केन्द्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण

विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board

Department of Water Resources, River Development and Ganga Rejuvenation,

Ministry of Jal Shakti

Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

Nuapada District
Odisha

दक्षिण पूर्वी क्षेत्र, भुवनेश्वर

South Eastern Region, Bhubaneswar

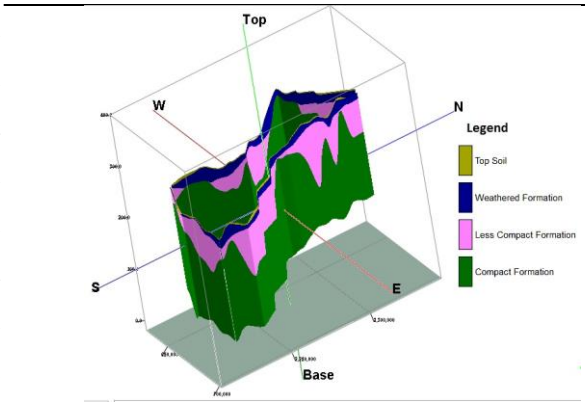
Government of India

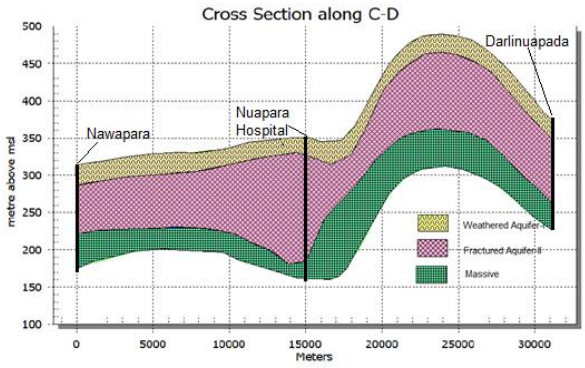
MINISTRY OF JAL SHAKTI,

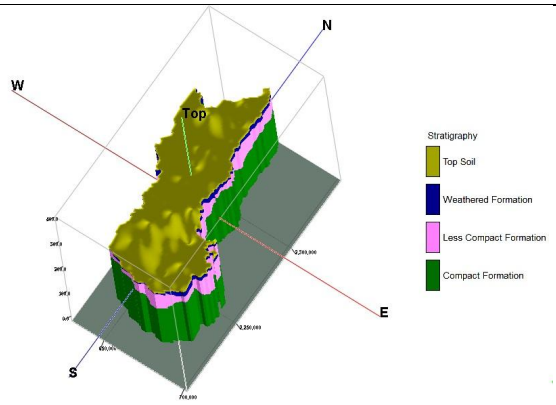
DEPARTMENT OF WATER RESOURCES, RIVER DEVELOPMENT & GANGA REJUVENATION

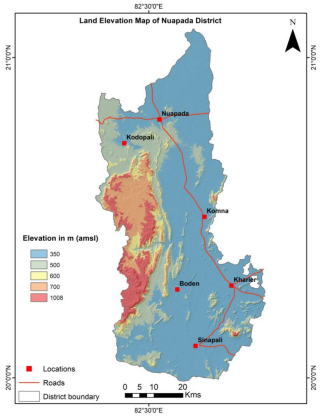
REPORT ON

AQUIFER MAPPING AND MANAGEMENT PLAN IN NUAPADA DISTRICT, ODISHA









CENTRAL GROUND WATER BOARD

South Eastern Region, Bhubaneswar

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FOREWORD

Nuapada district, located in the central parts of the Odisha state, bears an agrarian economy. The agriculture in the district is inevitably exposed to the vagaries of rainfall. Erratic rainfall is quite frequent and also the irrigation facilities are inadequate in the district, affecting the agriculture production from year to year. The agrarian development of the district can be boosted by tapping the groundwater resources through dug wells and medium-deep bore wells.

Due to wide variation in hydrogeological set up in the district, the occurrence and distribution of aquifers are non-uniform and so also their yielding properties. The common modes of groundwater exploitation in the district are dug well, dug-cum-bore well, shallow tube well etc. The hard crystalline rocks of the district form two distinct aquifer systems. The shallow aquifers formed by the weathered mantle, stores groundwater under phreatic condition. The deeper aquifer is formed by fracture zones, joints, etc holds groundwater in semi-confined/confined conditions. Granitic hard-rock aquifers have water yielding fracture zones and have average success rate with 2-5 lps of discharge. The places where weathering thickness is more and condition is favourable, the phreatic aquifer attains good yield potential and large diameter dug wells are suitable structures to extract water from them.

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

Based on the available data and the earlier hydrogeological studies taken up in 05 blocks of the district viz. Nuapada, Komna, Boden, khariar, Sinapali, covering 3852 Sq. Km. of mappable area, an attempt has been made in this report to compile all relevant information, such as hydrogeological, agriculture, irrigation, land use, rain fall, chemical quality of water and other collateral data. **Shri Rajeev kumar Tripathy, Scientist-'B'** has compiled and prepared the present report on **"Aquifer Mapping and Management Plan in Nuapada District, Odisha".** Their sincere efforts in preparation of the report will no doubt be very useful and benefit the state. It is hoped that, it will be of immense help to different groundwater user agencies, administrators and planners in preparation of groundwater development plans and will be a handy tool in effective management of groundwater resources in the district.

Date:08.07.2022

(P. K. Mohapatra)
Regional Director

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AQUIFER MAPPING AND MANAGEMENT PLAN IN NUAPADA DISTRICT (3852 Sq. Km)

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1 INTRODUCTION

1.1 Objective

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

The activities under NAQUIM are aimed at identifying the aquifer geometry, aquifer characteristics their yield potential along with the quality of water occurring at various depths, aquifer-wise assessment of ground water resources and development. Aquifer mapping itself is an improved form of groundwater management – recharge, conservation, harvesting and protocols of managing groundwater.With these aims, Aquifer Mapping was carried out in Nuapada district in Odisha covering an area of about 3852sq. km.The district has been divided into 5 Blocks namely, Nuapada, Komna, Khariar, Boden and Sinapali, 4 Tahasils, namely Nuapada, Komna, Khariar and Boden.

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

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

1.2 Approach and Methodology

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

The entire Nuapada district has been geologically mapped by the Geological Survey of India. The district has been covered through systematic hydrogeological surveys on 1:50,000scale by shri B.B. Basak,Scientist-B during field seasons 1976-77,1977-78.Shri P. K. Das, Scientist-Bof CGWB carried out the survey in field season of 1980-81.Shri S Suresh, Scientist-B of CGWB carried out reappraisal Hydrogeological ssurveys during field season 1989-90 in part of the district covering an area of 3000sq.Km.Under Ground water management studies. Sh P.K.Naik, Scientist-B of CGWB carried out special studies on Fluoride affected areas in Nuapada District.So far 32 exploratory wells, 11 observation wells have been drilled under exploratory drilling programme of CGWB to delineate ground water potential of deeper aquifers.Monitoring of Ground water regime in the district is being carried out through 24 Nos of National Hydrograph Network stations four times in a year.

1.2.1 Compilation of Existing Data and Identification of Data Gaps and Data Generation

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

From the data analysis it is found that only 20 NHNS monitoring wells found in the District. So additional 60 key well established to fill the gap of water level monitoring. **(Table.2.4)**

In case of exploratory 43 EWs driiled in the distrct before NAQUIM study. The state Government has banned drilling of bore wells in the district as the ground water in major part of the district is Fluoride affected. Similarly for Geophysical analysis data availability was zero. So 58 VES carried out in Nuapada district during NAQUIM studty to fill the Gap of exploration and Geophysical data. **(Annexure I)**

VES Data Generation

A total of 58 VES were carried out in Nuapada district. The VES locations are shown in figure 1.0

The Interpreted results of VES are given in Annexure I. Most of the CGWB boreholes are more than 1 km away from the existing VES points. After comparing the VES results with the local geology and hydrogeology, the resistivity characteristics of the near surface weathered rock and the underlying massive / fractured formation were established.

In the surveyed area of Nuapada district, in general, the weathered / semi weathered zone extends down to a depth of 18.3 m bgl. Thin fractured zones were identified by ‘current increase’, ‘curve break’ and ‘factor flat’. Mostly the 3^{rd}, 4^{th} or 5^{th} geoelectric layer, occasionally, the 6^{th} one with resistivities ranging

from 18 to 600 Ohm m, occasionally exceeds to 760 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 varies between 10 and 250 m, occasionally exceeds to 285m. The depth to bottom of this layer is, in general, varying from 18.3- to 300 m. The VES points in the vicinity of NE-SW and NW-SE trending lineaments are likely to be good Ground water potential Zones.

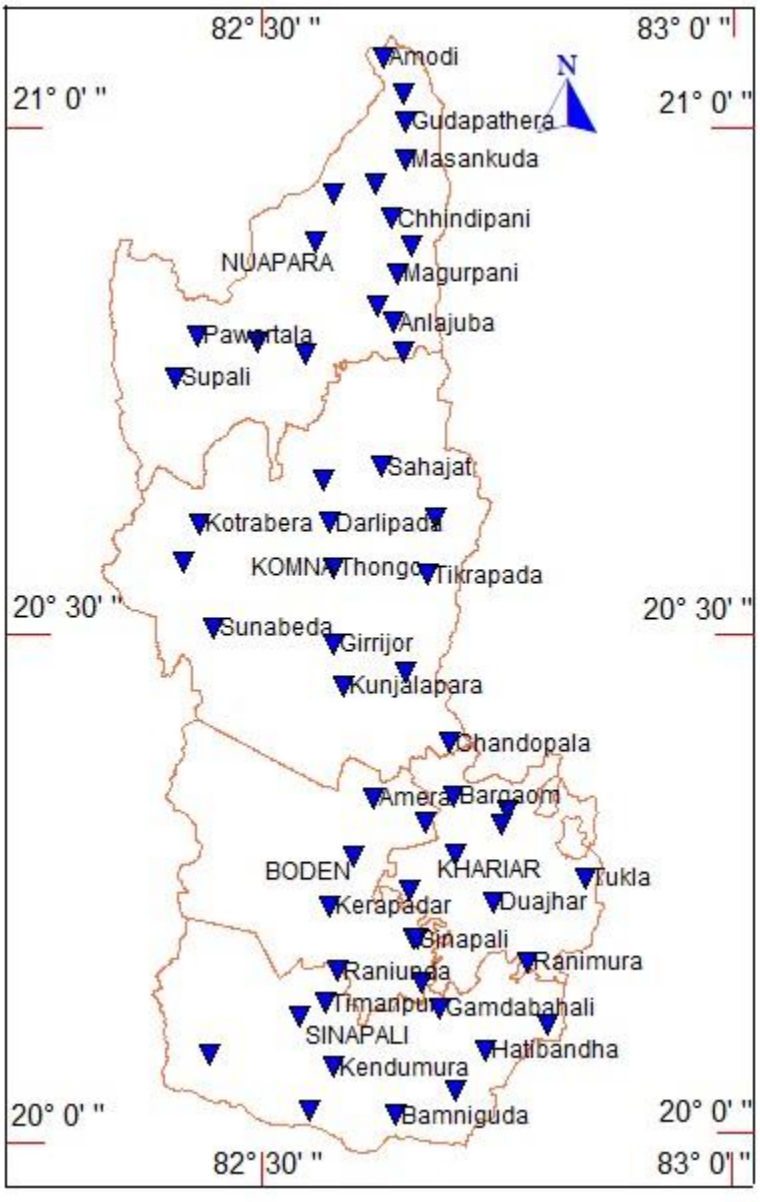


Figure 1.0 Location of VES Points in Nuapada District

1.2.2 Hydrogeological Investigations

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

1.2.3 Geo -hydrochemical Investigations

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

1.2.4 Generation of Thematic Layers Using GIS

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

1.2.5 Development of Aquifer-Wise Management Plan

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

1.2.6 Study area

During XII five year plan, the National Aquifer Mapping and Management (NAQUIM) programme were taken up under Annual Action Plan (AAP) 2020-21 for detailed hydrogeological investigation and Aquifer Mapping in Nuapada district.Nuapada District is located in the western part of Odisha, lies between $20^0$00’ and $21^0$05’ North latitudes and $82^0$28’ and $82^0$40’ East longitudesand falls in the Survey of India Toposheet Nos. 64L/5,64L/6,64L/7,64L/8,64L/9,64L/10,64L/11,64L/12,64L/15,64L/16,64K/12and64I/9 (1: 50,000 scale). Its boundaries extend in the north, west and south to Raipur district of Madhya Pradesh and in the east Bargarh, Bolangir and Kalahandi districts. This district is spread over an area of 3852 sq.kms and the

administrative headquarters is located at Nuapada. The district has only one sub-division namely Nuapada and 5 Community Development Blocks. The administrative map of the District is given in **Fig.1.1**. The district is well connected by roads and railways. Nuapada, the district head quarters is connected by state highways with the important towns like Bargarh, Sambalpur, Bolangir, Bhawanipatna. It is also connected with all the block head quarters by all weather roads. The Vijayanagaram – Raipur branch of S.E. Railways crosses the district in north-east.

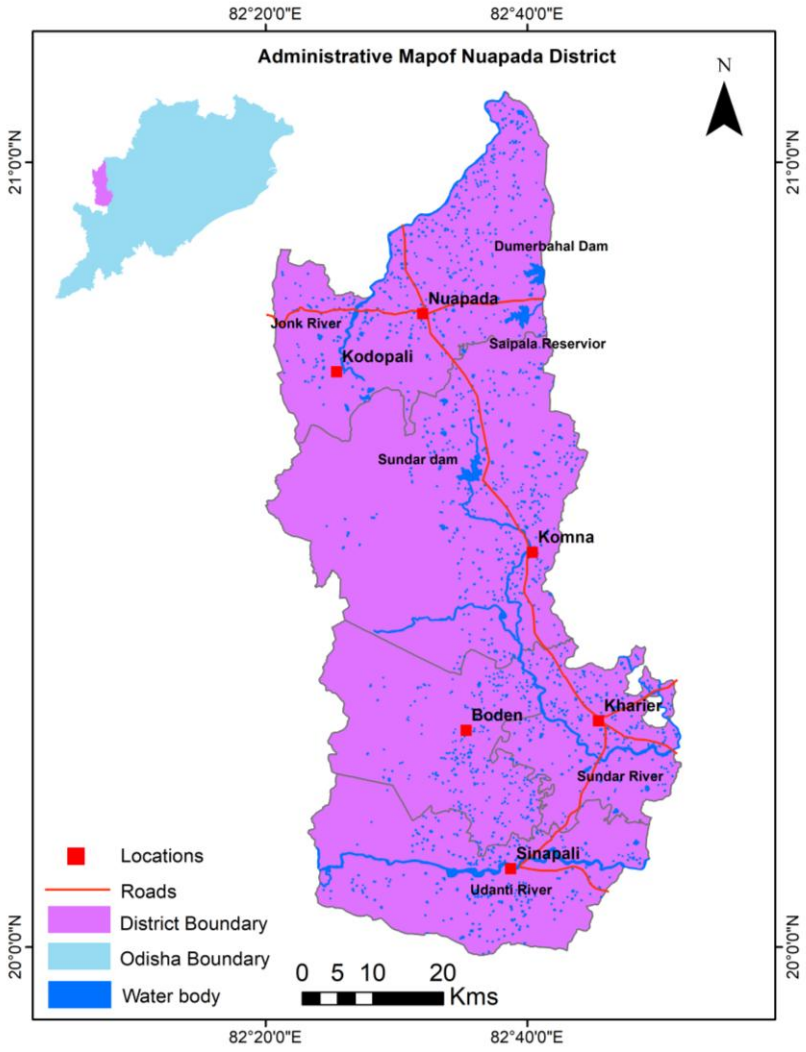


Fig. 1.1: Administrative Map of Nuapada District.

1.3 Demography

The district is having a total population of 6,10,382 with a rural population of 5,76,328 (94.42 percent) and urban population of 34,054 (5.58 percent) and 301962 males and 308420 females.The Schedule Caste (SC) and Schedule Tribe (ST) household of the district counts to 82159 (13.46 %) &2,06,327 (33.8 %) respectively.So, the district is more rural in its character though the district is experiencing increasing rate of urbanisation in recent years.Number of households in the district is 152210.The population density of the district is 158. The district recorded a decadal change of 15.02 percent during the period 2001-2011 in its population. A positive change is observed in the sex composition of the district with increased sex ratio from 1007 (census 2001) to 1021(census2011).

The district comprises 05CD Blocks namely Nuapada,Komna,Boden,Sinapali,and Khariar.In the District there are two urban centres i.e Khariar N.A.C and Khariar Road N.A.CThere are 109 Gram Panchayats with 668 villages. The block-wise demographic details are shown in **Table-1.1**.

Table-1.1: Block-Wise Demographic Details inNuapada District.

Sl No	Block/ Urban Area	Area (Sq.km)	GPs	Villages	Population (2011)			Decadal growth rate		
					Rural	Urban	Total	Rural	Urban	Total
1	Nuapada	879	28	169	136723	0	136723	13.96	0	13.96
2	Komna	1283	27	168	137364	0	137364	18.95	0	18.95
3	Boden	588	14	89	81687	0	81687	10.74	0	10.74
4	Sinapali	693	22	126	109870	0	109870	11.36	0	11.36
5	Khariar	409	18	116	110684	0	110684	19.83	0	18.91
6	Khariar N.A.C (urban)	23.83	-	-	0	15087	15087	0	12.51	12.51
7	Khariar Road N.A.C (Urban)	11.40	-	-	0	18967	18967	0	14.06	14.06
Total		**3852**	**109**	**668**	**576328**	**34054**	**610382**	**15.12**	**13.37**	**15.02**

Source; Census data (2011)ofNuapada district

1.4Rainfall and Climate

The rainfall in the district is mainly derived from the south west monsoon. The average annual rainfall is of the order of 1219.89 mm, out of which 91% is received during monsoon (mid-June to mid-October). Based on the average annual rainfall for 10 yrs(2011 – 2020)it was observed that during the last 10 years, from 2011 to 2020, the highest rainfall amounting 2034.1 mm occurred in Khariar block in 2014 and the lowest annual of 482.1 mm. in Boden block in 2012. It is also observed that the district is in general drought prone

with mild and normal drought more or less of equal spread only.The rainfall map is given in **Fig.1.2.**

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

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

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

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

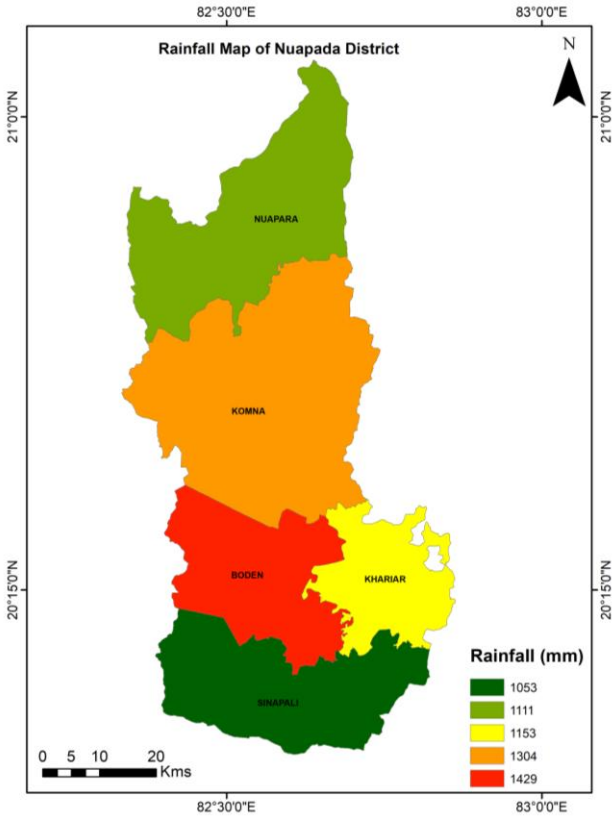


Fig. 1.2: RainfallMap of Nuapada District.

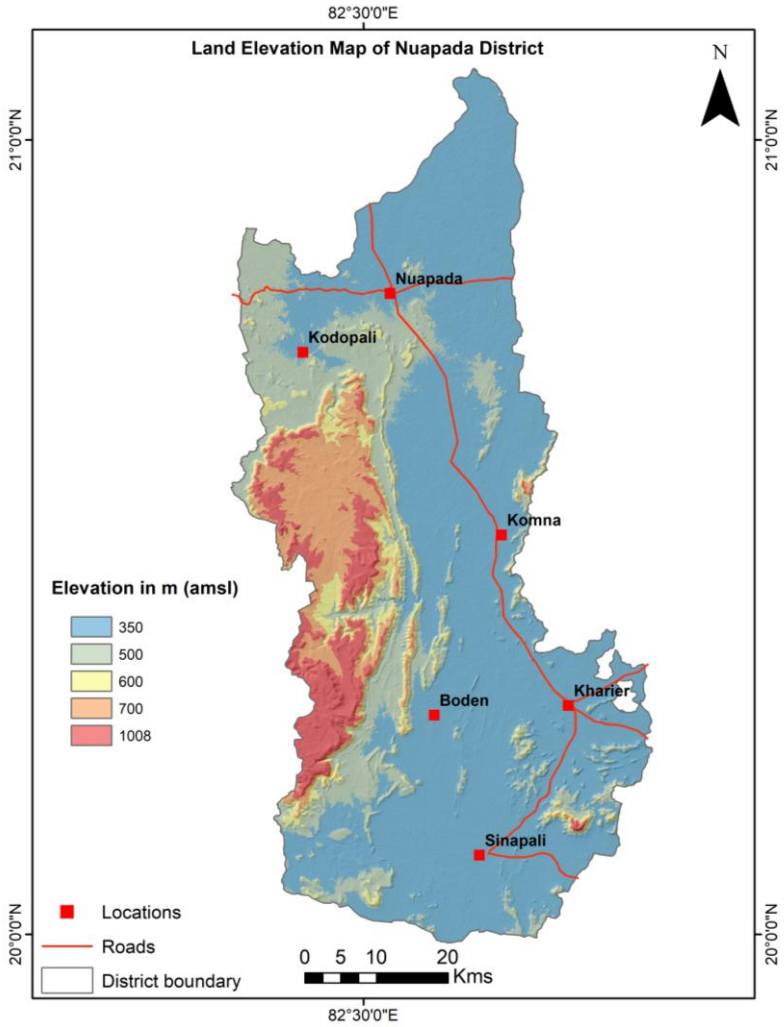


Fig. 1.3: Land Elevation Map of Nuapada District

1.5 Geomorphology

The study area presents conspicuous geomorphic variations comprising moderately high hills, isolated hillocks, undulating plains, intermontane valleys etc. The hilly tract lying to the west ranges in elevation from 610 to 915 meters above mean sea level. With an average elevation being 700 meters above mean sea level. They are represented by Structural hills, denudational hills, ridges, narrow intermontane valleys and escarpment. Denudational hills or residual hills occur in the eastern and south eastern part of the study or residual hills occur in the eastern and south eastern part of the study area. Lateritic uplands are met within the border areas of hills. Also, the undulating terrain which varies in altitudes from 350 to 240 m above mean sea level and occurs as bordering the hilly tract has dissected patches of inselbergs and

residual hills.,The area can be broadly divided into six geomorphic units viz,structural hills, Denudational Hills, Residual Hills, Intermontane valleys, Undulating plains, Lateritic uplands. The land elevation and Geomorphological map and map of Nuapada District is given in **Fig.1.3** and **Fig.1.4** respectively.

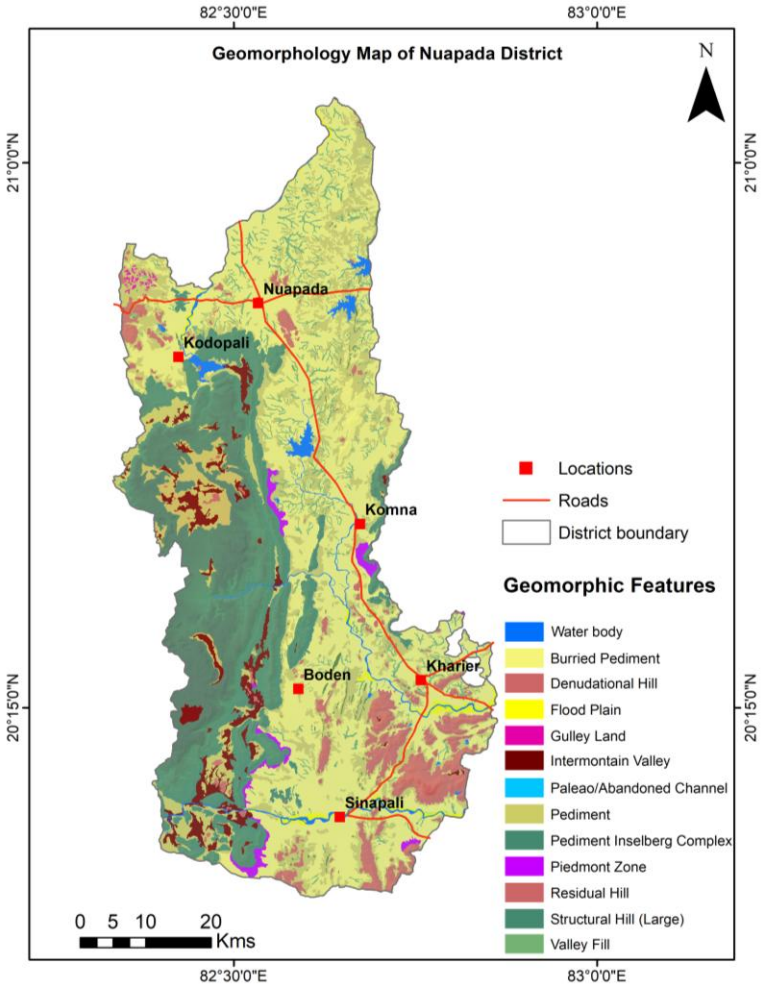


Fig. 1.4: Geomorphological map of Nuapada District.

1.6 Soil characteristics

The two major types of soils i.e Alfisols and Vertisols are commonly found in the district .

Alfisols :

(i) Red soil (Sandy): This is the most predominant soil mixed with lateritic nodules. Lateritic soil profile varying from 2- 15 meters containing hard ferruginous concretions form the duricrust. This soil is porous and acidic in nature and poor in organic matter.

These occupy comparatively lower elevations especially valley fills and are composed of clay mixed with sand and Kanker nodules.

(ii) Red and Black soil (loamy) : These are also found sporadically in Golamunda area and Salipara-Borda Sector and are fertile which supports luxuriant plant growth.

Vertisols :

Medium Black soil : Black soils are found in localized pockets in and around Turkel – Karlapara sector of 64 P/4 and in Khariar tehsil. It is rich in potassium and nitrogen but poor in phosphorous.The soil map of the Nuapada district is shown in **Fig. 1.5**

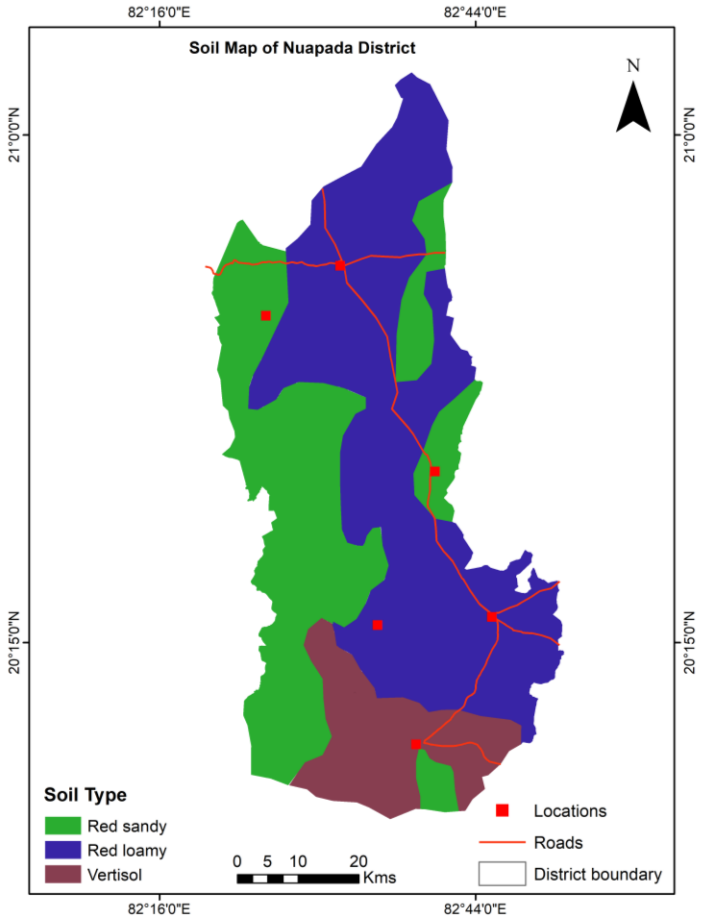


Fig. 1.5: Soil map of the Nuapada district

1.7 Landuse, Cropping Pattern and Irrigation Potential

The study area shows wide variation in the pattern of land utilization. The forest area is 14.64% of total geographical area.The net sown area of the district is 106964 ha .Agriculture is the main stay for the rural population of the district. The block-wise landuse pattern is shown in Table 1.2 and the thematic map on land use is shown in **Fig. 1.6**.The cultivation is mainly in the Kharif season. Rabi cultivation is restricted to areas with irrigation facilities. The different crops grown in the area are paddy, pulses (Arhar, Green and Black gram) and vegetables (potato, onion, garlic, turmeric, ginger and seasonal vegetables), etc.The major crop of the district is paddy. The paddy area in the district covers 58000 ha. Large percentage of the land in the district is kharif crop land which indicates that the land is used predominantly for agriculture. Crop land in Kharif is 75024 hectares where as in rabi it is 31947 hectares. The agriculture land is the major land use pattern having 64.07% of the total geographical area followed by forest land with 14.64%, pastures 6.07%. Agriculture land use includes Net Sown, Cultivable Waste, Land under miscellaneous tree crops & groves and Fallows Land. The average cropping intensity is 156%. and Net sown area constitute 68.07 % of the total Agriculture area.

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

Sl No	Year/Block	Forest	Land put to Non-Agri use	Barren &Non-Cultivable Land	Permanent pastures &other Grazing Land	Land under misctree Crop & groves not incuded net area sown	Cultivable Waste	Old Fallows	Current Fallows	Net sown Area	Total Area
1	**Boden**	7380	2905	356	2137	43	586	1904	3757	14825	33893
2	**Khariar**	2618	3672	1092	1577	150	220	2060	4850	15714	31953
3	**Komana**	7073	11925	3719	4609	111	2443	3673	5607	25626	64786
4	**Nuapada**	13425	6758	600	3819	143	2136	3590	8119	32051	70641
5	**Sinapali**	5195	4861	996	2495	86	1084	2369	5882	18570	41538
	ULB	217	346	67	263	6	17	99	1230	178	2423

Source.District Statistical Handbook,2018, Nuapada District,Govt of Odisha

1.8 (a) Source-wise Irrigation potential of Nuapada District

The source wise irrigation potential andcropwise cropping programme for Kharif and Rabi season for nuapada district is shown in the below Table 1.3, 1.4, 1.5 and 1.6. The different sources indicated in above mentioned Tables are Major& Medium, Minor Flow, Minor Lift and other sources include Open wells, Tube wells, Shallow Tube well etc. Irrigation Potential is shown in both Kharif and Rabi Seasons.

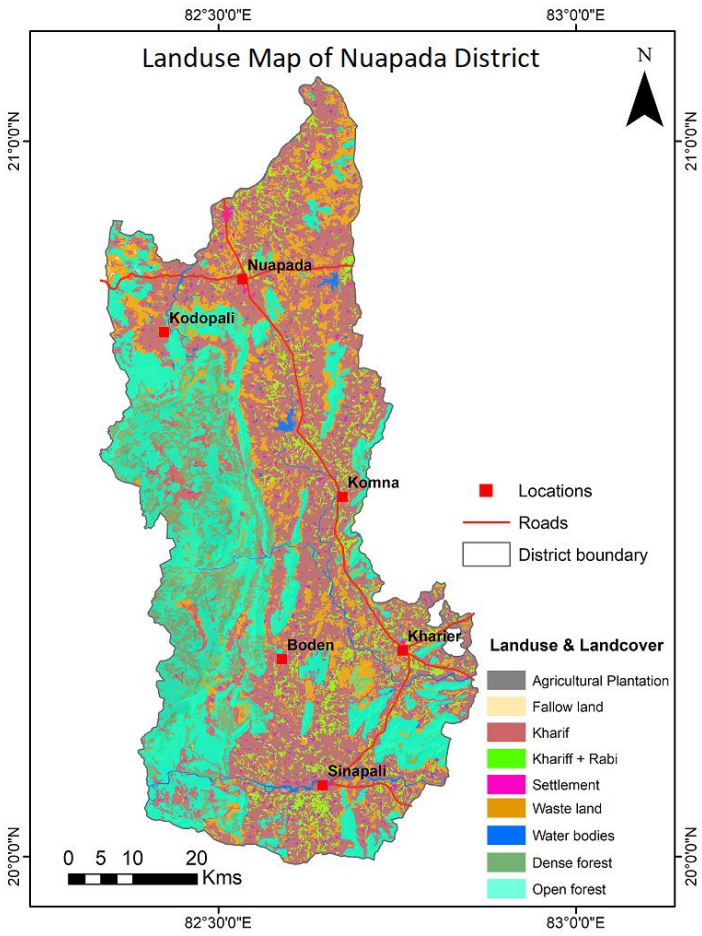


Fig. 1.6: Landuse map of Nuapada District.

1.8(b) Status of Water Availability

There are two major sources of water available in Nuapada district. Namely surface irrigation and ground water irrigation. The surface irrigations includes Canal (Major & Medium Irrigation), minor irrigation, lift irrigation, Various Water Bodies including Rain Water Harvesting, Untreated Effluent and Perennial sources of water. For the ground water includes Open well (Dug well), Deep Tube Well, Medium Tube Well (Bore well), Shallow Tube Wells respectively. All the area is divided as per seasons like Kharif and Rabi. Based on the season, the area under canal water in Kharif is 47917 ha, for Rabi season is 11515 ha and the total area under canal water is 59432 Ha. The total area available through minor irrigation is 9141 Ha, and the area under lift irrigation is 726 Ha. The area under the perennial sources of water extents is 1398Ha. 106 Similarly, the area under open well is 1564 Ha, Bore well is 44587 Ha.

1.9 Drainage and Hydrology

The area is mainly drained by the tributaries of the Tel and Ong rivers. The main tributaries of the Tel are Indra, Udanti, Hatti, Sagada etc. Which are perennial and effluent in nature and maintain sluggish flow during peak summer months. The Jonk river is a tributary of the river Mahanadi, flows in the westerly direction and forms the state border in the northwest. All these rivers at places, show linear flow path indicating probable structural control over their courses. The general drainage pattern in the undulating terrain is dendritic to sub-dendritic. More or less sub-parallel drainage is observed in the western part comprising Chattisgarh group of rocks, near foothill regions. Dendritic drainage pattern is very characteristic in the granitic terrain. **Fig. 1.7:** shows the drainage of Nuapada District.

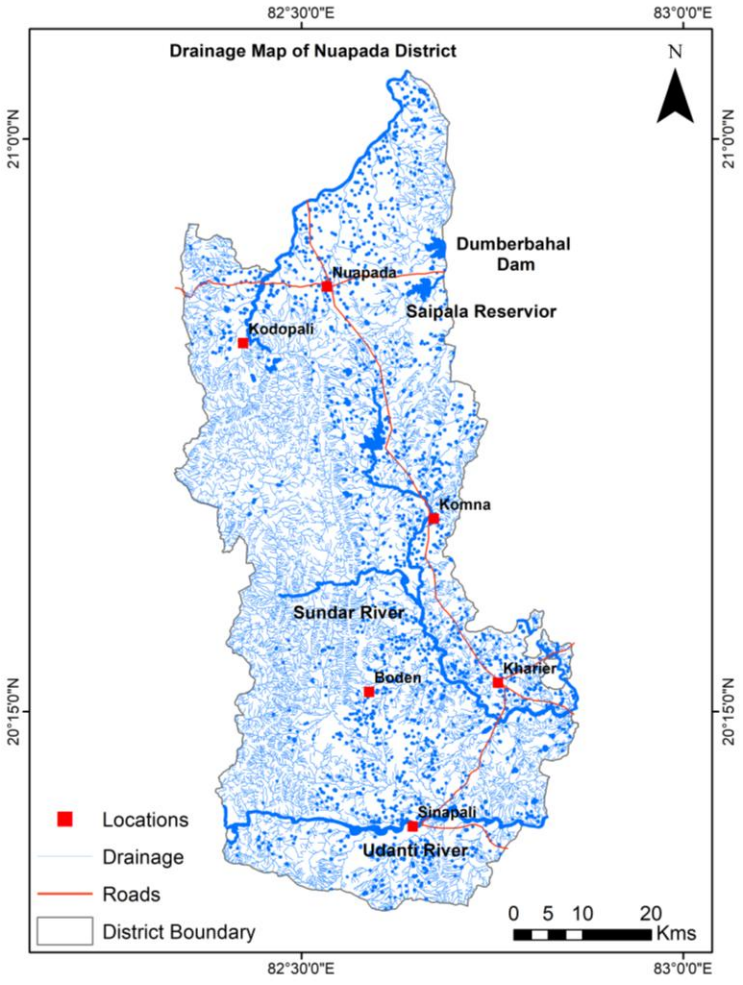


Fig. 1.7: Drainage Map of Nuapada District.

2 DATA COLLECTION AND GENERATION

2.1 Geology

The area is occupied by two distinct groups of formation viz., the Eastern Ghat group and the Purana (Chattisgarh group).

The Eastern Ghat group consists of granite gneisses, charnockite, khondalite with intrusives like anorthosites and amphibolites. While the Precambrian metasediments of Purana group (Chattisgarh group) includes purple and grayish shales, quartzites, limestones, etc.

The Chattisgarh group of rocks are exposed all along the western part of the district and the Eastern Ghat group of rocks occur in the eastern part. Country rocks are intruded by dolerite dykes and quartz, pegmatite veins. Laterites occur as capping over the older formations and at places fromduricrust. Alluvium of recent origin occurs as discontinuous thin patches along the major rivers and streams. The generalized stratigraphic sequence of the area is as follow :

Table2.1: Generalized stratigraphic sequence in Nuapada District

Stratigraphic Succession

Era	Group	Lithology
Quarternary	Recent Alluvium	Alluvium composed of sand, silt and clay of various grades with calcareous concretions.
	Laterite & lateritic Gravels	
~~Unconformity~~~~~~~~~~~~~~~~~~~~~~~~~~~~~		
Pre-Cambrian	Chattisgarh group	Quartzites, purple shale with limestone, silt stone etc.
~~Unconformity~~~~~~~~~~~~~~~~~~~~~~~~~~~~~		
	Younger intrusives	Amphibolite, Anorthosites, Granite gneiss, Charockite, Khondalie etc.
	Eastern Ghat group	

Eastern Ghat group of rocks :

Khondalite suite :

This suite of rocks consists of granite sillimunite gneisses and schists, calc-silicates, granulites, quartz-garnet rocks, Khondalites are grayish brown to pinkish brown in colour and are well foliated, usually form high hills with flat top and steep slope. General trend of fractures is in NE-SW direction. Prominent set of joints are (i) $N70^0E - S70^0W$ dipping 60^0 towards SE. (ii) $N50^0W - S50^0E$ dipping steeply towards SW.

Charnockite Suite :

This suite of rocks consists essentially hypersthene and are acidic to basic in composition. They are greenish grey to brownish black in colour, coarse grained with phenocorysts of felspar and garnet.

Granite gneiss and its variants :

These are the most predominant rock types occurring in the eastern part of the district. Porphyritic granite gneiss, garnetiferous granite gneiss, biotite granite gneiss etc. are the commonly occurring varieties in the area. These rocks mostly occupy the undulating plains dotted with hillocks.

Younger Intrusives :

Khondalite and charnockites are intruded by anorthosites and amphiboles which occur as discontinuous lenses. They are melanocractic and consist of essentially plagioclase, hornblendes, biotites. Quartz veins and pegmatite traverse the granite gneissic country along structurally weaker zones.

Chattisgarh group :

This group of rocks consist of purple and grey shale with limestone, quartzites, gritty sandstones and unconformably overlie the rocks of Eastern Ghat's group. Quartzites form hills in the western part of the district and shales occupy the intermontane valleys.

Laterites and Alluvium :

Laterites of pliestocene age occur as capping the older formations . Prominent occurrence of laterites are found in Khariar (64 L/15), Pagarani (64 L/9) and from duricrusts.

The alluvium occurrence is restricted in the form of pockets along the course of the major streams. Some of the prominent occurrences near the village Jambahal (64 L/12), Thoutibar (64L/10) and Bhusuri (64L/9). The vertical as well as horizontal extensions are very limited.

Structure :

The rocks of Eastern Ghat group have undergone intense structural and metamorphic deformation. The structural map is shown in Plate 5. They form prominent lineaments mostly fractures and joints of varying magnitude. The general trend of the group is NNE-SSW, having foliations with easterly dips, varying from 40^0 to 70^0. There are four sets of major lineaments found in the area trending in NE-SW, NW-SE, NNW-SSE and N-S directions. Predominant joints in granites trend N 20^0 E-S 20^0 W, N 50^0 E- S 50^0 W, N 50^0W- S 50^0 E.

Khondalites are highly foliated and jointed in nature. Important steeply dipping joints are (i) N 60^0 E- S 60^0 W, (ii) N-S, (iii) N 80^0 E- S 80^0 W. Charnockites are coarse grained massive and hard. Jointing almost identical to that of granites / granite gneisses.

The Chattisgarh group exposed mainly in the intermontane valleys and have a general trend of N-S with low dip. (20^0 – 30^0) towards west. These shales are highly sheared and folded. Two sets of prominent vertical joints are noticed in this litho-unit are S 50^0 W- N 50^0 E, N 40^0 W- S 40^0 E. The contact between the Eastern Ghat group and the Chattisgarh group is faulted the fault plane run North-South. The geological map of the study area is shown in **Fig. 2.1.**

2.2 Hydrogeology

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

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

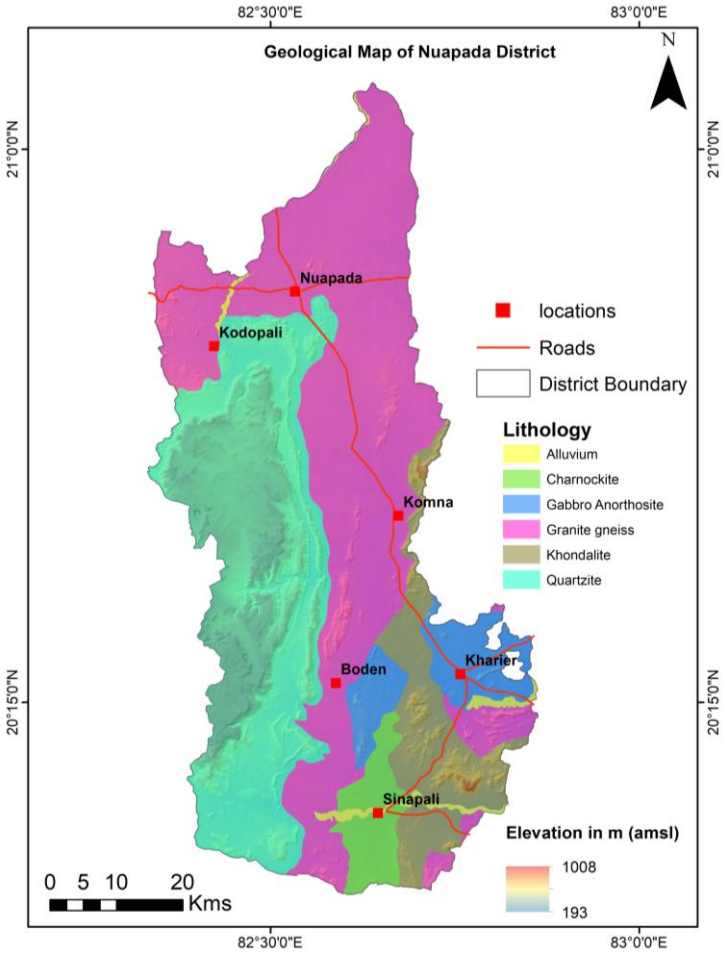


Fig. 2.1: Geological Map of Nuapada District.

Water Bearing Properties of Major Litho Units

2.2.1 Consolidated Formations

Almost the entire district is occupied by the consolidated formations comprising Granites, Granite gneiss,Quartzites,Khondalites and Charnockites, . These rocks are very hard and compact, and lack primary porosity. Ground water is stored mainly in the secondary porosity resulting from weathering and fracturing of the rocks. The aquifer materials are highly heterogeneous in character showing both vertical and lateral variations. The weathered residum form the main repositories of ground water, which occurs under water table conditions and circulates through deeper fractures and fissures. Ground water occurs under confined to semi-confined condition in the deeper fractured zones. The water yielding capacity of fractured rocks largely depends on the extent of fracturing, openness and size of fractures and extent of their interconnections into the near surface weathered zone.

Granite, Granite Gneisses and Quartzites

These are most predominant rock types in the district occupying undulating terrain and low-lying areas. On weathering these rocks yield sandy residuum. The thickness of the weathered zone varies from 5.10 m to 31.0m depending on topography, and foliated and jointed nature of the rocks. Most of the shallow ground water structures (dug wells) are located in these formations.Exploratory drilling by CGWB reveals existence of promising water bearing deeper fractures with a cumulative discharge of 13 LPS.

Khondalites and Charnockites

The khondalities are restricted to the eastern and southern part of the district. These rocks occupy the hill and have limited ground water development potentials. Due to well-foliated nature of the rock, weathering is quite deep.Khondalites are well jointed. The thickness of weathered zone varies from 12 to 25m.the Charnokites are restricted to southern part of the district and ground water potential is low in these rocks.

2.2.2 Unconsolidated Formations

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

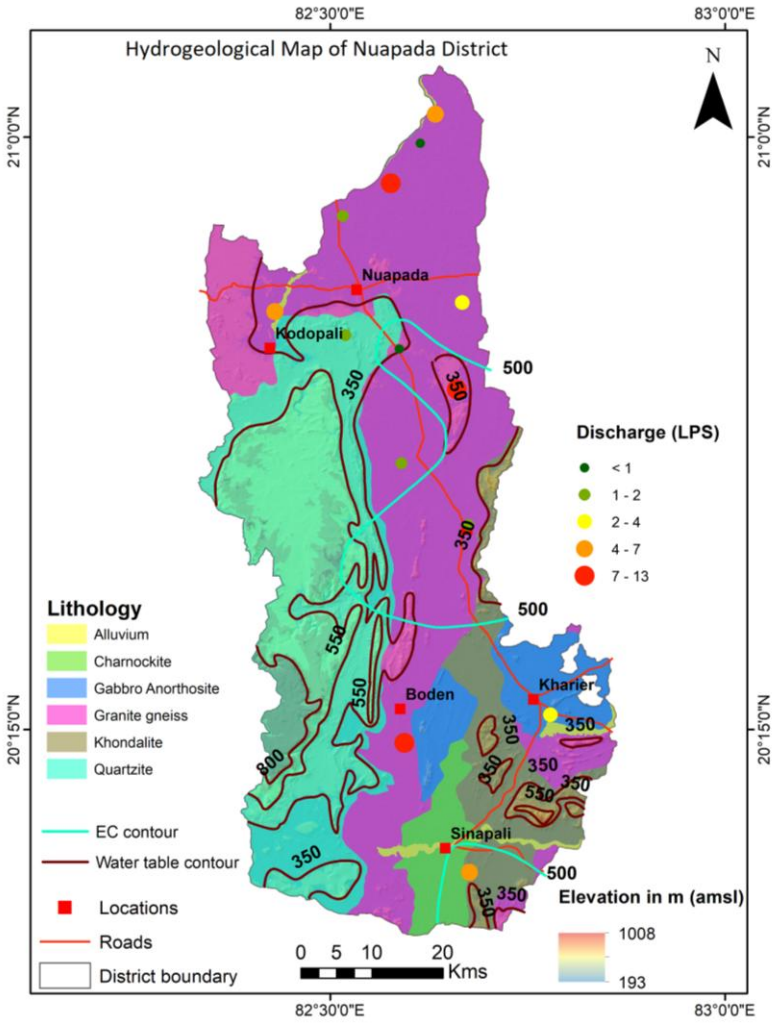


Fig. 2.2: Hydrogeological Map of Nuapada District.

2.3 Ground Water Exploration

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

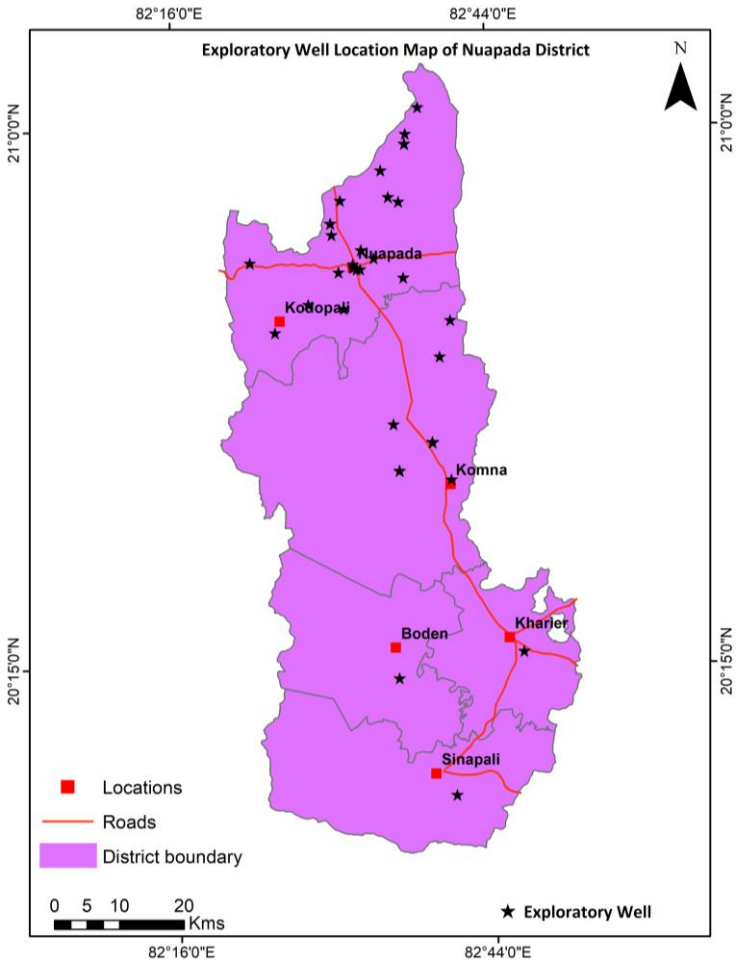


Fig. 2.3: Locations of ExploratoryWells Drilled by CGWB in Nuapada District.

2.4 Monitoring of Ground Water Regime

Due to covid19 pandemic situation in the year 2020 and 2021 the pre monsoon monitoring (April 2020) of water level could not taken in the district. So the pre monsoon and post monsoon water level of NHS 2019 data is taken into account for preparation of maps.. There are 20 National Hydrograph Network Stations (NHNS) exist in the District. Under NAQUIM, 60 Key Observation wells (dug wells).were established during post monsoon period 2020 The details of the National Hydrograph Network Stations (NHNS) are shown in **Table 2.3** and the locations of the monitoring stations are shown in**Fig. 2.4**.The list of Keywells established in nuapada District is given in **Table.2.4**The chemical quality of ground water in the district is monitored annually on a routine basis by CGWB through its National Hydrograph Network Stations. During the NAQUIM programme, 60water samples were collected from the monitoring wells and results of their chemical analysis is given in **Table 3.2.**Quality of ground water from deeper aquifers is assessed during the

drilling and pumping tests. The Ground water Quality data of Exploratory well in Nuapada Dist is given in **Table.2.5**

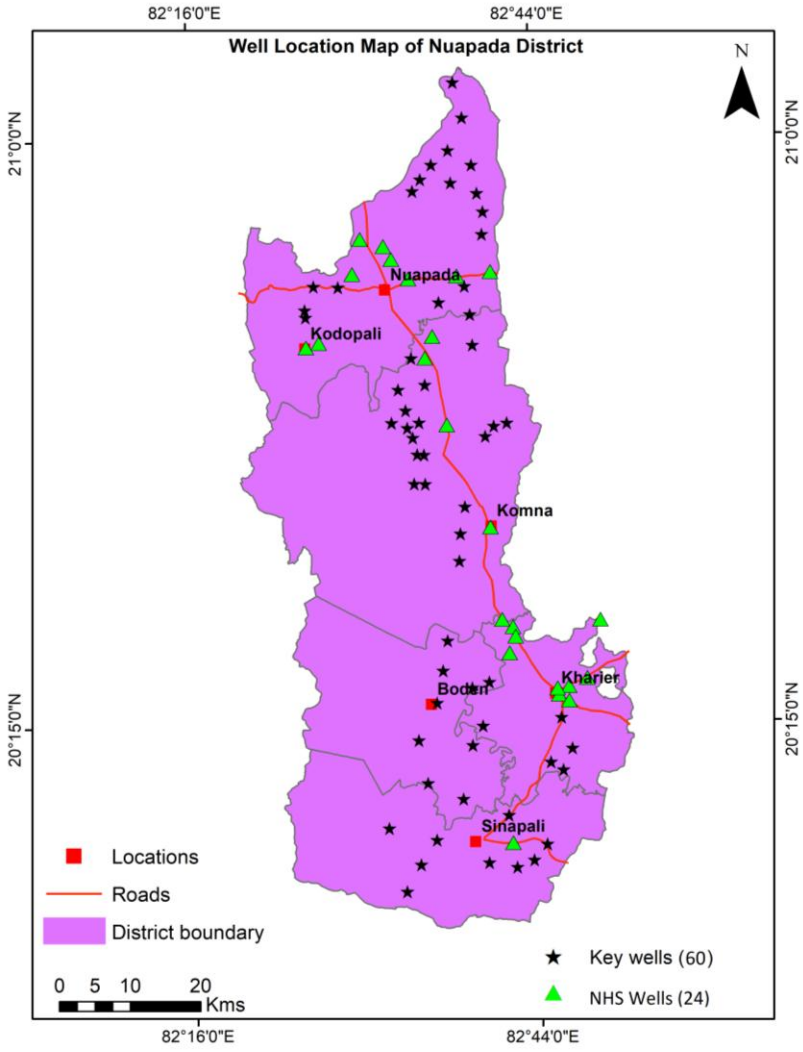


Fig. 2.4: Locations of NHS and Key wells in Nuapada District.

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

Sr,No	District	Block	Location	lat	long	Depth drilled (mbgl)	Lithology	Depth to Bed rock (mbgl) Casing Pipe Lowered	Granular zones/ deciphered (mbgl)	SWL (mbgl)	Discharge (lps)	Drawdown (m)	T (m^2 / day)	S
1	Nuapada	Nawapara	Nawapara	20.7492	82.5194	177.30	F.G. Gneiss	25.60	53,61,74,91,115, 127	9.23	1.67	13.55		
2	Nuapada	-do-	Kharia Road	20.9002	82.5162	181.70	-do-	20.00	33,72,84,102,116	6.16	1.98	21.46		
3	Nuapada	Komna	Tarbod	20.5870	82.5904	178.50	-do-	18.80	48,84, 105	5.85	1.20	22.30		
4	Nuapada	-do-	Komna	20.5090	82.6751	178.70	-do-	9.00	31,56	6.68	1.80	2.55		
5	Nuapada	Khariar	Khariar	20.2686	82.7789	200.20	-do-	9.30	60,117	6.10	2.50	28.54		
6	Nuapada	Sinapali	Sinapali	20.0693	82.6764	138.20	F.Gr.Gr.Quartzite	15.70	70,80, 123	6.70	6.11	9.35		
7	Nuapada	Boden	Boden	20.2331	82.5939	131.25	-do-	16.40	30,48,70,74,129	6.90	12.93	4.58		
8	Nuapada	Lakhna	Lakhna	20.6806	82.6604	124.00	F.Gr. Gneiss	11.60	12,100, 105,118	7.19	7.30	32.39		
9	Nuapada	-do-	-do-	20.6806	82.6604	142.30	-do-	8.60	37,81	7.05	2.04	32.36		
10	Nuapada	Nuapada	Beltukri	21.0289	82.6333	142.30	-do-	16.20	18,91	6.52	5.36	12.19		
11	Nuapada	-do-	Sarabong	20.7790	82.4302	180.00	F. Granite Gniess	-	21,26,37,117,163	9.23	5.0	14.80		
12	Nuapada	-do-	-do-	20.7790	82.4302	188.60	Alkalite Granite	-	160	7.20	9.0	18.67		
13	Nuapada	-do-	Sialhati	20.7317	82.5876	148.40	F. Granite		37,	6.75	0.5	-		
14	Nuapada	-do-	Saipalla	20.7907	82.6673	146.30	-do-		41,56	5.46	2.2	25.09		
15	Nuapada	-do-	Bisora	20.9921	82.6141	148.40	-do-	19.80	16,20,121,126, 141	5.02	0.5	-		
16	Nuapada	-do-	Parkod	20.9414	82.5768	148.40	-do-	28.00	80,138, 139	6.47	4.7	22.08		
17	Nuapada	-do-	Parkod	20.9414	82.5768	124.00	-do-	30.40	32,90, 122,124	6.99	10.39	17.33		

18	Nuapada	Nuapada	Nawapada Hospital	20.8061	82.5344	190.35	Granite gneiss	39.6	-	9.79	0.5			
19	Nuapada	Nuapada	Nawapada Police station	20.8106	82.5339	190.35	Granite gneiss	23.4	23.5	2.1	1	36.7	7.76	
20	Nuapada	Nuapada	Kotenchuan	20.7917	82.6083	184.6	Granite gneiss	10.3	24.8- 39	5.35	0.8			
21	Nuapada	Nuapada	Dumerpani	20.8522	82.5028	104.77	Granite gneiss	10.2	49	8.04				
22	Nuapada	Nuapada	Khariar Road Police station	20.7556	82.4667	184.5	Granite gneiss	5.1	29.9 - 42.1	4.26	0.5			
23	Nuapada	Nuapada	Veterenary Hospital	20.8042	82.5444	184.25	Granite gneiss	31.4	59-15-61.15,80.55-81.55		0.2			
24	Nuapada	Nuapada	Gudtiur	20.8000	82.5125	184.25	Granite gneiss	25						
25	Nuapada	Nuapada	ShradhapurUPSchool (Bisora)	20.9781	82.6125	172.1	Granite gneiss	27.5	74.5-76.6,107.1-108.1		5			
26	Nuapada	Nuapada	ShradhapurUPSchool(Bisora)	20.9783	82.6128	147.6	Granite gneiss	32	41-42,67.4-69.5		2.5			
27	Nuapada	Nuapada	Bhalukona	20.8975	82.6028	140.6	Granite gneiss	26.8	30.8-32.9,138.6-139.6		4			
28	Nuapada	Nuapada	Bhalukona	20.8975	82.6028	111.1	Granite gneiss	27.8	60.2-61.2		1.5			
29	Nuapada	Nuapada	Darlinuapada	20.9042	82.5875	102.2	Granite gneiss	20.46	65.2-67.2,101.20-102.20		6			
30	Nuapada	Nuapada	Darlinuapada	20.9042	82.5875	102.2	Granite gneiss	14.46	36.80-37.80,66.30-68.30		6.5			
31	Nuapada	Nuapada	Dharambandha	20.7167	82.4167	112.1	Granite gneiss	14.47	75.60, 92.80		2.5			
32	Nuapada	Nuapada	Beherakela	20.8306	82.5461	166	Granite gneiss	23.2	27.80,30.80,75.60,102	6.5	5	23.24	8.38	

33	Nuapada	Nuapada	Beherakela	20.8306	82.5464	159.6	Granite gneiss	26.3	58.30,87.70,98.20	6.29		22.24		
34	Nuapada	Nuapada	Gotama	20.8681	82.5011	112.1	Granite gneiss	21.1	23.70,30.80,98.20	6.3	11	12.05	41.6	
35	Nuapada	Nuapada	Gotama	20.8683	82.5014	92.8	Granite gneiss	20	26.80,80.60	6.3		11.3		
36	Nuapada	Nuapada	Godphula	20.8192	82.5650	178.2		19.8	20.70,50.10,67.40,157.80,181.00	6.6	3	18.86	9.13	
37	Nuapada	Komna	Jhagurai	20.5222	82.5983	184.3	Granite gneiss	18.9	25.70,69.50,158.0	7.14	4	11.9	24.2	
38	Nuapada	Komna	Jhagurai	20.5225	82.5986	184.1	Granite gneiss	19.9	45.30,88.70	6.83		3.04		
39	Nuapada	Komna	Udayabandha	20.5619	82.6478	164	Granite gneiss	20.5	31.80,47.10	3.55	1.5	31.09		
40	Nuapada	Nuapada	Sarbhanga	20.8144	82.3808	62.3	Granite gneiss	23.7	58.3	4.72	0.5			
41	Nuapada	Komna	Lakhna	20.7314	82.6769	62.3	Granite gneiss	6.1	27.80,44.0	4.52	0.3			
42	Nuapada	Komna	Udyanabandha	20.5611	82.6483	62.3	Granite gneiss	21.9		3.14	1.8			
43	Nuapada	Nuapada	Nuapada	20.8039	82.5394	62.3	Granite gneiss	31		5.85	Traces			

Table-2.3: List of NHS in Nuapada district (2019)

Sl No	District	Block	NHS	Depth	Lattitude	Longitude	RL	Pre_wl	Post_WL	Fluct_WL
1	Nuapada	Nuapada	Gotama	9.42	20.8717	82.5008	324.9	8.3	4.53	3.77
2	Nuapada	Nuapada	Kalyanpur	10	20.8625	82.5322	331	9.61	3.6	6.01
3	Nuapada	Nuapada	Patparpali	4.8	20.8456	82.5428	327.8	3.97	2.12	1.85
4	Nuapada	Nuapada	Sahipala	5.6	20.8281	82.6778	302.3	3.17	3.15	0.02
5	Nuapada	Nuapada	Godphula	7.7	20.8203	82.5658	349.4	6.84	2.73	4.11
6	Nuapada	Khariar	Bargaon-k	9.42	20.3403	82.6958	248.6	6.83	4.07	2.76
7	Nuapada	Khariar	Sanmaheswar	9.15	20.3736	82.7008	266.6	5.85	3.15	2.7
8	Nuapada	Khariar	Rishigaon	9	20.3814	82.8200	262.4	6.85	2.5	4.35
9	Nuapada	Khariar	Loharpalli	9	20.2864	82.7622	238.9	1.35	0.95	0.4
10	Nuapada	Khariar	Padampur	5.5	20.2969	82.7761	239.6	3.75	1.83	1.92
11	Nuapada	Komana	Kurumpuri	5.2	20.7189	82.5869	340.9	5.02	3.9	1.12
12	Nuapada	Komana	Deobahal	6.3	20.3614	82.7044	259.1	3.57	1.85	1.72
13	Nuapada	Komana	Komna1	9.05	20.5014	82.6728	280.7	6.25	4.17	2.08
14	Nuapada	Nuapada	Bhajipala	9.48	20.8272	82.4894	339.9	3.58	3.5	0.08
15	Nuapada	Nuapada	Dharambandah	10	20.7342	82.4253	337.4	3.23	2.23	1
16	Nuapada	Khariar	Khariar	13	20.2944	82.7603	245.5	7.07	4.32	2.75
17	Nuapada	Khariar	Junani	6.1	20.3072	82.8008	241.6	4.91	2.55	2.36
18	Nuapada	Khariar	Ranipur	6.63	20.2786	82.7758	237.6	6.12	4.38	1.74
19	Nuapada	Khariar	Bada-Maheswar	8.35	20.3833	82.6867	266.8	7.22	3.25	3.97
20	Nuapada	Sinapali	Ghantiguda	4.2	20.0975	82.6969	243.4	2.85	1.31	1.54

Table-2.4: List of Key wells established in Nuapada district

Sl No	Location	Village	Block	Lattitude	Longitude	RL	Depth mbmp	Dia (m)	MP	Date	SWL (mbmp)	**Post_WL (mbgl)**
1	DW is in H/o Babulal sahu in Khan para near transformer.	Jampani	Nuapada	20.876	82.6669	293.4	7.5	4.8	0.5	27.11.20	3	2.5
2	well is in the field,100m away from H/o Heera lal majhi infront of weekly market.	Chhindpani	Nuapada	20.9047	82.6687	296.8	8.4	6.2	0.4	27.11.20	1.8	1.4
3	DW is in H/O Kianri Sahu near Govt U.P school	Bhanpur	Nuapada	20.9285	82.6609	312.4	11.8	3.2	0.5	27.11.20	4.3	3.8
4	DW is in H/o Girdhari Sabar just next to forest Office.	Masankunda	Nuapada	20.9649	82.6542	324.7	8.3	5.3	0.5	27.11.20	4.3	3.8
5	DW is in H/o Visma Dev near Neem tree in bitch pada.	Kuliabandha	Nuapada	20.9422	82.6257	327.9	7.4	4.3	GL	27.11.20	3.9	3.9
6	DW is in H/o Puran Lal Dewangan,(Khusi Tailors)	Parkor	Nuapada	20.9321	82.5733	318.3	10.8	3.8	0.7	28.11.20	4.4	3.7
7	DW is in H/o Pando Majhi in front of Govt Pr school by the road side.	Babankera	Nuapada	20.9658	82.5994	311.8	8.3	5.8	0.3	28.11.20	5.2	4.9
8	DW is in H/o Baldev Pandey by the road side.	Bishora	Nuapada	20.9838	82.6224	303.1	6.3	2.3	0.4	28.11.20	2.9	2.5
9	DW is in premises of Anil Chandrakar infront of pipal tree and pond, back side of welding shop.	Beltukri	Nuapada	21.0255	82.6425	308.8	6.9	3.4	GL	28.11.20	2.5	2.5
10	DW is in premises of Sher Singh Chandrakar in Bajar para in front of telephone tower..	Amodi	Nuapada	21.0708	82.6304	298.6	12.1	4.8	0.3	28.11.20	4.3	4

11	DW is in premises of Kanti lal Pandey in Semeria Mill pada.	Semeria	Nuapada	20.9471	82.5839	319.9	9.1	3.8	0.3	28.11.20	4.3	4
12	DW is in H/o Purusottam Raut by the side of patel Garage.	Sarbang	Nuapada	20.8106	82.4699	327.7	5.3	1.2	0.4	28.11.20	4.2	3.8
13	Dw is by the side of Guddu Kirana shop in the middle of village. (Govt well)	Motanuapada	Nuapada	20.7819	82.4244	334.4	14.1	4.3	0.5	28.11.20	4.8	4.3
14	DW is in H/o Chittanand majhi in Gandhi Chowk.	Turra	Nuapada	20.7726	82.4251	336	8.4	2.4	0.5	28.11.20	4.1	3.6
15	Dw is in house premises of Devanand Patel.Dw is before Mota Nuapada on On Sarbang-Tarri road.	Jarridih	Nuapada	20.8119	82.4368	330.7	7.9	2.3	GL	28.11.20	1.8	1.8
16	DW is in H/o Prem singh majhi in Majhi pada.	Kusdona	Nuapada	20.7186	82.5684	349.1	6.2	2.5	0.3	29.11.20	1.9	1.6
17	well is in the field of Trinath Bhoi 100m after bridge left side.	Mundapala	Komna	20.6293	82.5615	321.2	5.4	5.4	GL	29.11.20	0.9	0.9
18	Well is in the premises of Arikshit Shabar in Talpara.	Kasipala	Komna	20.6844	82.5863	331.1	8.1	1.4	GL	29.11.20	2.6	2.6
19	DW is in H/o Lokdhar majhi near coconut treein tentel para.	Diyamunda	Komna	20.6784	82.5499	346.6	9.2	4.9	0.4	29.11.20	4.7	4.3
20	DW is in H/o Durga prasad Pandey,300mfrom hanuman mandir,bedi gudi Chowk..	Siyalati	Komna	20.6519	82.5597	340.2	10.8	3.6	0.3	29.11.20	6.6	6.3
21	well is in the field of Nila sunani on RHS ,opp to tamarind tree just before entry of village. 100m after bridge left side.	Belardona	Komna	20.6363	82.5404	338.3	7.8	4.6	0.3	29.11.20	2.8	2.5

22	DW is in H/o Paduram sahu near Neem tree..	Rengabahal	Komna	20.6363	82.5779	324.9	9.2	2.7	0.3	29.11.20	4.2	3.9
23	well is in the field,of Jida Naik on LHSof road near coconut tree,50m from anganwadi centre near transformer..	Darriparha	Komna	20.6169	82.5689	318.8	6.8	5.8	GL	29.11.20	2.7	2.7
24	DW is in H/o Bikram Biswal in Gauntia pada/talpada.	Ichhapur	Komna	20.5948	82.5838	308.1	9.2	2.8	0.4	29.11.20	3.2	2.8
25	Dw is in premises of Nandkumar ajhirin mahulpara.	Thongo	Komna	20.5953	82.5746	312.1	7.2	3.7	0.4	29.11.20	4.1	3.7
26	DW is in H/o Devendra Majhi in Karana Bahali pada	Michhapali	Komna	20.558	82.5699	302.1	9.4	5.7	0.3	29.11.20	4.9	4.6
27	Well is in field of jadava majhi in Dorlamunda in bagbeheli seripada.	Dolramunda	Komna	20.5574	82.5849	288.6	6.4	3.1	GL	29.11.20	2.1	2.1
28	DW is in H/o Prabhas Chandar Mahanty in doctor Khana pada.	Bhela	Komna	20.5278	82.6386	287.1	10.5	1.9	0.7	29.11.20	3.9	3.2
29	DW is in H/o sobin Beriha in talpara.	Aurajoba	Nuapada	20.8099	82.6422	310.7	7.8	5.7	0.3	30.11.20	3.4	3.1
30	DW is in H/o Babulal raut in Gaud pada.	Kotenchua	Nuapada	20.7897	82.6068	327.8	6.8	5.2	0.4	30.11.20	2.7	2.3
31	Well is in front of angan wadi kendra in Harijan Pada	Jhajhimura	Nuapada	20.7735	82.6492	324.5	7.9	1.9	0.8	30.11.20	4.5	3.7
32	Well is in field of Rudra singh Bariha in the end of village in purana Lakhna, 100m from railway line,near coconut tree.	Lakhna	Komna	20.7345	82.6519	339.5	8.3	4.8	0.6	30.11.20	3.2	2.6

33	DW is on LHS of road in field of Deba naik(owner) near mango tree,opp to Km sone showing Kandetara 1.5 Km.	Mahulbhata	Komna	20.6175	82.6674	294.4	9.3	5.8	GL	30.11.20	2.7	2.7
34	DW is in H/o Jugal singh Majhi in Majhipada.	Dhanujhola	Komna	20.6307	82.6792	297.6	8.4	8.1	0.5	30.11.20	2.7	2.2
35	DW is in H/o Jerulal sabar in sabar padaon LHS of road..	Ganramurra	Komna	20.6344	82.6971	301.3	5.1			30.11.20	2.8	2.8
36	DW is in H/o Ashok Nag near telephone tower.	Agrayan	Komna	20.4936	82.6318	276.8	9.1	3.8	GL	30.11.20	3.3	3.3
37	DW is on RHSin field of Mohan Ketki,50m from electric transformer and Girls Hostel.	Belgaon	Komna	20.4587	82.6298	265.7	8.1	2.8	0.3	30.11.20	2.4	2.1
38	DW is in H/o Mahant chhatriain ward No-10,Chhatria pada	Kirejhula	Boden	20.3569	82.612	282.4	7.9	3.4	GL	30.11.20	1.9	1.9
39	well is in Dansena pada at the end of village (owner-Anant ram dandsena)	Khaira	Boden	20.3186	82.6052	271	7.4	1.6	GL	30.11.20	1.4	1.4
40	DW in LHS of road in front of anganwadi kendra in the premises of Hridayalal satnami	Durkamunda	Rajkhariar	20.2964	82.6446	255.9	8.6	5.1	0.3	30.11.20	4.5	4.2
41	DW is in H/O Jagabandhu Baghel on LHS in front of Rohit computers	Nehna	Rajkhariar	20.2571	82.765	225.5	14.8	1.3	0.5	01.12.20	2.9	2.4
42	5 Km from Duajhar chhak,DW is in front of Anganwadi kendra (Govt well)	Sardhapur	Rajkhariar	20.2173	82.7793	236.8	6.8	1.8	0.5	01.12.20	3.6	3.1
43	DW is in H/O surendra meher,100m from Bus stand,Shiv Mandir	Gandabahali	Sinapali	20.1328	82.6918	242.4	8.9	2.4	0.6	01.12.20	2.1	1.5

44	DW is in front of gayatri Pragyan pitha,near VSNL tower	Hatibandha	Sinapali	20.0953	82.7433	240.1	6.8	1.4	0.5	01.12.20	3.8	3.3
45	Dw is in H/O Padmanabha Meher in middle of village(Kirana store) in Meher pada basti.	Litiguda	Sinapali	20.075	82.7254	241.9	9.1	1.2	0.6	01.12.20	3.7	3.1
46	Dw is in H/O Sodan Patel in patelpara on LHS of road.	Bharuamuda	Sinapali	20.0662	82.7021	253.9	6.7	0.9	0.6	01.12.20	2.8	2.2
47	Dw is in H/O Gautam Majhiin Kurla padaon LHS of road.	Mahagan	Sinapali	20.0724	82.6643	259.8	4.8	2.4	GL	01.12.20	2	2
48	Dw is in H/O Bansidhar Majhi in Majhi pada,Kendumunda	Kendumunda	Sinapali	20.071	82.5716	271.4	7.9	3.8	0.4	01.12.20	2.1	1.7
49	Govt well infront of Shivam Medical store,50m from M.E school,LHS of road.	Dhungiamunda	Sinapali	20.0365	82.5521	282.6	6.4	1.4	0.4	01.12.20	2.8	2.4
50	DW is in H/O Naba kumar Bagh.	Karangamal	Boden	20.1542	82.6303	254.7	8.3	1.4	0.6	01.12.20	4.5	3.9
51	Govt well in front of Forest Beat house,3 Km from Rokal.	Rokal	Rajkhariar	20.2227	82.644	271.2	10.3	5	0.6	01.12.20	2.9	2.3
52	DW is in H/O Chintamani sabar on LHS near transformer on Rajkhariar road.	Uparpita	Rajkhariar	20.2474	82.6584	261.2	5.8	5.8	GL	01.12.20	3.3	3.3
53	well is in field of Kapur Behera on LHS of road near market complex,50m from customer service point,SBI	Budhapada	Rajkhariar	20.3033	82.668	236.2	6.1	2	GL	02.12.20	1.5	1.5
54	well is in field of Amruta khamari on LHS of road while going towards Boden.	Sonapur	Boden	20.2773	82.5965	273.9	6.5	6.5	GL	02.12.20	1.5	1.5
55	DW is in H/O Dipak Panigrahi on LHS of road(Boden-Sinapali)	Kerapadar	Boden	20.2298	82.571	288.8	7.1	3.9	0.3	02.12.20	2.5	2.2

56	DW is in H/O Sunadhar Sabaria opp to pr school on Sinapali road.	Litisargi	Boden	20.1751	82.5826	276.5	9.1	4.3	GL	02.12.20	3.5	3.5
57	DW is on LHS of road under Neem tree on the road to Gorla in front of UGB Kiosk Bank.	Nilji	Sinapali	20.1021	82.5936	261.7	11.1	1.8	1	02.12.20	6.4	5.4
58	DW is in h/O Trinath Naik near tamarind tree and Grahak seva kendra Kiosk Banking.	Gorla	Sinapali	20.118	82.529	275.5	7.8	1.8	0.7	02.12.20	3.4	2.7
59	3 Km from Junapani main road. DW is in H/O Jitendra Bhoi near Jio telephone tower.	Mahulkot	Rajkhariar	20.1999	82.7499	244.1	8.3	6.8	0.4	02.12.20	2.7	2.3
60	DW is in h/O Gopal chandra Bagarti 100m from anganwadi kendra,Near kotamal trijunction and transformer	Kotmal	Rajkhariar	20.1899	82.7665	262.6	7.8	1.1	0.3	02.12.20	3.3	3

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

Sr.No	State	District	Block	Location	lat	long	EC	F
1	Odisha	Nuapada	Nuapada	Nawapara	20.7492	82.5194	330	
2	Odisha	Nuapada	Nuapada	Khariar Road	20.9002	82.5162	177	
3	Odisha	Nuapada	Komna	Tarbod	20.5870	82.5904	426	
4	Odisha	Nuapada	Komna	Komna	20.5090	82.6751	876	
5	Odisha	Nuapada	Khariar	Khariar	20.2686	82.7789	177	
6	Odisha	Nuapada	Sinapali	Sinapali	20.0693	82.6764	509	
7	Odisha	Nuapada	Boden	Boden	20.2331	82.5939	398	
8	Odisha	Nuapada	Lakhna	Lakhna	20.6806	82.6604	552	
9	Odisha	Nuapada	Nuapada	Beltukri	21.0289	82.6333	426	
10	Odisha	Nuapada	Nuapada	Parkod	20.9414	82.5768	455	
11	Odisha	Nuapada	Nuapada	Veterenary Hospital	20.8042	82.5444	380	
12	Odisha	Nuapada	Nuapada	Shradhapur UPSchool (Bisora)	20.9781	82.6125	560	
13	Odisha	Nuapada	Nuapada	Shradhapur OW UPSchool(Bisora)	20.9783	82.6128	550	
14	Odisha	Nuapada	Nuapada	Bhalukona	20.8975	82.6028	520	
15	Odisha	Nuapada	Nuapada	Darlinuapada	20.9042	82.5875	170	
16	Odisha	Nuapada	Nuapada	Dharambandha	20.7167	82.4167	270	
17	Odisha	Nuapada	Nuapada	Bherakela	20.8306	82.5461	400	
18	Odisha	Nuapada	Nuapada	Gotama	20.8681	82.5011	290	
19	Odisha	Nuapada	Nuapada	Godphula	20.8192	82.5650	310	
20	Odisha	Nuapada	Boden	khirmal	20.71889	82.58694	1120	0.78
21	Odisha	Nuapada	Khariar	Chanabeda	20.29944	82.75167	560	1.11
22	Odisha	Nuapada	Khariar	khariar	20.30028	82.75639	990	0.49
23	Odisha	Nuapada	Khariar	Gadramunda	20.31444	82.75722	1000	1.15
24	Odisha	Nuapada	Khariar	sargadi	20.27611	82.83361	600	0.42
25	Odisha	Nuapada	Khariar	Tukla	20.27056	82.83361	700	1.4
26	Odisha	Nuapada	Khariar	Khairabadi	20.28278	82.84333	530	1.32
27	Odisha	Nuapada	Khariar	Bhojpur	20.31111	82.92222	660	0.44

3 DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

3.1 Shallow Aquifer

Ground water occurs in phreatic condition in shallow aquifers and is utilized by means of dug wells or shallow tube wells. The depth of the dug wells used as observation points vary from 5.3 to 14.1 mbgl and their diameter ranges from 1.0 m to 8.1 m. The wells are generally lined to the total depth.

3.1.1 Pre-monsoon Depth to Water Level

The Depth to water level in pre-monsoon period varies from 1.35 mbgl (Loharpali) to 9.61 mbgl (Kalyanpur) the average being 5.25mbgl. In general, the study area has the depth to water level in between 3 to6 mbgl during the pre-monsoon. The locations where the depth to water level is more than 8 m bgl are Gotama (8.30mbgl), Kalyanpur (9.61mbgl). The pre-monsoon depth to water level map is shown in **Fig. 3.1**.

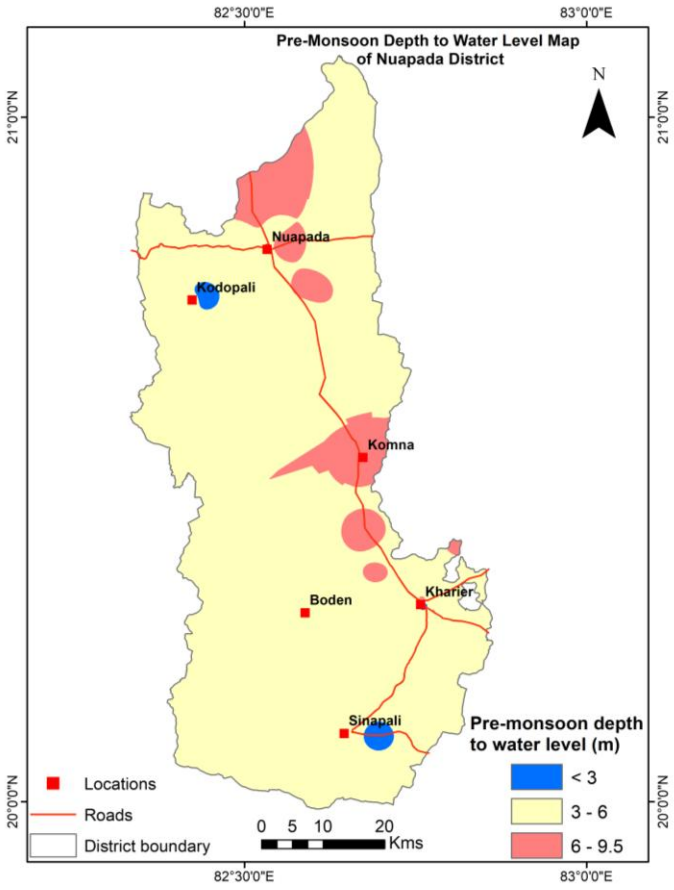


Fig. 3.1: Depth to Water Level in Phreatic Aquifer during Pre-monsoon.

3.1.2 Post-monsoon Depth to Water Level

Depth to water level in post-monsoon period varies from 0.95 mbgl (Loharpali) to 4.53 mbgl (Gotama) the average being 3.0 mbgl. The depth to water level of the study area during post-monsoon is in general within 3-4.5 mbgl. The locations where the depth to water level is more than 4.0 m bgl are Gotama (4.53mbgl), Bargaon-K (4.07mbgl),Komna (4.17mbgl),Khariar(4.32mbgl),and Ranipur (4.38mbgl).The post-monsoon depth to water level map is shown below in **Fig. 3.2**.

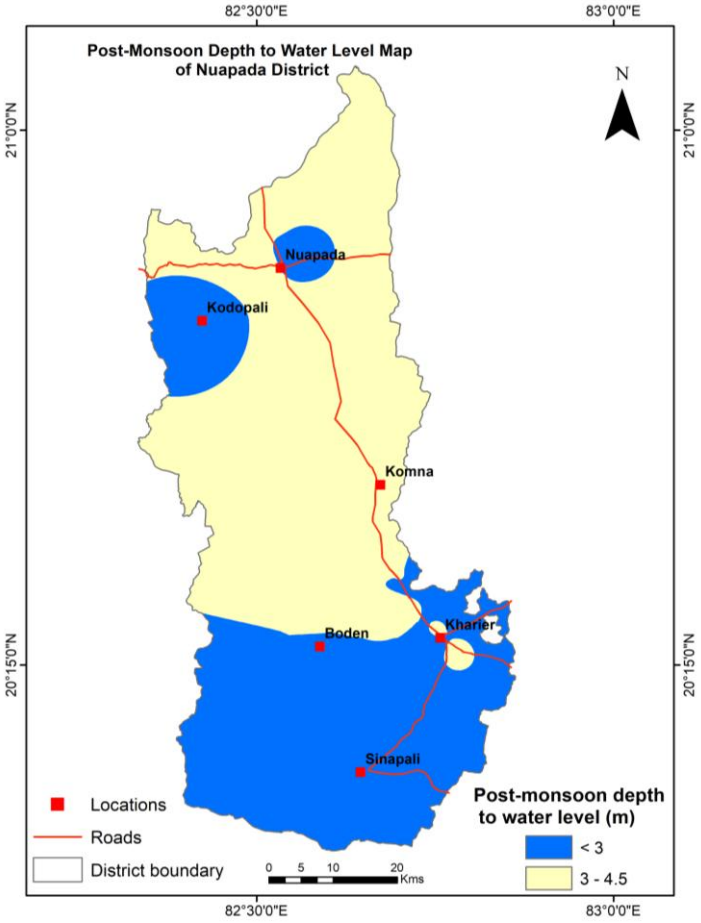


Fig. 3.2: Depth to Water Level in Phreatic Aquifer during Post-monsoon.

3.1.3 Seasonal Fluctuation of Water Level

The water level fluctuation varies from 0.02 mbgl (Sahipala) to 6.01mbgl (Kalyanpur) the average being 2.40 mbgl. The general range of fluctuation in water level in the study area is between 1-3m. The locations where the fluctuation of water level is more than 5 m is Kalyanpur(6.01). The shallow post-monsoon water level along with fluctuation pattern indicates that the annual replenishment of phreatic aquifer due to

monsoon rainfall is adequate in the district but deeper summer level is due to rapid dewatering of the phreatic aquifer .The seasonal fluctuation of water level of Aquifer-I is shown in **Fig. 3.3**.

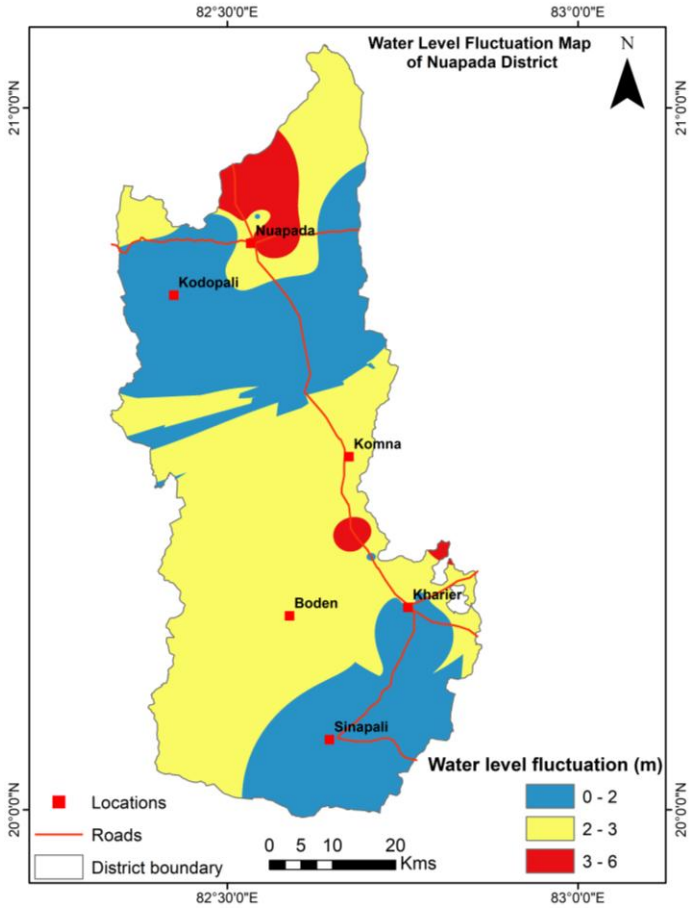


Fig. 3.3: Seasonal Fluctuation in Water Level in Phreatic Aquifer.

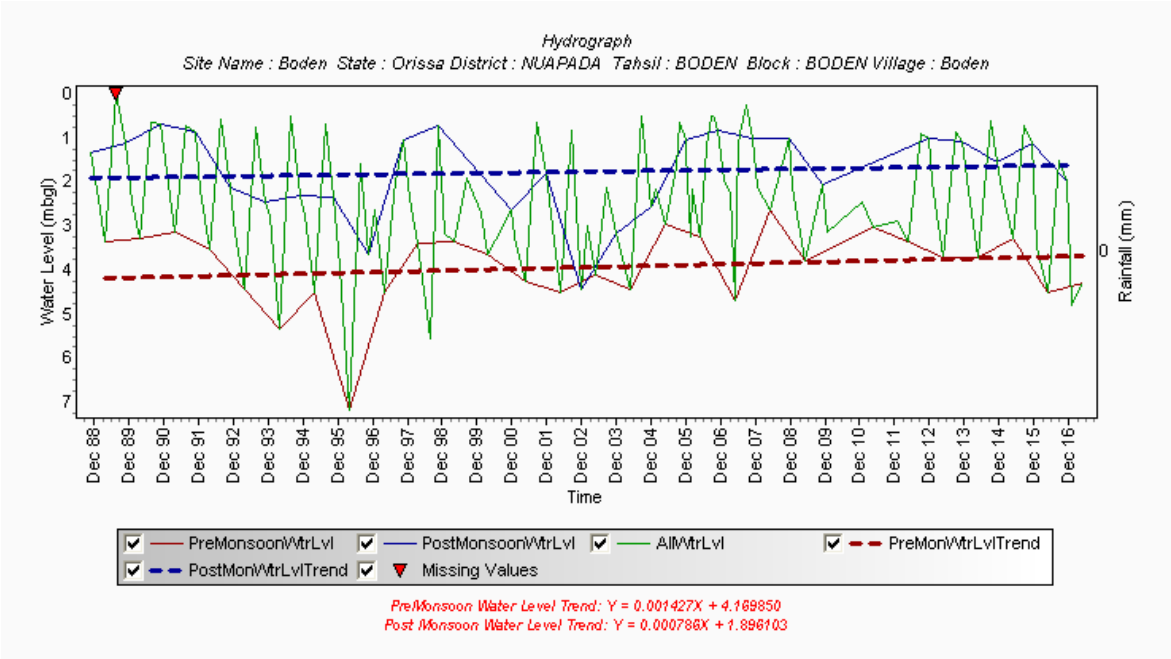
3.1.4 Decadal Water Level Trend

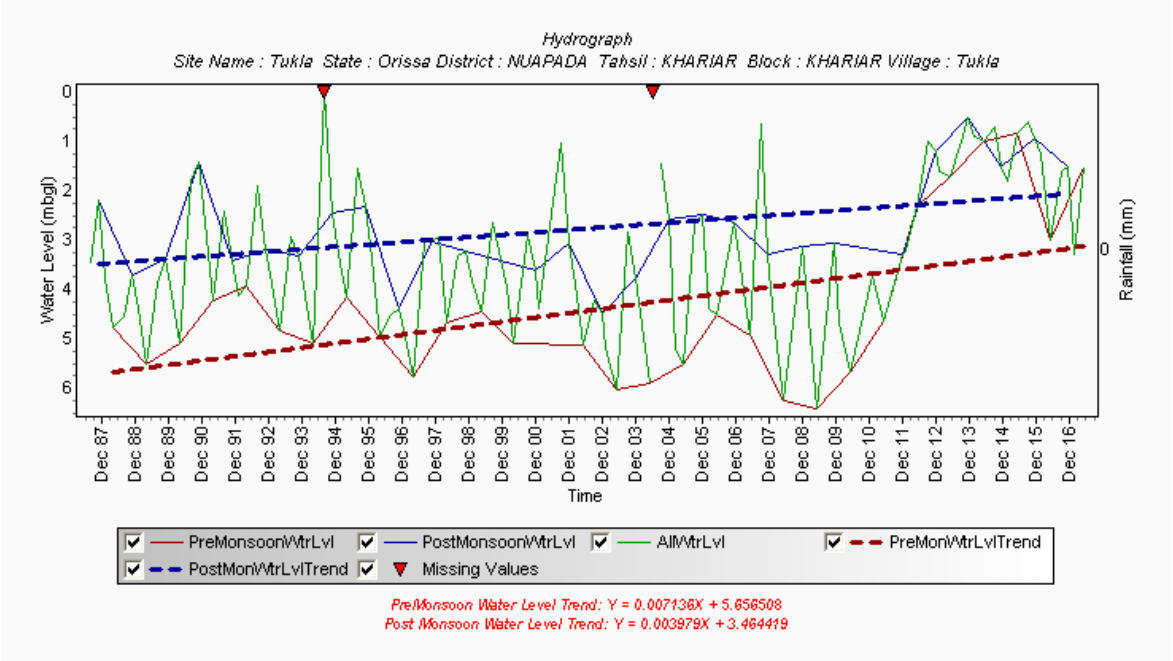
The National Hydrograph Network Stations (NHNS) data are considered for analysis of long-term trend for the period 2011-20. The trend of water level for both pre-monsoon and post-monsoon periods (2011-20)were analyzed. The results of trend analysis have been shown in **Table-3.1**. The long term trend analysis indicates that out of 17 stations, 15(88.23%) show falling trend and 2 stations (11.77%) show rising trend in pre-monsoon. In the post-monsoon out of 17 stations 08(47.05%) show rising trend and 9(52.95%) show falling trend.

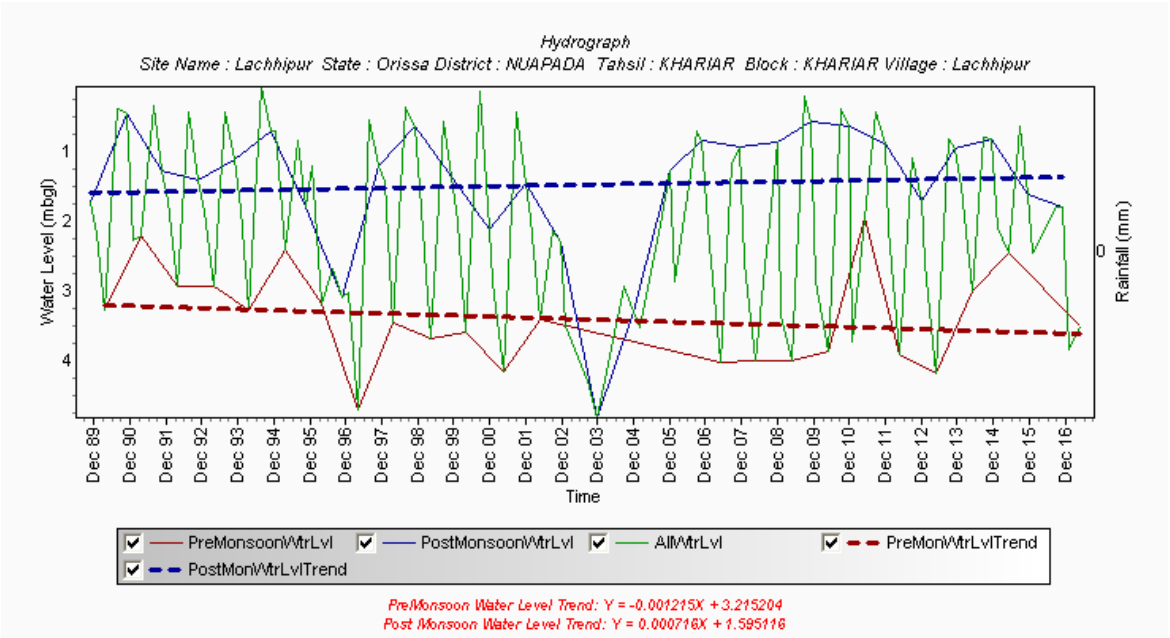
Table-3.1: Decadal Water Level Trend Analysis of CGWB NHS (period 2011-2020) in Nuapada District

Sl No.	Location	Block	Premonsoon		Postmonsoon	
			Trend (m/year)	Remark	Trend (m/year)	Remark
1	Patparpali	Nuapada	-0.0203	Fall	0.0231	Rise
2	Kalyanpur	Nuapada	-0.4514	Fall	- 0.0208	Fall
3	Deobahal	Komana	-0.1996	Fall	0.1144	Rise
4	Sahipala	Nuapada	-0.1823	Fall	-0.2531	Fall
5	Ranipur	Khariar	-0.0834	Fall	-0.0688	Fall
6	Loharapalli	Khariar	-0.0192	Fall	-0.0349	Fall
7	Junani	Khariar	-0.0347	Fall	0.2574	Rise
8	Kurumpuri	Komana	-0.1250	Fall	-0.3086	Fall
9	Godphula	Nuapada	-0.0309	Fall	0.0652	Rise
10	Khariar	Khariar	0.0587	Rise	0.0581	Rise
11	Nilji	Sinapali	-0.0373	Fall	-0.1920	Fall
12	Lachhipur	Nuapada	-0.0569	Fall	-0.1193	Fall
13	Tukla	Nuapada	0.3140	Rise	0.2465	Rise
14	Bargaon-k	Khariar	-0.0030	Fall	-0.0863	Fall
15	Sanmaheswar	Khariar	-0.1208	Fall	0.0084	Rise
16	Komna1	Komana	-0.1059	Fall	0.0201	Rise
17	Tarbod	Komana	-0.1066	Fall	-0.1708	Fall

3.1.5Hydrographs (NHNS) in different blocks of Nuapada District




Hydrograph
Site Name : Tukla State : Orissa District : NUAPADA Tahsil : KHARIAR Block : KHARIAR Village : Tukla
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
Missing Values
PreMonsoon Water Level Trend: Y = 0.007136X + 5.656508
Post Monsoon Water Level Trend: Y = 0.003979X + 3.464419


Hydrograph
Site Name : Lachhipur State : Orissa District : NUAPADA Tahsil : KHARIAR Block : KHARIAR Village : Lachhipur
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
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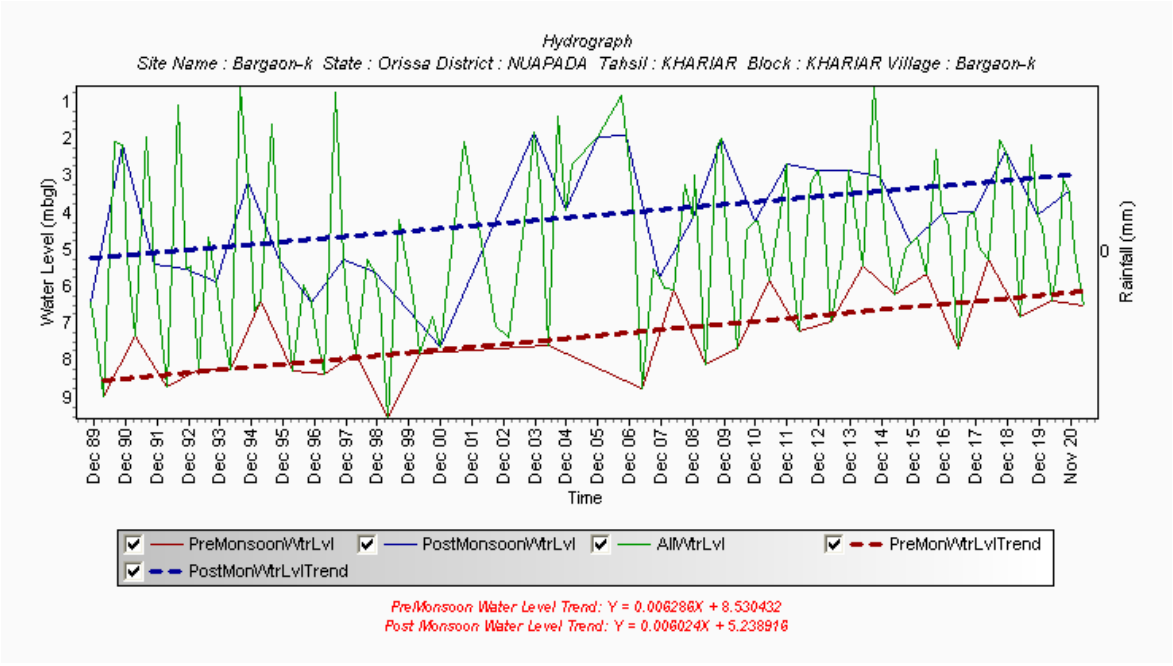
Post Monsoon Water Level Trend: Y = 0.000716X + 1.595116


Hydrograph
Site Name : Bargaon-k State : Orissa District : NUAPADA Tahsil : KHARIAR Block : KHARIAR Village : Bargaon-k
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
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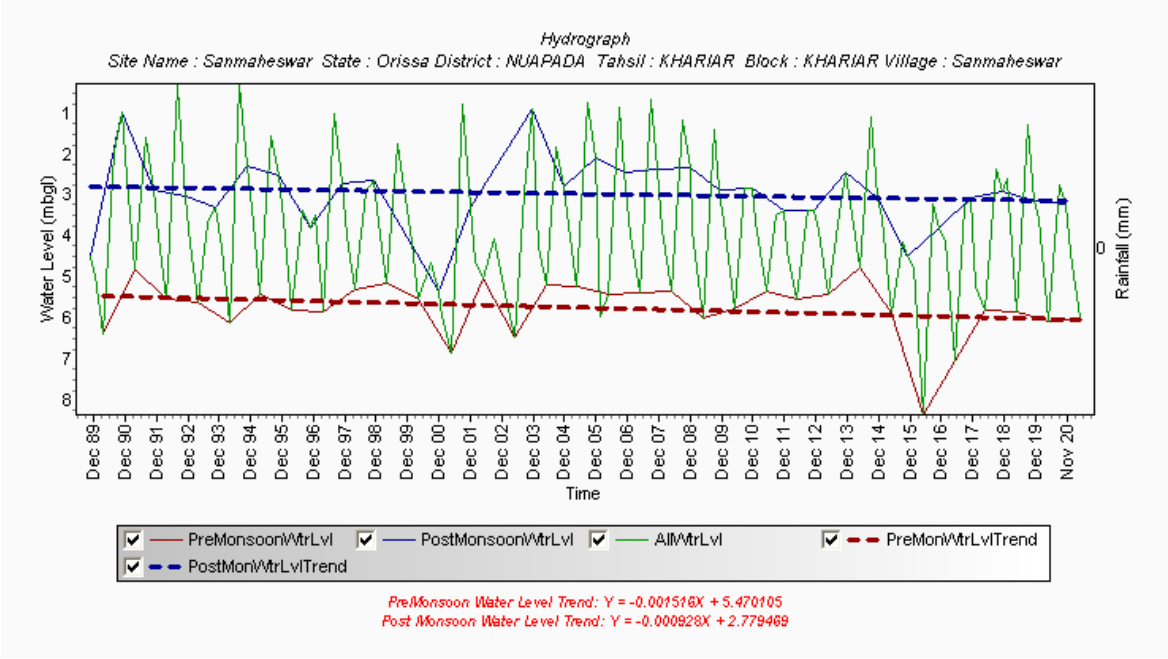
Post Monsoon Water Level Trend: Y = 0.006024X + 5.238916


Hydrograph
Site Name : Sanmaheswar State : Orissa District : NUAPADA Tahsil : KHARIAR Block : KHARIAR Village : Sanmaheswar
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
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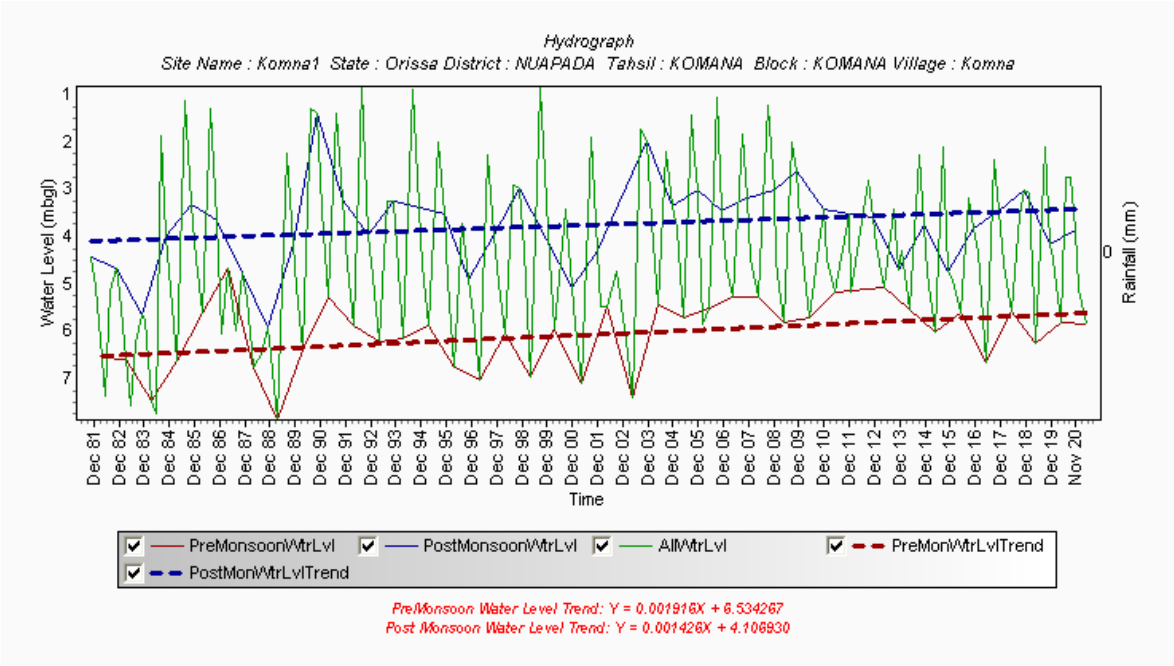
Post Monsoon Water Level Trend: Y = -0.000928X + 2.779469


Hydrograph
Site Name : Komna1 State : Orissa District : NUAPADA Tahsil : KOMANA Block : KOMANA Village : Komna
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
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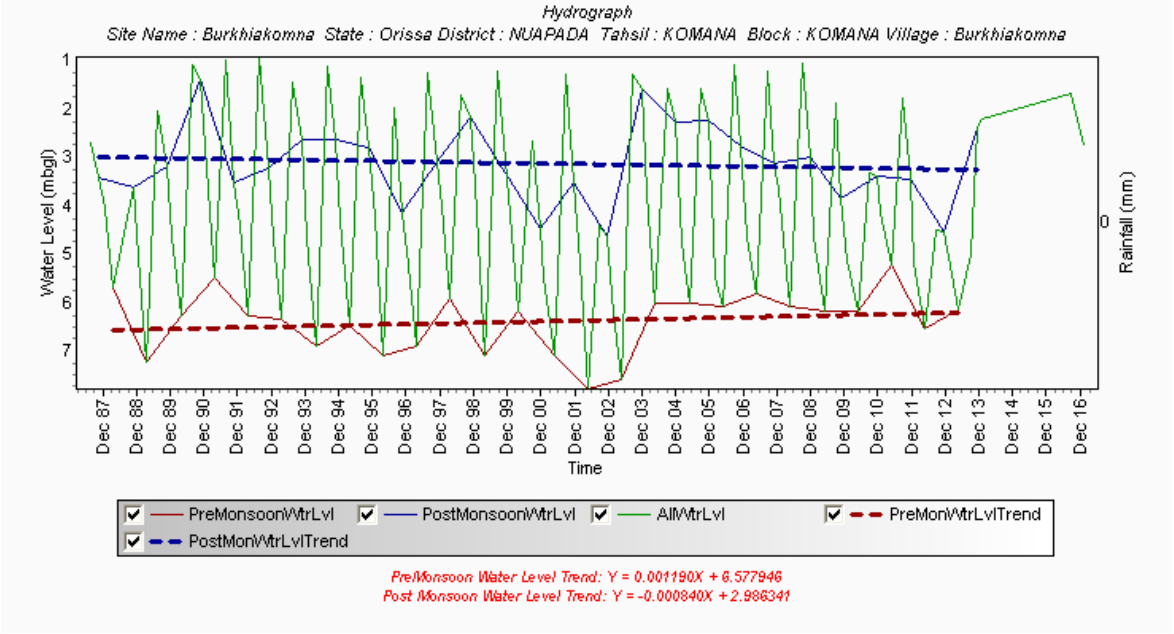
Post Monsoon Water Level Trend: Y = 0.001426X + 4.106930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Site Name : Burkhiakomna State : Orissa District : NUAPADA Tahsil : KOMANA Block : KOMANA Village : Burkhiakomna
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
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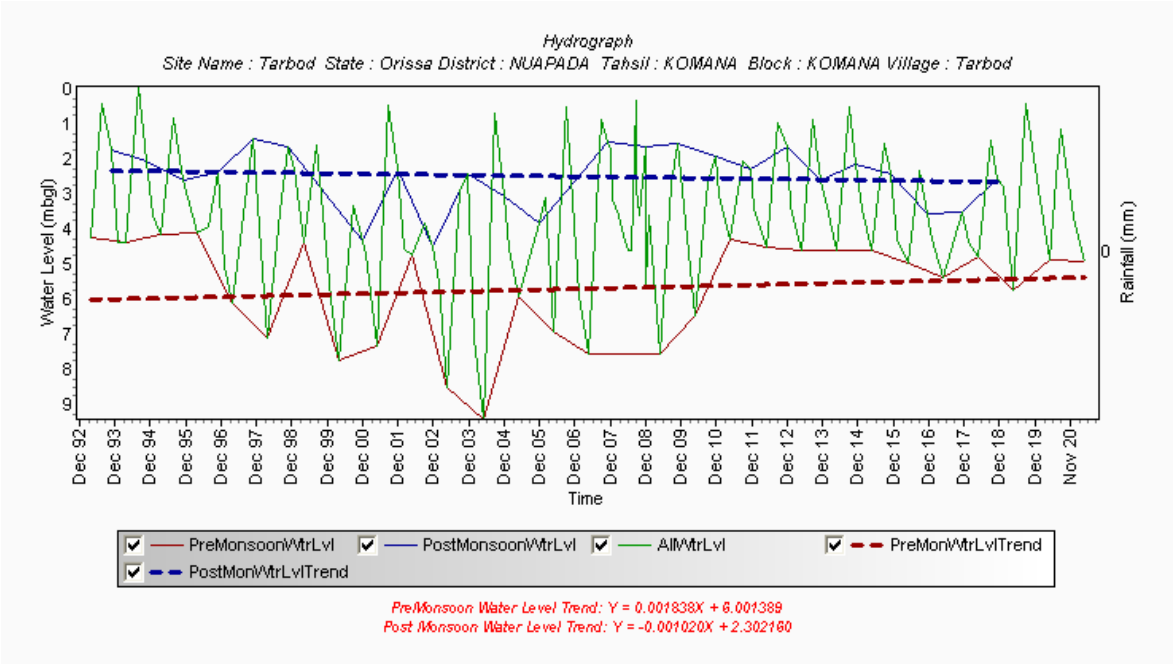
Hydrograph
Site Name : Tarbod State : Orissa District : NUAPADA Tahsil : KOMANA Block : KOMANA Village : Tarbod
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
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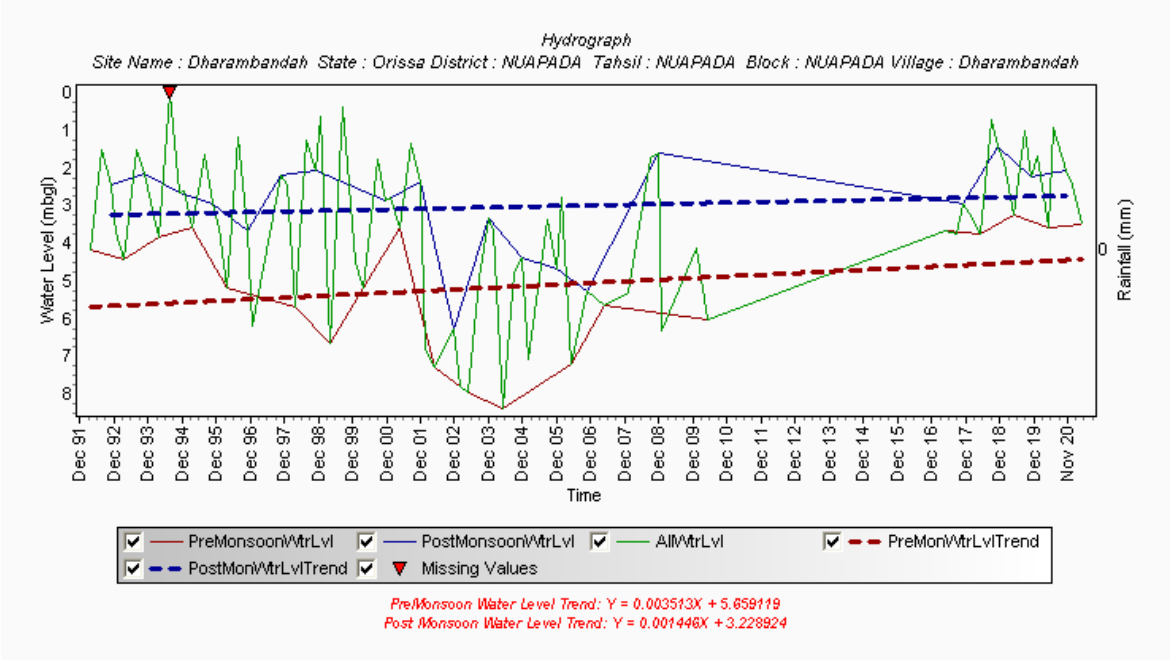
Hydrograph
Site Name : Dharambandah State : Orissa District : NUAPADA Tahsil : NUAPADA Block : NUAPADA Village : Dharambandah
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
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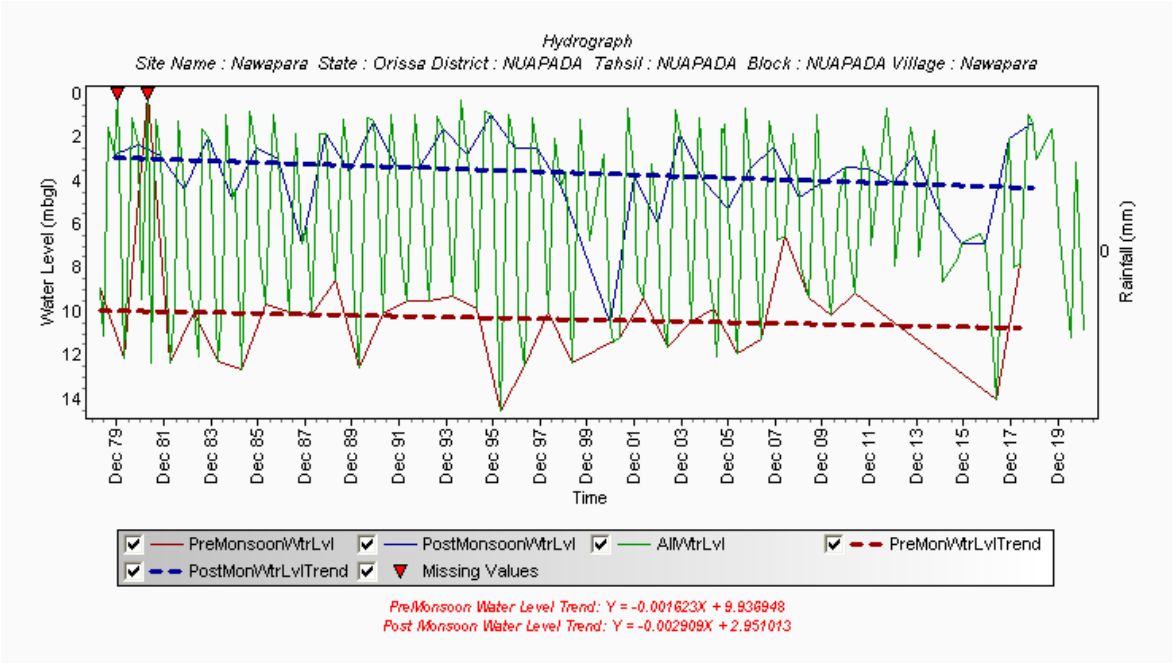
Hydrograph
Site Name : Nawapara State : Orissa District : NUAPADA Tahsil : NUAPADA Block : NUAPADA Village : Nawapara
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
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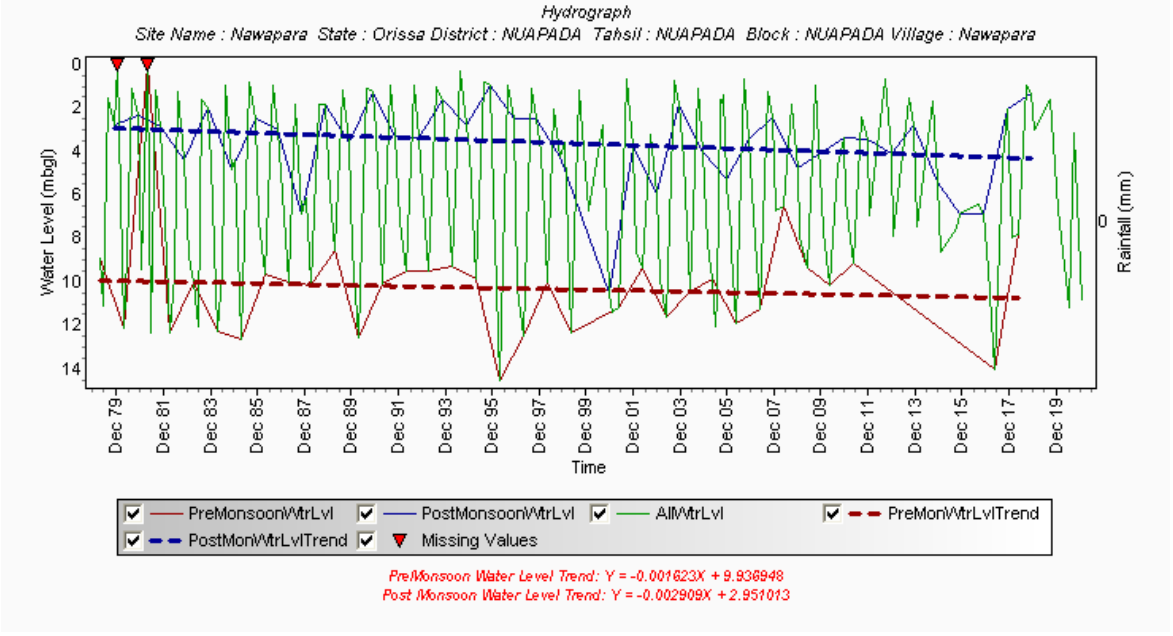
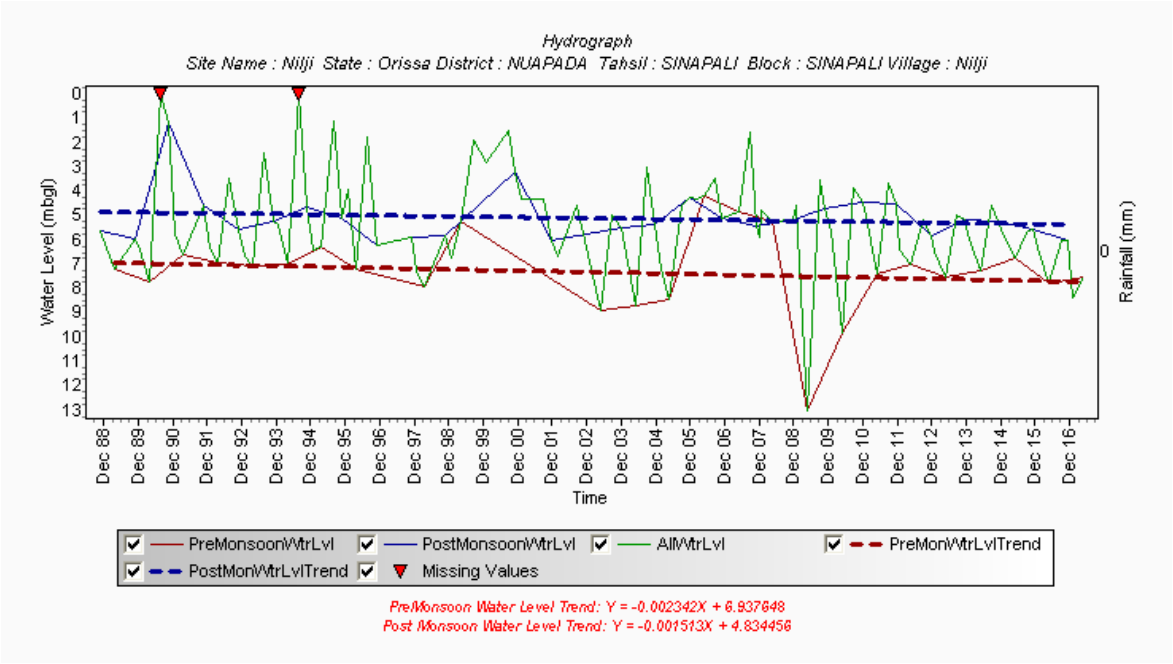

Hydrograph
Site Name : Nawapara State : Orissa District : NUAPADA Tahsil : NUAPADA Block : NUAPADA Village : Nawapara
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
Missing Values
PreMonsoon Water Level Trend: Y = -0.001623X + 9.936948
Post Monsoon Water Level Trend: Y = -0.002909X + 2.951013



3.2 Deeper Aquifer

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

CGWB has constructed 32 EW and 11 OW in Nuapada district through its Ground Water Exploration Programme,whose depthsrange from 62.30 m bgl (Sarbhanga,Lakhna,Udaybhanga,Nuapada)) to 200.20 mbgl (Khariar).The static water level varies from 2.1 m bgl (Nuapada P.S) to 9.79 m bgl (Nuapada Hospital).The discharge of successful borewells varies from 0.30 lps (Lakhna) to a maximum of 12.93 lps (Boden). The drawdown varies from 2.55 m (Komna) to 36.7m (Nuapada P.S). The transmissivity (T) of the aquifers ranges from 7.76 m^2/day (Nuapada P.S) to 41.6 m^2/day (Gotama). The details of the exploratory wells are given in **Table-2.2.**Generally 1 to 4 potential fracture zones are encountered within the depth range of 200 m. The first promising zone occurs in the depth range of 18 to 32 m., which is just below the zone of weathering. The depth range of prime importance is from 40 to 100 m. Normally, the fracture zones in this depth range have high water yielding capabilities and majority of successful bore wells in the study area tapped zones within this depth range.The other potential fracture zones are found at the depth ranges of 110-130, 150-160mbgl. Granite suites rocks have more promising aquifers in comparison to other rocks like Charnockites and Khondalites. However the success of bore wells is site specific and depends on topographic and hydrogeological conditions.

3.3 GROUND WATER QUALITY

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

Based on the chemical analysis of water samples from different sources, it was observed that, almost all chemical parameters lie within permissible limit for drinking and irrigation purpose except few samples of some isolated pockets. For example, fluoride in excess of permissible limit has been found certain villages, which is discussed in detail in Chapter-5. Water Quality Data of Monitoring wells (Key wells and NHS) in Nuapada District. Is given in **Table3.2** and the iso-conductivity map of phreatic aquifers of the district has been prepared and presented as **Fig.3.4**.The Chloride map and Fluoride map of phreatic aquifers of the district has been prepared and presented as **Fig. 3.5**and**Fig. 3.6.**The quality of ground water is generally good with EC ranging from 325 to 2000µs/cm.The suitability of the ground water for the purpose of irrigation analysed in the US-Salinity diagram as shown in **Fig. 3.7**.in which EC is taken as salinity hazard and SAR as alkalinity hazard.The predominant USSL classes of the water samples fall within C2S1and C3S1 classes. C3S1 class indicating high salinity and low alkali water which cannot be used on soil with restricted drainage and requires special arrangement for salinity control.The soil must be permeable and the drainage must be adequate, irrigation water must be added in excess to provide considerable leaching and tolerant crops and plants should be selected for such regions.The water samples represent Ca-HCO_3 type to mixed facies of Ca-Mg-Na-HCO_3-SO_4types as shown in the Piper diagram in **Fig. 3.8**. This indicates a transitional or mixing environment between the younger water and resident water.

Table-3.2: Ground Water Quality Data of Monitoring wells (Key wells and NHS) in Nuapada District.

Sl NO.	DISTRICT	VILLAGE	Type	Block	Lattitude	Longitude	pH	EC	TDS	Hardness	Alkalinity	Ca++	Mg++	Na+	K+	CO3--	HCO3-	Cl-	SO4--	NO3-	F -	U
1	Nuapada	Jampani	KW	Nuapada	20.876	82.6669	8.04	760.7	500.94008	248.51	239	42.3384	34.239	81.74	3.88	0.00	291.58	120.9	27.54	14.36	0.99	0.007
2	Nuapada	Chhindpani	KW	Nuapada	20.9047	82.6687	7.99	694	388.08192	276.12	199	47.8608	37.552	45.36	2.8	0.00	242.78	74.4	19.56	45.81	0.52	0.005
3	Nuapada	Bhanpur	KW	Nuapada	20.9285	82.6609	7.92	919.3	619.39758	280.72	243.78	64.428	28.716	95.23	29	0.00	297.406	139.5	38.02	5.92	0.246	0.009
4	Nuapada	Masankunda	KW	Nuapada	20.9649	82.6542	7.96	525.5	311.53107	220.9	164.18	60.5623	16.678	34.79	0.62	0.00	200.294	53.48	18.96	46.66	0.348	0.001
5	Nuapada	Kuliabandha	KW	Nuapada	20.9422	82.6257	7.77	1581	972.83482	561.44	422.88	134.378	54.12	129.6	27	0.00	515.908	244.1	27.25	26.24	0.162	0.008
6	Nuapada	Parkor	KW	Nuapada	20.9321	82.5733	7.91	503.7	333.68186	184.08	169.15	42.3384	18.776	35.78	4.42	0.00	206.363	69.75	12.48	11.71	0.197	BDL
7	Nuapada	Babankera	KW	Nuapada	20.9658	82.5994	8.1	673.8	439.12438	262.31	213.93	57.0648	28.716	55.91	9.91	0.00	260.989	93	24.95	35.83	0.084	BDL
8	Nuapada	Bishora	KW	Nuapada	20.9838	82.6224	8.17	1462	834.15316	474.01	427.85	112.289	46.388	129.4	2.9	0.00	521.977	172.1	21.96	10.37	1.27	0.005
9	Nuapada	Beltukri	KW	Nuapada	21.0255	82.6425	8.09	668.6	416.9449	294.53	233.83	62.5872	33.134	44	4.9	0.00	285.267	72.08	18.66	46.79	0.154	0.002
10	Nuapada	Amodi	KW	Nuapada	21.0708	82.6304	7.86	888.6	569.42882	280.72	268.65	58.9056	32.03	80.36	2.29	0.00	327.753	120.9	31.44	21.89	0.055	BDL
11	Nuapada	Semeria	KW	Nuapada	20.9471	82.5839	7.79	325	218.21338	147.26	124.38	29.4528	17.672	16.91	4.68	0.00	151.738	27.9	8.283	7.57	0.064	BDL
12	Nuapada	Sarbang	KW	Nuapada	20.810	82.46	7.9	348	242.2	207.	154.2	47.8	20.98	17.3	0.54	0.00	188.	27.	6.9	46.	0.3	0.00

					6	99	8		8762	09	3	608	5	7			155	9	86	98	83	2
13	Nuapada	Motanuapada	KW	Nuapada	20.7819	82.4244	7.97	945	656.8051	391.17	363.18	73.632	49.702	72.6	17.6	0.00	443.074	99.98	30.24	44.18	0.183	0.007
14	Nuapada	Turra	KW	Nuapada	20.7726	82.4251	8.15	1352	938.56546	358.96	482.58	66.2688	46.388	118.5	117.3	0.00	588.742	155.8	36.63	5.63	0.233	0.009
15	Nuapada	Jarridih	KW	Nuapada	20.8119	82.4368	8	665	446.6109	188.68	154.23	38.6568	22.09	90.9	19.9	0.00	188.155	14 4.2	12.08	24.78	0.282	BDL
16	Nuapada	Kusdona	KW	Nuapada	20.7186	82.5684	7.97	663.4	435.4513	239.3	253.73	40.4976	33.134	43.6	26.5	0.00	309.545	62.77	18.16	6.19	0.316	0.003
17	Nuapada	Mundapala	KW	Komna	20.6293	82.5615	7.95	485	311.0346	188.68	179.1	38.6568	22.09	38.53	4.14	0.00	218.502	62.78	6.986	26.46	0.274	BDL
18	Nuapada	Kasipala	KW	Komna	20.6844	82.5863	7.86	1806	1094.9302	612.07	398	156.468	53.015	176.8	5.4	0.00	485.56	330.2	54.29	23.27	0.566	0.008
19	Nuapada	Diyamunda	KW	Komna	20.6784	82.5499	8.19	907.5	636.5406	441.79	427.85	103.085	44.179	51.67	3.58	0.00	521.977	74.4	22.75	12.53	1.01	0.01
20	Nuapada	Siyalati	KW	Komna	20.6519	82.5597	8.01	937.2	594.94408	400.37	318.4	75.4728	50.806	66.23	3.36	0.00	388.448	123.2	29.24	7.16	0.416	0.003
21	Nuapada	Belardona	KW	Komna	20.6363	82.5404	8.21	579.2	391.30308	308.33	268.65	57.0648	39.761	27.29	1.43	0.00	327.753	51.15	10.38	42.74	3.53	0.008
22	Nuapada	Rengabahal	KW	Komna	20.6363	82.5779	7.95	1008	605.1927	262.31	263.68	31.2936	44.179	109.69	6.56	0.00	321.684	14 4.2	30.04	43.07	0.5	0.006
23	Nuapada	Darriparha	KW	Komna	20.6169	82.5689	8.09	1002	570.31026	280.72	223.88	53.3832	35.343	100.67	2.29	0.00	273.128	13 4.9	36.33	32.32	0.69	0.01
24	Nuapada	Ichhapur	KW	Komna	20.5948	82.5838	7.95	586	402.20078	280.72	243.78	55.224	34.239	21.8	19.8	0.00	297.406	39.53	20.16	25.55	0.27	0.005
25	Nuapada	Thongo	KW	Komna	20.5953	82.5746	8.01	521	292.36006	170.27	164.18	46.02	13.254	30.01	0.53	0.00	200.294	44.18	12.38	13.17	0.76	0.003

26	Nuapada	Michhapali	KW	Komna	20.558	82.5699	7.96	810	525.3668	326.74	288.55	66.2688	38.657	61.4	26.2	0.00	352.031	79.05	28.64	30.77	0.255	0.008
27	Nuapada	Dolramunda	KW	Komna	20.5574	82.5849	8.06	452	301.71136	234.7	218.9	44.1792	29.821	12.2	1.19	0.00	267.058	16.28	6.786	6.43	0.393	0.002
28	Nuapada	Bhela	KW	Komna	20.5278	82.6386	7.78	585	399.10778	322.14	303.48	62.5872	39.761	18.1	8.29	0.00	370.24	30.23	11.18	28.43	0.137	0.001
29	Nuapada	Aurajoba	KW	Nuapada	20.8099	82.6422	8.01	485	306.2179	216.29	164.18	40.4976	27.612	22.66	1.99	0.00	200.294	34.88	29.84	46.49	0.332	0.006
30	Nuapada	Kotenchua	KW	Nuapada	20.7897	82.6068	8.07	745	514.12164	358.96	268.65	64.428	47.493	48.09	1.1	0.00	327.753	90.68	18.86	16.21	0.794	0.005
31	Nuapada	Jhajhimura	KW	Nuapada	20.7735	82.6492	8.04	495	289.72376	239.3	159.2	46.02	29.821	25.34	0.38	0.00	194.224	41.85	12.77	42.99	0.821	BDL
32	Nuapada	Lakhna	KW	Komna	20.7345	82.6519	7.95	1325	792.09556	368.16	368.15	60.7464	51.911	112	61.5	0.00	449.143	151.1	41.52	49.14	0.362	0.009
33	Nuapada	Mahulbhata	KW	Komna	20.6175	82.6674	8.01	472	297.8239	193.28	164.18	58.9056	11.045	16	2.19	0.00	200.294	30.23	9.78	23.73	0.935	0.004
34	Nuapada	Dhanujhola	KW	Komna	20.6307	82.6792	8.02	898	619.32084	349.75	288.55	69.9504	41.97	102.64	3.24	0.00	352.031	146.5	19.16	6.59	0.406	0.003
35	Nuapada	Ganramurra	KW	Komna	20.6344	82.6971	8.03	625	426.71702	349.75	303.48	77.3136	37.552	25.06	1.7	0.00	370.24	44.18	11.78	2.06	0.418	0.004
36	Nuapada	Agrayan	KW	Komna	20.4936	82.6318	7.62	376.2	259.9669	184.08	134.33	36.816	22.09	27.18	5.66	0.00	163.877	51.15	16.27	25.91	0.117	BDL
37	Nuapada	Belgaon	KW	Komna	20.4587	82.6298	7.91	356	245.78674	156.47	124.38	38.6568	14.358	22.29	2.68	0.00	151.738	41.85	8.882	5.26	0.181	BDL
38	Nuapada	Kirejhula	KW	Boden	20.3569	82.612	7.87	845	455.40392	266.92	228.85	44.1792	37.552	55.2	33.3	0.00	279.197	81.38	30.84	46.48	0.976	0.004
39	Nuapada	Khaira	KW	Boden	20.318	82.60	8.1	767.9	449.9	276.	263.6	47.8	37.55	43.8	2.77	0.00	321.	62.	14.	10.	1.2	0.00

					6	52			8482	12	8	608	2	9			684	78	67	31	5	6
40	Nuapada	Durkamunda	KW	Rajkharia r	20.2964	82.6446	7.96	685	472.70596	230.1	189.05	51.5424	24.299	86.77	9	0.00	230.641	113.9	37.23	46.87	0.98	0.003
41	Nuapada	Nehna	KW	Rajkharia r	20.2571	82.765	8.06	1183	723.34504	400.37	368.15	71.7912	53.015	96.85	1.78	0.00	449.143	144.2	38.42	35.19	0.727	0.005
42	Nuapada	Sardhapur	KW	Rajkharia r	20.2173	82.7793	7.94	870.7	520.61746	257.71	293.53	44.1792	35.343	42.6	53.8	0.00	358.101	62.78	31.14	34.51	1.45	0.002
43	Nuapada	Gandabahali	KW	Sinapali	20.1328	82.6918	7.77	1552	1055.7012	331.34	502.48	69.9504	37.552	148	164.6	0.00	613.02	195.3	36.53	43.29	0.543	BDL
44	Nuapada	Hatibandha	KW	Sinapali	20.0953	82.7433	7.82	563	374.98086	230.1	174.13	51.5424	24.299	42.83	3.31	0.00	212.433	60.45	21.26	33.22	0.422	0.004
45	Nuapada	Litiguda	KW	Sinapali	20.075	82.7254	7.81	1352	746.05052	285.32	298.5	60.7464	32.03	142.9	24.3	0.00	364.17	211.6	22.36	42.51	0.744	0.004
46	Nuapada	Bharuamuda	KW	Sinapali	20.0662	82.7021	7.95	625	418.32396	266.92	218.9	47.8608	35.343	36.41	5.33	0.00	267.058	60.45	29.44	41.49	0.493	0.004
47	Nuapada	Mahagan	KW	Sinapali	20.0724	82.6643	7.95	625	364.84736	248.51	208.95	58.9056	24.299	24.32	0.32	0.00	254.919	46.5	15.57	11.03	0.541	0.002
48	Nuapada	Kendumunda	KW	Sinapali	20.071	82.5716	7.67	1640	941.5575	395.77	432.83	75.4728	49.702	135.2	95.9	0.00	528.047	211.6	45.31	48.53	0.604	0.005
49	Nuapada	Dhungiamunda	KW	Sinapali	20.0365	82.5521	7.84	1852	1196.0569	253.11	611.93	55.224	27.612	110	295.5	0.00	746.549	167.4	43.51	45.62	0.696	0.008
50	Nuapada	Karangamal	KW	Boden	20.1542	82.6303	8	983	636.38184	345.15	258.7	77.3136	36.448	98.7	9.8	0.00	315.614	153.5	23.95	46.06	0.349	0.006
51	Nuapada	Rokal	KW	Rajkharia r	20.2227	82.644	8.24	957.8	533.9394	179.48	208.95	53.3832	11.045	98.4	15.6	0.00	254.919	130.2	25.95	6.65	1.73	0.008
52	Nuapada	Uparpita	KW	Rajkharia r	20.2474	82.6584	8.01	952	558.44956	372.76	348.25	71.7912	46.388	51.2	14.4	0.00	424.865	79.05	33.33	11.98	0.352	BDL

53	Nuapada	Budhapada	KW	Rajkharia r	20.3033	82.668	8.1	485	308.38798	211.69	184.08	46.02	23.194	28.38	0.79	0.00	224.572	41.85	19.46	3.01	0.718	0.001
54	Nuapada	Sonapur	KW	Boden	20.2773	82.5965	8.28	956	560.55302	276.12	293.53	57.0648	32.03	97.31	4.43	0.00	358.101	130.2	21.46	3.07	1.97	0.008
55	Nuapada	Kerapadar	KW	Boden	20.2298	82.571	7.87	385	264.55942	207.09	184.08	47.8608	20.985	16.89	3.76	0.00	224.572	27.9	9.182	1.87	0.191	BDL
56	Nuapada	Litisargi	KW	Boden	20.1751	82.5826	8.02	987.2	641.6396	253.11	288.55	55.224	27.612	129.4	18.8	0.00	352.031	172.1	24.95	5.52	0.169	0.004
57	Nuapada	Nilji	KW	Sinapali	20.1021	82.5936	7.84	1035	634.31108	322.14	278.6	53.3832	45.284	85.1	60.5	0.00	339.892	148.8	31.44	34.95	0.515	0.008
58	Nuapada	Gorla	KW	Sinapali	20.118	82.529	7.54	825.3	516.7941	289.93	283.58	60.7464	33.134	53.3	34.7	0.00	345.962	69.75	21.76	36.47	0.352	0.002
59	Nuapada	Mahulkot	KW	Rajkharia r	20.1999	82.7499	8.02	601	406.18148	243.91	268.65	31.2936	39.761	33.64	26.4	0.00	327.753	53.48	19.56	4.59	0.88	0.007
60	Nuapada	Kotmal	KW	Rajkharia r	20.1899	82.7665	8.12	1064	646.20932	220.99	268.65	43.2584	27.084	131.3	25.8	0.00	327.753	172.1	28.14	21.11	0.809	0.009
61	Nuapada	Bhajipala	NHS	Nuapada	20.8272	82.4894	7.7	950.00	527.00	372.00	150.00	61.00	52.00	65.00	2.00	0.00	183.00	207.0	35.00	15.00	0.58	0
62	Nuapada	Darlimunda	NHS	Nuapada	20.8231	82.6317	8.2	650.00	369.00	194.00	269.00	31.00	28.00	80.00	4.00	0.00	328.00	47.00	14.00	5.00	1.67	0
63	Nuapada	Deobahal	NHS	Komana	20.3614	82.7044	7.8	400.00	205.00	179.00	160.00	43.00	17.00	13.00	2.00	0.00	196.00	25.00	8.00	1.00	0.36	0
64	Nuapada	Dharambandah	NHS	Nuapada	20.7342	82.4253	7.9	950.00	596.00	301.00	295.00	78.00	26.00	57.00	74.00	0.00	360.00	112.0	28.00	45.00	0.11	0
65	Nuapada	Godphula	NHS	Nuapada	20.8203	82.5658	7.9	350.00	189.00	158.00	83.00	39.00	15.00	8.00	5.00	0.00	101.00	42.00	26.00	5.00	0.02	0
66	Nuapada	Gotama	NHS	Nuapada	20.871	82.50	8.3	400.0	220.0	179.	150.0	51.0	12.00	9.00	10.0	0.00	183.	30.	12.	6.0	0.0	0

					7	08		0	0	00	0	0			0		00	00	00	0	2	
67	Nuapada	Kalyanpur	NHS	Nuapada	20.8625	82.5322	7.9	800.00	451.00	347.00	181.00	47.00	55.00	21.00	16.00	0.00	221.00	142.00	19.00	43.00	0.03	0
68	Nuapada	Khariar	NHS	Khariar	20.2944	82.7603	8.3	450.00	230.00	214.00	207.00	47.00	23.00	13.00	3.00	0.00	253.00	12.00	6.00	2.00	0.05	0
69	Nuapada	Komna 1	NHS	Komana	20.5014	82.6728	8.3	1100.00	565.00	224.00	492.00	20.00	41.00	151.00	5.00	0.00	600.00	32.00	19.00	3.00	1.40	0
70	Nuapada	Kurumpuri	NHS	Komana	20.7189	82.5869	7.8	800.00	427.00	306.00	212.00	41.00	49.00	50.00	6.00	0.00	259.00	112.0	26.00	17.00	0.09	0
71	Nuapada	Nawapara	NHS	Nuapada	20.7977	82.5361	8.3	650.00	372.00	255.00	145.00	41.00	36.00	37.00	1.00	0.00	177.00	120.0	22.00	28.00	0.07	0
72	Nuapada	Patparpalli	NHS	Nuapada	20.8456	82.5428	8	750.00	385.00	265.00	269.00	67.00	23.00	40.00	1.00	0.00	328.00	40.00	11.00	42.00	0.01	0
73	Nuapada	Potara	NHS	Nuapada	20.7397	82.4428	8.7	1050.00	589.00	173.00	398.00	18.00	30.00	168.00	6.00	9.00	467.00	117.0	11.00	2.00	1.86	0
74	Nuapada	Ranipur	NHS	Khariar	20.2786	82.7758	8	1000.00	546.00	378.00	316.00	20.00	78.00	73.00	5.00	0.00	385.00	112.0	34.00	35.00	0.67	0
75	Nuapada	Sahipala	NHS	Nuapada	20.8281	82.6778	7.3	2000.00	1058.00	597.00	455.00	55.00	109.00	150.00	70.00	0.00	556.00	297.0	55.00	50.00	0.08	0
76	Nuapada	Tarbod	NHS	Komana	20.6328	82.6153	8	400.00	225.00	168.00	129.00	49.00	11.00	20.00	2.00	0.00	158.00	37.00	12.00	17.00	0.45	0

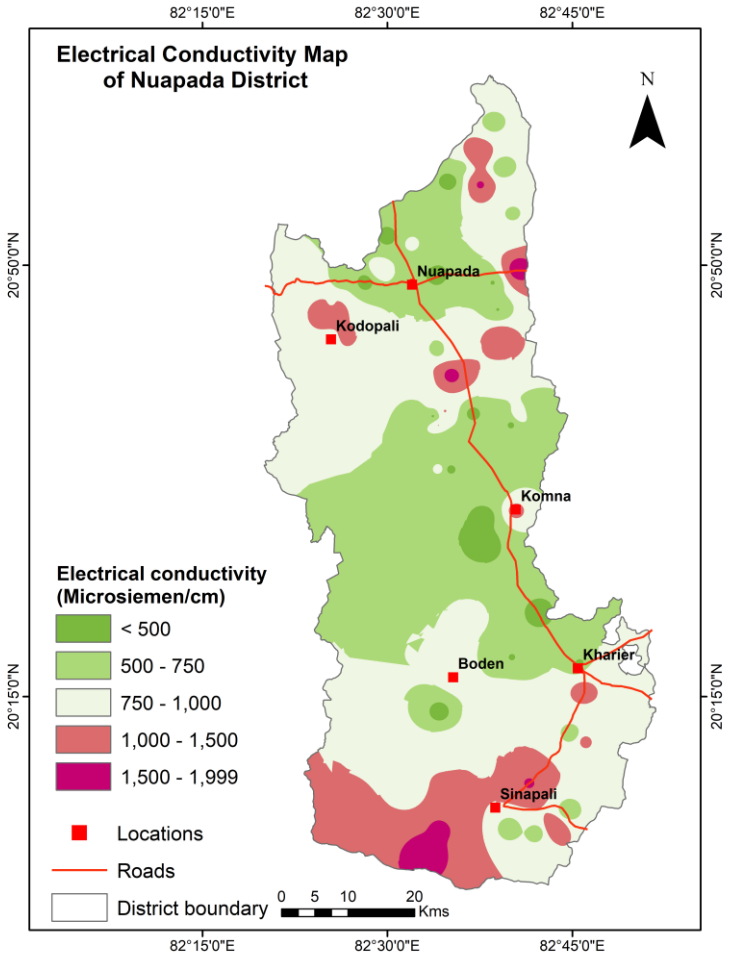


Fig. 3.4: Iso-conductivity Map of Phreatic Aquifer

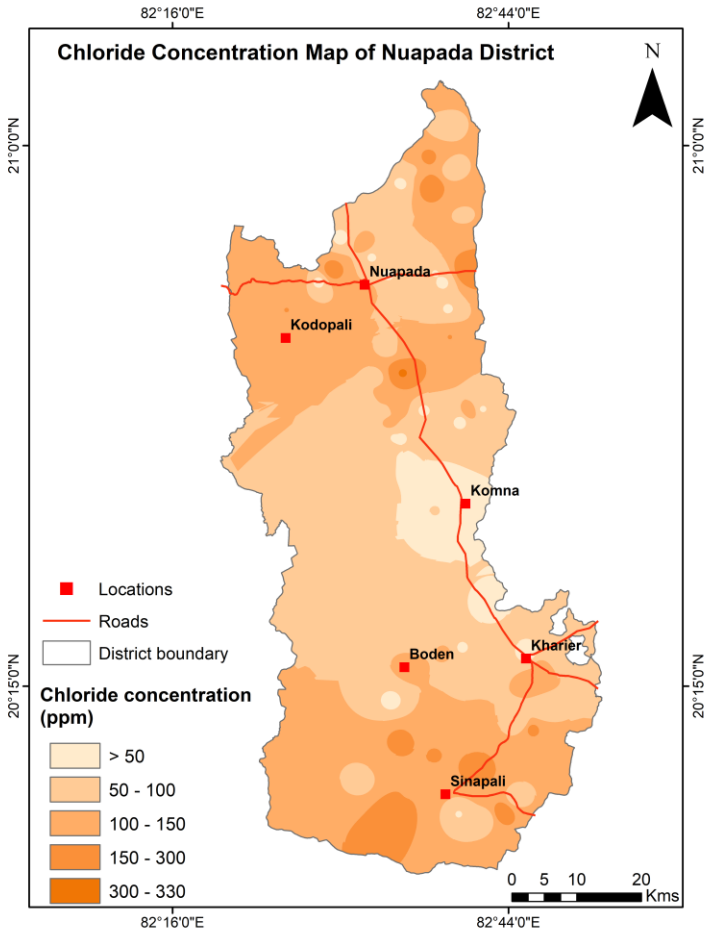


Fig. 3.5: Chloride Map of Phreatic Aquifer

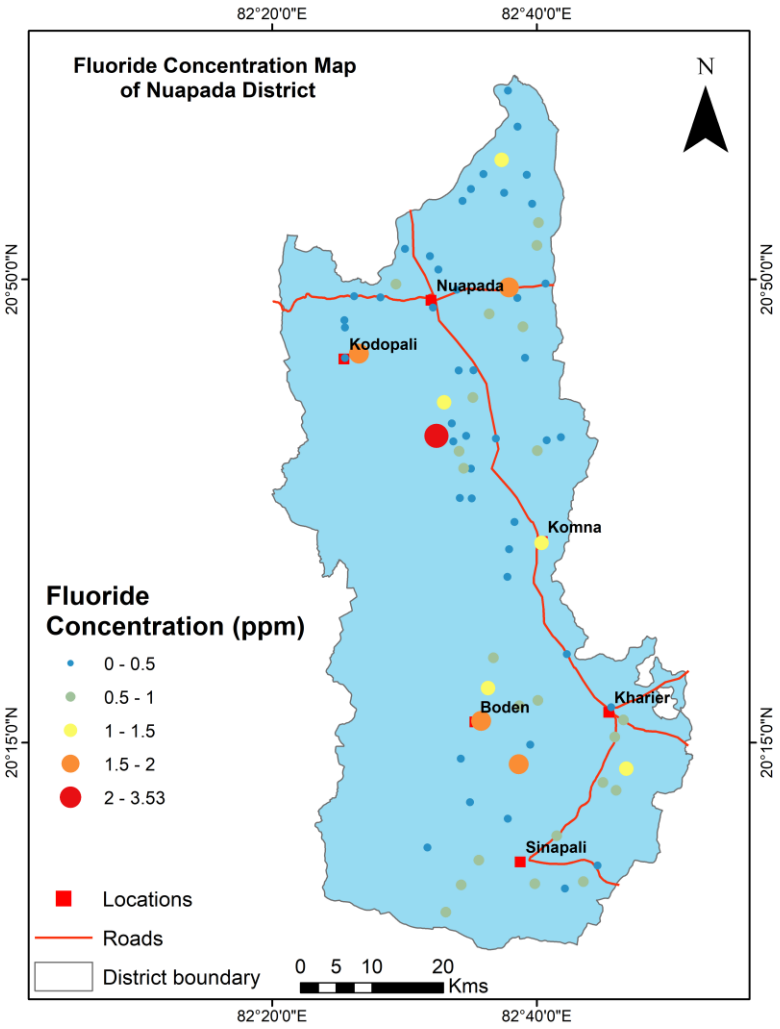


Fig. 3.6: Fluoride Map of Phreatic Aquifer.

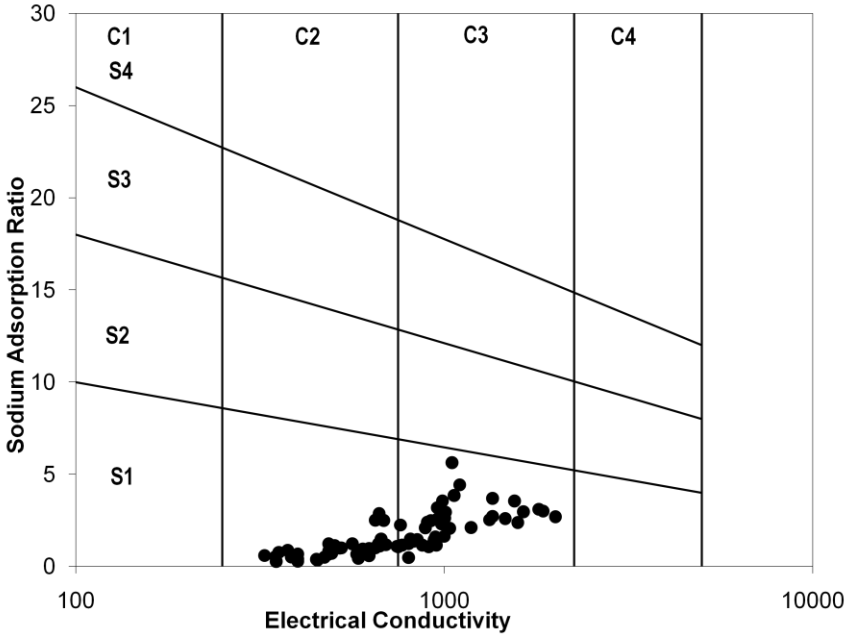


Fig. 3.7: US-Salinity Diagram, Phreatic Aquifer in Nuapada District.

(Suitability of water for irrigation use. Adapted from U.S. Salinity Laboratory Staff (1954).

S1, S2, S3 and S4 are Low, Medium, High and Very High Sodium Hazards respectively.

C1, C2, C3 and C4 are Low, Medium, High and Very High Salinity Hazards respectively.)

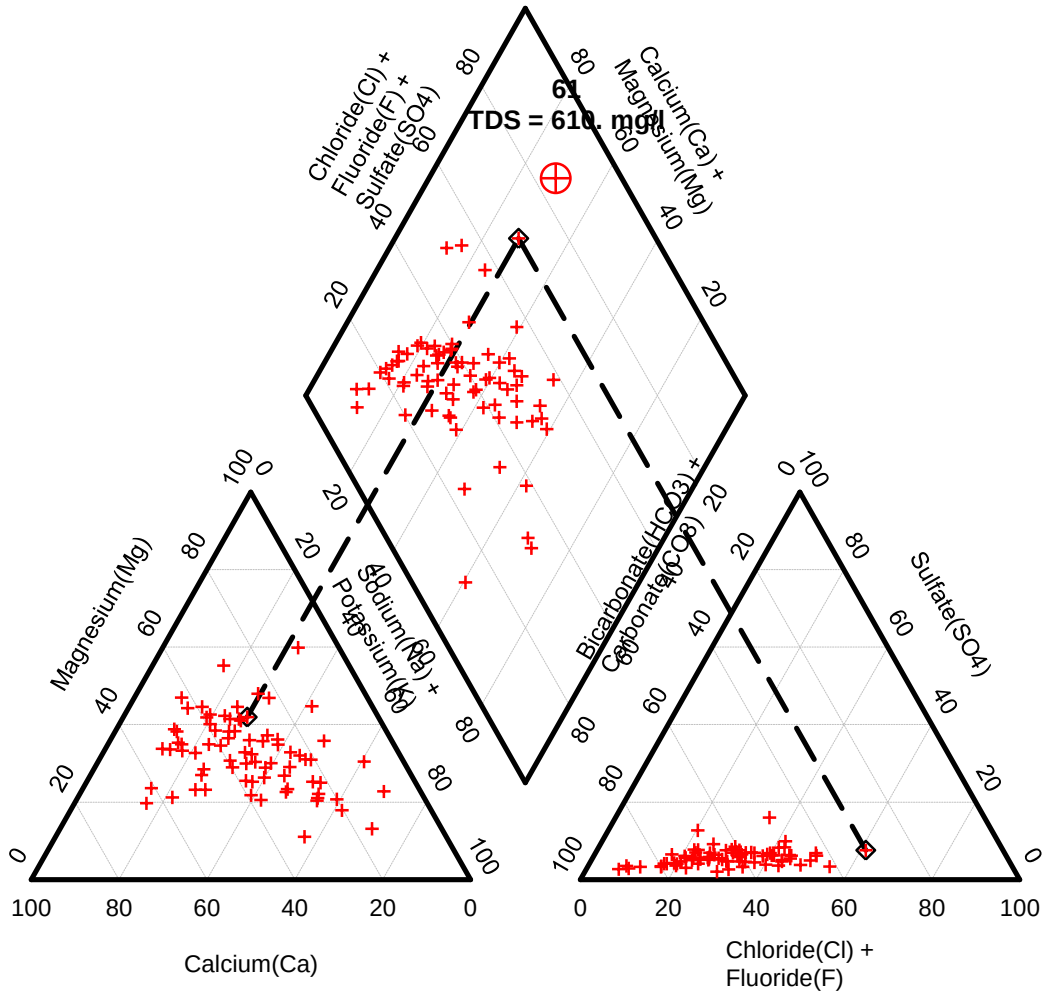


Fig. 3.8: Piper Diagram of Water Samples, Nuapada District

3.4 Aquifer Groups and Their Demarcation

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

Aquifer- I (Unconfined Aquifer): Unconfined aquifer, occurs in entire area except rocky outcrops, formed by the weathered mantle atop all crystalline formations and discontinuous alluvial tracts along major river

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

Aquifer-II(Semi-Confined to Confined Aquifer): Semi-confined to confined aquifer occurs as fracture zone aquifers in the entire area irrespective of rock types. However the aquifer properties, the yield of bore wells constructed in them depends on the rock type. As per the ground water exploration, carried out by CGWB. Aquifer-II in Granitic rocks has better yield in comparison to Charnockites and Khondalites. In general, most of the fracture zones are encountered within 30 to 180 mbgl and seldom beyond that. Thus the maximum depth for the Aquifer-II has been taken as 200 mbgl.

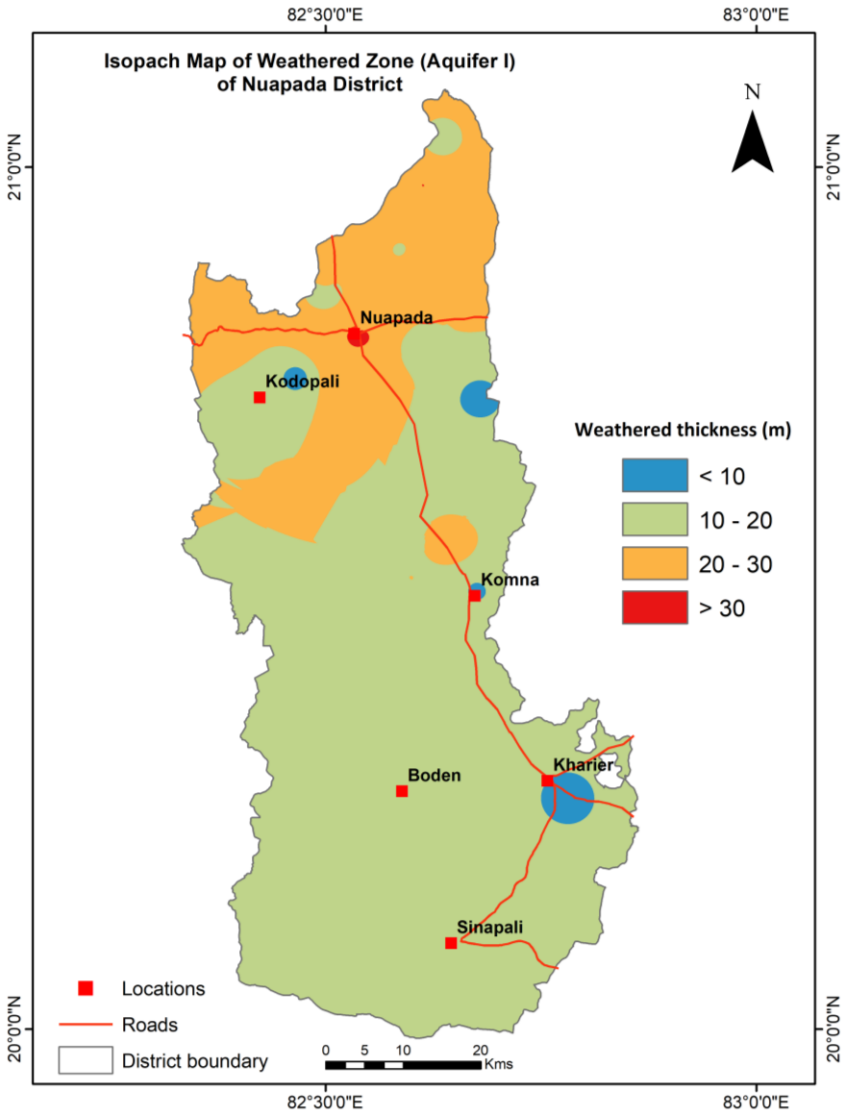


Fig. 3.9: Isopach of Weathered Zone (Aquifer-I) in Nuapada District.

The characteristics of the aquifer groups are summarized in **Table 3.2**.

Table 3.3: Characteristics of Aquifer Groups inNuapadaDistrict.

Type of Aquifer Group	Formation	Depth range (mbgl)	Yield	Aquifer parameter	Suitability for drinking/ irrigation
Aquifer-I (Phreatic)	**Unconsolidated and Weathered** **Recent**: Soil,sand, Alluvium & Laterite **Pre-cambrian**: Granite Gneiss, Charnockite, Khondalite,	0-30	12-580m^3/ day	Specific Capacity Index: 0.5-10.26 lpm/m/m^2	Yes for both
Aquifer-II (Semi-confined to Confined)	**Fractured** Granite Gneiss, Charnockite, Khondalite,	30-200	Negl.-13 lps	Transmissivity: 7.76-41.6	Yes for both

3.5 Aquifer Disposition

The ground water exploration data has been used to generate the disposition of the aquifer system. It comprises of all existing litho-units and the zones tapped during the ground water exploration, forming an aquifer. Six 2D schematic sections were drawn along lines A-B, C-D, E-F, G-H and I-J,K-L which are shown in plan view in Fig.3.10 and the corresponding 2D schematic sections are shown in Fig. 3.11 ,3.12, 3.13,3.14 3.15 and3.16. The 3D diagram for disposition of aquifer and fence digram of Nuapada District is given in Fig 3.17 and Fig.3.18

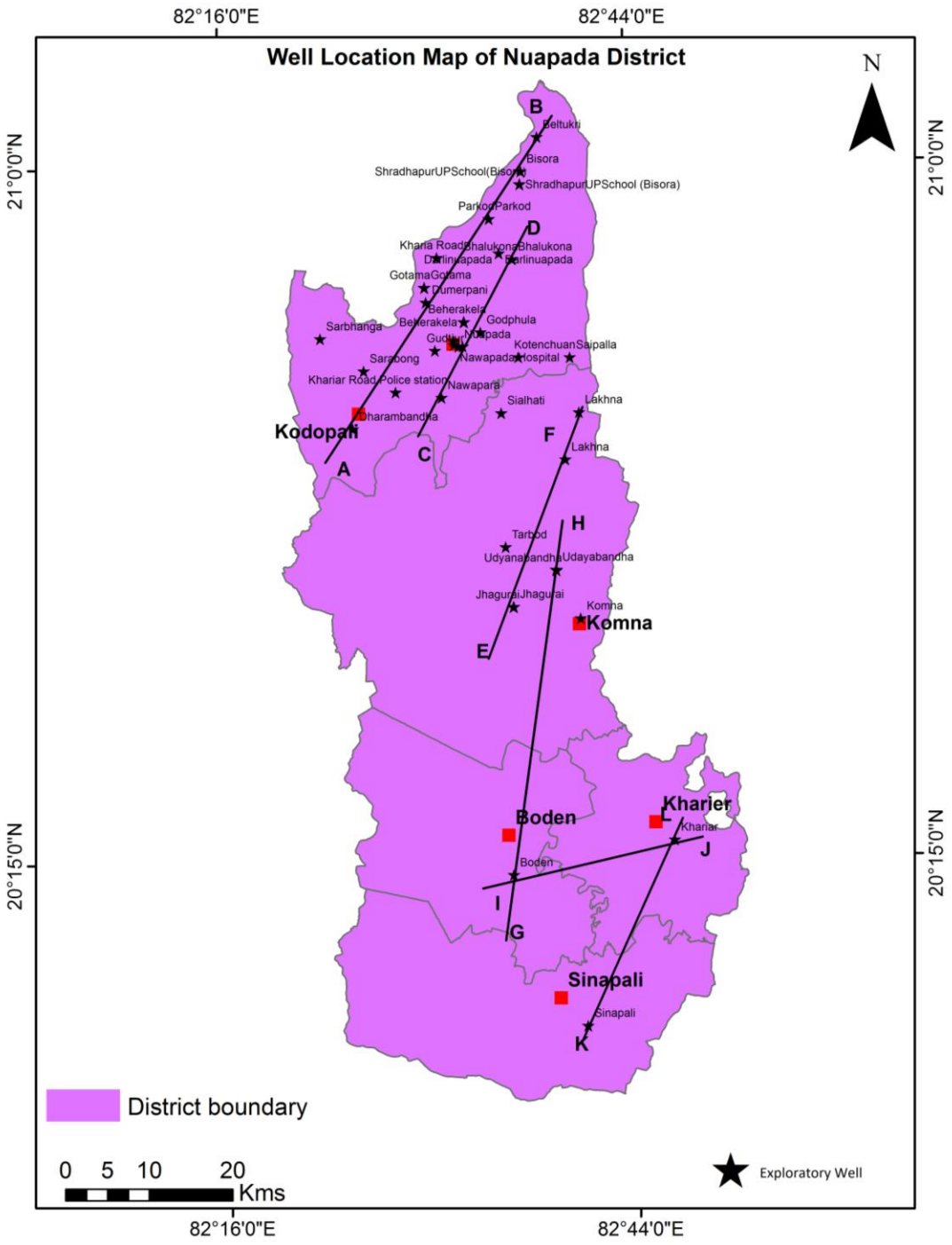


Fig. 3.10: Aquifer 2D Section Lines along A-B, C-D, E-F, G-H and I-J,K-L in Nuapada District.

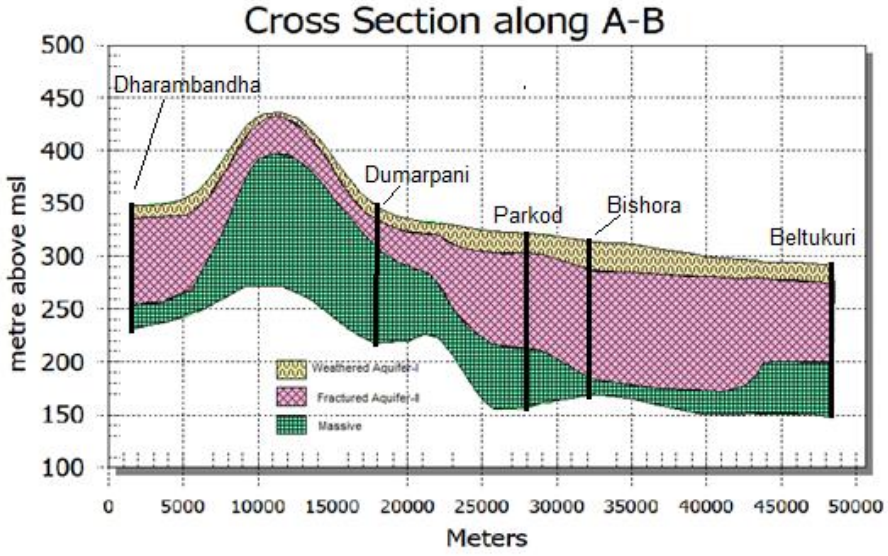


Fig. 3.11: Schematic Aquifer Cross-Section along A-B in Nuapada District.

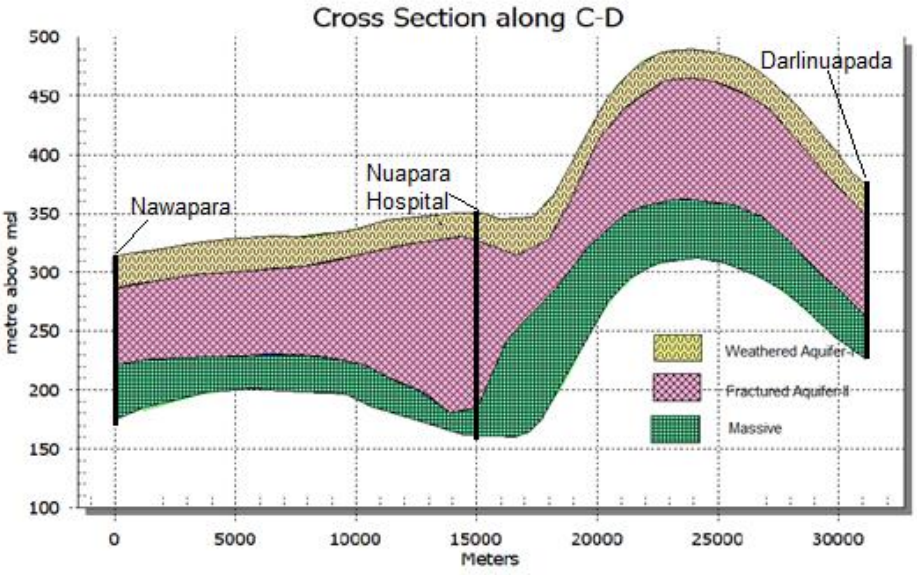


Fig. 3.12: Schematic Aquifer Cross-Section along C-D in Nuapada District.

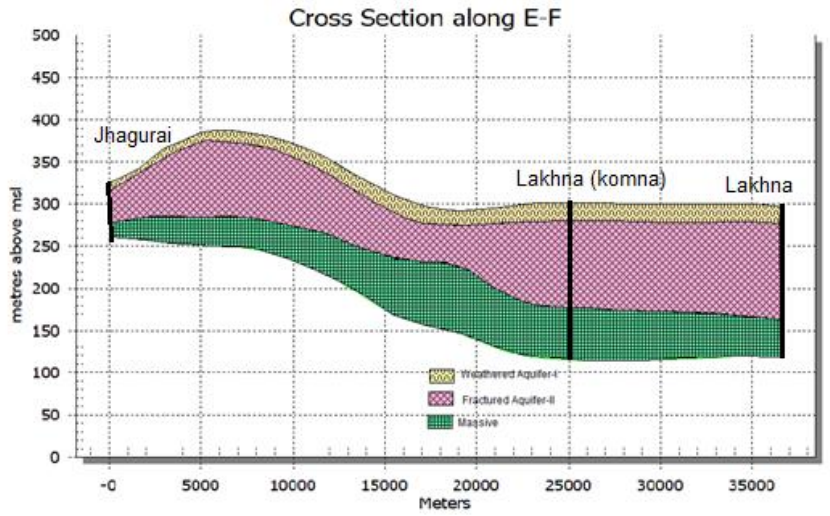


Fig. 3.13: Schematic Aquifer Cross-Section along E-F in Nuapada District.

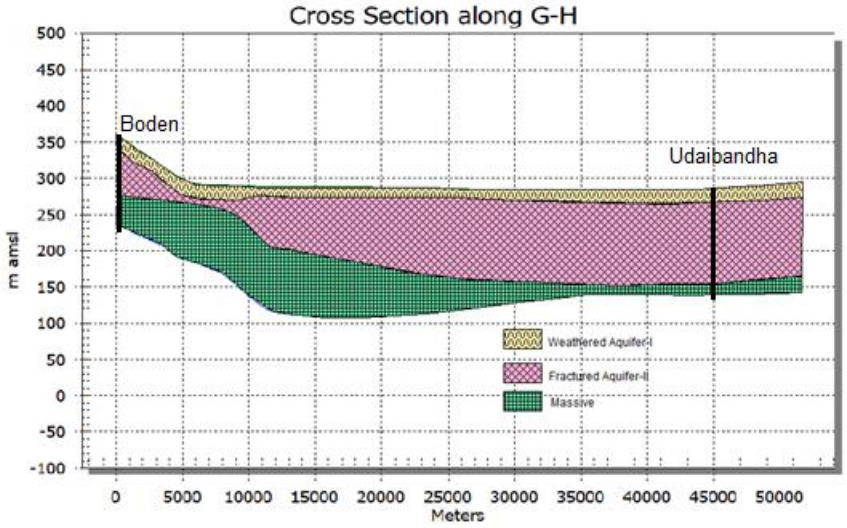


Fig. 3.14: Schematic Aquifer Cross-Section along G-H in Nuapada District.

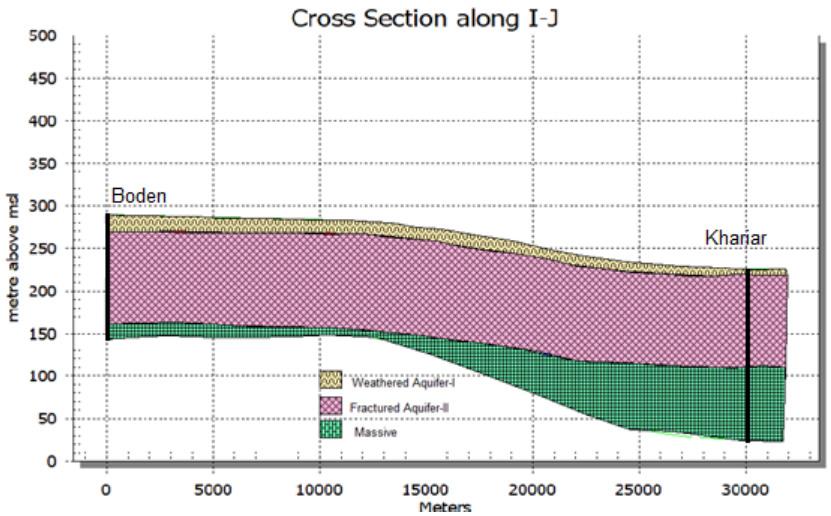


Fig. 3.15: Schematic Aquifer Cross-Section along I-J in Nuapada District.

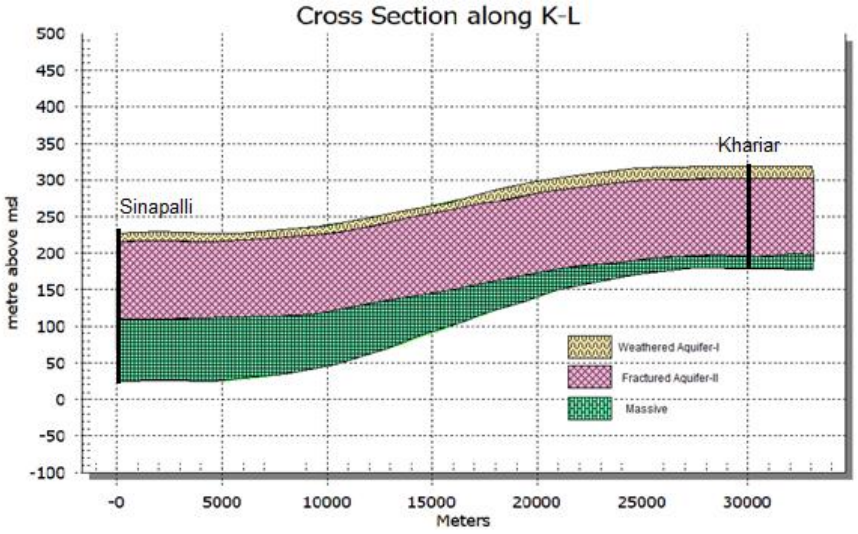


Fig. 3.16 Schematic Aquifer Cross-Section along K-L in Nuapada District.

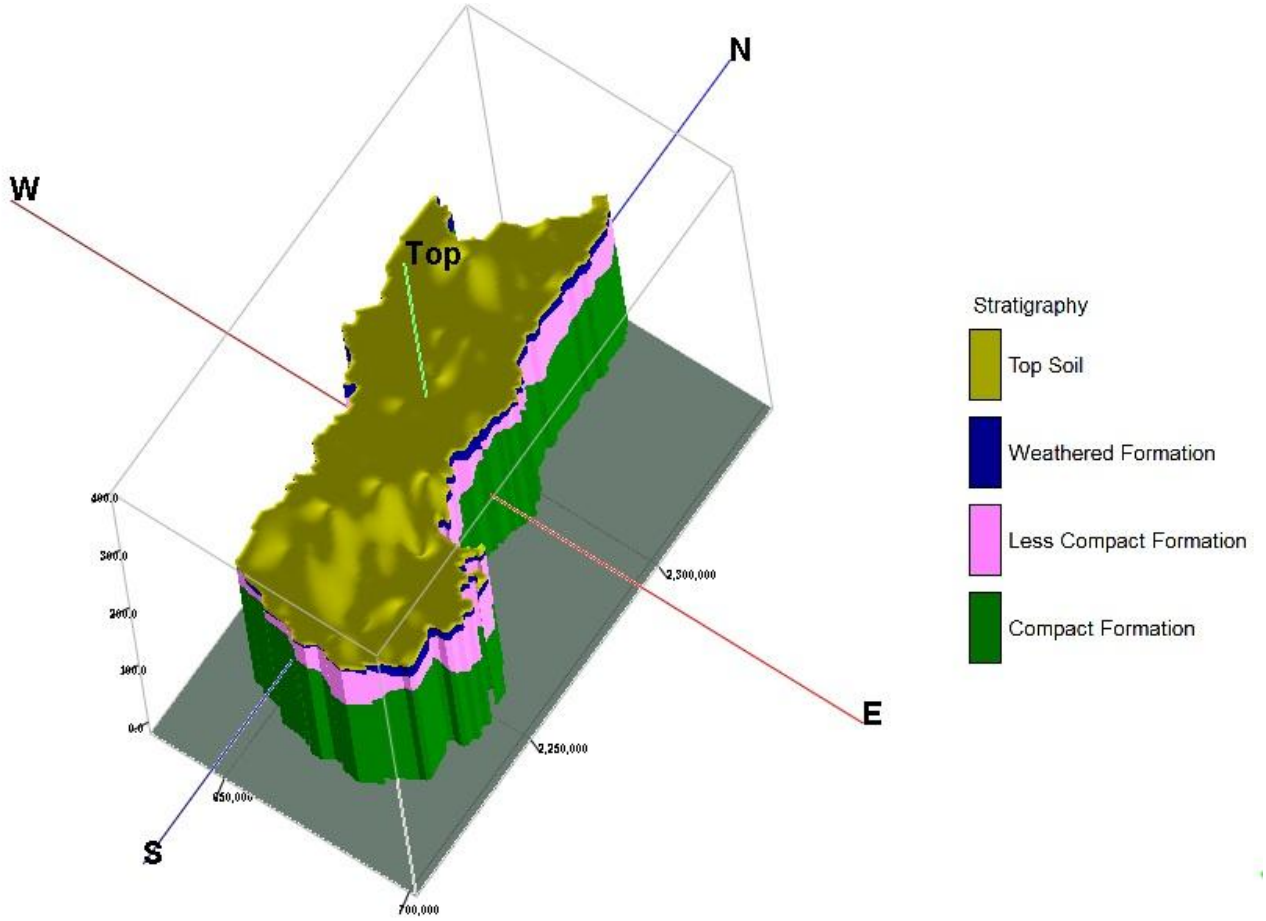


Fig. 3.17 3D Disposition of Aquifer in Nuapada District.

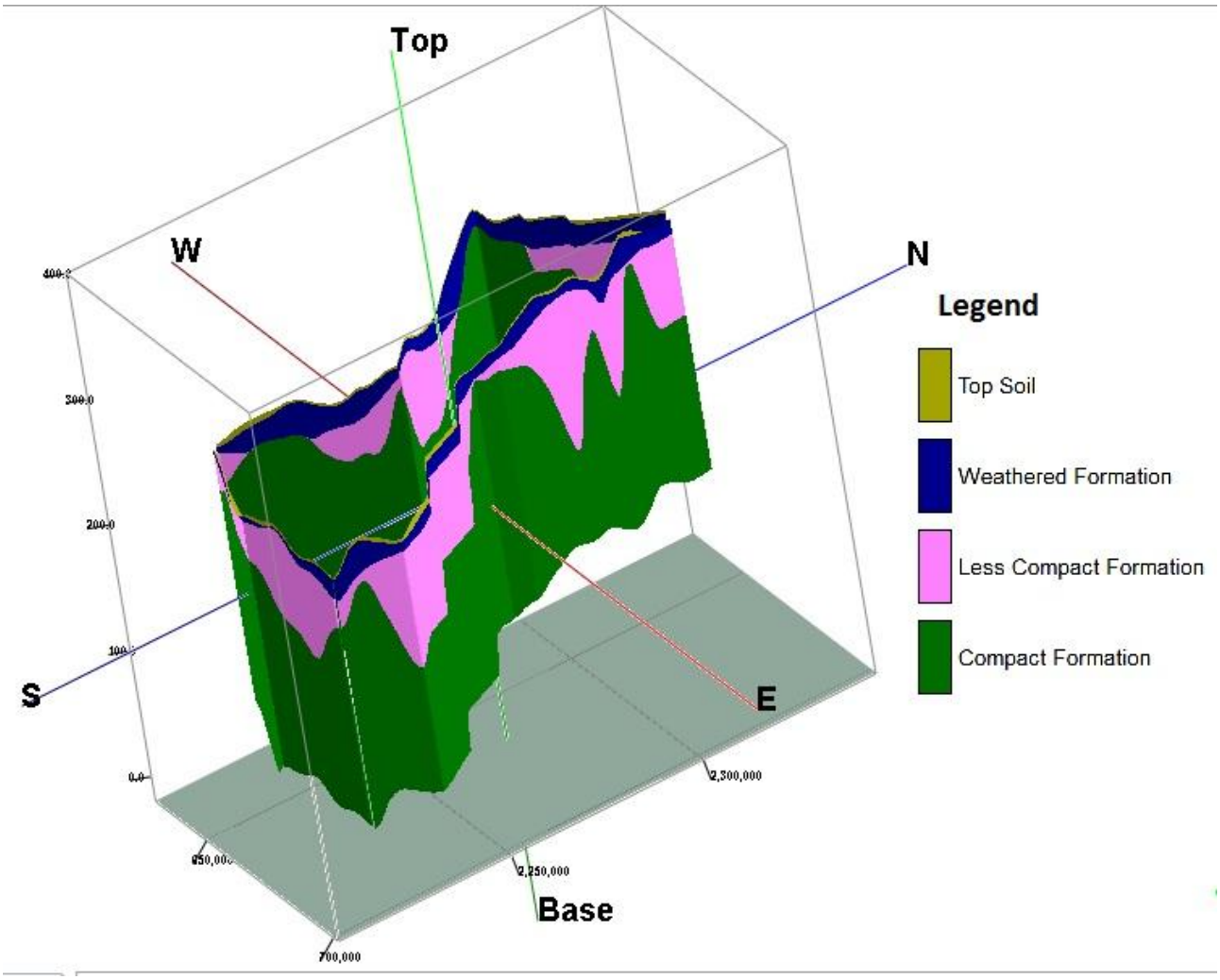


Fig. 3.18 Fence diagram of Exploratory wells in Nuapada District.

4 GROUND WATER RESOURCES

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

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

Sl No	Block	Net Annual Ground Water Availability	Existing Gross Ground Water Draft for Irrigation	Existing Gross Ground Water Draft for domestic & Industrial Supply	Existing Gross Ground Water Draft for all uses	Annual ground water allocation for domestic water supply as on 2025	Net Ground Water Availability for future irrigation development	Stage of Ground Water Development
		(Ham)	(Ham)	(Ham)	(Ham)	(Ham)	(Ham)	(%)
1	Boden	3417.85	1561.92	243.11	1805.04	252.49	1594.14	52.81
2	Khariar	4626.71	1859.29	565.62	2424.92	572.71	2148.21	52.41
3	Komna	8542.11	4578.79	414.98	4993.78	448.4	3505.61	58.46
4	Nuapada	8596.94	6070.95	406.90	6477.85	426.9	2085.84	75.35
5	Sinapali	4045.62	1949.42	323.35	2272.77	330.29	1751.97	56.17
	Total	29229.23	16020.37	1953.9	17974.36	2030.79	11085.77	**48.16**

The combined net ground water available is 29229.23 Ham and gross annual draft is 17974.36 Ham. The stage of ground water development is minimum for Khariar block which is 52.41 %. The highest ground water development is in Nuapada block that is 75.35 % .The Nuapada Block comes under semi-critical category.Other Blocks of the District are safe.The In-storage resources are calculated for Aquifer-I and II separately. However the semi-confined to confined deeper aquifers have linkage to the unconfined aquifer through the fractures and receive continuous recharge. The In-storage ground water resources of Aquifer-I are given in **Table 4.2** and the total resources of Aquifer-I in **Table 4.3**

below.

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

Sl No	Block	Assessment Area	Bottom Depth of Aquifer	Average Pre-monsoon Water Level	Total Effective Saturated Thickness 5% of (2-3)	Average Specific Yield	In Storage Ground Water Resources [(1)*(4)*(5)]
		(Ha) (1)	(mbgl) (2)	(mbgl) (3)	(m) (4)	(5)	(Ham) (6)
1	Boden	58787	30.00	5.60	24.4	0.03	2151.604
2	Khariar	40886	30.00	5.55	24.45	0.03	1499.494
3	Komna	128397	30.00	5.13	24.87	0.03	4789.85
4	Nuapada	87915	30.00	5.26	24.74	0.03	3262.526
5	Sinapali	69323	30.00	1.31	28.69	0.03	2983.315
	Total	385308					14686.79

Table 4.3: Total Ground Water Resources of Aquifer-I in Nuapada District. (2020)

Sl No	Block	Dynamic Resource	In Storage Resource	Total Ground Water
1	Boden	3417.85	2151.604	5569.454
2	Khariar	4626.71	1499.494	6126.204
3	Komna	8542.11	4789.85	13331.96
4	Nuapada	8596.94	3262.526	11859.47
5	Sinapali	4045.62	2983.315	7028.935
	Total	29229.23	14686.789	43916.02

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

Table 4.4: In-Storage Ground Water Resources of Aquifer-II in Nuapada District. (2020)

Sl No	Block	Assessment Area	Bottom Depth of Aquifer	Average Pre-monsoon Water Level	Total Effective Saturated Thickness 5% of (2-3)	Average Specific Yield	In Storage Ground Water Resources [(1)*(4)*(5)]
		(Ha) (1)	(mbgl) (2)	(mbgl) (3)	(m) (4)	(5)	(Ham) (6)
1	Boden	58787	200.00	5.60	9.72	0.03	17142.29
2	Khariar	40886	200.00	5.55	9.7225	0.03	11925.42
3	Komna	128397	200.00	5.13	9.7435	0.03	37531.09
4	Nuapada	87915	200.00	5.26	9.737	0.03	25680.85
5	Sinapali	69323	200.00	1.31	9.9345	0.03	20660.68
	Total	385308					**112940.3**

5 GROUND WATER RELATED ISSUES

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

5.1. Fluoride in Ground Water

Incidence of high concentration of fluoride in ground water of Nuapada district has been detected in the following areas as shownin Table5.1 and depicted in **Fig. 3.6**

Table 5.1: Fluoride Point Sourced Villages in Nuapada District.

Sl No	Village	Source	Block	Longitude	Latitude	Fluoride
1	Rokal	DW	Rajkhariar	82.644	20.2227	1.73
2	Sonapur	DW	Boden	82.5965	20.2773	1.97
3	Darlimuda	DW	Nuapada	82.6317	20.8231	1.67
4	Potara	DW	Nuapada	82.4428	20.7397	1.86
5	Komana	DW	Komna	82.6728	20.5014	1.4
6	Belardona	DW	Komna	82.5404	20.6363	3.53
Note: DW- Dug Well,						

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

5.2 Under Utilisation of Ground Water Resources

As per the ground water resource estimated jointly by CGWB and State Govt. in 2020, the Nuapada Block comes under semi-critical category and all other Blocks ofNuapada District comes under safe category.Thus there is ample scope exists for further ground water development in Blocks like Boden,Khariar,Komna,Sinapali. The Stages of ground water development in these Blocks are 52.81, 52.41, 58.46, and 56.17 % respectively. There is scope for extraction of water available from the phreatic aquifer keeping the percentage of ground water development within 60%.

5.3 Ground Water Problem in Hilly Areas

Nuapada district receives adequate rainfall and the normal annual rainfall is 1220mm. The western parts of the district are mainly of of hilly terrain and thus high run off zone. They act as recharge zones as well as good reservoir of ground water. Once they get saturated, during monsoon the excess water flows as run off and base flow. During the post-monsoon period, the thin weathered zones soon loose the entire storage water due to base flow. So there is scarcity of water in these areas in lean and summer season.

5.4 Depleted Water Level in Phreatic Aquifer

The Depth to water level in pre-monsoon period varies from 1.35 mbgl (Loharpali) to 9.61 mbgl (Kalyanpur) the average being 5.25mbgl. In general, the study area has the depth to water level in between 3 to6 mbgl during the pre-monsoon. The locations where the depth to water level is more than 8 m bgl are Gotama (8.30mbgl), Kalyanpur (9.61mbgl).The depth to water level of the study area during post-monsoon is in general within 3-4.5 mbgl. The locations where the depth to water level is more than 4.0 m bgl are Gotama (4.53mbgl), Bargaon-K (4.07mbgl),Komna (4.17mbgl),Khariar(4.32mbgl),and Ranipur (4.38mbgl).. The general range of fluctuation in water level in the study area is between 1-3m. The locations where the fluctuation of water level is more than 5 m is Kalyanpur(6.01). The shallow post-monsoon water level along with fluctuation pattern indicates that the annual replenishment of phreatic aquifer due to monsoon rainfall is adequate in the district but deeper summer level is due to rapid dewatering of the phreatic aquifer .The deeper level during the pre-monsoon indicates ground water scarcity in the areas during the summer months.

6 MANAGEMENT STRATEGIES

6.1 Management Plan for Higher Concentration of Fluoride

Though there are fluoride in many of the villages as discussed earlier, they are mostly found in shallow aquifers (dugwells) and medium deep borewells mostly drilled by the state govt. agencies. The occurrence of fluoride are point specific and there are alternate sources available. State Government has banned the construction of bore wells in the District and making arrangement to provide surface water from dams and river for domestic use.

6.2(a) Management Plan for Under-Utilisation of Ground Water

(For Komna, Khariar, Sinapali, Boden Blocks)

The Block wise water availability demand,and Gap scenario of the district is depicted in **Table 5.2,5.3** and Water Demand , Supply and Gap Scenario in Nuapada District.

Table.5.2 Blockwise Existing water Availability

Sl No	Block	Existing water Availability(BCM)		Total (BCM)
		Surface water	Ground water	
1	Nuapada	0.35	0.07833	0.42833
2	Komna	0.46	0.11665	0.57665
3	Boden	0.26	0.05247	0.31247
4	Khariar	0.16	0.03973	0.19973
5	Sinapali	0.27	0.04972	0.31972
Total		1.5	0.3369	1.8369

Source.District Irriation plan,Nuapada District,Govt of Odisha

Table.5.3 Block wise total water demand for various sectors(BCM)

Sl No	Block	Components				Demand projected for year 2020
		Domestic	Crop	Livestock	Total	
1	Nuapada	0.005701	0.546187	0.00195	0.553838	0.6303
2	Komna	0.004643	0.4542195	0.00287	0.4617325	0.5258
3	Boden	0.002799	0.2142025	0.00227	0.2192715	0.25
4	Khariar	0.004079	0.2909975	0.00266	0.2977365	0.3393
5	Sinapali	0.003815	0.27284	0.00256	0.279215	0.3182
Total		0.021037	1.7784465	0.01231	1.8117935	2.0639

Source.District Irriation plan,Nuapada District,Govt of Odisha

Table.5.4 Block wise total water Gap (BCM)

Sl No	Block	Water Demand (BCM)	Water Availabilty (BCM)	Gap
1	Nuapada	0.6303	0.42833	0.20197
2	Komna	0.5258	0.57665	-0.05085
3	Boden	0.25	0.31247	-0.06247
4	Khariar	0.3393	0.19973	0.13957
5	Sinapali	0.3182	0.31972	-0.00152
Total		2.0639	1.8369	0.227

Source.District Irriation plan,Nuapada District,Govt of Odisha

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

For the supply side intervention, further development of ground water resource is possible as there is sufficient scope for this is available in the district as the present ground water development ranges from 52.41 % to 58.46 % in the district. The quantum of water available for extraction from the phreatic aquifer is thus calculated, keeping the percentage of ground water development within 60%. The same is shown in the **Table 5.3**.

Table 5.5: Ground Water Development Potential of Nuapada District.

Block	Net Ground Water Availability (Ham)	Stage of Ground Water Development (% in 2020)	Present Ground Water Draft (Ham)	Ground Water draft at 60% Stage of development (Ham) (1)*0.6	Surplus Ground Water at Present Stage of development (Ham) (4)-(3)	Number of BW/ STW Recommended in Each block (assuming unit draft as 2.21 ham per structure per year) 50%	Number of DW Recommended in Each block(assuming unit draft as 0.26 ham per structure per year) 50%
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Boden	3417.85	52.81	1805.04	2050.71	245.67	56	472
Khariar	4626.71	52.41	2424.92	2776.026	351.106	79	675
Komna	8542.11	58.46	4993.78	5125.266	131.486	30	252
Sinapali	4045.62	56.17	2272.77	2427.372	154.602	35	297

StructuresFeasible: The feasible ground water structures and probable yield in different geological units in Nuapada district is given below:

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

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

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

6.2 (b) Management plan for Nuapada Block

As per the Ground water Resource estimation 2020 The Nuapada Block comes under Semi-critical category, all the other blocks namely Boden,Khariar,komna,Sinapali is under safe category. So the following intervention is made for Nuapada block to make it under safe category.

The ground water resources of the block werewas estimated jointly by CGWB and state ground water department using GEC 2015 methodology. The details are given below.

Table 5.6: Ground water resource estimation (2020) of Nuapada Block

Sl No	Block	Net Annual Ground Water Availability	Existing Gross Ground Water Draft for Irrigation	Existing Gross Ground Water Draft for domestic & Industrial Supply	Existing Gross Ground Water Draft for all uses	Annual ground water allocation for domestic water supply as on 2025	Net Ground Water Availability for future irrigation development	Stage of Ground Water Extraction	Categorization
		(Ham)	(Ham)	(Ham)	(Ham)	(Ham)	(Ham)	(%)	
1	Nuapada	8596.94	6070.95	406.90	6477.8	426.9	2085.	75.35	Semi critical

Table 5.7: Comparison of GWRA 2020 with that of GWRA 2017 of Nuapada Block

Sl No	Year	Net Annual Ground Water Availability	Existing Gross Ground Water Draft for Irrigation	Existing Gross Ground Water Draft for domestic & Industrial Supply	Existing Gross Ground Water Draft for all uses	Annual ground water allocation for domestic water supply as on 2025	Net Ground Water Availability for future irrigation development	Stage of Ground Water Development	Categorization
		(Ham)	(Ham)	(Ham)	(Ham)	(Ham)	(Ham)	(%)	
1	2017	8672.68	4560.32	397.12	4957.44	418.27	3670.93	57.16	Safe
2	2020	8596.94	6070.95	406.90	6477.85	426.9	2085.8	75.35	Semi-critical

Table 5.8: Demand and Supply Scenario of Nuapada block

Demand (Ham)				Supply (Ham)			
Domestic	Livestock	Crop Water	Total	SW+GW	GW	SW	Gap (Rainfed)
692.2	273	54618.7	55583.9	19662.7	6070.95	13591.8	34956

From the above table, It is evident that the net demand of water for domestic and livestock is negligible in comparison to the crop water demand.

a) Demand side measures

In Nuapada Block, the source-wise irrigated area during Kharif and Rabi season is given in **Table 5.9**. The irrigation through other sources i.e. ground water is 6316 Ha in Kharif and 2362 Ha in Rabi season.

Table 5.9Source-wise Irrigation potential (Ha) in Nuapada Block.

Year/Block (2017-18)	Major/Medium Irrigation Projects		Minor Irrigation Project				Other Sources		TOTAL	
			Flow		Lift					
	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
Nuapada	1204	2500	747	60	1660	1672	**6316**	**2362**	19927	6594

Source; District Statistical Hand Book (2018) of Nuapada District, Govt of Odisha

In rabi season Paddy is cultivated in 14127 Ha. As the Nuapada block has already attained semi-critical stage, cultivation of water intensive paddy in rabi season using ground water is unsustainable.

Therefore the following demand side measure is proposed:-

1. Change of cropping pattern by switching to low water intensive crops in place of paddy during the rabi season. By changing in cropping pattern to Moong (green gram), 0.9 Ham water can be saved

per hectare.

2. Other measures like drip Irrigation and Sprinkler irrigation techniques should be used to save water. Irrigation through surface water should be encouraged rather than using Ground water for Irrigation.

b) Supply side measures

As the Nuapada block has attained semi-critical stage, no supply side measure involving ground water is feasible other than augmenting the ground water resources through artificial recharge. To increase supply of water to meet the irrigation demand of the block enhancement and effective management of surface water irrigation schemes should be prioritised.

i) Source water availability;-

The Nuapada block receives about 1007.4 mm of rainfall annually. For adopting artificial recharge structures, the rain water will be the source of water.

ii)Feasibility of Artificial Recharge-

From the water level trend analysis for the period (2015-20), it is found that the north western and eastern part of the block shows post-monsoon falling trend of water level (Gotama-0.3753 m/year, and Sahipala-0.2596 m/year) and the depth to water level in this area is also within 4-5 mbgl and hence these areas are feasible for artificial recharge. Thus various artificial recharge structures are proposed to be constructed in the recharge areas of Nuapada block. To restore the ground water development in Nuapada block to below 60% from current 75.35%, the volume of water to be recharged to the aquifer is calculated in **Table-6.0** below.

Table-5.10 Number of proposed AR Structures in Nuapada Block

Number of Feasible AR structures									
Block	Net Ground Water Availability in Ham	Current Draft (at SOE 75.35%) in Ham	60 % of Available Resource in Ham (1*0.60)	Vol. of water in Ham to be Recharged to reduce stage to 60% (2-3)	Required water taking AR structures Efficiency 80% (4*1.2)	Percolation tank (40% of 5) @0.2 MCm	Checkdam (25% of 5) @0.15 MCM	Nala bund (25% of 5) @0.15 MCM	Farm pond (10% of 5) @0.10 MCM
	1	2	3	4	5	6	7	8	9
Nuapada	8596.94	6477.85	5158.164	1319.686	1583.6	32	26	26	16

The feasible artificial recharge structures are percolation tanks, nalah bunds, small check dams, farm ponds etc. and the required number of these structures is estimated as above.

iii) Types and Locations of artificial recharge structures

Allocation of different types of artificial recharge structures, presented in **Table 5.11**,have been done based on the topography. The area is a kind of mid-land area (300-600m amsl elevation). The number of structures to be constructed is worked out taking average gross capacity of one percolation tank as 200 TCM, for Nala bund /check dam as 150 TCM and for farm pond 100 TCM in multiple fillings.

The total number of recharge structures has been estimated as 32, 26, 26 and 16 for the percolation ponds, check dam, nala bunds and farm ponds respectively. The tentative locations for construction of these artificial recharge structures are shown in**Fig 5.1**.

iv) Cost Estimate of Artificial Recharge Structures

Taking into account the various Artificial Recharge Structures proposed in Nuapada Block as mentioned above the tentative cost estimate of total Artificial Recharge Structures proposed is given below in Table 5.11

v) Conclusion/reccomendations:

As per GWRA 2020 the annual extractable Ground water recharge is 8596.94 Ham, total draft accounts for 6477.85 ham at 75.35% stage of Ground water development. The block comes under semi-critical category. To bring back the block to safe category different supply side measures and demand side measures has been proposed. After adopting the measures the block may come under safe category.

Ground water proposed to recharge through AR by adopting supply side measures = 13.19 MCM, So that the block may come under safe category.

Table 5.11 Cost Estimate of Artificial Recharge Structures

Recharge Structures	Number of structures feasible	Unit cost of structure (in Lakhs)	Total Cost **(Rupees in Crores)**
Percolation tank (40%) @0.2 MCM	32	2	6.40
Checkdam (25%) @0.15 MCM	26	5	1.30
Nala bund (25%) @0.15 MCM	26	5	1.30
Farm pond (10%) @0.15 MCM	16	3	0.48
Total Cost (Rupees in Crores)			9.48

6.3 Management Plan for Scarcity of Water in Hilly Areas

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

6.4 Management Plan for Depleted Water Level in Phreatic Aquifer

The problem of water level depletion in the phreatic aquifers can be addressed through artificial recharge through various water conservation structures. However, as already discussed, water level between 3- 5 mbgl during post-monsoon period in most of the district shows adequate natural recharge and replenishment of phreatic aquifer.But there is still a lot of scope for artificial recharge to address the sustenance of phreatic aquifer to address the summer period water crisis due to deepening of water level. All the existing 1st order streams are suitable for construction of nala bunds.Similarly 2nd and 3rd order drainages are suitable for the construction of check dams.For the mitigation of deeper water level areas in thedistrict, the following measures can be taken up:

1. Contour trenching, staggered trenching and gabion structures to arrest the surface runoff in foot-hill areas.
2. Construction of farm ponds and renovation of existing water bodies.
3. Construction of 32 percolation tanks, 56 checkdams,26 nala bunds,23 farm ponds can be done in Nuapada District.

The proposed sites for artificial recharge structures are shown in **Fig. 6.1**

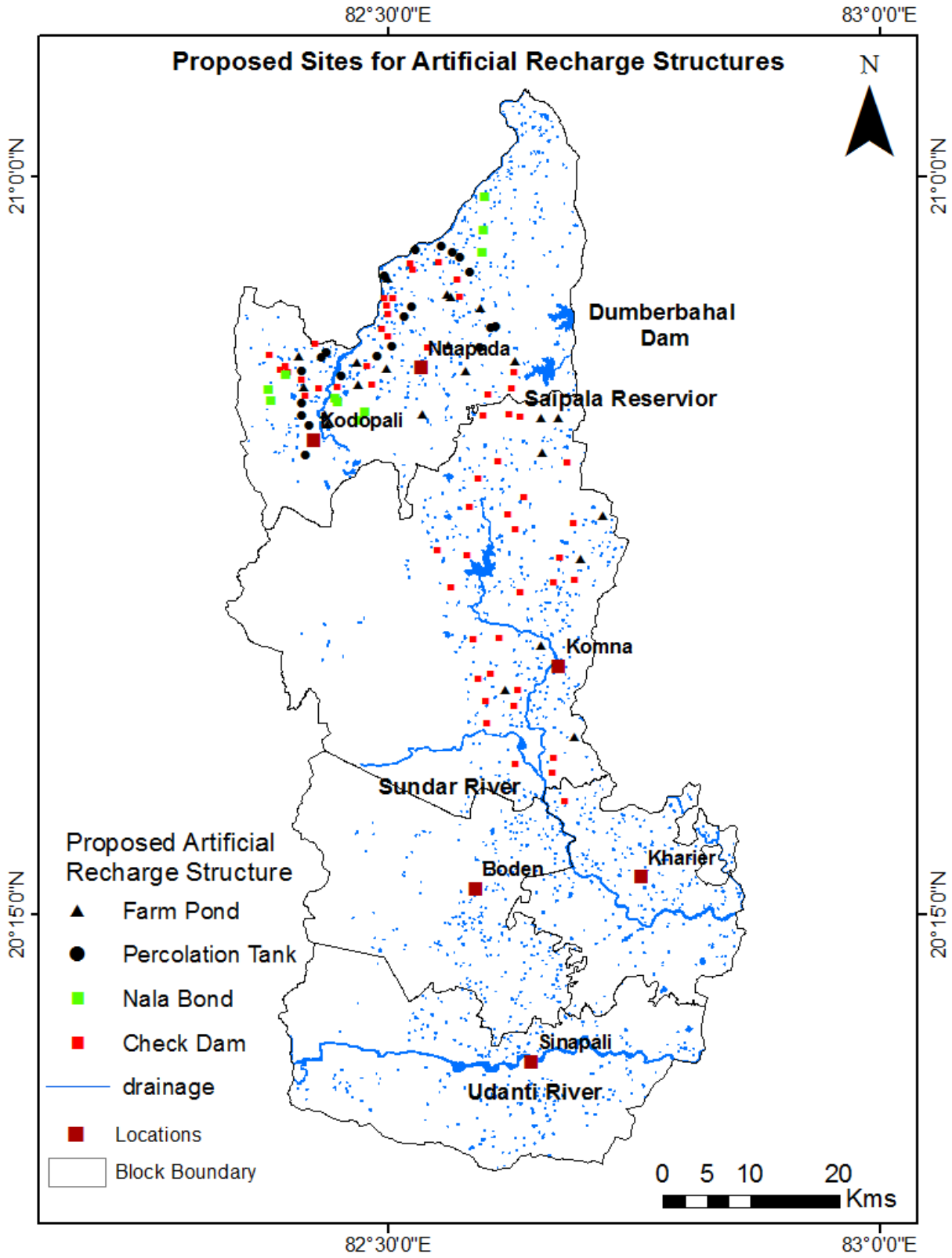


Fig 6.1 Proposed Artificial Recharge structures in Nuapada District

6.5 Organising Public interaction programmes(PIPs)

To create awareness among local public, farmers and various stake holders of Ground water CGWB has organized various PIPs and mass awareness programmes in the state of Odisha .In this context twopublic interaction programmes has been organized in Boden,Khariar blocks of Nuapada Districtto discuss about local issues,sustainable Ground water development and management, water conservation,Rain water Harvesting and Artificial Recharge techniques.

7 SUMMARY AND RECOMMENDATIONS

7.1 Summary

National Aquifer Mapping Programme (NAQUIM) was taken up for detailed hydrogeological investigation, data-gap analysis and Aquifer Mapping and Management in the district of Nuapada, covering five blocks namely Boden, Khariar, Komna, Sinapali,and Nuapada covering an area of 3852 sq. km., during the period 2020-21 The following are the summarised details.

1 Nuapada District is located in the western part of Odisha, lies between $20^0$00' and $21^0$05' North latitudes and $82^0$28' and $82^0$40' East longitudesand falls in the Survey of India Toposheet Nos. 64L/5,64L/6,64L/7,64L/8,64L/9,64L/10,64L/11,64L/12,64L/15,64L/16,64K/12and64I/9 (1:50,000 scale). Its boundaries extend in the north, west and south to Raipur district of Madhya Pradesh and in the east Bargarh, Bolangir and Kalahandi districts. The mappable area under NAQUIM is 3852 sq. Km, This study area was taken up after excluding the hilly areas.

2 The average annual rainfall for 10 yrs(2011 – 2020)is 1220 mm. it was observed that during the last 10 years, from 2011 to 2020, the highest rainfall amounting 2034.1mm occurred in Khariar block in 2014 and the lowest annual of 482.1 mm. in Boden block in 2012.

3 The forest area is 14.64% of total geographical area of 3852km^2. The net area sown is 68.07% with cropping intensity of 156.0 %.

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

5 The total cropped area is 157129 Ha out of which 68.07% (106971 Ha) is irrigated and rest 31.93% area are rainfed.

6 There are two major sources of water available in Nuapada district,namely surface irrigation and ground water irrigation. The surface irrigations include Canal (Major & Medium Irrigation), minor

irrigation, lift irrigation, Various Water Bodies including Rain Water Harvesting, Untreated Effluent and Perennial sources of water. For the ground water includes Open well (Dug well), Deep Tube Well, Medium Tube Well (Bore well), Shallow Tube Wells respectively. All the area is divided as per seasons like Kharif and Rabi. Based on the season, the area under canal water in Kharif is 47917 ha, for Rabi season is 11515 ha and the total area under canal water is 59432 Ha. The total area available through minor irrigation is 9141 Ha, and the area under lift irrigation is 726 Ha. The area under the perennial sources of water extents is 1398Ha. 106 Similarly, the area under open well is 1564 Ha, Bore well is 44587 Ha.

7 The district is underlain by Granite-gneiss and its variants,of Easern-ghat group and Chhattisgarh Group a small patch of alluvium and laterites.

8 The district is occupied by the consolidated formations comprising Granites, Granite gneiss, Quartzites, Khondalites and Charnockites, . These rocks are very hard and compact, and lack primary porosity. Ground water is stored mainly in the secondary porosity resulting from weathering and fracturing of the rocks. The aquifer materials are highly heterogeneous in character showing both vertical and lateral variations. The weathered residum form the main repositories of ground water, which occurs under water table conditions and circulates through deeper fractures and fissures. Ground water occurs under confined to semi-confined condition in the deeper fractured zones. The water yielding capacity of fractured rocks largely depends on the extent of fracturing, openness and size of fractures and extent of their interconnections into the near surface weathered zone.The Unconsolidated Formation includes alluvial deposits of recent origin occur as thin discontinuous patches along the prominent drainage channels. These mainly consist of silt, sand with gravel & pebble, which form potential shallow aquifers tapped through dug wells.

9 CGWB has constructed 32 EWs and 11 OWs during the ground water exploration programme. For the monitoring of ground water level and quality CGWB has established 20National Hydrograph Network Stations in the district.

10 The Depth to water level in pre-monsoon period varies from 1.35 mbgl (Loharpali) to 9.61 mbgl (Kalyanpur) the average being 5.25mbgl. Depth to water level in post-monsoon period varies from 0.95 mbgl (Loharpali) to 4.53 mbgl (Gotama) the average being 3.0 mbgl. The water level fluctuation varies from 0.02 mbgl (Sahipala) to 6.01mbgl (Kalyanpur) the average being 2.40 mbgl.The long term trend analysis indicates that out of 17 stations, 15(88.23%) show falling trend and 2 stations (11.77%) show rising trend in pre-monsoon. In the post-monsoon out of 17 stations

08(47.05%) show rising trend and 9(52.95%) show falling trend.

11 Based on the chemical analysis of water samples from different sources, it was observed that, almost all chemical parameters lie within permissible limit for drinking and irrigation purpose except few samples of some isolated pockets of Rajkhariar,Boden,Nuapada,Komna BlockswhereFluoride contamination above permissible limit has been detected. The higher fluoride concentration is restricted to shallow aquifers tapped by dugwells and shallow bore/tubewells. Deeper aquifer has fluoride content within permissible limit.

12 The estimated dynamic ground water resource is 29229.23 Ham and the stages of development of ground water range from 52.41 to 75.35 %.The ground water development is most in the Nuapadablock.

7.2 RECOMMENDATIONS

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

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

2 Diversification of crops from paddy to non paddy crops like oil seed, pulses and vegetables during rabi season at least in the high land and part of medium land areas is essential.

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

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

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

6 The occurrence of fluoride are point specific and there are alternate sources available. Deeper aquifers may be used for the domestic use in this area.Surface water should be used as alternate source for domestic use.

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

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

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

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

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

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Annexure

INTERPRETED VES RESULTS IN PARTS OF NUAPADA DISTRICT

Nuapada District_HR			WAPCOS Ltd.		PROJECT: VERTICAL ELECTRICAL SOUNDING(VES) IN ODISHA STATE DATA GENERATION									
S. No.	LOCATION	Block	VES NO.	EASTING/	NORTHING	Direct interpretion of VES layer parameters by software				Inferred lithology	Aquifer Charectristics			
				Longitude	Latitude	Layer	Resistivity (ohm.m)	Thickness (m)	Depth (m)		Aquifer	Depth Range(m)	Inferred aquifer water quality	
1	Amodi	Nuapada	141	44Q0669346	2330588	1	54	1.5	1.5	Top Soil				
						2	20	3.7	5.1	Weathered Formation(Alluvium)	Aquifer	1.5-5.1	Potable	
						3	4	4.1	9.2	Weathered Formation(Alluvium)				
						4	549			Compact Formation				
2	Gudapathera	Nuapada	142	44Q0671944	2323626	1	39	10	10.1	Weathered Formation	Aquifer	0-10.1	Potable	
						2	VH	53.4	63.5	Compact Formation				
						3	116	38.3	101.8	Less Compact Formation	Aquifer	63.5-101.8	Potable	
						4	VH			Compact Formation				

3	Saraipali	Nuapada	143	44Q06717 65	2326743	1	355	1.4	1.4	Top Soil				
						2	10	12.4	13.8	Weathered Formation	Aquifer	1.4-13.8	Potable	
						3	VH	28.9	42.7	Compact Formation				
						4	19.5			Less Compact Formation	Aquifer	42.7-?	Potable	
4	Masankuda	Nuapada	144	44Q06719 88	2319522	1	96	1.9	1.9	Top Soil				
						2	630	2.2	4.1	Top Soil				
						3	51	4.6	8.6	Weathered Formation	Aquifer	4.1-8.6	Potable	
						4	VH			Compact Formation				
5	Kuliabandha	Nuapada	145	44Q06687 93	2316901	1	146	1.7	1.7	Top Soil				
						2	47	9.5	11.2	Weathered Formation	Aquifer	1.7-11.2	Potable	
						3	VH			Compact Formation				
6	Chhindipani	Nuapada	146	44Q06704 59	2313095	1	54	0.8	0.8	Top Soil				
						2	25	7.0	7.8	Weathered Formation	Aquifer	0.8-7.8	Potable	
						3	VH	26.0	33.8	Compact Formation				
						4	18			Less Compact Formation	Aquifer	33.8-?	Potable	

7	Jampani	Nuapada	147	44Q0672654	2310090	1	90	2.2	2.2	Top Soil				
						2	35	1.5	3.7	Top Soil				
						3	76	25.1	28.8	Semi Weathered Formation	Aquifer	3.7-28.8	Potable	
						4	VH	57.4	86.2	Compact Formation				
						5	132			Less Compact Formation	Aquifer	86.2-?	Potable	
8	**Mahatamtora**	**Nuaoada**	148	**44Q0662186**	**2310407**	1	99	1.4	1.4	Top Soil				
						2	30	7.6	9.0	Weathered Formation	Aquifer	1.4-9.0	Potable	
						3	289	240.9	249.9	Less Compact Formation	Aquifer	9.0-250	Potable	
						4	VH			Compact Formation				
9	Parkod	Nuapada	149	44Q0664207	2315547	1	39	1.7	1.7	Top Soil				
						2	29	15.3	17.0	Weathered Formation	Aquifer	1.7-17	Potable	
						3	115	73.9	91.0	Less Compact Formation	Aquifer	17-91	Potable	
						4	521			Compact Formation				
10	**Magurpani**	**Nuaoada**	150	**44Q0671218**	**2307060**	1	49	0.9	0.9	Top Soil				
						2	19	3.2	4.1	Weathered Formation	Aquif	0.9-4.1	Potabl	

											er		e	
						3	254	14.2	18.3	Less Compact Formation	Aquifer	4.1-18.3	Potable	
						4	935			Compact Formation				
11	Kaliapani	Nuapada	151	44Q06712 16	2307061	1	47	1.3	1.3	Top Soil				
						2	23	10.5	11.8	Weathered Formation	Aquifer	1.3-11.8	Potable	
						3	VH			Compact Formation				
12	Anlajuba	Nuapada	152	44Q06707 34	2301642	1	58	1.8	1.8	Top Soil				
						2	27	5.1	6.9	Weathered Formation	Aquifer	1.8-6.9	Potable	
						3	VH	18.6	25.5	Compact Formation				
						4	115			Less Compact Formation	Aquifer	25.5-?	Potable	
13	Darlimunda	Nuapada	153	44q06691 22	2303429	1	10	2.1	2.1	Top Soil				
						2	56	14.1	16.1	Weathered Formation	Aquifer	2.1-16.1	Potable	
						3	VH	17.2	33.3	Compact Formation				
						4	503			Compact Formation				
14	Jhajhimura	Nuapada	154	44Q06718 77	2298383	1	42	0.4	0.4	Top Soil				
						2	120	0.8	1.2	Top Soil				

						3	11	1.7	2.9	Weathered Formation	Aquifer	1.2-2.9	Potable	
						4	376	158.0	160.9	Less Compact Formation	Aquifer	2.9-161	Potable	
						5	VH			Compact Formation				
15	**Mahuabhata**	**Nuaoada**	155	**44Q0661210**	**2298205**	1	101	0.7	0.7	Top Soil				
						2	31	11.3	11.9	Weathered Formation	Aquifer	0.7-11.9	Potable	
						3	800			Compact Formation				
16	Supali	Nuapada	156	44Q0646985	2295512	1	211	1.1	1.1	Top Soil				
						2	36	10.8	11.9	Weathered Formation	Aquifer	1.1-11.9	Potable	
						3	VH			Compact Formation				
17	Pawartala	Nuapada	157	44Q0649285	2300043	1	296	0.7	0.7	Top Soil				
						2	146	14.0	14.7	Semi Weathered Formation	----	----	---	
						3	849	43.3	58.0	Compact Formation				
						4	VH			Compact Formation				
18	Mahulibhata	Nuapada	158	44Q0655870	2299349	1	221	1.6	1.6	Top Soil				
						2	65	15.9	17.5	Weathered Formation	Aquifer	1.6-17.5	Potable	

						3	348	245.1	262.6	Less Compact Formation	Aquifer	17.5-263	Potable	
						4	VH			Compact Formation				
19	**Sahajat**	**Komana**	159	**44Q0669609**	**2285947**	1	38	2.5	2.5	Top Soil				
						2	73	12.4	14.9	Weathered Formation	Aquifer	2.5-14.9	Potable	
						3	VH			Compact Formation				
20	**Girrijor**	**Komana**	160	**44Q0664522**	**2266531**	1	7	1.5	1.5	Top Soil				
						2	42	9.3	10.7	Weathered Formation	Aquifer	1.5-10.7	Potable	
						3	VH	21.0	31.7	Compact Formation				
						4	614			Less Compact Formation				
21	**Kunjalapara**	**Komana**	161	**44Q0665825**	**2262019**	1	10	1.9	1.9	Top Soil				
						2	24	3.8	5.7	Weathered Formation	Aquifer	1.9-5.7	Potable	
						3	VH			Compact Formation				
22	**Dumarbahal**	**Komana**	162	**44Q0672417**	**2263514**	1	14	0.9	0.9	Top Soil				
						2	90	1.0	1.9	Top Soil				
						3	7	2.2	4.1	Weathered Formation	Aquif	1.9-4.1	Potabl	

											er		e	
						4	VH	20.6	24.7	Compact Formation				
						5	135	72.0	96.7	Less Compact Formation	Aquifer	24.7-96.7	Potable	
						6	VH			Compact Formation				
23	**Tikrapada**	**Komana**	163	**44Q0674876**	**2274201**	1	9	0.6	0.6	Top Soil				
						2	5	3.6	4.2	Weathered Formation	---	----	---	
						3	VH			Compact Formation				
24	Thongo	Komana	164	44Q0664476	2274884	1	32	0.9	0.9	Top Soil				
						2	20	6.0	7.0	Weathered Formation	Aquifer	0.9-7	Potable	
						3	VH	14.7	21.7	Compact Formation				
						4	97			Less Compact Formation	Aquifer	21.7-?	Potable	
25	Darlipada	Komana	165	44Q0664027	2279831	1	104	0.90	0.9	Top Soil				
						2	23	3.18	4.1	Weathered Formation				
						3	43	14.23	18.3	Weathered Formation	Aquifer	0.9-18.3	Potable	
						4	470			Less Compact Formation	Aquifer	18.3-?	Potable	
26	**Kandetera**	**Komana**	16	**44Q0675661**	**2280434**	1	401	0.5	0.5	Top Soil				

			6											
						2	84	2.2	2.7	Semi Weathered Formation				
						3	28	13.2	15.9	Weathered Formation	Aquifer	2.7-15.9	Potable	
						4	766			Compact Formation				
27	Siyalati	Komana	167	44Q06634	2284338	1	62	0.7	0.7	Top Soil				
						2	39	5.9	6.5	Weathered Formation	Aquifer	0.7-6.5	Potable	
						3	VH			Compact Formation				
28	Kotrabera	Komana	168	44Q06497	2279522	1	172	1.6	1.6	Top Soil				
						2	87	1.7	3.3	Weathered Formation	Aquifer	1.6-3.3	Potable	
						3	140	21.2	24.5	Less Compact Formation	Aquifer	3.3-24.5	Potable	
						4	732	199.2	223.7	Less Compact Formation (LST)				
						5	VH			Compact Formation				
29	Sunabeda	Komana	169	44Q06513	2268211	1	130	2.4	2.4	Top Soil				
						2	308	7.6	10.0	Semi Weathered Formation	----	----	----	
						3	568	97.6	107.6	Less Compact Formation				

										(LST)				
						4	VH			Compact Formation				
30	Dhenkunpani	Komana	170	44Q06479 60	2275338	1	86	0.6	0.6	Top Soil				
						2	51	13.6	14.2	Weathered Formation	Aquifer	0.6-14.2	Potable	
						3	262	68.3	82.5	Less Compact Formation (SST)	Aquifer	14.2-82.5	Potable	
						4	851			Compact Formation (LST)				
31	Bargaom	Khariar	171	44Q06779 20	2250106	1	70	0.4	0.4	Top Soil				
						2	22	6.4	6.8	Weathered Formation	Aquifer	0.4-6.8	Potable	
						3	97	58.3	65.1	Less Compact Formation	Aquifer	6.8-65.1	Potable	
						4	325			Less Compact Formation	Aquifer	65.1-?	Potable	
32	**Chandapola**	**Khariar**	172	**44Q0677493**	**2255849**	1	9	1.9	1.9	Top Soil				
						2	12	6.7	8.7	Weathered Formation				
						3	7	9.7	18.3	Weathered Formation	Aquifer	1.9-18.3	Potable	
						4	78	157.6	175.9	Less Compact Formation	Aquifer	18.3-176	Potable	

						5	667			Compact Formation				
33	Kushmal	Khariar	173	44Q0678211	2243678	1	7	4.4	4.4	Weathered Formaton				
						2	VH			Compact Formation	----	----	---	
34	Khariar	Khariar	174	44Q0683323	2247081	1	11	1.9	1.9	Top Soil				
						2	32	6.8	8.7	Weathered Formation				
						3	51	9.7	18.4	Weathered Formation	Aquifer	1.9-18.4	Potable	
						4	VH	64.2	82.5	Compact Formation				
						5	477			Less Compact Formation	Aquifer	82.5-?	Potable	
35	Sonapur	Buden	175	44Q0667026	2243392	1	6	0.5	0.5	Top Soil				
						2	13	3.1	3.6	Weathered Formation	Aquifer	0.5-3.6	Potable	
						3	VH	21.6	25.2	Compact Formation				
						4	375			Less Compact Formation	Aquifer	25.2-?	Potable	
36	Amera	Buden	176	44Q0669160	2249770	1	24	0.8	0.8	Top Soil				
						2	7	0.9	1.7	Top Soil				
						3	67	15.7	17.4	Weathered Formation	Aquifer	1.7-17.4	Potable	
						4	633			Compact				

										Formation				
37	Chanabeda	Khariar	177	44Q06838 61	2248533	1	79	1.9	1.9	Top Soil				
						2	376	2.2	4.1	Top Soil				
						3	72	4.6	8.6	Weathered Formation	Aquifer	4.1-8.6	Potable	
						4	761	91.0	99.6	Less Compact Formation				
						5	VH			Compact Formation				
38	**Ranimunda**	**Buden**	178	44Q06654 38	2230863	1	10	0.7	0.7	Top Soil				
						2	42	9.6	10.3	Weathered Formation	Aquifer	0.7-10.3	Potable	
						3	VH			Compact Formation				
39	Kampur	Buden	179	44Q06747 35	2229679	1	127	0.6	0.6	Top Soil				
						2	26	2.2	2.8	Top Soil				
						3	53	14.3	17.1	Weathered Formation	Aquifer	2.8-17.1	Potable	
						4	433	284.8	301.9	Less Compact Formation	Aquifer	17.1-302	Potable	
						5	VH			Compact Formation				
40	Timanpur	Buden	180	44Q06641 78	2227338	1	119	0.4	0.4	Top Soil				
						2	41	3.5	3.9	Top Soil				

						3	125	12.8	16.7	Weathered Formation	Aquifer	3.9-16.7	Potable	
						4	VH	280.8	297.5	Compact Formation				
						5	VH			Compact Formation				
41	Kerapadar	Sinapali	181	44Q06643 38	2237921	1	8	0.2	0.2	Top Soil				
						2	20	5.2	5.4	Weathered Formation	Aquifer	0.2-5.4	Potable	
						3	934			Compact Formation				
42	Bhatapani	Sinapali	182	44Q06512 84	2221703	1	324	0.3	0.3	Top Soil				
						2	23	5.0	5.3	Weathered Formation(SST)	Aquifer	0.3-5.3	Potable	
						3	96	28.7	34.0	Less Compact Formation(SST)	Aquifer	5.3-34	Potable	
						4	VH			Compact Formation				
43	Gorla	Sinapali	183	44Q06612 56	2225913	1	8	0.8	0.8	Top Soil				
						2	11	7.8	8.6	Weathered Formation	Aquifer	0.8-8.6	Potable	
						3	VH			Compact Formation				
44	Kendumura	Sinapali	184	44Q06651 31	2220427	1	8.63	3.94	3.9	Weathered Formation	Aquifer	0-3.9	Potable	
						2	VH			Compact				

										Formation				
45	Bamniguda	Sinapali	185	44Q06718 49	2215197	1	12	0.4	0.4	Top Soil				
	Close to theV W-SE lineament					2	22	5.0	5.4	Weathered Formation	Aquifer	0.4-5.4	Potable	
						3	120	30.2	35.6	Less Compact Formation	Aquifer	5.4-35.6	Potable	
	Contact of Khondakites and Granites					4	912			Compact Formation				
46	Dhengiamunda	Sinapali	186	44Q06625 13	2215653	1	48	1.1	1.1	Top Soil				
						2	26	3.9	4.9	Weathered Formation	Aquifer	1.1-4.9	Potable	
						3	195	14.1	19.0	Less Compact Formation	Aquifer	4.9-19	Potable	
						4	VH			Compact Formation				
47	Hatibandha	Sinapali	187	44Q06818 16	2222458	1	45	1.94	1.9	Top Soil				
						2	24	6.71	8.7	Weathered Formation	Aquifer	1.9-8.7	Potable	
						3	VH	9.67	18.3	Compact Formation				
						4	179	69.50	87.8	Less Compact	Aquif	18.3-87.8	Potabl	

										Formation	er		e	
						5	VH			Compact Formation				
48	Sinapali	Sinapali	188	44Q06737 40	22234460	1	34	0.6	0.6	Top Soil				
						2	18	8.1	8.7	Weathered Formation	Aquifer	0.6-8.7	Potable	
						3	88	28.5	37.2	Less Compact Formation	Aquifer	8.7-37.2	Potable	
						4	646			Compact Formation				
49	Gambharigud a	Sinapali	189	44Q06783 95	2217890	1	47	1.9	1.9	Top Soil				
						2	11	2.2	4.1	Weathered Formation	Aquifer	1.9-4.1	Potable	
						3	499			Less Compact Formation	Aquifer	4.1-?	Potable	
50	Liar	Sinapali	190	44Q06886 31	2225195	1	131	0.9	0.9	Top Soil				
						2	220	1.0	1.9	Top Soil				
						3	116	6.7	8.6	Semi Weathered Formation				
						4	20	9.7	18.3	Weathered Formation	Aquifer	6.7-9.7	Potable	
						5	78	20.5	38.8	Less Compact Formation	Aquifer	9.7-20.5	Potable	
						6	304			Less Compact Formation	Aquifer	20.5-?	Potable	

51	Gamdabahali	Sinapali	191	44Q0676563	2226920	1	6	1.5	1.5	Top Soil(Alluvium)				
						2	3	2.3	3.8	Weathered Formation(Alluvium)	Aquifer	1.5-3.8	Potable	
						3	VH			Compact Formation				
52	Ranimura	Khariar	192	44Q0686197	2232069	1	14	1.7	1.7	Top Soil				
						2	6	5.5	7.2	Weathered Formation	Aquifer	1.7-7.2	Potable	
						3	VH			Compact Formation				
53	Duajhar	Khariar	193	44Q0682445	2238618	1	101	0.4	0.4	Top Soil				
	(Close to the NE-SW fault)					2	561	0.9	1.3	Top Soil				
						3	19	10.8	12.1	Weathered Formation	Aquifer	1.3-12.1	Potable	
						4	VH	27.7	39.8	Compact Formation				
						5	73.3			Less Compact Formation	Aquifer	39.8-?	Potable	
54	Tukla	Khariar	194	44Q0692474	2241358	1	95	0.9	0.9	Top Soil				
						2	188	1.0	1.9	Top Soil				
						3	51	6.7	8.6	Weathered Formation	Aquifer	1.9-8.6	Potable	
						4	128	9.7	18.3	Less Compact Formation	Aquifer	8.6-18.3	Potable	
						5	564	87.5	10	Less	Aq	18.3-	Pot	

									5.8	Compact Formation	uifer	106	able	
						6	VH			Compact Formation				
55	Larka	Khariar	195	44Q06742 02	2234588	1	57	0.8	0.8	Top Soil				
	(Close to the NE-SW fault)					2	161	7.3	8.1	Semi Weathered Formation				
						3	34	34.3	42.4	Less Compact Formation	Aquifer	8.1-42.4	Potable	
	Contact of Khondakites and Granites					4	83	248.0	290.4	Less Compact Formation	Aquifer	42.4-290.4	Potable	
						5	VH			Compact Formation				
56	Uparpita	Khariar	196	44Q06731 05	2239639	1	19	0.9	0.9	Top Soil				
						2	10	1.0	1.9	Top Soil				
						3	27	6.7	8.6	Weathered Formation	Aquifer	1.9-8.6	Potable	
						4	VH	77.2	85.9	Compact Formation				
						5	98			Less Compact Formation	Aquifer	85.9-?	Potable	
57	Palsada	Khariar	197	44Q06748 14	2247079	1	19	0.9	0.9	Top Soil				
						2	5	1.0	1.9	Top Soil				
						3	18	6.7	8.	Weathered	Aq	1.9-	Pot	

									6	Formation	uifer	8.6	able	
						4	72	9.7	18.3	Less Compact Formation	Aquifer	8.6-18.3	Potable	
						5	VH	64.5	82.8	Compact Formation				
						6	338			Less Compact Formation	Aquifer	82.8-?	Potable	
58	Mantritarai	Khariar	198	44Q0683323	2247081	1	8	1.0	1.0	Top Soil				
						2	4	3.3	4.3	Top Soil				
						3	27	10.7	15.0	Weathered Formation	Aquifer	4.3-15	Potable	
						4	VH			Compact Formation				

Table.1.3BLOCK WISE AND SOURCE WISE IRRIGATION PROGRAMME DURING KHARIF-2021 OF NUAPADA DISTRICT(Area in Hectare)

Sl. No	Name of the block	Major IP		Med.I.P.		M.I.P.		CRLIP(OLIC)		LIP(Pvt.)		Dug-well		Bore-well Agril.Dept.		Cluster Bore-well (OLIC)		Cluster MRLP		Others	Total
		No	Area	No	Area	No	Area	No	Area	No	Area	No.	Area	No	Area	No	Area	No	Area	Area	
1	Nuapada	0	0	3	11621	6	734	100	2016	76	247	1106	221	649	649	1610	8410	0	0	689	24587
2	Komna	0	0	1	4452	10	1965	73	1484	9	20	1202	240	1298	1298	1298	6247	3	15	300	16021
3	Boden	1	1699	0	0	9	2741	70	1466	4	8	440	89	8	8	270	1841	0	0	44	7896
4	Khariar	1	11491	0	0	11	1357	125	2540	29	140	850	170	65	65	454	2395	0	0	32	18190
5	Sinapali	0	0	0	0	6	1611	101	2216	55	109	747	149	166	166	671	3990	0	0	89	8330
	Total	**1**	**13190**	**4**	**16073**	**42**	**8408**	**469**	**9722**	**173**	**524**	**4345**	**869**	**2186**	**2186**	**4303**	**22883**	**3**	**15**	**1154**	**75024**

Source.District Agriculture Department, Nuapada,Govt of Odisha

Table.1.4SOURCE WISE AND CROP WISE CROPPING PROGRAMME UNDER DIFFERENT SOURCES OF IRRIGATION FOR KHARIF -2021 OF NUAPADA DISTRICT. (Area in Hectare)

Sl. No.	Name of the crop	Major IP	Med. I.P.	M.I.P.	CLIP (OLIC)	LIP (Pvt)	Dug-well	Bore-well (Agril. Dept)	Cluster Bore-well (OLIC)	Cluster MLIP	Other	Total
1	Paddy	12000	14000	6000	6000	200	100	700	9000	0	0	48000
2	Maize	500	700	600	900	50	110	500	631	4	5	4000
3	Oil-seeds	500	723	800	1522	100	120	500	1220	5	10	5500
4	Vegetable	90	500	400	600	80	300	346	11078	6	600	14000
5	Spices	0	0	8	200	30	139	40	844	0	239	1500
6	Others	100	150	600	500	64	100	100	110	0	300	2024
	Total	**13190**	**16073**	**8408**	**9722**	**524**	**869**	**2186**	**22883**	**15**	**1154**	**75024**

Source.District Agriculture Department, Nuapada,Govt of Odisha

Table.1.5 BLOCK WISE AND SOURCE WISE IRRIGATION PROGRAMME DURING RABI -2020-21OF NUAPADA DISTRICT

(Area in Hectare)

Sl. No.	Name of the block	Med.I.P.		M.I.P.		Govt. LIP (OLIC)		LIP(Pvt.)		Dug-well		Bore-well PLIP (Agril. deptt)		Cluster Bore-well (OLIC)		Perennial stream, check dam Riverlift etc.	Total
		No	Area	No	Area	No	Area	No	Area	No.	Area	No	Area	No	Area	Area	Area
1	Nuapada	2	2760	3	95	87	1060	14	32	650	152	591	827	1348	6740	84	11750
2	Komna	1	2696	6	193	68	832	4	8	740	155	753	476	1018	5090	58	9508
3	Boden	0	0	3	65	59	742	2	6	300	60	10	14	252	1260	50	2197
4	Khariar	0	0	5	190	111	1344	29	140	850	170	63	95	420	2100	32	4071
5	Sinapali	0	0	3	190	87	1146	8	16	844	158	65	31	572	2860	20	4421
	Total	**3**	**5456**	**20**	**733**	**412**	**5124**	**57**	**202**	**3384**	**695**	**1482**	**1443**	**3610**	**18050**	**244**	31947

Source.District Agriculture Department, Nuapada,Govt of Odisha

Table.1.6 **SOURCE WISE AND CROP WISE CROPPING PROGRAMME UNDER DIFFERENT SOURCES OF IRRIGATION FOR RABI -2020-21 OF NUAPADA DISTRICT**. (Area in Hectare)

Sl. No.	Name of the crop	Med.I.P.	M.I.P.	Govt. LIP (OLIC)	LIP(Pvt.)	Dug-well	Bore-well PLIP (Agril. deptt)	Cluster Bore- well (OLIC)	Perennial stream, check dam River lift etc	Total
1	Paddy	4790	330	2200	20	0	50	2610	0	10000
2	Wheat	0	10	50	20	60	30	30	0	200
3	Maize	10	20	50	20	30	50	120	0	300
4	Ragi	0	0	50	30	100	40	680	0	900
5	Groundnut	500	193	300	20	20	100	1857	10	3000
6	Sunflower	80	20	70	10	10	150	260	0	600
7	Potato	0	10	120	10	30	100	220	10	500
8	Onion	60	50	600	15	124	111	4000	50	5010
9	Other Vegetable	16	100	1440	8	201	737	4420	50	6972
10	Chilly	0	0	60	5	40	30	855	10	1000
11	Garlic	0	0	10	5	10	10	360	5	400
12	Coriander	0	0	144	31	38	20	603	74	910
13	Sugarcane	0	0	20	5	25	10	35	5	100
14	Others	0	0	10	3	7	5	2000	30	2055
	Total	**5456**	**733**	**5124**	**202**	**695**	**1443**	**18050**	**244**	**31947**

Source.District Agriculture Department, Nuapada, Govt of Odisha