	Compact formation			
						3	VH			Compact formation			

Annexure 7 Exploratory wells details explored by CGWB

Sl. No	Block	Location	Lat decimal	Long decimal	Overburden casing pipe installation depth in (m)	Total Depth of well constructed(mbgl)	Major Lithology encountered	Zones /Fractured encountered (m bgl)				S.W.L (m.bgl)	Discharge in lps	Draw-down (m)
								Ist fracture	II nd fracture	III rd Fracture	IVth fracture			
1	B. Cuttack	Kumardhimini	19.3817	83.5444	15.0	63.0	Fractured Charnockite					4.90	10.50	9.10
2	B.Cuttack	Durgi	19.3407	83.5721	24.00	198.0	Khondalite	46.7	61.9	65.8				-
3	B.Cuttack	Kumardhamini	19.3817	83.5444	14.50	75	Fractured Charnockite	41.6	55.8	71.1		5.44	7.50	-
4	Gunupur	Gunupur	19.0614	83.8425	44.70	185.0	Gr.Gneiss						.5	-
5	Kalyansitghpur	Kalyansigpur	19.5102	83.3035	28.0	105.35	Gr.Gneiss	38	42	46	78	14.3	12.0	9.76
6	Kalyansitghpur	Kalyansigpur	19.5102	83.3035	27.06	91.80	Gr.Gneiss	43	82	87	105	18.7	23.50	6.30
7	Ramnaguda	Ramnaguda	19.2122	83.6727	25.90	138.20	Granite	46.7	52.8	57.9		3.57	4.70	-
8	Ramnaguda	Ramnaguda	19.2122	83.6727	22.80	132.0	Granite	45.5	51.7	56.5		3.57	4.5	-
9	Rayagada	Rayagada I	19.1173	83.4003	49.4	50.5	Alluvium	50				16.26	1.33	15.98
10	Rayagada	Rayagada II	19.1042	83.4516		25.60	Alluvium						1.0	-
11	Rayagada	Rayagada III	19.1284	83.4556	57.74	200.60	Khondalite	160				6.25	1.35	49.4

Annexure 8 **Exploratory wells details explored by CGWB through outsourcing**

Sl. No	Block	Location	Lat decimal	Long decimal	Overburden casing pipe installation depth in (m) AGL	Total Depth of well constructed(mbgl)	Major Lithology encountered	Zones /Fractured encountered (m bgl)						S.W.L (m.bgl)	Discharge in lps	Draw - down (m)	T (m2 /d)	Storativity
								Ist fracture	II nd fracture	III rd Fracture	Ivth fracture	Vth fracture	VIth fracture					
1	Bissamcuttack	Hatamuniguda	19.58861	83.50056	24	201	Granite	24 - 33	36 - 37	53 - 54	56 - 57	102 - 105		6.14	1.43	23.07	1.62	
2	Chandrapur	Piskapanga	19.55917	83.64361	12	200	Khondalite								0.4 lps			
3	CHANDRAPUR	Turiguda	19.63167	83.56389	19	139	Khondalite	31 - 39						2.2	4.7	18.19	6.15	
4	Chandrapur	S.Hirba	19.54083	83.65306	24	200	Khondalite							3.35	3.3	20.02	11.76	2.97x10-4
5	Chandrapur	S.Hirba	19.54056	83.65194	24	200	Khondalite	113 - 114						2.3	2.3	21.41	11.19	
6	Chandrapur	Bangarada	19.61667	83.605	25	200	Khondalite	93 - 94						4.46	1.5	18.99	1.72	
7	Gudari	Jalanidhi	19.34722	83.81667	24	200	Granite	187 - 190	195 - 196						0.1 lps			
8	Gudari	Koiraguda	19.35583	83.88167	16	201	Granite	42 - 43	47 - 48	185 - 187				7.92	4.61	38.33	23.36	
9	Gudari	Kodma	19.16722	83.13222	29.5	201	Khondalite	33 - 34	74 - 75	94 - 96	120 - 122							
10	Gudari	Koiraguda	19.35583	83.88167	31	201	Granite							8.25		6.27	102.87	3.06 x 10^-6
11	Gudari	Korlaghati	19.48556	83.68417	18	201	Khondalite							1.52		8.19	22.73	2.05 x 10^-4
12	Gudari	Korlaghati	19.48556	83.68417	12	183	Khondalite	16 - 25	27 - 34	42 - 43	63 - 64	127 - 131	136 - 137	2.62		13.2	70.15	
13	Gunpur	Bhimpurguda	19.20389	83.93389	11.6	102	Granite	53 - 55						Artesian	5.2	8.45	14.2	

14	Gunpur	Bhimpur	19.1875	83.94389	35.6	200	Granite	39 - 47	51 - 51.5									
15	Gunupur	Jaltar	19.10611	83.89167	12	200	Granite	15 - 24	29 - 30	35 - 35.5	52 - 52.5	84 - 88		1.94	4.5	10.04	40.05	
16	k.singhpur	Badadwarasahi	19.1875	83.94389	12	200	Granite	56 - 57						7.38	0.82			
17	k.singhpur	Badanaikguda	19.1875	83.94389	15	200	Granite	19 - 21										
18	Kashipur	Chandragiri	19.38417	82.98611	44	200	Granite								DRY			
19	Kashipur	Hadiguda	19.22083	83.04167	12	200	Granite	Dry							Dry			
20	Kashipur	Kaliapada	19.17417	83.13222	22.8	200	Granite	Dry							Dry			
21	Kashipur	Kashipur	19.35056	83.12694	55.4	200	Granite	Dry							Dry			
22	Kashipur	GoudaRout Ghati	19.27139	83.05417	31	200	Granite											
23	Kolnara	Gujalpadu	19.33778	83.4475	48.4	200	Granite	Dry							Dry			
24	Kolnara	Rebatiguda	19.29917	83.42778	61	152	Khondalite	107 - 109	147 - 150					25.9	18.5	16.78	33.94	
25	Kolnara	Dumuriguda	19.36806	83.43778	12.5	200	Granite	159 - 162	174 - 176	179 - 182	187 - 188			8.39			0.35	
26	Kolnara	Rebatiguda	19.29917	83.42778	59	152	Khondalite							26.1		15	41.69	1.90x10-4
27	Kolnara	Belangapadar	19.20389	83.595	34	152	Khondalite	36 - 39						4.16			0.95	
28	Muniguda	Paikranipinda	19.81972	83.455	9	200	Granite	16 - 17	31 - 34	59 - 60	151 - 162			15.9	393 lpm	18.14	44.15	
29	Muniguda	Jagdalpur	19.76278	83.55722	37	200	Granite	70 - 73	119 - 122						0.4 lps			
30	Muniguda	Ambadola	19.82472	83.46806	24	200	Granite	25 - 31	36 - 37	48 - 49	109 - 112	158 - 159			0.1 lps			
31	Muniguda	Muniguda	19.63167	83.56389	24	126	Granite	108 - 111	120 - 121					7.1	6.25	16.21	10.1	

32	Muniguda	Laxmipur & Pandramunda	19.10611	83.89167	31	105	Granite	85 - 86						8.9	4.5	12.68	8.82	
33	Muniguda	Shibapadar	19.73167	83.48139	15	101	Granite	79 - 79.5	83 - 83.5					10	1.67	6.24	15.38	
34	Muniguda	Paikranipinda	19.81972	83.45528	12	200	Granite							16.2		11.07	37.46	1.18 x 10^-4
35	Padampur	Akhusing	19.27389	83.85028	12.19	200	Granite	153 - 162						3.1	Dry		0.44	
36	Padampur	Khillapadar	19.21167	83.81056	34.13	200	Granite	94.5 - 95.5						5.02	1.89	4	44.03	
37	Padampur	Khambariguda	19.29611	83.89056	18	207	Granite	20 - 21	22 - 23	90 - 93	101 - 102			4.3			0.74	
38	Padampur	Jhitika	19.28028	83.88389	21	200	Granite	27 - 28	42 - 44					5.8			0.22	
39	Ramanaguda	Gulunthi	19.18444	83.65611	66	200	Granite	120 - 123						4.76	138	29.05	1.92	
40	Rayagada	Japakhal	19.18833	83.33444	12	200	Granite	Dry							Dry			
41	Rayagada	Utkapadu	19.20917	83.48028	38	200	Granite	132 - 134						18.9	96	6.05	13.7	
42	Rayagada	Badachandili	19.24444	83.40583	60	200	Granite	63 - 64	73 - 74	137 - 138	155 - 156							

Annexure 9. Chemical quality analytical results of major elements from all key wells and NHNS wells (Shallow aquifer), Rayagada District.

District	Location	pH	COND	TDS	Meas_Hardness	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	F
Rayagada	Akhusingi	8.6	1250	559.1	184	16	35.03	83	113	9	343	129	36		0.2
Rayagada	Alangi	7.4	530	264	225	36	32.81	5	19.4	0	238	37	9	8	0.200
Rayagada	Ambadola	8.2	220	119.2	71	25	2.1	9	11	0	76	22	7		0.063
Rayagada	Angulapadar	8.11	728	474	178	41	18	20	46	0	219	30	22	41	0.435
Rayagada	Badagotiguda	7.42	1491	1034	481	76	70	64	18	0	436	99	85	25	0.443
Rayagada	Badamajusikopa	7.31	450	279	124	26	14	3	11	0	93	5	9	46	0.158
Rayagada	Badiguda	8.17	810	417	255	44	35.24	51	26.9	0	366	50	30	1	0.350
Rayagada	Bandhamandi	8.22	530	263	190	48	17.01	32	4	0	287	17	3	1	0.310
Rayagada	Bandhuguda	7.9	315	213	94	18	12	11	5	0	125	17	11	1	0.341
Rayagada	Bangi Chowk	8.6	390	211.2	158	35	17.18	24	1	9	178	25	13		0.25
Rayagada	Barchiguda	8	480	304	139	47	5	20	3	0	138	30	15	8	0.304
Rayagada	Barkudu	7.69	1440	784	365	32	69.26	127	60.9	0	549	125	55	46	0.410
Rayagada	Bijapur	7.96	680	458	178	49	13	27	34	0	181	42	27	40	0.175
Rayagada	Bissamcuttack-Pz	7.86	280	182	89	20	10	10	2	0	100	16	3	0	0.261
Rayagada	Bissumcuttack	7.89	1180	828	337	88	28	51	45	0	342	79	60	50	0.574
Rayagada	Budaguda	7.9	428	287	119	33	9	12	15	0	131	19	8	26	0.360
Rayagada	Chakunda	8.6	500	291.8	163	25	24.47	37	1	9	171	52	13		0.263
Rayagada	Cheliana	7.88	490	346	144	49	5	10	26	0	144	15	14	27	0.321
Rayagada	Chichipanga	8.11	520	432	178	61	6	35	20	0	201	54	27	6	0.295
Rayagada	Chintalguda	7.97	380	261	124	26	14	12	2	0	125	19	13	9	0.312
Rayagada	D.Karol	8.16	490	274	160	30	20.66	21	27.8	0	183	37	12	36	0.110
Rayagada	Dambasara	8.6	900	485.7	296	61	34.96	75	37	9	285	126	60		0.24
Rayagada	Dhepagaon	7.69	2770	1490	625	78	104.5	345	4.5	0	671	532	58	39	0.480
Rayagada	Dhepaguda	8.18	700	339	250	34	40.1	43	1.3	0	360	32	6	6	0.290

Rayagada	Donduli	8.12	400	227	160	40	14.58	13	7.8	0	122	15	67	10	0.150
Rayagada	Dongasil	8.08	640	363	205	50	19.44	26	44	0	232	62	1	47	0.070
Rayagada	Dumbaguda	8.4	1840	920	565	62	99.63	158	8.9	0	488	252	77	23	0.740
Rayagada	Dumulupadar	7.75	270	124	120	24	14.58	5	1	0	122	10	1	9	0.130
Rayagada	Getipada	8.04	610	340	205	50	19.44	41	8.3	0	165	82	14	44	0.080
Rayagada	Ghughupadar	8	480	320	139	39	20	12	2	0	194	19	6	6	0.381
Rayagada	Ghurtuli	8.3	680	364	255	56	27.95	19	32.9	0	299	40	3	39	0.170
Rayagada	Gobardhan	7.58	410	249	80	37	17	15	2	0	169	23	10	5	0.252
Rayagada	Gokulamunda	7.87	240	124	100	32	4.86	5	3.5	0	110	15	4	6	0.070
Rayagada	Gorakhpur	8.5	60	78.31	31	8	2.68	3	1	6	19	5	4		0.053
Rayagada	Gorakhpur	7.51	176	117	55	10	7	2	1	0	56	3	9	6	0.134
Rayagada	Gumda	8.6	800	403.1	245	72	15.89	47	40	9	241	89	44		0.223
Rayagada	Gumkudi	8.04	510	359	168	33	20	12	3	0	156	18	10	36	0.257
Rayagada	Gumma	8	300	149.6	107	35	4.78	17	4	0	140	17	12		0.296
Rayagada	Gumma	7.87	580	393	188	45	18	14	3	0	225	22	8	5	0.361
Rayagada	Gunupur1	8.3	275	149.9	117	20	16.31	16	2	0	159	15	3		0.264
Rayagada	Kailaspur	8.24	300	165	120	32	9.72	3	18	0	128	17	6	17	0.140
Rayagada	Kaliapada	7.61	230	144	64	24	1	9	2	0	69	13	3	8	0.187
Rayagada	Kaliapada	8.34	1470	818	355	80	37.67	91	141	0	476	140	47	48	0.280
Rayagada	Kaliapada	8.2	240	119.6	77	18	7.8	17	3	0	89	27	3		0.284
Rayagada	Kashipur	8.3	750	410.5	276	41	42.23	30	29	0	305	77	4		0.15
Rayagada	Kashipur	7.6	470	322	139	30	16	10	15	0	112	16	11	46	0.241
Rayagada	Kenduguda	8.4	1050	523.7	286	57	34.96	100	3	3	228	208	43		0.398
Rayagada	Kenduguda NHS	7.68	2900	1498	885	108	149.4	257	4.3	0	238	770	90	3	0.520
Rayagada	Keskapadi	7.98	350	184	135	40	8.505	15	3.7	0	128	32	3	19	0.230
Rayagada	Khilundisahi	7.36	280	194	89	16	12	8	7	0	100	12	4	9	0.170
Rayagada	Kirama	7.66	180	122	59	8	9	5	2	0	63	8	7	1	0.153

Rayagada	Kiribiri	8.1	880	630	268	24	50	11	73	0	295	18	39	20	0.659
Rayagada	Kodapadu	8.6	400	194.2	173	41	17.19	12	4	9	184	15	7		0.149
Rayagada	Kodapadu	7.86	590	397	178	59	7	9	2	0	181	15	12	40	0.198
Rayagada	Kumbhikota	8.2	740	369	315	26	60.75	15	16.4	0	238	35	52	47	0.190
Rayagada	Kutragarh	7.92	1250	870	377	110	24	51	28	0	366	79	55	44	0.421
Rayagada	Kutrupalli	7.67	280	188	84	14	12	18	2	0	100	27	8	3	0.262
Rayagada	Kutudukupa	7.82	1350	922	391	98	35	75	2	0	394	115	29	3	1.230
Rayagada	Lataguda	7.82	498	335	134	39	9	13	17	0	131	20	17	42	0.284
Rayagada	Manaiguda	7.74	297	206	95	18	12	6	5	0	118	10	8	4	0.231
Rayagada	Matuguda	8.18	630	322	280	54	35.24	6	15.6	0	275	17	19	40	0.290
Rayagada	Minahala Colony	8.07	480	327	149	39	12	12	7	0	156	18	12	18	0.359
Rayagada	Minajhola	8.5	350	177.8	133	37	9.89	19	2	6	171	12	6		0.168
Rayagada	Minajhola	8.04	510	347	153	34	13	45	2	0	201	74	4	11	0.268
Rayagada	Mukundpur	8.6	400	201.5	133	37	9.89	26	4	9	152	37	8		0.133
Rayagada	Murchiguda	7.92	620	431	168	47	12	18	36	0	150	27	28	49	0.163
Rayagada	Narainpur	8.4	250	201.9	102	29	7.21	10	6	3	108	20	4		0.074
Rayagada	Nua Dakasikula	8.4	1300	702.6	128	31	12.32	164	109	3	387	166	74		0.523
Rayagada	Nuagada	7.66	270	153	120	32	9.72	1.5	7.7	0	122	15	3	24	0.180
Rayagada	Nuagaon	7.89	625	425	198	45	15	20	2	0	250	36	6	17	0.328
Rayagada	Padaguda	7.79	1190	643	330	50	49.82	72	84.3	0	488	112	30	6	0.250
Rayagada	Padampur2	8.4	520	263.6	128	33	11.1	58	2	3	140	79	28		0.144
Rayagada	Paikpara	7.87	740	504	188	43	19	92	7	0	205	142	30	24	0.633
Rayagada	Pandaguruda	8.1	410	288	134	31	13	10	3	0	150	15	6	15	0.319
Rayagada	Podapadi	8.27	620	321	215	44	25.52	22	35.8	0	305	40	2	2	0.120
Rayagada	Purna Baliguda	8.35	510	254	195	48	18.23	25	1.8	0	220	50	2	1	0.230
Rayagada	Ramnaguda2	8.5	430	216.1	128	33	11.1	34	4	6	190	20	9		0.255
Rayagada	Renga	8.22	320	158	140	24	19.44	6	1.6	0	122	15	24	8	0.130

Rayagada	Sankarada	8.25	360	202	115	30	9.72	12	30	0	140	32	7	13	0.150
Rayagada	Sarpadu	7.82	1050	612	310	60	38.88	33	111	0	366	92	56	42	0.340
Rayagada	Shirikona	8.4	500	163.6	107	37	3.57	25	1	3	140	20	15		0.164
Rayagada	Shirikona	7.8	650	405	188	41	20	18	5	0	225	28	17	4	0.231
Rayagada	Sikarpai	8.1	790	426	260	48	34.02	35	42.7	0	336	47	16	39	0.180
Rayagada	Simili	8.26	1270	678	195	32	27.95	200	1.5	0	519	92	35	35	2.980
Rayagada	Sirikana	8.24	560	270	225	34	34.02	22	2.3	0	250	27	8.5	20	0.210
Rayagada	T.Budoni	8.04	580	400	188	53	13	12	11	0	219	19	10	5	0.423
Rayagada	Tandikana	8.4	280	145.2	107	33	6	13	2	3	133	12	5		0.131
Rayagada	Therabali	8.5	450	216.2	107	16	16.31	49	1	9	133	59	11		0.146
Rayagada	Therubali	7.65	840	585	233	61	19	95	2	0	247	147	34	18	0.316
Rayagada	Thunpadi	8.07	1186	790	287	110	3	43	86	0	344	66	44	48	0.541
Rayagada	Ulkamba	8.18	1030	724	287	67	29	62	57	0	307	95	38	34	0.278

Annexure 10. Iron data of key wells (Shallow aquifer), Rayagada District.

SL NO.	DIST	Block	VILLAGE	Lat	Long	SAMPLING DATE (dd-mm-yy)	Iron mg/L
1	RAYGADA	Padampur	Nuagada	19-21-04	83-57-42	26.10.2021	0.30
2	RAYGADA	Kolnara	Dhepaguda	19-15-12	83-27-01	27.10.2021	2.04
3	RAYGADA	Kolnara	Dhepaguda	19-15-10	83-27-38	27.10.2021	BDL
4	RAYGADA	Kolnara	Kaliaspur	19-13-36	83-32-27	27.10.2021	BDL
5	RAYGADA	Padampur	Sarpadu	19-16-40	83-43-57	27.10.2021	BDL
6	RAYGADA	Padampur	Matuguda	19-18-27	83-42-04	27.10.2021	0.05
7	RAYGADA	Gudari	Dumbaguda	19-22-13	83-47-25	27.10.2021	0.79
8	RAYGADA	Gudari	Badiguda	19-22-00	83-47-33	28.10.2021	0.20
9	RAYGADA	Rayagada	Kumbhikota	19 07 19	83 15 01	28.10.2021	0.05
10	RAYGADA	Kashipur	Kalipada	19 10 31	83 07 52	28.10.2021	0.03
11	RAYGADA	Kashipur	D.Karol	19 10 47	83 00 50	28.10.2021	0.01
12	RAYGADA	Kashipur	Dongasai	19 14.202	82 59.202	28.10.2021	0.11
13	RAYGADA	Kashipur	Renga	19 18.294	83 06.894	28.10.2021	0.11
14	RAYGADA	Raygada	Getipada	19 15 21	83 24 32	29.10.2021	0.10
15	RAYGADA	Kolnara	Padaguda	19 19 40	83 21 40	29.10.2021	0.08
16	RAYGADA	Bissumcuttack	Badagotiguda	19 28 58	83 29 10	30.10.2021	0.10
17	RAYGADA	Bissumcuttack	Bissumcuttack	19 30 57	83 30 16	30.10.2021	0.05
18	RAYGADA	Bissumcuttack	Thunpadi	19 32 32	83 32 42	30.10.2021	0.13
19	RAYGADA	Bissumcuttack	Kutragarh	19 36 50	83 32 52	30.10.2021	0.20
20	RAYGADA	Chandrapur	Chichipanga	19 35.293	83 52.173	30.10.2021	0.34
21	RAYGADA	Chandrapur	Murchiguda	19 28.241	83 53.385	30.10.2021	0.05
22	RAYGADA	Bissumcuttack	Kiribiri	19 27 40	83 32 23	31.10.2021	0.29
23	RAYGADA	Bissumcuttack	Bissamcuttack-PZ	19 31 27	83 30 07	01.11.2021	0.36

24	RAYGADA	Bissumcuttack	Bandhuguda	19 34 30	83 29 42	01.11.2021	0.61
25	RAYGADA	Muniguda	Kutrupalli	19 48 32	83 26 49	01.11.2021	0.06
26	RAYGADA	Muniguda	Gobardhan	19 36 41	83 30 29	01.11.2021	0.10
27	RAYGADA	Kolnara	Minajhola	19 15 56	83 36 22	02.11.2021	0.29
28	RAYGADA	Ramnaguda	Ulkamba	19 09 56	83 47 36	02.11.2021	2.08
29	RAYGADA	Kashipur	Gorakhpur	19.237262	83.111195	11.11.2021	BDL
30	RAYGADA	Raygada	Shirikona	19.176666	83.381947	11.11.2021	BDL
31	RAYGADA	Raygada	Gumma	19.194645	83.290154	11.11.2021	0.03
32	RAYGADA	Kashipur	Kashipur	19.355101	83.118571	11.11.2021	0.03
33	RAYGADA	Ramnaguda	KodapaDU	19.189333	83.340683	11.11.2021	BDL
34	RAYGADA	Kashipur	Kalipada	19.174784	83.128129	11.11.2021	0.39
35	RAYGADA	Ramnaguda	Gumda	19.219776	83.770068	10.11.2021	BDL
36	RAYGADA	Kolnara	Minajhola	19.26537	83.606636	10.11.2021	BDL
37	RAYGADA	Ramnaguda	Tandikana	19.262333	83.628981	10.11.2021	BDL
38	RAYGADA	Padampur	Nuadakasikula	19.197747	83.829907	10.11.2021	BDL
39	RAYGADA	Kolnara	Therabali	19.333309	83.410961	10.11.2021	BDL
40	RAYGADA	Padampur	Kenduguda	19.297983	83.893679	10.11.2021	0.01
41	RAYGADA	Padampur	Narainpur	19.362601	83.966169	10.11.2021	0.29
42	RAYGADA	Gunupur	Gunupur1	19.060628	83.823146	10.11.2021	0.46
43	RAYGADA	Ramnaguda	Bangichowk	19.203589	83.705373	10.11.2021	0.39
44	RAYGADA	Ramnaguda	Chakunda	19.212562	83.682688	10.11.2021	0.06
45	RAYGADA	Kolnara	Mukundpur	19.225652	83.558337	10.11.2021	0.06
46	RAYGADA	Padampur	Padampur	19.240506	83.813177	10.11.2021	0.06
47	RAYGADA	Gunupur	Dambasara	19.168167	83.838199	10.11.2021	0.03
48	RAYGADA	Padampur	Akhusingi	19.271033	83.848714	10.11.2021	0.03