केंद्रीय 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

BALASORE DISTRICT, ODISHA

दक्षिण पूर्वी क्षेत्र, भुवनेश्वर

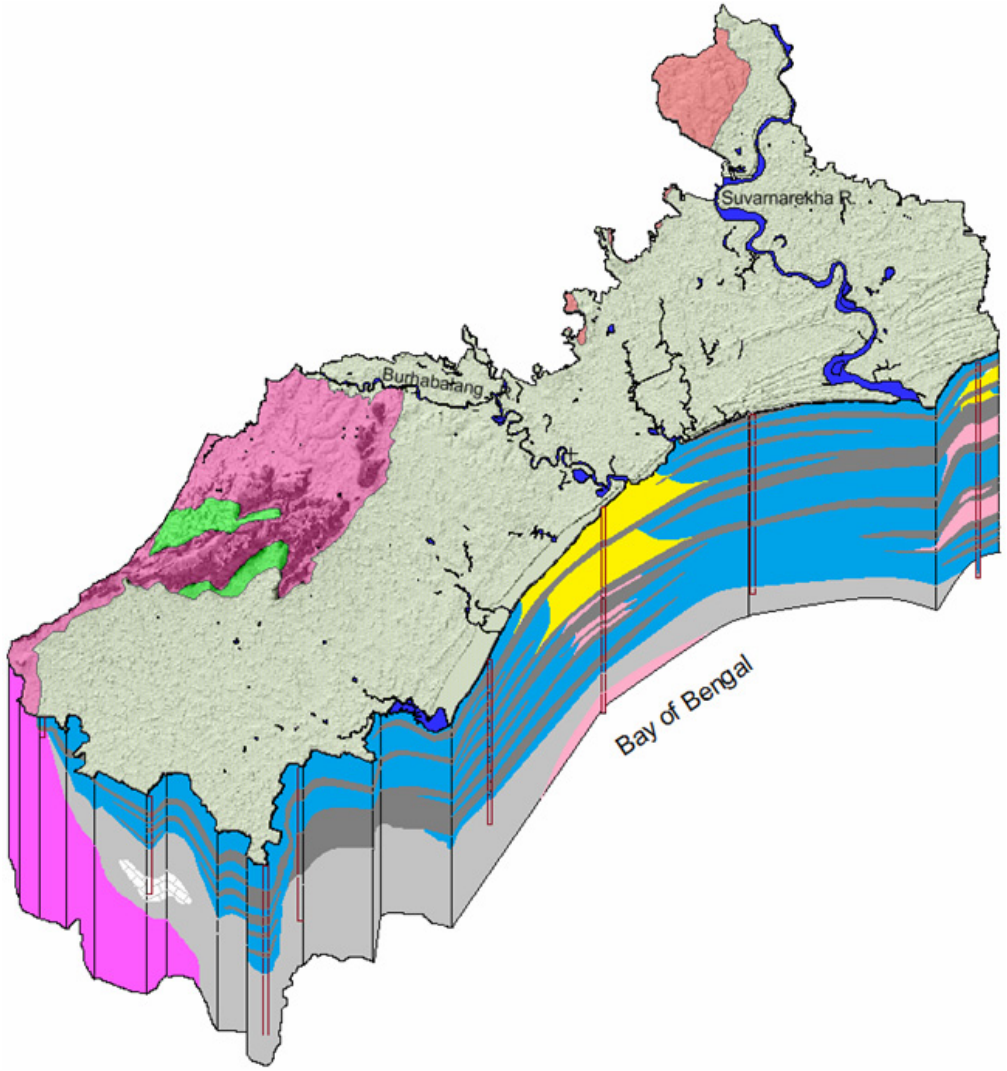
South Eastern Region, Bhubaneswar

Government of India

MINISTRY OF WATER RESOURCES, RIVER DEVELOPMENT & GANGA REJUVENATION

NATIONAL AQUIFER MAPPING & MANAGEMENT

HYDROGEOLOGICAL FRAMEWORK, GROUND WATER DEVELOPMENT PROSPECTS & AQUIFER MANAGEMENT PLAN OF BALASORE DISTRICT, ODISHA



CENTRAL GROUND WATER BOARD
South Eastern Region, Bhubaneswar
May – 2017

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BALASORE DISTRICT AT A GLANCE

I. GENERAL PARTICULARS

(a) Location	:	21° 04′ to 21° 58′ North Latitudes 86° 16′ to 87° 29′ East Longitudes
(b) Area	:	**3806 Km²**
(c) District Head quarters	:	**Balasore**
(d) Subdivision	:	**2** – *1. Balasore* *2. Nilgiri*
(e)Tehsils		**12**
(f) Blocks	:	**12**

Bahanaga, *Balasore*, *Baliapal*, *Basta*, *Bhograi*, *Jaleswar*, *Khaira*, *Nilgiri*, *Oupada*, *Remuna*, *Simulia*, *Soro*

(g) Towns *(including Census Towns)*	:	5 – Balasore, Jaleswar, Nilgiri, Remuna, Soro
(h) Municipalities	:	1 – Balasore
(i) N.A.C.s	:	3 – Jaleswar, Nilgiri, Soro
(j) Police Stations	:	23
(k) Gram Panchayats	:	289
(l) Villages	:	Total : 2953 *Inhabited : 2588* *Uninhabited : 365*
(m) Parliamentary Constituency	:	1 - Balasore
(n) Assembly Constituency	:	8 - Balasore, Basta, Bhograi, Jaleswar, Nilgiri, Remuna, Simulia, Soro
(g) Population *(as per Census 2011)*	:	Total : 23,20,529 *Male : 11,85,787* *Female : 11,34,742* *Sex Ratio : 957* *Density : 610 / Km²* *Growth : 14.62 % (Decadal Growth Rate)*

II CLIMATOLOGY

(a) Normal Annual Rainfall	:	1592 mm
(b) Average Annual Rainfall	:	1723 mm *(1995 – 2014)*
(b) Temperature	:	Maximum – 45 °C Minimum – 9 °C
(c) Relative humidity	:	90 % (Morning – 0830 Hrs) 71 % (Evening – 1730 Hrs)

III LAND USE

(a) Forest Land	:	10,735 Ha
(b) Non Agricultural Land	:	46,316 Ha
(c) Barren & Non-Cultivable Land	:	4,222 Ha
(d) Permanent Pastures & Grazing Land	:	18,077 Ha
(e) Misc. Tree, Crop & Groves Land	:	9,659 Ha
(f) Cultivable Waste	:	22,610 Ha
(g) Old Fallows	:	7,101 Ha
(h) Current Fallows	:	17,263 Ha
(i) Net Sown Area	:	2,13,687 Ha

IV IRRIGATION POTENTIAL CREATED

(source -wise) (2011)

		Kharif (Ha)	Rabi (Ha)
(a) Major irrigation Projects (Flow)	:	19,910	835
(b) Minor irrigation Projects (Flow)	:	8,321	254
(c) Minor irrigation Projects (Lift)	:	9,485	8,960
(d) Others	:	8,821	7,671

V EXPLORATORY WELLS

Bore wells drilled by CGWB under Normal Exploration Programme	:	*Exploratory Wells*	*:*	121
		Observation Wells	***:***	56
		Deposit Wells	***:***	11
		Piezometers	***:***	12

VI DYNAMIC GROUND WATER RESOURCES (As on 31.03.2013)

a) Annual ground water resource assessed	:	1,10,063 ham
b) Annual ground water draft (for all uses)	:	58,651.12 ham
c) Balance ground water resource for future irrigation use	:	47,434.71 ham

VII Stage of ground water development : 53.29%

VIII Ground Water Issues

Ground Water Troughs	3 – Basta – Baliapal Sector Balasore Town – Chandipur Sector Soro – Anantapur Sector
Water Quality Issues	***Coastal Salinity*** *Kalyani – Chandaneswar Sector* ***Fluoride*** *Parts of Nilgiri Block* ***Iron*** *Isolated patches bordering the lateritic formation*

FOREWORD

Balasore district is located on the north eastern border of the Odisha state. The district is endowed with vast arable lands and one of the most agriculturally developed district of Odisha. The district is underlain by thick alluvial deposits and is endowed with a huge ground water resource potential. The agrarian development of the district is boosted by tapping this enormous ground water resources through dug well, shallow and filter point tube well, medium deep tube wells.

The present stage of ground water development is only 48.58% leaving a vast scope for ground water development in the district. Ground water irrigation practices can insure increased agricultural production by enhancing the area irrigated and scope of irrigation. Apart from irrigation, drinking water scarcity can also be mitigated through judicious utilization of ground water.

With the fast agricultural development, rapid ground water decline during rabi season ie Feb- May has been noted in pockets of Jaleswar and Bhograi Blocks. The over exploitation may lead to saline water ingress in coastal track of the district. In the coastal tract within a width range of 5 to 10 kms from the coast, the saline water is occurring above the fresh ground water.

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 ground water exploitation in the district are dug well, dug-cum-bore well, shallow tube well etc. Proper site and designing of wells hold the key to the success of ground water development, which requires a thorough knowledge of hydrogeology and pattern of water usage in the terrain.

Based on the available data and the earlier hydrogeological studies taken up in the district, 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 A. Choudhury, AHG** & **Dr. N. C. Nayak, Scientist-'D'**, have compiled and prepared the present report on **"Hydrogeological Framework, Ground Water Development Prospects & Aquifer Management Plan of Balasore District, Odisha"**. Their sincere efforts in preparation of the report will no doubt be very useful and benefit the state. It is hoped that, it will be of immense help to different ground water user agencies, administrators and planners in preparation of ground water development plans and will be a handy tool in effective management of ground water resources in the district.

Place : Bhubaneswar
Date : 15th May 2017

(D. P. Pati)
Regional Director

EXECUTIVE SUMMARRY

National Aquifer Mapping & Management(NAQUIM) in the District of Balasore was undertaken during the XIIth Plan Period of 2012 – 2017. The district has a geographic area of 3806 Sq Kms and is divided into 12 Community Development Blocks, which in turn are further subdivided into 289 Gram Panchayats comprising of 2953 villages in the rural front and on the urban side it comprises of 1 Municipal Corporation of Balasore and 4 Notified Area Councils. As per the Census Data of 2011, the total population of the District is 23,20,529. Of this the Male population is 11,85,787 and the female population is 11,34,742. This gives a over all sex ratio of 957 females per 1000 males. The decadal growth rate is pegged at 14.62 % with a population density of 610 persons per square kilometres.

The district enjoys Humid sub tropical climate where the temperature of the warmest month is over 22 °C and at least 4 months the temperature remains over 10° C. Southwest monsoon is the principal source of precipitation in the district. The normal annual rainfall of the district is 1568.4, out of which about 85% is received during monsoon season (mid June to mid October). The month of July and August gets the heaviest rainfall of the year, though rainfall is not very regular throughout the season but fairly uniform throughout the district. There are on the average 60 – 85 rainy days in a year. Besides, the relative humidity varies between 30 % to 86 %.

The land elevation varies from as low as near mean sea level in the southern part to as high as about 600 m above mean sea level in the north western part. In between a major part covering more than 75% of the geographical area is having elevation within the range of 2 – 10 metres above mean sea level.

The drainage in the area is controlled by Subarnarekha, Panchpara, Burhabalang, Jamira, Kansbans, Sono rivers and their tributaries and distributaries. All these rivers are having south easterly flow direction. Hydrogeomorphological features of Balasore district are mainly attributed to fluviomarine, erosional, denudational and depositional processes. The coastal plain has been developed due to fluviomarine processes. The alluvial plains owe their origin due to various fluviatile actions of major rivers.

Four main types of soil groups(USDA Soil Classification System) can be observed in the Balasore District. These are Alfisols, Aridisols, Entisols and Ultisols. The district being primarily agrarian can be appreciated from the fact that the major land use in this district is Arable land covers more than 70% of the geographical area. . Rice is the principal crop grown in this district, followed by other cereals, pulses, oilseeds, vegetables, spices and sugarcane. The district is blessed with a number of natural and man made water bodies like rivers, streams, nalas, tanks and ponds. In addition to this, there exists a smart network of canals, which together takes care of the flow irrigation system in the district.

There a number of large scale Industrial establishments and factories in and around the district town of Balasore. Apart from these, there are a number of small and medium scale agro based industries including seafood packaging industries in the areas proximal to the Bay of Bengal.

The major parts of the district are underlain by Tertiary & Quarternary Alluvium(including Recent Alluvium). The north western part is underlain by the Archaeo-Proterozoic Basement Granites and Granite Gneisses with minor Pegmatites and vein Quartz. The recent alluvium occurs in limited patches along the river courses. The Tertiary deposits comprise of lower marine fossiliferous sequence of Miocene' age and an upper estuarine sequence of Mio-Pliocene age. The crystalline are devoid of primary porosity but possess secondary porosity on being weathered and fractured. However, the unconsolidated sand and gravel layers of Tertiary and Quaternary age, form good repository of ground water. Ground water occurs under water table conditions in shallow aquifers and under semi confined to confined conditions in deeper aquifers. Hydrogeologically all the formations encountered in the district can be broadly divided into three sub groups viz. 1 - Crystalline formations 2- Sedimentary formations and 3 - Laterites. The crystalline formations are mainly constituted by granite gneisses (Nilgiri Granites) while the sedimentaries are constituted by younger and older alluvium and Tertiary formations.

The occurrence of fresh water aquifers in coastal tract of Balasore restricted by two important factors- (i) Occurrence of hard rocks in the western side and (ii) Salinity hazard problems in the eastern part. In the narrow tract, close to the coast line extending right from Chandaneswar in the North to Bahanga/ Simulia in the south in the district, salinity problem occurs where both the saline water bearing and fresh water

EXECUTIVE SUMMARRY

bearing aquifers occurs at different depths. The depth of occurrence of saline water bearing aquifers is not uniform along the entire tract. The width of the coastal saline tract is generally ranging from 4 to 5 km running from Bahanaga to Baliapal block near Subranarekha river, where from towards further north east it encroaches further inland ward and in Bhogarai block its width generally range from 5 to 10 km. At places auto flowing situations are observed in the deeper confined aquifers. At Soud (Bahanaga block) the piezometers tapping the aquifers at 211 m to 217 m below ground level, is exhibiting auto flowing situation/ where the piezometric head is observed at 1.50m above ground level.

Water level measurements were carried out using the existing National Hydrographs Network stations(61 Dug Wells and 6 Piezometers) as well as by establishing a dedicated network of Key Wells. This involved measurement of water levels of both the phreatic aquifer through dug wells and measurement of Piezometric surface through the existing piezometers as well as through established dug wells and tube wells(217 Nos).

During the Pre-Monsoon season, the depth to water level in major part of the District remained within 6 – 8 metres below ground level. During the Post-Monsoon season, the depth to water level in major part of the District remained within 4 – 6 metres below ground level. The fluctuation in the Pre & Post Monsoon Water Level in the Phreatic Aquifer shows that there is a distinct rise in water level of 2 metres in most part of the District. Perusal of the data and hydrographs reveal that in major part of the district, the phreatic aquifer does not show any significant decline.

Pre-monsoon depth to piezometric surface varies from as low as 1.5 to as high as 21 metres below ground level. Majority of the areas have the piezometirc surface pegged between 6 – 12 metres below ground level. Deeper piezometric surface(> 12 metres below ground level) are found in the blocks of Nilgiri, Basta, Baliapal, Balasore & Soro. Post-monsoon depth to piezometric surface varies from as low as 0.95 to as high as 12.95 metres below ground level. Majority of the areas have the piezometirc surface pegged between 4 – 8 metres below ground level. Pre vs post-monsoon fluctuation in depth to piezometric surface ranges from fall of about 0.75 metres to a raise of about 12 metres. This unique nature could be seen in Bhograi Block in the district. But overall, there is distinct rise in piezometric surface in the post monsoon season over the pre monsoon piezometric surface.

The pre-monsoon elevation of piezometric surface varies from as low as 18 m below sea level to as high as 82.5 metres above mean sea level. Three distinct ground water troughs having piezometric surface below mean sea level could be deciphered – Basta-Baliapal Sector, Balasore-Chandbali Sector, Soro-Anantapur Sector. Post-monsoon elevation varies from as low as 8 m below sea level to as high as 87.5 metres above mean sea level. there is a distinct 8 – 12 metres rise in piezometric surface elevations in those ground water trough bearing sectors in the post-monsoon period over its pre-monsoon configuration.

A perusal of the water quality analysis data reveals that majority of the wells in both phresatic and deeper aquifers have potable water. However, the Wells at Chandipur have relatively higher electrical conductivity and matching higher Total Dissolved Solid Content. The Piezometer monitored at Kasafal have anomalous higher EC & TDS, implying saline water formation being tapped. Some of the wells monitored in Nilgiri & Soro Blocks have marginally higher fluoride content as well. Collation of chemical analysis data from RWS&S, Govt, of Odisha reveals that some wells in the blocks of Balasore, Bahanaga, Bhograi, Jaleswar, Oupada, Simulia & Remuna have relatively higher iron content as well.

The 3D Disposition of the Aquifer System Map of Balasore District clearly depicts a 3 layered aquifer system in the area. In the north western part, the basement is that of the Basement Granite Gneisses which are intruded by the Basic and Ultrabasic intrusives. This basement layer dips towards Southerly and south easterly to give rise to a significantly huge and thick pile of sediments of more than 650 metres in the eastern and south eastern part of the district. Just above this basement there are presence of carbonaceous Tertiary sediments, which are overlain by a sediment pile of fluviatile and marine provenance. There is also a lateritic capping over both the weathered residuum as well as over the Older Quarternary sediments. Quality wise also there is clear picture that there exists potentially vulnerable zones in the south eastern and eastern part of the district, bordering the Bay of Bengal at Chandipur and at Karnajiasul area.

EXECUTIVE SUMMARRY

Most of the blocks of the district have already high levels of resource utilization. Bhograi is the block with highest ground water utilization of 68.77% in the district. Nilgiri is the block with lowest ground water utilization of 32.42% in the district. Net ground water availability of the district is assessed to be 1,10,063 HM and the gross annual draft for domestic, industrial, and irrigation uses is 58,651.12 HM. The average stage of ground water development in the district is 53.29%. All the 12 blocks have been classified as SAFE. The fresh in-storage resource in hard rock area is 36,771 HM and the same in alluvial area is 1,52,109 HM, thus the total fresh in storage resource is 1,88,880 HM. The saline in-storage resource in hard rock area is NIL and the same in alluvial area is 26,560 HM, thus the total saline in storage resource is 26,560 HM. Thus the total in storage resource including both the fresh and the saline water for the entire district is 2,15,440 HM. The total Fresh water resource for the entire district combining both the dynamic and the in-storage component is 2,98,943 HM.

A synopsis of data and maps reveals that major Ground Water related issues can be clubbed under the following heads – (1) Presence of Ground Water Troughs in both pre & post monsoon season in the Deeper Aquifers(II & III) in the 3 Areas : Basta- Baliapal Sector, Balasore-Chandipur Sector & Soro-Anantapur Sector; (2) Presence of inherent salinity affected areas along the coast line in the Kalyani-Chandipur-Chandaneswar tract spanning the Balsore, Baliapal & Bhograi Blocks; (3) Presence of Iron & Fluoride above permissible limits in certain habitations of the districts.

Primarily, aquifer management strategy includes recommendation for construction of 550 recharge wells in the Basta-Baliapal Sector and about 50 farm ponds with injection wells in the Soro-Anantapur Sector. In the Balasore-Chandipur sector it is recommended to tapo the potential of Burhabalang and Sono rive for urban water supply. Additionallty it is proposed to reduce the dependence on ground water for irrigation, domestic and industrial purpose and shift the dependence on surface water and other alternative sources to ensure sustainability of the sub-surface aquifer system. In the Westrn part of the district, it is proposed to construict check weirs form higher order drainages and gabion structures on the lower order drainages to facuilitate additional ground water recharge and create alternate source for fluoride mitigation.

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1.0 INTRODUCTION

1.1 Objective : In XII five year plan, National Aquifer Mapping (NAQUIM) has been introduced to carry out detailed hydrogeological investigation on topo-sheet wise on a scale of 1:50,000.The proposed activities include toposheet wise micro level hydrogeological data acquisition supported by geophysical and hydro-chemical investigations supplemented with ground water exploration down to the depths of 200 meters, including quality monitoring (intensive inventory of wells), Hydrological and Hydro meteorological studies, Infiltration Tests, Geophysical Surveys, Water Quality Analysis, Isotope Study, Specific Yield determination, Slug Test, GIS data integration & analysis, Preparation of Aquifer map, Compilation of Data and Printing of reports etc. 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 of an aquifer wise GIS based water supply management plan. This clear demarcation of aquifers and their potential will help the agencies involved in water supply in ascertaining, how much volume of water is under their control. This work will be systematically implemented in the country, by involving state organisations / institutions across India.

Aquifer mapping itself is an improved form of groundwater management – recharge, conservation, harvesting and protocols of managing groundwater. These protocols will be the real derivatives of the aquifer mapping exercise and will find a place in the output (the map) and the outcome (changes within social behaviour that reflects these protocols). In fact, some important socio-economic information at the scale of well will form the basic sample of groundwater information and can be collected as part of the aquifer mapping effort todefine the aquifer geometry, type of aquifers, ground water regime behaviours, hydraulic characteristics and geochemistry of Multi-layered aquifer systems on 1:50,000 scale.

The accelerated aquifer information data generation will require sincere effort in organizing the field work with required state of the art advance techniques and latest equipment's with a dedicated team by involving central, state agencies and creation of aquifer unit wise resource centre with local community participation in data collection and implementation of the aquifer management plan.

1.2 Scope of the study : National Aquifer Mapping Programme (NAQUIM) is the thrust area of CGWB activities in the 12th and 13th plan period, there has been lot of deliberations and Concept note / implementation strategies are being finalized by CGWB. In view of the challenging work ahead, involvement of State Ground Water Department being the implementing agency in the area of ground water development and management is of prime importance to achieve the objectives envisaged under NAQUIM. In the 12th five-year plan it is proposed to cover thrust areas and requires scientific interventions through participatory approach of end users.

Aquifer mapping is a multidisciplinary study 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. This involves in depth studies of the Aquifer Disposition in the Balasore District(Administrative Block wise) in respect of availability, potential, quality & quantity, identification of problems and finding solutions which require immediate interventions. The following were the broad objectives for the same:

- To define the aquifer geometry with precise lateral and vertical demarcation.
- To define Ground water regime behaviour in time and space.
- To study the hydraulic characteristics of both shallow and deeper aquifer.

- To study the Geochemistry of aquifer systems down to the depth of 200 m in Hard Rock areas and upto a depth of 300 m(or upto Bed Rock) in Alluvial areas.
- To prepare Aquifer Maps indicating dispositions of aquifers along with their characterization.
- To formulate the Aquifer Management Plans for sustainable development and management of ground water resources.

1.3 Approach and methodology : Geologically, the major parts of the District is underlain by the Quarternary to Holocene(Recent) unconsolidated Alluvial formations, with the Pre-Cambrian to Proterozoic rock of the Singhbhum Granites or its equivalent, serving as basements in most of the cases and in some places, the Tertiary Limestones serves as the basement. Some of the Older Alluvial Formations(mostly of fluvial nature) are often lateritized at the top.

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

suggests the use of latest technology as well as the process of participatory data collection and management of ground water.

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

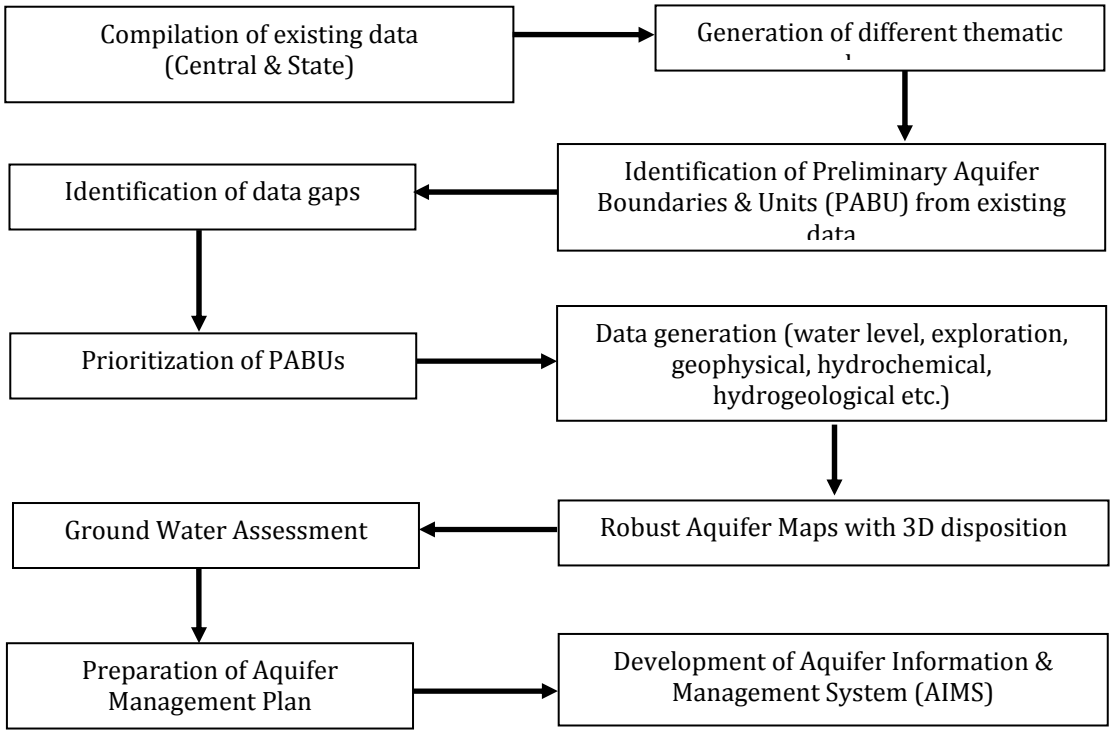


Figure – 1.3 : Approach Methodology

Five major steps have been identified for Aquifer mapping, namely:

1. Compilation of existing ground water data and data gap analysis
2. Generation of additional ground water data
3. Preparation of Aquifer Maps
4. Preparation of Aquifer Management Plans
5. Participatory ground water management.

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

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

1.3.2 Generation of additional ground water data : The data generation to bring out validated ground information on aquifer geometry, its characteristics, status of development and stress acting in localized aquifer system like quality and scarcity, need for augmentation with suitable site and design and other factors controlling the ground water occurrence and movement in surface and sub-surface will be optimized. Specific scientific data required will be generated and used for better understanding of the total ground water system including the interaction with surface water

1.3.3 Preparation of Aquifer Maps :

a) Institutional and project management support – SPV, CGWB, State, District and Block level organizations.

b) Identification of Aquifer Management Units (AMU) and operationalisation at appropriate scales.

c) Prioritization and work programme on the basis of quantity, quality and stage of development of ground water and criticality of groundwater quality issues.

d) Investigation and data compilation for each / cluster of AMUs through participation of para-hydrogeologists, block and district level support and State Groundwater Co-ordination Committees.

1.3.4 Preparation of Aquifer Management Plans :

a) Facilitate State Government Organizations and other stakeholders in the Preparation of Aquifer Management Plan and supporting tools while taking into consideration the quantity and quality aspects of ground water.

b) Development of Aquifer Information and Management System (AIMS).

c) Articulate and share information across hydrological units for crop planning, drinking water security and urban water security, as the case may be. It is important to consider these three because some aquifers might transect rural-urban divides and may require an integrated management plan that includes both types of requirement.

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

a) Demystify the science of ground water hydrology through capacity building and community level participation in real time data collection planning and development.

b) Establishment of protocols for participatory ground water management through

   i. Suggesting mechanism for collection of required data / parameters for seasonal assessment of ground water resources and their regular updating at local level involving the end users.

   ii. Formulating appropriate strategies and methodology for strengthening local institutions and end users for ground water management and capacity building of stakeholders (staff / officials/PRIs/NGOs/CSOs etc.).

c) Strengthen local institutions to address emerging ground water issues in respect of quantity and quality of ground water resources.

d) Transform the perception of groundwater from private property to that of a "common good", where individual farmers take decisions for collective good.

1.4 Study area : Central Ground Water Board has initiated the National Aquifer Mapping Programme (NAQUIM) in India during XIIth five year plan. All the 12 blocks of Balasore District – namely : covering an area of 3,086 sq. km. were taken up for detailed hydrogeological investigation, data-gap analysis and Aquifer Mapping during the period 2012-2015. The index map of the study area is presented in **Fig.1.4a** while an administrative map is presented as **Fig. 1.4b.**

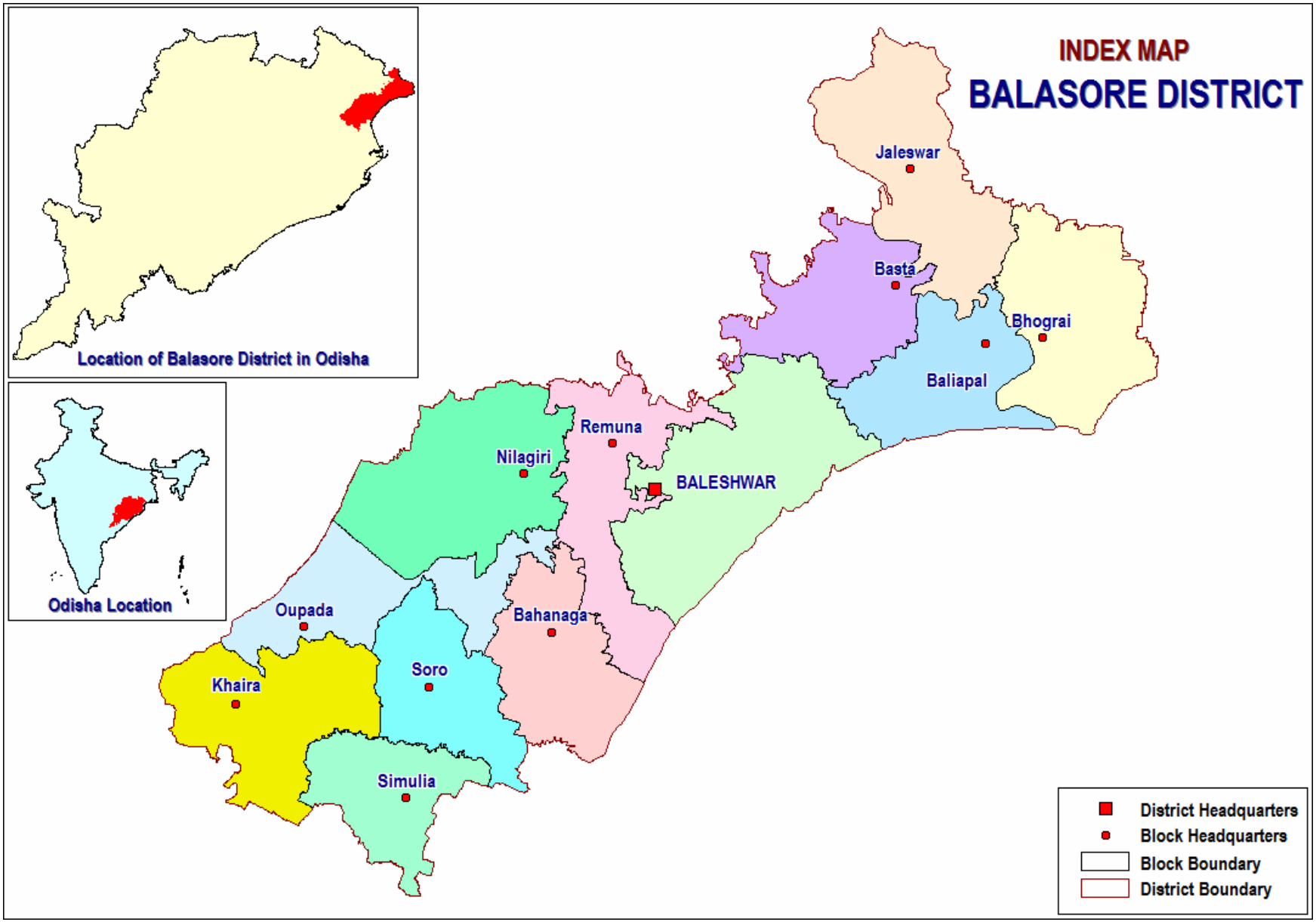


Figure 1.4a : Index Map of Balasore District, Odisha

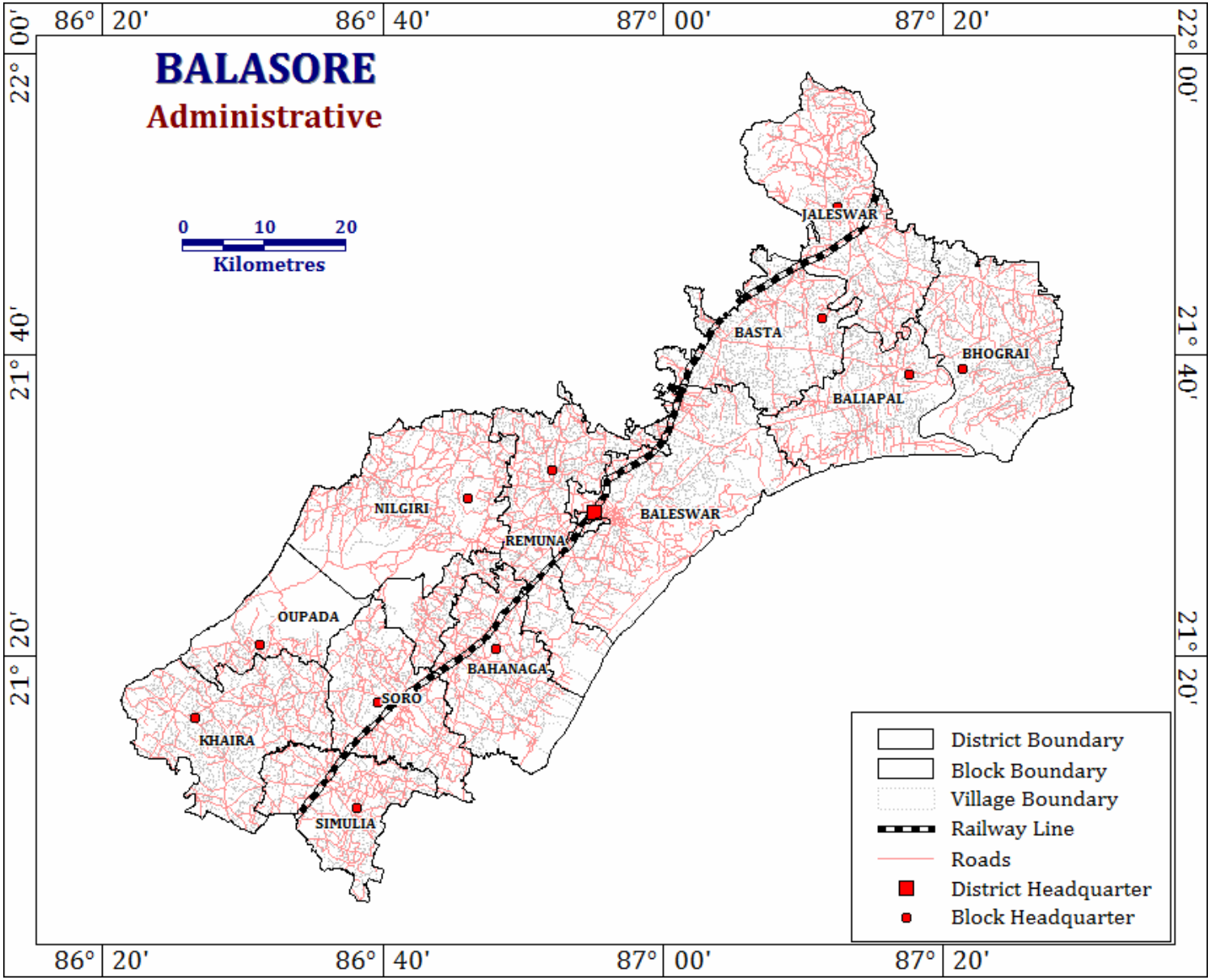


Fig 1.4b : Administrative Map of Balasore District, Odisha

1.4.1 Administrative Setup : The district is divided into 12 Community Development Blocks, which in turn are further subdivided into 289 Gram Panchayats comprising of 2953 villages in the rural front and on the urban side it comprises of 1 Municipal Corporation of Balasore and 4 Notified Area Councils

Table – 1.4a : Administrative Setup of Balasore District

Sl No	Block	Geographical Area (Km^2)	Gram Panchayats	Total Villages	Municipality	NAC
1	Bahanaga	274	21	174		
2	Balasore	477	27	289	1	
3	Baliapal	264	27	239		
4	Basta	272	22	341		
5	Bhograi	349	32	340		
6	Jaleswar	380	27	257		1
7	Khaira	337	30	368		
8	Nilgiri	414	25	158		1
9	Oupada	270	11	162		
10	Remuna	309	28	301		1
11	Simulia	211	17	154		
12	Soro	249	22	170		1
	TOTAL	**3806**	**289**	**2953**	**1**	**4**

1.4.2 Demographic Setup : As per the Census Data of 2011, the total population of the District is 23,20,529. Of this the Male population is 11,85,787 and the female population is 11,34,742. This gives a over all sex ratio of 957 females per 1000 males. The decadal growth rate is pegged at 14.62 % with a population density of 610 persons per square kilometres.

Table – 1.4b : Demographic Setup of Balasore District

Sl No	Block	Total Population			Sex Ratio	Literacy Rate
		Rural	Urban	Total		(%)
1	Bahanaga	138369		138369	942	84.62
2	Balasore	240821	144373	385194	941	76.54
3	Baliapal	197259		197259	956	82.52
4	Basta	188768		188768	951	79.12
5	Bhograi	283586		283586	933	84.7
6	Jaleswar	204090	25747	229837	953	74.43
7	Khaira	179884		179884	1017	81.64
8	Nilgiri	129360	17264	146624	999	65.33
9	Oupada	82917		82917	972	74.48
10	Remuna	160059	33378	193437	953	75.94
11	Simulia	121516		121516	959	82.06
12	Soro	140607	32531	173138	941	82.55
	TOTAL	**2067236**	**253293**	**2320529**	**957**	**79.18**

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

- ***Exploratory Wells***
- ***Geophysical Surveys***
- ***Ground Water Monitoring and***
- ***Ground Water Quality***

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

In the study area a part is hardrock area(Nilgiri & parts of Oupada Block) where ground water occurs in phreatic condition in weathered portion generally within 15 - 30 meters depth and in Semi - confined condition between 30 to 50 depths. Beyond this depth it is the domain of confined aquifers. Only two Aquifer system in hardrock areas i.e. Aquifer-I which extends upto weathered Zone followed by Aquifer-II which normally extends in the fractured portion of hardrock generally between 30 to 200 metrs depth. Generally, water-bearing fractures also not uniform, the depth of water bearing fractures varies from one exploratory well to another.

1.5.1 Exploratory Wells : The information in respect of un-confined/Phreatic aquifer has been generated from the dug wells present in the area. Data from CGWB Exploratory wells (EW), OW and Piezometers are necessary for establishing aquifer geometry and determining aquifer parameters. The existing exploratory wells drilled in the area under Ground Water Exploration programme of CGWB is presented in Fig1.2 and the adequacy of Exploration data is given in Table 1.1. The data gap analysis indicate that, 31 additional exploratory wells are required in the area.

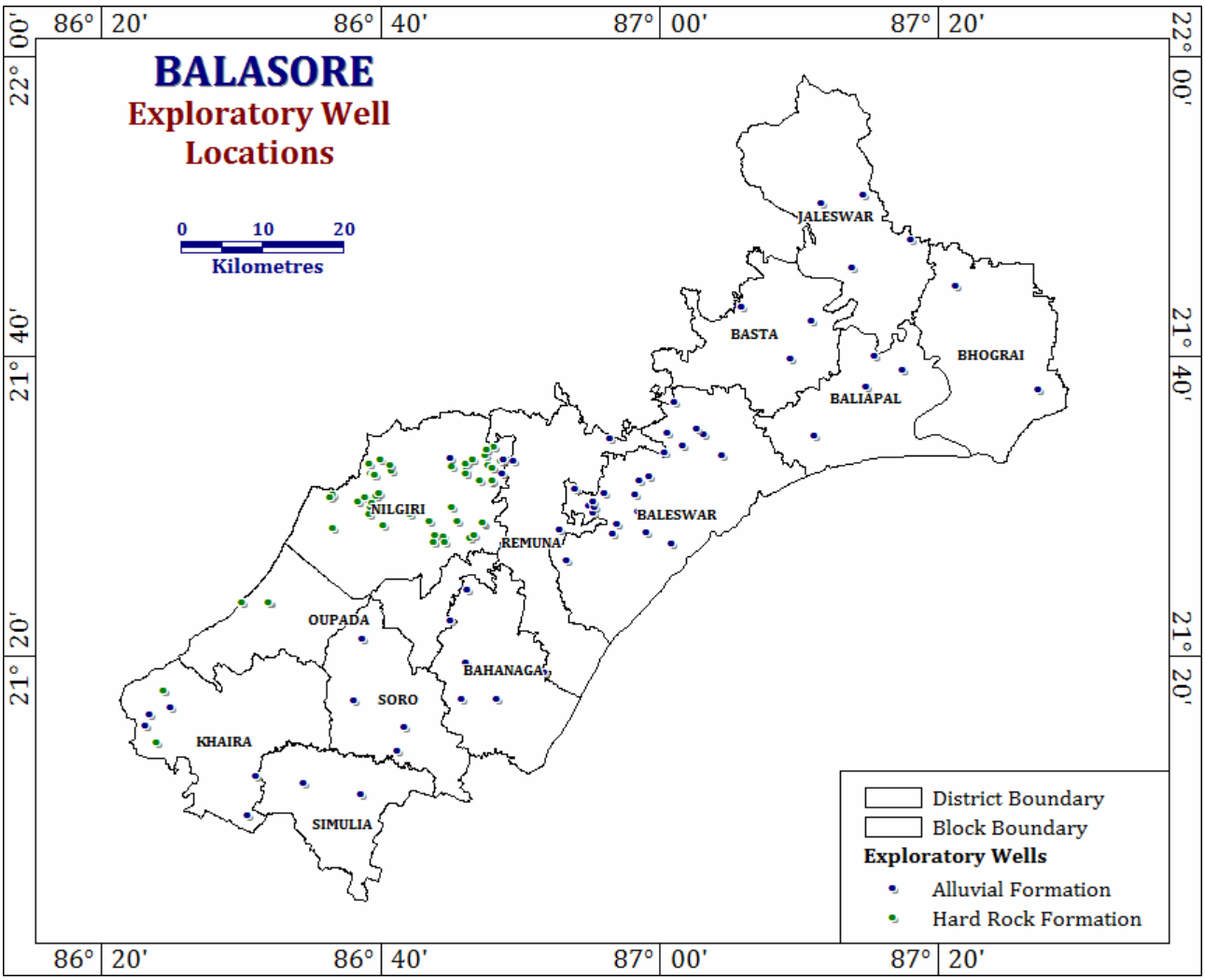


Fig 1.5a: Location of existing Exploratory wells, Balasore District, Odisha

Table – 1.5.1 a: Existing Exploration Details of Bahanaga Block, Balasore District, Odisha

Sl. No.	Name of Site	Depth of Drilling	Aquifers Tapped (mbl)			Aquifer Parameter									Aquifer Quality			Any Other Information
			Aq-I	Aq-II	Aq-III	Aq-I			Aq-II			Aq-III			Aq-I	Aq-II	Aq-III	
						K	T	S	K	T	S	K	T	S				
1	Bahanaga (Pz)	252.3	20-32															SWL=6.88 m bgl
2	Kalyani – 1 (Pz-HP)	161			151-157												F	SWL=2.04 m bgl
3	Kalyani – 21 (Pz-HP)	102		92-98												F		SWL=2.91 m bgl
4	Kasbajeypore (DW)	286	33-37 45-50 58-65 70-73	84-92 99-105			200 m2/ day (cum.)			200 m2/ day (cum)					F	F		SWL=2.85 m bgl Y=31.38 lps Dd=19.7 m
5	Soud – 11 (Pz-HP)	223			211-217												F	SWL=2.04 m agl
6	Soud – 21 (Pz-HP)	68	58-64												F			SWL=1.48 m bgl

Table – 1.5.1 b : Existing Exploration Details of Soro Block, Balasore District, Odisha

Sl. No.	Name of Site	Depth of Drilling	Aquifers Tapped (mbgl)			Aquifer Parameter									Aquifer Quality			Any Other Information
			Aq-I	Aq-II	Aq-III	Aq-I			Aq-II			Aq-III			Aq-I	Aq-II	Aq-III	
						K	T	S	K	T	S	K	T	S				
1	Gopinathpur	63	36-38 48-51 56-60															
2	Gopinathpur (OW)	63	36-38 48-51 56-60															
3	Hansapatna	110.76																Well abandoned
4	Iswarpur	122.56	45-63															
5	Podadiha (Pz-HP)	100		90-96												F		
6	Soro	295.96	24 m (cum. Thickness)				181 m2/day (cum)			181 m2/day (cum)			181 m2/ day (cum)		F	F	F	SWL=1.52 m bgl Y=11.38 lps Dd=12.8 m
7	Talnagar (Pz-HP)	86		76-82												F		SWL=1.33 m bgl
8	Khandasahi (Ward No. 10)	132	42-45 55-58	82-88 126-129														
9	Lingapada (Ward no 7)	84	44-47 56-68	78-81														

Table – 1.5.1 c : Existing Exploration Details of Balasore Block, Balasore District, Odisha

Sl. No.	Name of Site	Depth of Drilling	Aquifers Tapped			Aquifer Parameter									Aquifer Quality			Any Other Information
			Aq-I	Aq-II	Aq-III	Aq-I			Aq-II			Aq-III			Aq-I	Aq-II	Aq-III	
						K	T	S	K	T	S	K	T	S				
1	Kuruda	77.5	41-44, 52-61, 68-71 m				490											Yield- 36 lps DD-7.95m
2	Arad Bazar	70	39-46, 52-66 m															Yield- 12.5 lps DD-8.81m
3	Balasore-I	102		90-96 m												Fresh		
5	Bankakhejuri	81	50-54, 58-64, 70-78 m				299								Fresh			Yield- 8.5 lps DD-9.5m
6	Bhimpara	76.97	17-25, 30-50, 55-70 m				491.7								Fresh			Yield- 54 lps DD-12.2m
7	Chandipur	307	12-157, 157-244, 244-307 m				217 m^2 / day								12-157(S), 157-244 (F) 244-307 (S)			Yield- 4.72 lps DD- 13.1m
8	Darjipokhari	64	36-39, 42-46, 56-51m				142								Fresh			Yield- 11 lps DD- 11.3m
9	Dharampur	302.63	18-25, 32-39, 44-63, 66-72, 84-90				661								Fresh			Yield- 21 lps DD- 11.31m
10	Haldipada (Nayapara)	112	38-44				873	$1.3x10^{-3}$										Yield- 40 lps DD- 6.7m
12	Malisahi	222			155-185, 200-220 m								1160 m^2 / day				Fresh	Yield- 65.83 lps DD-10.775m
13	Padabanagaon	268.55	20-30, 34-42, 57-65, 73-86, 100-115, 160-168				261								Fresh			Yield- 49 lps DD- 13.81m
15	Rupsa	124		61-67, 87-93, 97-103, 118-121											Fresh			Yield- 30 lps DD- 3.5m
16	Sartha	215			158-170, 185-191, 195-201, 209-212												Fresh	Yield- 30 lps DD- 3.5m
17	Sunhat	309	37-40, 43-52, 55-59, 63-75, 89-92 m				217								0-214 (F) 214-304 (B)			Yield- 34.4 lps DD- 18.34 m
21	Balashram	100.35	33-36, 38-50, 53-58, 60-64, 82-86 m				265.5								Fresh			Yield- 34 lps DD- 14.29 m
23	Balasore MNC	103.35	33-36, 38-50, 53-58, 60-64, 82-86.5 m				265.5								Fresh			Yield- 34.57 lps DD- 14.29 m
25	Bhaskargunj	73	44-50, 52-55, 67-70 m												Fresh			Yield- 25 lps DD- 2.1 m
26	Ganeswarpur	101.2	30-33, 36.5-44, 45.5-47, 49-52, 57.5-55.5,				374.5								Fresh			Yield- 31 lps DD- 7.21 m

Sl. No.	Name of Site	Depth of Drilling	Aquifers Tapped			Aquifer Parameter									Aquifer Quality			Any Other Information
			Aq-I	Aq-II	Aq-III	Aq-I			Aq-II			Aq-III			Aq-I	Aq-II	Aq-III	
						K	T	S	K	T	S	K	T	S				
			57-62, 64-66 m															
31	Matasahi	103.78	34- 38, 45-51, 57- 60 m												Fresh			Yield- 10 lps DD- 2.84 m
33	Police Line	84	47-54, 67-75.0m				202								Fresh			Yield- 26.28 lps DD- 8.59 m
34	Public High School	71.68	42-48, 51-55, 60-66 m				405								Fresh			Yield- 37.8 lps DD- 4.6 m
37	Sobharampur	74	44-56,62-65 m				411								Fresh			Yield- 36 lps DD- 17 m

Table – 1.5.1 d : Existing Exploration Details of Remuna Block, Balasore District, Odisha

Sl. No.	Name of Site	Depth of Drilling	Aquifers Tapped			Aquifer Parameter									Aquifer Quality			Any Other Information
			Aq-I	Aq-II	Aq-III	Aq-I			Aq-II			Aq-III			Aq-I	Aq-II	Aq-III	
						K	T	S	K	T	S	K	T	S				
1	Mardrajpur	61	**48-58 m**												**All Fresh**			**Yield-** 12 **lps** **DD- ×**
2	Remuna	300	**34-40, 44-50, 55-61, 84-96 m**				**1734 m² / day**								**All Fresh**			**Yield-** 50.69 **lps** **DD-** 8.77
3	Shipura	330.26	**20-44, 53-59, 68-71, 78-84, 91-100, 92-121, 128-132, 138-144, 164-168 m**				**254 m² / day**								**All Fresh**			**Yield-** 48.8 **lps** **DD-** 15.04 m
4	Srikrushnapur	88	**32-35, 38-44, 52-55, 56-62, 82-85 m**				×								**All Fresh**			**Yield-** 25 **lps** **DD-** 4.8 m

Table – 1.5.1 e : Existing Exploration Details of Baliapal Block, Balasore District, Odisha

Sl. No.	Name of Site	Depth of Drilling	Aquifers Tapped			Aquifer Parameter									Aquifer Quality			Any Other Information
			Aq-I	Aq-II	Aq-III	Aq-I			Aq-II			Aq-III			Aq-I	Aq-II	Aq-III	
						K	T	S	K	T	S	K	T	S				
1	Baliapal	307	**30-40, 44-49, 53-58, 60-66, 69-74, 76-80, 99-110, 113-124, 166-179 m**				**1650 m² / day**								**All Fresh**			**Yield- 65.2 lps DD- 15.63 m**
3	Baliapal – I	138		**128-134 m**												**All Fresh**		
4	Baliapal – II	100		**90-96 m**												**All Fresh**		
5	Bharamareswar	316.58	**45-50, 90-96, 116-121, 125-150 m**				**3800 m² / day**								**0-15 (S),15-300 (F)**			**Yield- 11.21 lps DD- 53.98 m**
6	Debhog	307	**44-56, 60-70, 91-98, 112-124, 129-139, 152-158 m**				**252 m² / day**								**All Fresh**			**Yield- 61.6 lps DD- ×**

Sl. No.	Name of Site	Depth of Drilling	Aquifers Tapped			Aquifer Parameter									Aquifer Quality			Any Other Information
			Aq-I	Aq-II	Aq-III	Aq-I			Aq-II			Aq-III			Aq-I	Aq-II	Aq-III	
						K	T	S	K	T	S	K	T	S				
7	Madhupura	289.64	30-35, 46-55, 60-77, 88-92, 110-140 m			1115 m² / day									All Fresh			Yield- 69.26 lps DD- 7.16 m
8	Pokrisahi	284		116-121, 127-156, 211-223 m												All Fresh		Yield- 38.33lps DD-24.13 m
9	Remu	171.92	30-33, 35-58, 62-72, 120-125 m			978 m² / day									All Fresh			Yield- 68.6 lps DD-9.54 m

Table – 1.5.1 f : Existing Exploration Details of Basta Block, Balasore District, Odisha

Sl. No.	Name of Site	Agency	Depth of Drilling	Aquifers Tapped			Aquifer Parameter									Aquifer Quality			Any Other Information
				Aq-I	Aq-II	Aq-III	Aq-I			Aq-II			Aq-III			Aq-I	Aq-II	Aq-III	
							K	T	S	K	T	S	K	T	S				
1	Barhapal	CGWB	292.81	7-12, 18-34	55-63, 67-74, 101-111 m		259.8 m² / day									All Fresh			Yield- 54 lps DD-11.75m
2	Basta	CGWB	151.8		96-110 m												All Fresh		
3	Shyamsunderpur	CGWB	281.73		90-126, 135-158 m		571 m² / day										All Fresh		Yield- 65 lps DD-10.6m

Table – 1.5.1 g : Existing Exploration Details of Bhograi Block, Balasore District, Odisha

Sl. No.	Name of Site	Depth of Drilling	Aquifers Tapped			Aquifer Parameter									Aquifer Quality			Any Other Information
			Aq-I	Aq-II	Aq-III	Aq-I			Aq-II			Aq-III			Aq-I	Aq-II	Aq-III	
						K	T	S	K	T	S	K	T	S				
1	Karanjasole	600	21-27, 93-120, 136-145, 146-151, 154-158, 160-179, 263-246, 250-253, 257-260, 265-270, 280-294, 296-315 m			680 m² / day									0.0-26 (F), 26-72 (S), 72-133 (B), 133-179 (F), 179-226 (B), 226-315 (F) 315-590 (S)			Yield- 61.6 lps DD-13.7m
2	Kasbakundra	304.8																

Table – 1.5.1 h : Existing Exploration Details of Jaleswar Block, Balasore District, Odisha

Sl. No.	Name of Site	Depth of Drilling	Aquifers Tapped			Aquifer Parameter									Aquifer Quality			Any Other Information
			Aq-I	Aq-II	Aq-III	Aq-I			Aq-II			Aq-III			Aq-I	Aq-II	Aq-III	
						K	T	S	K	T	S	K	T	S				
1	Amleta	311.5	37-45, 63-73,75-79,	93-108 ,112-119, 189-209 m		1266 m² / day									All Fresh			
2	Dhanasimulia-I	300.8		98-104 m												All Fresh		Yield- 15 lps

Sl. No.	Name of Site	Depth of Drilling	Aquifers Tapped			Aquifer Parameter									Aquifer Quality			Any Other Information
			Aq-I	Aq-II	Aq-III	Aq-I			Aq-II			Aq-III			Aq-I	Aq-II	Aq-III	
						K	T	S	K	T	S	K	T	S				
																		DD- ×
3	Dhanasimulia-II	46	**30-36 m**													**All Fresh**		**Yield- 20 lps DD- ×**
5	Laksmannath Road	230.4	**42-54, 61.91,**	**123-137, 191-203 m**		**1786 m^2 / day**									**All Fresh**			**Yield- 61.6lps DD- 5.83 m**

Table – 1.5.1 i Existing Exploration Details of Nilgiri Block, Balasore District, Odisha

Sl. No.	Name of Site	Depth of Drilling	Aquifers Tapped (Fractures)			Aquifer Parameter									Aquifer Quality			Any Other Information
			Aq-I	Aq-II	Aq-III	Aq-I			Aq-II			Aq-III			Aq-I	Aq-II	Aq-III	
						K	T m^2/Day	S	K	T	S	K	T	S				
1	Nilgiri (Proposed New Bus Stand)	99.1		**60-1.92-1.94-2,98-6 m**														Yield-10 lps DD- 26 m
2	Raj Berhampur–1	172.3	37,40,45 m				73.2											Yield-6 lps DD- 3.7 m
3	Raj Berhampur–2	38.1	27,30,36 m				66.1											Yield-11 lps DD- 4.62m
4	Saladhara–1	73.4	17,23m				19.8											Yield-6 lps DD- 6.83m
5	Saladhara –2	101.2	35,44,92,101m				11.63											Yield-11 lps DD- 27.3 m
6	Sajnagarh	91		58,66,81,90 m						115.34								
7	Podasul	56.4	54.40-55.40 m				581.2											Yield-18 lps DD- 1.55 m
8	Kalakad	50.3	21.90-27 m				321.02											Yield-19 lps DD- 2.65 m
10	Bhalukposi	86.9	36.10-42.10 m				61.9											Yield-14 lps DD- 7.6 m
11	Bhalukposi OW	86.9	12.7,35.1,39.2,52.40 m				47.64											Yield-14 lps DD- 8.5 m
12	Sankaliapada	95.1		85.90,90.0 m						67.77								Yield-7 lps DD- 16.4m
13	Baunspal	74.7		57, 74 m						14.13								Yield-7.5 lps DD- 17.01m
14	Nilgiri (Rathadanda)	161.2		96 m						×								Yield-neg DD- ×
15	Gopinathpur	105.2		99 m						×								Yield-0.5 lps DD- ×
16	Bagmara	79.8		71.2 m						6.5								Yield-3.5lps

Sl. No.	Name of Site	Depth of Drilling	Aquifers Tapped (Fractures)			Aquifer Parameter									Aquifer Quality			Any Other Information
			Aq-I	Aq-II	Aq-III	Aq-I			Aq-II			Aq-III			Aq-I	Aq-II	Aq-III	
						K	T m^2/Day	S	K	T	S	K	T	S				
																		DD- 28.1 m
19	Arbandh	50.3	28.10, 32.10, 39.20, 43.2 m				75.94											Yield-15lps DD- 9.45m
20	Arbandh	102.2	25.90, 29.0, 32.0, 35.10, 37.10, 46.30 m				42.8											Yield-15lps DD- 3.75m
22	Begunia	89	15.80,51.30,64. 60,70.7,86.90 m				195											Yield-12lps DD- 8.35m
23	Begunia	68.6	25.90, 34.10, 38.10, 49.30, 64.60 m				267.75											Yield-15 lps DD- 11.05m
24	Chandipur	136.8	26.90, 77.80 m				5.65											Yield-3 lps DD- 10.6m
25	Jagannathpur	66.6	38.10, 43.20, 46.30, 51.40, 56.40, 64.60 m				735.9											Yield-20 lps DD- 2.1 m
27	Khumtana	99.1	26,00, 85.90 m				25.52											Yield-12 lps DD- 11.5m
29	Telipal	105	46.60, 60.80, 63.90, 68.90, 77.10, 80.10 m				14.38											Yield-10 lps DD- 21.6 m
30	Upardiha	150	57.8 m															Yield-0.5 lps DD- ×
31	Betei	154	30.0, 90.0, 117.0 m				10.2											Yield-2 lps DD- 20.45m
32	Bankisahi	105.2	41.20,47.30, 58.50, 81.90 m															Yield-5 lps DD- 21.85m
33	Betkota	50	15.8, 36.10, 50.60 m				124.3											Yield-12 lps DD- 18.85m
34	Bhalukasuni	135.8	47.3, 56.40 m				12.17											Yield-4 lps DD- 31.5m
35	Gopinathpur(Sasan)	73.2		59.5, 68.60m						287.66								Yield-12 lps DD- 13.75 m
36	Gujudiha	150																Dry
37	Gujudiha (Adibasi Sahi)	130		72.7 m						33.12								Yield-3 lps DD- 25.1 m
38	Jambani	82.9	24.90, 74.7 m				16.6											Yield-6.5 lps DD- 22.6m
39	Jambani	80.8	9.70, 73.70 m				15.5											Yield-9 lps DD- 19.6 m
41	Pithahata GP Office	154		81.8 m														Yield-neg DD- ×
42	Siadimal	68		60.50, 63.60, 66.60m						267.75								Yield-25 lps DD- 10.32m
43	Siadimal	76.8	47.2.49.2, 67.6, 74.8 m				439.5											Yield-20 lps

Sl. No.	Name of Site	Depth of Drilling	Aquifers Tapped (Fractures)			Aquifer Parameter									Aquifer Quality			Any Other Information
			Aq-I	Aq-II	Aq-III	Aq-I			Aq-II			Aq-III			Aq-I	Aq-II	Aq-III	
						K	T m^2/Day	S	K	T	S	K	T	S				
																		DD- 3.62 m
44	Chekamara - EW	62.5	24.90, 29, 39.20, 44.20 m				178.3											Yield-16lps DD- 5.45m
45	Chekamara - OW	62.5	29, 41.20, 46.20 m				45.2											Yield-12.2 lps DD- 6.5 m
47	Kuarpur Mahal(Tailasahi)-EW	78.8	37.40, 40.50 m				×											Yield-18 lps DD- 11.25m
66	Patna	106.3	43.20, 91 m					×										Yield-9.55 lps DD- 10.55m
67	Raipal	56.4	9.30, 27.0, 34.10 m					×										Yield-4.55 lps DD- 139.2m
69	Rigidi	185	28.4 m					×										Yield-0.5 lps DD- ×
70	Telipal - Ashram School	32	21.9, 27, 29 m					112.1										Yield-20 lps DD- 8.15 m

1.5.2 Ground Water Geophysical Surveys : Ground water geophysical survey data (VES) is required for filling gaps while establishing aquifer geometry. So far, in the aquifer mapping area of Balasore district, till the onset of NAQUIM 62 Bpore Hole Electrical Logging and 53 Vertical Electrical Soundings were carried out.

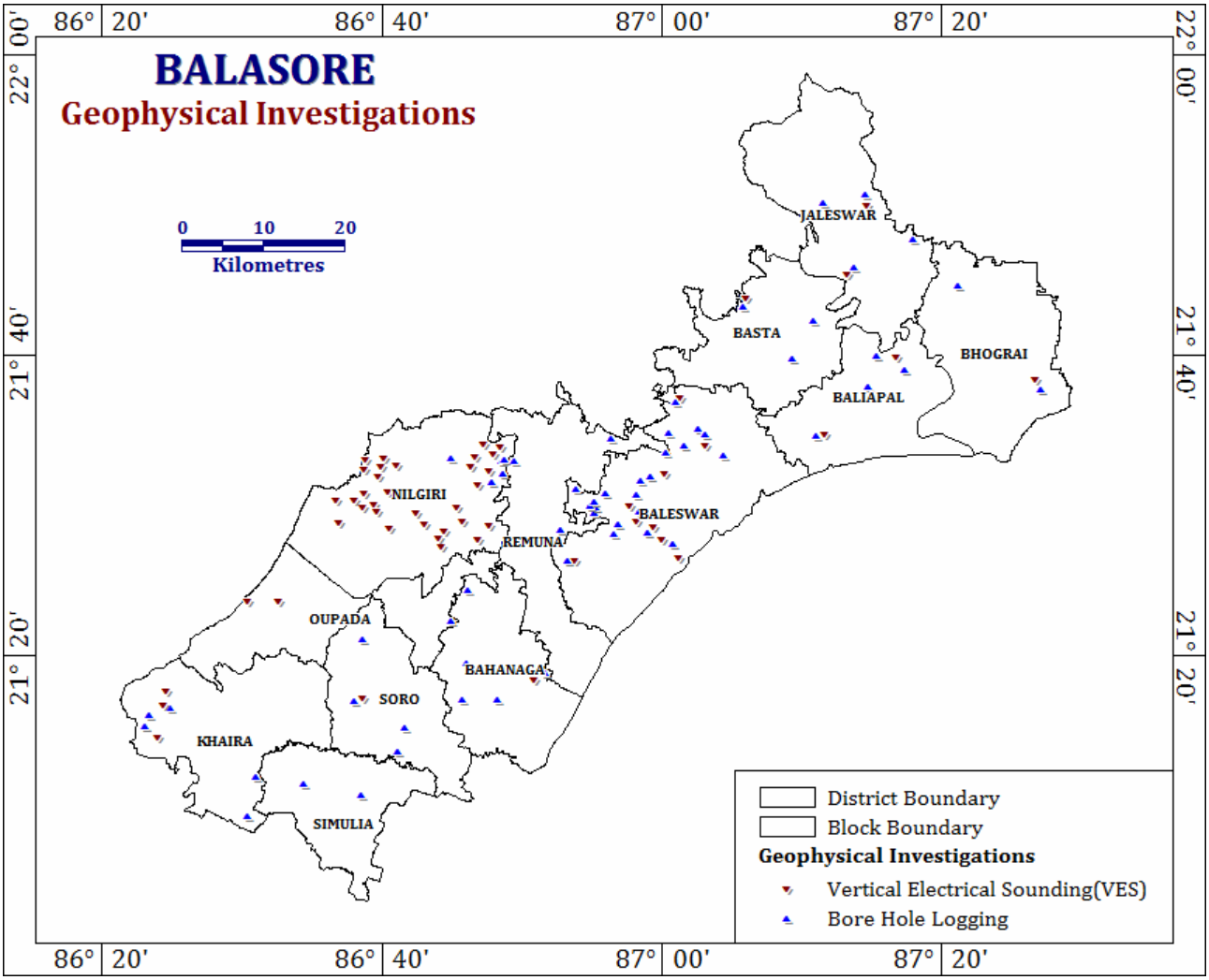


Figure – 1.5b : Geophysical Investigations carried out in Balasore District, Odisha

1.5.3 Ground Water Monitoring : For ground water regime monitoring, open/dugwells were considered for phreatic aquifer and piezometers for monitoring deeper aquifers. The frequency of monitoring is four times annually (April, August, November & January). These wells have been monitored for a long time. These wells are categorized as National Hydrograph Network Stations(NHNS).

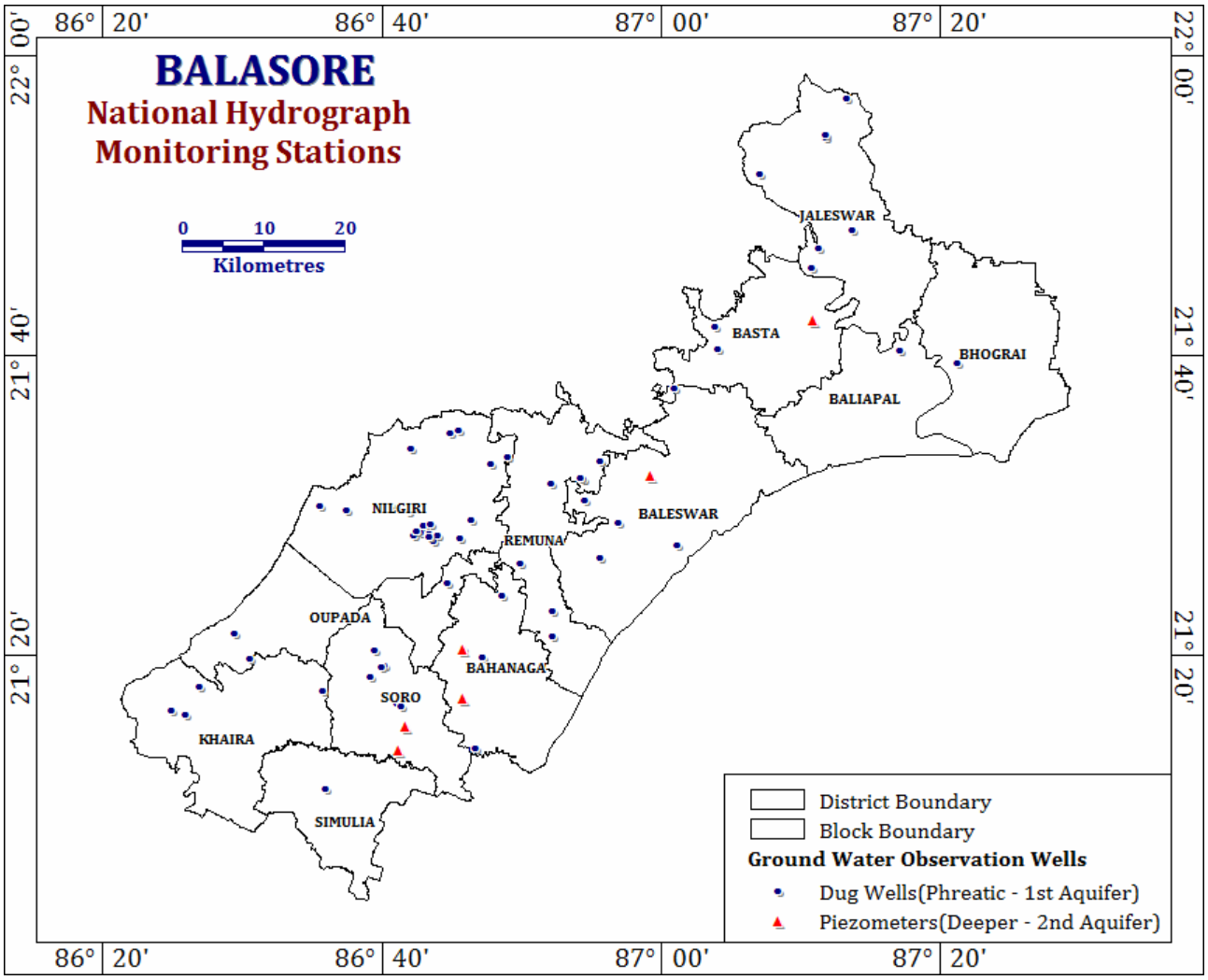


Fig 1.5c: Location of existing GW monitoring stations, Balasore District, Odisha

Table – 1.5.3 : Existing Ground Water Monitoring Statojns in Balasore District, Odisha

Sl. No	Name of Site	Block	Type of Well	Depth in m (bgl)	Water Levels				Remarks
					Phreatic	Aq-I	Aq-II	Aq-III	
1	Bhahanaga	Bahanaga	Dug well	12.59	Y				
2	Sathi	Bahanaga	Dug Well	9	Y				
3	Baghudi	Soro	Dug Well	7.84	Y				
4	Lingapada	Soro	Dug Well	10.2	Y				
5	Soro	Soro	Dug Well	16	Y				
6	Khantapada	Nilgiri	DW	11.2	Y				
7	Chekamara	Nilgiri	DW	9.1	Y				
8	Baband	Nilgiri	DW	11	Y				
9	Siadimal	Nilgiri	DW	9.3	Y				
10	Benthiapada	Nilgiri	DW	8.1	Y				
11	Nilgiri	Nilgiri	DW	8.26	Y				
12	Bhalukasuni	Nilgiri	DW	8.2	Y				
13	Bhagabondh	Nilgiri	DW	8	Y				
14	Darkholi	Nilgiri	DW	9.45	Y				
15	Kunchibenia	Nilgiri	DW	11.2	Y				
16	Mitrapur	Nilgiri	DW	10.13	Y				
17	Nuaporhi	Nilgiri	DW	7.81	Y				
18	Kansa	Nilgiri	DW	9.81	Y				
19	Chandipur	Balasore	DW	7.25	Y				
20	Sasanbar	Balasore	DW	8.43	Y				
21	Rupsa	Balasore	DW	8.2	Y				
22	Remuna	Remuna	DW	9.22	y				
23	Govindpur	Remuna	DW	9.8	Y				
24	Baliapal	Baliapal	DW	9.07	y				

Sl. No	Name of Site	Block	Type of Well	Depth in m (bgl)	Water Levels				Remarks
					Phreatic	Aq-I	Aq-II	Aq-III	
25	Baliapal-1	Baliapal	Pz	102	N		Aq-II		
26	Baliapal-2	Baliapal	Pz	67	N	Y			
27	Srirampur	Baliapal	Pz	84.75	N		Y		
28	Chalanti	Basta	DW	10.1	Y				
29	Basta	Basta	DW	8	Y				
30	KULIDA	Basta	HP	60-70	N	Y			
31	Komrda	Bhograi	Pz	131.95	N		Y		
32	Sunderai	Bhograi	Pz	68. 30	N	Y			
33	Raibania	Jaleswar	DW	11.4	Y				
34	Sugo	Jaleswar	Pz	95.85	N		Y		

1.5.4 Ground Water Quality : For the assessment of ground water quality, water sample from open/dugwell has to be collected for phreatic aquifer and for frature zone aquifer water sample may be collected from EW/OW constructed for exploration. The locations of existing groundwater quality stations is given in Fig. 1.5 and the data is tabulated in Table- 1.3. The data gap analysis indicate that the 419 additional ground water sampling stations are required in the area.

Table – 1.5.4 : Ground Water Monitoring Stations

Sl. No	Name of Site	Block	Depth of Drilling (m)	Aquifers Tapped				EC			Region Specific Quality (F)			Any Other Information
				Phreatic	Aq-I	Aq-II	Aq-III	µS/cm			ppm			
								Aq-I	Aq-II	Aq-III	Aq-I	Aq-II	Aq-III	
1	Bahanaga	Bahanaga	252.3	Y	20-32									
2	Gopinathpur	Soro	63	N	36-38 48-51 56-60									
3	Gopinathpur (OW)	Soro	63	N	36-38 48-51 56-60									
4	Hansapatna	Soro	110.76	N										
5	Iswarpur	Soro	122.56	N	45-63									
6	Podadiha Pz	Soro	100	N		90-96								
7	Soro	Soro	295.96	N	24 m (Cummulative)									
8	Talnagar Pz	Soro	86	N		76-82								
9	Khandasahi	Soro	132	N	42-45 55-58	82-88 126-129								
10	Lingapada	Soro	84	N	44-47 56-68	78-81								
11	Baghudi	Soro	7.84	Y				314			0.8			
12	Lingapada	Soro	10.2	Y										
13	Soro	Soro	16	Y				336			0.55			
14	Nilgiri	Nilgiri	99.1	N	Aq-II									
15	Raj Berhampur 1	Nilgiri	172.3	N	Aq-I	1000	0.67							
16	Raj Berhampur 2	Nilgiri	38.1	N	Aq-I									
17	Saladhara 1	Nilgiri	73.4	N	Aq-I									

Sl. No	Name of Site	Block	Depth of Drilling (m)	Aquifers Tapped				EC			Region Specific Quality (F)			Any Other Information
				Phreatic	Aq-I	Aq-II	Aq-III	µS/cm			ppm			
								Aq-I	Aq-II	Aq-III	Aq-I	Aq-II	Aq-III	
18	Saladhara 2	Nilgiri	101.2	N	Aq-I & Aq-II									
19	Sajnagarh	Nilgiri	91	N	Aq-II	540	1.09							
20	do	Nilgiri	105.2	N	Aq-II									
21	Kalakad	Nilgiri	50.3	N	Aq-I	780	0.20							
22	Kalakad-OW	Nilgiri	30.5	N	Aq-I									
23	Bhalukposi	Nilgiri	86.9	N	Aq-I									
24	Bhalukposi-OW	Nilgiri	86.9	N	Aq-I									
25	Sankaliapada	Nilgiri	95.1	N	Aq-II									
26	Baunspal	Nilgiri	74.7	N	Aq-II									
27	Nilgiri Rathadanda	Nilgiri	161.2	N	Aq-II									
28	Gopinathpur	Nilgiri	105.2	N	Aq-II									
29	Bagmara	Nilgiri	79.8	N	Aq-II									
30	Olaichandi	Nilgiri	137.8	N	Aq-I									
31	Olaichandi	Nilgiri	139.8	N	Aq-I									
32	Arbandh	Nilgiri	50.3	N	Aq-I									
33	Arbandh	Nilgiri	102.2	N	Aq-I									
34	Babandh	Nilgiri	139.8	N	Aq-II									
35	Begunia	Nilgiri	89	N	Aq-I & Aq-II									
36	Begunia	Nilgiri	68.6	N	Aq-I & Aq-II									
37	Chandipur	Nilgiri	136.8	N	Aq-I & Aq-II									
38	Jagannathpur	Nilgiri	66.6	N	Aq-I & Aq-II									
39	Jagannathpur	Nilgiri	62.5	N	Aq-I & Aq-II									
40	Khumtana	Nilgiri	99.1	N	Aq-I & Aq-II									
41	Telipal	Nilgiri	82.1	N	Aq-I & Aq-II									
42	Telipal	Nilgiri	105	N	Aq-I & Aq-II									
43	Upardiha	Nilgiri	150	N	Aq-II									
44	Betei	Nilgiri	154	N	Aq-I & Aq-II									
45	Bankisahi	Nilgiri	105.2	N	Aq-I & Aq-II									
46	Betkota	Nilgiri	50	N	Aq-I & Aq-II									
47	Bhalukasuni	Nilgiri	135.8	N	Aq-I	15								
48	Jambani	Nilgiri	82.9	N	Aq-I & Aq-II	170	0.52							
49	Jambani	Nilgiri	80.8	N	Aq-I & Aq-II	20								
50	Gujudiha	Nilgiri	141.8	N										
51	Gujudiha (Adibasi Sahi)	Nilgiri	130	N	Aq-II	51								
52	Pithahata	Nilgiri	153	N	Aq-I									
53	Pithahata - Panchayat Office	Nilgiri	154	N		35								
54	Betkota	Nilgiri	50	N	Aq-I	66								
55	Berhampur (Mandir Sahi)	Nilgiri	151	N	Aq-II	114								
56	Chekamara	Nilgiri	62.5	N	Aq-I	1350	0.29							
57	Chekamara	Nilgiri	62.5	N	Aq-I	211								
58	Kathaguchiani	Nilgiri	62.3	N	Aq-I	37								
59	Kuarpur Mahal(Tailasahi)	Nilgiri	78.8	N	Aq-I	35								
60	Machhua	Nilgiri	155	N	Aq-I	210	0.91							
61	Patna	Nilgiri	106.3	N	Aq-I & Aq-II	20								
62	Raipal	Nilgiri	56.4	N	Aq-I	17								
63	Raipal	Nilgiri	54.9	N	Aq-I	26								
64	Rigidi	Nilgiri	185	N	Aq-I	22								

Sl. No	Name of Site	Block	Depth of Drilling (m)	Aquifers Tapped				EC			Region Specific Quality (F)			Any Other Information
				Phreatic	Aq-I	Aq-II	Aq-III	µS/cm			ppm			
								Aq-I	Aq-II	Aq-III	Aq-I	Aq-II	Aq-III	
65	Telipal - Ashram School	Nilgiri	32	N	Aq-I	34								
66	Nilgiri	Nilgiri	8.26	N	Phreatic	386	0.61							
67	Mitrapur	Nilgiri	10.13	N	Phreatic	253	0.5							
68	Kansa	Nilgiri	9.81	N	Phreatic	373	0.46							
69	Kuruda	Balasore	77.5	N	Aq-I	510	0.44							
70	Arad Bazar	Balasore	70	N	Aq-I	530	0.9							
71	Balasore-I	Balasore	102	N	Aq-II									
72	Balasore-II	Balasore	73	N	Aq-I									
73	Bankakhejuri	Balasore	81	N	Aq-I & Aq-II	520	0.9							
74	Bhimpara	Balasore	76.97	N	Aq-I									
75	Chandipur	Balasore	307	N	Aq-I & Aq-II									
76	Darjipokhari	Balasore	64	N	Aq-I									
77	Dharampur	Balasore	302.63	N	Aq-I & Aq-II									
78	Haldipada (Nayapara)	Balasore	112	N	Aq-I									
79	Haldipada-II	Balasore	52	N	Aq-I									
80	Malisahi	Balasore	222	N	Aq-III									
81	Padabanagaon	Balasore	268.55	N	Aq-I & Aq-II	1062								
82	Padmapur	Balasore	54	N	Aq-I									
83	Rupsa	Balasore	124	N	Aq-II									
84	Sartha	Balasore	215	N	Aq-III									
85	Sunhat	Balasore	309	N	Aq-I & Aq-II									
86	Angargadia	Balasore	73	N	Aq-I									
87	Badakhua	Balasore	125	N	Aq-I	510	0.44							
88	Badakhua	Balasore	60	N	Aq-I									
89	Balashram	Balasore	100.35	N	Aq-I & Aq-II									
90	Balasore MNC	Balasore	301	N	Aq-I									
91	Balasore MNC	Balasore	103.35	N	Aq-I & Aq-II									
92	Balia	Balasore	174.8	N	Aq-I									
93	Bhaskargunj	Balasore	73	N	Aq-I									
94	Ganeswarpur	Balasore	101.2	N	Aq-I	336	0.4							
95	Golapokhari	Balasore	77	N	Aq-I									
96	Kadrabad(Ward No 5)	Balasore	77	N	Aq-I									
97	Khaprapada	Balasore	71	N	Aq-I									
98	Makalpur	Balasore	103	N	Aq-I									
99	Matasahi	Balasore	103.78	N	Aq-I									
100	Matasahi	Balasore	72	N	Aq-I	257	0.51							
101	Police Line	Balasore	84	N	Aq-I									
102	Public High School	Balasore	71.68	N	Aq-I	510	0.44							
103	Sahadevkhunta	Balasore	94.6	N	Aq-I									
104	Sobharampur	Balasore	103	N	Aq-I	340	0.41							
105	Sobharampur	Balasore	74	N	Aq-I									
106	Balasore sadar	Balasore		Y	Phreatic	353	0.67							
107	Chandipur	Balasore	7.25	Y	Phreatic									
108	Sasanbar	Balasore	8.43	Y	Phreatic									
109	Rupsa	Balasore	8.2	Y	Phreatic	257	0.57							
110	Mardrajpur	Remuna	61	N	Aq-I									
111	Remuna	Remuna	300	N	Aq-I & Aq-II									

Sl. No	Name of Site	Block	Depth of Drilling (m)	Aquifers Tapped				EC			Region Specific Quality (F)			Any Other Information
				Phreatic	Aq-I	Aq-II	Aq-III	µS/cm			ppm			
								Aq-I	Aq-II	Aq-III	Aq-I	Aq-II	Aq-III	
112	Remuna	Remuna	153.61	N	Aq-I									
113	Shipura	Remuna	330.26	N	Aq-I & Aq-II									
114	Srikrushnapur	Remuna	88	N	Aq-1									
115	Remuna	Remuna	9.22	Y	Phreatic									
116	Govindpur	Remuna	9.8	Y	Phreatic	379	0.47							
117	Baliapal	Baliapal	307	N	Aq-I, Aq-II & Aq2-III	650								
118	Baliapal	Baliapal	300	N		600								
119	Baliapal – I	Baliapal	138	N	Aq-II									
120	Baliapal – II	Baliapal	100	N	Aq-II									
121	Bharamareswar	Baliapal	316.58	N	Aq-I & Aq-II									
122	Debhog	Baliapal	307	N	Aq-I & Aq-II	900								
123	Madhupura	Baliapal	289.64	N	Aq-I & Aq-II	229-550								
124	Pokrisahi	Baliapal	284	N	Aq-II & Aq-III	1631-1704								
125	Remu	Baliapal	171.92	N	Aq-I & Aq-II	600								
126	Baliapal	Baliapal	9.07	Y	DW	316	0.73							
127	Barhapal	Basta	292.81	N	Aq-I & Aq-II									
128	Basta	Basta	153.31	N	Aq-I									
129	Basta	Basta	151.8	N	Aq-II	809								
130	Shyamsunderpur	Basta	281.73	N	Aq-II									
131	Singla	Basta	305.41	N										
132	Chalanti	Basta	10.1	Y	Phreatic	151	0.14							
133	Basta	Basta	8	Y	Phreatic	467	1.08							
134	Karanjasole	Bhograi	600	N	Aq-I, Aq-II & Aq-III	660	0.16							
135	Kasbakundra	Bhograi	304.8	N										
136	Komrda	Bhograi	131.95	N	Aq-II									
137	Sunderai	Bhograi	68. 30	N	Aq-I									
138	Amleta	Jaleswar	311.5	EW	Aq-I, Aq-II & Aq-III	600								
139	Dhanasimulia-I	Jaleswar	300.8	Pz	Aq-I, Aq-II & Aq-III									
140	Dhanasimulia-II	Jaleswar	46	Pz	Aq-I									
141	Jaleswar	Jaleswar	-	EW										
142	Laksmannath Road	Jaleswar	230.4	EW	Aq-I, Aq-II & Aq-III	580								
143	Raibania	Jaleswar	11.4	NHS	Phreatic	318	0.76							
144	Sugo	Jaleswar	95.85	Pz	Aq-II									

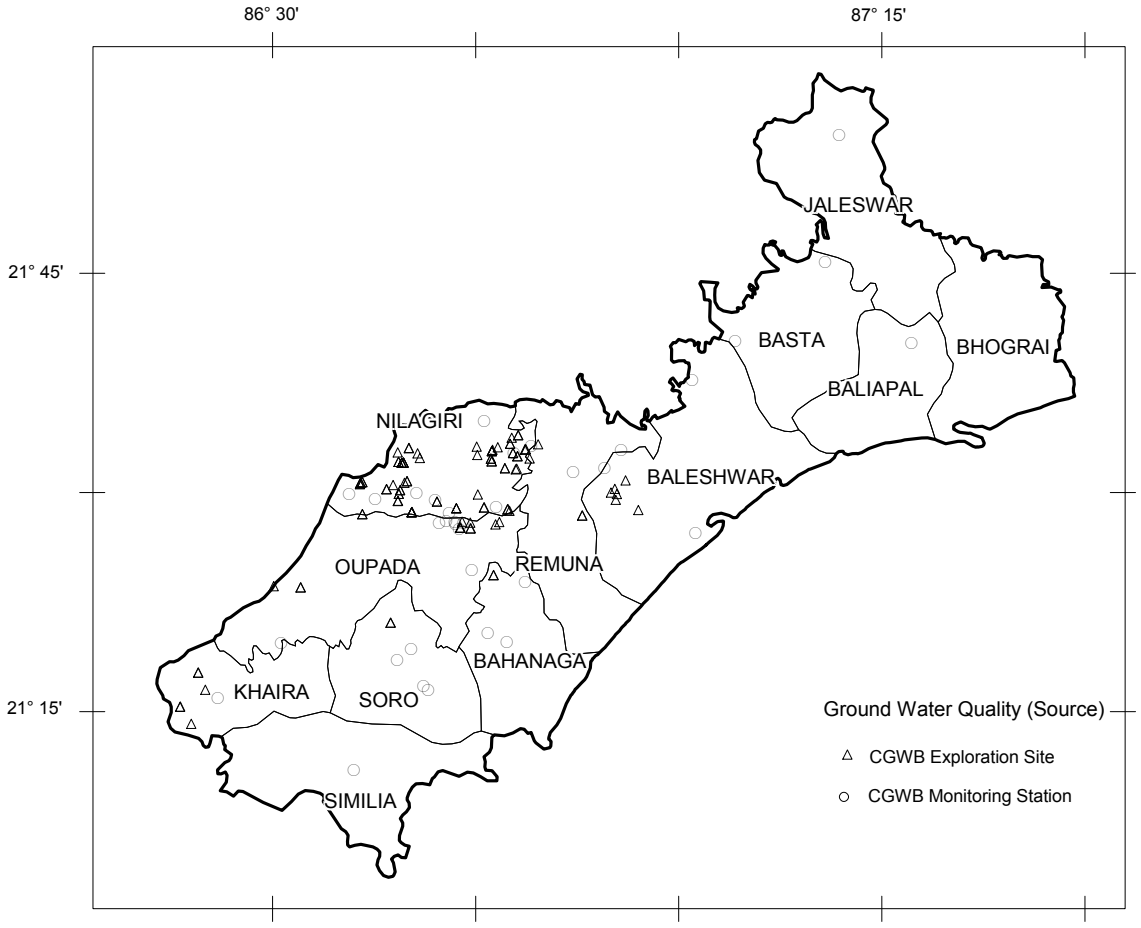


Figure 1.5.4 : Ground Water Quality Monitoring Locations in Balasore District, Odisha

1.6 Data Gap Identification : The details of data gap analysis is presented in Table 1.4. The summarised details of required, existing and datagap of Exploratory Wells, Ground Water Monitoring Stations and Ground Water Quality Stations is given below and discussed in detail.

Table – 1.6.a : DATA GAP ANALYSIS (Hard Rock Area)

Block with area in sq.km	No. of Additional EW required				No. of Additional VES/TEM required	Nos of Additional water level monitoring stations required					Nos of additional water quality stations required					Remarks
	Present Status	Total Reqd.	Aq-I	Aq-II	Total Reqd	Total Reqd	Present Status	Ph	Aq-I	Aq-II	Total Reqd	Present Status	Ph	Aq-I	Aq-II	
Nilgiri (238 sq.km)	Total: 42 Aq-I=18 Aq-II=24 T (value)= 29 (A1-16, A2-6, Cum-7)	**0**			**0**	**0**	Total= 37 Dw- 22 Pz(Aq-I)=-15 Pz(Aq-II)=0 Pz(cum)=0				**0**	Total=35 DW=16 Aq-I=19 Aq-II=0				

N.B.: **Ph:** Phreatic (DW Zone); **Aq-I**: 60 m depth ; **Aq-II**:- 200 m depth, T(value)= No of wells having T value

Table – 1.6b : DATA GAP ANALYSIS (Alluvial Area)

Block with area in sq.km	No. of Additional EW required					No. of Additional VES/TEM required	Nos of Additional water level monitoring stations required						Nos of additional water quality stations required						Remarks
	Present Status	Total Reqd.	Aq-I	Aq-II	Aq-III	Total Reqd	Present Status	Total Reqd	Ph	Aq-I	Aq-II	Aq-III	Present Status	Total Reqd	Ph	Aq-I	Aq-II	Aq-III	
Balasore (477 sq.km)	Total=26 Aq-I=12 Aq-II=3 Aq-III=3 Aq(cum)=8 T =16 (A1-8,A3-1,cum-7)	**0**				**20**	Total=48 Dw-48 Pz(Aq-I)=-0 Pz(Aq-II)=0 Pz(Aq-III)=0 Pz(cum)=0	**0**					Total=82 DW=30 Aq-I=50 Aq-II=2 Aq-III=0 Aq(cum)=1	**0**					
Remuna (327 sq.km)	Total=8 Aq-I=3 Aq-II=2 Aq-III=0 Aq(cum)=3 T =2 (all cum)	**0**				**13**	Total=35 Dw- 12 Pz(Aq-I)=-23 Pz(Aq-II)=0 Pz(Aq-III)=0 Pz(cum)=0	**0**					Total= 50 DW= 27 Aq-I=23 Aq-II=0 Aq-III=0 Aq(cum)=0	**0**					
Baliapal (225 sq.km)	Total=8 Aq-I=0 Aq-II=2 Aq-III=0 Aq(cum)=6 T =5(all cum)	**0**				**8**	Total=4 Dw-1 Pz(Aq-I)=-1 Pz(Aq-II)=2 Pz(Aq-III)=0 Pz(cum)=0	**19**					Total=1 Dw-1 Pz(Aq-I)=-0 Pz(Aq-II)=0 Pz(Aq-III)=0 Pz(cum)=0	**33**					
Basta (283 sq.km)	Total=3 Aq-I=0 Aq-II=2 Aq-III=0 Aq(cum)=1 T =2(A2-1,	**1**			1	**10**	Total=2 Dw-2 Pz(Aq-I)=-0 Pz(Aq-II)=0 Pz(Aq-III)=0 Pz(cum)=0	**26**					Total=2 Dw-2 Pz(Aq-I)=-0 Pz(Aq-II)=0 Pz(Aq-III)=0 Pz(cum)=0	**40**					

Block with area in sq.km	No. of Additional EW required					No. of Additional VES/TEM required	Nos of Additional water level monitoring stations required						Nos of additional water quality stations required						Remarks
	Present Status	Total Reqd.	Aq-I	Aq-II	Aq-III	Total Reqd	Present Status	Total Reqd	Ph	Aq-I	Aq-II	Aq-III	Present Status	Total Reqd	Ph	Aq-I	Aq-II	Aq-III	
	cum-1)																		
Bhograi (325 sq.km)	Total=1 Aq-I=0 Aq-II=0 Aq-III=0 Aq(cum)=1 T =1(cum-1)	**3**	1	1	1	**12**	Total=2 Dw-0 Pz(Aq-I)=-1 Pz(Aq-II)=1 Pz(Aq-III)=0 Pz(cum)=0	**31**					Total=4 Dw-0 Pz(Aq-I)=-1 Pz(Aq-II)=1 Pz(Aq-III)=0 Pz(cum)=2	**45**					
Jaleswar (367sq.km)	Total=4 Aq-I=1 Aq-II=1 Aq-III=0 Aq(cum)=2 T =2(cum-2)	**2**	1	1		**14**	Total=3 Dw-2 Pz(Aq-I)=-0 Pz(Aq-II)=1 Pz(Aq-III)=0 Pz(cum)=0	**34**					Total=1 Dw-1 Pz(Aq-I)=-0 Pz(Aq-II)=0 Pz(Aq-III)=0 Pz(cum)=0	**54**					
Bahanaga (234.3 sq kms)	Total= 6 Aq-I= 2 Aq-II= 1 Aq-III= 2 Aq (cum)= 1 T (value)= 1	**0**			**10**	**21**	Total= 2 DW= 2 Pz (Aq-I)= Pz (Aq-II)= Pz (Aq-III)= Pz (cum)=	**27**					Total= 8 DW= 2 Aq-I= 2 Aq-II= Aq-III= 2 Aq(cum)= 2	**0**					
Soro (254 sq kms)	Total= 9 Aq-I= 3 Aq-II= 1 Aq-III= Aq (cum)= T (value)=	**0**			**18**	**22**	Total= 3 DW= 3 Pz (Aq-I)= Pz (Aq-II)= Pz (Aq-III)= Pz (cum)=	**26**					Total= 12 DW= 3 Aq-I= 3 Aq-II= 1 Aq-III= Aq(cum)= 5	**0**					

2.0 CLIMATE & RAINFALL

2.1 Climate : The district enjoys Humid sub tropical climate where the temperature of the warmest month is over 22 °C and at least 4 months the temperature remains over 10° C. The winter season extends from November to end of February, which is followed by summer season from March to the middle of June, and rainy season from middle of June to middle of October.

2.2 Rainfall : Southwest monsoon is the principal source of precipitation in the district. The normal annual rainfall of the district is 1568.4, out of which about 85% is received during monsoon season (mid June to mid October). The month of July and August gets the heaviest rainfall of the year, though rainfall is not very regular throughout the season but fairly uniform throughout the district. There are on the average 60 – 85 rainy days in a year. Besides, the relative humidity varies between 30 % to 86 %. The district faces occasional flash floods, which, because of the terrain, cause heavy damage to roads and crops. Drought is an almost constant feature that visits the district almost every alternate year.

Table – 2.2a : Yearwise Monthly Rainfall in Balasore District, Odisha

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Year	(Rainfall in mm)												
1995	12	50	39	15	423	193	228	426	306	265	213	0	**2170**
1996	13	12	0	21	51	215	346	534	77	141	4	0	**1414**
1997	18	25	108	182	95	330	346	584	362	61	36	54	**2201**
1998	29	31	95	113	101	170	199	156	458	182	72	0	**1606**
1999	0	0	0	9	224	300	240	352	445	530	110	0	**2210**
2000	8	87	0	72	166	291	246	220	332	53	2	0	**1477**
2001	0	10	68	49	167	366	397	385	152	211	33	0	**1838**
2002	28	0	46	80	57	232	121	272	373	52	60	0	**1321**
2003	0	12	50	26	76	287	340	213	184	538	34	16	**1776**
2004	0	0	4	37	78	260	326	388	231	266	0	0	**1590**
2005	16	0	63	71	88	227	403	222	549	432	0	0	**2071**
2006	0	0	25	27	112	240	370	524	429	25	22	0	**1774**
2007	3	93	0	19	97	296	452	544	603	44	35	0	**2186**
2008	67	18	4	23	98	633	263	287	304	10	35	0	**1742**
2009	0	0	9	0	171	90	430	303	336	199	42	0	**1580**
2010	0	0	2	2	201	93	254	177	306	199	6	27	**1267**
2011	0	16	3	33	109	348	112	374	472	20	0	0	**1487**
2012	71	0	0	80	30	97	147	291	233	28	33	18	**1028**
2013	1	2	5	50	192	241	252	0	346	697	0	0	**1786**
2014	0	42	44	24	225	177	479	490	316	134	0	0	**1931**
Average	**13.3**	**19.9**	**28.25**	**46.65**	**138.05**	**254.3**	**297.6**	**337.1**	**340.7**	**204.35**	**36.9**	**5.75**	**1723**

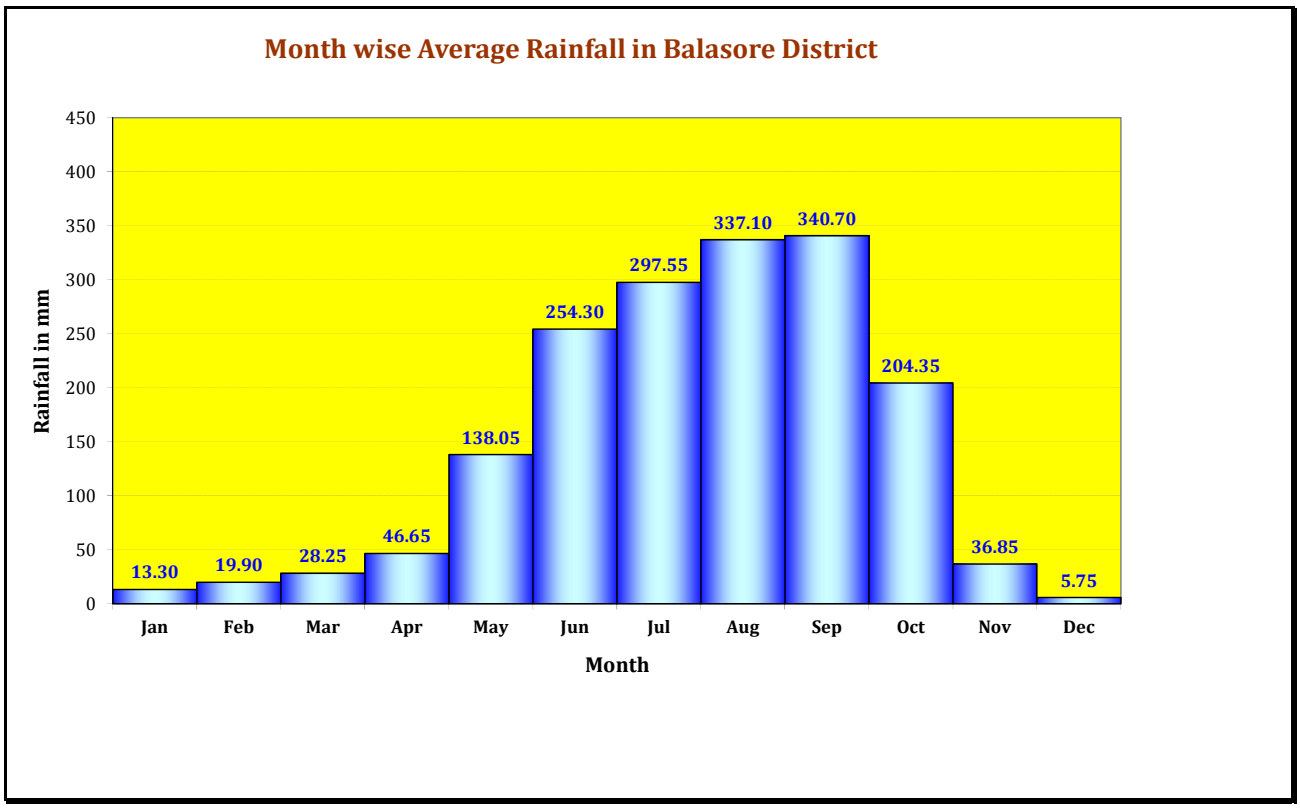


Figure – 2.2b : Year wise average monthly rainfall in Balasore District, Odisha

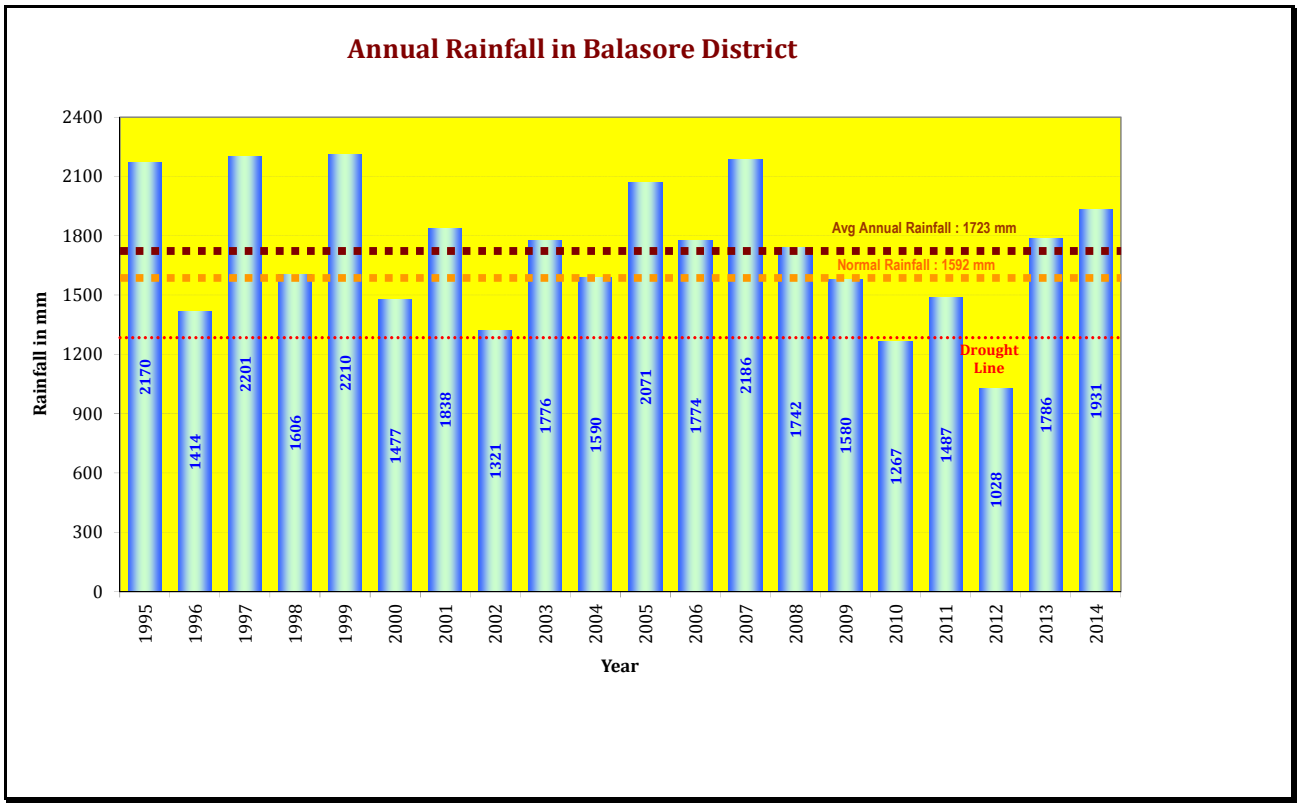


Figure – 2.2c : Year wise annual rainfall in Balasore District, Odisha

Table – 2.2b : Long Term Rainfall Analysis of Balasore District, Odisha

Year	Normal Rainfall (mm)	Actual Rainfall (mm)	Departure From Normal (mm)	Departure From Normal (%)	Remarks
1995	1592	2170	578	36.31	Excess
1996	1592	1414	-178	-11.18	Deficit - Normal
1997	1592	2201	609	38.25	Excess
1998	1592	1606	14	0.88	Normal
1999	1592	2210	618	38.82	Excess
2000	1592	1477	-115	-7.22	Deficit - Normal
2001	1592	1838	246	15.45	Normal
2002	1592	1321	-271	-17.02	Deficit - Normal
2003	1592	1776	184	11.56	Normal
2004	1592	1590	-2	-0.13	Deficit - Normal
2005	1592	2071	479	30.09	Excess
2006	1592	1774	182	11.43	Normal
2007	1592	2186	594	37.31	Excess
2008	1592	1742	150	9.42	Normal
2009	1592	1580	-12	-0.75	Deficit - Normal
2010	1592	1267	-325	-20.41	Deficit - Mild Drought
2011	1592	1487	-105	-6.6	Deficit - Normal
2012	1592	1028	-564	-35.43	Deficit - Severe Drought
2013	1592	1786	194	12.19	Normal
2014	1592	1931	339	21.29	Excess

Table – 2.2c : Mean Annual Precipitation events in Balasore District, Odisha

Month	Yearly Mean Number of days with				
	RAIN	HAIL	THUNDER	FOG	SQUALL
January	1.0	0.0	0.3	0.7	0.0
February	2.4	0.0	1.7	0.9	0.0
March	2.6	0.1	3.3	0.5	0.0
April	4.3	0.3	4.7	0.0	0.3
May	7.3	0.1	6.3	0.0	0.5
June	11.3	0.0	5.8	0.0	0.2
July	13.6	0.0	5.5	0.0	0.0
August	15.3	0.0	5.9	0.0	0.0
September	11.5	0.0	6.6	0.0	0.0
October	5.9	0.0	3.5	0.1	0.0
November	1.7	0.0	0.2	0.0	0.0
December	0.5	0.0	0.0	0.1	0.0
Annual	**77.5**	**0.5**	**43.9**	**2.2**	**1.1**

2.3 Temperature: During summer months the maximum temperature rises up to 45° C and May is the hottest month. December is the coldest month of the year when the night temperature sometimes drops down to 9° C.

Table – 2.3 : Monthly Long Term Average Temperatures of Balasore District, Odisha

Month	Daily Mean Temperature (°C)		
	Minimum	Maximum	Average
January	14.4	27.1	20.8
February	17.5	29.5	23.5
March	21.4	33.4	27.4
April	24.4	35.9	30.2
May	25.7	35.7	30.7
June	26.0	33.9	30.0
July	25.7	32.2	29.0
August	25.6	31.7	28.7
September	25.2	32.1	28.7
October	23.1	31.9	27.5
November	18.7	30.1	24.4
December	14.5	27.4	21.0
ANNUAL	**21.9**	**31.7**	**26.8**

2.4 Humidity : Relative humidity is around 26 - 82% throughout the year. Humidity of the air is generally high during southwest monsoon season and decreases from the end of November due to cold wave.

Table – 2.4 : Monthly Long Term Average Relative Humidity of Balasore District, Odisha

Month	Daily Mean Relative Humidity (Expressed as %)		
	0830	1730	Average
January	67	64	66
February	60	55	58
March	59	60	60
April	63	64	64
May	74	74	74
June	77	76	77
July	78	77	78
August	78	79	79
September	81	89	85
October	81	83	82
November	61	69	65
December	63	65	64
ANNUAL	**70**	**71**	**71**

2.5 Wind : Wind is generally light to moderate. During summer and southwest 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 southwest direction is very common. The southern part of the district is prone to cyclonic storms.

3.0 GENERAL SETUP

3.1 Physiography : The District of Balasore is having unique physiographic setup. It is bounded by the Bay of Bengal in its southern part and in the north western part it is marked by a set of hillocks and mounds including a north east – south west trending Hilly patch in the Nilgiri, Khaira & Oupada Blocks. The land elevation varies from as low as near mean sea level in the southern part to as high as about 600 m above mean sea level in the north western part. In between a major part covering more than 75% of the geographical area is having elevation within the range of 2 – 10 metres above mean sea level. In the extreme eastern part of the district, within the alluvial tracts of the River Subarnarekha & Burhabalang, the average elevation is within 1 – 2 metres above mean sea level.

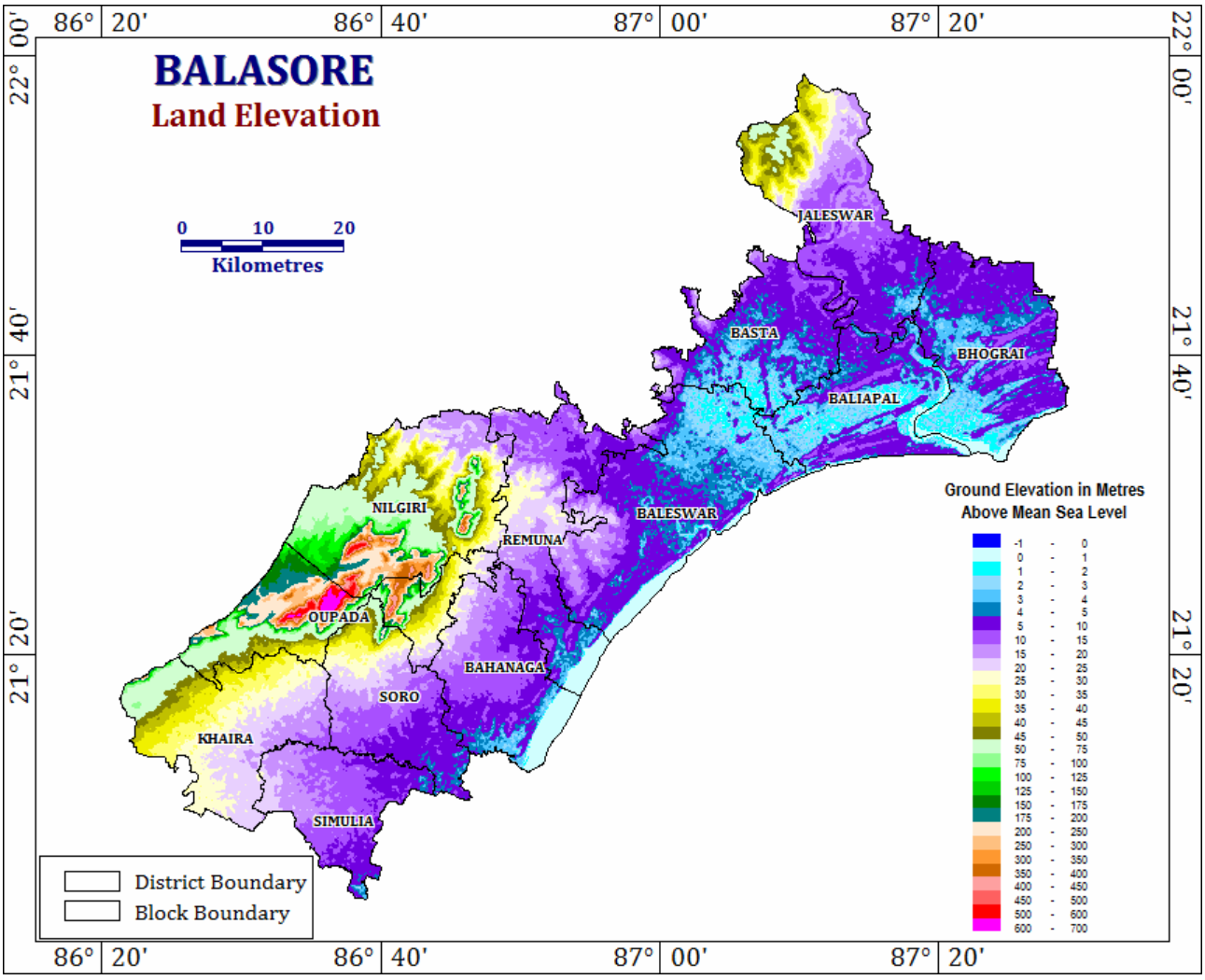


Figure – 3.1 : Land Elevation Map of Balasore District, Odisha

3.2 Drainage : The drainage in the area is controlled by Subarnarekha, Panchpara, Burhabalang, Jamira, Kansbans, Sono rivers and their tributaries and distributaries. All these rivers are having south easterly flow direction. Due to flattening of topography nearby the coast, drainage congestion takes place along the month of the river and during high tide often the tidal water ingress into quite a long distance into the mainland. During heavy downpour also, the runoff water inundates the low lying areas due to very low capacity of the rivers and the streams. The rivers often meander giving rise to the occasional formation of oxbow lakes along their courses. The drainage patterns of the streams are dendritic nearby the foothills.

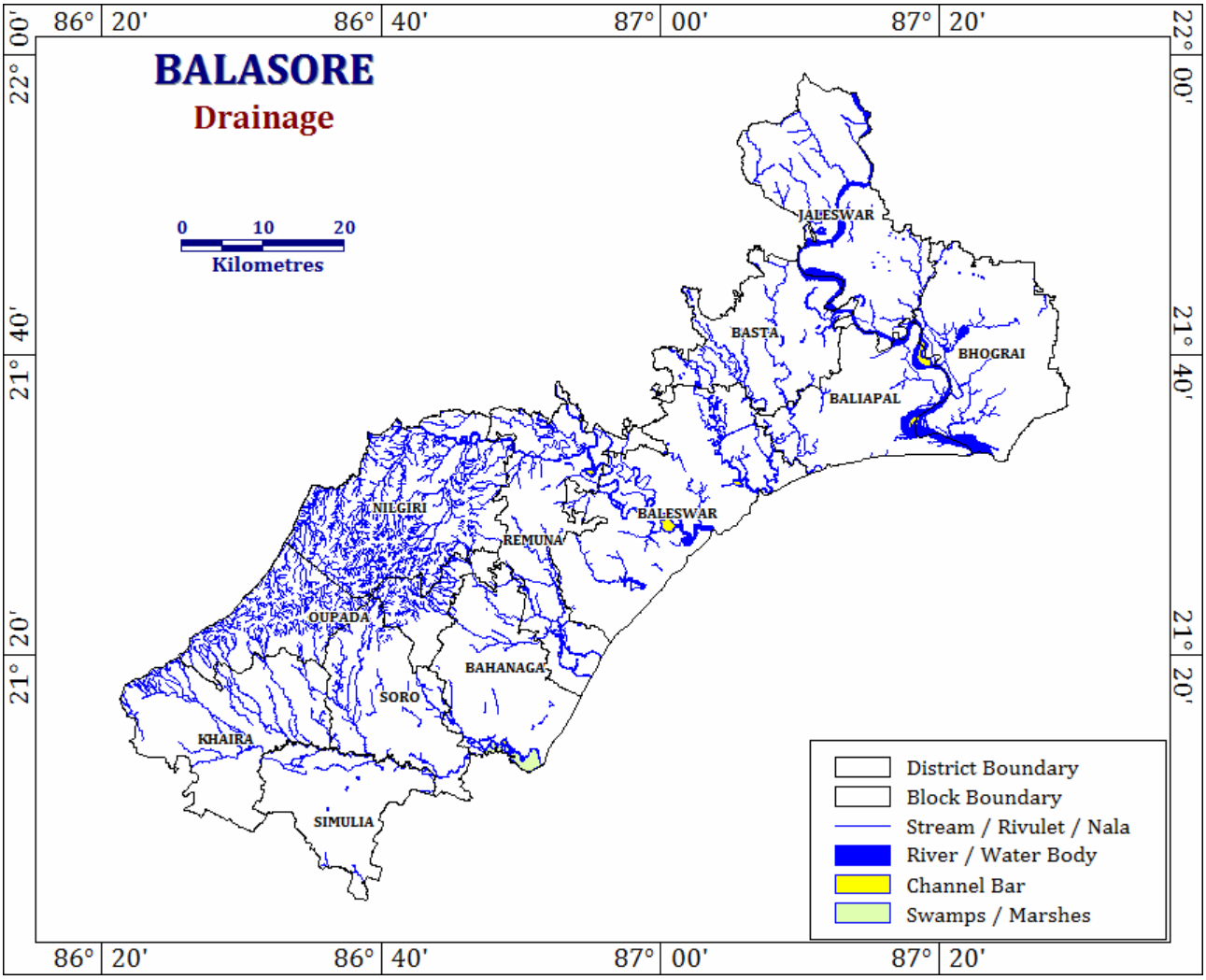


Figure – 3.2 : Drainage Map of Balasore District, Odisha

3.3 Geomorphology : Hydrogeomorphological features of Balasore district are mainly attributed to fluviomarine, erosional, denudational and depositional processes. The coastal plain has been developed due to fluviomarine processes. The alluvial plains owe their origin due to various fluviatile actions of major rivers. The details of the geomorphic unit as identified are as below:

3.3.1 Coastal Plain: Coastal plain predominantly consist of sand silt and clay is developed all along the coast of Balasore district. It is developed all along the coast of Balasore district. It is gently slopping plain occurring parallel to the coast. The saline marshy tract with shrubby vegetation comes under this coastal plain. Tidal streams are very active during high tide time. Ground water prospect is good but salinity is a major problem in this tract.

3.3.2 Beach: Beach is mainly formed by marine action. Beach ridges are very common and these are formed due to sea waves. They are mainly consisting of sand mixed with silt etc. Ground water prospect is good within a depth of 30-40 m, where fresh ground water pockets are available. Deep tube wells in these areas may lead to sea water ingress.

3.3.3 Mud flat: This is an relatively marshy area covered with fine silt and mud along the shore. Mangroves vegetation is very common. Ground water quality is mostly saline.

3.3.4 Paleo mud flat: These are the ancient mud flat consisting of fine sand and mud. These are mostly converted to agricultural land in due course of time. Due to marine regression ground water quality is saline.

3.3.5 Off shore Bar: Off shore bar is an elongated bar of sand occurring in the sea more or less parallel with the coast line. These comprises of sand. Ground water quality is saline.

3.3.6 Channel Bar: It is a depositional fluvial land form developed inside the channel due to the recession of the velocity of water. It is mainly consist of alluvial deposits. Ground water prospect is good.

3.3.7 Meander Deposits: This is an abandoned river course mostly filled with alluvial deposits. Ground water prospects are good to excellent.

3.3.8 Oxbow Lake: This is a cut off meander filled with alluvial material. The shape of the land form looks like an oxbow. Ground water prospect is excellent.

3.3.9 Paleo Channel: This includes buried as well as abandoned channels. These are mostly comprised of fluvial deposits of varying grain size. Ground water prospect is good to excellent.

3.3.10 Flood Plain: This is an area adjacent to the river and mostly built up by river borne deposits during high floods. Flood plains primarily consist of unconsolidated materials like sand, gravel and silt. Groundwater prospect is good to very good.

3.3.11 Younger Alluvial Plain: This is a flat to gently undulating plain of large extent formed by river action. The area encompasses various fluvial landforms in the latter stage of deposition in the fluvial cycle. This constitutes unconsolidated

materials like gravel, sand and clay of varying size and forms prolific aquifers. Ground water prospects is good to excellent.

3.3.12 Older Alluvial Plain: These landforms have been developed during earlier cycle of deposition in a fluviatile environment. The lithology and ground water prospect is similar to that of younger alluvial plain.

3.3.13 Lateritic Upland: These are mostly formed on the highland areas and over early Pleistocene sediments. The lateritic appears to form in the surfacial decomposition zone of iron rich rocks where the seasonal rainfall regime causes considerable water table fluctuation, where the rainfall is heavy enough to cause leaching and deep weathering. Lateritic uplands are occurring in the western hilly tact in Nilgiri and northern tertiary tract bordering Mayurbhanj district. The thickness of this lateritic crust varies from 10 to 12 m. The depth to water level is deeper in these formations.

3.3.14 Denudational Hills: These are the hills, which have undergone the processes of weathering and denudation and are still under active process of denudation. Nilgiri granites form these landforms. These are traversed by joints, fractures and lineaments etc. These acts mainly as runoff zone. Ground water prospect is poor and limited along fractures and fissures.

3.3.15 Residual Hills: These are isolated hills of height 10-15m above ground level. These are the residual masses left out after weathering and denudation. These are occurring in the western part of the district in Nilgiri, Oupada sector. These units act as runoff zones and are poor in ground water potential.

3.3.16 Pediments: These are erosional rocky surfaces having thin soil cover. This geomorphic unitis found bordering the hilly terrain and also localized patches in the western part of the district. These are sometimes traversed by fractures and joints especially in the granitic area. Groundwater potential is poor and limited.

3.3.17 Deeply Weathered Buried Pedi plain: This is a moderately undulating plain with a thick weathered soil profile. The thickness of weathered mantle varies from 10 to 20m, depending on the nature of topography. This unit occurs in the Nilgiri-Oupada-Khaira, with good ground Water prospect.

Table – 3.3 : Geographical distribution of Geomorphic units of Balasore District, Odisha

Sl	BLOCKS	Bahanaga	Balasore	Baliapal	Basta	Bhograi	Jaleswar	Khaira	Nilgiri	Oupada	Remuna	Simulia	Soro	TOTAL
No	Geomorphic Units	Area in Km²												
1	Alluvial Plain	194.33	234.58	49.33	234.02	138.20	249.95	272.93	54.93	72.78	215.93	210.01	225.52	**2152.51**
2	Back Swamp		1.42	0.17	2.99		0.32		0.86					**5.76**
3	Beach	0.29	2.18	0.71		0.96					0.16			**4.30**
4	Beach Ridge	3.81	0.49	2.05		4.83					0.62			**11.80**
5	Beach Ridge Complex		11.96	0.79							0.63			**13.38**
6	Burried Pediment							8.80	126.01	13.38			6.25	**154.44**
7	Channel Bar	0.14	0.61	7.25	0.68	3.96	1.96				0.51			**15.11**
8	Coastal Plain-Older	35.61	139.12	107.71		60.57					12.96	0.01	2.13	**358.11**
9	Denudational / Residual Hill							0.62	17.79					**18.41**
10	Flood Plain		5.04	2.12	1.91	2.98	61.39	1.27	6.34		34.63			**115.68**
11	Gulley Land								3.53	0.93				**4.46**
12	Inselberg								0.15					**0.15**
13	Intertidal Zone	25.51	23.76	4.55		3.08					12.94			**69.84**
14	Lateritic Upland		1.10		3.46		48.04	2.54	44.48	0.11				**99.73**
15	Linear Ridge / Dyke								2.66	1.04				**3.70**
16	Mud Flat	3.61	21.37	0.66		7.05					13.73			**46.42**
17	Natural Levee			2.40	18.94		2.25		4.41		1.45	1.06	0.14	**30.65**
18	Offshore Island / Bar					0.31								**0.31**
19	Overbank Plain		17.31						1.22		1.71		4.55	**24.79**
20	Oxbox Lake	0.70	0.97		0.21		0.58							**2.46**
21	Paleo Beach Ridge	8.32	2.74	6.82		2.55								**20.43**
22	Palaeo Beach Ridge Complex		4.44	44.77		62.94			2.39		4.24			**118.78**
23	Palaeo Channel		3.08	5.83	4.12		1.02				0.24			**14.29**
24	Pediment							11.20	60.61	62.38			6.58	**140.77**
25	Piedmont Zone							35.06		16.47				**51.53**
26	Spit		0.08						74.81		0.42			**75.31**
27	Structural Hill							4.58		104.56			2.89	**112.03**
28	Swale			14.30		52.16								**66.46**
29	Valley Fill							0.17	9.87	0.19				**10.23**
30	Water Body	1.98	10.28	14.37	6.14	8.37	11.55	0.03	5.33		5.90		0.21	**64.16**

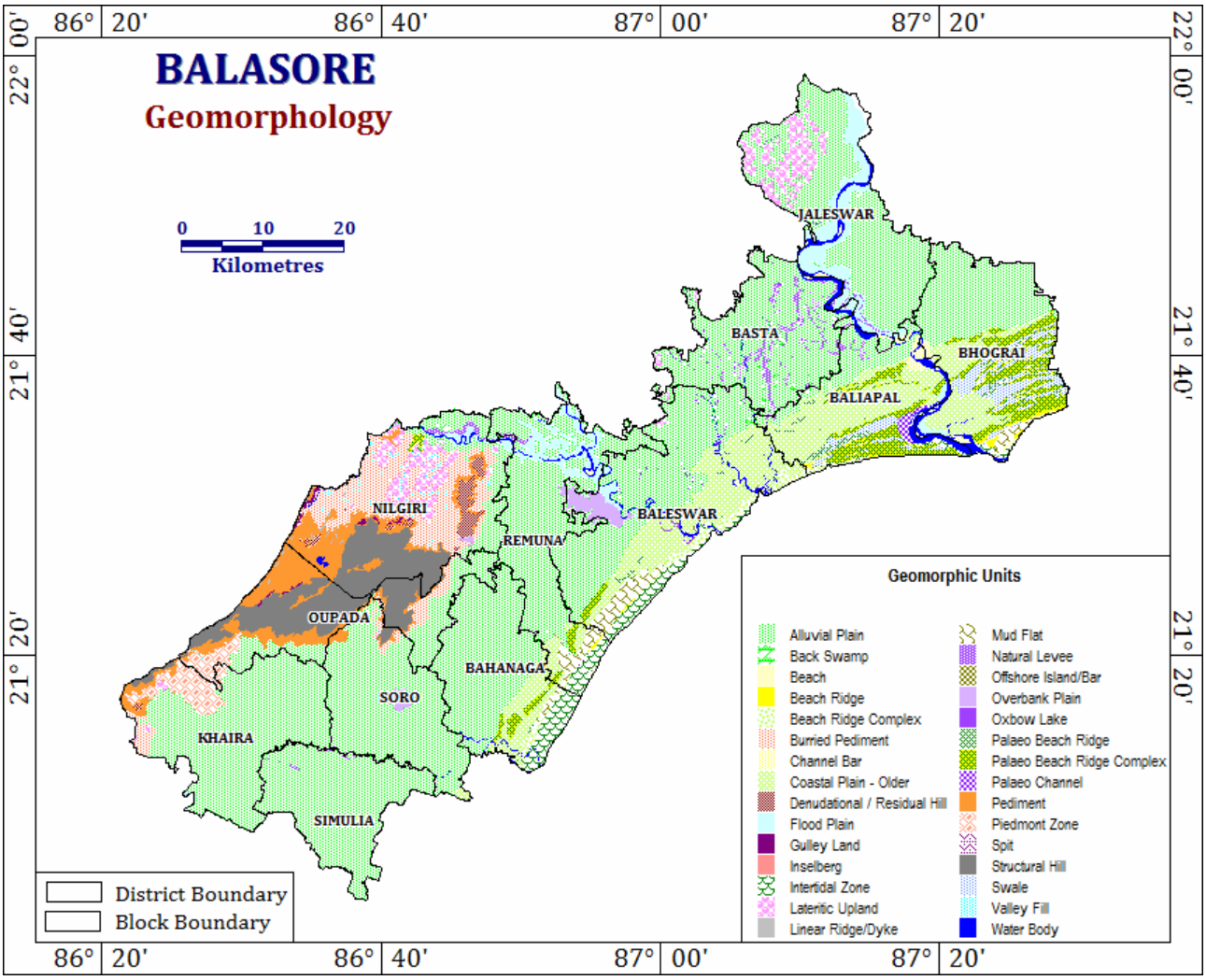


Figure – 3.3 : Geomorphological map of Balasore District, Odisha

3.4 Pedology : Four main types of soil groups(USDA Soil Classification System) can be observed in the Balasore District. These are Alfisols, Aridisols, Entisols and Ultisols. The brief description of each of these pedologic units are given below :

3.4.1 Alfisols : Alfisols form in semiarid to humid areas, typically under a hardwood forest cover. They have a clay-enriched subsoil and relatively high native fertility. "Alf" refers to aluminium (Al) and iron (Fe). Because of their productivity and abundance, the Alfisols represent one of the more important soil orders for food and fiber production. They are widely used both in agriculture and forestry, and are generally easier to keep fertile than other humid-climate soils. Alfisols have undergone only moderate leaching. By

definition, they have at least 35% base saturation, meaning calcium, magnesium, and potassium are relatively abundant. They are the most dominant soil groups in the district, occupying approximately 55% of the geographical area. They can be further sub-divided into Older Alluvial Soils, Red Gravelly Soils and Red Sandy Soils.

3.4.2 Entisols : Entisols are defined as soils that do not show any profile development other than an A horizon. An entisol has no diagnostic horizons, and most are basically unaltered from their parent material, which can be unconsolidated sediment or rock. Entisols have been abundant in the paleopedological record ever since Silurian, though, unlike other soil orders, they do not have value as indicators of climate. This soil group is the second most pre-dominant soil group in the Balsore District occupying around 35% of the geographical area. They can be further sub—divided into Coastal Alluvial Soils and Coastal Sandy Soils.

3.4.3 Aridisols : Aridisols (from the Latin aridus, for "dry", and solum) form in an arid or semi-arid climate. Aridisols dominate the deserts and xeric shrublands, Aridisols have a very low concentration of organic matter, reflecting the paucity of vegetative production on these dry soils. Water deficiency is the major defining characteristic of aridisols. Also required is sufficient age to exhibit sub-soil weathering and development. Limited leaching in aridisols often results in one or more subsurface soil horizons in which suspended or dissolved minerals have been deposited: silicate clays, sodium, calcium carbonate, gypsum or soluble salts. These subsoil horizons can also be cemented by carbonates, gypsum or silica. Accumulation of salts on the surface can result in salinization.

This soil group is the third most pre-dominant pedologic unit in Balsore District covering about 5% of the geographic area. They can be further sub-divided into Saline& Saline Alkaline soils and Saline Beach Soils.

3.4.4 Ultisols : Commonly known as red clay soils**.** They are defined as mineral soils which contain no calcareous material anywhere within the soil, have less than 10% weatherable minerals in the extreme top layer of soil, and have less than 35% base saturation throughout the soil. Ultisols occur in humid temperate or tropical regions. The word "ultisol" is derived from "ultimate", because ultisols were seen as the ultimate product of continuous weathering of minerals in a humid, temperate climate without new soil formation via glaciation. Ultisols vary in color from purplish-red, to a bright reddish-orange, to pale yellowish-orange and even some subdued yellowish-brown tones. They are typically quite acidic, often having a pH of less than 5. The red and yellow colors result from the accumulation of iron oxide (rust), which is highly insoluble in water. Major nutrients, such as calcium and potassium, are typically deficient in ultisols, which means they generally cannot be used for sedentary agriculture without the aid of lime and other fertilizers, such as superphosphate. However, they can be cultivated over a relatively wide range of moisture conditions. Ultisols can have a variety of clay minerals, but in many cases the dominant mineral is kaolinite. This clay has good bearing capacity and no shrink–swell property. Consequently, well-drained kaolinitic ultisols are suitable for urban development. This soil group is the least abundant of the four major pedologic units mentioned earlier and cover about 3% of the geographical area. They can be further sub-divided into Lateritic Soils and Red & Yellow Soils. The balance 2 % of the geographical area is covered by water bodies.

Table – 3.4 : Block wise distribution of Pedologic Units in Balsore District, Odisha

Sl No	BLOCKS	Bahanaga	Balasore	Baliapal	Basta	Bhograi	Jaleswar	Khaira	Nilgiri	Oupada	Remuna	Simulia	Soro	TOTAL
	Pedologic Units	Area in Km²												
1	Alfisol - Older Alluvial Soil	78.58	40.55	12.73	158.16	46.03	334.19	324.93	117.75	94.95	181.67	160.07	140.56	1690.17
2	Alfisol - Red Gravelly Soil								118.72	3.66				122.38
3	Alfisol - Red Sandy Soil							11.66	74.48	172.74			30.24	289.12
4	Aridisol - Saline and Saline Alkaline Soil	24.02	47.25	23.69		33.08					12.67			140.71
5	Aridisol - Saline Beach Soil		20.59	7.03		13.46								41.08
6	Entisol - Coastal Alluvial Soil	169.89	358.75	155.91	108.06	213.79	3.31				105.71	51.14	77.36	1243.92
7	Entisol - Coastal Sandy Soil			49.24		29.06								78.30
8	Ultisol - Lateritic Soil						24.86		100.43					125.29
9	Ultisol - Red and Yellow Soil													0.00
10	Water Body	1.81	13.41	15.28	5.50	12.74	17.50		3.11		5.68			75.03

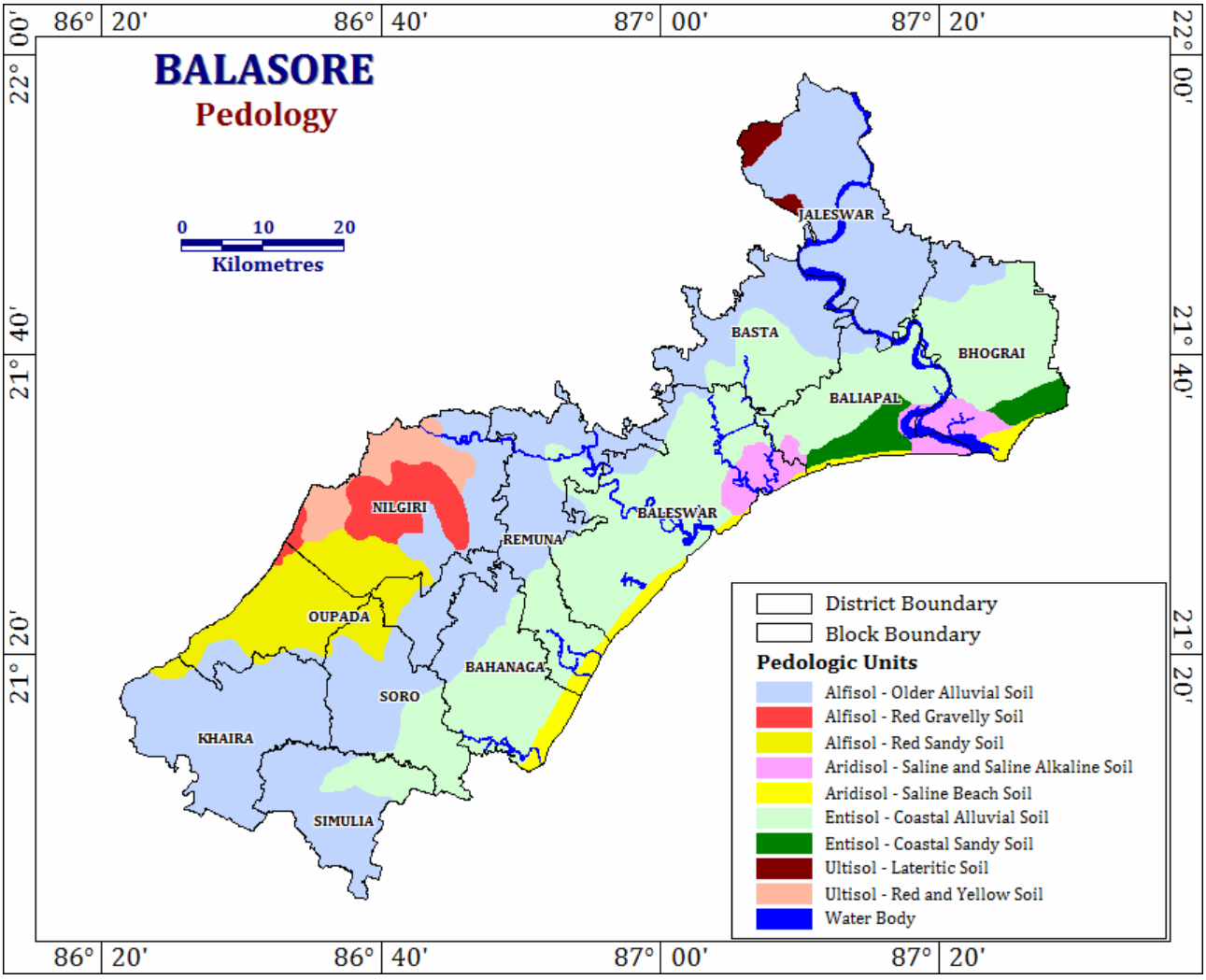


Figure – 3.4 : Distribution of Pedologic Units in Balasore District, Odisha

3.5 Landuse : The district being primarily agrarian can be appreciated from the fact that the major landuse in this district is Arable land covers more than 70% of the geographical area. This is followed by Rural Settlements which covers around 12.37% of the geographical area. Total forest land grouped together covers around 9.94% of the geographical area. This is followed by water bodies which covers around 2.51% of the geographical area. Water logged part and wet lands cover around 1.9% of the total geographical area of the Balasore District, Odisha.

Table – 3.5 : Block wise Landuse / Landcover Distribution in Balasore District, Odisha

Sl No	BLOCKS	Geographical Area percent	Bahanaga	Balasore	Baliapal	Basta	Bhograi	Jaleswar	Khaira	Nilgiri	Oupada	Remuna	Simulia	Soro	TOTAL
	Landuse	(%)							Area in Km²						
1	Arable Land	70.33	214.72	354.44	186.02	213.44	237.37	280.31	288.53	170.74	113	231.65	186.85	199.81	2676.88
2	Fallows	0.56	0.11	0.81	0.23	0.25	7.12	1.14	1.83	6.1	0.54	2.92	0.26	0.05	21.36
3	Forest - Coastal	0.17		1.79	2.79		0.2	0		0.82	0.81	0.08			6.49
4	Forest - Dense	1.21			0.32				0.46	21.2	23.41			0.55	45.94
5	Forest - Mangroves	0.03					1.27								1.27
6	Forest - Open	4.33			0.95	0.22	0.08	4.5	0.3	74.03	82.81			1.81	164.7
7	Forest - Scrubs	4.20	0.83	0.4	0.36	0.16	0.93	18.14	6.43	91.26	31.88	2.01	1.4	6.1	159.9
8	Marshes / Swamps	0.25		0.89	6.89		1.58								9.36
9	Mud Flats	0.35	0.18	7.56	1.47		3.82					0.29			13.32
10	Plantations	0.39	0.25	0.35	2.58	0.35	8.66	0.68	0.97		0.05	0.31	0.37	0.2	14.77
11	Settlements - Rural	12.37	29.42	41.82	40.16	52.17	60.63	60.7	37.77	36.71	15.57	41.78	21.58	32.32	470.63
12	Settlements - Urban	0.69		17.54								1.94		6.87	26.35
13	Waste Land	0.75		0.17	3.99	2.19	0.32	6.5	0.05	11.79	3.39	0.17		0.02	28.59
14	Water Body	2.51	3.08	32.41	15.85	2.5	20.71	7.69	0.33	2.04	0.18	9.75	0.47	0.46	95.47
15	Water Logged Land	0.12	0.13	0.96	2.2	0.44	0.32	0.17				0.5			4.72
16	Wet Lands	1.74	25.58	21.29	0.03	0.04	4.94	0.08				14.29			66.25

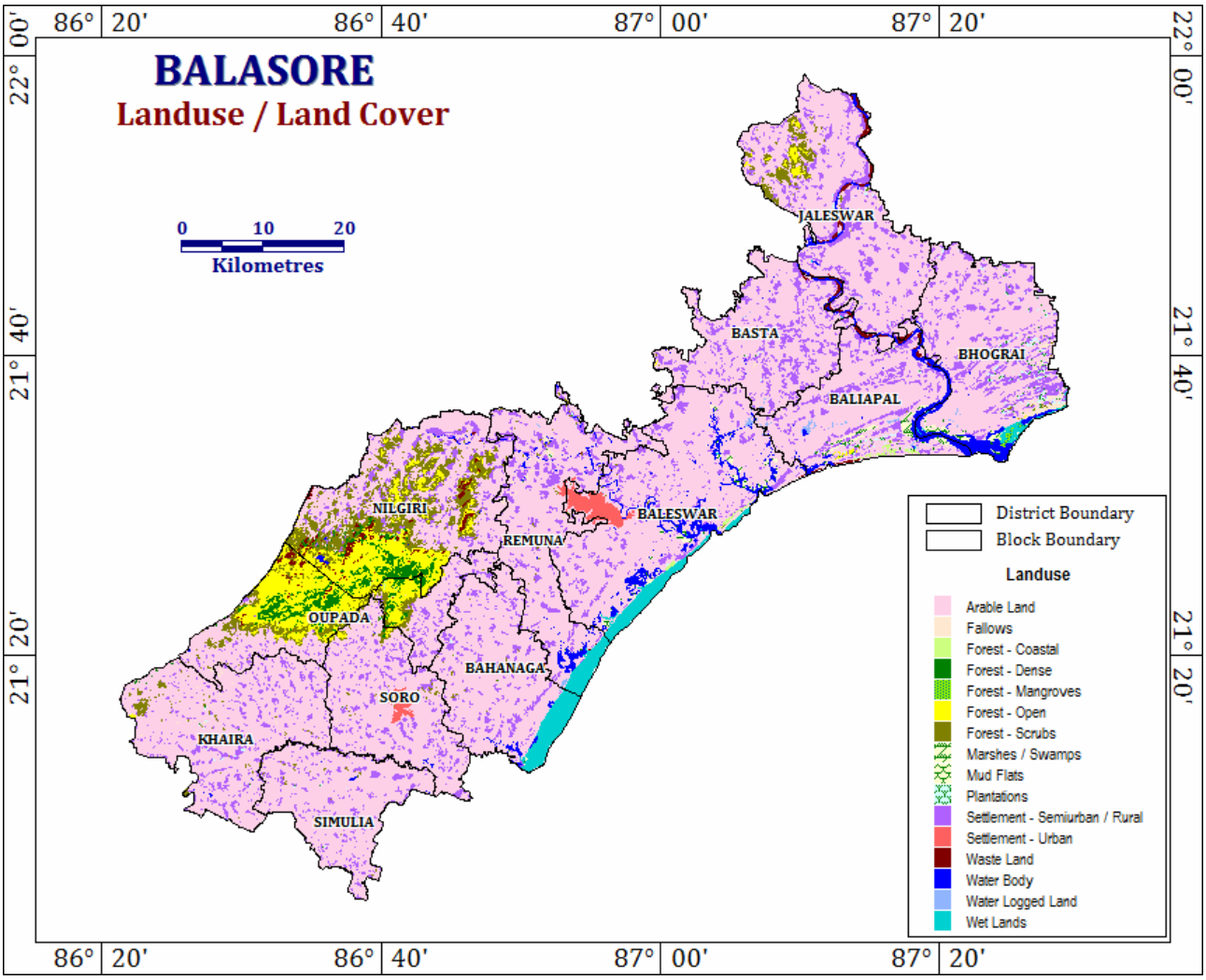


Figure – 3.5 a: Landuse / Landcover Map of Balasore District, Odisha

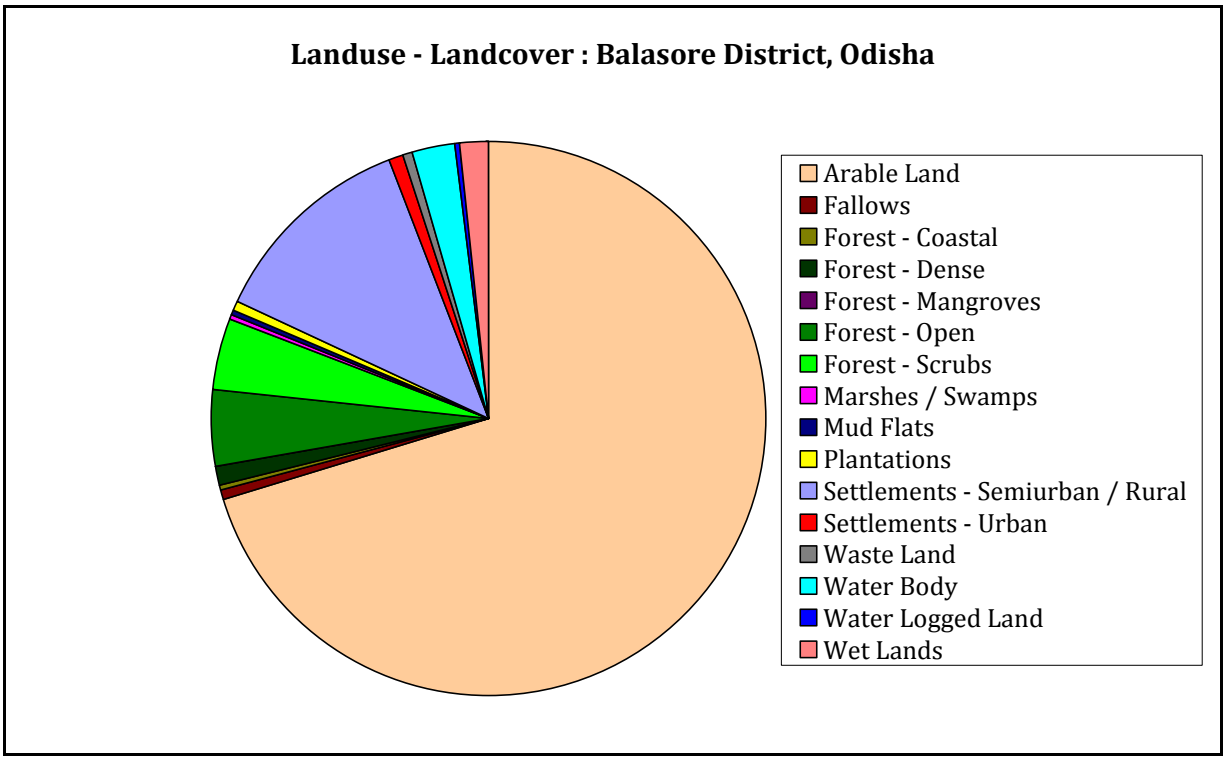


Figure – 3.5 b : Landuse / Landcover Distribution in Balasore District, Odisha

3.6 Agriculture : As already pointed out, that agriculture is the main livelihood of the people in Balasore District. It is therefore also designated as the food bowl of Odisha. Rice is the principal crop grown in this district, followed by other cereals, pulses, oilseeds, vegetables, spices and sugarcane. The agricultural statistics for the district is shown in subsequent tables below :

Table – 3.6a: Crop Coverage Area of Balasore District, Odisha

Crop	Khariff		Rabi		Annual	TOTAL	
	Area ('000 ha)	(% of Cropped Area	Area ('000 ha)	% of Cropped Area	Area ('000 ha)	Gross Cropped Area ('000 ha)	% of Gross Cropped Area
Rice	206.14	91.62	33.47	34.38		239.61	72.03
Cereals	0.31	0.14	0.79	0.82		1.10	0.33
Pulses	0.48	0.21	21.64	22.55		22.12	6.65
Oilseeds	0.13	0.06	14.38	20.20		19.51	5.87
Vegetables	13.04	5.80	16.14	16.82		29.18	8.77
Fibres	2.20	0.98	-	-		2.20	0.66
Spices	2.69	1.19	4.08	4.25		6.77	2.04
Sugarcane	-	-	0.46	0.48		0.46	0.14
Tobacco	-	-	-	-		-	-
Fruits	-	-	-	-	11.68	11.68	3.51
TOTAL	**224.99**	**100**	**95.96**	**100**	**11.68**	**332.63**	**100**

Table – 3.6b: Area, Yield & Production of Crops in Balasore District, Odisha

Crop	Area ('000 Hectare)	Yield (Kg / Hectare)	Production ('000 MTS)
Rice	239.61	1852	443.75
Paddy	-	2764	662.31
Cereals	240.71	1849	445.06
Pulses	22.12	529	11.70
Foodgrains	262.83	1738	456.76
Oilseeds	19.51	885	17.27
Fibres	2.20	1137	13.90
Vegetables	29.18	11903	347.32
Spices	6.77	1716	11.62
Sugarcane	0.46	48869	22.48
Tobacco	-	-	-
TOTAL	**320.95**	**2709**	**869.35**

3.7 Irrigation : The district of Balasore is blessed with a number of natural and man made water bodies like rivers, streams, nalas, tanks and ponds. In addition to this, there exists a smart network of canals, which together takes care of the flow irrigation system in the

district. Apart from this, the prolific sub-surface aquifer acts as dependable source for lift irrigation practices for agriculture.

Table – 3.7 : Block & source wise Irrigation Potential in Balasore District, Odisha

Sl	Block	Major / Medium Irrigation Projects		Minor Irrigation Projects				Other Sources		Total	
				Flow		Lift					
		Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
		(Area in '00 hectares)									
1	Bahanaga	0	0	0	0	1155	1366	165	149	1320	1515
2	Balasore	0	0	80	0	1232	816	2500	975	3812	1791
3	Baliapal	0	0	0	0	728	925	690	939	1418	1864
4	Basta	0	0	2007	254	698	893	520	615	3225	1762
5	Bhograi	0	0	0	0	1020	1600	1250	1436	2270	3036
6	Jaleswar	0	0	1458	0	1345	950	730	950	3533	1900
7	Khaira	5210	0	766	0	151	85	376	210	6503	295
8	Nilgiri	1950	0	2856	0	399	198	700	435	5905	633
9	Oupada	0	0	370	0	227	144	300	50	897	194
10	Remuna	0	0	0	0	1430	1085	935	335	2365	1420
11	Simulia	12750	835	0	0	148	114	105	1077	13003	2026
12	Soro	0	0	784	0	952	784	550	500	2286	1284
	TOTAL	**19910**	**835**	**8321**	**254**	**9485**	**8960**	**8821**	**7671**	**46537**	**17720**

3.8 Industries : Through the district is primarily agrarian, there a number of large scale Industrial establishments and factories in and around the district town of Balasore. Apart from these, there are a number of small and medium scale agro based industries including seafood packaging industries in the areas proximal to the Bay of Bengal. There are a few market Industrial areas in Chhanpur, Remuna, Somanathpur, Ganeswarpur where industries involved in PVC Pipes, Insulated Cable, Pharmaceuticals, Latex products manufacturing, Polymer based manufacturing etc. are also observed. The district also possess around five number of registered stone quarries for road metal and dimension stone mining. As per the latest data available form the Directorate of Industries, there are a total of 28 large scale industries and around 1190 small and medium scale industries in the district. While the number of large scale industries remained more or less the same through the years, the

number of small scale industries have increased, exponentially, over time. The details of major industries in Balasore District are shown below :

Table – 3.9 : Details of Major Industries in Balasore District, Odisha

Sl No	Name of Industry	Block	Location	Commodity
1	Birla Tyres Ltd	Remuna	Chhanpur	Tyres & Flap Manufacturing
2	Indian Oil Corporation Ltd	Balasore	Chhanpur	LPG Bottling Plant
3	G M B Ceramics Ltd	Balasore	Somanathpur	Ceramic & Refractories
4	Emami Paper Mills Ltd	Remuna	Balgopalpur	Paper Manufacturing
5	Balasore Alloys Ltd	Remuna	Balgopalpur	Ferro Alloys Manufacturing
6	Hindusthan Petroleum Corporation Ltd	Balasore	Somanathpur	Fuel Depot & Terminal
7	Indian Oil Corporation Ltd	Balasore	Chhanpur	Fuel Depot & Terminal
8	Bharat Petroleum Corporation Ltd	Balasore	Chhanpur	Fuel Depot & Terminal
9	Krishi Rasayan	Balasore	Maitapur	Fertilizer Manufacturing
10	Stork Ferro & Minerals Ltd	Remuna	Somanathpur	Ferro Alloys Manufacturing

3.9 Natural Disasters : One of the major indicators of development is the preparedness in mitigating natural disasters. Being proximal to the Bay of Bengal, the district is potentially vulnerable to a plethora of disasters and calamities like Drought, Flood, Cyclone, Tsunami to name a few.

Table – 3.9a : Potential Vulnerability to Natural Disasters – Balasore District, Odisha

Sl No	Disaster / Hazard	Probable Time of Occurrence (Month)	Year Of Occurrence	Potential Impact	Vulnerable Areas
1	Flood	June - September	1989-1995, 1998-1999, 2001, 2003-2008, 2011, 2013-2014	Loss of human life, livestock, crop & infrastructure	Entire District except Blocks of Khaira & Oupada
2	Cyclone	June - October	1990, 1999, 2013	Loss of human life, livestock, crop & infrastructure	Entire District except Blocks of Simulia, Khaira, Nilgiri & Oupada
3	Drought	July - October	1998-1999, 2002, 2010, 2012, 2015	Loss of Crop, Water Scarcity	Entire District
4	Heat Stroke	April - June	1998-1999, 2002, 2010, 2012, 2015	Loss of human life	Entire District
5	Epidemic	Anytime	None so far	Loss of human life	Entire District
6	Fire Accidents	March - May	Almost every year	Loss of human life & infrastructure, rarely crop loss & livestock casualty	Entire District
7	Earthquake	Anytime	None so far	Loss of human life, livestock, crop & infrastructure	Entire District
8	Hailstorm	April - June	1989, 1992, 1993, 2013	Loss of human life, livestock, crop & infrastructure	Entire District
9	Tsunami	Anytime	None so far	Loss of human life, livestock, crop & infrastructure	Six Blocks proximal to Bay of Bengal – Bhograi, Baliapal, Balasore, Remuna & Bahanaga

Table – 3.9 b : Block wise Details of Tsunami Vulnerability in Balasore District, Odisha

Sl No	Likely to be Affected			
	Blocks	Gram Panchayats	Villages	Population
1	Bahanaga	5	15	19,473
2	Balasore	8	15	34,754
3	Baliapal	6	9	33,604
4	Bhograi	5	14	18,102
5	Remuna	3	10	10,858
	DISTRICT TOTAL	**27**	**63**	**1,16,791**

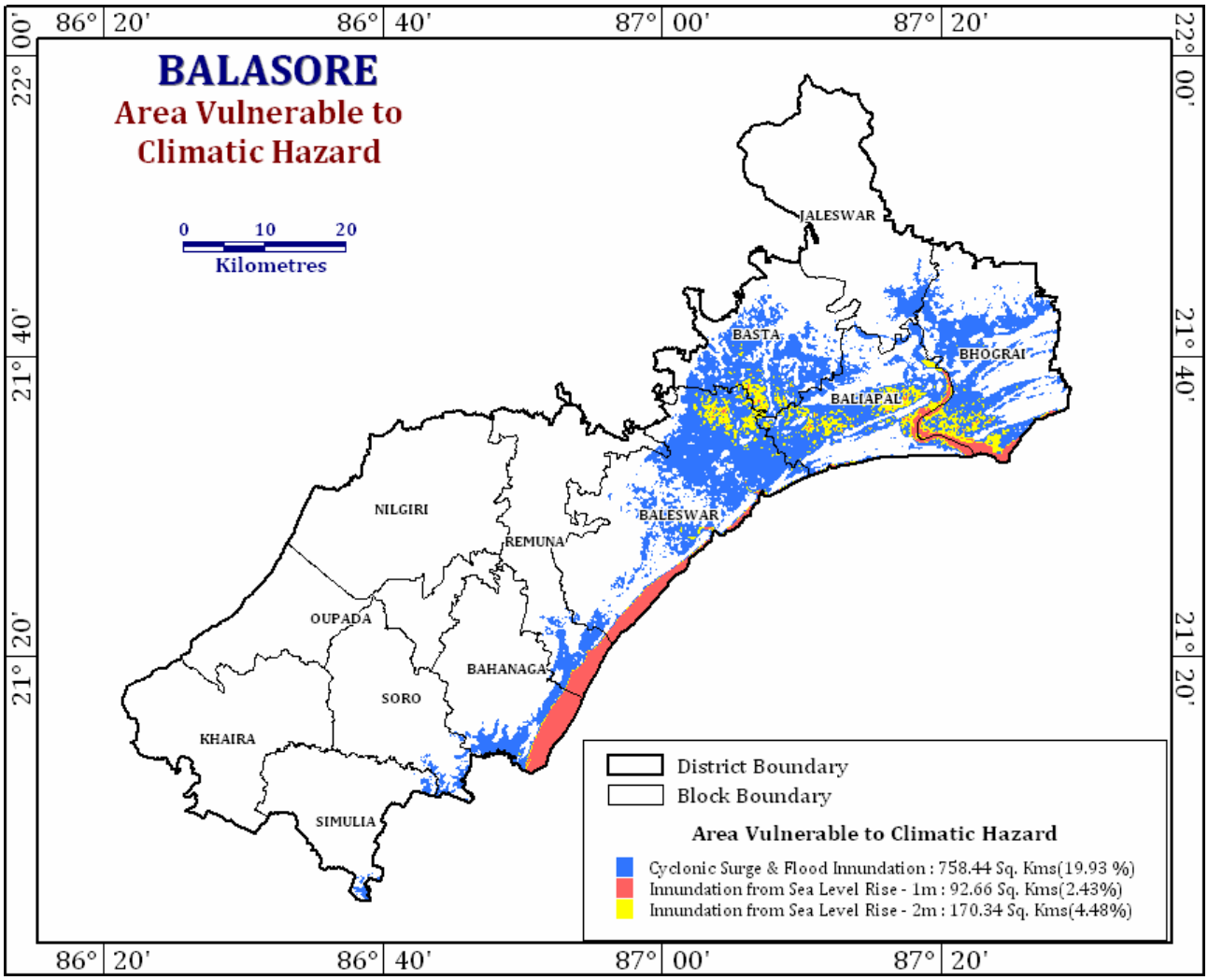


Figure – 3.9 : Vulnerability to Climate Change related events, Balasore District, Odisha

Table – 3.9 C : Vulnerability to Climate Change related events, Balasore District, Odisha

Sl No	Block Name	Geographical Area (Sq Kms)	Vulnerable Area					
			Sea Level Rise (1m)		Sea Level Rise (2m)		Cyclonic Surge (5m) & Flood Inundation	
			Affected Area	% of Geographical Area	Affected Area	% of Geographical Area	Affected Area	% of Geographical Area
1	Bahanaga	234.30	27.23	11.62	28.35	12.10	56.54	24.13
2	Balasore	475.94	24.19	5.08	42.23	8.87	224.58	47.19
3	Baliapal	233.49	10.88	4.66	41.35	17.71	153.53	65.75
4	Basta	282.60	0.62	0.22	9.83	3.48	105.62	37.37
5	Bhograi	326.44	13.97	4.28	32.23	9.87	149.65	45.84
6	Jaleswar	366.40	0.00	0.00	0.01	0.00	15.36	4.19
7	Khaira	322.94	0.00	0.00	0.00	0.00	0.00	0.00
8	Nilgiri	265.64	0.00	0.00	0.00	0.00	0.00	0.00
9	Oupada	419.76	0.00	0.00	0.00	0.00	0.00	0.00
10	Remuna	288.17	15.77	5.47	16.34	5.67	39.07	13.56
11	Simulia	343.63	0.00	0.00	0.00	0.00	5.03	1.46
12	Soro	246.69	0.00	0.00	0.00	0.00	9.06	3.67
	TOTAL	**3806.00**	**92.66**	**2.43**	**170.34**	**4.48**	**758.44**	**19.93**

4. GEOLOGY & HYDROGEOLOGY

4.1 Geology : The major parts of the district are underlain by Tertiary & Quarternary Alluvium(including Recent Alluvium). The north western part is underlain by the Archaeo-Proterozoic Basement Granites and Granite Gneisses with minor Pegmatites and vein Quartz. The recent alluvium occurs in limited patches along the river courses. The Tertiary deposits comprise of lower marine fossiliferous sequence of Miocene' age and an upper estuarine sequence of Mio-Pliocene age. The generalized stratigraphic sequence of Balasore district is given below.

Stratigraphic sequence

Era	Group/Super group	Lithology
Quaternary Recent to sub-Recent	Holocene	Dune sand, Newer alluvium, older alluvium, Laterite.
		Laterites and lateritic gravels
	~~ Unconformity ~~~~~~~~~~	
Tertiary	Mio-Pliocene	Brown, yellowish and grey sand, gravel and clays, gritty sandstones.
	Miocene	Grey Clays, sand, Lime stones with molluscan shells
	~~ Unconformity ~~~~~~~~~~	
Archaean to Proterozoic		Associated intrusives, Nilgiri granites, Quartzite and phyllite, amphibolites, unclassified gneisses.

4.1.1 Archeans and Pre-Cambrians: The Archean formation comprises of amphibolites, quartzite, phyllite, unclassified gneisses and the pluton of Nilgiri granites. The unclassified gneisses are biotite bearing and both fine to coarse grained. The coarse types are known as Nilgiri granites. The hornblende granites occur as intrusives into this Nilgiri granites. The young dolerites are found as intrusives into the country rocks.

4.1.2 Tertiary Formations : The tertiary sediment occurring in the district comprise of lower marine fossiliferous sequence of Miocene age, overlain by estuarine sequence of Mio-Pliocene age. The fossiliferous marine formations are met

within the exploratory boreholes at different depths ranging from 69.8 to 273 metres below ground level. The younger unfossiliferous estuarine sediments are encountered from almost ground level down to about 307 m depth in different boreholes.

4.1.3 Quaternaries: The older alluvium of Pleistocene age overlies the tertiary formations. The sediments are grey to brown colour, unfossiliferous but possesses plenty of calcareous concretion. Laterites commonly occur on the hill tops, flaks of hills and occasionally in the undulating plains in the north, a topping the tertiary sediments. They are also encouraged at depth ranging from almost ground level to 35 m or more.

4.1.4 Recent to Sub-Recent : The laterites occur extensively as capping over the Khondalite in topographic lows as also over granite gneiss. These are ferruginous in nature and highly porous having a spongy look and at places form a nodular mass. The recent to sub recent alluvium occurs as flood plains and channel deposits of the Subernarekha, Burhabalng, Jamira river and its tributaries. It comprises of sand, gravel, silt and clay. Dune sand occurs along the sea coast.

4.1.5 Structure: The granites forming the Nilgiri hills are affected by orogenic movements. The granites and gneisses which occur as intrusives into quartzites and phyllites rocks show sub vertical joints trending NE-SW and NW-SE. Quartzite also exhibit similar type of joint system. Ptygmatic folds in pegmatite and quartz veins are also seen within the Nilgiri granites. The foliation in

granite gneisses have differing trends varying from N-S to NW- SE with foliation dips varying from 60-75°.

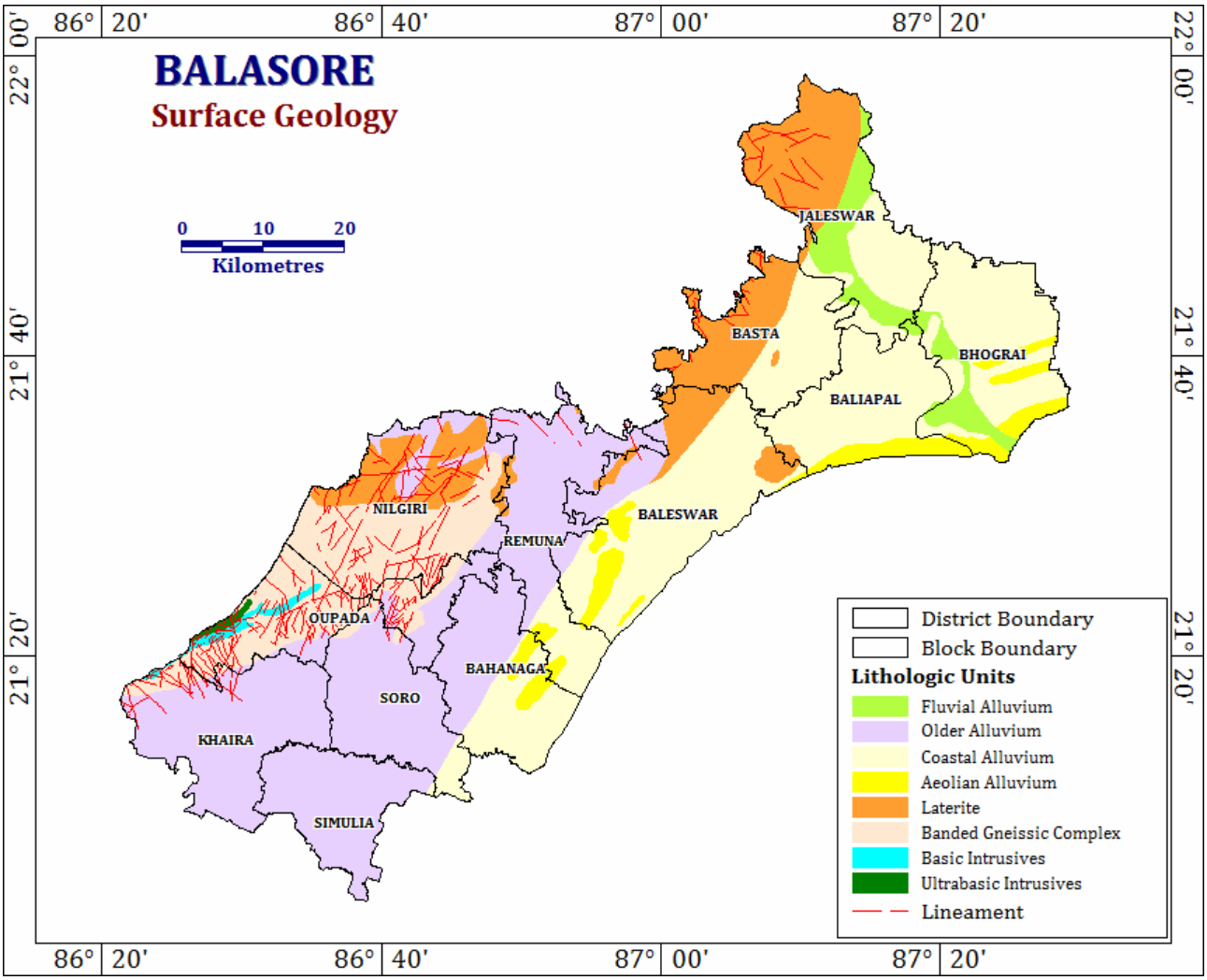


Figure – 4.1 : Lithological Map of Balasore District, Odisha

Table – 4.1 : Block wise distribution of various lithounits in Balasore District, Odisha

Sl	BLOCKS	Bahanaga	Balasore	Baliapal	Basta	Bhograi	Jaleswar	Khaira	Nilgiri	Oupada	Remuna	Simulia	Soro	TOTAL
No	Lithologic Units	Area in Km²												
1	Fluvial Alluvium			4.32	0.85	48.94	82.26							136.37
2	Older Alluvium	138.43	66.25		1.22			310.84	64.81	74.43	226.08	209.96	216.51	1308.53
3	Coastal Alluvium					221.14	92.51							313.65
4	Aeolian Alluvium	135.88	345.06	254.80	130.75	78.06	28.48				71.40	1.24	21.32	1066.99
5	Laterite		69.25	4.77	138.90		176.61		124.40		8.21			522.14
6	Banded Gneissic Complex							23.41	225.28	170.31	0.04		10.33	429.37
7	Basic Intrusives							2.34		18.86				21.20
8	Ultrabasic Intrusives									7.75				7.75

4.2 Hydrogeology : The geological formations in the district spans in age from Archean to Recent (Quaternary) .The Tertiary and Quaternary formations are covering major part of the district while Archeans occupy the hilly areas and the areas under higher altitude in the west.

The crystalline are devoid of primary porosity but possess secondary porosity on being weathered and fractured. However, the unconsolidated sand and gravel layers of Tertiary and Quaternary age, form good repository of ground water. Ground water occurs under water table conditions in shallow aquifers and under semi confined to confined conditions in deeper aquifers. Hydrogeologically all the formations encountered in the district can be broadly divided into three sub groups viz. 1 - Crystalline formations 2- Sedimentary formations and 3 - Laterites. The crystalline formations are mainly constituted by granite gneisses (Nilgiri Granites) while the sedimentaries are constituted by younger and older alluvium and Tertiary formations.

4.2.1 Water bearing properties of litho-units: Water bearing properties of various litho-units vary widely. A brief account is as below-

4.2.1.1 Granite gneiss: The granite gneisses are well foliated, jointed and weathered easily. Generally the depth of weathering extends down to a depth of 15 meters with in exceptional cases e.g. at Nilgiri it was 42.5 m b g l. This weathered zone forms the main repository of ground water in hard rock areas and is tapped by dug wells. The yield of dug wells range from 6 to 10 m^3/ day. As the area has undergone several phases of tectonic deformations deep-seated fractures are developed which form a conduit for downward percolation of ground water and form aquifers in deeper conditions. These deeper fractures are generally encountered in bore wells. Deeper fractures are tapped by bore wells in Nilgiri, Oupada and Simulia blocks. Aquifers parameters of granite gneisses are as below-

Table – 4.2.1.1 : Aquifer parameters of granite-gneiss formations

Parameters	Shallow Aquifers	Deeper Aquifers
Yield	6-10 m^3/day	1-8 lps
Specific Capacity	0.0009–0.034 m^3/min/m	------
Transmissivity	5-36 m^2/day	12-36 m^2/day

4.2.1.2 Sedimentary formations: The Tertiary, older and younger alluviums constitute the sedimentary formations. These are unconsolidated formations. The sands and gravels are porous and permeable and form the repository of ground water. Finer clastics progressively dominate towards the coast. Extensive shallow aquifers exist in the alluvium within the depth range of 25 to 60 meters with a cumulative thickness of aquifers varying from 10 to 25 meters. These aquifers are tapped by dug wells, shallow and filter point tube wells. The yield of the dug wells varies from 50 to 100 m^3/day and of shallow tube wells vary from 5 to 25 lps. Besides the shallow aquifers, deeper aquifers are also encountered down to a depth of 300 meters. Along the saline tract, the fresh aquifers lie within the depth range of 130 to 300 meters besides the occasional top fresh aquifers within 20 to 25 m depth. The yield of the deep tube wells vary from 15 to 40 lps in the saline tract as well as in Tertiary, older alluvial areas and more than 40 lps in inland alluvium formations areas. Due to extensive development since 1985 through construction of shallow tube wells, the shallow aquifers at places in Bhograi and Jaleswar blocks shows ground water decline in summer months (February to May). In such formations (unconsolidated alluvial

and Tertiary) ground water occurs under unconfined condition in the shallow aquifers and under semi confined to confined conditions in deeper aquifers. As stated above shallow aquifers exist between 25 to 30 m depth yields 5 to 25 l p s water though shallow tube wells. Transmissivity and Storativity of these shallow to medium deep aquifers vary from 122.1 to 3415 ^{2}/day and 9.3 x 10 $^{-2}$ to 2.9 x 10 $^{-4}$ respectively. Yield of deep tube wells (constructed down to 300 m b g l depths) vary from 5 to 66 lps with an average of 40 lps. A summarized data of aquifers parameters of alluvial formations are as below-

Table – 4.2.1.2 : Aquifer parameters of alluvial formations

Parameters	Shallow Aquifers		Deeper Aquifers	Deeper aquifer in Saline tract
Structures	Dug Wells	Shallow Tube Wells	Deep tube wells	Deep tube wells
Depth Range	8-12 m	25-60 m	300 m	Top fresh 20-25 m & 130-300 m
Yield	50 -100 m^3/day	5 to 25 lps	5 to 66 or Avg > 40 lps	15 to 40 lps
Transmissivity	-	122.1-3415 m^2/day		
Storativity	-	9.3 x 10 $^{-2}$ to 2.9 x 10 $^{-4}$		

4.2.1.3 Laterites: Laterites occur as capping over the weathered crystalline and Tertiary formations in the west and north western part of the district. Being porous and highly permeable in nature it also forms prolific aquifers which support a large number of domestic dug wells. The thickness of Laterites varies from 5 to 15 m. The yield of dug wells in such formations ranges from 30 to 50 m3/ day. The Specific Capacity and Transmissivity of lateritic aquifers vary from 0.0012 to 0.20 m3 /min/m and 2.8 m2 /day to 490.22 m2 /day.

4.2.2 Distribution of Saline / fresh water aquifers: The occurrence of fresh water aquifers in coastal tract of Balasore restricted by two important factors-(i) Occurrence of hard rocks in the western side and (ii) Salinity hazard problems in the eastern part. In the narrow tract, close to the coast line extending right from Chandaneswar in the North to Bahanga/ Simulia in the south in the district, salinity problem occurs where both the saline water bearing and fresh water bearing aquifers occurs at different depths. The depth of occurrence of saline water bearing aquifers is not uniform along the entire tract. The study of lithological logs and electrical logs of boreholes and results of zone tests etc. indicate occurrence of saline water either above or below fresh water bearing aquifers and also both above and below the fresh water aquifers,

The width of the coastal saline tract is generally ranging from 4 to 5 km running from Bahanaga to Baliapal block near Subranarekha river, where from towards further north east it encroaches further inland ward and in Bhogarai block its width generally range from 5 to 10 km . In general the top aquifers up to 150 meter are saline. However, during the detailed studies in the area, it is observed that up to the depth range of 25 to 30m, fresh aquifers are occurring having a thickness of 5 to 15 meters, which are tapped by shallow tube wells. Below 150m the aquifers are fresh up to 220m below which up to 250m below ground level the aquifers are saline. The salinity hazards occur in a narrow tract along the eastern margin adjoining the sea coast and in the rest part of coastal alluvium fresh water occurs all through down to the bed rock. Disposition of fresh and saline water in district is shown as Map No-3. The occurrence of aquifers and its yield potential etc. are described below.

4.2.2.1 Non-saline area: The depth of the bore holes varied from 103m to 330 and the depth of the tube wells varied from 96 to 208m. The bed rocks were encountered at Hanspatna (11Om) and at Soro (295m).

In the Jaleswar-Basta-Baliapal-Remuna-Balasore tract a group of aquifers usually varies in thickness from 3 to 15m, attains a maximum cumulative thickness of around 40 to 50m. The yield varies from 20 to 66 Ips against the drawdown of pumping water level varying between 5.83 to 15 60m. The static water levels vary from 2.13 to 10.68m bgl. The discharge in general is less in the southern part of this tract.

In the area around Soro and Markona a group of aquifers consisting fine to coarse sands which generally occur below 46m depth attains a cumulative thickness of about 125m and the thickness of aquifers dwindles towards west. The discharge is generally low and varies between 11 to 24 Ips against the draw down more than 15m.

In and around Gopalpur of Bahanaga block aquifers are thin and mixed with finer materials and are low yielding. Also in Kasbajaypur-Bahanga area the formation are predominantly argillaceous in nature and sand horizon are lesser. The yield generally varies between 20 to 30 lps against the draw down around 20m. In this area auto flowing condition occurs from deeper aquifer blow 200m depths at Soud.

In general in the northern part (north of Balasore town) thickness of aquifers as well as yield is more in comparison to southern part of the district (south of Balasore town).

4.2.2.2 **Saline Hazard Area:** The saline hazard area occurs as a narrow elongated tract along the eastern margin of the district, bordering the Bay of Bengal in the east. The salinity problem is conspicuous along Karanjasual / Chandaneswar to Chandipur section. In this section fresh water bearing aquifers are sandwiched between top and bottom saline zones and the bottom saline zone extends down to 600m depth. The top saline aquifers (barring few meters at top, average 10 to 12m, maximum around 30m is fresh) in Karanjasul-Chandaneswar-Narayan Mohanty Poria area extends down to 70m depth and in Chandipur it extends down to 150m depth. Below this saline water zone fresh water zone occurs and extend down to 300/350m depth in Karanjasole- Narayan Mohanty Poria area and at Chandipur fresh zone extends down to 250m depth. The fresh aquifers attain considerable cumulative thickness in Karanasul-Narayan Mohanty Poria area while it is thin in Chandipur area. Similarly the yield in Karanjasul area is very high (>60lps) and is very low (10 to 15lps) at Chandipur. The aquifers at top as well as bottom 50m of fresh water zone occurring between top and bottom saline zone in Karanjasole-Narayan Mohanty Poria area contain water with chloride content up to 350mg/l at places. The chloride content in the middle part

of aquifer (fresh zone) is much less than that of the desirable limit (250mg/l) of chloride for drinking water specification, which indicates that the water is very fresh.

The areal extension as well as depth persistence of top saline zone could not be determined further south of Chandipur due to non-existence of exploratory bore hole near the coast and also non availability of any reliable data from any other sources. The nearest bore hole drilled by CGWB (at Kalyani in Bhogaari Block 3km inland from coastline) is 30 km due south of Chandipur. This bore hole was drilled down to 240m depth and entire depth of bore hole was found to be fresh water bearing. From the above it may be concluded that the top saline zone in the south of Chandipur may have either disappeared towards south or it occurs by occupying very thin width just along the coast line and this could not be confirmed due to lack of bore hole data.

The width of the above mentioned saline area is around 10 to 12 Km in the extreme north eastern part of the district in Karanjasul area and it is around 6 to 7 kms in Chandipur area. Beyond Chandipur in the south it appears that the width has become less than 3km or the saline zone is altogether absent. Though the salinity problem occurs along a narrow tract in Balasore district but occurrence of saline and brackish water has also been noted at different depth that isolated pockets occurring further inland. At Dhansimulia (near Jaleswar) brackwish water encountered

between 109 to 190 m depth followed by saline water down to 251m depth. At Basta brackish to fresh water (chloride content 300mg/l) encountered below 100m depth at isolated pockets. At Brahmapur-Pokarisahi (south of Rupsa) area brackish to fresh water (chloride 300 to 350mg/l) encountered at pockets. At Sunhat in Balasore town (eastern part) brackish to fresh water encountered below 214m depth.

The blocks which are mainly affected by salinity problem are Bhogarai and Baliapal in the north, Bahanga in the south and Balasore and Remuna in between.

The yield from deeper fresh water zone varies widely from north to south due to variation in thickness of aquifers zones. Prominence of argillaceous materials are noted in the middle and southern part i.e. Chandipur and area lying south of Chandipur. The yield in extreme northeast (Karanjasul-Chandaneswar-Narayan Mohanty Poria) is more than 50lps against a drawdown of 8 to 9m, in Baliapal block it is around 30 to 40 lps against 10 to 12m drawdown and in Chandipur and beyond Chandipur,(due south), it varies from 12 and 25lps against draw downs varying between 15 and 25m.

The thickness of very top fresh water zone within saline hazard area, varies from negligible to a maximum of around 30m and thickness depends upon the local geological formations. Thick

and horizontally extensive palaeo and recent sand dunes always form shallow aquifer down to 30m depth fresh water zones. The yield from this top zone varies from 5 to 10 lps.

4.2.3 Auto flow: At places auto flowing situations are observed in the deeper confined aquifers. At Soud (Bahanaga block) the piezometers tapping the aquifers at 211 m to 217 m below ground level, is exhibiting auto flowing situation/ where the piezometric head is observed at 1.50m above ground level.

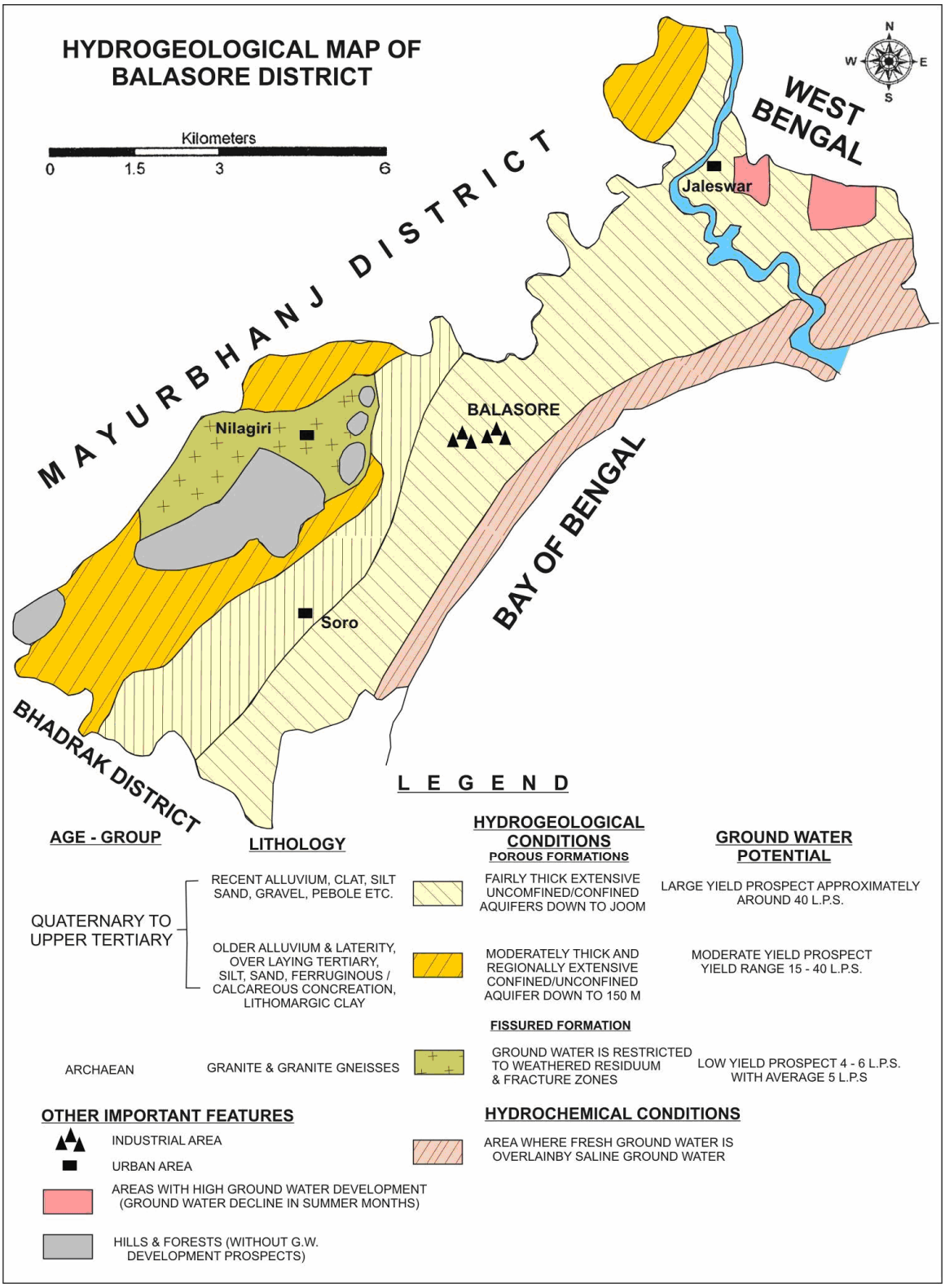


Figure – 4.2 : Hydrogeological map of Balasore District, Odisha

5. DATA GENERATION

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

Table – 5 : NAQUIM Data Collection Status

Sl No		Item	Sub Item	Source wise Data Collated & Compiled		
				CGWB	State Govt Agencies & Departments	Total
1	a	Ground Water Level Data	NHNS - Phreatic	61	43	104
	b		NHNS - Piezometric	6	15	21
	c		Additional Observation Wells (Phreatic)	127	12	139
	d		Additional Observation Wells (Piezometric)	217	55	272
2	a	Ground Water Quality Data	Phreatic	69	135	204
	b		Deeper	170	55	225
3		Exploratory Well Data		170	55	225
4		Vertical Electrical Sounding		160	100	260
5		Bore Hole Geophysical Logging		210	135	345
6		Water Harvesting Structures		0	129	129

5.1 Water Level Measurements : Water level measurements was carried out using the existing National Hydrographs Network stations(61 Dug Wells and 6 Piezometers) as well as by establishing a dedicated network of Key Wells. This involved measurement of water levels of both the phreatic aquifer through dug wells and measurement of Piezometric surface through the existing piezometers as well as through established dug wells and tube wells(217 Nos).

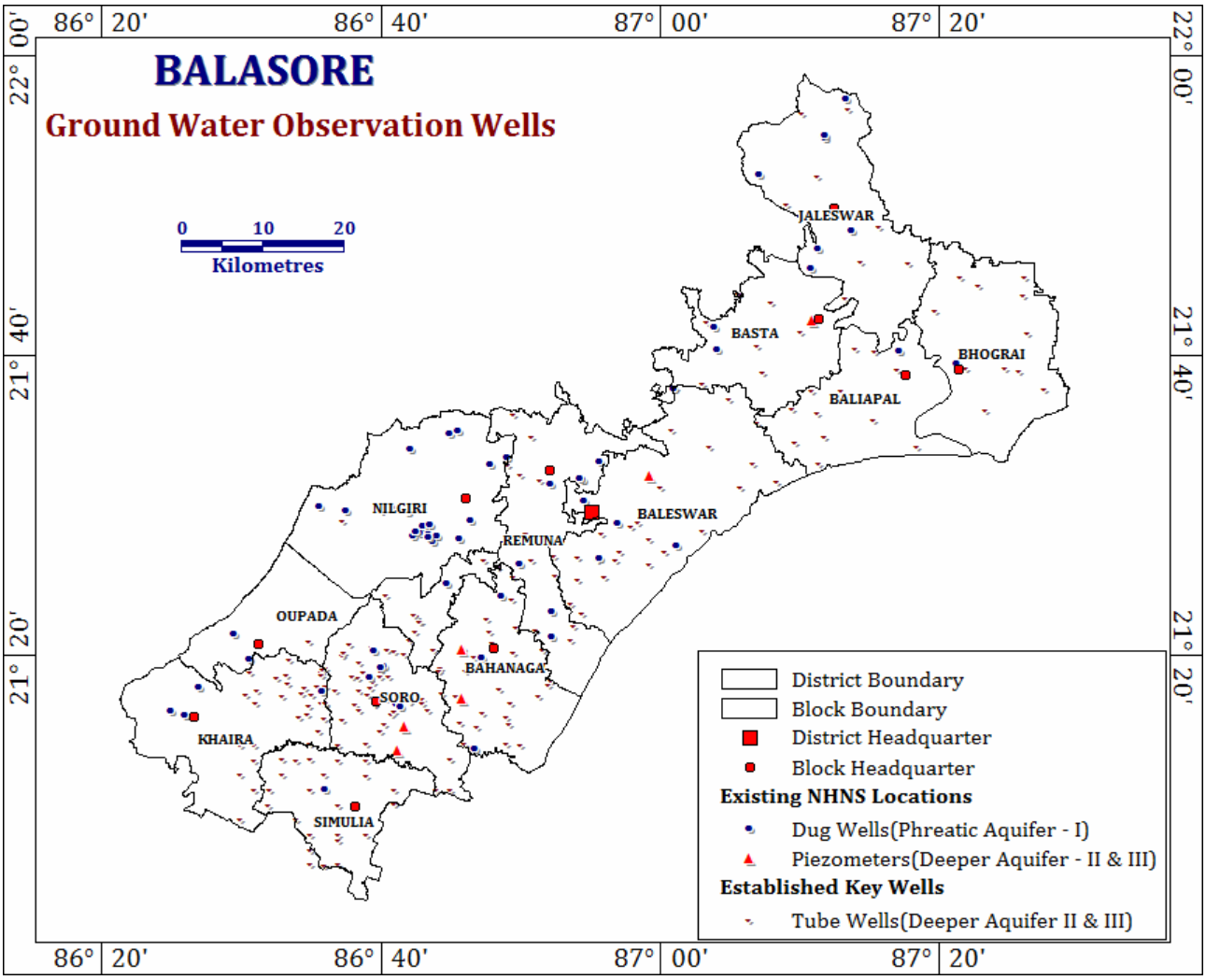


Figure – 5.1 : Ground Water Observation Wells, Balasore District, Odisha

5.1.1 Pre-Monsoon - Phreatic Aquifer : During the Pre-Monsoon season, the depth to water level in major part of the District remained within 6 – 8 metres below ground level. The relatively shallower water levels were confined in the Basta-Baliapal sector in the Central part and in the extreme western part in the Khaira Block, where it was even shallower in the range of 2 – 4 metres below ground level. The mid western part – mainly having the hard rock areas and the transition zones had relatively deeper water level in the range of 6 – 10 metres below ground level. These deeper water levels also coincided with the urban and industrial pockets of Remuna & Balasore Blocks as well as in the agricultural hot pocket of Soro-Anantapur area.

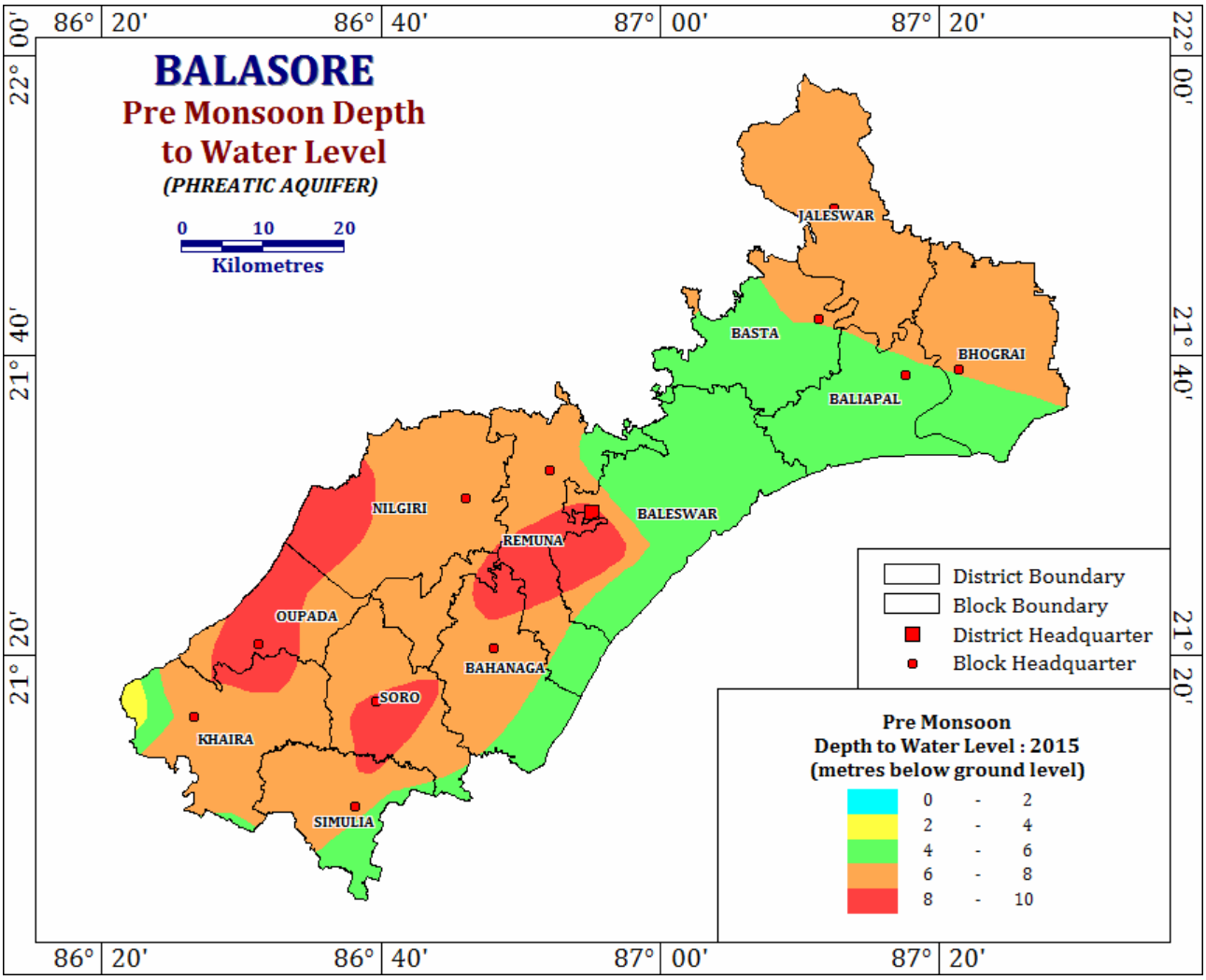


Figure – 5.1.1 : Pre-Monsoon Depth to Water Level(Phreatic), Balasore District, Odisha

5.1.2 Post-Monsoon - Phreatic Aquifer : During the Post-Monsoon season, the depth to water level in major part of the District remained within 4 – 6 metres below ground level. The relatively shallower water levels were confined in the Basta-Baliapal and southern part of Balasore-Remuna-Bahanaga Blocks in the Central part. In the extreme western part in the Khaira Block, where it was even shallower in the range of 0 – 2 metres below ground level. The mid western part – mainly having the hard rock areas and the transition zones had relatively deeper water level in the range of 6 – 8 metres below ground level. These deeper water levels also coincided with the urban and industrial pockets of

Remuna & Balasore Blocks as well as in the agricultural hot pocket of Soro-Anantapur area.

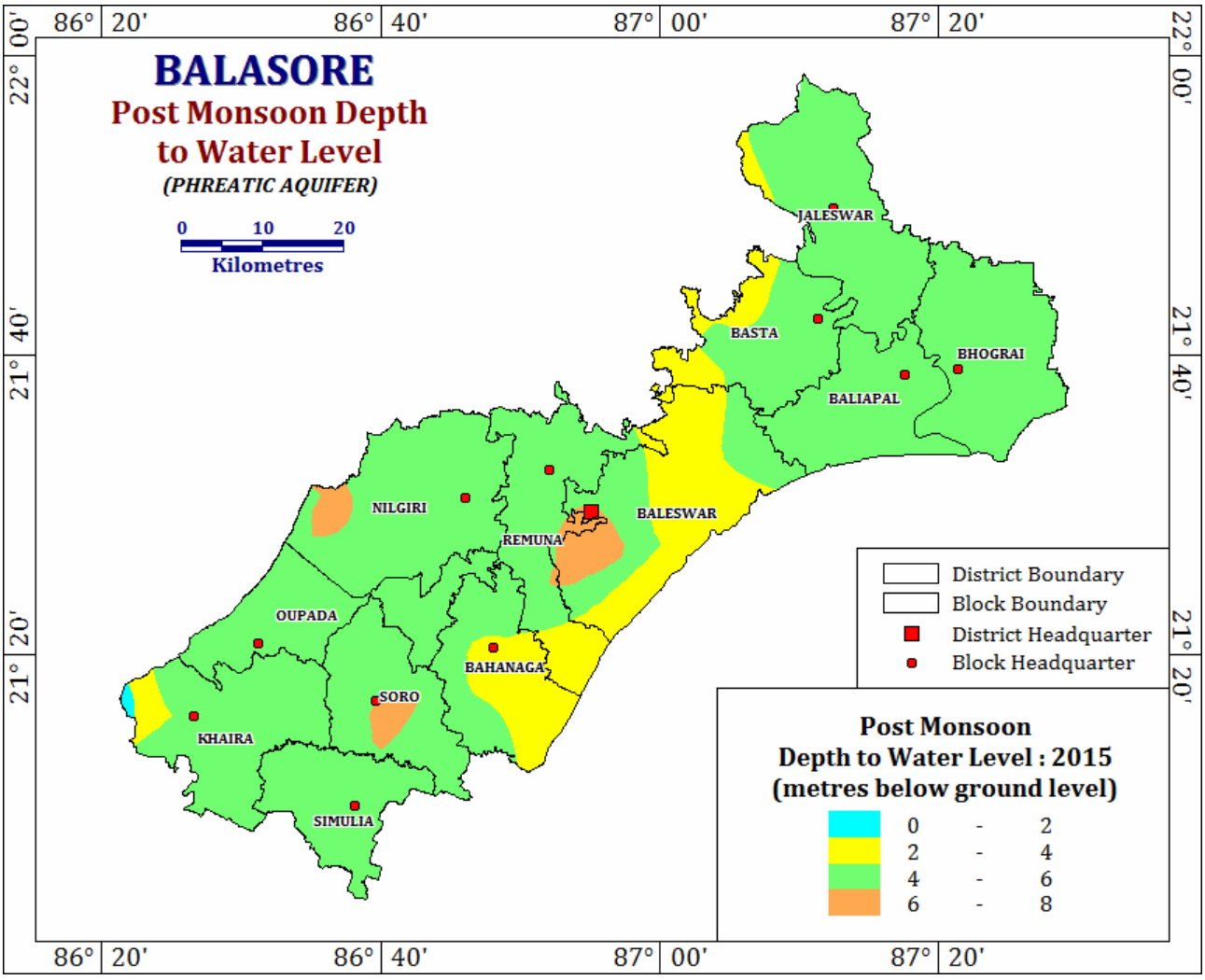


Figure – 5.1.2 : Post-Monsoon Depth to Water Level(Phreatic), Balasore District, Odisha

5.1.3 Pre vs Post-Monsoon Fluctuation - Phreatic Aquifer : As already narrated in the earlier paragraphs, the fluctuation in the Pre & Post Monsoon Water Level in the Phreatic Aquifer shows that there is a distinct rise in water level of 2 metres in most part of the District. The least rise in water level in the range of 0-1 metres could be seen in the north eastern part of the Balasore & Remuna Blocks bordering the Sono River, Southern part of Simulia Blocks and extreme western part of Khaira Block. The highest rise in water level in the Post Monsoon season in the range of 3 – 5 metres could be seen in the mid-central

part of the District in the Blocks of Balasore-Remuna-Bahanaga-Soro. This indicates that there is probably appreciable rainfall recharge going on in these blocks and in most probability the ground water draft for irrigation might have reduced in the monsoon and post-monsoon season.

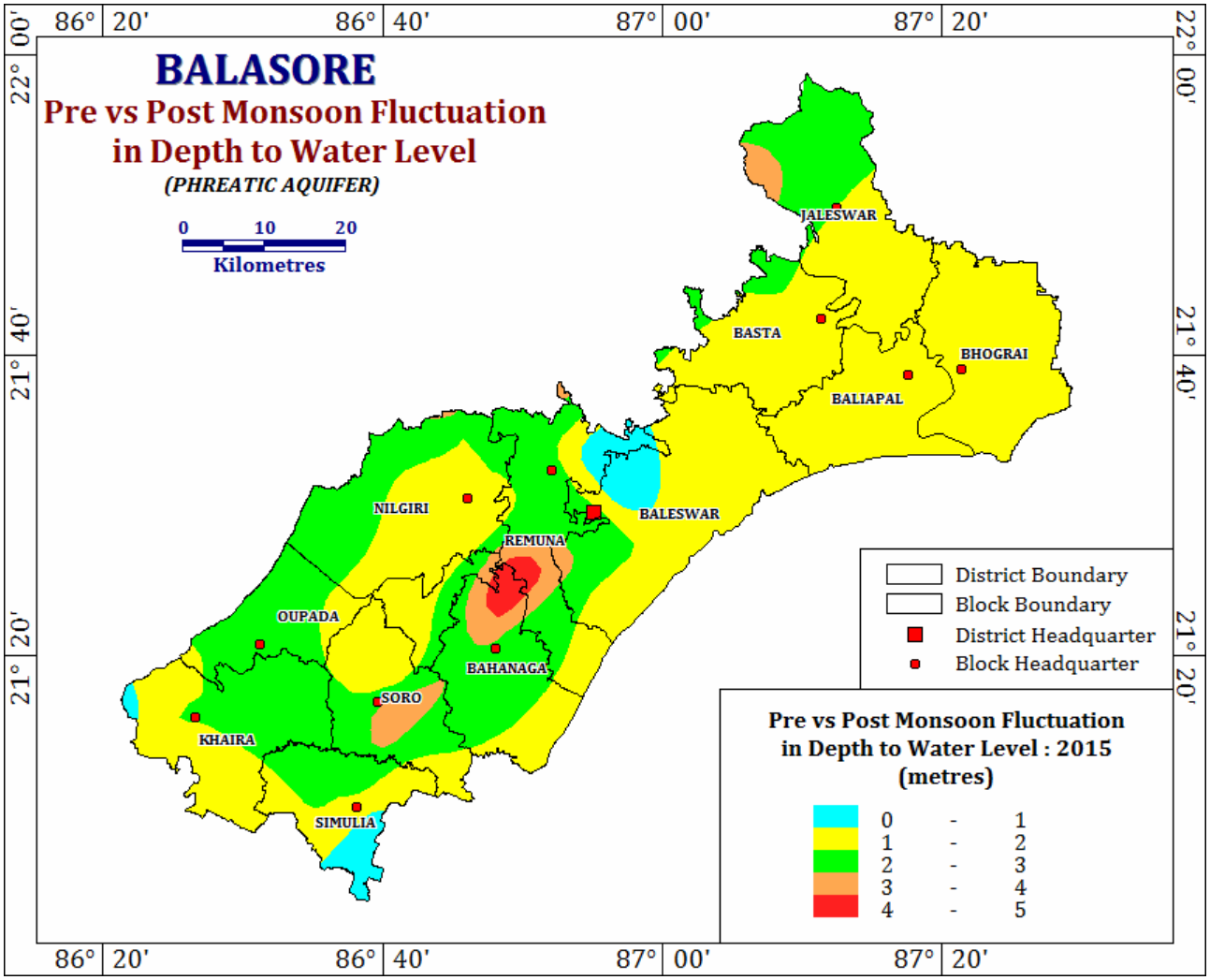


Figure – 5.1.3 : Pre vs Post-Monsoon Fluctuation in Depth to Water Level(Phreatic), Balasore District, Odisha

5.1.4 Pre-Monsoon Water Table Elevation-Phreatic Aquifer : A perusal of data and maps of the elevation of the water level of the phreatic aquifer indicates that the entire District have water level above the mean sea level in the pre-monsoon season. However, a majority of the area bordering the Bay of Bengal in the Blocks of Bhograi, Baliapal, Balasore, Remuna, Bahanaga and in part of Soro,

the water level is just within 0 – 5 metres above mean sea level. These areas could be potentially vulnerable areas in future if the current rate of ground water extraction continues unabated without additional recharge augmentation. Ground water flow direction is from both the eastern and western part to the south eastern part to Bay of Bengal.

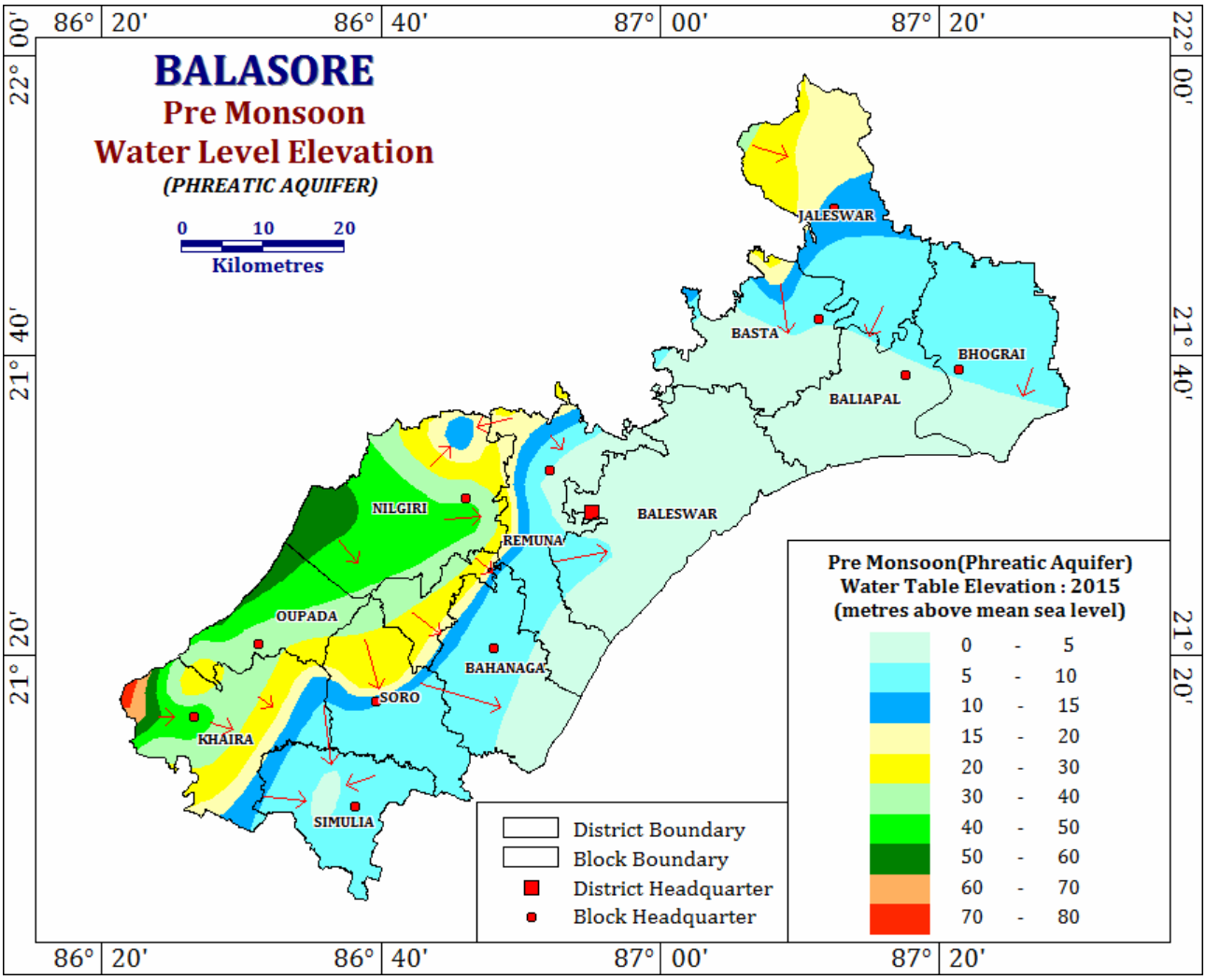


Figure – 5.1.4 : Pre-Monsoon Water Table Elevation, Balasore District, Odisha

5.1.5 Post-Monsoon Water Table Elevation-Phreatic Aquifer : A perusal of data and maps of the elevation of the water level of the phreatic aquifer indicates that the entire District have water level above the mean sea level in the post-monsoon season. However, a majority of the area bordering the Bay of Bengal in the Blocks of Bhograi, Baliapal, Balasore, Remuna, Bahanaga and in part of Soro, the water level is just within 0 – 5 metres above mean sea level. These areas

could be potentially vulnerable areas in future if the current rate of ground water extraction continues unabated without additional recharge augmentation. Ground water flow direction is from both the eastern and western part to the south eastern part to Bay of Bengal. The difference between the pre and post-monsoon water table elevation is quite minor and it reflects the rise in water table of 2 meters in the post monsoon season over pre-monsoon depth to water level.

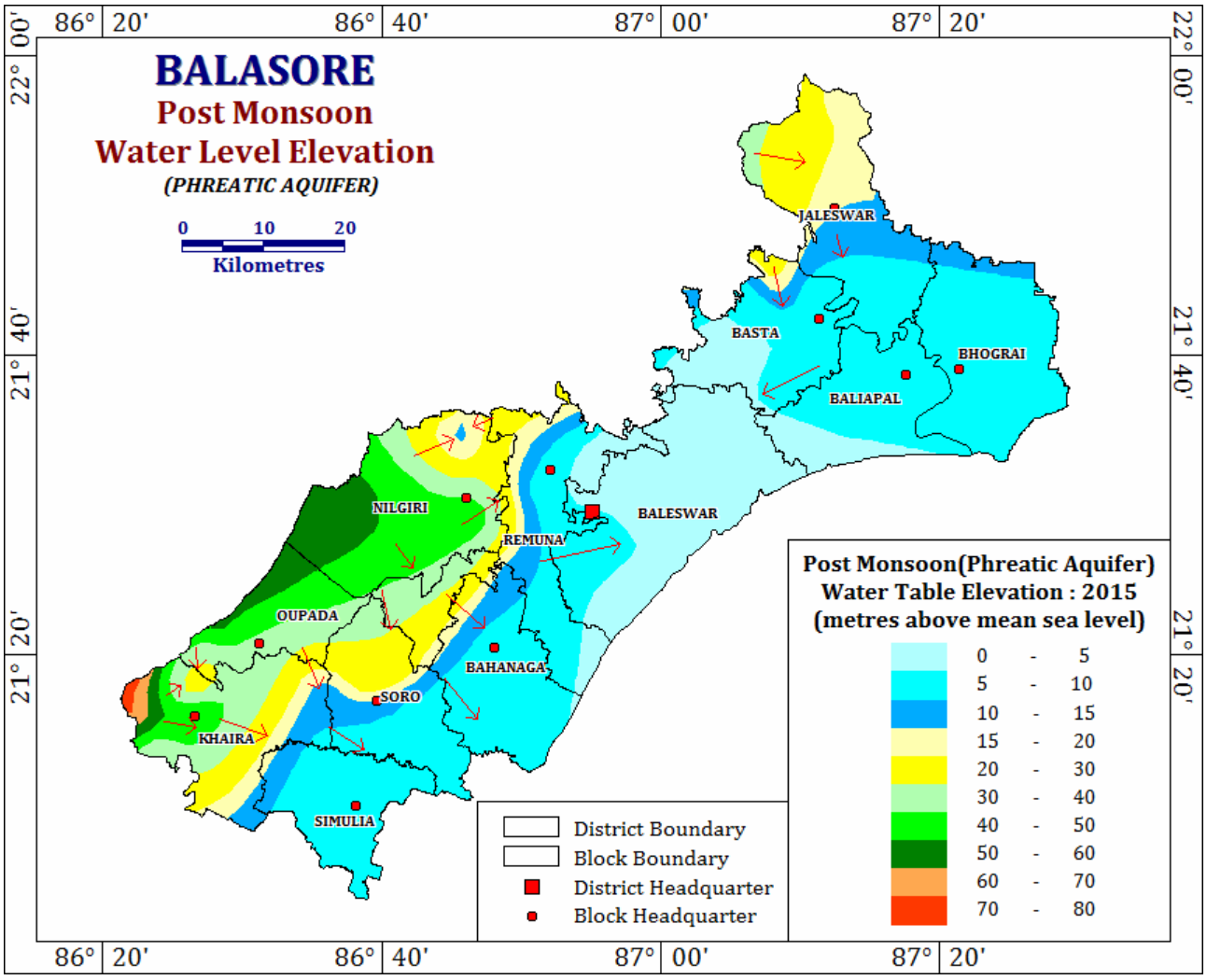


Figure – 5.1.5 : Post-Monsoon Water Table Elevation, Balasore District, Odisha

5.1.6 Long Term Water Table Trend – Phreatic Aquifer : Long term trend water table is being deciphered from the hydrographs of the National Hydrograph Network Stations with depth to water level and seasonal

trends plotted on a single figure for easy comprehensibility. Limited hydrographs are being reproduced and represented in this report for a synoptic assessment, which are shown subsequently.

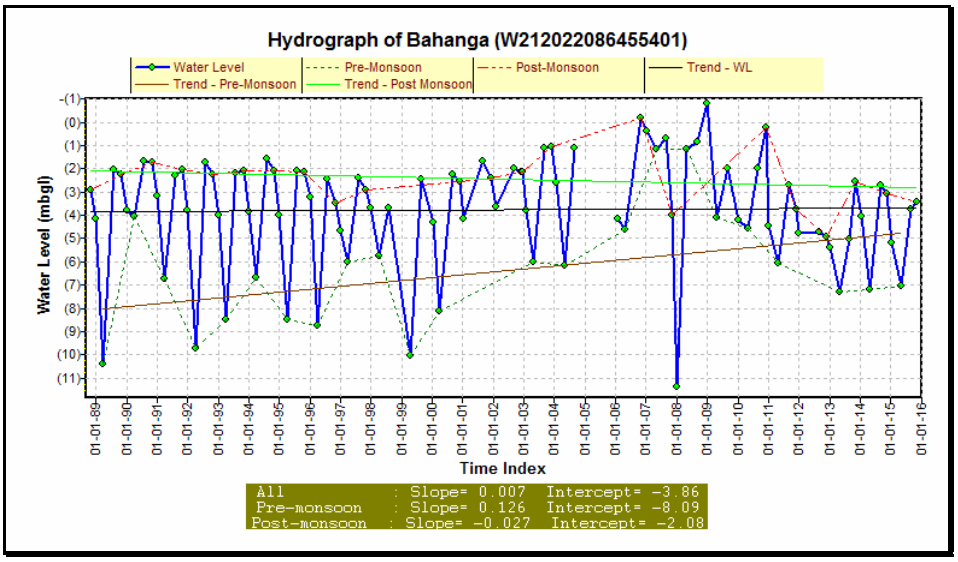


Figure – 5.1.6 a: Hydrograph of Bahanaga(Bahanaga Block)

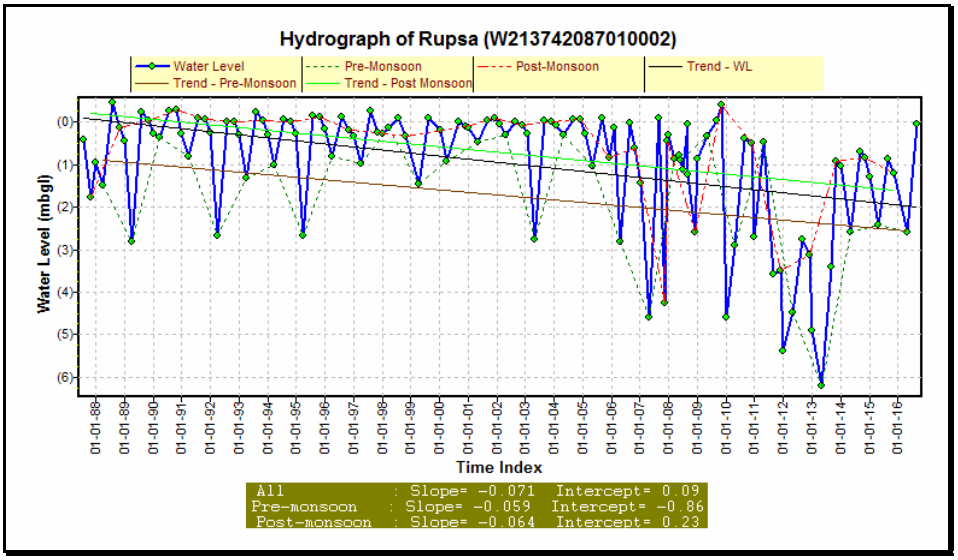


Figure – 5.1.6 b : Hydrograph of Rupsa(Balasore Block)

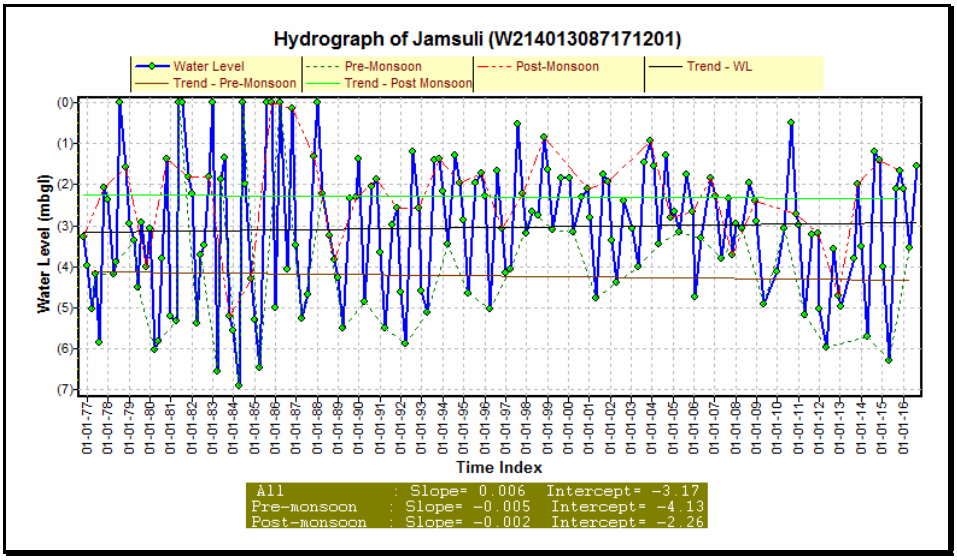


Figure – 5.1.6 c : Hydrograph of Jamsuli(Baliapal Block)

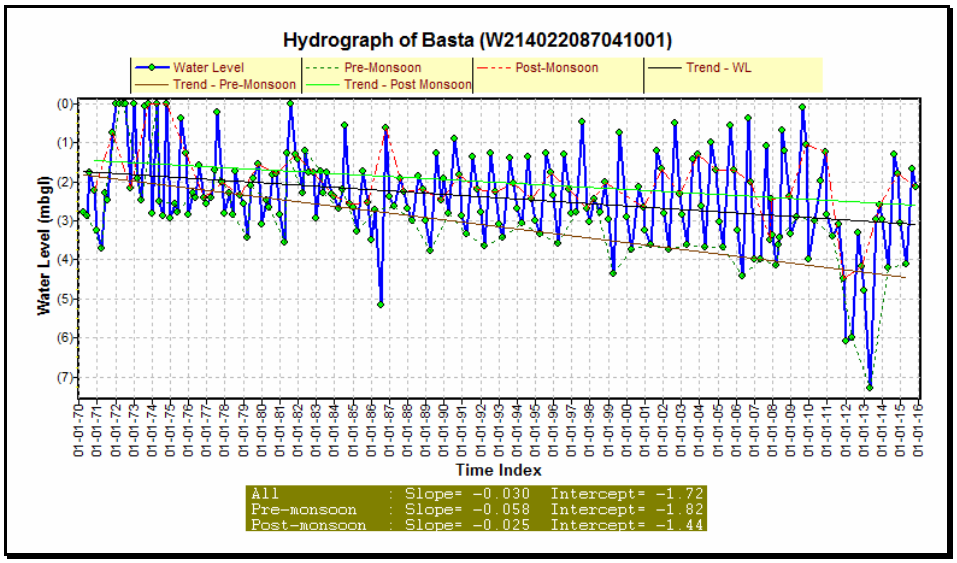


Figure – 5.1.6 d : Hydrograph of Basta(Basta Block)

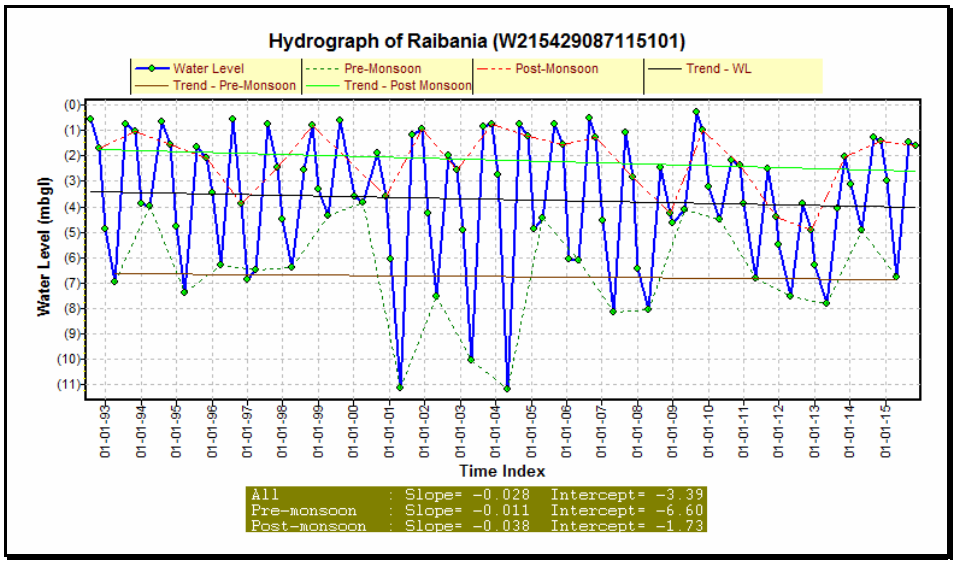


Figure – 5.1.6 e : Hydrograph of Raibania(Jaleswar Block)

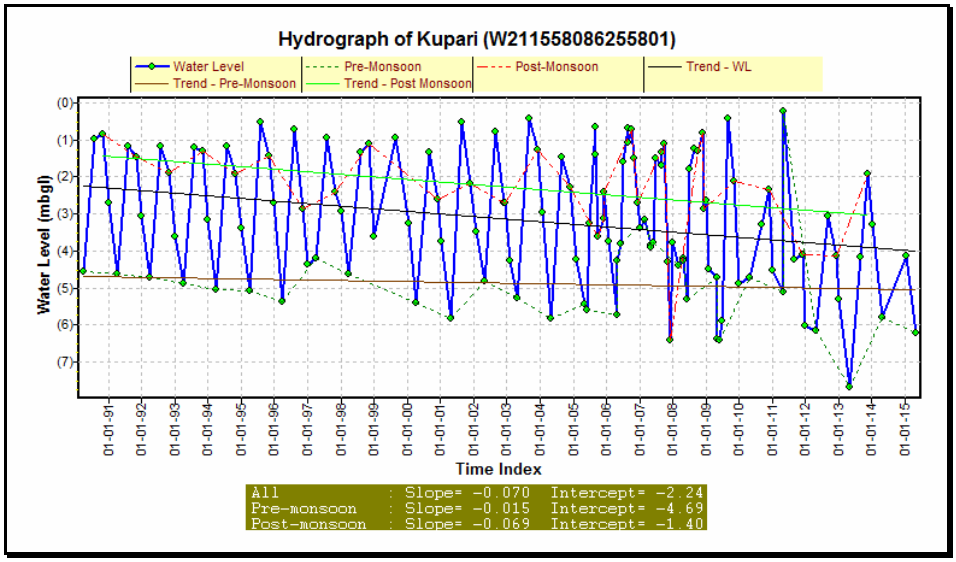


Figure – 5.1.6 f : Hydrograph of Kupari(Khaira Block)

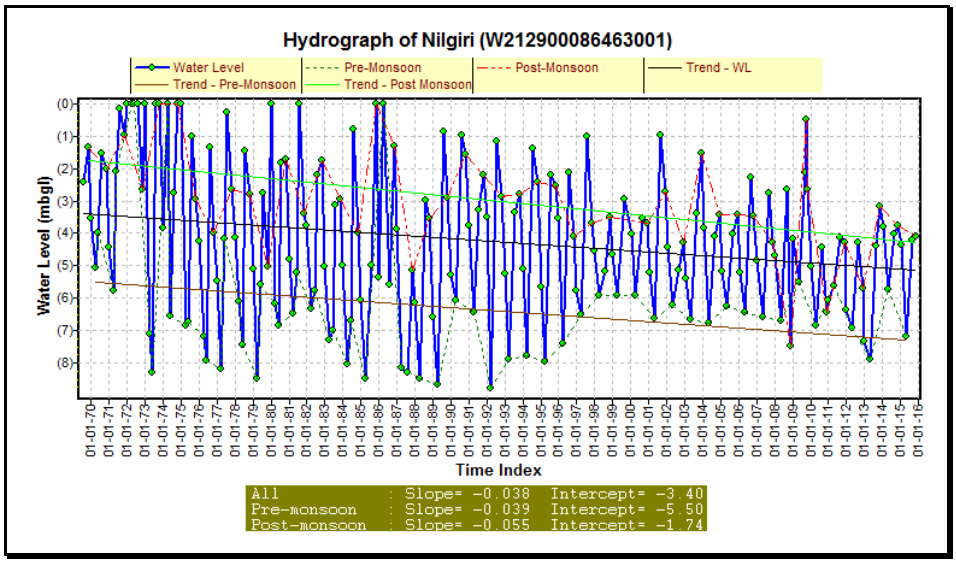


Figure – 5.1.6 g : Hydrograph of Nilgiri(Nilgiri Block)

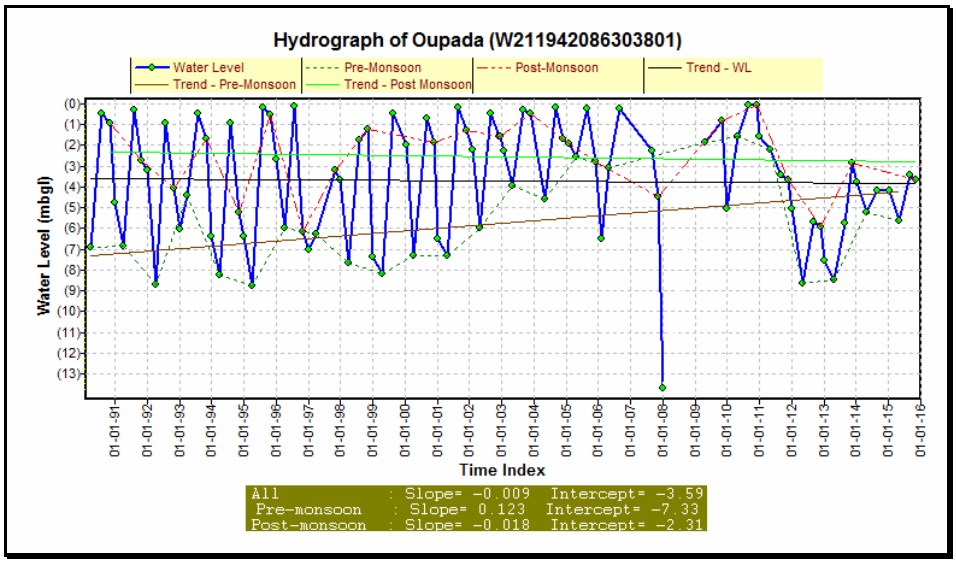


Figure – 5.1.6 h : Hydrograph of Oupada(Oupada Block)

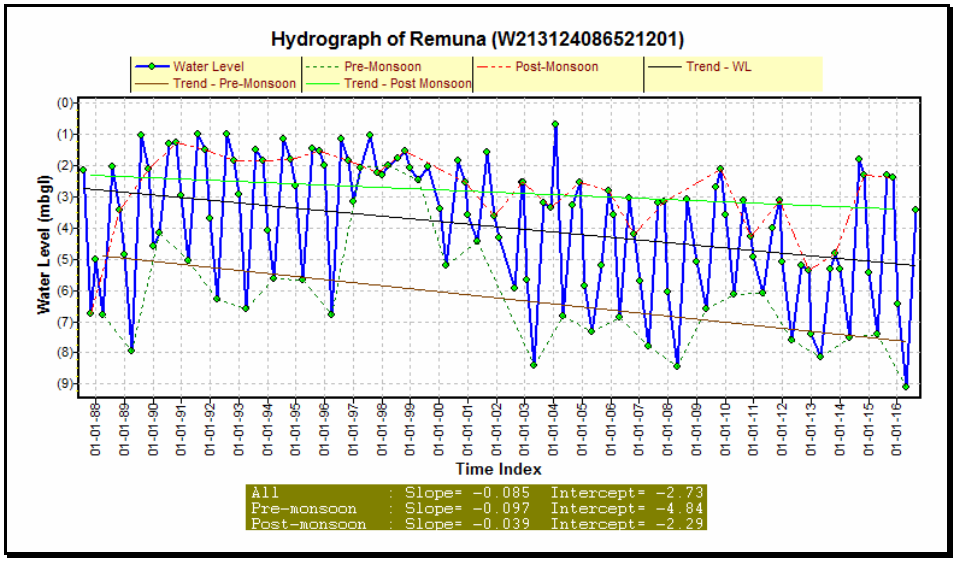


Figure – 5.1.6 i : Hydrograph of Remuna(Remuna Block)

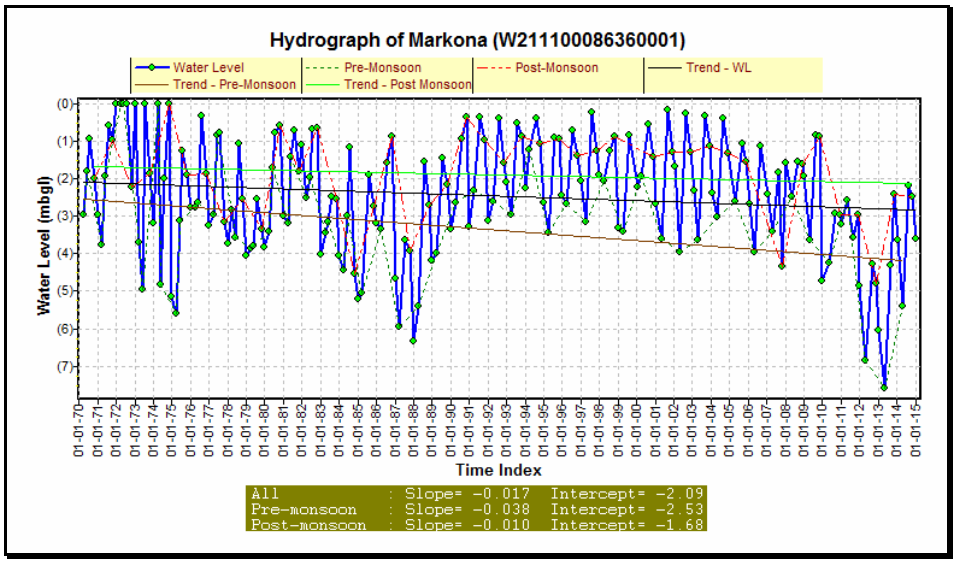


Figure – 5.1.6 j : Hydrograph of Markona(Simulia Block)

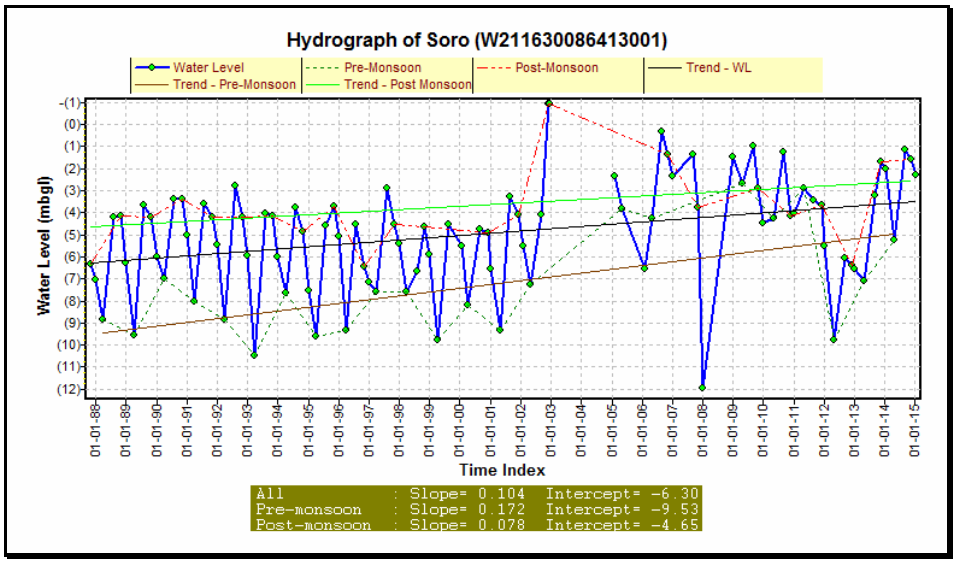


Figure – 5.1.6 j : Hydrograph of Soro(Soro Block)

Perusal of the data and subsequent hydrographs reveal that in major part of the district, the phreatic aquifer does not show any significant decline. In fact in couple of blocks like Oupada & Soro, there is rising trend. However, as already revealed in the depth to water level data and maps in certain blocks like Balasore, Basta, Khaira, Nilgiri, Remuna, there is declining trend. In other blocks, though there is slight declining trend in the pre-monsoon season, the mild rise or near static post-monsoon season compensates the annual ground water table trend.

5.1.7 Pre-Monsoon Depth to Piezometric Surface : A perusal of data and map reveals that the pre-monsoon depth to piezometric surface varies from as low as 1.5 to as high as 21 metres below ground level. Majority of the areas have the piezometirc surface pegged between 6 – 12 metres below ground level. Deeper piezometric surface(> 12 metres below ground level) are found in the blocks of Nilgiri, Basta, Baliapal, Balasore & Soro.

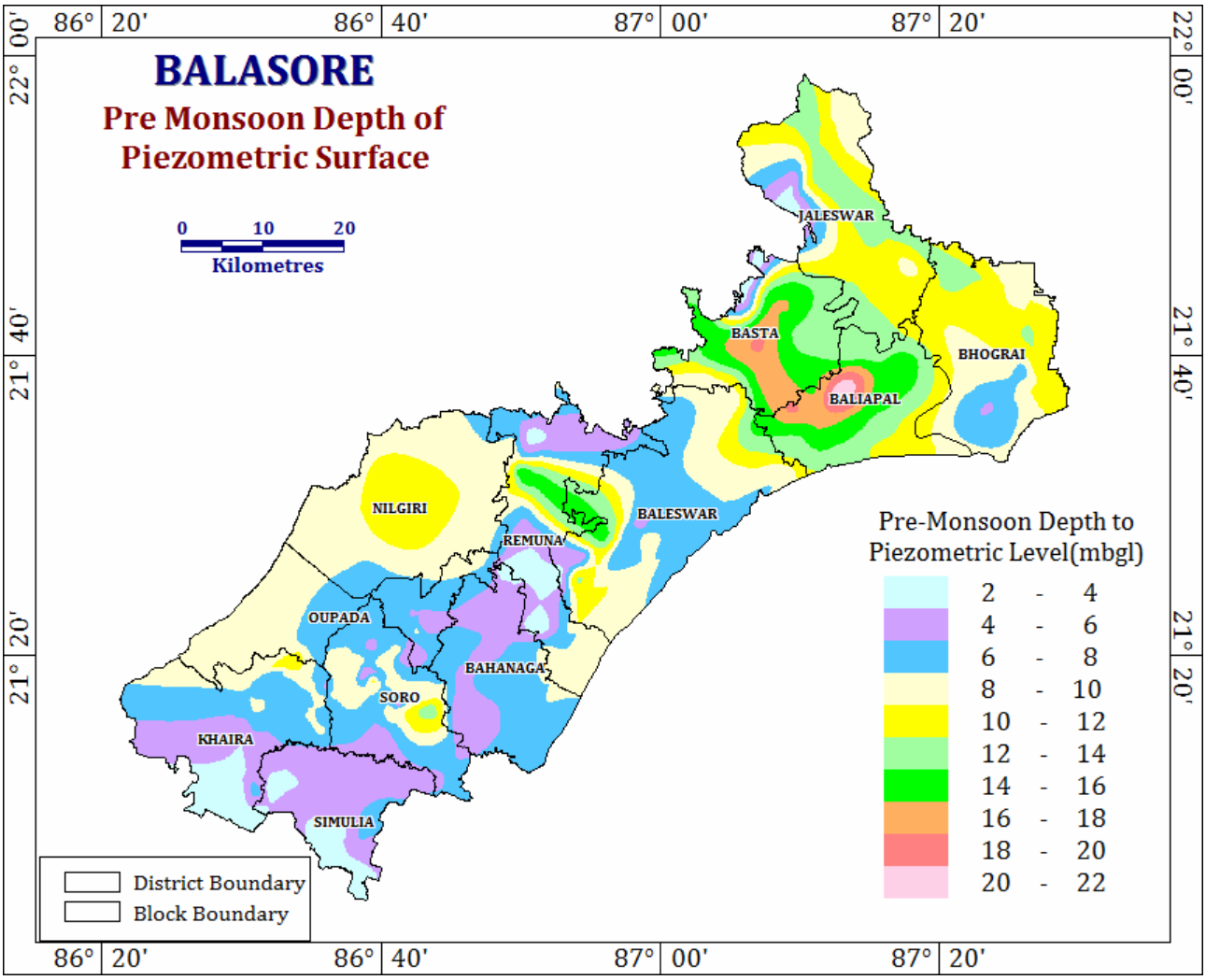


Figure – 5.1.7 : Pre-Monsoon Depth to Piezometric Surface, Balasore District, Odisha

5.1.8 Post-Monsoon Depth to Piezometric Surface : A perusal of data and map reveals that the post-monsoon depth to piezometric surface varies from as low as 0.95 to as high as 12.95 metres below ground level. Majority of the areas have the piezometirc surface pegged between 4 – 8 metres below ground level. Relatively deeper piezometric surface(> 8 metres below ground level) are found in the blocks of Nilgiri, Basta, Baliapal, Balasore & Soro.

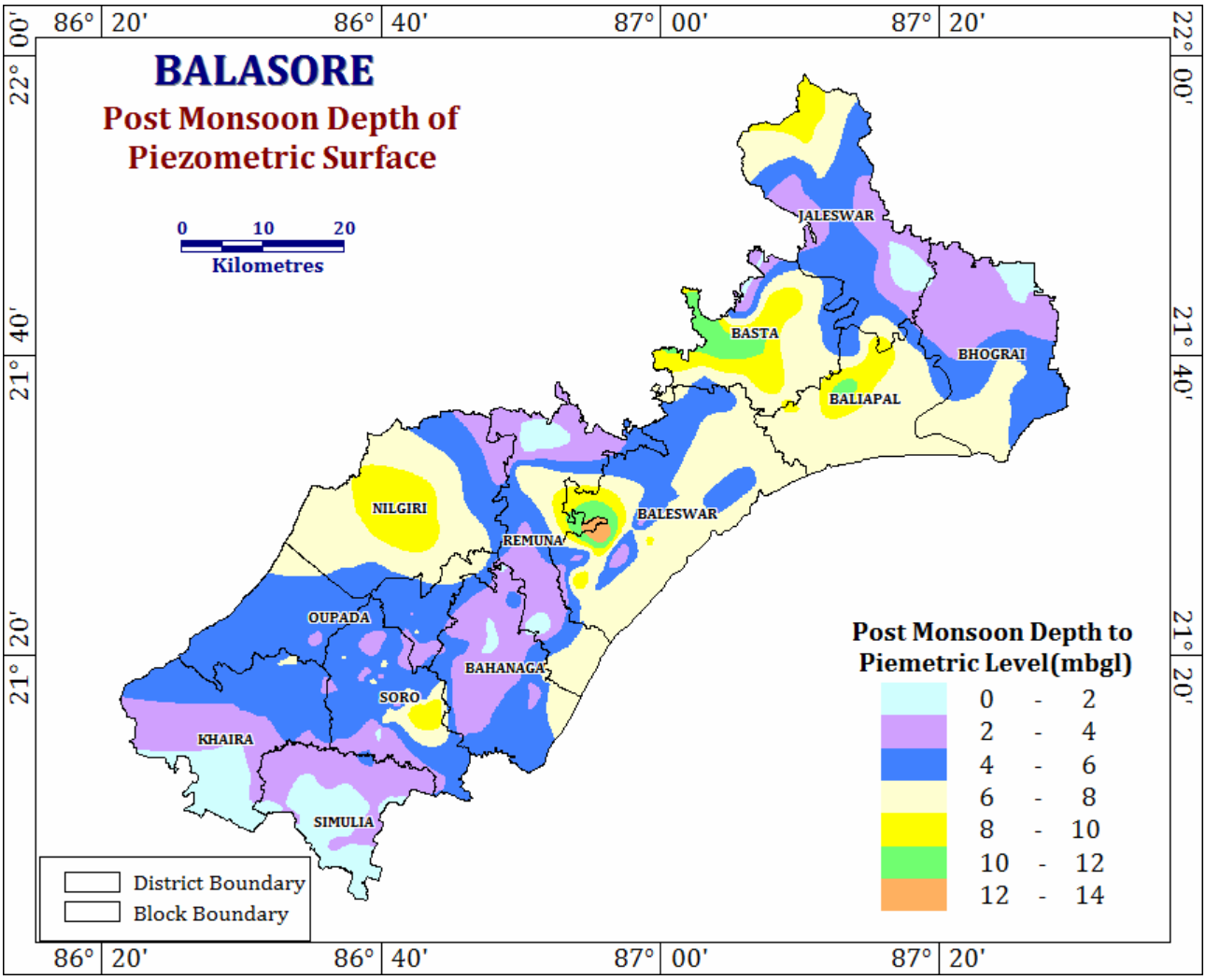


Figure – 5.1.8 : Post-Monsoon Depth to Piezometric Surface, Balasore District, Odisha

5.1.9 Pre vs Post-Monsoon Fluctuation in Depth to Piezometric Surface : A perusal of data and map reveals that the Pre vs post-monsoon fluctuation in depth to piezometric surface ranges from fall of about 0.75 metres to a raise of about 12 metres. This unique nature could be seen in Bhograi Block in the district. But overall, there is distinct rise in piezometric surface in the post monsoon season over the pre monsoon piezometric surface. The highest amount of rise of the order of 8 – 12 metres could be seen in the Blocks of Basta, Baliapal, Bhograi and Jaleswar. The western part of the district shows average rise of about 2 – 4 metres and in the eastern part shows average rise of 6 – 8 metres.

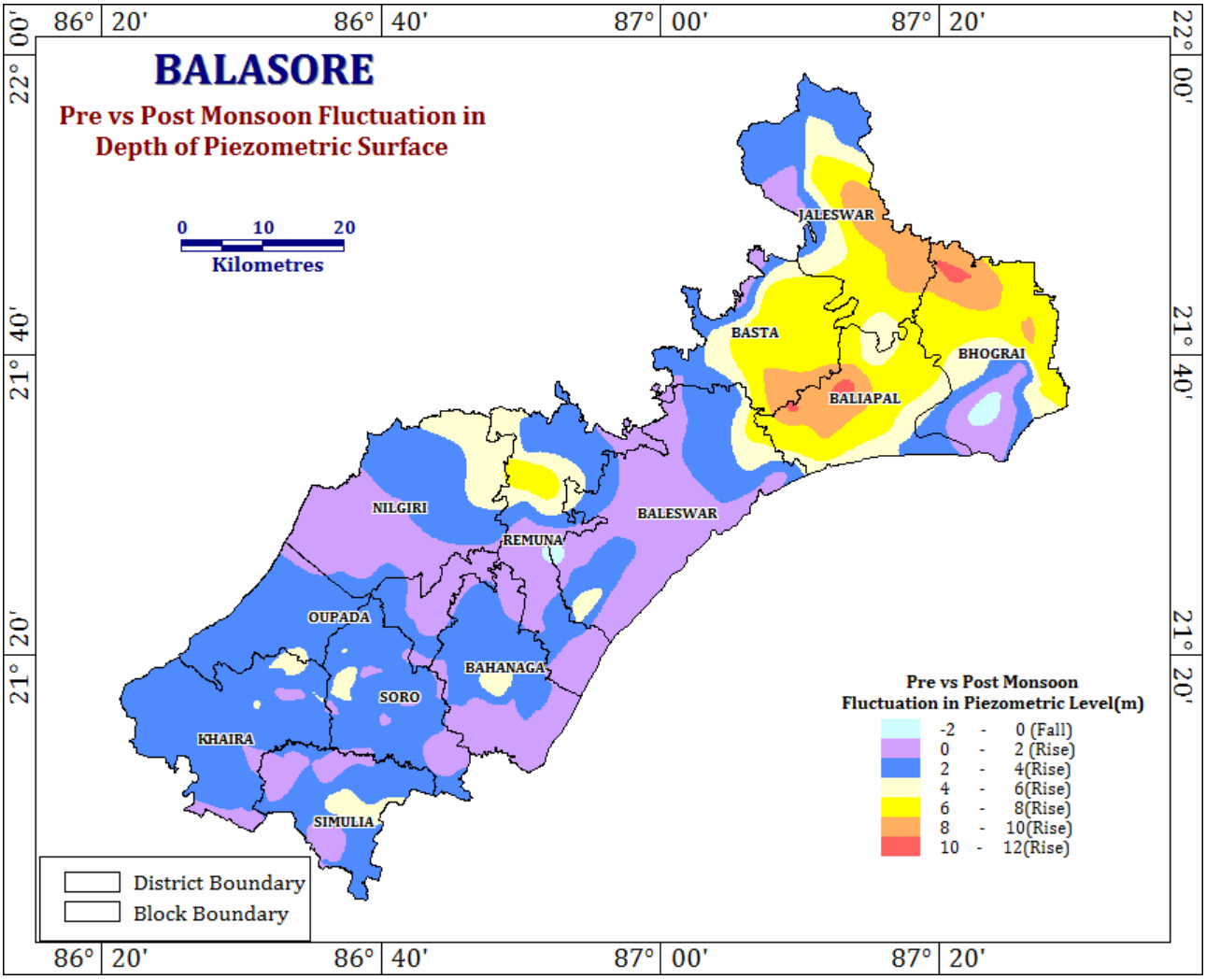


Figure – 5.1.9 : Pre vs Post-Monsoon fluctuation in Depth to Piezometric Surface in Balasore District, Odisha

5.1.10 Pre Monsoon Piezometric Surface Elevation : A perusal of data and maps of elevation of Piezometric Surface(ground elevation calculated from Interpolated SRTM-III DEM with limited field checks) reveals that the pre-monsoon elevation varies from as low as 18 m below sea level to as high as 82.5 metres above mean sea level. Three distinct ground water troughs having piezometric surface below mean sea level could be deciphered – Basta-Baliapal Sector, Balasore-Chandbali Sector, Soro-Anantapur Sector.

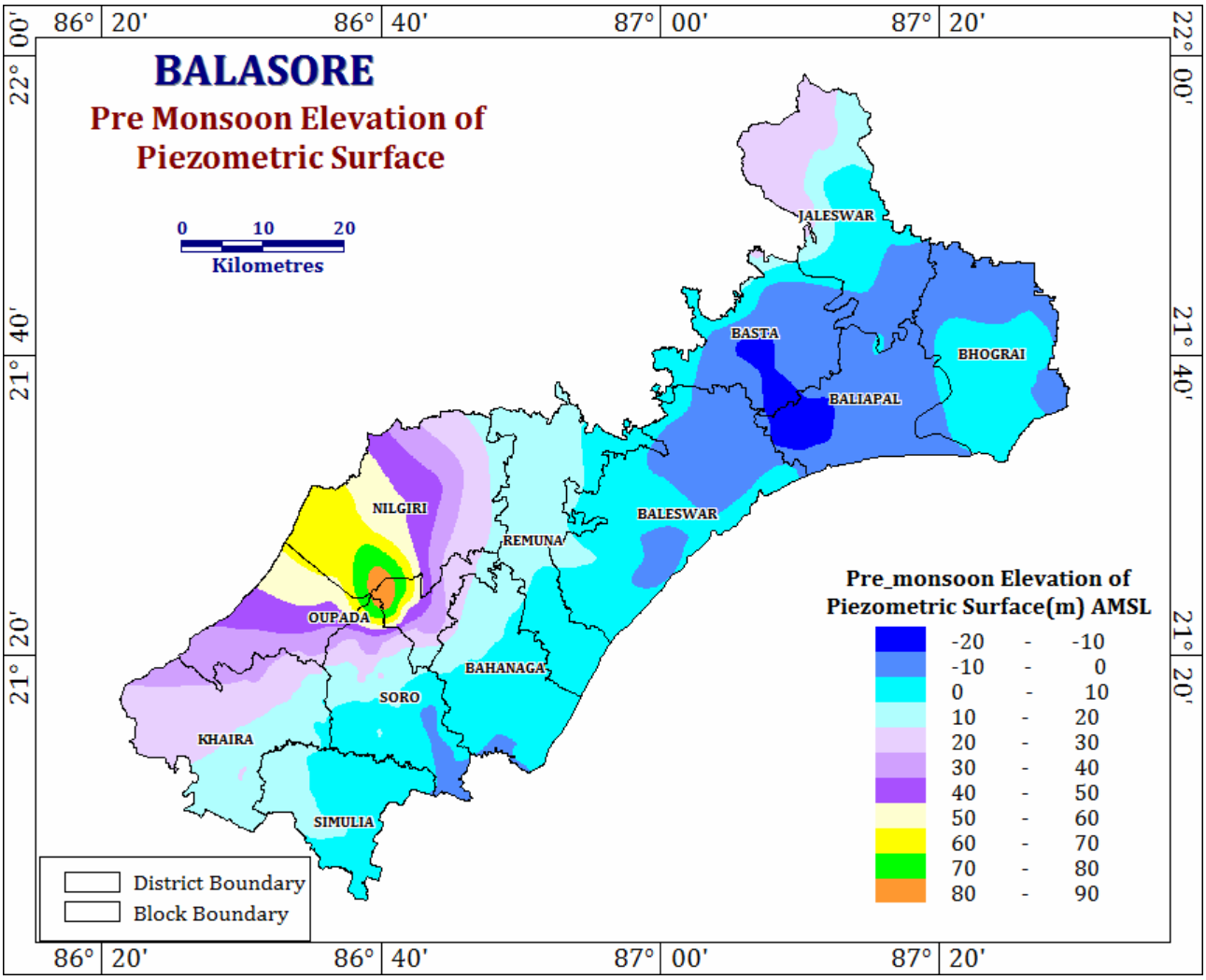


Figure – 5.1.10 : Pre-Monsoon Elevation of Piezometric Surface in Balasore District, Odisha

5.1.11 Post Monsoon Piezometric Surface Elevation : A perusal of data and maps of elevation of Piezometric Surface(ground elevation calculated from Interpolated SRTM-III DEM with limited field checks) reveals that the post-monsoon elevation varies from as low as 8 m below sea level to as high as 87.5 metres above mean sea level. Three distinct ground water troughs having piezometric surface below mean sea level could be deciphered – Basta-Baliapal Sector, Balasore-Chandbali Sector, Soro-Anantapur Sector. But there is a distinct 8 – 12 metres rise in piezometric surface elevations in those ground water trough bearing sectors in the post-monsoon period over its pre-monsoon configuration.

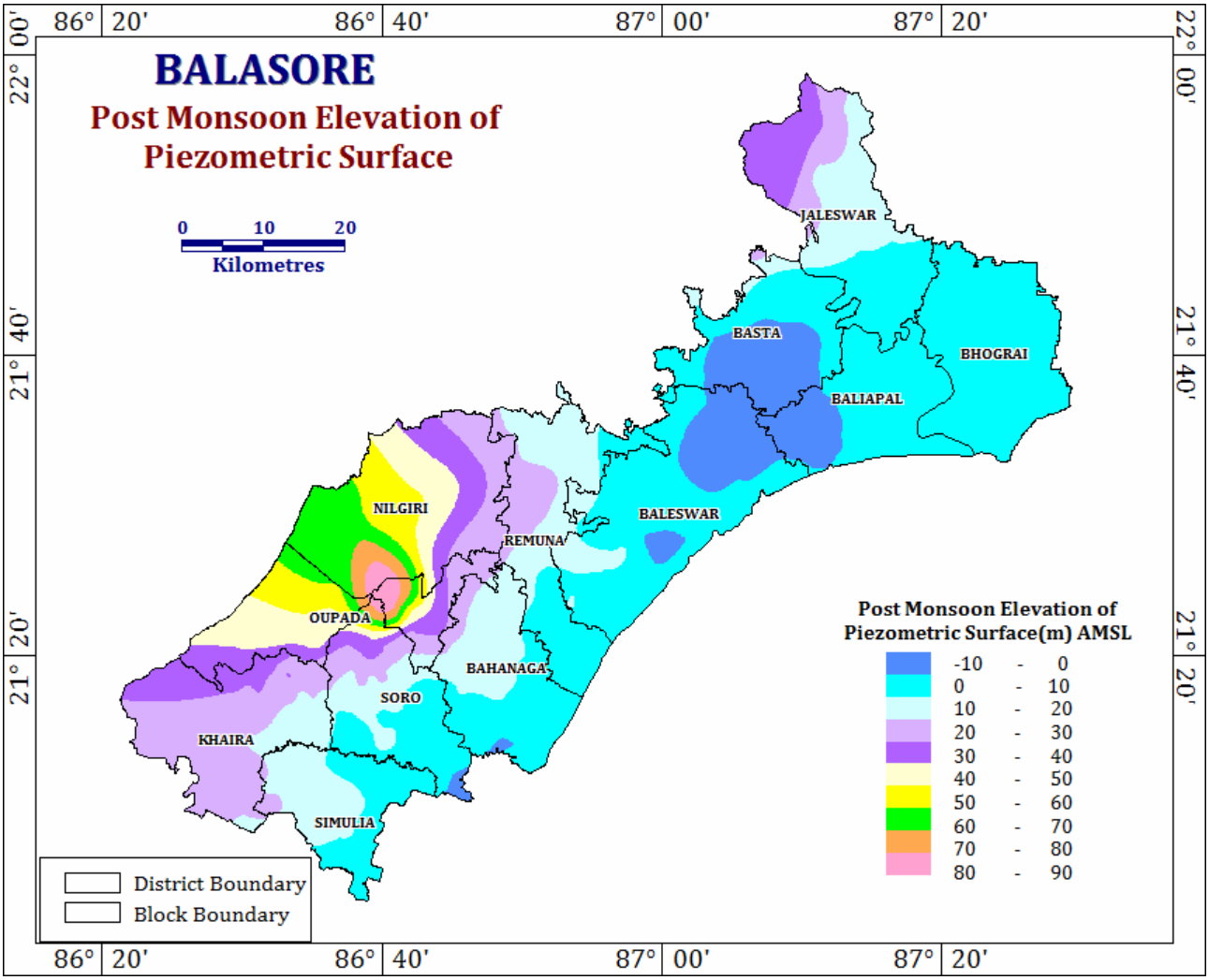


Figure – 5.1.11 : Pre-Monsoon Elevation of Piezometric Surface in Balasore District, Odisha

5.2 Geophysical Investigations : Since the area is difficult to access in all the seasons through drilling rigs, a bulk of the are was covered under Geophysical investigation, mainly through close spaced vertical electrical soundings(VES). Not only Schlumberger configuration but Werner and Pole-Dipole & Dipole-Dipole method too was utilized. Wherever there was space constraint, Half-Schlumberger method was utilized. Objective behind VES was to accurately demarcate the Fresh-Saline interface on a geographic plane. The collected data was plotted using IP2WIN Software and interpreted More than 80 VES data was used for interpretative purpose. However, because of inherent salinity problem, individual geoelectrical layer wise interpretation could not be obtained beyond 30 metres depth.

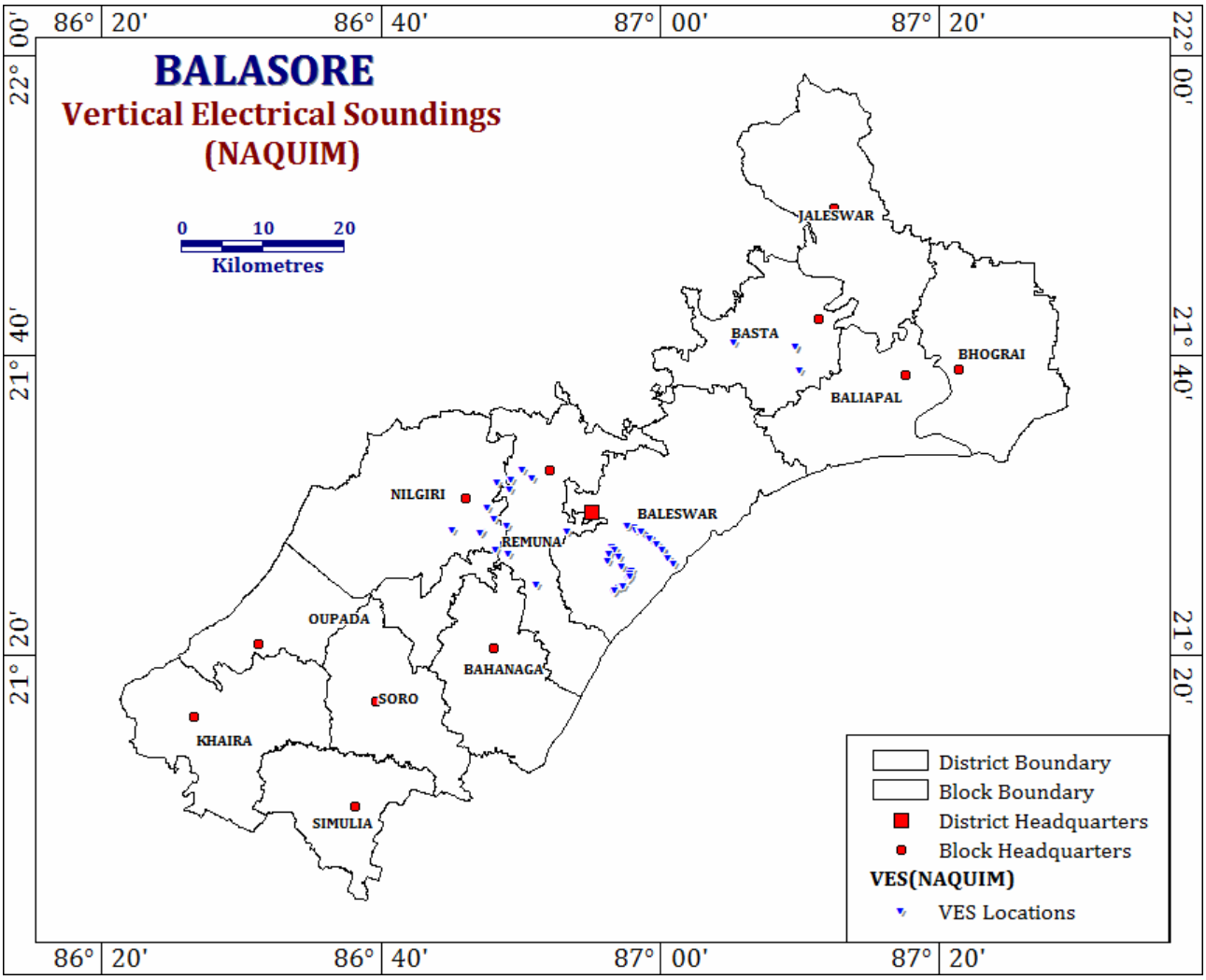


Figure – 5.2 a : NAQUIM VES Locations in Balasore District, Odisha

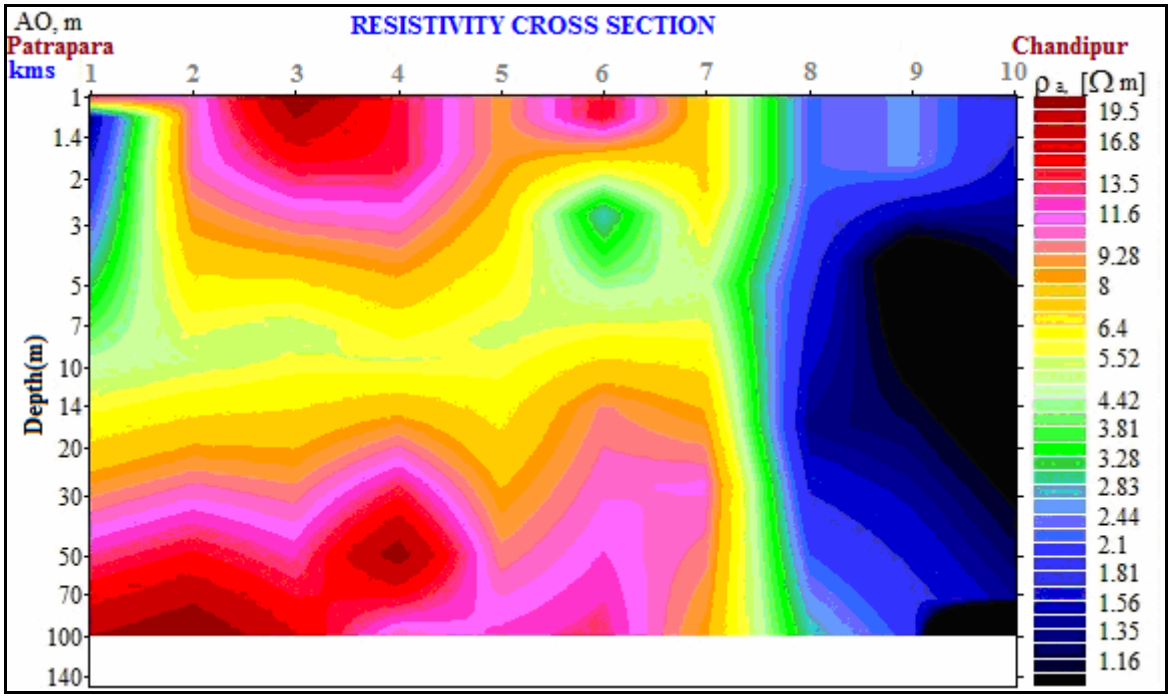


Figure – 5.2 b : Resistivity Cross Section(Patrapada-Chandipur)

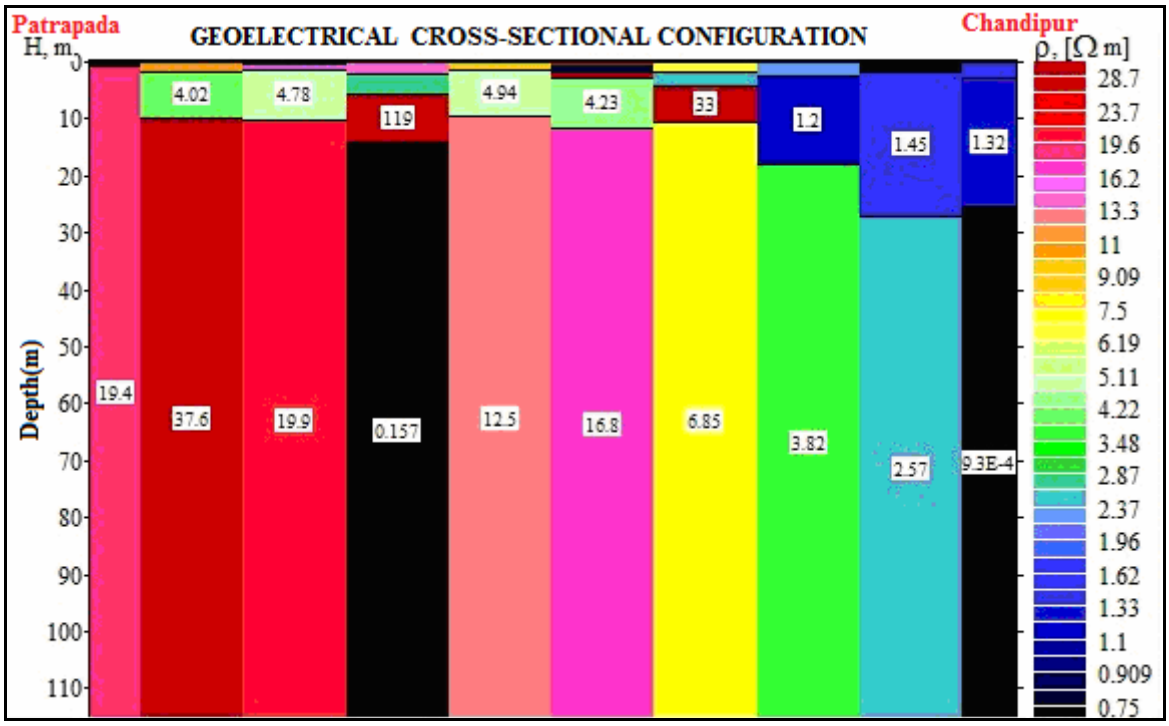


Figure – 5.2 c : Geoelectrical Cross Section(Patrapada-Chandipur)

5.3 Ground Water Quality – Sampling & Analysis : For ascertaining ground water quality, water samples were collected from the existing network of National Hydrographs Network Monitoring Stations[Aquifer – I(Phreatic)] and also from the Tube wells[Aquifer II & III] during the pre-monsoon season and analysed in the Regional Chemical Laboratory suing the Standard Analytical Protocols of APHA. In addition to this, a number of chemical data of Rural Water Supply & Sanitation of Department of Rural Development, Govt. of Odisha, available in website of the Department of Drinking Water Supply, Govt. of Odisha too was collected and collated. These data were used to interpret the chemical characteristics of the Aquifer(s) concerned. In general, it was found that the Water Quality of the Phreatic Aquifer are potable and conforms to the BIS : 10500 standards for drinking water. However, in the Deeper Aquifers(Aquifer II & III), there are some quality related issues which will be discussed later in the relevant section.

Table – 5.2a : Summarized Chemical Quality of the Phreatic Aquifer(Aquifer-I)

PARAMETER	UNIT	Minimum	Maximum	Average
pH		7.50	8.30	8.05
Electrical Conductivity(EC)	µS/cm at 25°C	250.00	850.00	390.91
Total Dissolved Solids(TDS)	mg/L	121.00	474.00	198.45
Total Hardness(TH) as $CaCO_3$	mg/L	80.00	165.00	123.64
Total Alkalinity(TA)	mg/L	80.00	325.00	139.09
Calcium(Ca^{++})	mg/L	20.00	54.00	33.09
Magnesium(Mg^{++})	mg/L	1.00	21.00	9.95
Sodium(Na^{+})	mg/L	8.00	150.00	29.73
Potassium(K^{+})	mg/L	0.00	1.00	0.05
Carbonate(CO_3^{--})	mg/L	0.00	0.00	0.00
Bicarbonate(HCO_3^{-})	mg/L	98.00	397.00	169.68
Chloride(Cl^{-})	mg/L	14.00	46.00	26.68
Sulphate(SO_4^{--})	mg/L	2.00	39.00	13.95
Fluoride(F^{-})	mg/L	0.20	1.00	0.56

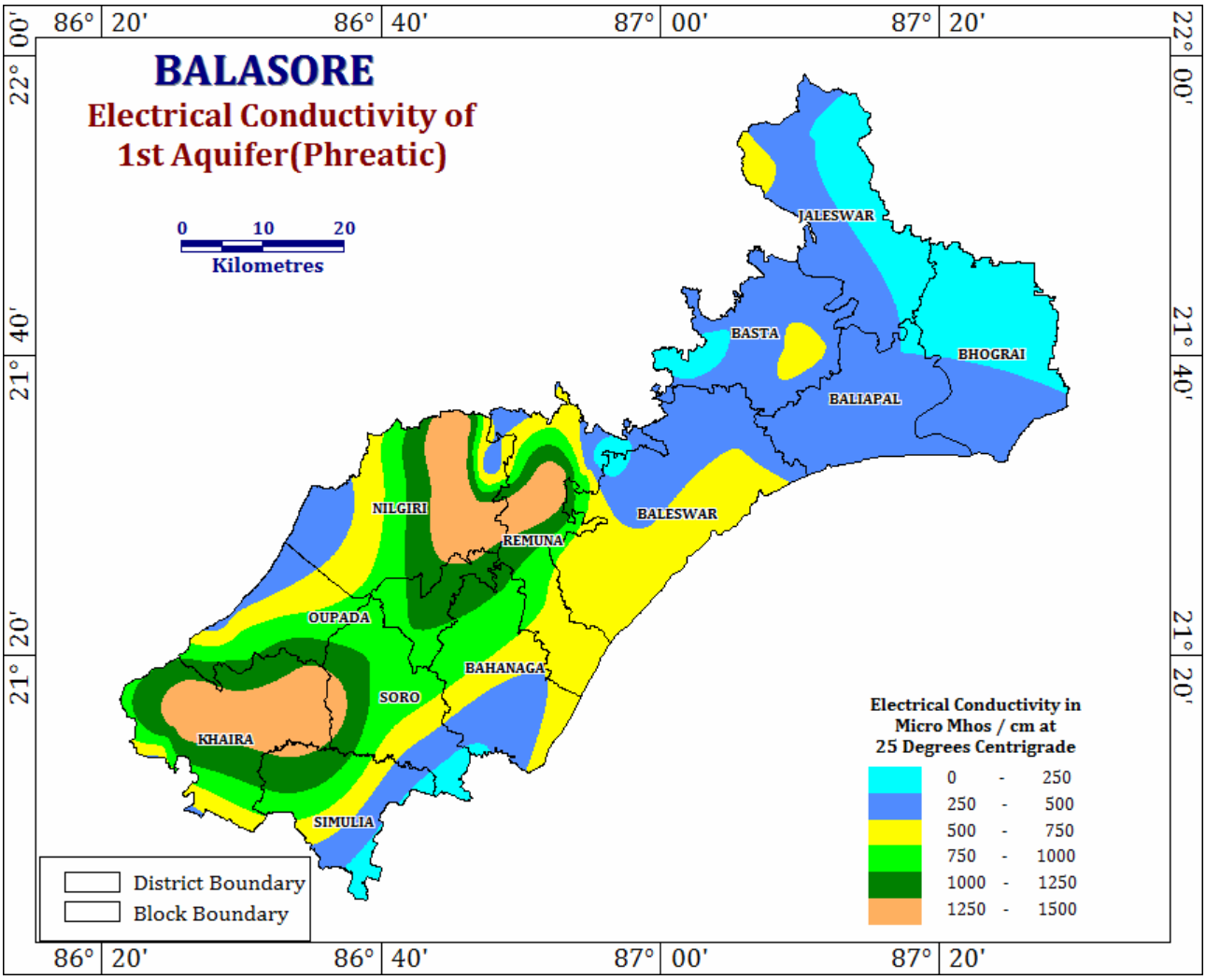


Figure – 5.2 a: Electrical Conductivity of the Phreatic Aquifer(Aquifer-I)

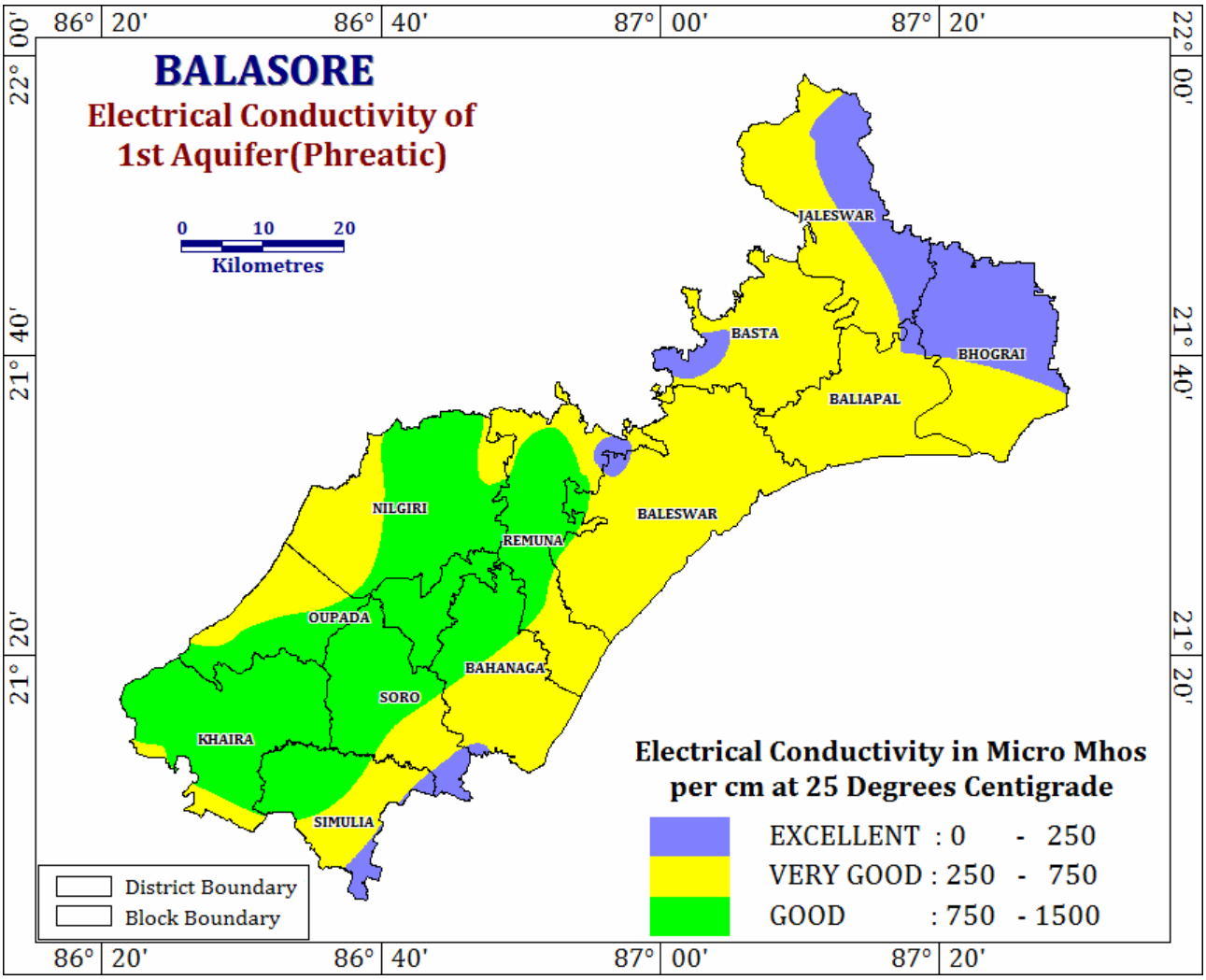


Figure – 5.2 b: Electrical Conductivity(USSL Class) of the Phreatic Aquifer(Aquifer-I)

A general perusal of the data provided in the table suggests that all the parameters mentioned are well within the permissible limits of the BIS Standard 10500 for drinking water. The Sodium Absorption Ration(SAR) and Electrical Conductivity(EC) used to classify the United States Salinity Laboratories Classification(Wilcox), too, shows that the water from the phreatic aquifers are good to excellent for agricultural use as well. As such the waters of the phreatic aquifers are perfectly potable for all uses in this district of Balasore.

Table – 5.2b : Summarized Chemical Quality of the Exploratory Wells(Aquifer-II & III)

PARAMETER	UNIT	Minimum	Maximum	Average
pH		6.96	8.42	7.86
Electrical Conductivity(EC)	μS/cm at 25°C	170.00	1680.00	713.25
Total Dissolved Solids(TDS)	mg/L	93.00	901.00	368.26
Total Hardness(TH) as $CaCO_3$	mg/L	60.00	575.00	225.75
Total Alkalinity(TA)	mg/L	50.00	380.00	239.50
Calcium(Ca^{++})	mg/L	8.00	100.00	41.85
Magnesium(Mg^{++})	mg/L	0.00	117.90	29.44
Sodium(Na^{+})	mg/L	0.45	233.50	60.42
Potassium(K^{+})	mg/L	0.10	6.70	2.04
Carbonate(CO_3^{--})	mg/L	0.00	30.00	0.75
Bicarbonate(HCO_3^{-})	mg/L	61.00	464.00	290.72
Chloride(Cl^{-})	mg/L	11.00	302.00	72.77
Sulphate(SO_4^{--})	mg/L	0.60	110.50	14.93
Fluoride(F^{-})	mg/L	0.09	2.10	0.82

Table – 5.2C : Summarized Chemical Quality of the Ground Water Observation Wells(Aquifer-II & III)

PARAMETER	UNIT	Minimum	Maximum	Average
pH		7.36	8.65	8.04
Electrical Conductivity(EC)	μS/cm at 25°C	97	17030	616
Total Dissolved Solids(TDS)	mg/L	41	9771	308
Total Hardness(TH) as $CaCO_3$	mg/L	30	705	170
Total Alkalinity(TA)	mg/L	15	415	174
Calcium(Ca^{++})	mg/L	6	158	33.1
Magnesium(Mg^{++})	mg/L	2	113	21.2
Sodium(Na^{+})	mg/L	1.5	3697	57.8
Potassium(K^{+})	mg/L	0	20	1.2
Carbonate(CO_3^{--})	mg/L	0	15	0.62
Bicarbonate(HCO_3^{-})	mg/L	18	506	211
Chloride(Cl^{-})	mg/L	7	5707	80.1
Sulphate(SO_4^{--})	mg/L	0	189	10.3
Fluoride(F^{-})	mg/L	0.07	1.67	0.65

A perusal of the above data shows that majority of the wells have potable water. However, the Wells at Chandipur have relatively higher electrical conductivity and matching higher Total Dissolved Solid Content. The Piezometer monitored at Kasafal have anomalous higher EC & TDS, implying saline water formation being tapped. Some of the wells monitored in Nilgiri & Soro Blocks have marginally higher fluoride content as well. Collation of chemical analysis data from RWS&S, Govt, of Odisha reveals that some wells in the blocks of Balasore, Bahanaga, Bhograi, Jaleswar, Oupada, Simulia & Remuna have relatively higher iron content as well.

6. Data Integration & Aquifer Mapping

During the course of National Aquifer Mapping & Management, all the historical data available with the Central Ground Water Board, South Eastern Region, in terms of Ground Water Regime Monitoring, Ground Water Exploration, Systematic Surveys, Ground Water Reappraisal Surveys, Ground Water Management Studies, Special Studies etc were compiled and collated. Available data was compared with the mandated data requirement to identify the data gaps.

Data available from other agencies like Directorate of Ground Water Development, Rural Water Supply & Sanitation, Public Health Engineering Department, Soil Conservation Directorate, Directorate of Minor Irrigation, Department of Water Resources, Office of the Special Relief Commissioner, Department of Agriculture & Food Production, Directorate of Livestock & Animal Husbandry, India Meteorological Department were compiled to check for any further data gaps.

The data so obtained was converted into digital form with geographic attributes to transform it into a GIS compatible database, using Survey of India 1: 50,000 Scale Toposheets as base maps for the same.

Available published data from National Remote Sensing Agencies, Odisha Space Application Centre too were utilized to digitize these data into different thematic layers for preparation of various thematic maps and using it for block wise analysis of the collated data both in spatial & time domain within statistically significant 2σ limit(95% Confidence limit).

6.1 Aquifer Characteristics : The hard rock areas of the district are mainly confined in Nilgiri block , north-western part of Remuna block, and parts of Oupada Block. These areas are characterized by the presence of Granites, Granite Gneiss, Pegmatite, Basic and Ultrabasic Intrusive. Often the top of these formations are weathered and capped with a lateritic layer over the relatively fresh country rocks. These Pre-Cambrian crystalline formations are hard, compact and does not have primary porosity and hence impermeable. Weathering, jointing and fracturing induces secondary porosity. Ground water occurs under phreatic/ unconfined condition in weathered residuum from which water moves downward through joints, fractures etc. Ground water occurs in semi-confined to confined conditions in such deep fracture zones. The depth of weathering varies from as low as 5 metres below ground level to as high as 45 metres below ground level. The top weathered zone is generally tapped by a medium to large diameter dug well(2 – 5 m diameter).

In the rest part of the district, above the basement granite gneisses lies a thick pile of sediments of Tertiary and Quarternary age. Tertiary sediments are represented by Calcareous or Carbonaceous deposits of Marl, Limestone and medium to fine grained silts and clays. Most of these finer sediments are brownish in colour representing oxidative provenance or terrestrial origin.

The Quaternary formations are represented by Sand, Silt and clay of various proportions, deposited in both fluvial as well as marine environments. The interfingering of fluviatile and marine origin can be attributed to numerous paleo-episodes of transgression and regression events giving rise to a complex pattern of fresh and saline formation water in the sub-surface disposition of aquifers. These are overlain by the recent sand dunes of reworked aeolian provenance, which on coalescing gave rise to distinct beach ridge and swale complex in the district, proximal to the Bay of Bengal.

Aquifers in these sediments occur in semi-confined to confined condition. Based on the grain size characteristics these sediments in general have moderate to prolific yields and is much higher than the Pre-Cambrian formations of the north-western part of the district. These are tapped by both dug wells and tube wells

Laterites occurs as capping over the underlain weathered hard rock as well as over the unconsolidated formations. They are mostly tapped by dug wells and in general have poor yields.

6.2 Aquifer 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 three types of aquifers can be demarcated and the details are given below:

6.2.1 Aquifer – I : These are the unconfined aquifer comprising the top weathered and phreatic aquifer and occurring upto a depth of 50 metres below ground level.

6.2.2 Aquifer – II : These are semi-confined to confined aquifers which are represented as fractured aquifers in the Consolidated formation in the north western part of the district and as porous and pervious zones in the unconsolidated sedimentary formations in the rest of the district. These aquifers are presumably classified to occur between the depth range of 50 – 150 metres below ground level.

6.2.3 Aquifer – III : These are confined aquifers occurring in the depth range of 150 – 300 metres below ground level. They are more pronounced in the eastern part of the district with thick pile of sediments.

In general, the sediment thickness increases remarkably from the north-western part to the eastern and south eastern part. The depth to basement map of the district is shown below :

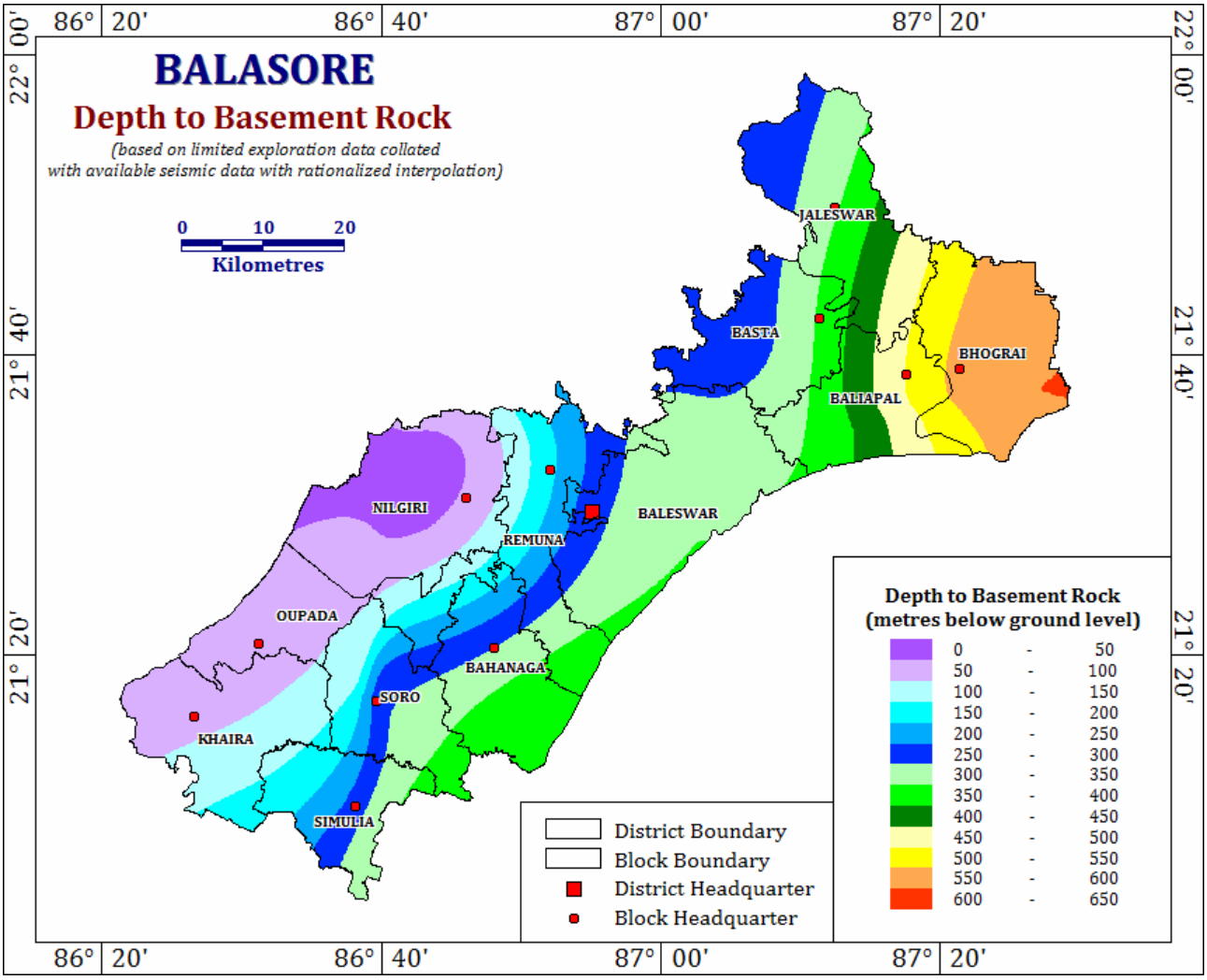


Figure – 6.2 : Depth to Basement Rock in Balasore District, Odisha

6.3 Aquifer Disposition : Based on the Historical Ground Water Exploration Data of CGWB, available ground water exploration data from other line departments and agencies, the aquifer disposition of the district is derived. The same are shown below :

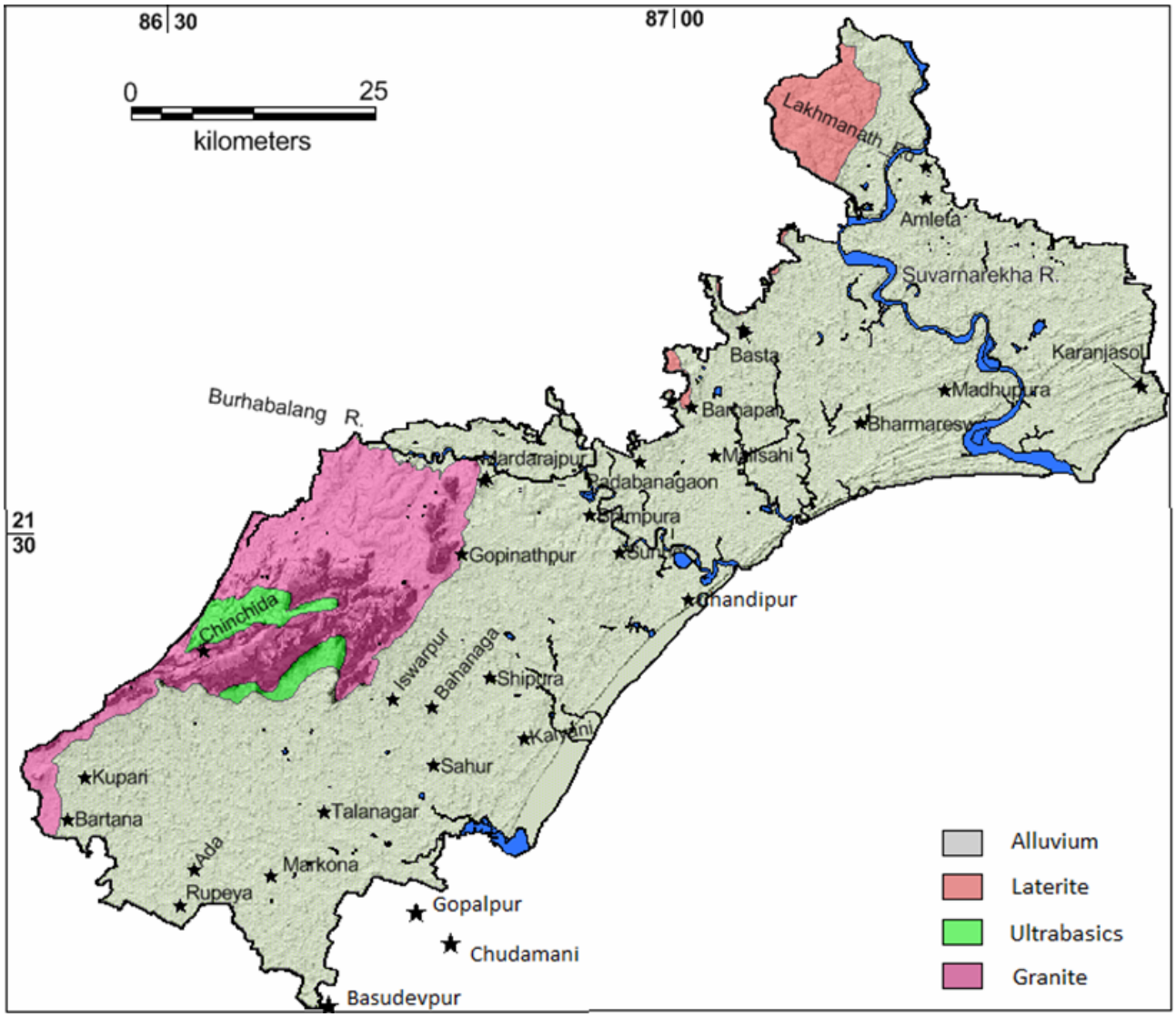


Figure – 6.3 a : Exploration Data Considered for Preparation of 3D Aquifer Map

Though a number of wells have been constructed in all the formations and aquifers of Balasore District, but for preparation of 3D Aquifer Map, about 64 exploratory wells, constructed by Central ground Water Board have been considered. The rest of the wells of CGWB as well as that from the other agencies were utilized for validating this 3D Aquifer Map. This was done to ensure uniformity of formation wise and aquifer wise characteristics for meaningful and rational correlation in demarcation and classification of the relevant aquifer groups along with their chemical signature and aquifer parameter characterization.

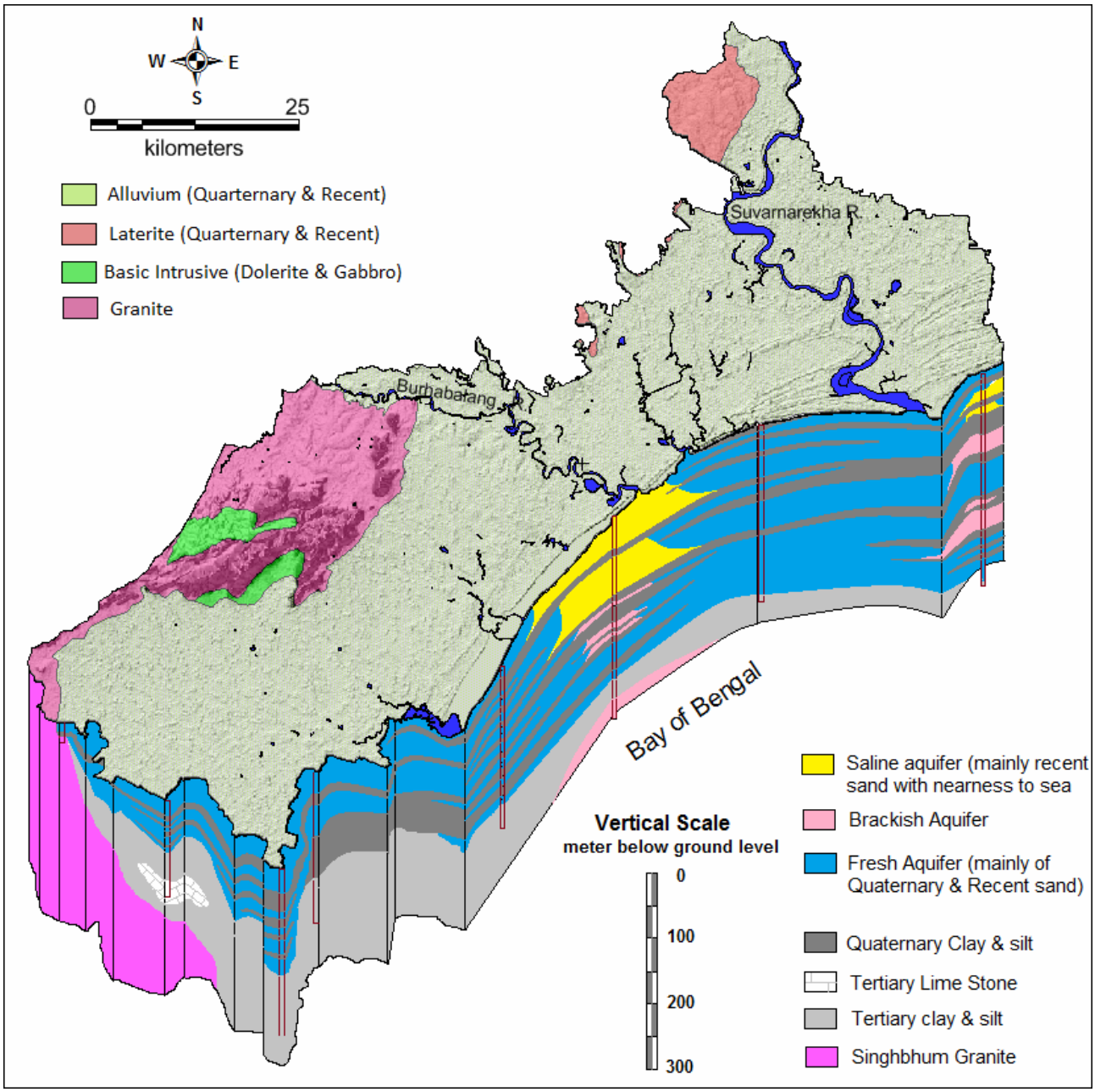


Figure – 6.3 b : 3D Disposition of the Aquifer System of Balasore District, Odisha

The 3D Disposition of the Aquifer System Map of Balasore District clearly depicts a 3 layered aquifer system in the area. In the north western part, the basement is that of the Basement Granite Gneisses which are intruded by the Basic and Ultrabasic intrusives. This basement layer dips towards Southerly and south easterly to give rise to a significantly huge and thick pile of sediments of more than 650 metres in the eastern and south eastern part of the district. Just above this basement there are presence of carbonaceous Tertiary sediments, which are overlain by a sediment pile of fluviatile and marine provenance. There is also a

lateritic capping over both the weathered residuum as well as over the Older Quarternary sediments.

Quality wise also there is clear picture that there exists potentially vulnerable zones in the south eastern and eastern part of the district, bordering the Bay of Bengal at Chandipur and at Karnajiasul area. Different Aquifer section, elucidating the 3D Aquifer map is shown subsequently.

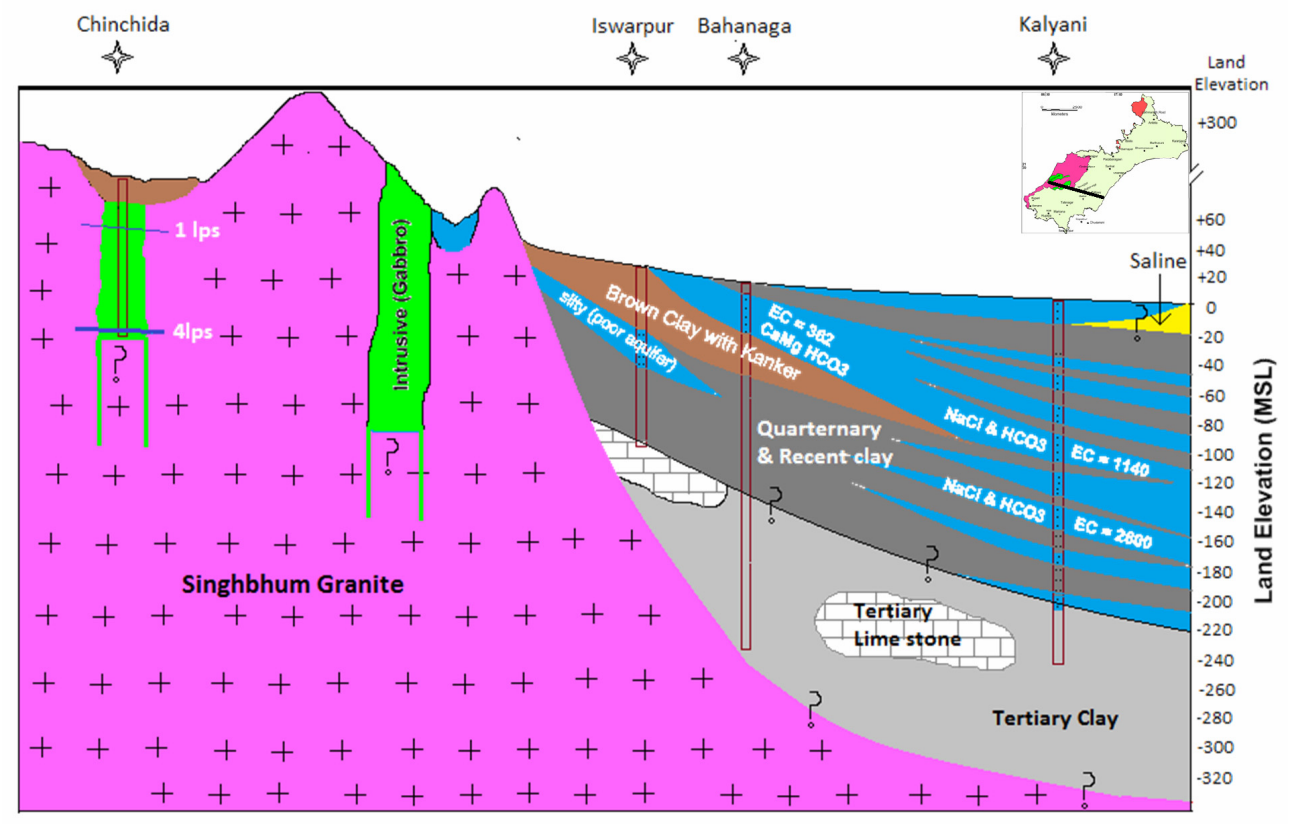


Figure – 6.3 c : Aquifer Section along Chinchida – Kalyani Sector

This is a northwest – southeast trending section in the western half of the district. It clearly shows that the western part is underlain by the basement granite gneisses, intruded by the basic and ultrabasic intrusives and dipping south-easterly. This is immediately overlain by a Tertiary Clay and Carbonaceous sediments and further overlain by an interlayering sand and clay beds of Quaternary Age. Aquifers in the sediments are limited predominantly within these Quaternary sediments. With depth the water quality is turning brackish and mainly of

Sodium Bi-Carbonate type of water. The top aquifer is already infested with the presence of saline water near the coastal part.

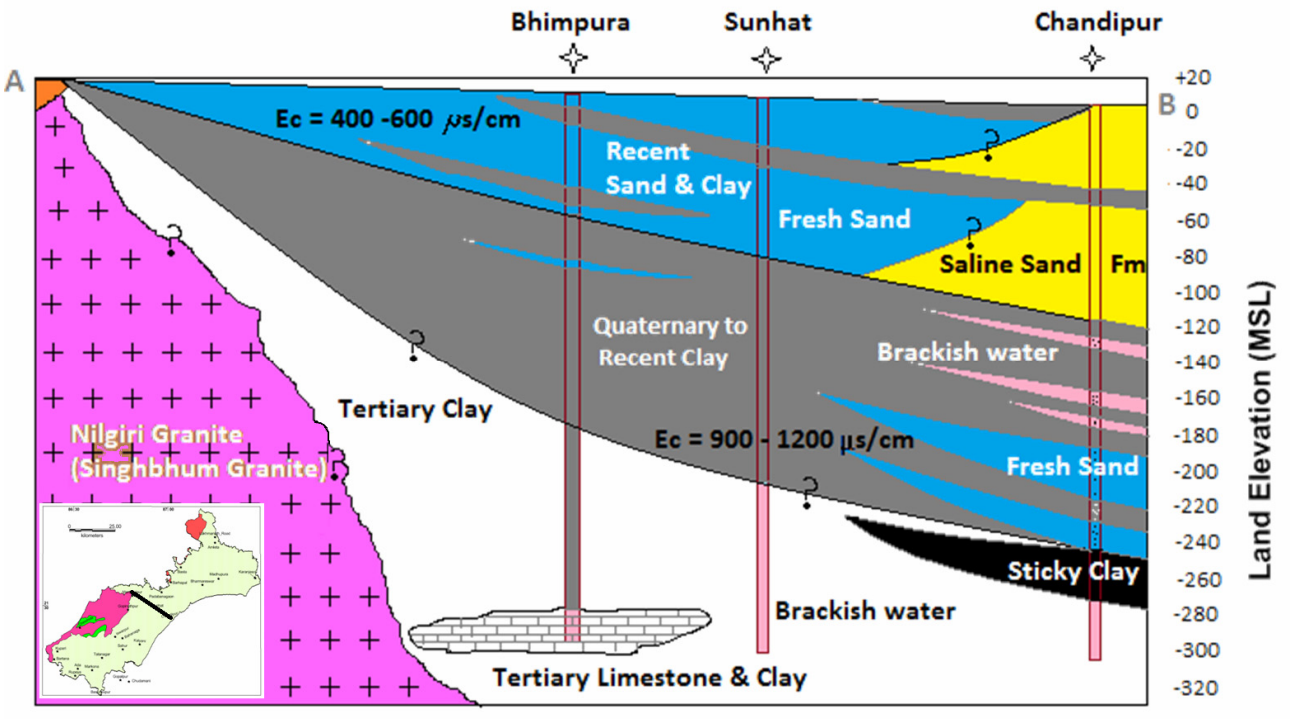


Figure – 6.3 d : Aquifer Section along Mitrapur – Chandipur Sector

This is again another northwest – southeast trending section passing through Mitrapur area of Remuna Blocks and Chandipur Area in Balasore Block. The western part of the area has got lateritic capping on the top, developed over the Nilgiri Granites and Granite Gneisses. These are again overlain by the Tertiary Clay and Carbonaceous sediments, which is represented in form of limestone encountered in one of the tube wells at Bhimpura. Away from the coast of Bay of Bengal, in this sector, there exists only two aquifers – I & II, which are extremely fresh, having electrical conductivity within 400 – 600 µS/cm. Towards the coastal part, though all the three aquifer system can be deciphered, but the top two aquifers are saline. Fresh water aquifers near the coastal part at Chandipur can be detected within a depth range of 190 – 250 metres below ground level. In the area in between, the extremities, the fresh water is restricted mostly within 60 – 80 metres below ground level and only two aquifers can be detected, which are underlain by a thick pile of Quaternary Clay beds.

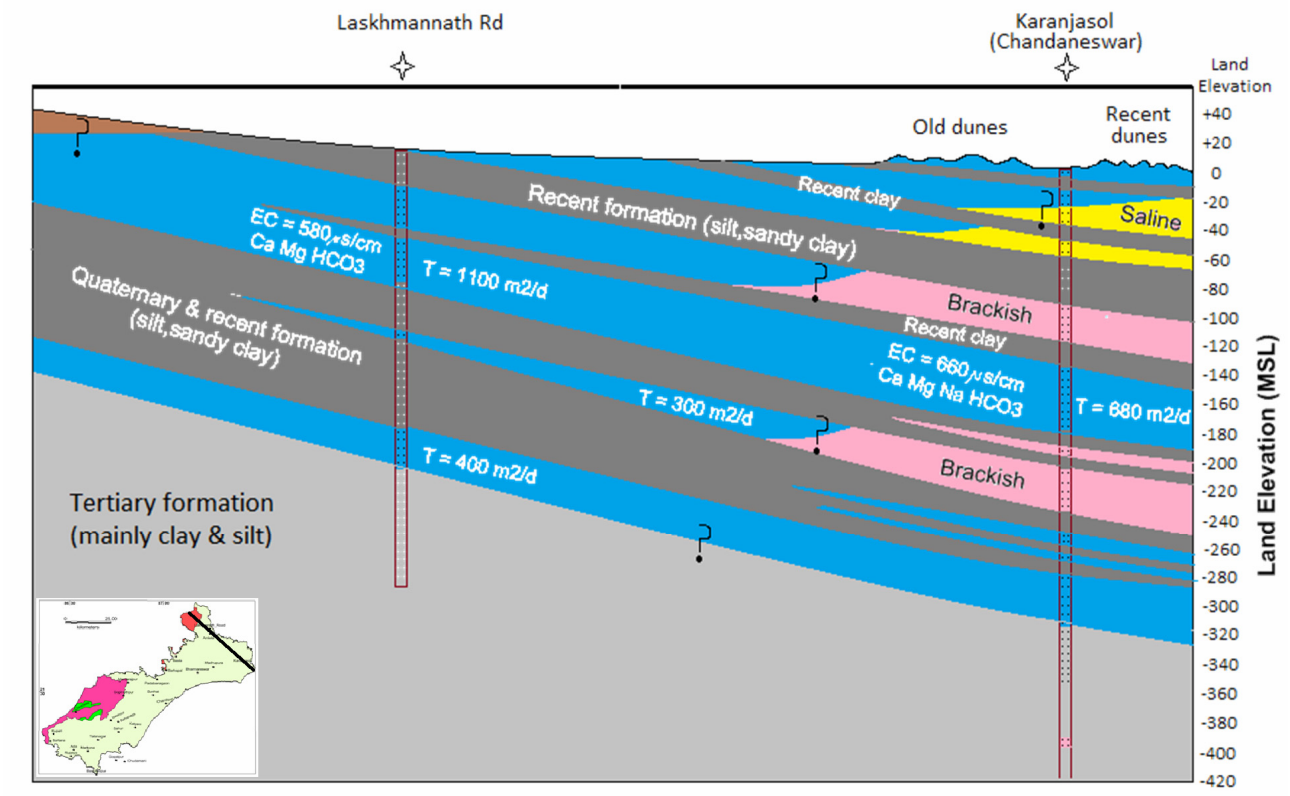


Figure – 6.3 e : Aquifer Section along Lakshmannath – Karanjiasol Sector

This is yet another northwest-southeast trending aquifer section passing through Jaleswar and Bhograi Blocks in the extreme eastern part of the district. Here the top most part is that of lateritic capping over the Recent fluvial alluvium. In the extreme north-eastern part aquifer system I & III are present. There is no aquifer system – II as per the NAQUIM demarcation. These two aquifers are separated by a thick deposit of Quaternary Silt and sandy clay. The first aquifer dips and branches out to give rise to aquifer – II near the coastal part near Karanjiasol. The aquifer is of prolific nature having transmissivity values as high as 1100m^2/day which reduces somewhat to around 880m^2/day, as the coastal proximity is reached. In the near vicinity of the coast only the sparse dune aquifer is fresh, which is used by the local population for domestic and drinking water purpose. Rest upto 150 metres, the aquifer is saline followed by brackish quality. Te aquifer – III is fresh upto 190 metres , beyond which it turns brackish and then again fresh from 265 to 300 metres. These brackishness and salinity continues inwards till the end of the old dune footprints.

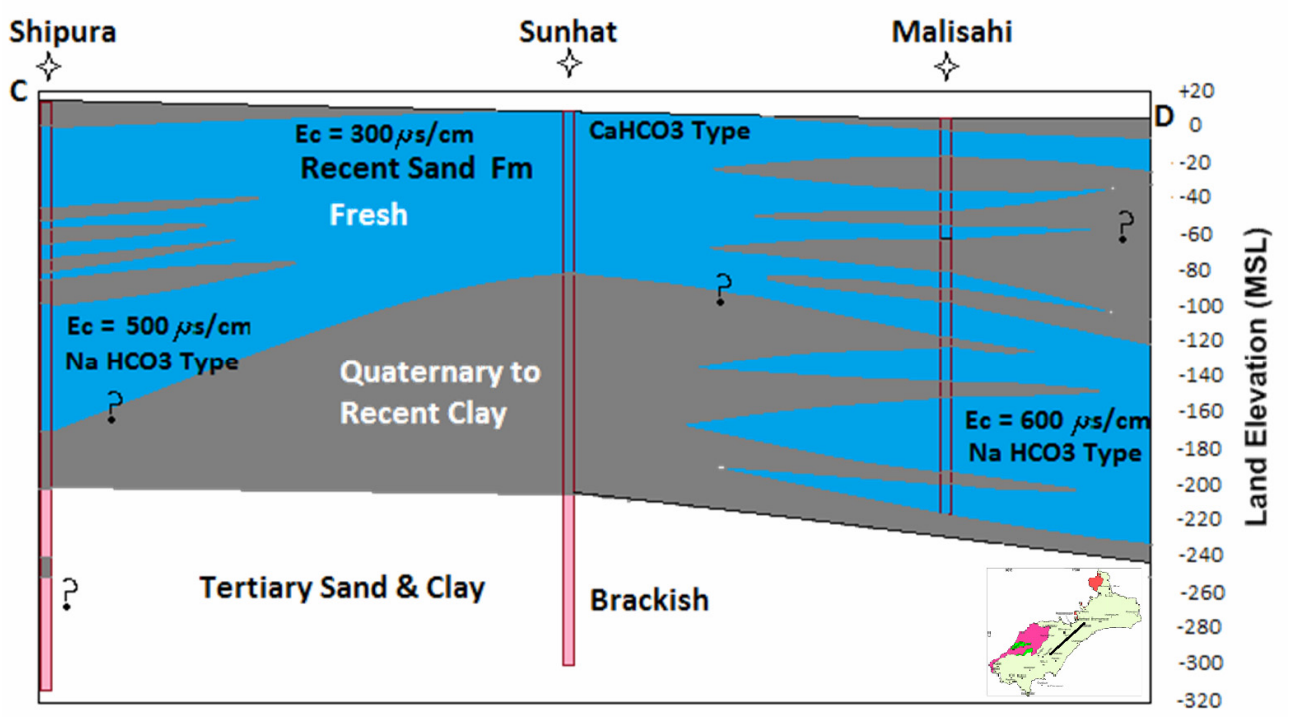


Figure – 6.3 f: Aquifer Section along Shipura – Malisahi Sector

This is a southwest-northeast trending section in the mid-central part of the district initiating from Shipura in the west and ending at Malisahi in the east, This sector is remarkably devoid of any significant phreatic aquifer. In the central part of this section, is a domal divide of Quaternary clay beds underlain by the Tertiary Sand and Clays which are of brackish nature. Above this clay layer is a thin veneer of top fresh aquifer which gets branched out in the fringes to form the aquifer – II. In a nutshell therefore, both these aquifers are fresh with Sodium Bicarbonate type of water having electrical conductivity in the range of 500 µS/cm. The top part of this aquifer is mainly formed from the recent sands of fluvial and aeolian origin having Calcium Bicarbonate type of water and electrical conductivity in the range of 300 µS/cm. The yield is somewhat low in the middle portion than compared to the fringes.

6.4 Aquifer parameters : The data from the ground water exploration was collected and collated to derive at the formation wise characteristics of aquifers in Balasore District.

6.4.1 Unconsolidated Formation(Phreatic) : This formation is tapped by dug wells, which are capable of sustained ground water withdrawal for 2 – 5 hours with and average yield of around 3 – 7m^3/hour. The depth of drilling varied from as low as 37 metres below ground level to as deep as 201 metres below ground level. Similarly the discharge in these wells varies from as low as negligible to as high as 25 litres per second in Siadimal. The static water levels remained within the range of 3 – 10 metres below ground level with an average of around 5 -7 metres below ground level. The drawdowns are mostly restricted within 18 – 25 metres with some minor anomalous exceptions. The transmissivity values too varied widely from as low as 2 m^2/day to a maximum of 65 m^2/day.

6.4.2 Consolidated Formation : The granite gneisses are well foliated, jointed and weathered easily. The depth of weathering expands down to a depth of 15 meters. In exceptional cases e.g. at Nilgiri it was 42.5 mbgl. This weathered zone forms the main repository of ground water in hard rock areas and is tapped by dug wells. The yield of dug wells range from 6 to 10m^3/ day. As the area has undergone several phases of tectonic deformations deep-seated fractures are developed which form a conduit for downward percolation of ground water and form aquifers in deeper conditions. These deeper fractures are generally encountered in bore wells. Deeper fractures are tapped by bore wells in Nilgiri, Oupada and Simulia blocks. Aquifers parameters of granite gneisses are as below -

Table – 6.4.2 : Aquifer parameters of Consolidated formations

Parameters	Shallow Aquifers	Deeper Aquifers
Yield	6-10 m^3/day	1-8 lps
Specific Capacity	0.0009–0.034 m^3/min/m	------
Transmissivity	5-36 m^2/day	12-36 m^2/day

6.4.3 Unconsolidated Formation(Semi-Confined & Confined) : The Tertiary, older and younger alluviums constitute the sedimentary formations. These are unconsolidated formations. The sands and gravels are porous and permeable and form the repository of ground water. Finer clastics progressively dominate towards the coast. Extensive shallow aquifers exist in the alluvium within the depth range of 25 to 60 meters with a cumulative thickness of aquifers varying from 10 to 25 meters. These aquifers are tapped by dug wells, shallow and filter point tube wells. The yield of the dug wells varies from 50 to 100 m^3/day and of shallow tube wells vary from 5 to 25 l p s. Besides the shallow aquifers, deeper aquifers are also encountered down to a depth of 300 meters. Along the saline tract, the fresh aquifers lie within the depth range of 130 to 300 meters besides the occasional top fresh aquifers within 20 to 25 m depth. The yield of the deep tube wells vary from 15 to 40 lps in the saline tract as well as in Tertiary, older alluvial areas and more than 40 lps in inland alluvium formations areas. Due to extensive development since 1985 through construction of shallow tube wells, the shallow aquifers at places in Bhograi and Jaleswar blocks shows ground water decline in summer months (February to May). In such formations (unconsolidated alluvial and Tertiary) ground water occurs under unconfined condition in the shallow aquifers and under semi confined to confined conditions in deeper aquifers. As stated above shallow aquifers exist between 25 to 30 m depth yields 5 to 25 l p s water though shallow tube wells. Transmissivity and Storativity of these shallow to medium deep aquifers vary from 122.1 to 3415 ^{2}/day and 9.3 x 10^{-2} to 2.9 x 10^{-4} respectively. Yield of deep tube wells (constructed down to 300 m b g l depths) vary from 5 to 66 l p s with an average of 40 l p s. A summarized data of aquifers parameters of alluvial formations are as below-

Table – 6.4.3 : Aquifer parameters of Alluvial formations

Parameters	Shallow Aquifers		Deeper Aquifers	Deeper aquifer in Saline tract
Structures	Dug Wells	Shallow Tube Wells	Deep tube wells	Deep tube wells
Depth Range	8-12 m	25-60 m	300 m	Top fresh 20-25 m & 130-300 m
Yield	50 -100 m^3/day	5 to 25 lps	5 to 66 or Avg > 40 lps	15 to 40 lps
Transmissivity	-	122.1-3415 ^{2}/day		
Storativity	-	9.3 x 10^{-2} to 2.9 x 10^{-4}		

6.4.4 Semi-Consolidated Formation(Laterites) : Laterites occur as capping over the weathered crystalline and Tertiary formations in the west and north western part of the district. Being porous and highly permeable in nature it also forms prolific aquifers which support a large number of domestic dug wells. The thickness of Laterites varies from 5 to 15 m. The yield of dug wells in such formations ranges from 30 to 50 m^3/ day. The Specific Capacity and Transmissivity of lateritic aquifers vary from 0.0012 to 0.20 m^3 /min/m and 2.8 m^2 /day to 490.22 m^2 /day.

6.5 Distribution of Saline/fresh water aquifers: The occurrence of fresh water aquifers in coastal tract of Balasore restricted by two important factors-(i) Occurrence of hard rocks in the western side and (ii) Salinity hazard problems in the eastern part. In the narrow tract, close to the coast line extending right from Chandaneswar in the North to Bahanga/ Simulia in the south in the district, salinity problem occurs where both the saline water bearing and fresh water bearing aquifers occurs at different depths. The depth of occurrence of saline water bearing aquifers is not uniform along the entire tract. The study of lithological logs and electrical logs of boreholes and results of zone tests etc. indicate occurrence of saline water either above or below fresh water bearing aquifers and also both above and below the fresh water aquifers,

The width of the coastal saline tract is generally ranging from 4 to 5 km running from Bahanaga to Baliapal block near Subranarekha river, where from towards further north east it encroaches further inland ward and in Bhograi block its width generally range from 5 to 10 km . In general the top aquifers up to 150 meter are saline. However, during the detailed studies in the area, it is observed that up to the depth range of 25 to 30m, fresh aquifers are occurring having a thickness of 5 to 15 meters, which are tapped by shallow tube wells. Below 150m the aquifers are fresh up to 220m below which up to 250m below ground level the aquifers are saline.

The salinity hazards occur in a narrow tract along the eastern margin adjoining the sea coast and in the rest part of coastal alluvium fresh water occurs all through down to the bed rock. Disposition of fresh and saline water in district is shown as Map No-3.The occurrence of aquifers and its yield potential etc. are described below.

6.5.1 Non-saline area: The depth of the bore holes varied from 103m to 330 and the depth of the tube wells varied from 96 to 208m. The bed rocks were encountered at Hanspatna (110m) and at Soro (295m).

In the Jaleswar-Basta-Baliapal-Remuna-Balasore tract a group of aquifers usually varies in thickness from 3 to 15m, attains a maximum cumulative thickness of around 40 to 50m. The yield varies from 20 to 66 Ips against the drawdown of pumping water level varying between 5.83 to 15 60m. The static water levels vary from 2.13 to 10.68m bgl. The discharge in general is less in the southern part of this tract.

In the area around Soro and Markona a group of aquifers consisting fine to coarse sands which generally occur below 46m depth attains a cumulative thickness of about 125m and the thickness of aquifers dwindles towards west. The discharge is generally low and varies between 11 to 24 Ips against the draw down more than 15m.

In and around Gopalpur of Bahanaga block aquifers are thin and mixed with finer materials and are low yielding. Also in Kasbajaypur-Bahanga area the formation are predominantly argillaceous in nature and sand horizon are lesser. The yield generally varies between 20 to 30 lps against the draw down around 20m. In this area auto flowing condition occurs from deeper aquifer blow 200m depths at Soud.

In general in the northern part (north of Balasore town) thickness of aquifers as well as yield is more in comparison to southern part of the district (south of Balasore town).

6.5.2 Saline Hazard Area: The saline hazard area occurs as a narrow elongated tract along the eastern margin of the district, bordering the Bay of Bengal in the east. The salinity problem is conspicuous along Karanjasual / Chandaneswar to Chandipur section. In this section fresh water bearing aquifers are sandwiched between top and bottom saline zones and the bottom saline zone extends down to 600m depth. The top saline aquifers (barring few meters at top, average 10 to 12m, maximum around 30m is fresh) in Karanjasul-Cahndaneswar-Narayan Mohanty Poria area extends down to 70m depth and in Chandipur it extends down to 150m depth. Below this saline water zone fresh water zone occurs and

extend down to 300/350m depth in Karanjasole- Narayan Mohanty Poria area and at Chandipur fresh zone extends down to 250m depth. The fresh aquifers attain considerable cumulative thickness in Karanasul-Narayan Mohanty Poria area while it is thin in Chandipur area. Similarly the yield in Karanjasul area is very high (>60lps) and is very low (10 to 15lps) at Chandipur. The aquifers at top as well as bottom 50m of fresh water zone occurring between top and bottom saline zone in Karanjasole-Narayan Mohanty Poria area contain water with chloride content up to 350mg/l at places. The chloride content in the middle part of aquifer (fresh zone) is much less than that of the desirable limit (250mg/l) of chloride for drinking water specification, which indicates that the water is very fresh.

The areal extension as well as depth persistence of top saline zone could not be determined further south of Chandipur due to non-existence of exploratory bore hole near the coast and also non availability of any reliable data from any other sources. The nearest bore hole drilled by CGWB (at Kalyani in Bhogaari Block 3km inland from coastline) is 30 km due south of Chandipur. This bore hole was drilled down to 240m depth and entire depth of bore hole was found to be fresh water bearing. From the above it may be concluded that the top saline zone in the south of Chandipur may have either disappeared towards south or it occurs by occupying very thin width just along the coast line and this could not be confirmed due to lack of bore hole data.

The width of the above mentioned saline area is around 10 to 12km in the extreme north eastern part of the district in Karanjasul area and it is around 6 to 7km in Chandipur area. Beyond Chandipur in the south it appears that the

width has become less than 3km or the saline zone is altogether absent. Though the salinity problem occurs along a narrow tract in Balasore district but occurrence of saline and brackish water has also been noted at different depth that isolated pockets occurring further inland. At Dhansimulia (near Jaleswar) brackwish water encountered between 109 to 190 m depth followed by saline water down to 251m depth. At Basta brackish to fresh water (chloride content 300mg/l) encountered below 100m depth at isolated pockets. At Brahmapur-Pokarisahi (south of Rupsa) area brackish to fresh water (chloride 300 to 350mg/l) encountered at pockets. At Sunhat in Balasore town (eastern part) brackish to fresh water encountered below 214m depth.

The blocks which are mainly affected by salinity problem are Bhogarai and Baliapal in the north, Bahanga in the south and Balasore and Remuna in between.

The yield from deeper fresh water zone varies widely from north to south due to variation in thickness of aquifers zones. Prominence of argillaceous materials are noted in the middle and southern part i.e. Chandipur and area lying south of Chandipur. The yield in extreme northeast (Karanjasul-Chandaneswar-Narayan Mohanty Poria) is more than 50lps against a drawdown of 8 to 9m, in Baliapal block it is around 30 to 40 lps against 10 to 12m drawdown and in Chandipur and beyond Chandipur,(due south), it varies from 12 and 25lps against draw downs varying between 15 and 25m.

The thickness of very top fresh water zone within saline hazard area, varies from negligible to a maximum of around 30m and thickness depends upon the

local geological formations. Thick and horizontally extensive palaeo and recent sand dunes always form shallow aquifer down to 30m depth fresh water zones. The yield from this top zone varies from 5 to 10 lps.

6.5.3 Auto flow: At places auto flowing situations are observed in the deeper confined aquifers. At Soud (Bahanaga block) the piezometers tapping the aquifers at 211 m to 217 m below ground level, is exhibiting auto flowing situation/ where the piezometric head is observed at 1.50m above ground level.

7. Ground Water Resources

7.1 Dynamic Ground Water Resources : Dynamic Ground Water Resources for the Entire District have been calculated block wise, following the Ground Water Resource Estimation Committee(GEC – 1997) guidelines on and from 1999 to 2013, till date. As per the latest assessment of dynamic ground water resources of 2013(31.03.2013) the current blockwise dynamic resource figures are shown below :

Table – 7.1a : Dynamic Ground Water Resources of Balasore District, Odisha(As on 31.03.2013)

Sl No	Block	Command / Non-Command / Total	Total Annual Ground Water Recharge (HM)	Net Annual Ground Water Availability	Existing Gross Ground Water Draft for Irrigation	Existing Gross Ground Water Draft for domestic & Industrial Supply	Existing Gross Ground Water Draft for all uses	Provision for domestic & industrial requirement supply for next 25 years	Net Ground Water Availability for future irrigation development	Stage of Ground Water Development
			(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(%)
1	Bahanaga	Command Area	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Non-Command Area	9704.00	9219.00	5696.46	294.54	5991.00	458.00	3064.54	64.99
		Total	**9704.00**	**9219.00**	**5696.46**	**294.54**	**5991.00**	**458.00**	**3064.54**	**64.99**
2	Balasore	Command Area	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Non-Command Area	8933.00	8486.00	3986.46	450.36	4436.82	1223.00	3276.54	52.28
		Total	**8933.00**	**8486.00**	**3986.46**	**450.36**	**4436.82**	**1223.00**	**3276.54**	**52.28**
3	Baliapal	Command Area	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Non-Command Area	4923.00	4677.00	3008.62	176.22	3184.84	705.00	963.38	68.10
		Total	**4923.00**	**4677.00**	**3008.62**	**176.22**	**3184.84**	**705.00**	**963.38**	**68.10**
4	Basta	Command Area	2775.00	2497.00	1085.11	73.98	1159.09	92.48	1319.41	46.42
		Non-Command Area	9273.00	8809.00	4329.05	312.90	4641.95	544.00	3935.95	52.70
		Total	**12048.00**	**11306.00**	**5414.16**	**386.88**	**5801.04**	**636.48**	**5255.36**	**51.31**
5	Bhograi	Command Area	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Non-Command Area	6109.00	5804.00	3694.76	296.64	3991.40	959.00	1150.24	68.77
		Total	**6109.00**	**5804.00**	**3694.76**	**296.64**	**3991.40**	**959.00**	**1150.24**	**68.77**
6	Jaleswar	Command Area	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Non-Command Area	12959.00	12311.00	7182.01	485.82	7667.83	733.00	4395.99	62.28
		Total	**12959.00**	**12311.00**	**7182.01**	**485.82**	**7667.83**	**733.00**	**4395.99**	**62.28**
7	Khaira	Command Area	4787.00	4308.00	1886.89	121.56	2008.45	151.95	2269.16	46.62
		Non-Command Area	9413.00	8942.00	4726.29	294.00	5020.29	534.00	3681.71	56.14
		Total	**14200.00**	**13250.00**	**6613.18**	**415.56**	**7028.74**	**685.95**	**5950.87**	**53.05**
8	Nilgiri	Command Area	2036.00	1832.00	217.37	58.14	275.51	72.68	1541.95	15.04
		Non-Command Area	6815.00	6474.00	2162.42	254.64	2417.06	440.00	3871.58	37.33
		Total	**8851.00**	**8306.00**	**2379.79**	**312.78**	**2692.57**	**512.68**	**5413.53**	**32.42**
9	Oupada	Command Area	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Non-Command Area	8485.00	8061.00	2713.33	175.62	2888.95	265.00	5082.67	35.84
		Total	**8485.00**	**8061.00**	**2713.33**	**175.62**	**2888.95**	**265.00**	**5082.67**	**35.84**
10	Remuna	Command Area	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Non-Command Area	10763.00	10225.00	3695.33	2465.97	6161.30	2835.87	3693.80	60.26
		Total	**10763.00**	**10225.00**	**3695.33**	**2465.97**	**6161.30**	**2835.87**	**3693.80**	**60.26**
11	Simulia	Command Area	8669.00	8236.00	2198.79	154.02	2352.81	256.00	5781.21	28.57
		Non-Command Area	1978.00	1780.00	1092.05	108.78	1200.83	142.00	545.95	67.46
		Total	**10647.00**	**10016.00**	**3290.84**	**262.80**	**3553.64**	**398.00**	**6327.16**	**35.48**
12	Soro	Command Area	352.00	317.00	144.41	46.68	191.09	103.08	69.51	60.28
		Non-Command Area	8511.00	8085.00	4736.88	325.02	5061.90	557.00	2791.12	62.61
		Total	**8863.00**	**8402.00**	**4881.29**	**371.70**	**5252.99**	**660.08**	**2860.63**	**62.52**
	District Total	Command Area	18619.00	17190.00	5532.57	454.38	5986.95	676.19	10981.24	34.83
		Non-Command Area	97866.00	92873.00	47023.66	5640.51	52664.17	9395.87	36453.47	56.71
		Total	**116485.00**	**110063.00**	**52556.23**	**6094.89**	**58651.12**	**10072.06**	**47434.71**	**53.29**

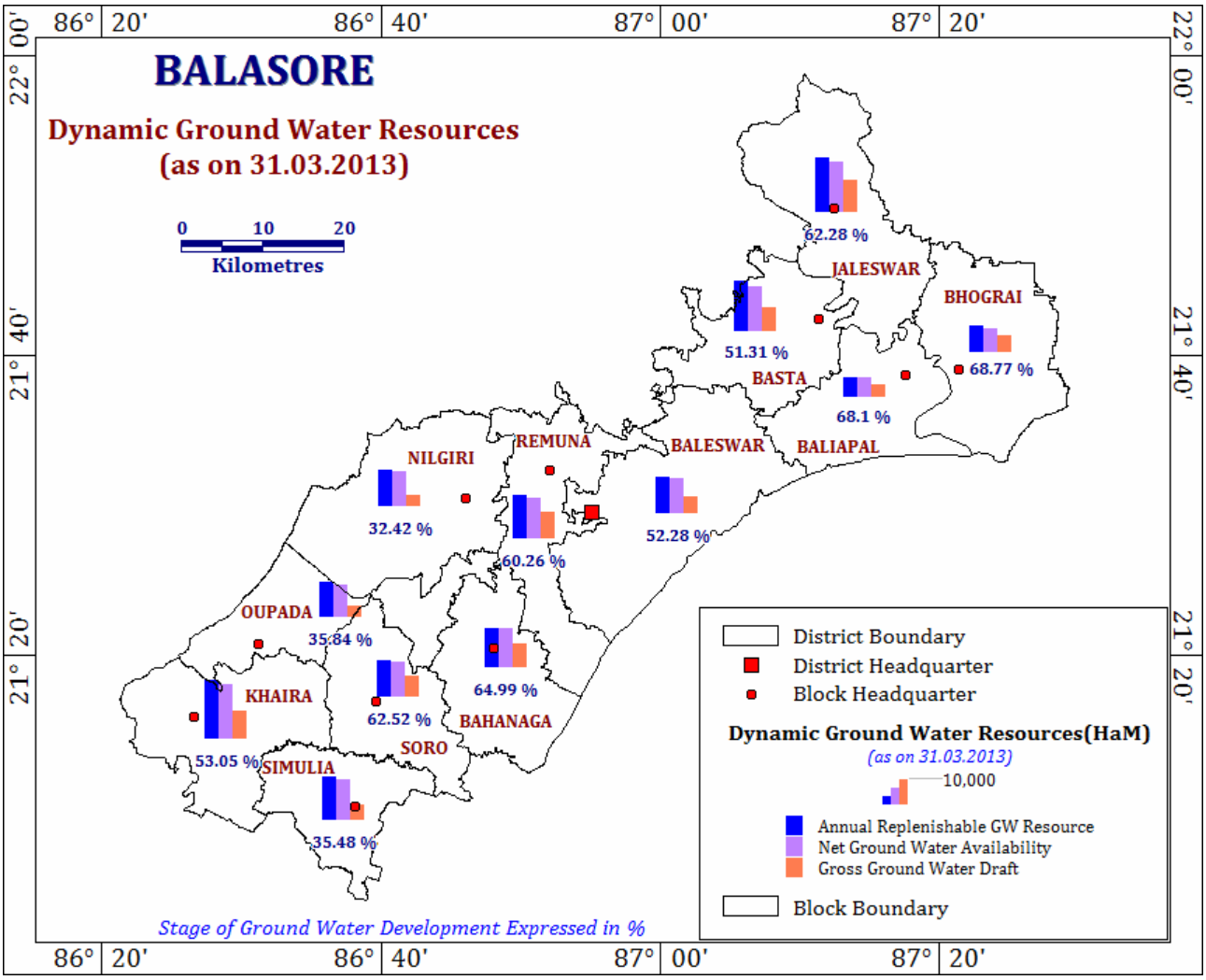


Figure – 7.1 a: Block Wise Dynamic Ground Water Resources, Balasore District, Odisha

Table – 7.1 b: Trend of Ground Water Development in Balasore District, Odisha

Parameters	1999	2004	2009	2011	2013
Net Ground Water Availability (HaM)	99888	99882	110063.00	110063.00	110063.00
Gross Ground Water Draft (HaM)	41804	47404	53471.00	57937.28	58651.12
Stage of Ground Water Development (%)	**41.85**	**47.46**	**48.58**	**52.64**	**53.29**

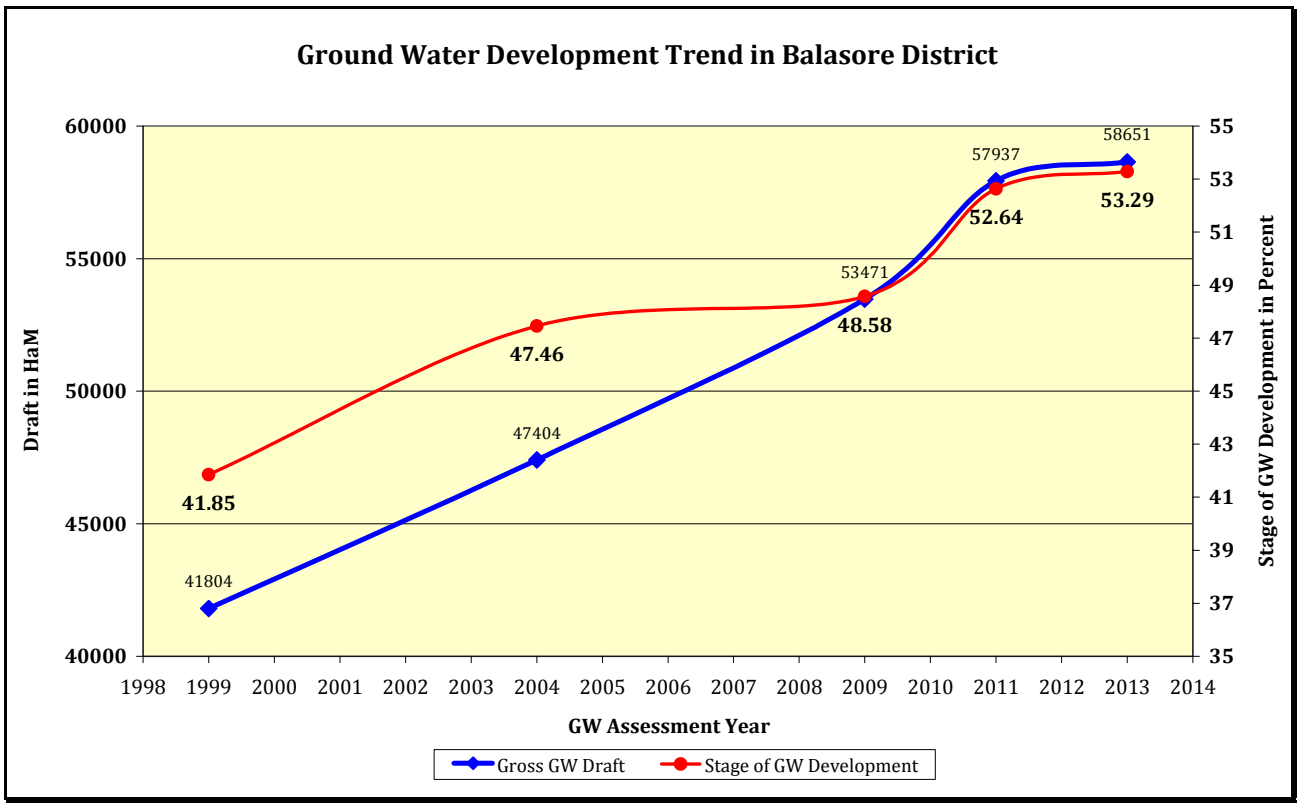
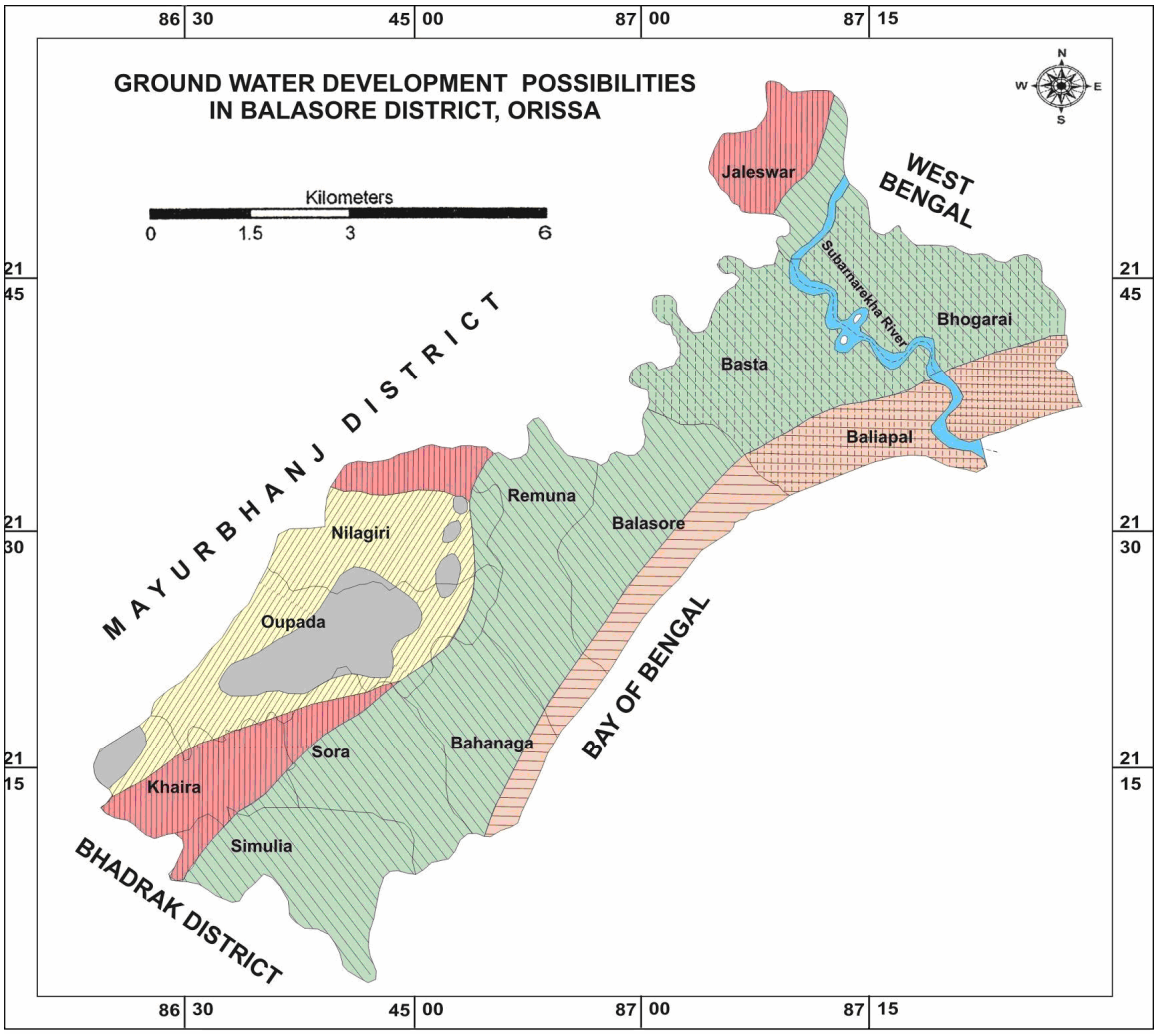


Figure – 7.1 b : Trend of Ground Water Development in Balasore District, Odisha

Pre-Cambrian crystalline rocks occupy a small area of Nilgiri, Oupada and Khaira blocks in the western fringe of the district. The rest of the area in the district is underlain by unconsolidated formations with increasing thickness towards east. Dug wells are feasible in the hard rock terrain and also in the alluvial fringe. The filter point tube wells and shallow tube wells are feasible in the major parts of the district excepting the eastern parts, close to coast where top aquifers are saline in nature. The filter point tube wells are feasible in parts of Jaleswar, Basta, Balasore, Remuna, Bahanaga, and Soro blocks. Among the twelve blocks of the district 6 blocks are affected by salinity problems. Most of the blocks of the district have already high levels of resource utilization. Bhograi is the block with highest ground water utilization of 68.77% in the district. Nilgiri is the block with lowest ground water utilization of 32.42% in the district. Net ground water availability of the district is assessed to be 1,10,063 HM and the gross annual draft for domestic, industrial, and irrigation uses is 58,651.12 HM. The average stage of ground water development in the district is 53.29%. All the 12 blocks have been classified as SAFE.



LEGEND

FEASIBLE STRUCTURE	WELL DESIGN DEPTH(m.)	DIA(m.)	PUMP SPECIFICATION PUMP	H.P.	YIELD
DUG WELL	9 - 12	4.5 - 6	CENTRIFUGAL	1.5 - 2	UPTO 3 L.P.S
BORE WELL	60 - 100	0.15	SUBMERSIBLE	2	< 5 L.P.S
DUG WELL	9 - 12	4.5 - 6	CENTRIFUGAL	1.5 - 2	UPTO 5 L.P.S
SHALLOW & MEDIUM DEEP TUBEWELL	50 - 100	0.15 - 0.203	SUBMERSIBLE	5 - 12.5	15 TO 40 L.P.S
SHALLOW & FILTER POINT TUBEWELLS	25 - 60	0.11 - 0.15	SUBMERSIBLE (CENTRIFUGAL WHERE WELL DENSITY IS LESS)/TURBINE	3 - 8	5 TO 25 L.P.S
MEDIUM & DEEP TUBE WELLS	60 - 100	0.203 - 0.304	SUBMERSIBLE TURBINE	12.5 - 30	25 TO > 40 L.P.S
SHALLOW & FILTER POINT TUBE WELLS	25 - 30	0.11 - 0.15	SUBMERSIBLE	3 - 5	< 15 L.P.S
DEEP TUBE WELLS	130 - 170	0.15 - 0.203	SUBMERSIBLE	5 - 20	15 TO 40 L.P.S

AREAS WITH RAPID GROUND WATER DEVELOPMENT

GROUND WATER DEVELOPMENT POSIBILITIES RESTRICTED
INTERMONTANE VALLEY AREA (YIELD OF BORE WELL < 1 L.P.S.)

HILLS AND FOREST

Figure 7.1 c: Ground Water Development Possibility in Balasore District, Odisha

7.2 In-storage & Total Ground Water Resources : Among the twelve blocks of the district 6 blocks are affected by salinity problems. Most of the blocks of the district have already high levels of resource utilization. The general depth of development of aquifers is upto 100 metres in Hard Rock area and in the alluvial area it is maximum upto the depth of

250 metres. Net annual ground water availability of the district is assessed to be 1,10,063 HM. The fresh in-storage resource in hard rock area is 36,771 HM and the same in alluvial area is 1,52,109 HM, thus the total fresh in storage resource is 1,88,880 HM. The saline in-storage resource in hard rock area is NIL and the same in alluvial area is 26,560 HM, thus the total saline in storage resource is 26,560 HM. Thus the total in storage resource including both the fresh and the saline water for the entire district is 2,15,440 HM. The total Fresh water resource for the entire district combining both the dynamic and the in-storage component is 2,98,943 HM.

Table – 7.2 a : Total In-storage Ground Water Resources of Balasore District, Odisha

Sl No	Assessment Unit - Block	In Storage Ground Water Resources(HaM)						
		Fresh			Brackish / Saline			TOTAL
		Hard Rock	Soft Rock	Total	Hard Rock	Soft Rock	Total	
1	Bahanaga	-	20025	20025	-	477	477	20502
2	Balasore	-	17133	17133	-	13698	13698	30831
3	Baliapal	-	3349	3349	-	5386	5386	8735
4	Basta	-	5567	5567	-	272	272	5839
5	Bhograi	-	5619	5619	-	6356	6356	11975
6	Jaleswar	-	13036	13036	-	0	0	13036
7	Khaira	-	53079	53079	-	0	0	53079
8	Nilgiri	18459	0	18459	0	0	0	18459
9	Oupada	18312	0	18312	0	0	0	18312
10	Remuna	-	8681	8681	-	372	372	9053
11	Simulia	-	10578	10578	-	0	0	10578
12	Soro	-	15042	15042	-	0	0	15042
	District Total	**36771**	**152109**	**188880**	**0**	**26560**	**26560**	**215440**

Table – 7.2 b : Total Fresh In-storage Ground Water Resources of Balasore District, Odisha

Sl No	Assessment Unit (Block)	Net Ground Water Availability	Fresh In Storage Ground Water Resources	Total Availability of Ground Water Resources
		(HaM)	(HaM)	(HaM)
1	Bahanaga	9219	20025	29244
2	Balasore	8486	17133	25619
3	Baliapal	4677	3349	8026
4	Basta	11306	5567	16873
5	Bhograi	5804	5619	11423
6	Jaleswar	12311	13036	25347
7	Khaira	13250	53079	66329
8	Nilgiri	8306	18459	26765
9	Oupada	8061	18312	26373
10	Remuna	10225	8681	18906
11	Simulia	10016	10578	20594
12	Soro	8402	15042	23444
	District Total	**110063**	**188880**	**298943**

8. Ground Water Quality

As already elucidated earlier, the overall ground water quality of the Phreatic Aquifer(Aquifer – I) is potable and fir for both domestic, drinking, irrigation and other Industrial purpose. However, the deeper Aquifer(Both Aquifer II & III) are infested with certain issues and problems, having certain parameters marginally above the BIS standards, in some isolated places.

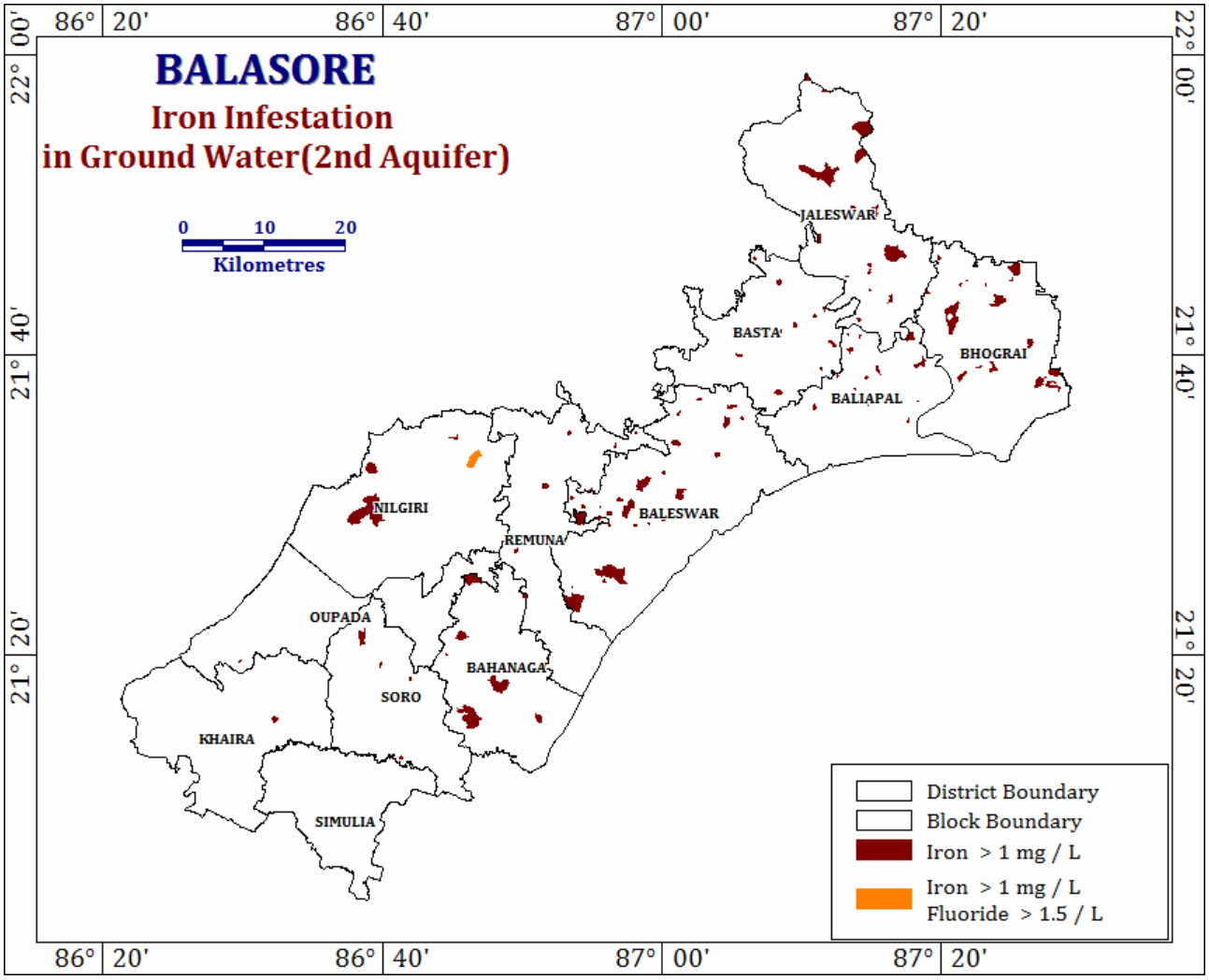


Figure – 8 a : Iron Infestation in Deeper Aquifers(II & III), Balasore District, Odisha

As evident from the perusal of the above map, Iron above the BIS permissible limits of 1 mg/L is found extensively in almost all the blocks in scattered habitations of the District. However, the interesting trend is that these iron infestations are bordering the laterite contact with the older alluvium in most part. Iron occurrence is basically of geogenic nature.

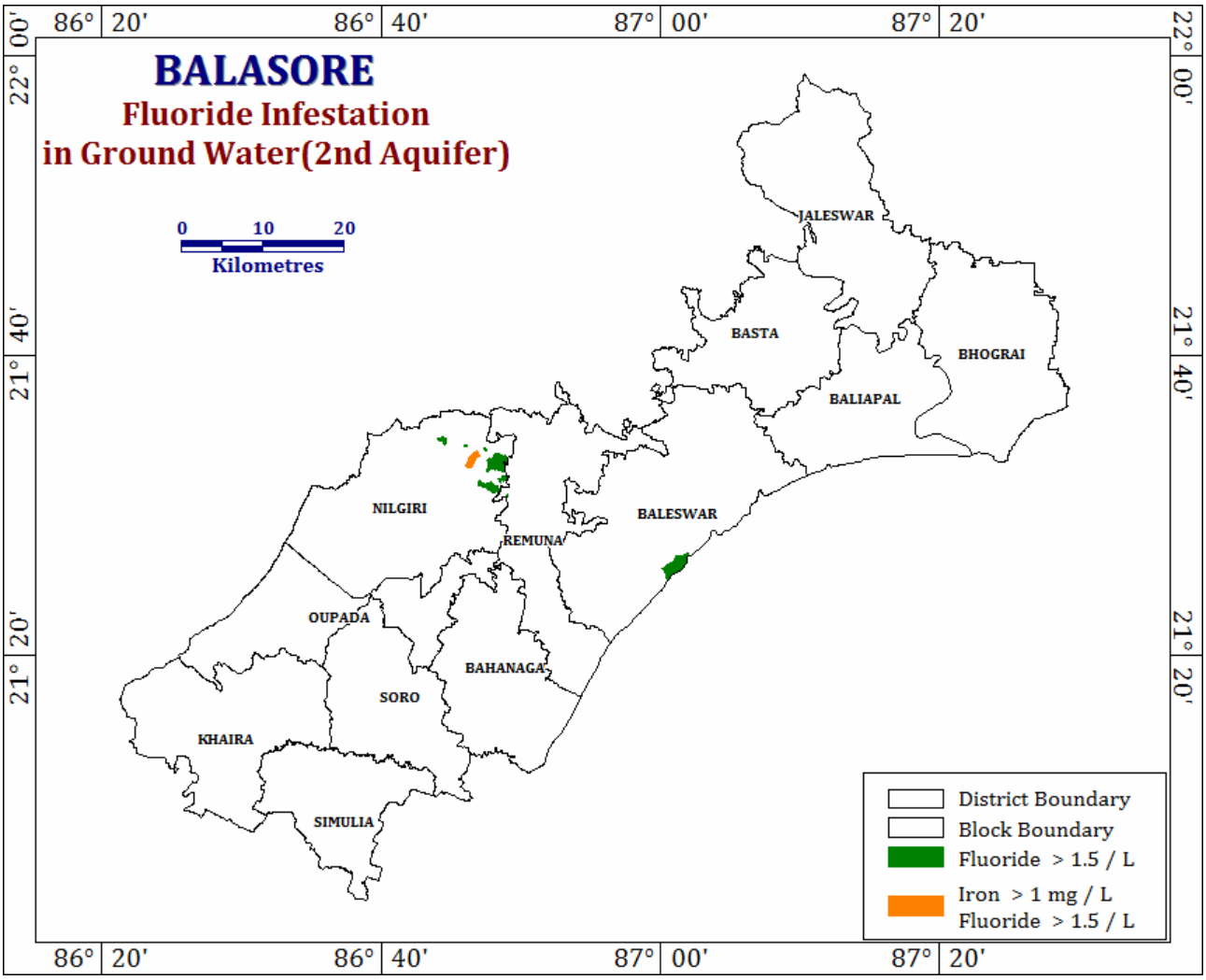


Figure – 8 b : Fluoride Infestation in Deeper Aquifers(II & III), Balasore District, Odisha

As evident from the perusal of the above map, Fluoride above the BIS permissible limits of 1.5 mg/L is found to be of patchy occurrence in scattered habitations of the Nilgiri, Remuna & Balasore Blocks of the District. The Fluoride occurrence in the Nilgiri and Northern part of Remuna Block is mostly associated with hard rock formation where there exist a contact between the granite / granite gneiss with the intrusive pegamatitic veins. In many of the literatures and in earlier studies, this has been attributed to the presence of fluoride bearing minerals in the associated country rocks. In addition to it, even in the alluvial formations in the Remuna and near Chandipur in Balasore block, fluoride has been observed. This may be attributable to the presence of fluoride bearing minerals in the detritus or because of paleo salinity(sea water / connate water lenses) pockets within the formation. This too is entirely geogenic in nature.

9. Ground Water Related Issues

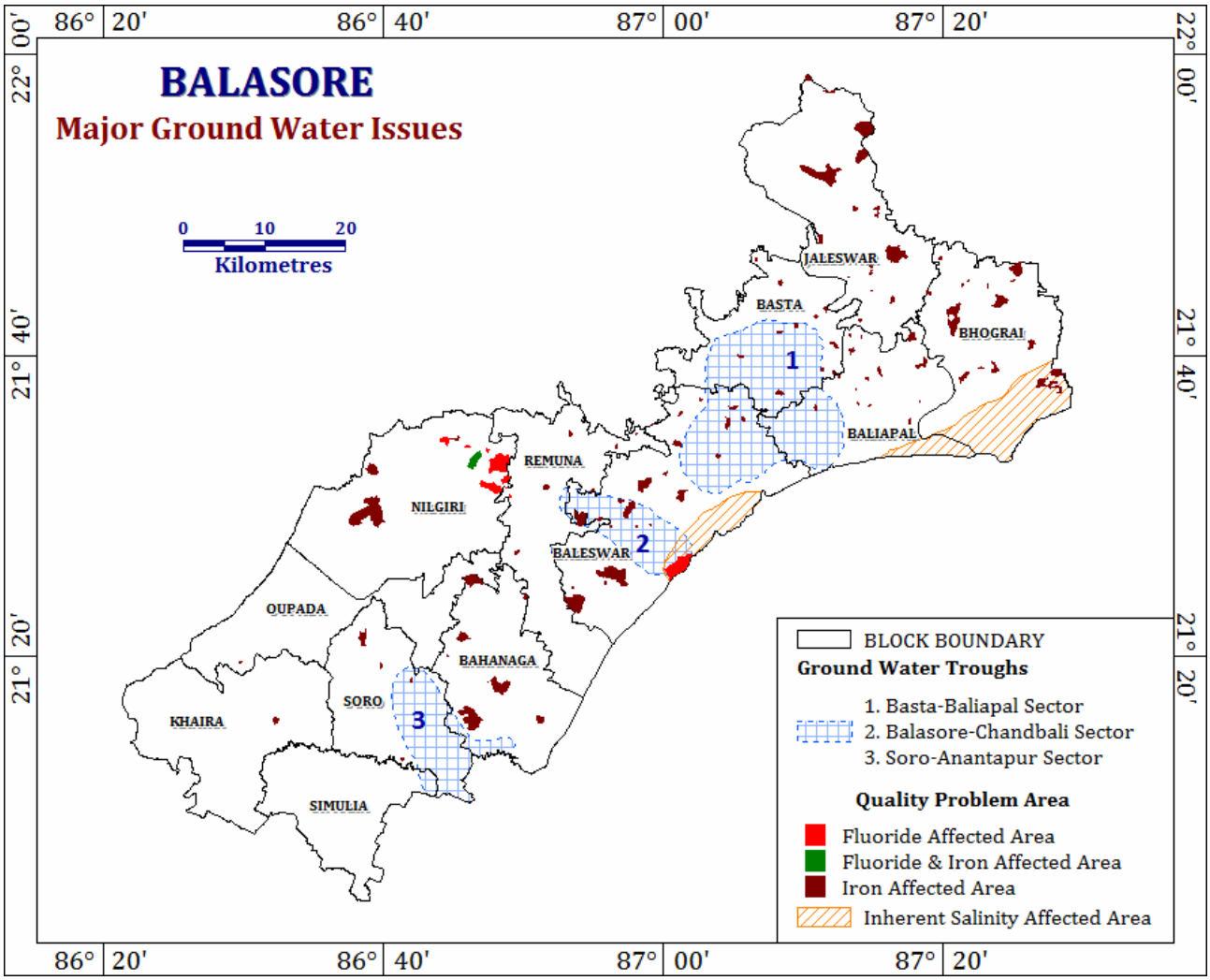


Figure – 9 : Major Ground Water Related Issues

A synopsis of data and maps reveals that major Ground Water related issues can be clubbed under the following heads :

- Presence of Ground Water Troughs in both pre & post monsoon season in the Deeper Aquifers(II & III) in the 3 Areas : Basta- Baliapal Sector, Balasore-Chandipur Sector & Soro-Anantapur Sector.
- Presence of inherent salinity affected areas along the coast line in the Kalyani-Chandipur-Chandaneswar tract spanning the Balsore, Baliapal & Bhograi Blocks.
- Presence of Iron & Fluoride above permissible limits in certain habitations of the districts.

10. Aquifer Management

10.1 Ground Water Troughs : As already elaborated in the earlier chapters, the perusal of data and maps of the elevation of the piezometric surface, above mean sea level in both the pre & post monsoon season reveals that distinct ground water troughs have developed in the three areas described below :

a. Basta Baliapal Tract(Irrigational Draft)

b. Balasore Urban(Domestic Draft) & adjoining Angargadia-Chhanpur - Somanathpur Industrial Tract(Industrial Draft)

c. Anantapur Soro Tract(Irrigational Draft)

10.1.1 BASTA–BALIAPAL SECTOR

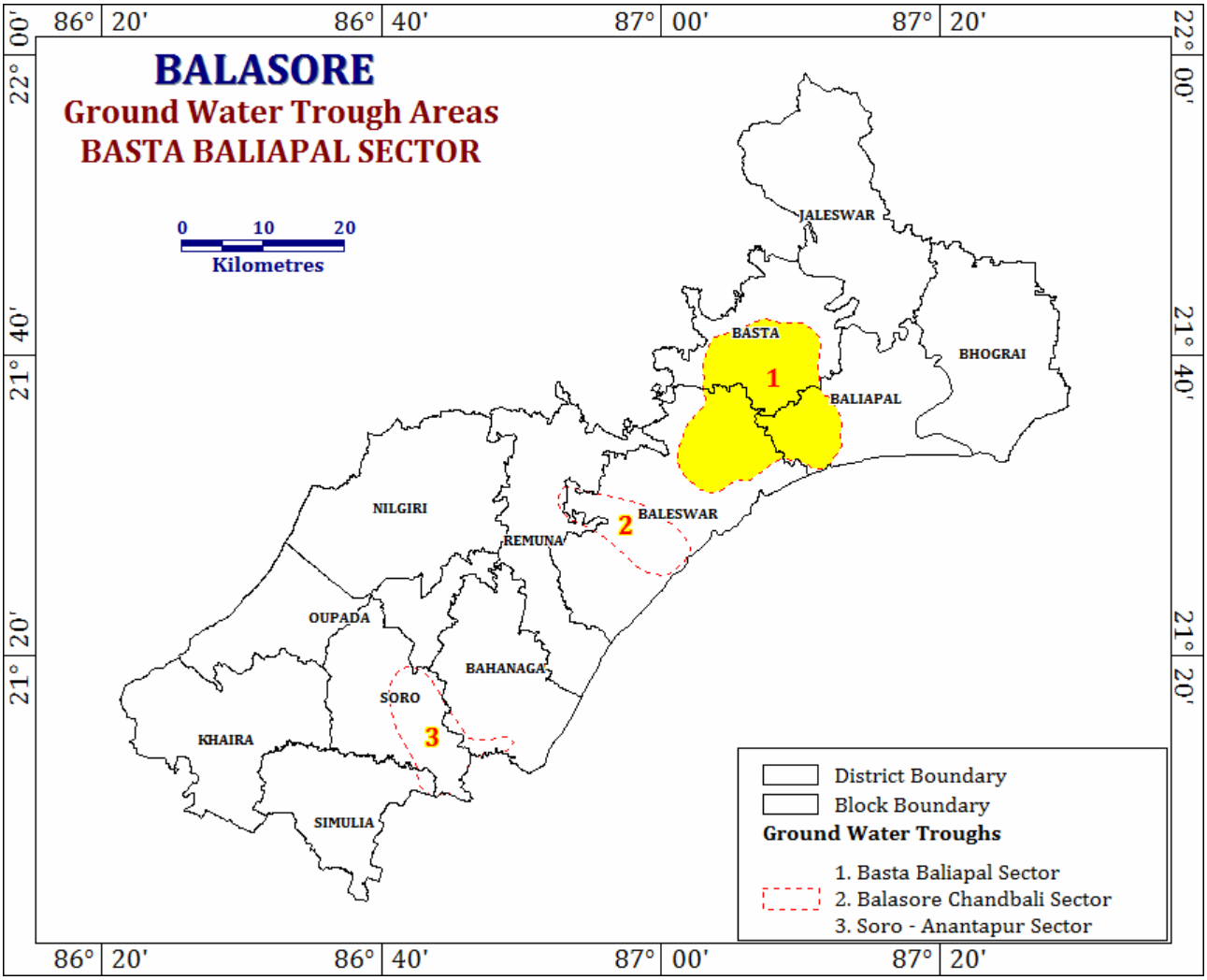


Figure – 10.1 a : Ground Water Trough in Basta-Baliapal Sector

General Features :

- Average elevation 0 – 3mAMSL
- Very Low Master Slope
- Anastomosing drainage network
- Acute drainage congestion
- Surface Water Logging
- Annual Rainfall 1700 mm
- Highly Productive Agricultural Area

Field Observations :

- Irrigational water requirement with absolute dependence on ground water
- Agricultural draft from all sources ≈ *40 MCM*
- Decline in ground water level over the years
- Formation of ground water troughs(both Pre & Post Monsoon ≈ *300 Sq. Kms Area*) –below mean sea level
- Pre-monsoon piezometric surface about 15 – 20m bmsl
- Post-Monsoon piezometric surface about 5 – 10 m bmsl

Rationale behind Aquifer Management Strategy :

- Average elevation 12 - 20 mAMSL
- Low Drainage Density
- Highly Populated
- Urban, Peri-Urban & Industrial Area
- Ground Water main source of Water Supply

Aquifer Management Plan :

- The water requirement for irrigation should migrate from entire ground water dependence to surface water one as far as feasible
- The average yield and transmissivity of shallow aquifers(60 m) is ≈ ***20 lps & 500m²/day*** respectively.
- Hence 550 m3/day of recharge per well for 120 days can add around 0.55 MCM of recharge per year per well.
- Thus around ***500 wells*** needs to be in place to negate the effect of ground water withdrawal and subsequent formation of ground water trough.
- Quantum of Additional Recharge through this 500 proposed wells ≈ ***33 MCM / year***
- Existing energized agricultural tube wells to be converted to dual use (abstraction cum recharge) with suitable silt trap and filtering mechanism.
- Existing nalas and other surface water channels to be utilized as source for ground water recharge by construction of additional ***50 wells***.
- These wells being specially designed - expected to have recharge intake capacity of at least 0.15 MCM/ Year.
- Expected quantum of Additional Recharge ≈ ***7.5 MCM /year***
- Creation of additional drainage to free the drainage congestion and prevent scope of soil mineralization in future.
- The remaining run off water should be channelized through these additional drainage channels

10.1.2 BALASORE–CHANDBALI SECTOR

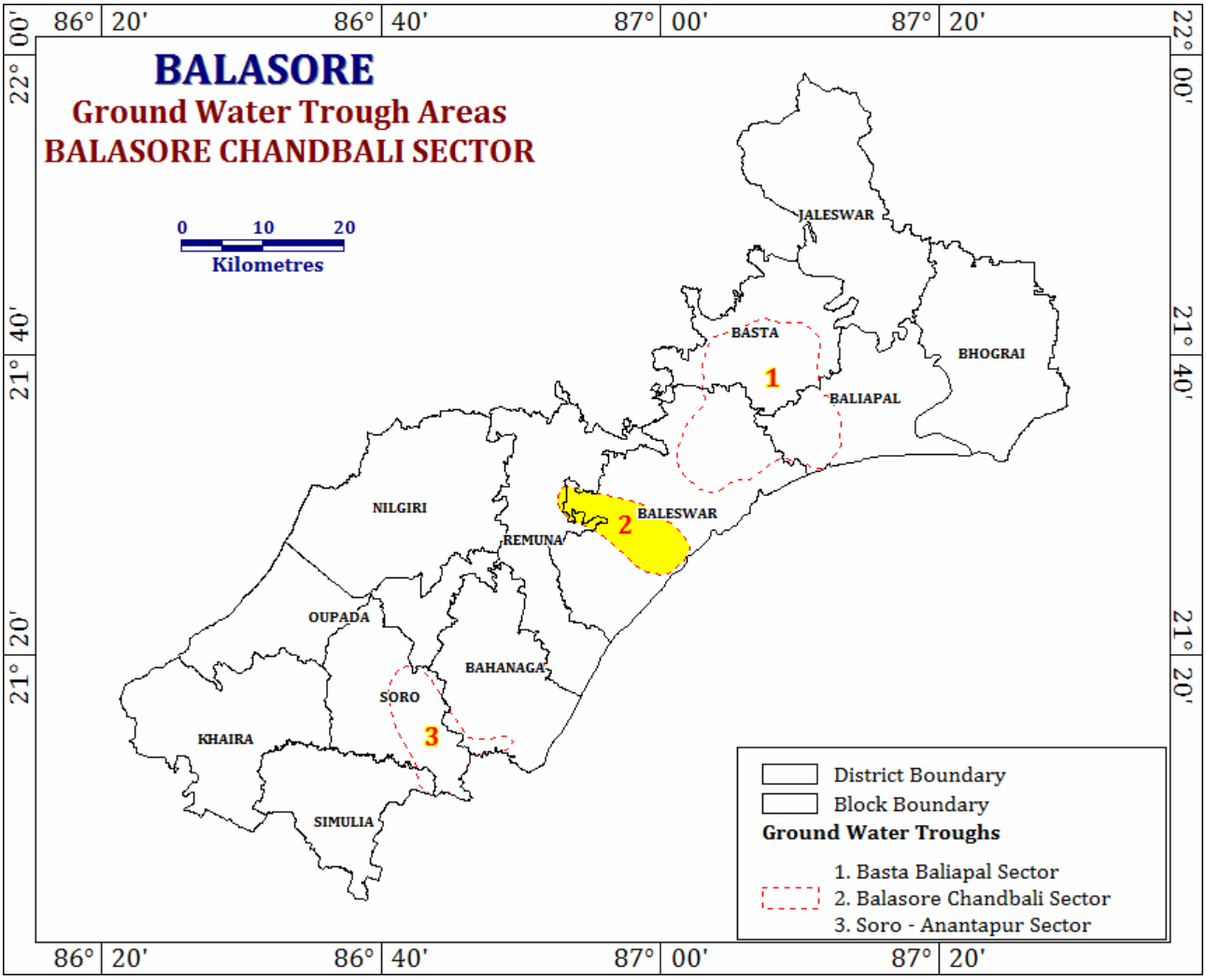


Figure – 10.1b : Ground Water Trough in Balasore-Chandbali Sector

General Features :

- Average elevation 12 - 20 mAMSL
- Low Drainage Density
- Highly Populated
- Urban, Peri-Urban & Industrial Area
- Ground Water main source of Water Supply

Field Observations :

- The Domestic utilization by PHED alone is about **20 MLD** from Ground Water ≈ **7.3 MCM/Year**.

- Additionally unaccounted domestic utilization (pro-rata based on population) is ≈ **0.7 MCM/Year**
- Total Domestic Utilization from Ground Water ≈ **8 MCM /year**.
- Industrial Draft near vicinity of Balasore town in the Chhanpur – Angargadia - Somanathpur area ≈ **5 MCM / Year**.
- The average depth of Piezometric surface ≈ 12(Post-Monsoon) – 16(Pre-Monsoon) mbgl ⇒ **just at MSL**
- ***Thus an imminent threat of salinity ingress for its proximity to sea.***
- There is frequent reporting of well turning saline in the Chandipur Defence Post(within 500 meters of high tide line), over the years.

Rationale behind Aquifer Management Strategy :

- The average scope for artificial recharge in Balasore Urban area is about 6 to 8 metres .
- Ample roof top area available in form of Govt. Buildings and Large Roof Tops Pvt. Buildings(> 100 Sq. m area)

Aquifer Management Plan :

- Proposed - **10,000** Buildings to adopt Roof Top Rain Water Harvesting.
- At least ≈ **153 m^3** Rain Water can be harvested per house ⇒ **1.53 MCM**

- Piezometric Surface expected stabilize and rise by ≈ **1.6 m** at current draft rate
- Water Supply dependence shifted to Surface Water Sources - Barrage over Sona River ≈ **12 Kms** from the Town.
- The priority for such supply Chandipur ⇒ Balasore Urban ⇒ Industrial Estates.

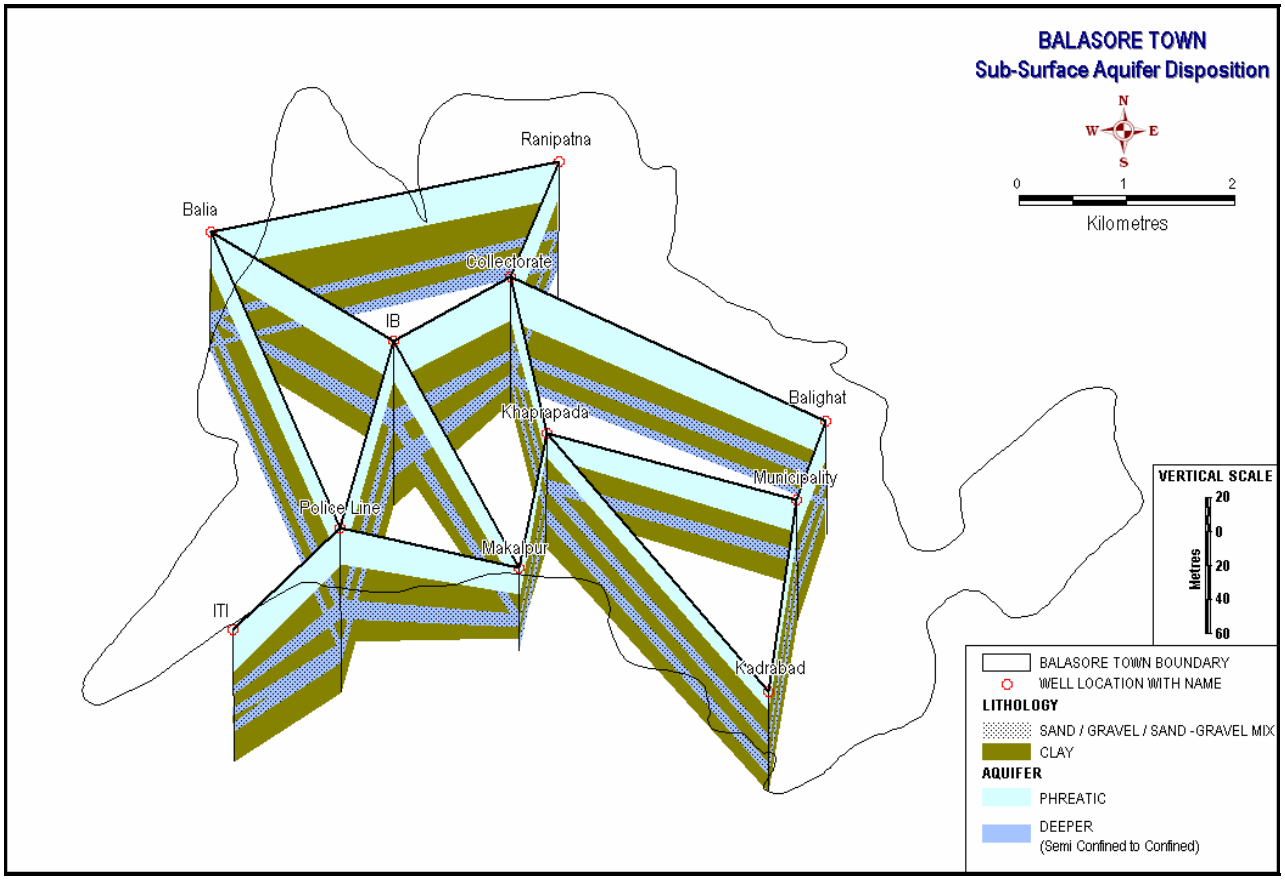


Figure – 10.1 c : Sub-surface disposition of Aquifers in Balasore Town

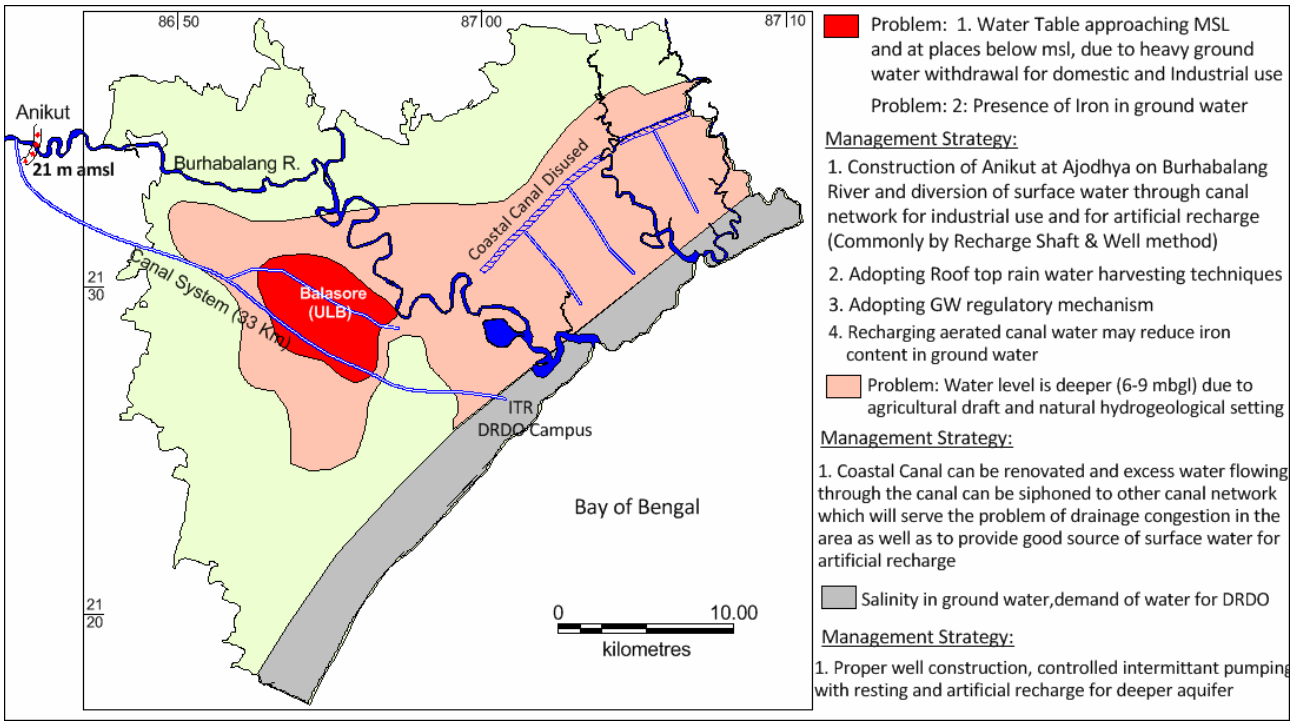


Figure – 10.1 d : Aquifer management Strategy for Balasore-Chandbali Sector

10.1.3 SORO-ANANTAPUR SECTOR

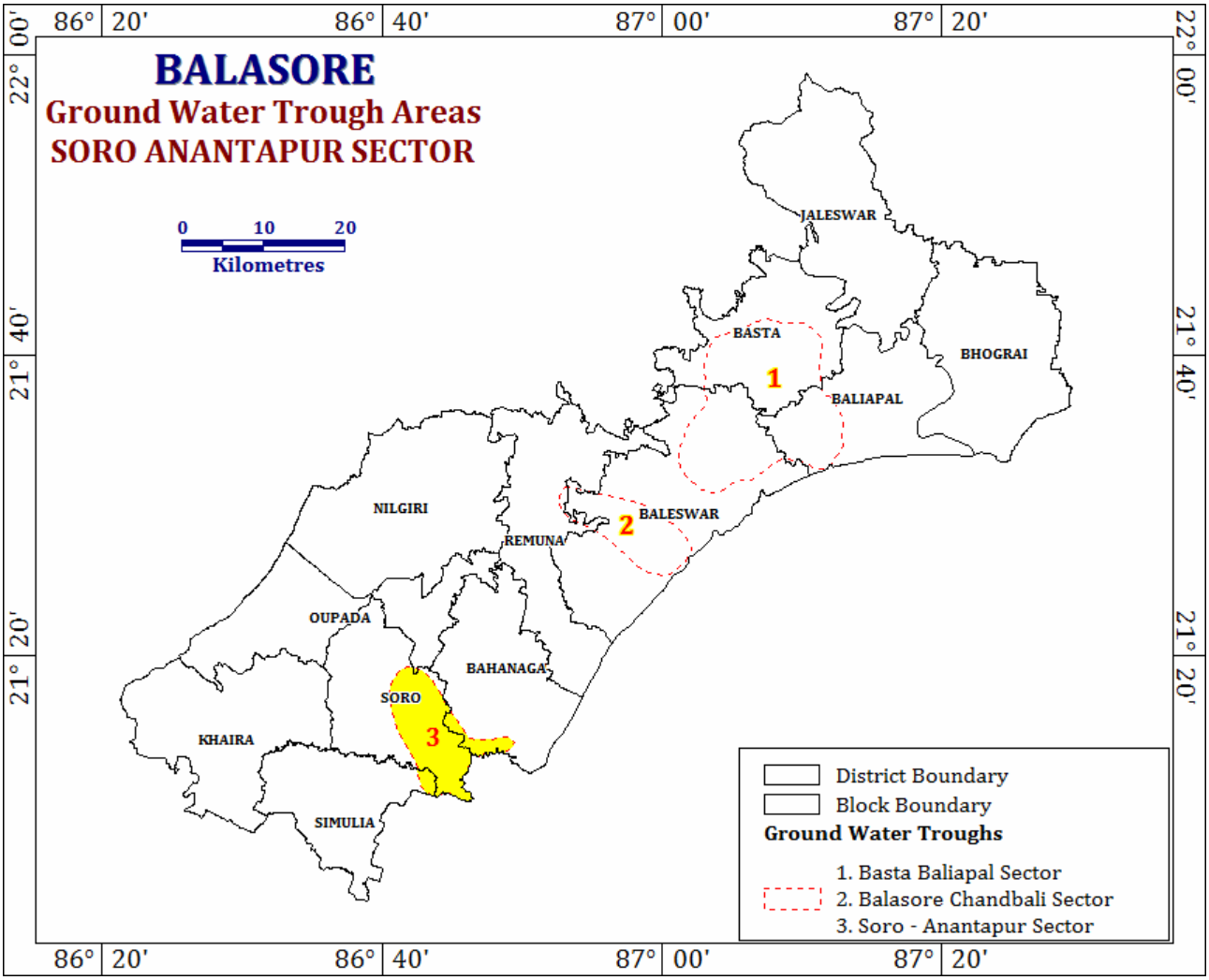


Figure – 10.1 e : Ground Water Trough in Soro-Anantapur Sector

General Features :

- Average elevation of 3 - 12 mAML & Surface water logged pockets
- Devoid of major drainage channel
- Lot of small scale farm ponds – both for agriculture & aquaculture
- Agricultural water requirement met from ground water(Rabi Season Paddy cultivation)
- Medium to large crop lands ≈ 5 – 10 Ha each

Field Observation :

- Water Requirement for agriculture, aquaculture (pisci culture)
- Piezometric surface ≈ 8 – 14 mbgl (Pre-Monsoon)
- Piezometric surface ≈ 4 – 8 mbgl (Post-Monsoon)
- Ample space for Artificial recharge
- No risk of ground water logging – post recharge

Rationale behind Aquifer Management Strategy :

- Agricultural practices may be suitably modified
- Farm ponds best suited for run-off harvesting & storage
- Larger farm lands including Govt. Grazing lands of larger dimensions to construct farm ponds of dimensions of 30m X 30m X 3m

Aquifer Management Plan :

- **50 farm ponds** with injection wells needs to be constructed
- Each farm pond will harvest around **2700 Sq m** of water per filling - Multiple fillings possible

- Harvested water to be channelized through suitable sediment trap mechanism, filter system
- Filtered Water injected to the underlying aquifer system through injection tube wells
- Top and mostly well exploited aquifer lies within **20 – 60 m** depth.
- Expected recharge around **3.3 MCM / year** in total

10.2 Ground Water Quality Problem : Here, only the iron and fluoride infestation in ground water from deeper aquifer(II & III) are being considered for redressal

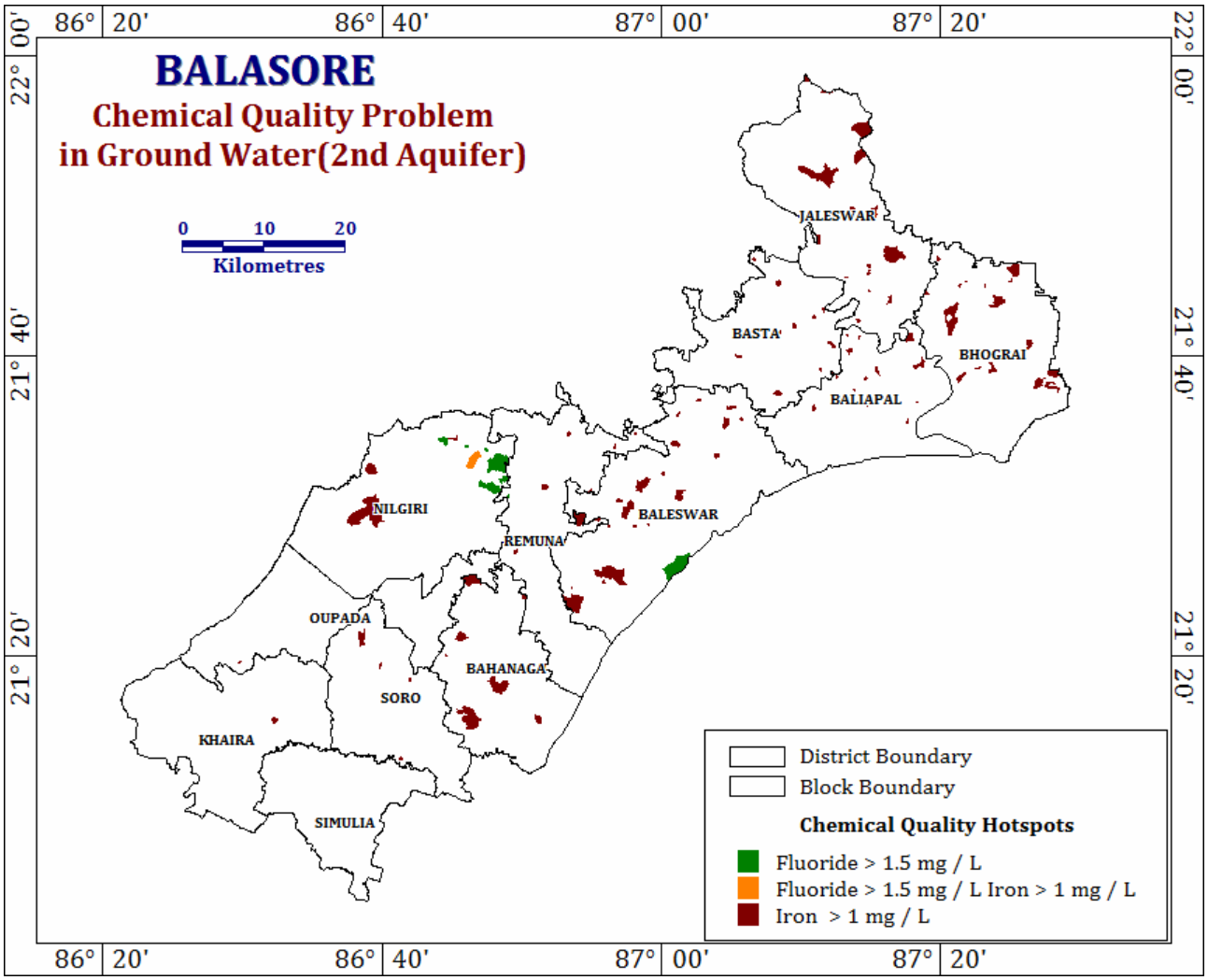


Figure 10.2 a: Iron & Fluoride Infestation in Deeper Aquifers, Balasore District, Odisha

General Features :

- Iron infestation associated mainly with alluvial formations and deeper aquifers(II & III) whwre average ground elevation ranges between 5 – 15 mAMSL
- Drainage channels few, anastomosing and mostly became obscure
- Fluoride mostly associated with hard rock formation(aquifer-II) where surface average elevation > 70 mAMSL

Field Observation :

- Isolated fluoride occurrence associated with pegmatitic formations in contact with Nilgiri Granite(≅ Singhbhum Granite) & Newer Doleritic & Ultrabasic Dyke bodies
- These are mostly in the northern part of the Block(in the north western part of the District) in places like Nilgiri, Raj Berhampur etc.
- Most of these wells are having comparatively higher yield at shallow to moderate depth fractures within 80 – 100 m depths.
- One patch in the Chandipur associated with Salinization(≈Cement Sealing Leakage) of well in the Defence Establishment

Aquifer Management Strategy :

- Construct gabion structures and check weirs in the hilly tracts of Nilgiri and Oupada Block
- Harvested water to be channelled & stored in specially constructed Pond / Tank / Reservoir

- Stored Water to be suitably filtered, processed in appropriate water works for supplying drinking water to the residents of the Nilgiri Block, which are affected by fluoride.
- Pockets of piezometric head> 8 m in the post monsoon), to go for Artificial Recharge through bore wells,
- This will additionally help in reducing the fluoride concentration.
- If it is successful on a pilot scale, the same may be replicated else where.

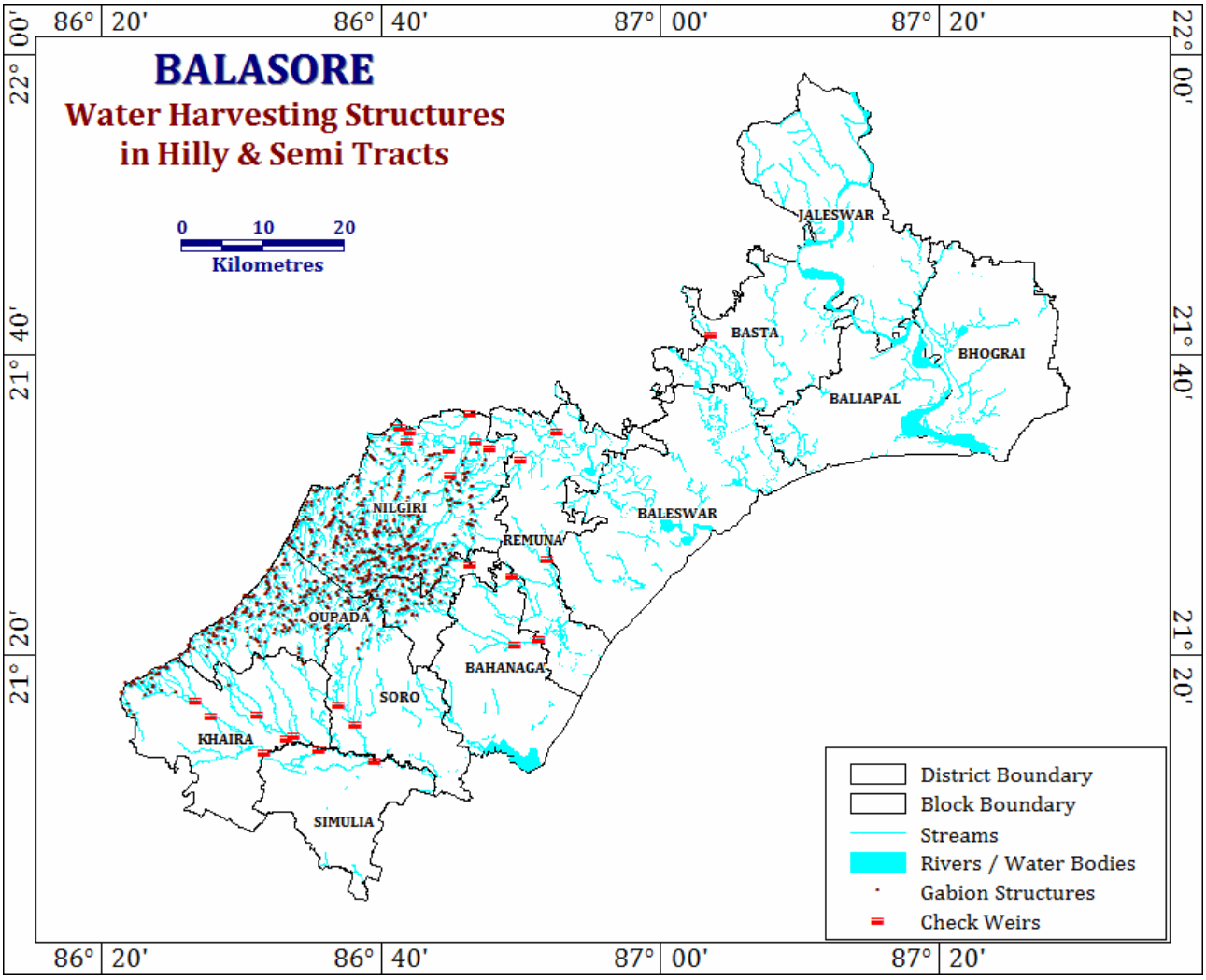


Figure 10.2 b : Suggested Water Harvesting Structure for Fluoride Mitigation

Table – 10.2 a : Suggested Blockwise Construction of Check Weirs

Sl	Block	Number
1	Bahanaga	1
2	Basta	1
3	Khaira	6
4	Nilgiri	8
5	Oupada	1
6	Remuna	5
7	Simulia	2
8	Soro	2
	DISTRICT TOTAL	**26**

Table – 10.2 b : Suggested Blockwise Construction of Gabion Structures

Sl	Block	Number
1	Khaira	37
2	Nilgiri	463
3	Oupada	303
4	Soro	15
	DISTRICT TOTAL	**818**

Figure 10.2 c : Illustrative Check Weir in Operation

Figure 10.2 d : Illustrative Gabion Structure in Operation

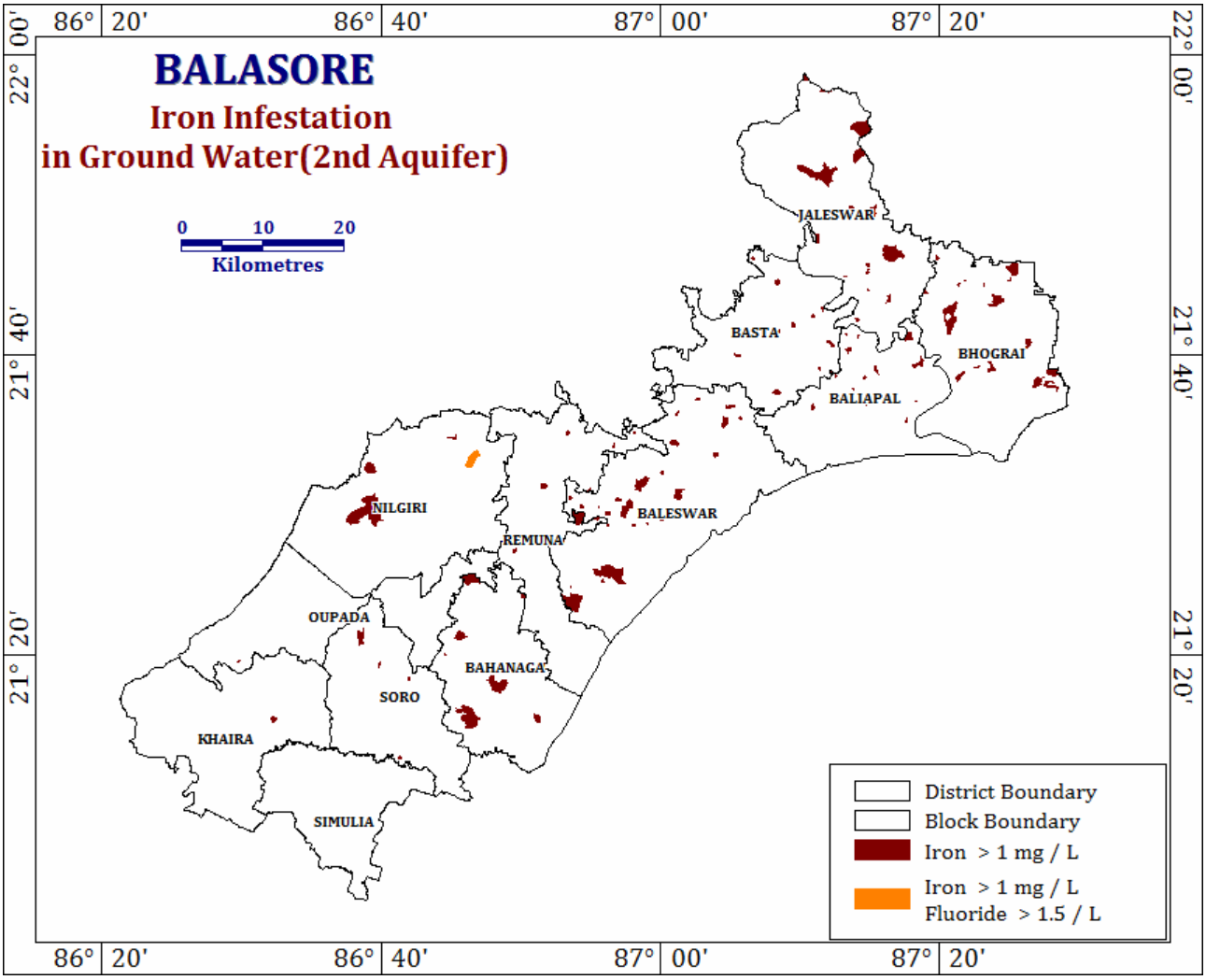


Figure 10.2 e : Iron Infestation in Deepr Aquifers, Balasore District

Field Observation :

- As common in coastal tracts of Odisha, sporadic and isolated pockets of marginally high values of Iron is found in Balasore District
- The Iron concentrations are mostly within *1 – 3 mg/L*
- There is no definite pattern of iron occurrence
- Neither it is co-relatable to any particular formation or aquifer in particular

AquiferManagement Strategy :

- Use of aeration technique
- Use of Terrafil Filters
- Iron removal Plants
- Alternate source of Water in extreme cases

10.3 Inherent Salinty Problems : As already stated earlier, the Kalyani-Chandipur-Chandaneswar Sector is infested with inherent salinity problem. The brief features of this area along with its geographic disposition is described below :

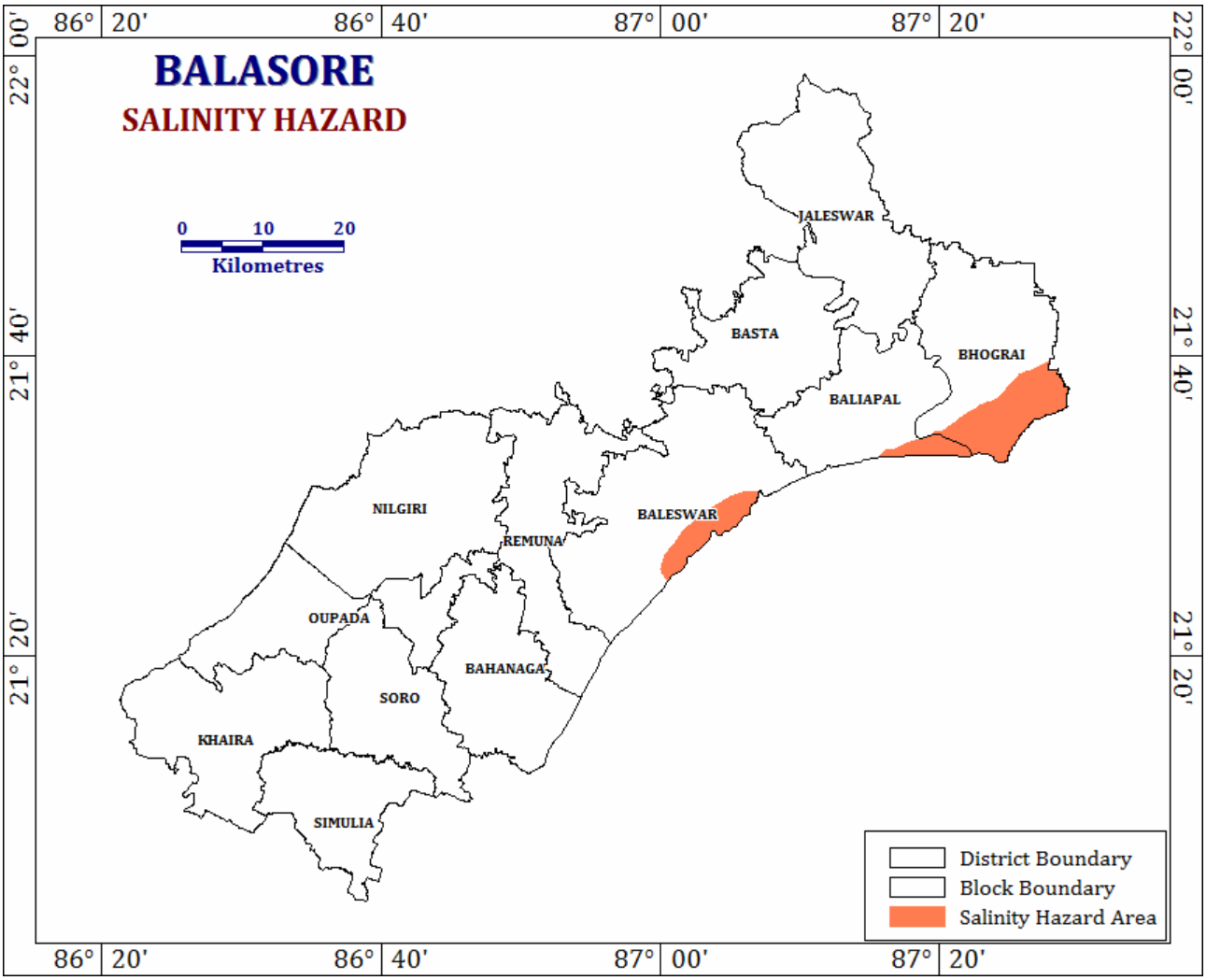


Figure – 10.3 : Inherent Salinity Hazard Area, Balasore District, Odisha

General Features :

- Inherent low lying area with average elevation 0 – 3 mAMSL.
- Higher elevation are occupied by the coalescing beach dunes and paleo strand lines

Field Observation :

- The saline tract covers Chandaneswar - Chandipur - Kalyani Sector close proximity to Bay of Bengal
- Approx ***100 Sq Kms*** in the eastern part and ***50 Sq Kms*** in the Central Part
- The aquifer disposition shows that First aquifer is completely saline in the north eastern part
- The First Aquifer and have ***EC*** in the range of ***1200 – 2600 μS/cm*** in the south western part

Aquifer Management Strategy :

- In the north eastern part only deeper aquifer can be exploited for drinking water only.
- Cement Sealing of Saline Zones overlying Fresh Aquifers to be done perfectly
- In the south western part, since EC and Chloride content is relatively high(USDA Class : C_4S_3), care should be taken while planning for irrigation

10.4 Cost Implications : One of the inherent part of any Management Plans or Strategy is to analyse the cost component therein. Efforts have been made to arrive at the individual cost components for all the aquifer management plans to the extent of the quantification possible. For items and parameters of qualitative interpretations, cost component have been avoided to avoid and confusion and is left best to the discrimination of the Planners and Policy makers for their implementation.

Management of ground Water Troughs in Basta-Baliapal & Soro Anantapur Sector

EXPENDITURES

Construction Cost of Injection Well(7" Dia)(50-60m)	: Rs. 2.00 Lakhs
Cost of 30m X 30m X 3m Farm Pond	: Rs. 1.50 Lakhs
Cost of Filter Chamber & Other Misc. etc.	: Rs. 0.50 Lakhs
UNIT COST	: **Rs. 4.00 Lakhs**
No. of Structures	: 600
Basta-Baliapal	*: 500 + 50(Nalaside)*
Soro – Anantapur	*: 50*
TOTAL	: Rs. 24.00 Crores
Minus Cost Escalation @ 8% / year	
Plus Interest on Capital Expenditure @ 8% / year	
GRAND TOTAL	: **Rs. 24.00 Crores**
Life of Structure	: 20 years
Cost / year	: Rs. 1.20 Crores

BENEFIT

Recharge Volume	: 43.8 MCM
Basta-Baliapal	*: 33 + 7.5(Nalaside)*
Soro – Anantapur	*: 3.3*
	≈ 44 MCM
Additional Irrigation Potential Created	: 5500 Ha
(Taking 0.8m of Water Requirement for Paddy)	
Water Cess / Ha of Irrigation	: Rs. 1000/-
Benefit towards irrigation	: Rs. 55.00 Lakhs
Pisci Culture @ Rs. 12,000/- per pond for 550 ponds	: Rs. 66.00 Lakhs
Embankment for Horticulture Development	: Rs. 13.75 Lakhs
(@ Rs. 2500/- for 550 Ponds)	
TOTAL BENEFIT /YEAR	**: Rs. 1.35 Crores**
COST/ YEAR	**: Rs. 1.20 Crores**
Benefit Cost Ratio	**: 1.125**

11. Summarry & Conclusion

National Aquifer Mapping & Management(NAQUIM) in the District of Balasore was undertaken during the XIIth Plan Period of 2012 – 2017. As per the initial work plan it was designed to be carried out on toposheet basis, which was then modified to be carried out on administrative demarcations for better understanding of the sub-surface aquifer system and subsequent implementations of the aquifer management plans at the field level.

During the course of the NAQUIM activities, all the historical data generated by CGWB was collected, compiled and collated with the data generated during rhe NAQUIMs XIIth Plan Perid work. This was further co-rellated with the data collected from various other line departments and agencies of both Govt. of India & Govt. of Odisha – IMD, Census of India(2011), Bore well and tube well data(including chemical quality) from Rural Water Supply & Sanitation(Govt. of Odisha), Public health Engineering Department(Govt. of Odisha), Data from Directorate of Ground Water Development(formerly Directorate of Ground Water Survey & Investigation, Govt. of Odisha), Data from Directorate of Minor Irrigation, Odisha Lift Irrigation Corporation Limited, Department of Water Resources, Climatological Data from the Special Relief Commissioner(Govt. of Odisha), Agricultural Data from the Department of Agriculture & Food Production(Govt. of Odisha), Water Harvesting Structure data from Odisha Watershed Development Mission & Directorate of Soil Conservation, Data from Odisha State Disaster Management Authority etc. to name a few.

It was found that the district was underlain by the consolidated formation of Archean-Pre-Cambrian age, which are overlain by the Tertiary Carbonaceous Sediments and Clay. These were further overlain by the Older & Younger Quaternary Alluvium followed by recent Fluvial and Aeolian sediments. There is appreciable and extensive laterite capping on the northern part of the district.

Ground water was found to be occurring in unconfined, semiconfined and confined condition in the district. Unconfined aquifers are mostly exploited by constructing dug wells of 2 – 3 meters diameter and of 5-12 metres depth. The hard rock formations are tapped by using medium deep bore wells and the alluvium formation is tapped by using medium deep to deep tube wells, depending on the sub-surface aquifer disposition.

The western part of the district is underlain by hard rock formation and is also associated with patchy occurrence of fluoride in some of the habitation. Iron infestation is common in the alluvial areas bordering the laterite cappings. There are also inherent salinity problems in the blocks bordering the Bay of Bengal.

Being a agriculture dominated district, the irrigation draft in some of the bloks like Basta-Baliapal, Bhograi, Soro are quite high, Similarly the thickly populated areas of Balasore Urban areas upto the Chandipur Defence establishment is withdrawing huge quantity of ground water for meeting the domestic water requirements. This has given rise to three district ground water troughs, where the ground water levels in the deeper aquifers have gone below the mean sea level. This unique situation needs immediate intervention to prevent any future disaster.

The intervention would have to be in form of immediate augmnentaion of ground water recharging, over and above the natural recharge phenomenon. Some of the short term and long term management principles suggested are :

- Large scale planning should be adopted for formulation of groundwater development strategies, which may be preceded by intensive hydrogeological, geophysical and remote sensing studies.

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

- Institutional financing system should incorporate all groups of farmers especially the marginal (including SC, ST & others) through community tube well system so that they can irrigate their own land instead of irrigating it at high price from affluent farmers.

- The State Govt. authorities should render proper guidance to the farmers especially in the hard rock areas in siting proper ground water structure in favorable hydrogeological settings.

- Mass awareness programme among the farmers should be taken up to educate them about the peril of ground water decline.

- Suitable water conservation measures like roof top rainwater harvesting and artificial recharge practices may be adopted for augmentation of ground water resources in urban and the areas with higher stage of ground water development.

- Ground water resources in and around Balasore town and Chandipur should be augmented by means artificial recharge. Rain water and roof top harvesting structures must be made mandatory for all.

- To avoid failure of tube wells in saline hazard tract it is essential to precisely, identify the fresh water aquifers, through borehole logging, Cement sealing should also be invariably done precisely to seal off the saline aquifers.

- Unregulated exploitation may disturb the hydro chemical balance of fresh and saline water leading to saline water ingress. Proper care should be taken to avoid it. Clustering of tube wells should be avoided in the saline hazard tracts and particularly near seacoast.

- The scope of conjunctive use of surface and ground water may also be studied in the command areas of Salandi and Baitarini irrigation project areas to avoid problems like water logging, soil salinity etc.

Data Source

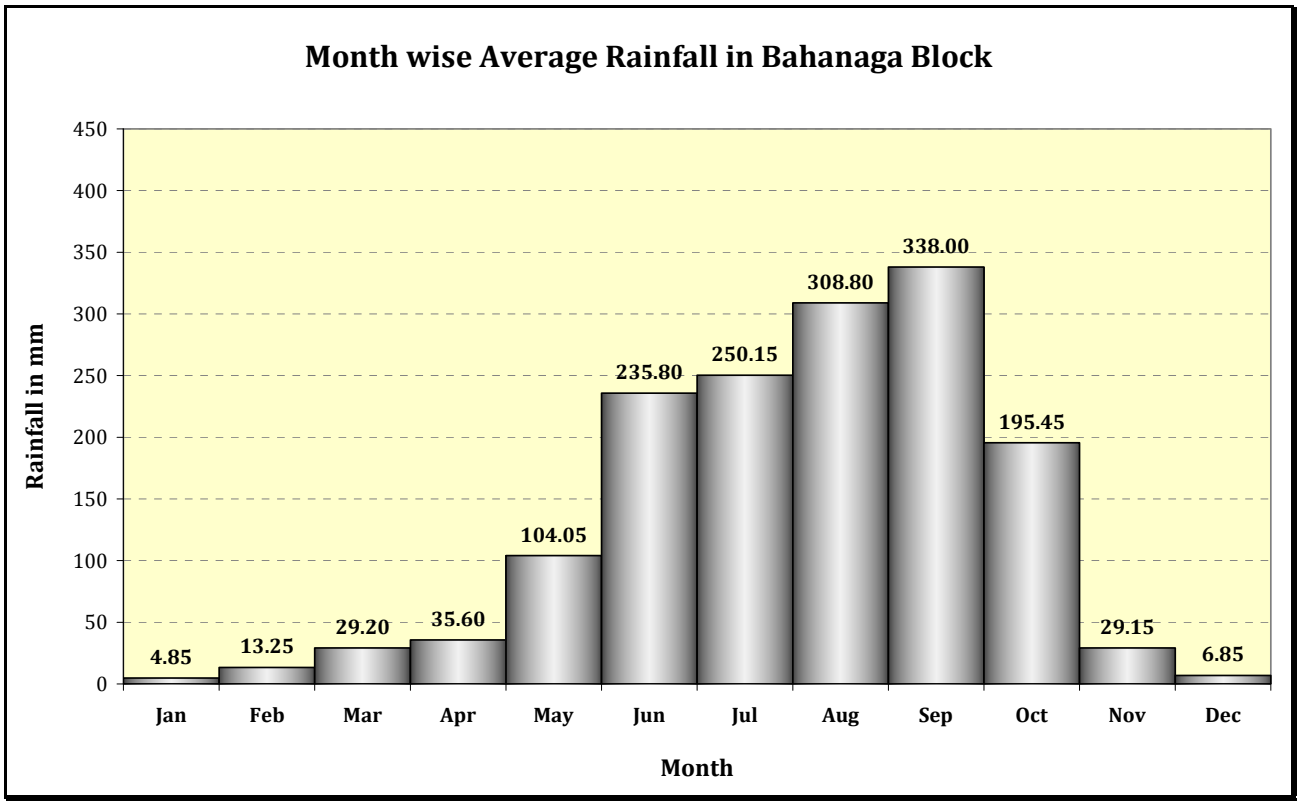
Sl	Type of Data	Source
1	Meteorological Data	India Meteorological Department Special Relief Commissioner Odisha State Disaster Management Authority Collectorate, Balasore Odisha Statistical Handbook
2	Water Level Data	Central Ground Water Board Directorate of Ground Water Development
3	Land Related Data	Collectorate, Balasore Odisha Statistical Handbook
4	Demoghraphy Data	Census of India(2011) Collectorate, Balasore Odisha Statistical Handbook
5	Ground Water Exploration Data	Central Ground Water Board Rural Water Supply & Sanitation Public Health Engineering Department Directorate of Ground Water Development
6	Irrigation Data	Department of Water Resources, Govt. of Odisha Directorate of Agriculture & Food Production Collectorate, Balasore Odisha Statistical Handbook
7	Agriculture Data	Directorate of Agriculture & Food Production Department of Water Resources, Govt. of Odisha Collectorate, Balasore Odisha Statistical Handbook
8	Geological Data	Geological Survey of India Central Ground Water Board Directorate of Geology
9	Geomorphological Data	Odisha Space Application Centre Central Ground Water Board Directorate of Geology
10	Base Maps	Survey of India National Remote Sensing Centre Odisha Space Application Centre

ANNEXURES

ANNEXURE – 1: Block wise Rainfall

Month wise Annual Rainfall in Bahanaga Block, Balasore District, Odisha

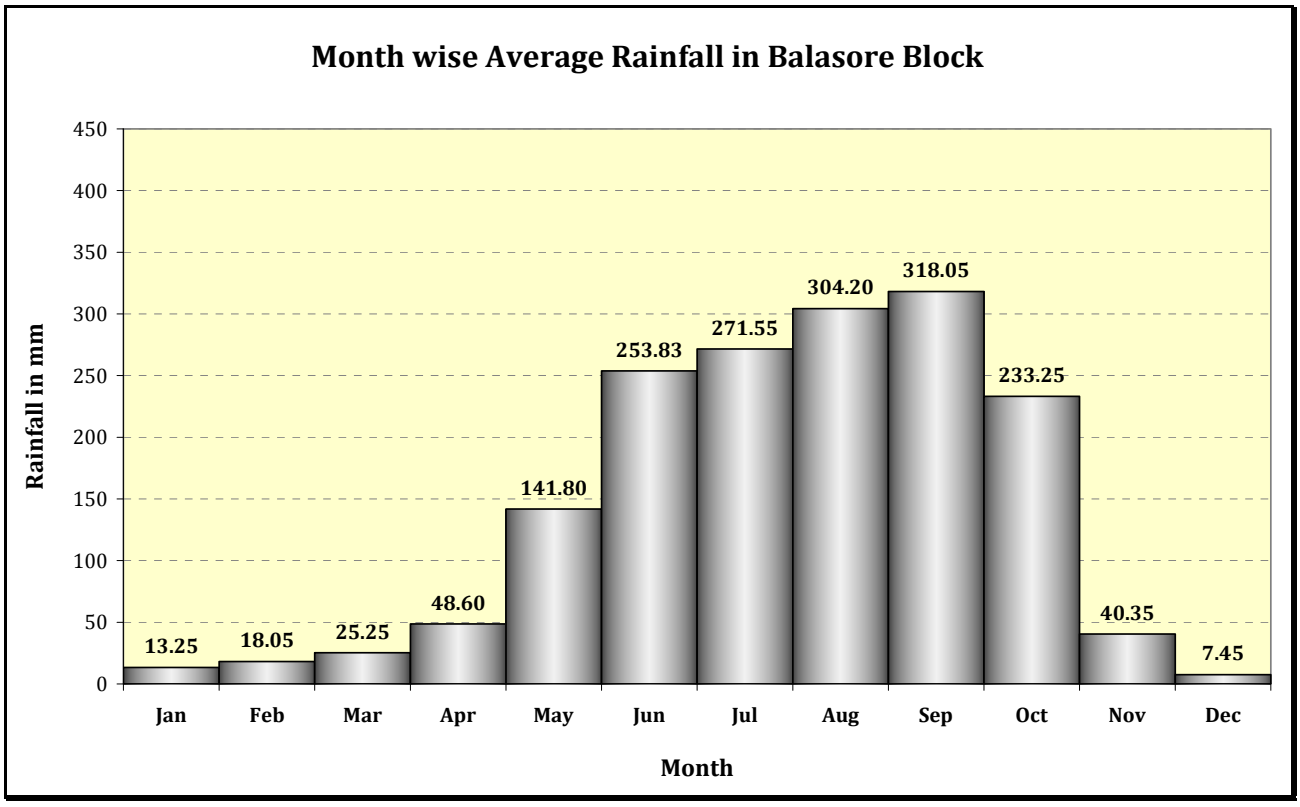
Month / Year	Rainfall in mm												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1995	0	12	49	31	330	64	163	538	205	153	178	0	**1723**
1996	0	0	0	0	16	115	359	485	28	133	0	0	**1136**
1997	0	36	93	152	99	467	299	456	263	69	21	98	**2053**
1998	16	22	116	94	105	100	156	206	388	109	60	0	**1372**
1999	0	0	0	54	201	260	191	225	374	684	137	0	**2126**
2000	0	118	0	81	144	250	216	214	338	86	0	0	**1447**
2001	0	7	71	56	160	393	414	523	285	112	4	0	**2025**
2002	9	0	13	57	41	252	81	208	338	15	35	0	**1049**
2003	0	0	56	25	65	402	238	133	185	425	13	0	**1542**
2004	0	0	0	13	40	243	320	316	300	211	0	0	**1443**
2005	11	0	61	61	43	237	323	134	644	386	0	0	**1900**
2006	0	0	49	13	82	229	287	611	472	15	17	0	**1775**
2007	4	66	0	27	93	471	439	445	740	57	2	0	**2344**
2008	13	0	0	0	41	528	229	271	206	66	2	0	**1356**
2009	0	0	15	0	123	123	525	317	382	224	67	0	**1776**
2010	0	0	0	0	121	18	137	140	376	222	0	27	**1041**
2011	0	0	0	4	92	168	71	305	500	3	0	0	**1143**
2012	44	0	0	27	0	36	104	249	167	25	47	12	**711**
2013	0	0	6	17	125	190	166	0	293	784	0	0	**1581**
2014	0	4	55	0	160	170	285	400	276	130	0	0	**1480**
Average	**4.85**	**13.25**	**29.20**	**35.60**	**104.05**	**235.80**	**250.15**	**308.80**	**338.00**	**195.45**	**29.15**	**6.85**	**1551**



ANNEXURE – 1: Block wise Rainfall

Month wise Annual Rainfall in Balasore Block, Balasore District, Odisha

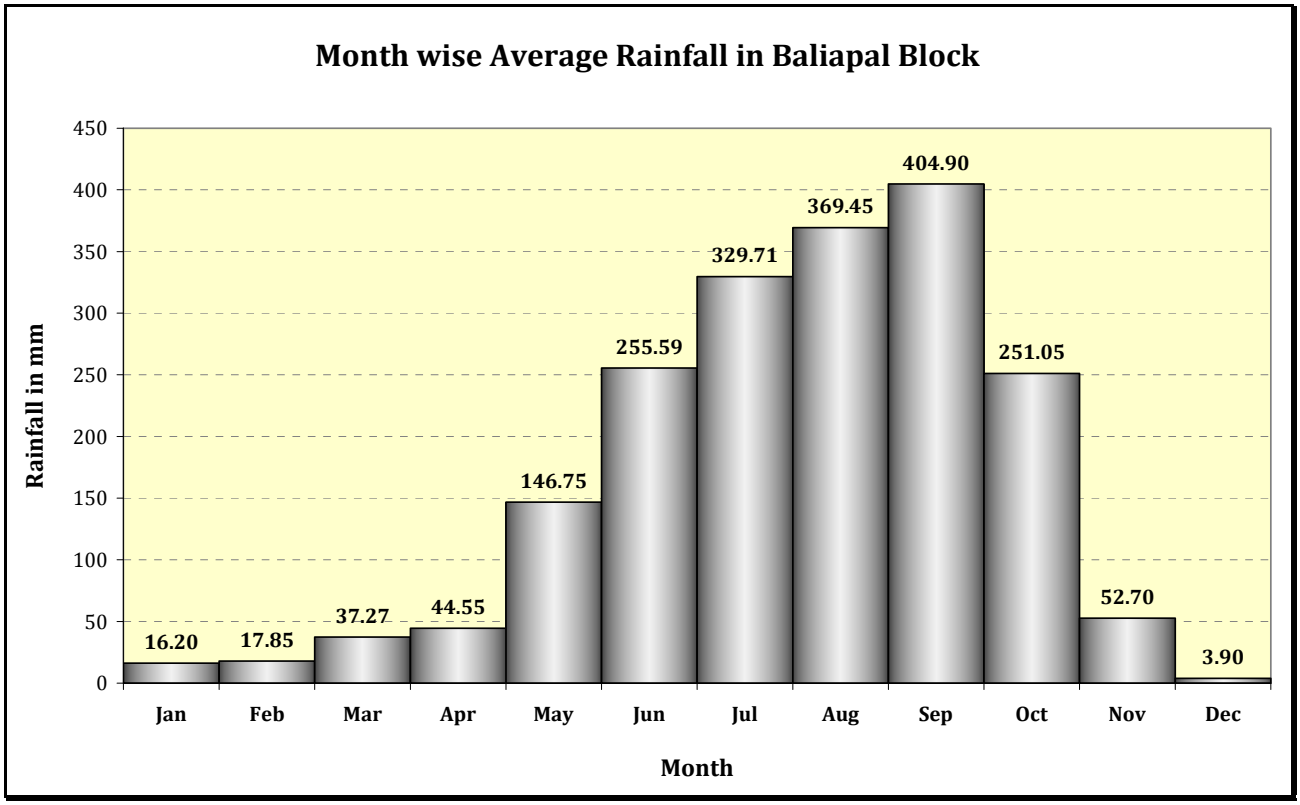
Month/ Year	Rainfall in mm												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1995	27	16	90	36	512	254	194	352	194	255	219	0	**2149**
1996	15	0	0	0	60	209	385	381	55	234	0	0	**1339**
1997	7	24	81	151	93	344	248	642	388	60	125	46	**2209**
1998	34	57	38	66	108	140	177	96	328	149	61	0	**1254**
1999	0	0	0	2	166	343	162	205	407	434	40	0	**1759**
2000	0	70	0	38	83	231	137	108	195	13	0	0	**875**
2001	0	20	53	20	145	390	477	309	142	310	38	0	**1904**
2002	26	0	35	40	30	291	93	195	378	52	68	0	**1208**
2003	0	9	59	10	34	297	515	392	265	1044	82	37	**2744**
2004	0	0	0	83	104	437	412	549	285	456	0	0	**2326**
2005	5	0	68	130	187	274	323	267	468	336	0	0	**2058**
2006	0	0	16	62	63	196	237	492	405	43	46	0	**1560**
2007	2	41	0	17	60	137	321	406	548	27	24	0	**1583**
2008	31	4	0	22	82	619	323	210	312	5	24	0	**1632**
2009	0	0	17	0	226	78	323	232	339	183	41	0	**1439**
2010	0	0	8	0	235	72	123	208	411	185	3	29	**1274**
2011	0	40	0	13	79	244	135	312	413	10	0	0	**1246**
2012	117	0	0	181	19	93.5	138	193	203	9	36	37	**1027**
2013	1	4	0	82	190	257	236	0	361	736	0	0	**1867**
2014	0	76	40	19	360	170	472	535	264	124	0	0	**2060**
Average	**13.25**	**18.05**	**25.25**	**48.6**	**141.8**	**253.83**	**271.55**	**304.2**	**318.05**	**233.25**	**40.35**	**7.45**	**1676**



ANNEXURE – 1: Block wise Rainfall

Month wise Annual Rainfall in Baliapal Block, Balasore District, Odisha

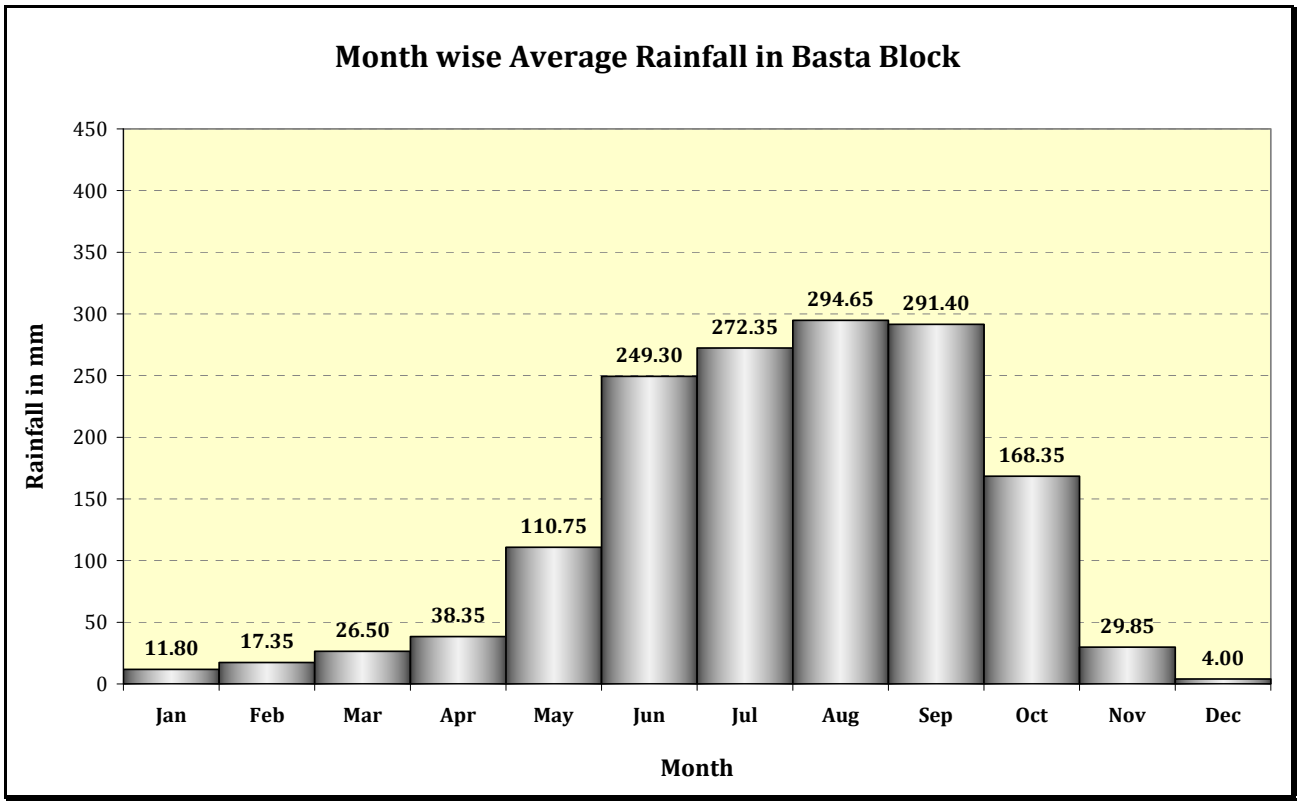
Month/ Year	Rainfall in mm												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
1995	40	25	27	2	549	75	304	262	310	309	278	0	**2181**
1996	7	17	0	0	0	257	329	845	61	231	9	0	**1756**
1997	36	61	161	150	101	325	479	801	488	61	45	44	**2752**
1998	21	23	144	211	69	138	193	206	731	397	150	0	**2283**
1999	0	0	0	0	317	306	403	513	760	437	56	0	**2792**
2000	0	49	0	65	124	557.8	455	285	555	110	0	0	**2201**
2001	0	0	85	138	298	440	412	378	218	391	40	0	**2400**
2002	62	0	157	34	76	290	97	254	756	41	105	0	**1872**
2003	0	2	55	5	59	267	262	212	292	655	40	5	**1854**
2004	0	0	5	58	70	210	336	404	127	365	0	0	**1575**
2005	10	0	90	85	90	105	340.2	211	849	848	0	0	**2628**
2006	0	0	6	0	104	267	487	343	477	2	0	0	**1686**
2007	2	122	0	10	24	222	526	837	536	27	141	0	**2447**
2008	37	15	0	13	40	564	223	199	206	4	141	0	**1442**
2009	0	0	1	0	248	9	257	228	290	100	7	0	**1140**
2010	0	0	0	0	142	36	277	185	248	160	15	24	**1087**
2011	0	0	0	3	112	392	76	410	371	57	0	0	**1421**
2012	109	0	0	91	45	99	132	368	310	31	27	5	**1217**
2013	0	5	0	26	246	395	312	0	177	673	0	0	**1834**
2014	0	38	14.3	0	221	157	694	448	336	122	0	0	**2030**
Average	**16.2**	**17.85**	**37.27**	**44.55**	**146.75**	**255.59**	**329.71**	**369.45**	**404.9**	**251.05**	**52.7**	**3.9**	**1930**



ANNEXURE – 1: Block wise Rainfall

Month wise Annual Rainfall in Basta Block, Balasore District, Odisha

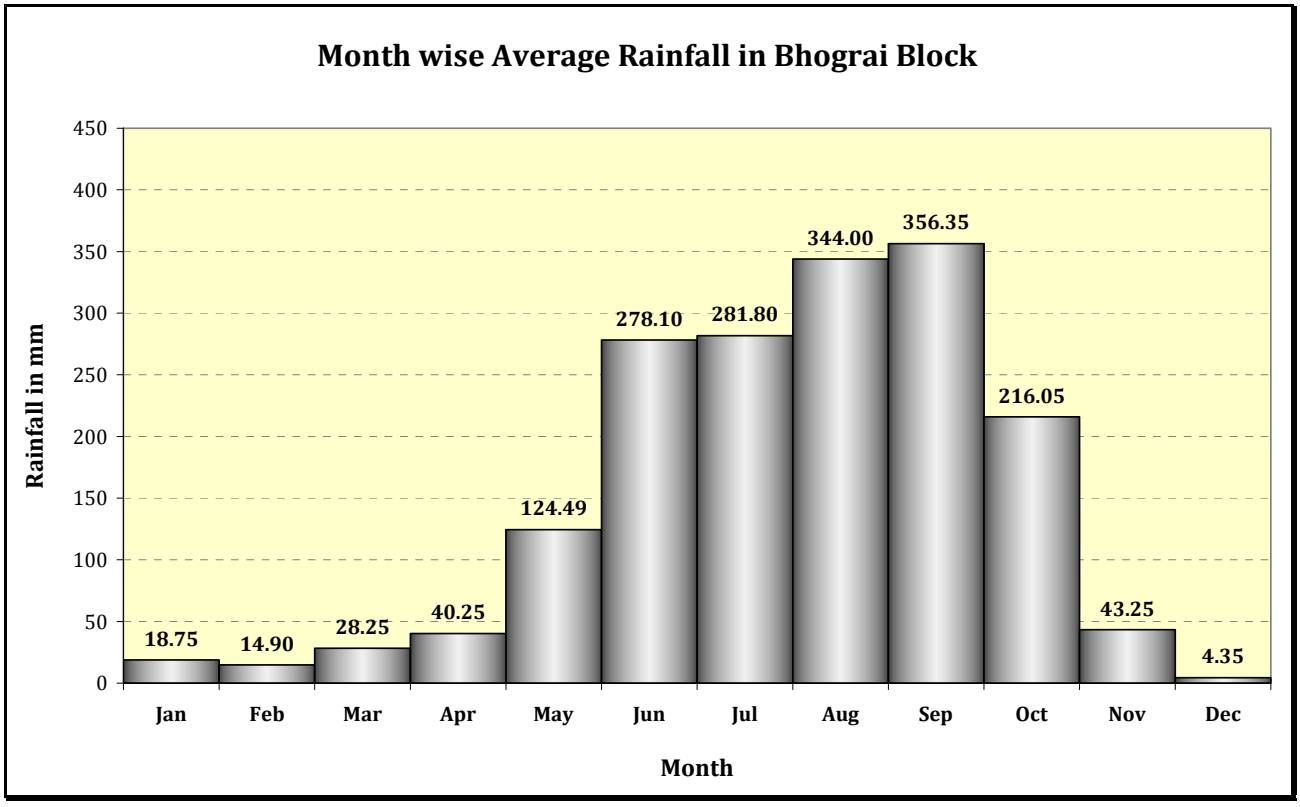
Month/ Year	Rainfall in mm												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1995	5	28	11	31	298	204	144	327	188	279	123	0	**1638**
1996	0	37	0	0	48	163	185	484	38	54	3	0	**1012**
1997	28	9	213	129	62	229	407	489	300	28	22	20	**1936**
1998	55	15	87	115	100	132	117	62	373	167	45	0	**1268**
1999	0	0	0	0	120	352	291	290	386	130	48	0	**1617**
2000	0	90	0	88	103	256	326	129	304	30	0	0	**1326**
2001	0	0	49	66	145	390	238	307	129	298	27	0	**1649**
2002	17	0	53	37	24	208	88	304	367	56	58	0	**1212**
2003	0	8	49	3	94	188	242	117	112	441	45	5	**1304**
2004	0	0	0	1	48	174	129	307	126	212	0	0	**997**
2005	1	0	50	25	34	221	172	216	508	364	0	0	**1591**
2006	0	0	2	20	85	205	627	428	360	42	20	0	**1789**
2007	4	93	0	50	63	183	562	619	519	60	58	0	**2211**
2008	75	53	0	11	37	870	187	280	250	0	58	0	**1821**
2009	0	0	2	0	163	118	320	270	198	127	38	0	**1236**
2010	0	0	0	0	207	78	216	155	296	142	38	27	**1159**
2011	0	0	0	27	191	406	107	250	379	0	0	0	**1360**
2012	51	0	0	101	58	123	290	329	237	82	14	28	**1313**
2013	0	2	0	58	165	364	273	0	446	699	0	0	**2007**
2014	0	12	14	5	170	122	526	530	312	156	0	0	**1847**
Average	**11.8**	**17.35**	**26.5**	**38.35**	**110.75**	**249.3**	**272.35**	**294.65**	**291.4**	**168.35**	**29.85**	**4**	**1515**



ANNEXURE – 1: Block wise Rainfall

Month wise Annual Rainfall in Bhograi Block, Balasore District, Odisha

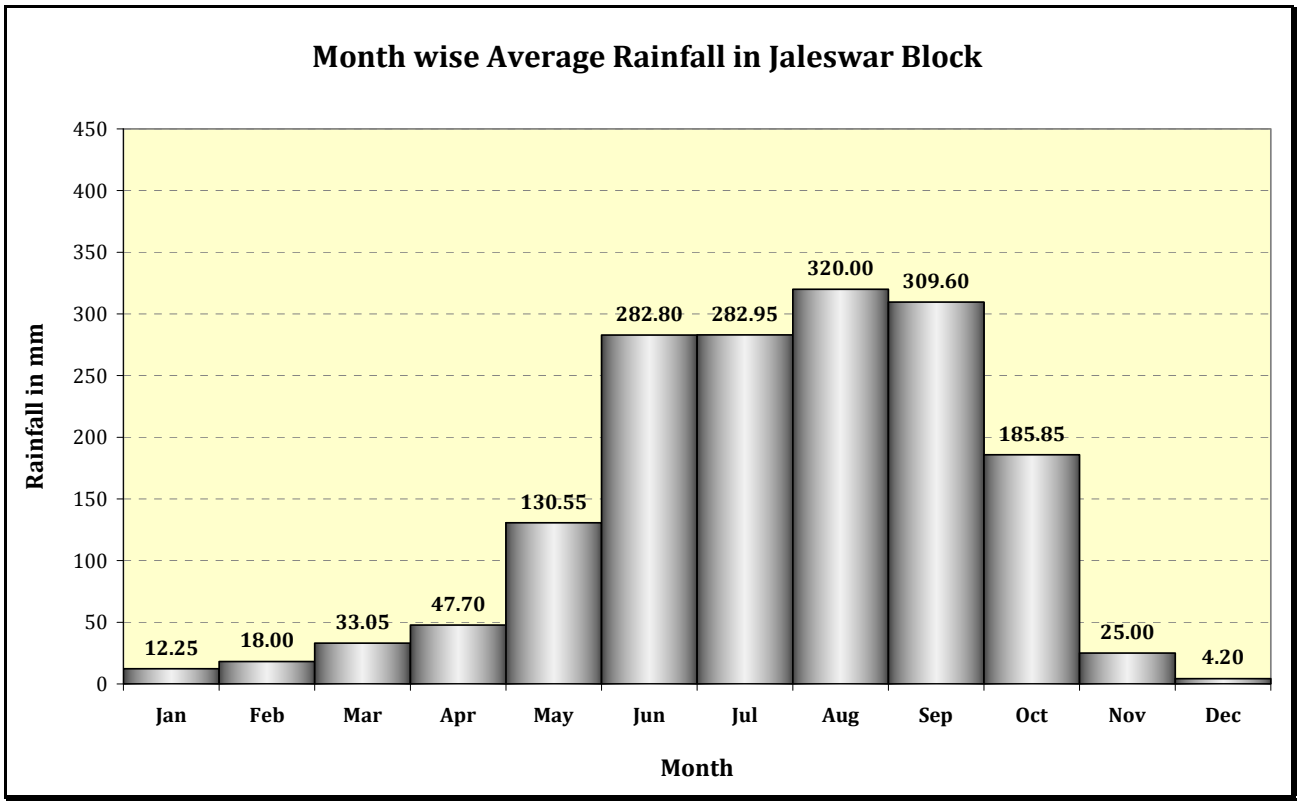
Month/ Year	Rainfall in mm												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1995	6	34	14	28	449	169	236	405	336	128	221	0	**2026**
1996	12	5	0	13	12	229	325	625	169	160	20	0	**1570**
1997	55	26	66	213	55.8	234	271	477	594	22	17	34	**2065**
1998	39	25	176	111	60	295	136	153	631	327	86	0	**2039**
1999	0	0	0	2	243	231	205	293	474	308	71	0	**1827**
2000	0	42	0	56	162	329	212	227	275	81	12	0	**1396**
2001	0	0	62	85	113	337	168	264	116	142	48	0	**1335**
2002	32	0	65	85	125	302	187	239	451	31	130	0	**1647**
2003	0	10	69	10	59	336	364	286	129	632	10	22	**1927**
2004	0	0	0	28	36	412	353	338	148	284	0	0	**1599**
2005	5	0	80	20	75	192	305	394	850	1040	0	0	**2961**
2006	0	0	12	0	96	353	467	400	373	52	10	0	**1763**
2007	0	64	0	0	75	228	478	909	355	24	84	0	**2217**
2008	139	50	0	20	102	565	187	197	280	19	84	0	**1643**
2009	0	0	0	0	248	73	303	317	256	116	34	0	**1347**
2010	0	0	2	0	55	122	223	191	198	162	0	25	**978**
2011	0	0	0	8	106	485	174	570	518	48	0	0	**1909**
2012	87	0	0	63	30	163	169	106	250	33	38	6	**945**
2013	0	0	0	63	151	293	291	0	382	600	0	0	**1780**
2014	0	42	19	0	237	214	582	489	342	112	0	0	**2037**
Average	**18.75**	**14.9**	**28.25**	**40.25**	**124.49**	**278.1**	**281.8**	**344**	**356.35**	**216.05**	**43.25**	**4.35**	**1751**



ANNEXURE – 1: Block wise Rainfall

Month wise Annual Rainfall in Jaleswar Block, Balasore District, Odisha

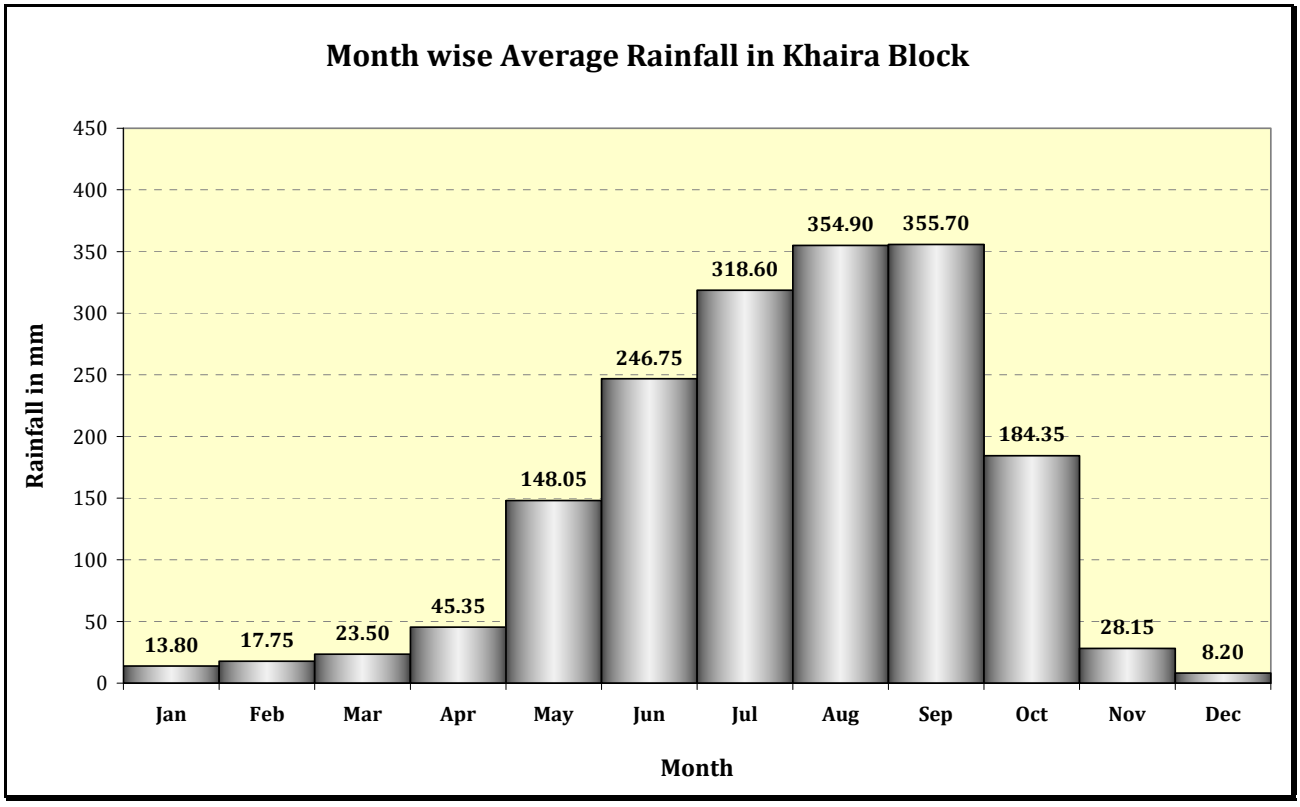
Month/ Year	Rainfall in mm												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1995	5	27	19	0	390	227	202	420	300	195	229	0	**2014**
1996	0	14	0	0	12	299	341	507	78	81	5	0	**1337**
1997	24	37	86	201	115	188	259	536	299	212	6	22	**1985**
1998	75	5	139	117	57	125	175	52	676	215	106	0	**1742**
1999	0	0	0	0	480	377	301	389	350	219	26	0	**2142**
2000	3	79	0	86	122	286	189	127	427	37	3	0	**1359**
2001	0	0	42	87	234	535	283	310	174	321	19	0	**2005**
2002	24	0	6	149	136	166	54	273	555	72	72	0	**1507**
2003	0	10	43	19	101	296	217	194	98	491	0	2	**1471**
2004	0	0	38	22	42	318	218	403	93	251	0	0	**1385**
2005	2	0	167	39	115	126	387	285	500	597	0	0	**2218**
2006	0	0	42	38	46	322	575	344	432	2	0	0	**1801**
2007	2	70	0	77	52	441	544	689	364	67	0	0	**2306**
2008	77	52	33	4	65	771	376	485	230	7	0	0	**2100**
2009	0	0	0	0	96	68	175	184	147	96	6	0	**772**
2010	0	0	7	0	123	236	346	134	171	113	0	35	**1165**
2011	0	0	0	24	122	360	72	427	370	1	0	0	**1376**
2012	32	0	0	28	16	96	150	251	282	17	28	25	**925**
2013	1	6	5	63	155	277	289	0	357	611	0	0	**1764**
2014	0	60	34	0	132	142	506	390	289	112	0	0	**1665**
Average	**12.25**	**18**	**33.05**	**47.7**	**130.55**	**282.8**	**282.95**	**320**	**309.6**	**185.85**	**25**	**4.2**	**1652**



ANNEXURE – 1: Block wise Rainfall

Month wise Annual Rainfall in Khaira Block, Balasore District, Odisha

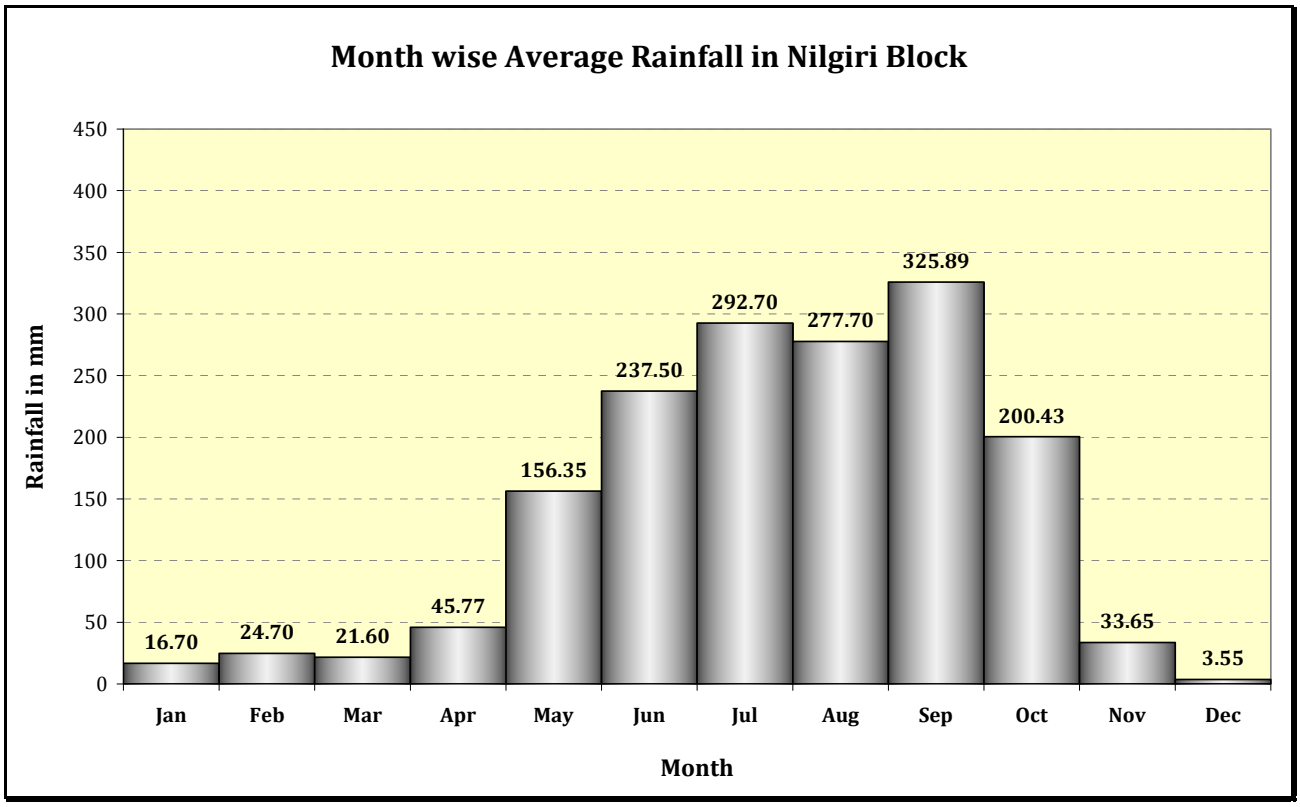
Month/ Year	Rainfall in mm												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1995	3	78	14	0	319	254	166	526	373	259	176	0	**2168**
1996	23	22	0	59	45	120	225	412	49	78	2	0	**1035**
1997	13	30	67	174	72	279	371	571	301	35	29	113	**2055**
1998	28	10	57	101	137	188	158	177	424	88	30	0	**1398**
1999	0	0	0	1	156	213	102	280	443	635	30	0	**1860**
2000	8	51	0	40	195	229	251	250	282	86	0	0	**1392**
2001	0	3	123	15	188	386	490	400	151	136	41	0	**1933**
2002	48	0	20	146	62	118	169	372	179	47	38	0	**1199**
2003	0	19	39	110	105	191	357	279	82	327	35	24	**1568**
2004	0	0	5	30	125	227	413	392	288	179	0	0	**1659**
2005	17	0	23	130	44	215	505	138	348	291	0	0	**1711**
2006	0	0	40	3	10	295	279	650	364	31	12	0	**1684**
2007	5	82	0	10	171	282	284	406	583	35	0	0	**1858**
2008	105	3	0	7	152	811	318	389	434	0	0	0	**2219**
2009	0	0	0	0	119	146	560	388	334	326	91	0	**1964**
2010	0	0	0	0	344	18	458	82	374	160	0	23	**1459**
2011	0	0	0	14	32	443	61	447	737	0	0	0	**1734**
2012	26	0	0	26	72	56	173	349	409	39	79	4	**1233**
2013	0	2	14	10	364	270	520	0	639	773	0	0	**2592**
2014	0	55	68	31	249	194	512	590	320	162	0	0	**2181**
Average	**13.8**	**17.75**	**23.5**	**45.35**	**148.05**	**246.75**	**318.6**	**354.9**	**355.7**	**184.35**	**28.15**	**8.2**	**1745**



ANNEXURE – 1: Block wise Rainfall

Month wise Annual Rainfall in Nilgiri Block, Balasore District, Odisha

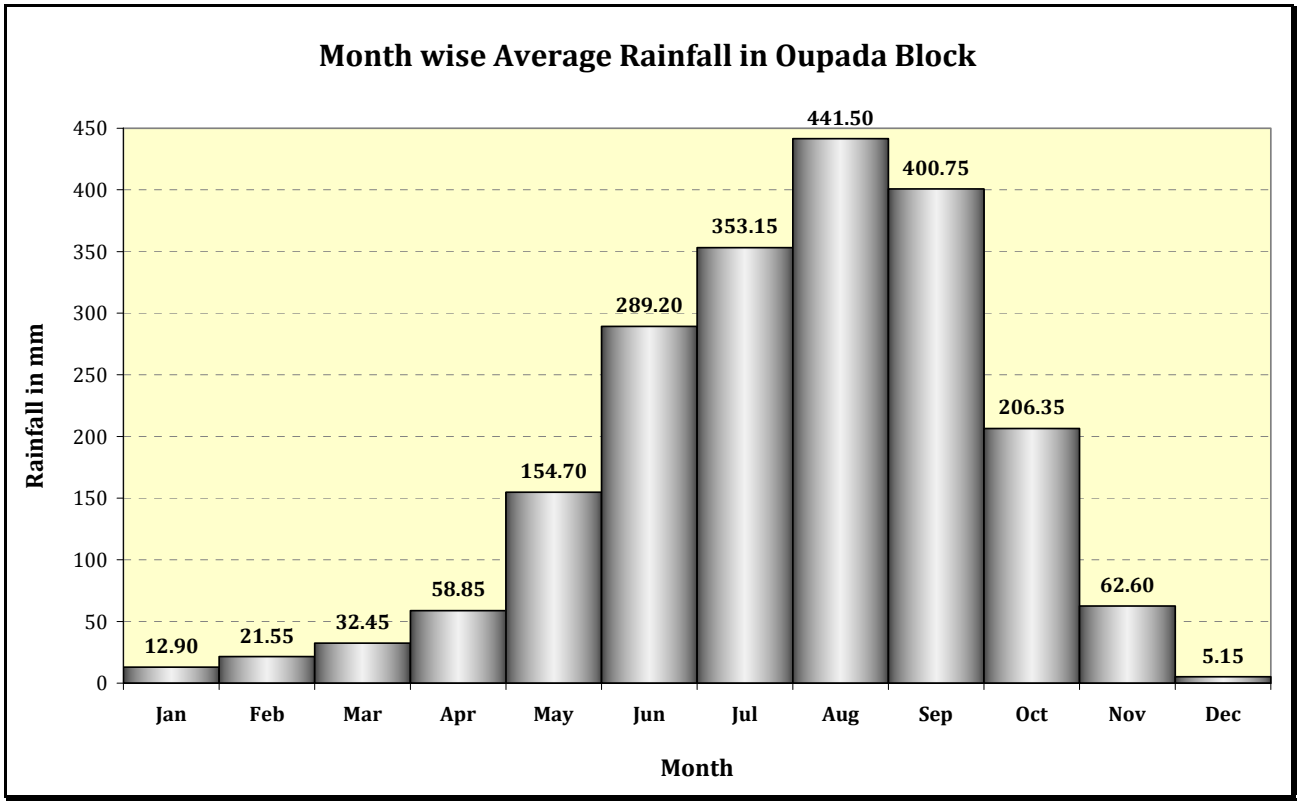
Month/ Year	Rainfall in mm												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1995	16	29	65	9	575	202	249	326	251	212	254	0	**2188**
1996	0	34	0	16	100	235	354	450	109	113	0	0	**1411**
1997	30	21	82	152	134	272	380	511	322	69	39	28	**2040**
1998	29	50	72	93	98	138	351	162	471	161	55	0	**1680**
1999	0	0	0	27	268	331	256	305	331	574	80	0	**2172**
2000	37	121	0	48	200	333	192	116	191	23	0	0	**1261**
2001	0	9	37	20	46	244	532	312	80	219	20	0	**1519**
2002	16	0	10	86	46	305	120	220	344	21	41	0	**1209**
2003	0	0	16	17	34	239	323	134	156	313	12	2	**1246**
2004	0	0	0	33	58	124	211	177	219	174	0	0	**996**
2005	5	0	36	104	85	174	338	112	506	303	0	0	**1663**
2006	0	0	19	25	138	246	315	625	496.5	12	67	0	**1944**
2007	7	97	0	9.4	143	247	397	439	787	33	25	0	**2184**
2008	45	0	0	26	109	614	255	274	360	2	25	0	**1710**
2009	0	0	43	0	161	109	425	227	329	340	26	0	**1660**
2010	0	0	0	0	327	145	280	133	320	231	4	24	**1464**
2011	0	52	0	50	155	341	121	214	329.2	3.5	0	0	**1266**
2012	149	0	0	57	6	50	133	286	221	14	25	17	**958**
2013	0	2	0	103	185	263	220	0	362	1094	0	0	**2229**
2014	0	79	52	40	259	138	402	531	333	97	0	0	**1931**
Average	**16.7**	**24.7**	**21.6**	**45.77**	**156.35**	**237.5**	**292.7**	**277.7**	**325.89**	**200.43**	**33.65**	**3.55**	**1637**



ANNEXURE – 1: Block wise Rainfall

Month wise Annual Rainfall in Oupada Block, Balasore District, Odisha

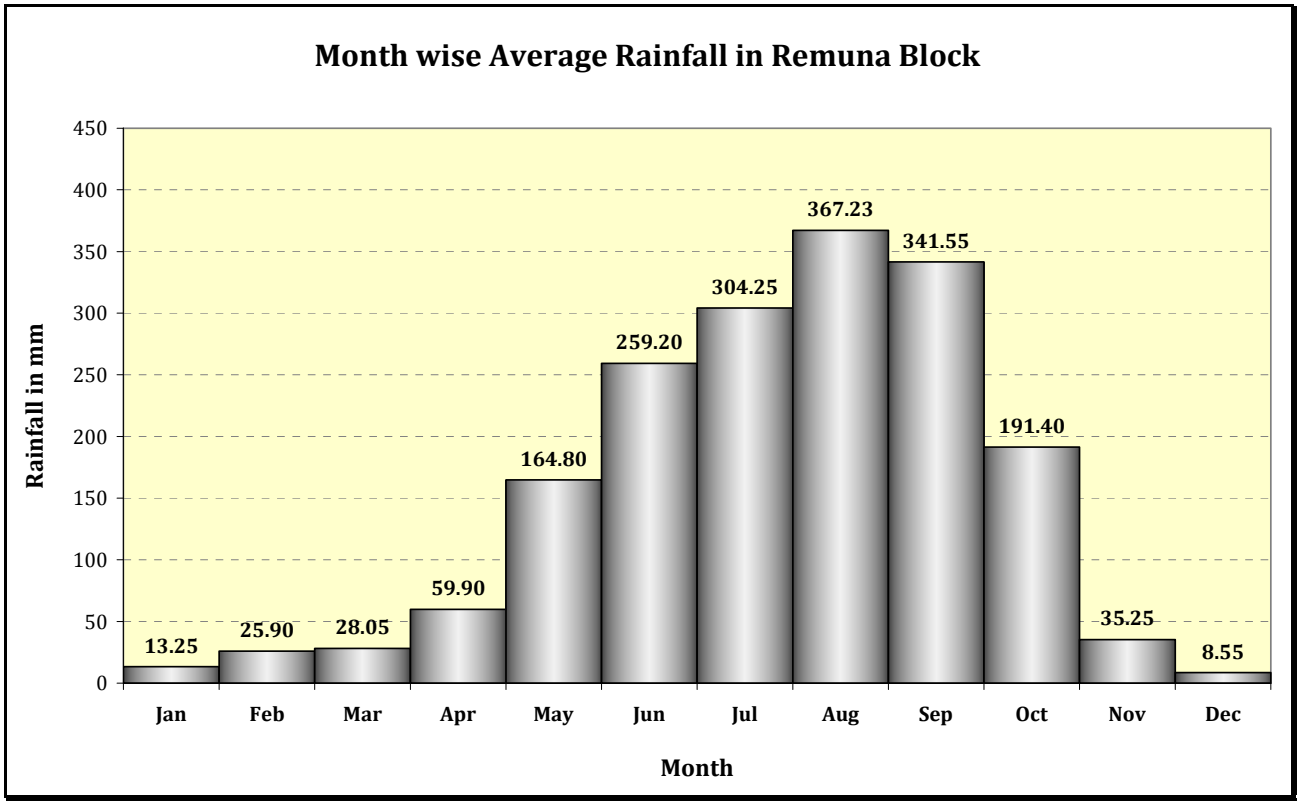
Month/ Year	Rainfall in mm												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1995	5	76	24	0	264	271	257	613	503	204	168	0	2385
1996	19	0	0	66	37	201	344	583	52	44	3	0	1349
1997	7	19	99	210	82	430	373	553	224	43	42	53	2135
1998	7	5	45	155	105	282	238	201	483	130	44	0	1695
1999	0	0	0	0	172	293	433	833	849	1374	650	0	4604
2000	31	135	0	122	388	285	295	442	674	68	5	0	2445
2001	0	29	137	44	293	541	820	659	172	178	57	0	2930
2002	13	0	95	129	38	247	220	522	349	46	33	0	1692
2003	0	34	61	88	176	355	410	254	152	398	98	14	2040
2004	0	0	2	57	133	240	451	456	334	194	0	0	1867
2005	22	0	95	113	104	429	673	275	482	287	0	0	2480
2006	0	0	49	29	236	248	350	664	503	3	33	0	2115
2007	0	27	0	12	127	426	324	414	774	6	0	0	2110
2008	115	0	0	12	31	529	193	325	384	0	0	0	1589
2009	0	0	0	0	147	80	542	577	476	204	83	0	2109
2010	0	0	0	19	333	40	154	207	262	163	0	23	1201
2011	0	83	25	50	72	377	108	477	494	25	0	0	1711
2012	39	0	0	10	21	54	84	275	228	8	36	13	768
2013	0	0	0	4	130	160	222	0	294	609	0	0	1419
2014	0	23	17	57	205	296	572	500	326	143	0	0	2139
Average	**12.90**	**21.55**	**32.45**	**58.85**	**154.70**	**289.20**	**353.15**	**441.50**	**400.75**	**206.35**	**62.60**	**5.15**	**2039**



ANNEXURE – 1: Block wise Rainfall

Month wise Annual Rainfall in Remuna Block, Balasore District, Odisha

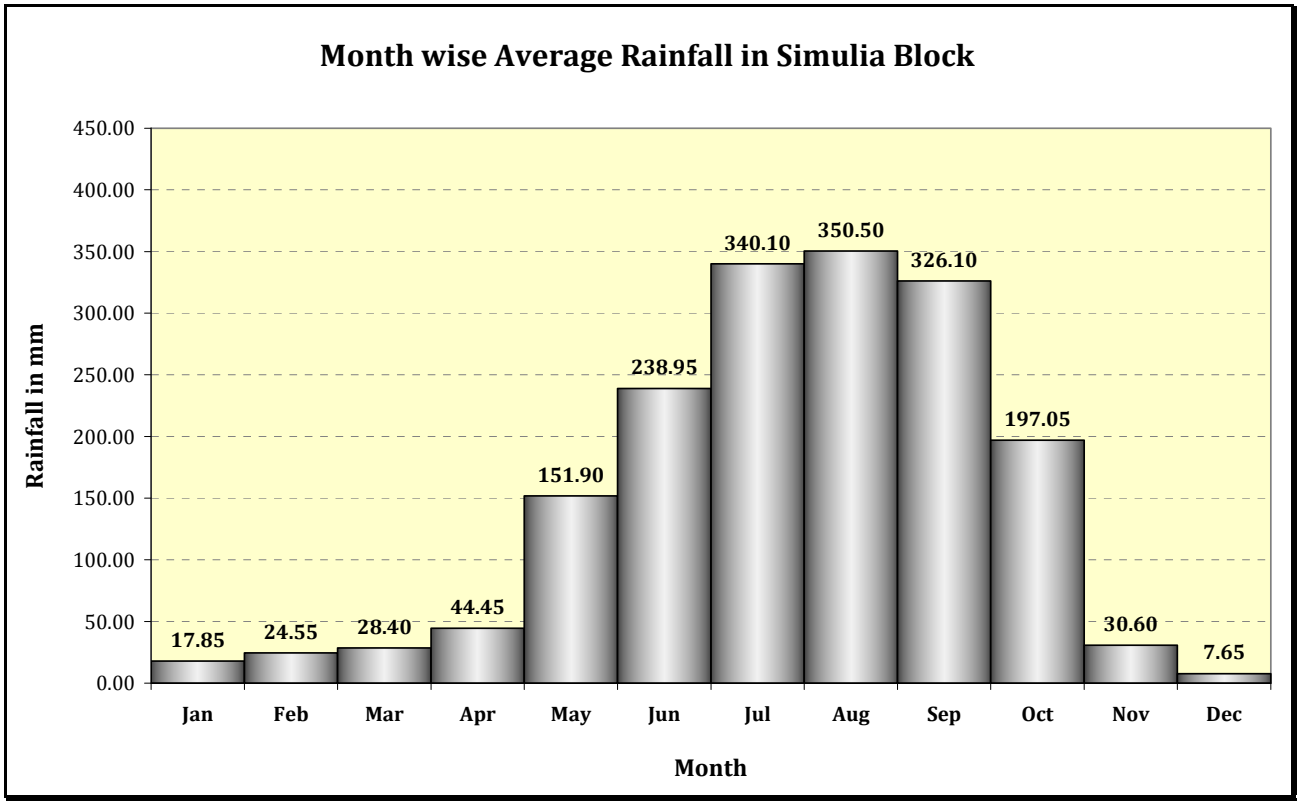
Month/ Year	Rainfall in mm												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1995	28	76	73	42	592	367	295	516	363	403	318	0	**3073**
1996	42	9	0	17	199	387	757	809	192	313	0	0	**2725**
1997	20	0	144	267	173	541	538	936	555	54	16	87	**3331**
1998	41	83	100	127	215	258	349	229	359	108	82	0	**1951**
1999	0	0	0	0	142	330	130	212	308	452	26	0	**1600**
2000	0	112	0	69	185	231	237	314	278	18	0	0	**1444**
2001	0	18	53	18	187	273	393	318	173	215	43	0	**1691**
2002	37	0	46	33	23	187	85	259	343	64	34	0	**1111**
2003	0	0	32	0	37	235	351	186	183	552	42	25	**1643**
2004	0	0	0	36	70	245	265	395	168	250	0	0	**1429**
2005	13	0	20	69	126	185	317	270	470	283	0	0	**1753**
2006	0	0	35	82	67	178	259	439	426	44	33	0	**1563**
2007	2	179	0	5	139	237	452	403	702	43	36	0	**2198**
2008	21	0	0	52	120	578	432	258	372	5	36	0	**1874**
2009	0	0	25	0	229	79	307	266	290	147	9	0	**1352**
2010	0	0	2	0	226	0	90	390.5	553	325	9	46	**1642**
2011	0	0	0	82	152	290	158	470	652	8	0	0	**1812**
2012	61	0	0	177	44	207	140	158	77	11	21	13	**909**
2013	0	2	0	90	190	252	150	0	135	392	0	0	**1211**
2014	0	39	31	32	180	124	380	516	232	141	0	0	**1675**
Average	**13.25**	**25.9**	**28.05**	**59.9**	**164.8**	**259.2**	**304.25**	**367.23**	**341.55**	**191.4**	**35.25**	**8.55**	**1799**



ANNEXURE – 1: Block wise Rainfall

Month wise Annual Rainfall in Simulia Block, Balasore District, Odisha

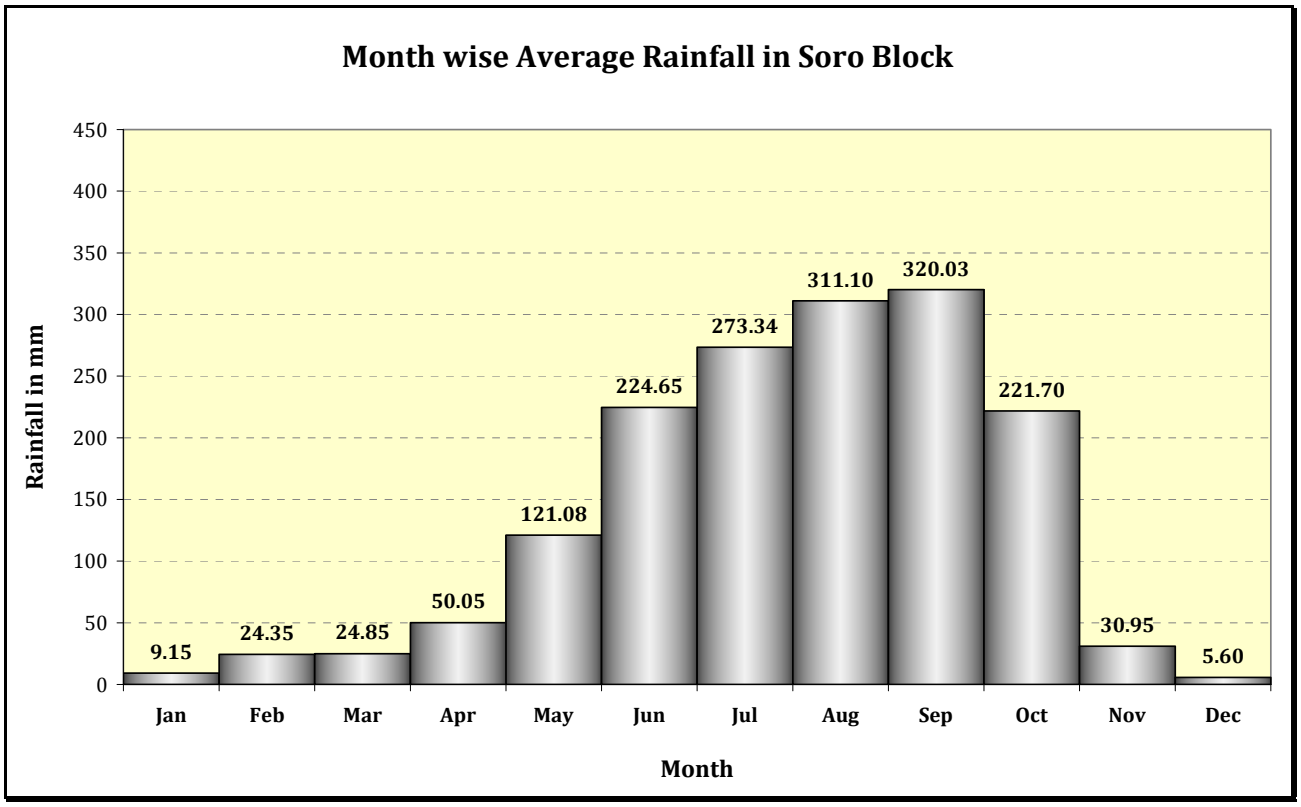
Month/ Year	Rainfall in mm												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1995	3	103	38	0	380	92	260	358	296	421	168	0	**2119**
1996	35	0	0	79	61	224	301	449	64	147	0	0	**1360**
1997	0	23	87	230	20	308	252	502	301	10	53	58	**1844**
1998	2	41	121	105	83	81	257	205	343	123	88	0	**1449**
1999	0	0	0	15	239	269	181	342	373	465	47	0	**1931**
2000	0	121	0	84	168	287	266	252	155	37	0	0	**1370**
2001	0	37	47	11	117	265	236	384	82	45	11	0	**1235**
2002	22	0	6	55	36	141	133	199	170	97	52	0	**911**
2003	0	8	57	10	90	278	486	233	268	696	20	45	**2191**
2004	0	0	0	27	135	349	546	587	345	349	0	0	**2338**
2005	77	0	47	39	86	330	811	216	539	257	0	0	**2402**
2006	0	0	15	54	350	229	355	793	558	44	8	0	**2406**
2007	8	129	0	13	170	416	683	548	850	68	49	0	**2934**
2008	128	21	8	63	326	702	288	382	365	9	49	0	**2341**
2009	0	0	0	0	139	58	572	333	397	221	47	0	**1767**
2010	0	0	0	0	167	165	347	182	204	196	0	33	**1294**
2011	0	0	0	16	47	304	79	278	329	11	0	0	**1064**
2012	68	0	0	43	22	103	81	356	149	55	20	17	**914**
2013	14	0	14	12	130	100	296	0	319	551	0	0	**1436**
2014	0	8	128	33	272	78	372	411	415	139	0	0	**1856**
Average	**17.85**	**24.55**	**28.40**	**44.45**	**151.90**	**238.95**	**340.10**	**350.50**	**326.10**	**197.05**	**30.60**	**7.65**	**1758**



ANNEXURE – 1: Block wise Rainfall

Month wise Annual Rainfall in Soro Block, Balasore District, Odisha

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1995	10	94	39	4	423	133	268	465	356	367	220	0	**2379**
1996	0	0	0	0	19	137	245.3	375	28	99	7	0	**910**
1997	0	15	113	159	138	348	278	533	305	74	13	47	**2023**
1998	5	40	43	61	76	157	79	119	283	210	60	0	**1133**
1999	0	0	0	3	185	295	224	339	283	643	106	0	**2078**
2000	19	52	0	83	112	215	176	176	304	43	0	0	**1180**
2001	0	0	60	23	78	192	297	459	106	161	43	0	**1419**
2002	34	0	46	114	49	278	121	217	244	80	52	0	**1235**
2003	0	42	65	16	56	362	309.5	135	283	480	15	11	**1775**
2004	0	0	0	55	72	146	259.5	329	344	268	0	0	**1474**
2005	23	0	20	41	61	238	346	146	426	189	0	0	**1490**
2006	0	0	12	0	65	114	201	497	285	7	20	0	**1201**
2007	2	141	0	0	46	260	414	414	476	84	2	0	**1839**
2008	20	19	4	42	76	439	150	172	249	6	2	0	**1179**
2009	0	0	0	0	148	142	851.5	297	595	309	51	0	**2394**
2010	0	0	0	0	127	189	391	113	254.5	324	0	10	**1409**
2011	0	17	15	101	147.5	369	187	326	575	71	0	0	**1809**
2012	70	0	0	156	26	87	167	570	267	11	28	44	**1426**
2013	0	4	25	70	267	70	53	0	386	836	0	0	**1711**
2014	0	63	55	73	250	322	449	540	351	172	0	0	**2275**
Average	**9.15**	**24.35**	**24.85**	**50.05**	**121.08**	**224.65**	**273.34**	**311.1**	**320.03**	**221.7**	**30.95**	**5.6**	**1617**



ANNEXURE – 2: Chemical Analysis of Water Samples(NHS : Phreatic Aquifer)

Location	pH	EC	TDS	TH	TA	Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4	F
		µS/cm	mg/L											
Baband	7.5	550	258	115	200	24	13	63	0.2	0	244	32	4	0.5
Baghudi	7.8	400	196	155	150	38	15	16	0	0	183	28	7	0.7
Bahanga	8.2	250	121	100	95	20	12	8	0	0	116	21	2	0.5
Bankisial	8	550	260	125	205	40	6	60	0	0	250	25	4	0.5
Basta	8.2	300	157	115	115	30	10	15	0	0	140	18	14	0.6
Benthiapada	8.1	400	203	150	145	38	13	19	0	0	177	32	12	0.4
Bhagabondh	8	450	218	160	165	34	18	22	0	0	201	32	11	1
Bhalukasuni	8.2	300	142	125	115	24	16	8	0	0	140	14	10	0.6
Chalanti	7.8	300	170	80	85	26	4	33	0	0	104	28	27	0.2
Chandipur	7.9	500	248	105	185	36	4	58	0	0	226	25	12	0.5
Chekamara	8	400	200	155	140	28	21	22	0	0	171	32	11	1
Darkholi	8.2	300	151	115	110	32	9	13	0	0	134	18	12	0.5
Jamsuli	8.2	250	128	100	95	36	2	8	0	0	116	14	10	0.6
Kansa	8.3	400	198	150	150	32	17	18	0	0	183	28	11	0.4
Khontopara	8	300	171	85	85	30	2	32	0	0	104	28	27	0.2
Kunchibenia	8.2	300	153	120	110	46	1	13	0	0	134	14	12	0.6
Kupari	8	450	225	165	160	42	15	21	0	0	195	39	10	1
Markona	8	350	187	150	120	54	4	12	0	0	146	28	16	0.6
Mitrapur	8.2	350	177	135	120	26	17	17	0	0	146	32	12	0.4
Raibania	8	300	164	80	80	20	7	32	0	0	98	28	28	0.2
Sathi	8.2	850	474	100	325	38	1	150	1	0	397	46	39	0.8
Soro	8	350	165	135	105	34	12	14	0	0	128	25	16	0.6

ANNEXURE – 3: Chemical Analysis of Water Samples[Exploratory Wells : Deeper Aquifer(II & III)]

Location	pH	EC	TDS	TH	TA	Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4	F
		µS/cm	mg/L											
Raipal	7.74	210	111.735	60	60	12	7.3	15.9	1.7	0	73	31.9	6.26	0.91
Chakmara	7.05	1350	646.085	575	380	36	117.9	54.3	3.1	0	464	205.6	1.57	0.29
Bhaluka Suni	7.88	420	204.405	135	150	16	23.1	33.7	1.3	0	183	35.5	4.57	0.63
Jambani	7.05	170	93	60	50	8	9.7	11.7	1.3	0	61	28.4	1.44	0.52
Chhatrapur	7.86	600	306.02	230	85	56	21.87	31.2	3.7	0	103.7	120.7	20.5	0.2
Raj Berhampur	8.16	1000	523.585	275	250	48	37.665	93.9	3.8	0	305	81.65	105.4	0.67
Sajnagarh	8.42	540	273.58	180	225	60	7.29	34	2	30	213.5	24.85	7.6	1.09
Kalakud	7.91	780	418.31	320	105	100	17.01	31.8	3.8	0	128.1	173.95	27.5	0.2
Simulia	8.15	1200	654.555	390	275	86	42.525	94.6	3.4	0	335.5	149.1	110.5	0.68
Kalijhati	7.83	480	266	215	230	32	32.805	29.7	0.3	0	281	28	2	0.42
Mundugura Sahi	7.98	520	292	240	250	40	34.02	26.1	0.7	0	305	36	2	0.4
Telipal	7.75	630	351	280	310	34	47.385	33	0.5	0	378	43	4	0.51
Charanapal	7.73	600	305	215	250	38	29.16	41.7	0.3	0	305	39	3	0.89
Sahajan Nagar	7.26	740	400	340	330	50	52.245	36	0.1	0	403	53	7	0.53
Jaydev Kasba	7.65	660	323	260	175	28	46.17	29.4	0.1	0	214	103	8	0.85
P.H.No 6	8.09	1290	717	140	355	24	19.44	233.5	0.8	0	433	156	65	1.89
P.H.No 7	8.01	1050	567	185	330	50	14.58	155	0.6	0	403	128	16	1.33
P.H.No 8	8.12	1130	616	125	365	32	10.935	201	0.8	0	445	128	19	2.1
P.H.No 9	8.07	1150	637	140	365	48	4.86	200.5	1	0	445	135	23	1.66
P.H.No 11	7.95	1170	588	125	345	50	0	188	1	0	421	110	27	1.42
P.H.No 12	8.08	1680	901	350	350	38	61.965	223	2	0	427	302	59	1.74
Kantabania	7.97	680	338	225	215	32	35.235	53.5	0.1	0	262	78	7	1.51
Desabandha	7.2	620	307	275	210	62	29.16	15.9	0.1	0	256	64	7	0.55
Tasarda	7.54	900	449	350	325	80	36.45	44.7	2	0	397	82	5	0.087
Shrijang	8.12	410	195	165	135	28	23.085	16	2	0	165	39	4	0.85
Jharanaghati	8.11	450	233	145	180	28	18.225	36.2	6.2	0	220	28	4.9	1.17
Betkata	7.88	580	282	230	245	50	25.515	24.4	6.7	0	299	21	4.2	0.264
Talagadia	7.86	840	418	340	350	54	49.815	47.8	0.2	0	427	43	9.2	0.698
Talagadia	7.92	850	419	345	350	56	49.815	37.9	0.4	0	427	53	7.2	0.775
Tartari	6.96	670	332	245	295	60	23.085	36.64	2.24	0	360	28	1.2	0.447
Khurwantola	7.22	380	192	140	160	36	12.15	22.56	1.19	0	195	21	1.6	0.428
Darakholi	8.05	530	262	175	210	30	24	39.5	1.5	0	256	32	6.9	0.196
Tasarda	8.25	610	307	195	260	40	23	51	0.8	0	317	28	4.5	0.734

ANNEXURE – 3: Chemical Analysis of Water Samples[Exploratory Wells : Deeper Aquifer(II & III)]

Location	pH	EC	TDS	TH	TA	Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4	F
		µS/cm	mg/L											
Ringpur	8.1	540	276	170	180	22	28	43.2	3.1	0	220	64	4.3	1.49
Ringpur	7.46	440	217	140	130	18	23	35.1	2.2	0	159	57	1.3	1.39
Talagadia	8.21	450	224	125	165	12	23	42.51	1.8	0	201	39	4.2	1.156
Betakata	8.24	280	138	140	120	30	16	0.45	2.4	0	146	14	1.6	0.23
Betakata	8.28	380	189	185	175	48	16	1.54	3.5	0	214	11	1.5	0.44
Deshabandha	8.25	780	383	290	330	48	41	38.32	6.6	0	403	46	0.8	0.81
Deshabandha	8.15	770	375	310	310	54	43	31.61	6.2	0	378	50	0.6	0.78

ANNEXURE – 4: Chemical Analysis of Water Samples[Piezometers / Observation Wells : Deeper Aquifer(II & III)]

Location	pH	EC	TDS	TH	TA	Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4	F
		µS/cm	mg/L											
Rapeya	8.15	1570	669	325	415	60	43	127.5	20	0	506	110	60.2	0.5
Narayanpur	7.92	320	156	135	105	44	6	6.9	1.8	0	128	28	5.3	0.85
Sasan (Ada)	8.14	490	232	200	175	54	16	16.3	1.5	0	214	35	3.4	0.85
Manitri	8.08	1750	826	520	250	142	40	120.8	2.4	0	305	326	44.9	0.79
Kalasuni	8.24	310	139	125	110	44	4	3	0.5	0	134	18	2.9	0.68
Hat Maitapur	8.25	1240	552	380	335	92	36	56.7	8.7	0	409	121	36.8	0.5
Kharigaria	7.97	380	215	200	175	30	30	11.3	1	0	214	32	5.3	0.88
Raghubindha	7.93	570	263	155	105	46	10	38.1	2	0	128	78	25.6	0.73
Iswarpur	8.05	310	158	155	125	36	16	4	0.4	0	153	21	4.8	0.69
Sabang	8.12	410	194	165	135	28	23	16	2	0	165	39	3.9	0.85
Kundi	8.05	380	200	175	175	36	21	13.6	0.6	0	214	21	1.6	0.9
Bhogapur	8.1	370	213	200	190	28	32	13.9	0.7	0	232	21	2.8	1.17
Alipur	7.69	420	226	210	210	36	29	13.3	1.1	0	256	18	2.02	1.11
Ambagaria	8.06	430	226	185	205	24	30	24.8	0.9	0	250	18	4.9	0.97
Sardang	8.25	1870	876	705	225	158	75	62.4	1.4	0	275	432	11.06	1.04
Ajipur	8.22	400	171	140	140	34	13	14.9	0.6	0	171	21	2.6	0.99
Raikula	7.99	2690	1097	675	160	84	113	139	20	0	195	588	56.8	0.51
Anandapur	8.21	680	324	135	230	20	21	82.7	2	0	281	35	24.4	0.9
Markona	7.85	530	245	200	165	40	24	22	0.8	0	201	53	5.3	1.09
Kapura	8.15	370	162	150	130	38	13	7.5	0.5	0	159	21	2.7	1.45
Rampo	8.16	350	181	165	145	32	21	10.1	0.7	0	177	28	2.02	0.79
Bauripada	8.22	500	238	210	215	52	19	15.5	0.6	0	262	18	3.3	0.81
Pandu	8.22	520	284	250	240	48	32	19.5	0.9	0	293	28	11.06	0.73
Agatpur	8.14	400	188	180	170	40	19	7.5	0.5	0	207	14	4.9	1.09
Krushnakharji	7.55	420	213	175	205	40	18	4.5	1.4	0	250	21	4.3	1.21
Bari	7.85	750	328	220	90	52	22	38.3	1.1	0	110	135	25.2	0.68
Maharana	8.1	430	180	155	145	38	15	12.1	0.5	0	177	21	5.9	1.1
Kaneibindha	8.04	480	265	250	230	34	40	12.9	1.7	0	281	35	2.6	1.3
Shyamsundarpur	8.12	310	160	150	135	36	15	5.1	0.3	0	165	18	3.9	1.02
Jamjhari	8.1	370	165	120	90	36	7	16.4	0.2	0	110	39	11.5	0.9
Gopalpur	8.14	380	202	185	170	28	28	11.7	0.4	0	207	25	5.8	1.18
Patuli	8.04	440	190	155	140	32	18	16	0.6	0	171	32	6.9	0.97
Khatanagar	8.17	410	232	210	205	36	29	16.5	0.7	0	250	21	5.2	1.24
Talnagar	8.19	380	202	185	175	62	7	4.2	0.9	0	214	14	7.9	0.89

ANNEXURE – 4: Chemical Analysis of Water Samples[Piezometers / Observation Wells : Deeper Aquifer(II & III)]

Location	pH	EC	TDS	TH	TA	Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4	F
		µS/cm	mg/L											
Nuniachand	8.1	380	166	135	140	34	12	14.6	0.6	0	171	11	8.8	1.18
Khirapada	8.21	390	211	215	190	30	34	4.7	0.5	0	232	21	6.1	0.89
Sabira	8.15	320	160	145	125	30	17	7.5	0.7	0	153	21	8.4	0.73
Sirapur	8.09	380	163	145	100	36	13	4.9	0.6	0	122	35	12.5	0.99
Kasba	8.11	430	209	175	170	24	28	22.4	0.7	0	207	21	10.08	1.09
Keshpur	8.22	280	124	115	85	32	9	5.4	0.4	0	104	21	4.3	0.99
Bati	8.09	320	137	130	95	34	11	2.4	0.2	0	116	28	3.42	1.04
Khirkona	8.22	430	255	250	240	34	40	11.3	0.3	0	293	21	3.7	1.32
Haripur	8.12	430	212	190	135	42	21	9.7	0.3	0	165	53	3.8	1.35
Asita	8.24	550	247	240	200	46	30	13.3	0.6	0	244	32	4.5	1.35
Belapur	8.23	530	307	285	265	44	43	17.3	0.3	0	323	39	3.3	1.51
Dhumpur	8.27	280	108	110	75	24	12	1.5	0.2	0	92	21	3.2	0.72
Ada	8.23	240	113	110	90	42	1	1.8	0.1	0	110	14	0	0.5
Jalanga	8.11	380	204	180	180	28	27	15.7	0.3	0	220	21	3.6	0.88
Alipur	8.17	380	183	150	160	34	16	13.4	0.3	0	195	18	4.4	1.1
Chhabatia	8.21	390	167	120	140	24	15	22.1	0.5	0	171	14	6.2	0.91
Chuapada	8.15	340	158	140	130	36	12	9.3	0.3	0	159	21	0	0.99
Kharigaria	8.18	390	178	160	160	30	21	11.5	0.2	0	195	18	0	1.26
Simulia	8.14	280	131	130	105	28	15	3.6	0.1	0	128	21	0	0.84
Amara	8.22	650	338	90	240	16	12	106.8	0.2	0	293	57	1.2	0.83
Nagnam	8.24	550	280	180	190	42	18	44.3	0.2	0	232	60	1	1.13
Nijampur	8.09	430	214	175	140	36	21	18	0.1	0	171	53	1.2	0.42
Remuna	8.12	280	131	125	115	24	16	6.9	0.01	0	140	14	1.2	0.51
Balgopalpur	8.19	300	151	130	95	26	16	11.8	0.01	0	116	39	1	0.27
Nuaparhi	8.07	390	195	170	125	38	18	11.7	0.01	0	153	50	2	0.45
Mitrapur	7.97	490	242	210	140	36	29	18.3	0.1	0	171	71	3	0.48
Machuachk	7.99	610	295	240	170	30	40	32	0.1	0	207	85	5	1.67
Mada Bazar	7.95	410	199	170	125	40	17	15.2	0.001	0	153	50	1	0.37
Kothpal	8.07	380	184	155	130	30	19	15.3	0.01	0	159	39	1.8	0.66
Lingapeda	7.68	710	352	220	280	40	29	59.3	1.9	0	342	50	4.01	0.615
Mobanakpur	7.87	340	173	130	110	40	7	17.8	0.5	0	134	35	6.7	0.574
Sirpur	7.96	390	201	160	130	40	15	19.5	0.6	0	159	39	8.75	0.621
Ulaskharpur	8.04	670	349	145	210	28	18	82.9	2.5	0	256	67	24.78	0.389
Bentala	8.17	460	233	165	165	40	16	33.7	0.8	0	201	39	4.1	0.483

ANNEXURE – 4: Chemical Analysis of Water Samples[Piezometers / Observation Wells : Deeper Aquifer(II & III)]

Location	pH	EC	TDS	TH	TA	Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4	F
		µS/cm	mg/L											
Mangeswarpur	8.19	520	261	150	185	34	16	51.5	1.1	0	226	39	8.5	0.491
Tolopari	8.18	500	269	155	160	50	7	42.5	0.8	0	195	35	37.75	0.802
Dondeharipur	8.09	620	331	135	205	26	17	85.2	1.8	0	250	71	6.96	0.502
Siadimol	8.3	790	406	225	220	32	35	77.5	1	0	268	121	7.68	0.613
Babend	8.29	920	485	310	130	64	36	68.3	1.7	0	159	234	2.6	0.232
Bankisial	8.15	780	397	240	160	36	36	69.7	0.4	0	195	156	2.8	0.686
Jamghati	8.02	580	288	185	205	30	27	48.4	0.3	0	250	57	2.4	0.468
Sialghat	7.94	500	261	150	130	28	19	46.9	0.9	0	159	85	2.6	0.281
Tenda	7.98	700	363	155	200	24	23	89	0.7	0	244	103	2.7	0.945
Benthipeda	8.28	810	413	200	295	30	30	93.5	1.2	0	360	78	2.6	1.12
Bhalukesuni	8.06	120	63	50	50	12	5	5.6	0.6	0	61	7	2.8	0.074
Chekmara	8.21	750	366	255	235	26	46	54.8	2.8	0	287	92	3	0.437
Gohiri	8.07	640	312	225	245	32	35	42.5	2.5	0	299	50	3.12	0.327
Bhagabandh	8.17	690	360	215	160	30	34	52	10	0	195	110	28.3	0.205
Bonkheda	8.1	610	306	145	225	24	21	74.4	1	0	275	46	3.8	1.36
Telipal	8.3	600	277	200	235	22	35	45.9	0.6	0	287	25	7.5	0.508
Kunchibaria	8.18	280	141	95	85	22	10	18.1	2.3	0	104	35	2.31	0.143
Dasenathipur Sasan	8.3	740	387	210	160	32	32	74.5	0.8	0	195	149	2.5	0.317
Shyamasundarpur	8.11	490	243	155	175	20	26	38.7	0.6	0	214	50	2.6	0.446
Kandagaradi	8.22	440	226	140	140	36	12	37.1	0.8	0	171	53	2.7	0.352
Belpada	8.15	620	319	175	160	24	28	62.3	0.3	0	195	106	2.6	0.441
Kendganari	8.2	800	409	275	170	46	39	58.3	0.8	0	207	160	2.7	0.359
Keshuipur	8.12	560	281	150	240	26	21	59.7	2.2	0	293	25	3.2	0.61
Boldipada	8.27	390	186	175	155	36	21	8.9	0.5	0	189	25	1.96	0.498
Mahumma	8.25	480	243	170	135	32	22	32.4	1.1	0	165	71	2.7	0.557
Champur	8.18	380	189	160	145	36	17	13.2	0.4	0	177	25	10.1	0.636
Radhabalavpur	8.23	400	194	140	135	26	18	25.7	0.8	0	165	39	3.2	0.369
Barokhari	8.22	390	196	150	140	34	16	20.9	0.4	0	171	32	8.75	0.579
Mugunipur	8.25	400	204	130	150	30	13	33.3	0.4	0	183	35	1.96	0.46
Bidu	8.23	580	295	145	235	22	22	63.7	1.5	0	287	28	16.46	0.5043
Soro	7.61	340	170	130	125	28	15	16.8	1.5	0	153	32	1.5	0.714
Basudevpur	7.6	500	251	220	195	52	22	14.4	1.4	0	238	35	8.75	0.685
Nadigaon	7.4	350	170	140	145	32	15	13.9	0.5	0	177	21	0.53	0.699
Madhusudanpur	7.61	460	230	180	155	38	21	22.1	1.1	0	189	50	4.5	0.685

ANNEXURE – 4: Chemical Analysis of Water Samples[Piezometers / Observation Wells : Deeper Aquifer(II & III)]

Location	pH	EC	TDS	TH	TA	Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4	F
		µS/cm	mg/L											
Kurei	7.48	480	240	190	160	40	22	22.8	1.2	0	195	53	4.75	0.711
Odda	7.56	270	134	105	110	26	10	12.4	0.3	0	134	18	0.62	0.555
Sonvapeda	7.62	510	239	180	195	22	30	34.1	1.4	0	238	28	6.11	0.738
Kusudnduspur	7.65	380	181	155	145	28	21	15.3	0.8	0	177	28	0.45	0.682
Khajuridiha	7.69	400	197	170	150	34	21	14.9	0.8	0	183	35	0.98	0.738
Machada	7.54	380	184	155	160	40	13	15.1	0.8	0	195	18	1	0.467
Janlapeda	7.65	420	202	175	160	30	24	15.4	0.6	0	195	35	1	0.726
Gondra	7.67	420	207	130	155	20	19	35.1	2.2	0	189	35	1.8	0.845
Bholpara	7.62	290	144	115	120	32	9	11.7	0.6	0	146	18	0.3	0.512
Kuruni	7.64	410	196	160	155	30	21	16.2	0.6	0	189	35	0.31	0.772
Budei	7.67	400	194	170	160	48	12	11.4	0.5	0	195	25	1.05	0.514
Parisials	7.65	470	233	195	185	36	26	16.7	0.5	0	226	32	9.969	0.655
Chatare	7.69	380	186	135	160	26	17	25.4	0.6	0	195	21	0.38	0.562
Tentulipada	7.78	430	219	150	175	28	19	28.5	1.5	0	214	35	0.96	0.917
Rafeilpur	7.77	420	203	150	185	26	21	25.2	0.8	0	226	18	0.9	0.613
Raghunathpur	7.74	430	212	185	165	40	21	16.2	0.7	0	201	35	0.32	0.682
Manipur	7.72	450	216	190	180	40	22	16.4	0.8	0	220	28	0.29	0.712
Balianta Monganijpur	7.74	430	206	155	180	20	26	25.7	0.9	0	220	25	0.31	0.591
Alpur	7.77	440	218	160	170	26	23	28.2	1.5	0	207	35	1.5	0.896
Rosha	7.78	470	231	165	200	28	23	28	1.2	0	244	28	2.26	0.921
Hansipatna	7.76	320	161	130	135	28	15	14.6	0.3	0	165	21	0.71	0.628
Dalong	7.74	400	191	170	165	48	12	9.7	0.7	0	201	21	0.31	0.562
Bilabankia	7.76	340	166	140	145	30	16	13.7	0.4	0	177	18	0.28	0.616
Khairars	7.71	450	218	205	175	40	26	10	0.9	0	214	35	0.29	0.586
Balipur	7.75	340	164	140	140	30	16	14.7	0.3	0	171	18	0.26	0.593
Nalpara	7.79	400	194	175	155	46	15	10.5	1	0	189	28	0.29	0.581
Sonasankh	7.85	520	256	175	215	28	26	40	0.4	0	262	28	4.97	0.608
Braohmansahi	7.88	450	223	145	165	22	22	38.9	0.6	0	201	35	5.2	0.613
Gopinathpur	7.76	470	230	155	180	14	29	37.6	0.2	0	220	35	5.6	0.579
Hedergadia	7.91	430	220	130	150	32	12	38	0.4	0	183	43	4.5	0.588
Bankitira	7.82	320	162	125	120	36	9	16.9	0.2	0	146	25	3.1	0.522
Ponharajpur	7.75	320	156	120	115	22	16	17.8	0.3	0	140	28	2.64	0.54
Tuto	7.94	500	257	125	200	34	10	56.7	0.5	0	244	32	4.11	0.621
Kunnamla Sasan	8.05	570	288	165	220	32	21	58.1	0.2	0	268	39	6.21	0.634

ANNEXURE – 4: Chemical Analysis of Water Samples[Piezometers / Observation Wells : Deeper Aquifer(II & III)]

Location	pH	EC	TDS	TH	TA	Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4	F
		µS/cm	mg/L											
Achhulpur	7.98	450	229	110	185	28	10	51	0.5	0	226	25	3.65	0.574
Basidipur	7.97	470	233	125	190	20	18	49.4	0.4	0	232	28	2.64	0.714
Nijansa	7.98	490	246	135	190	26	17	50.2	0.4	0	232	35	3.26	0.688
Jhatia	7.91	230	117	90	85	34	1	9.7	0.2	0	104	18	2.87	0.54
Rudungia	7.78	290	139	125	105	24	16	9.3	0.4	0	128	21	4.6	0.522
Kalajhatia	7.84	450	224	140	175	26	18	38.4	0.2	0	214	32	4.11	0.514
Mohatipur	7.98	480	228	155	200	30	19	37.8	0.2	0	244	18	3.03	0.415
Gopindpur	7.98	490	244	155	195	22	24	44.1	0.6	0	238	32	3.8	0.668
Ambadina	7.92	520	257	160	200	16	29	44.7	0.2	0	244	43	3.88	0.762
Romahandrapur	8.25	850	434	195	330	24	33	104	5.9	0	403	60	9.16	0.626
Sarestia	8.26	850	430	180	325	22	30	110	5.8	0	397	57	9.86	0.621
Ovpada	8.08	730	390	200	180	42	23	78	3.6	0	220	110	25.3	0.261
Talakia	7.96	750	392	175	190	32	23	94.4	3.6	0	232	99	26.3	0.226
Palaspur	7.89	770	407	200	160	44	22	83.8	0.4	0	195	152	8.7	0.495
Janalapal	7.99	460	233	130	190	20	19	46.5	0.1	0	232	28	5.05	0.509
Sonvgaon	7.87	820	435	225	155	40	30	84.9	0.2	0	189	181	6.21	0.489
Singarpur	7.65	550	271	175	225	24	28	46.5	0.2	0	275	32	5.05	0.831
Ganvdahota	7.97	820	422	245	195	48	30	68.3	0.2	0	238	152	6.52	0.503
Gendiben	7.92	720	367	240	190	28	41	49.7	16.7	0	232	106	11.3	0.485
Solendgedia	8.09	520	258	165	215	22	27	46	0.1	0	262	28	5.9	0.491
Kalia	7.94	660	352	205	165	38	27	48.4	11.1	0	201	117	11.1	0.483
Kuronda	7.96	680	354	225	180	40	30	49.5	8	0	220	106	11.8	0.493
Gopinathpur	8.07	540	273	165	205	32	21	48.8	0.3	0	250	39	8.7	0.679
Nandun	8.11	560	290	170	205	38	18	49.3	0.1	0	250	53	8.6	0.668
Asuria	8.14	550	280	165	200	28	23	49.5	0.2	0	244	50	8.9	0.702
Ambaliatha	8.12	460	214	210	190	56	17	9.8	0.3	0	232	11	5.4398	0.661
Nampo	8.19	479	241	190	205	52	15	28.4	0.1	0	250	21	1.6338	0.6
Kamarda	7.94	494	226	185	130	38	22	23.3	0	0	159	60	3.9174	0.55
Uplahat	8.01	422	196	160	155	40	15	19.1	0.1	0	189	25	3.44165	0.38
Dingasol(Jampua)	7.95	572	238	195	170	46	19	29.1	0.1	0	207	39	2.87075	0.5
Kuluda	7.97	667	340	180	205	36	22	63.1	0.3	0	250	50	46.164	0.35
Danara	7.99	735	371	205	180	48	21	58.4	0.4	0	220	74	61.1977	0.18
Ghamaria	8.34	635	325	145	255	34	15	75.2	0.2	3	305	39	8.77005	0.55
Nikhira	8.31	390	190	115	160	30	10	35.7	0.1	3	189	14	4.298	0.44

ANNEXURE – 4: Chemical Analysis of Water Samples[Piezometers / Observation Wells : Deeper Aquifer(II & III)]

Location	pH	EC	TDS	TH	TA	Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4	F
		µS/cm	mg/L											
Judagadia(Bahadurpur)	8.1	642	310	175	195	24	28	58.1	0.2	0	238	64	19.1414	0.43
Balaranpur	7.96	838	412	225	185	40	30	70.3	0.4	0	226	117	43.02405	0.58
Punchupalli	7.98	721	349	185	180	38	22	65.3	0.3	0	220	106	9.53125	0.22
Jambhinai	8.1	621	304	100	200	44	-2	76.8	0.2	0	244	64	1.0629	0.1
Mahabala	8.11	580	286	160	195	34	18	56.6	0.2	0	238	50	10.007	0.08
Chk Gobindpur	8.15	661	322	130	190	30	13	76.4	0.2	0	232	82	6.86705	0.07
Kasafal	7.44	17030	9771	350	115	60	49	3697	0.7	0	140	5707	189	0.09
Banapur	8.27	772	367	155	200	26	22	83.2	0.3	0	244	99	16.6675	0.13
Irda	8.09	952	448	220	245	36	32	86.9	0.4	0	299	121	24.8	0.1
Nayapara Chhk	8.12	2012	881	265	245	36	43	268.3	0.2	0	299	369	17.8	0.3
Haldipal	8.26	1310	637	290	215	42	45	128	0.3	0	262	216	76.70715	0.8
Nalbahal	8.18	750	361	130	245	22	18	90.8	0.2	0	299	64	18.85595	0.4
Basta	8.16	835	425	145	225	26	19	112	0.2	0	275	85	47.40095	0.87
Chinchargoida	8.14	680	328	160	240	24	24	64.5	0.3	0	293	28	43.3095	0.5
Andhari	7.36	97	41	30	15	8	2	4	0	0	18	14	3.63195	0.15
Basta	7.84	123	66	55	40	14	5	3	0	0	49	11	8.3	0.77
Asankhali	8.28	606	286	80	230	14	11	85	0.3	0	281	32	5.6301	0.81
Kendudiha	8.18	420	232	135	160	36	11	45.5	0.3	0	195	21	22.3	0.34
Rupsa	8.59	1238	615	40	375	6	6	250	0.2	12	433	128	0.492	0.12
Salpata	8.47	671	357	90	255	20	10	104	0.3	9	293	46	23.99405	0.22
Rangamatia	8.56	668	323	55	200	12	6	110.7	0.3	12	220	64	9.6	0.22
Jhampara	8.64	919	560	85	405	16	11	189.4	0.4	15	464	92	8.2943	0.2
Balramgadi	8.58	928	463	50	320	10	6	165.5	0.3	15	360	82	7.7234	0.207
Balramgadi Mirzapur	8.58	951	484	125	300	22	17	147.8	0.3	15	336	99	18.1899	0.41
Angula	8.65	1149	618	135	345	28	16	197	0.2	15	390	149	21.71045	0.406
Alumara-Bangsi	8.56	810	367	155	265	32	18	91.5	0.3	15	293	60	5.4398	1.4
Dandipada	8.24	560	256	120	190	24	15	53.4	0.3	0	232	46	3.06105	0.14
Brahmpur	8	150	78	55	45	12	6	8.6	1	0	55	21	2.4	0.12
Kabatghohi	8.2	370	180	130	155	30	13	23.9	3.1	0	189	14	2.8	0.26
Shalikotha	8.4	280	144	120	120	14	21	16	1.7	6	134	14	4.7	0.5
Baliapal	8.5	763	414	150	270	26	21	108.3	2.5	9	311	74	20.7	0.37
Nachhinda	8.13	419	222	125	190	24	16	40.9	1.1	0	232	18	7.4	0.56
Baunshidiha	8	379	189	140	140	28	17	23.1	7.1	0	171	28	1.6	0.52
Priyabag	8.2	410	200	150	130	30	18	23.9	2	0	159	39	8.6	0.32

ANNEXURE – 4: Chemical Analysis of Water Samples[Piezometers / Observation Wells : Deeper Aquifer(II & III)]

Location	pH	EC	TDS	TH	TA	Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4	F
		µS/cm	mg/L											
Chandaneswar	8.2	498	258	135	205	20	21	49.9	3.9	0	250	28	12.7	0.22
Barbatia	8.1	388	199	160	135	28	22	20.4	4.5	0	165	39	4.3	0.13
Deola	8.4	590	316	185	190	30	27	49.9	9.9	6	220	64	20.8	0.11
Routra	8.2	860	434	215	150	34	32	79.8	3.5	0	183	138	56.9	0.1
Dharamdwar	8.6	843	470	105	375	8	21	147	1.6	9	439	18	49.6	1.01
Sribatsapur	8.5	551	301	140	215	20	22	66.5	0.19	9	244	43	20	0.32
Bhograi	8.2	408	211	100	115	22	11	36.5	3.4	0	140	35	34	0.21
Ranaxitha	8.2	634	348	160	215	28	22	69.6	4.3	0	262	57	38.5	0.19
Chaumukhi	8.1	825	421	205	135	38	27	72.8	4.4	0	165	138	60	0.19
Baliwanda	7.9	377	151	125	100	30	12	14.2	0.8	0	122	28	4.9	0.91
Baliwanda	8	335	179	110	145	20	15	28.9	1.3	0	177	21	5.7	0.79
Somnathpur	8	344	183	115	125	30	10	12.8	0.6	0	153	53	1.3	0.67
Ramabandha	7.9	395	156	125	145	32	11	9.8	0.8	0	177	14	1	0.45
Balinbani	7.9	252	117	95	100	26	7	8	0.4	0	122	11	3.8	0.61
Anantapur	8.11	460	220	145	165	28	18	38.2	0.1	0	201.3	28.4	7.1	0.77
Auradiha	8.15	490	238	200	135	40	24	20.3	0.1	0	164.7	67.45	4.1	0.85
Poradiha	8	490	239	200	145	38	26	20.9	0.1	0	176.9	60.35	5.28	0.74
Abhana	7.83	600	303	195	145	36	26	42	0.1	0	176.9	102.95	7.3	0.95
Kharasahapur	8.09	550	272	170	175	28	24	46.3	0.1	0	213.5	60.35	6.13	0.81
Balikhanda	7.94	420	186	175	140	20	30	10.7	0.2	0	170.8	35.5	3.9	0.86
Balikhanda	8.01	450	237	170	210	28	24	33	0.1	0	256.2	17.75	5.8	0.59
Chakradharpur	7.92	400	185	180	145	32	24	8.3	0.1	0	176.9	28.4	3.4	0.71
Somnathpur	8.12	470	215	195	150	42	22	9.1	0.1	0	183	46.15	4.5	0.76
Ramakrishnapur	7.96	360	165	150	125	38	13	6.8	0.1	0	152.5	24.85	5.8	0.67
Mrutunge	7.93	400	188	170	150	30	23	11	0.1	0	183	28.4	3.9	0.86
Purushottampur	7.69	400	202	165	170	30	22	17.8	0.2	0	207.4	24.85	3.9	1.11
Maitapur	7.84	500	222	185	135	50	15	12.2	0.1	0	164.7	56.8	5.2	1.09
Shyamsunderapur	7.82	350	153	140	135	30	16	7.1	0.1	0	164.7	17.75	0	0.643
Balibania	7.75	400	162	140	125	34	13	12.1	0.1	0	152.5	21.3	5.4	0.801
Kakharpada	7.81	300	134	130	110	32	12	5.4	0.1	0	134.2	17.75	0	0.717
Chhanagadia	7.86	400	187	150	155	22	23	14.9	0.1	0	189.1	21.3	11.4	0.991
Chhanagadia	7.91	420	197	185	155	24	30	13.6	0.1	0	189.1	31.95	3.03	1.06
Gopibindha	7.96	480	208	155	160	24	23	27.8	0.2	0	195.2	21.3	13.8	1.15
Sudarshanpur	7.91	350	155	135	110	30	15	11.8	0.1	0	134.2	28.4	2.5	0.89

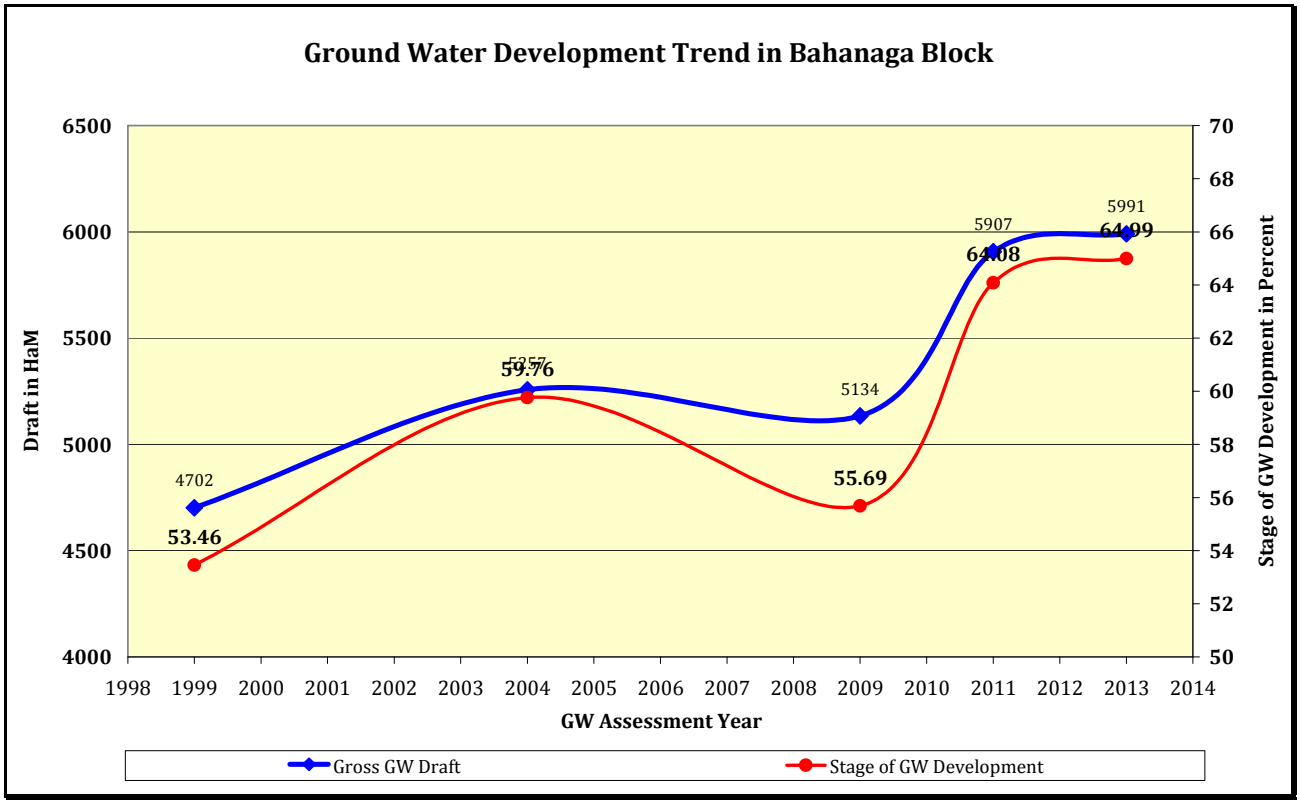
ANNEXURE – 4: Chemical Analysis of Water Samples[Piezometers / Observation Wells : Deeper Aquifer(II & III)]

Location	pH	EC	TDS	TH	TA	Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4	F
		µS/cm	mg/L											
Dayanidhipur	8.06	1550	760	175	155	26	27	212.5	0.2	0	189.1	287.55	112.1	0.778
Dayanidhipur	8.06	810	387	165	225	20	28	100.2	0.2	0	274.5	95.85	5.5	0.663
Solagaon	8.05	840	422	145	185	22	22	116	0.4	0	225.7	102.95	45.6	0.44
Durgapur	7.99	510	224	95	115	26	7	52.8	0.1	0	140.3	63.9	3.8	0.94
Balang	7.83	390	178	125	140	24	16	24	0.1	0	170.8	24.85	3.4	1.03
Sudarshanpur	8.05	440	244	175	155	26	27	29.9	0.1	0	189.1	46.15	20.4	1.04
Bachhipur	7.97	1900	841	325	145	46	51	205	0.9	0	176.9	429.55	20.5	0.76

ANNEXURE – 5: Blockwise Dynamic Ground Water Resource Trend

Dynamic Ground Water Resiources Trend – Bahanaga Block, Balasore District

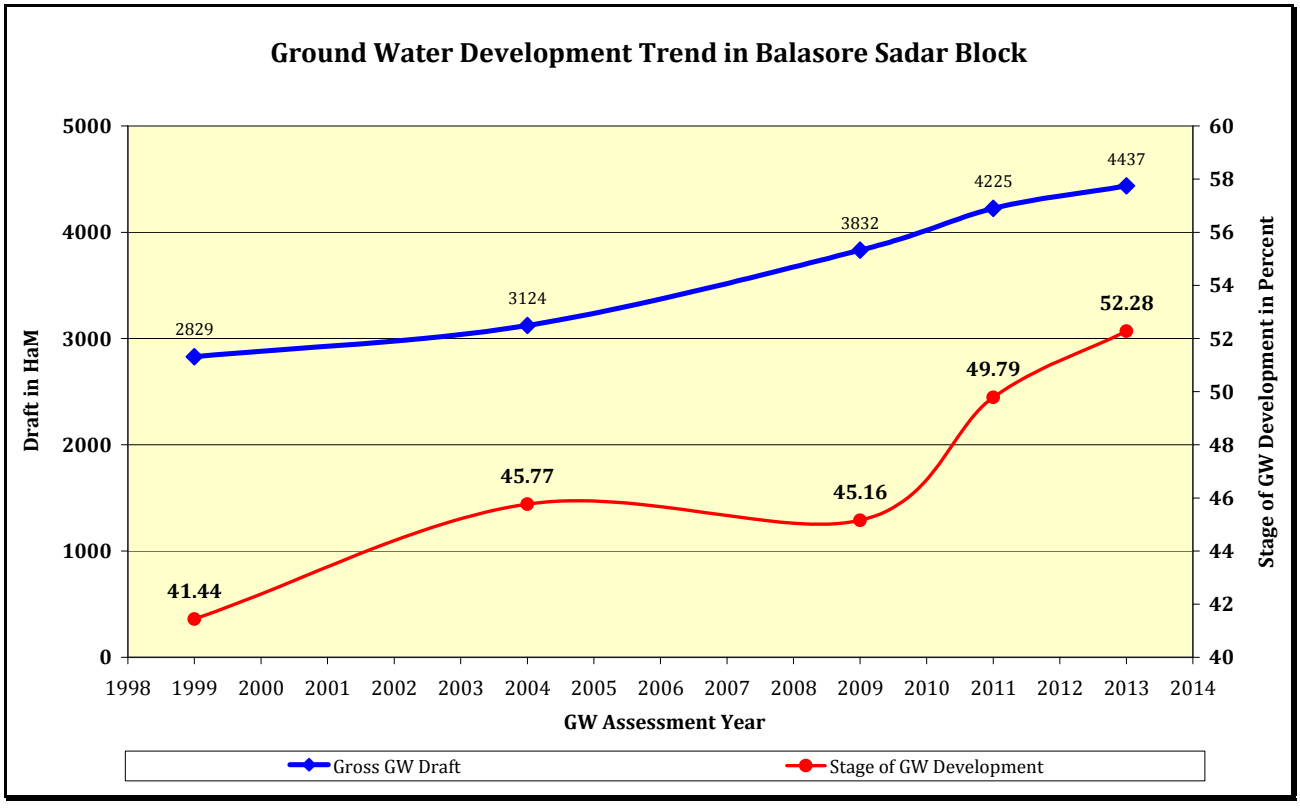
Parameters	1999	2004	2009	2011	2013
Net Ground Water Availability(HaM)	8796	8797	9219.00	9219.00	9219.00
Gross Ground Water Draft(HaM)	4702	5257	5134.00	5907.13	5991.00
Stage of Ground Water Development(%)	**53.46**	**59.76**	**55.69**	**64.08**	**64.99**
Category	**Safe**	**Safe**	**Safe**	**Safe**	**Safe**



ANNEXURE – 5: Blockwise Dynamic Ground Water Resource Trend

Dynamic Ground Water Resiources Trend – Balasore Block, Balasore District

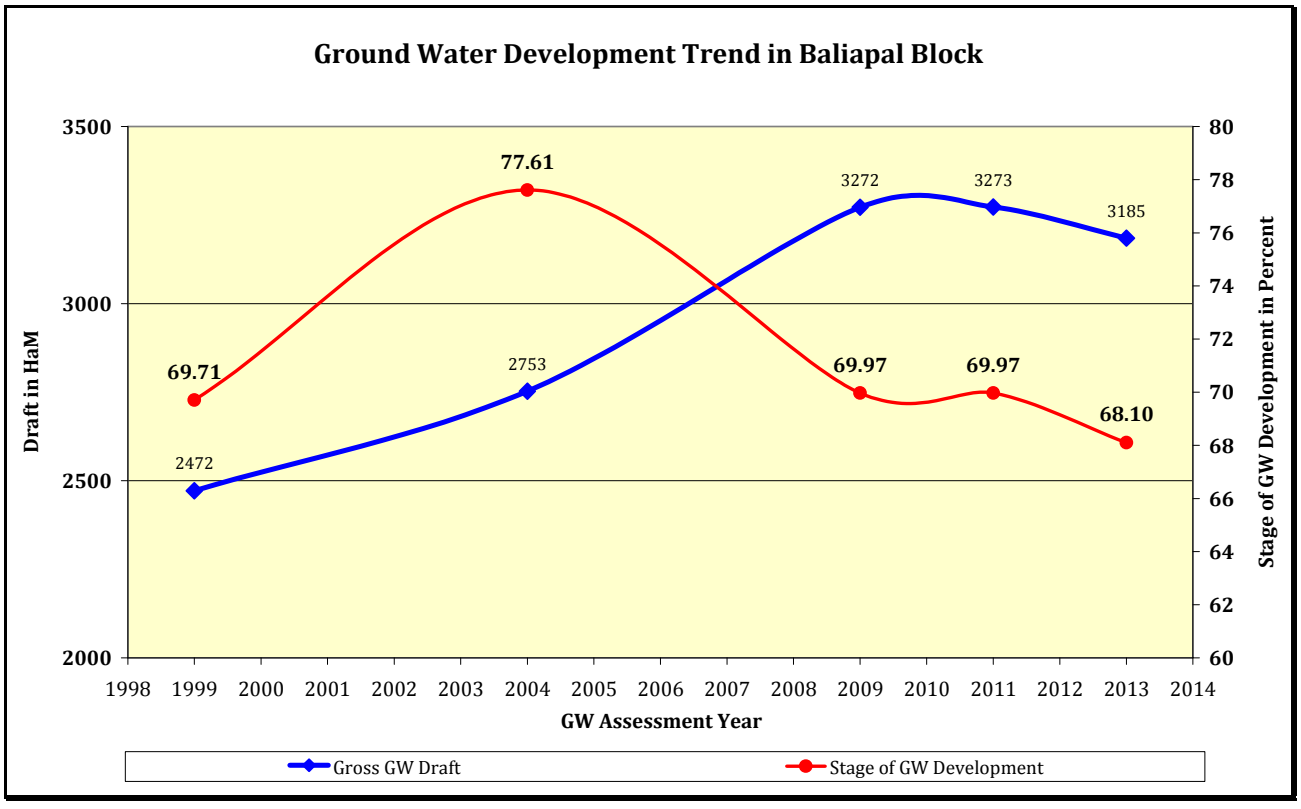
Parameters	1999	2004	2009	2011	2013
Net Ground Water Availability(HaM)	6826	6825	8486.00	8486.00	8486.00
Gross Ground Water Draft(HaM)	2829	3124	3832.00	4225.24	4436.82
Stage of Ground Water Development(%)	**41.44**	**45.77**	**45.16**	**49.79**	**52.28**
Category	**Safe**	**Safe**	**Safe**	**Safe**	**Safe**



ANNEXURE – 5: Blockwise Dynamic Ground Water Resource Trend

Dynamic Ground Water Resiources Trend – Baliapal Block, Balasore District

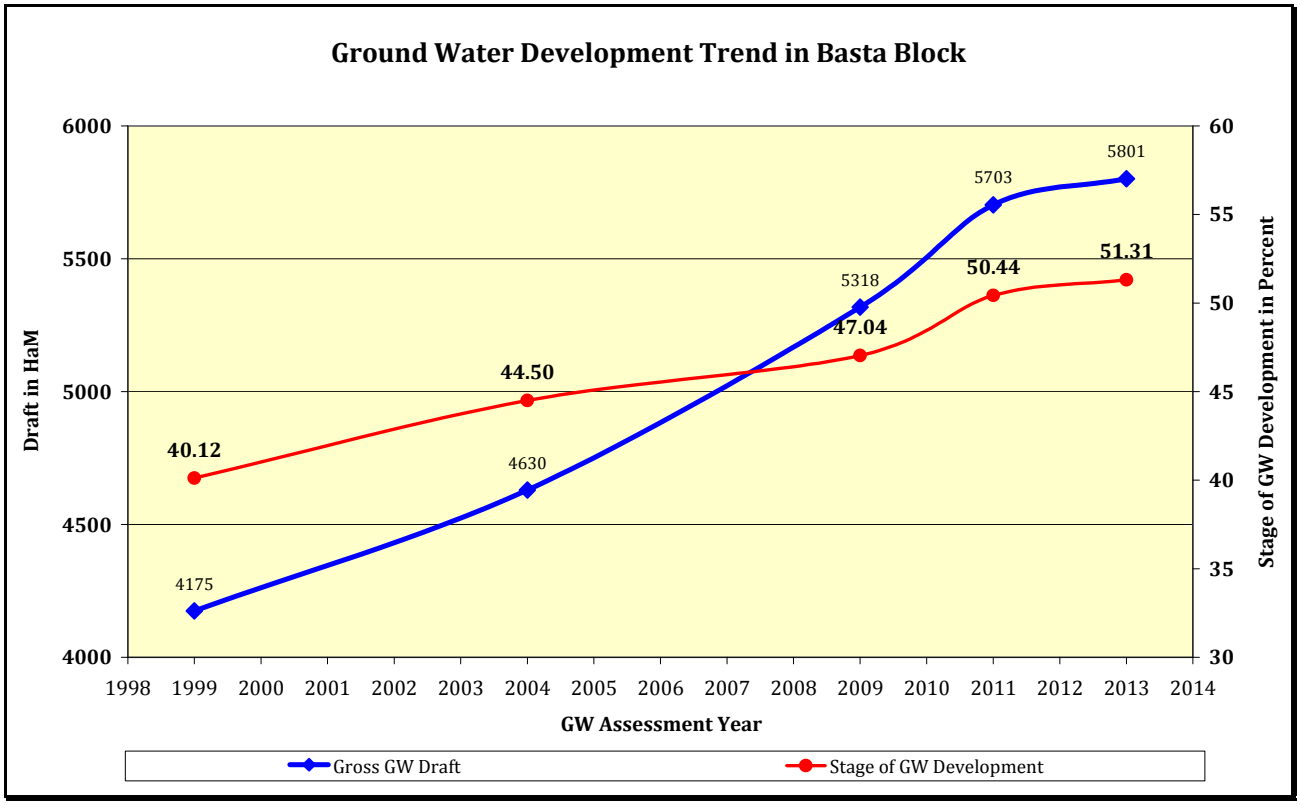
Parameters	1999	2004	2009	2011	2013
Net Ground Water Availability(HaM)	3546	3547	4677.00	4677.00	4677.00
Gross Ground Water Draft(HaM)	2472	2753	3272.00	3272.65	3184.84
Stage of Ground Water Development(%)	**69.71**	**77.61**	**69.97**	**69.97**	**68.10**
Category	**Safe**	**Safe**	**Safe**	**Safe**	**Safe**



ANNEXURE – 5: Blockwise Dynamic Ground Water Resource Trend

Dynamic Ground Water Resiources Trend – Basta Block, Balasore District

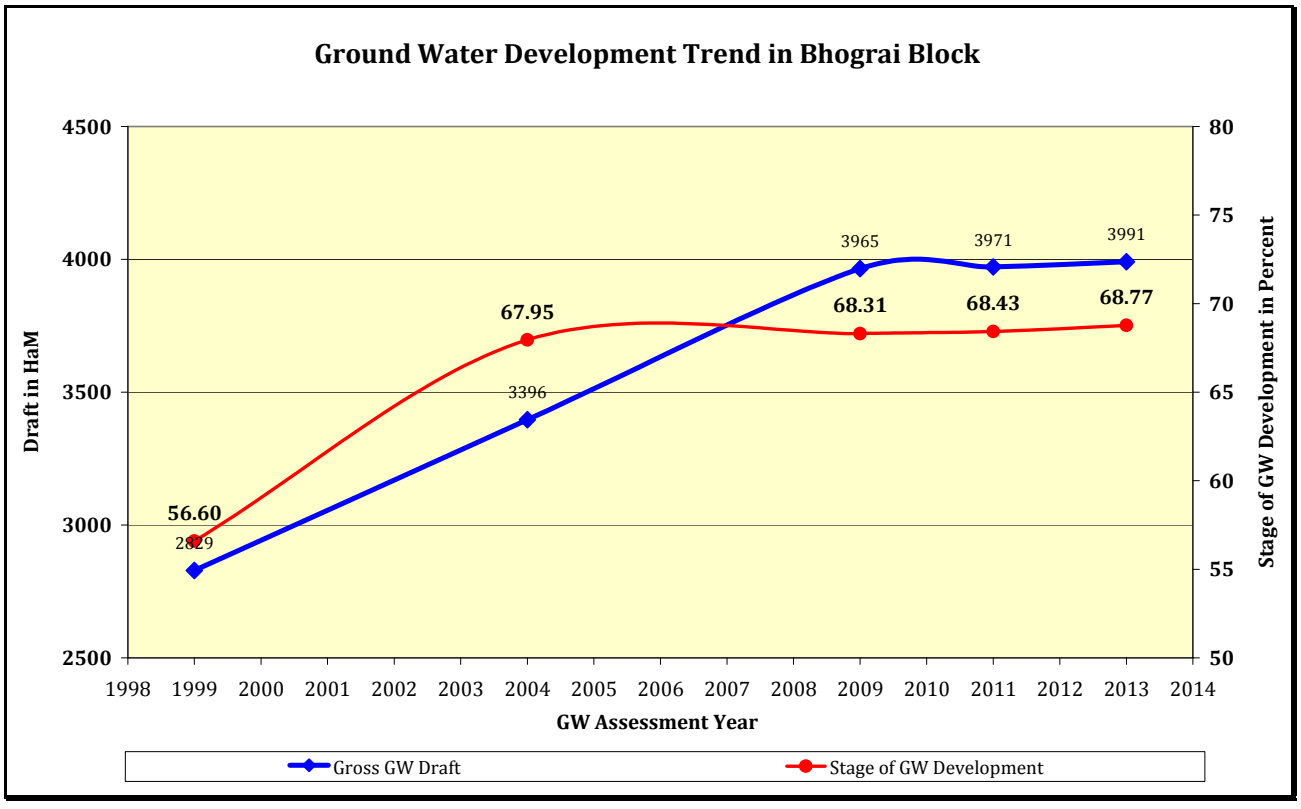
Parameters	1999	2004	2009	2011	2013
Net Ground Water Availability(HaM)	10406	10405	11306.00	11306.00	11306.00
Gross Ground Water Draft(HaM)	4175	4630	5318.00	5703.18	5801.04
Stage of Ground Water Development(%)	**40.12**	**44.50**	**47.04**	**50.44**	**51.31**
Category	**Safe**	**Safe**	**Safe**	**Safe**	**Safe**



ANNEXURE – 5: Blockwise Dynamic Ground Water Resource Trend

Dynamic Ground Water Resiources Trend – Bhograi Block, Balasore District

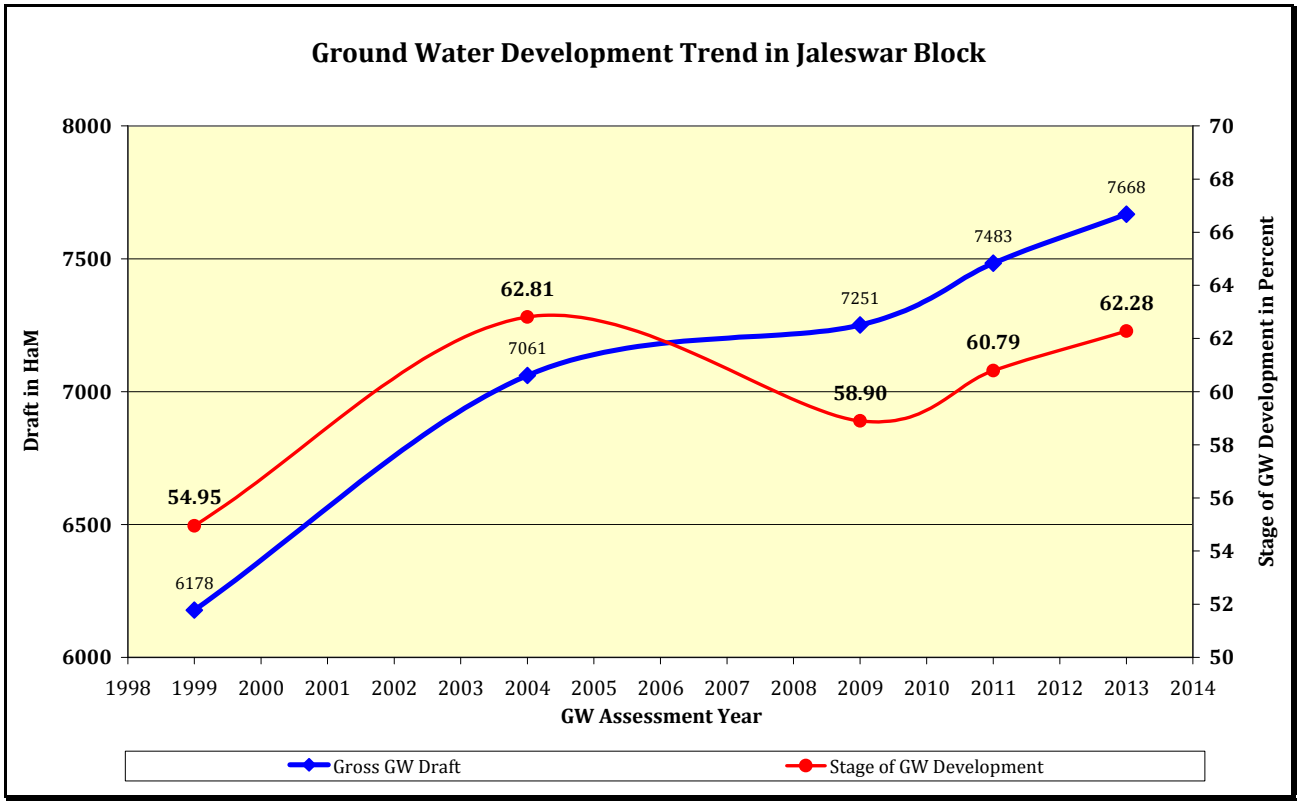
Parameters	1999	2004	2009	2011	2013
Net Ground Water Availability(HaM)	4998	4998	5804.00	5804.00	5804.00
Gross Ground Water Draft(HaM)	2829	3396	3965.00	3971.40	3991.40
Stage of Ground Water Development(%)	**56.60**	**67.95**	**68.31**	**68.43**	**68.77**
Category	**Safe**	**Safe**	**Safe**	**Safe**	**Safe**



ANNEXURE – 5: Blockwise Dynamic Ground Water Resource Trend

Dynamic Ground Water Resiources Trend – Jaleswar Block, Balasore District

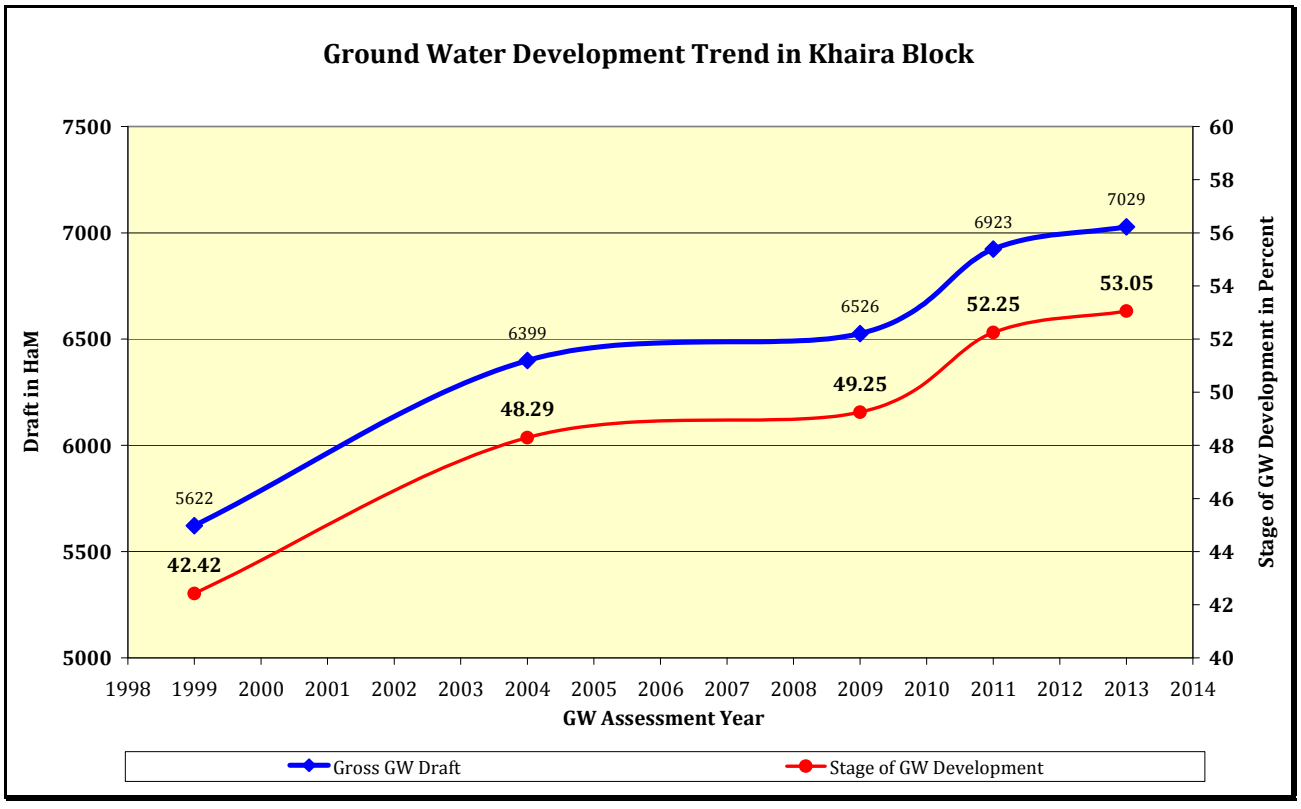
Parameters	1999	2004	2009	2011	2013
Net Ground Water Availability(HaM)	11243	11242	12311.00	12311.00	12311.00
Gross Ground Water Draft(HaM)	6178	7061	7251.00	7483.42	7667.83
Stage of Ground Water Development(%)	**54.95**	**62.81**	**58.90**	**60.79**	**62.28**
Category	**Safe**	**Safe**	**Safe**	**Safe**	**Safe**



ANNEXURE – 5: Blockwise Dynamic Ground Water Resource Trend

Dynamic Ground Water Resiources Trend – Khaira Block, Balasore District

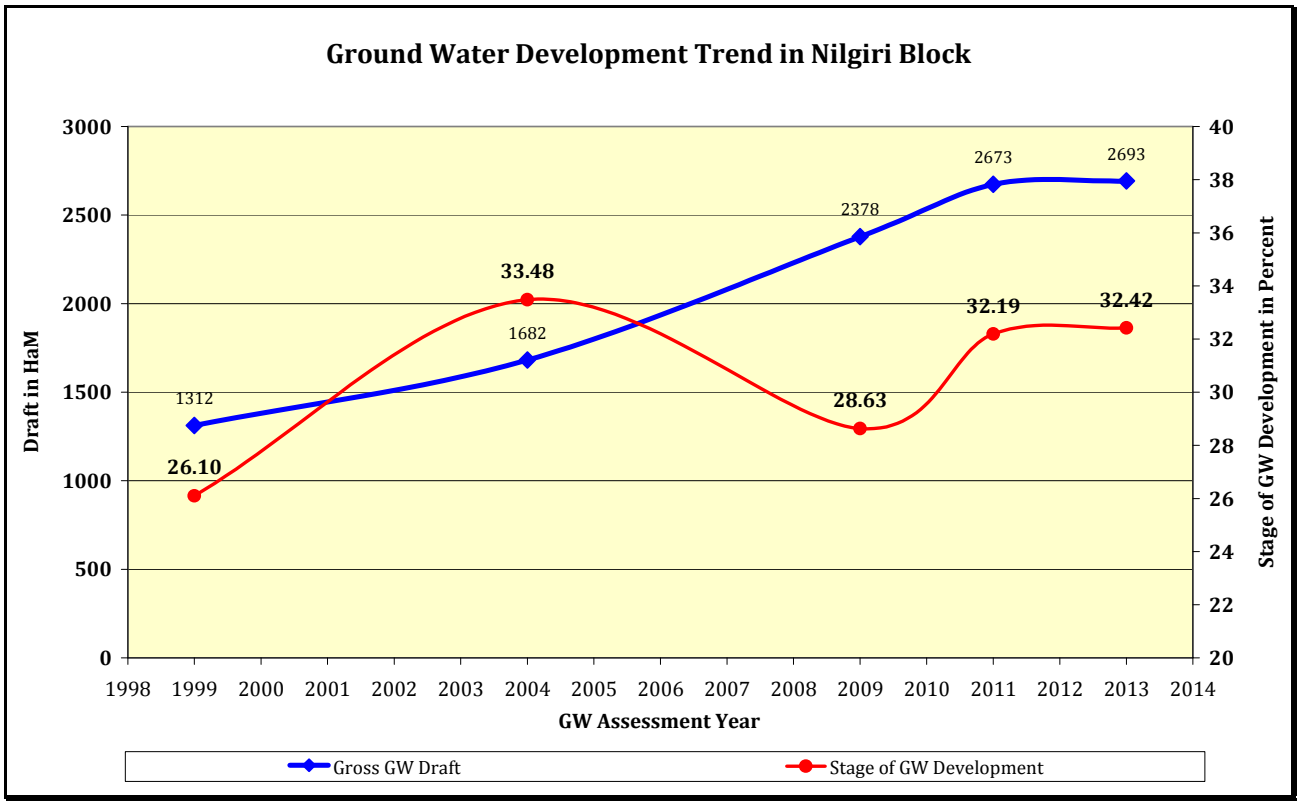
Parameters	1999	2004	2009	2011	2013
Net Ground Water Availability(HaM)	13253	13252	13250.00	13250.00	13250.00
Gross Ground Water Draft(HaM)	5622	6399	6526.00	6923.43	7028.74
Stage of Ground Water Development(%)	**42.42**	**48.29**	**49.25**	**52.25**	**53.05**
Category	**Safe**	**Safe**	**Safe**	**Safe**	**Safe**



ANNEXURE – 5: Blockwise Dynamic Ground Water Resource Trend

Dynamic Ground Water Resiources Trend – Nilgiri Block, Balasore District

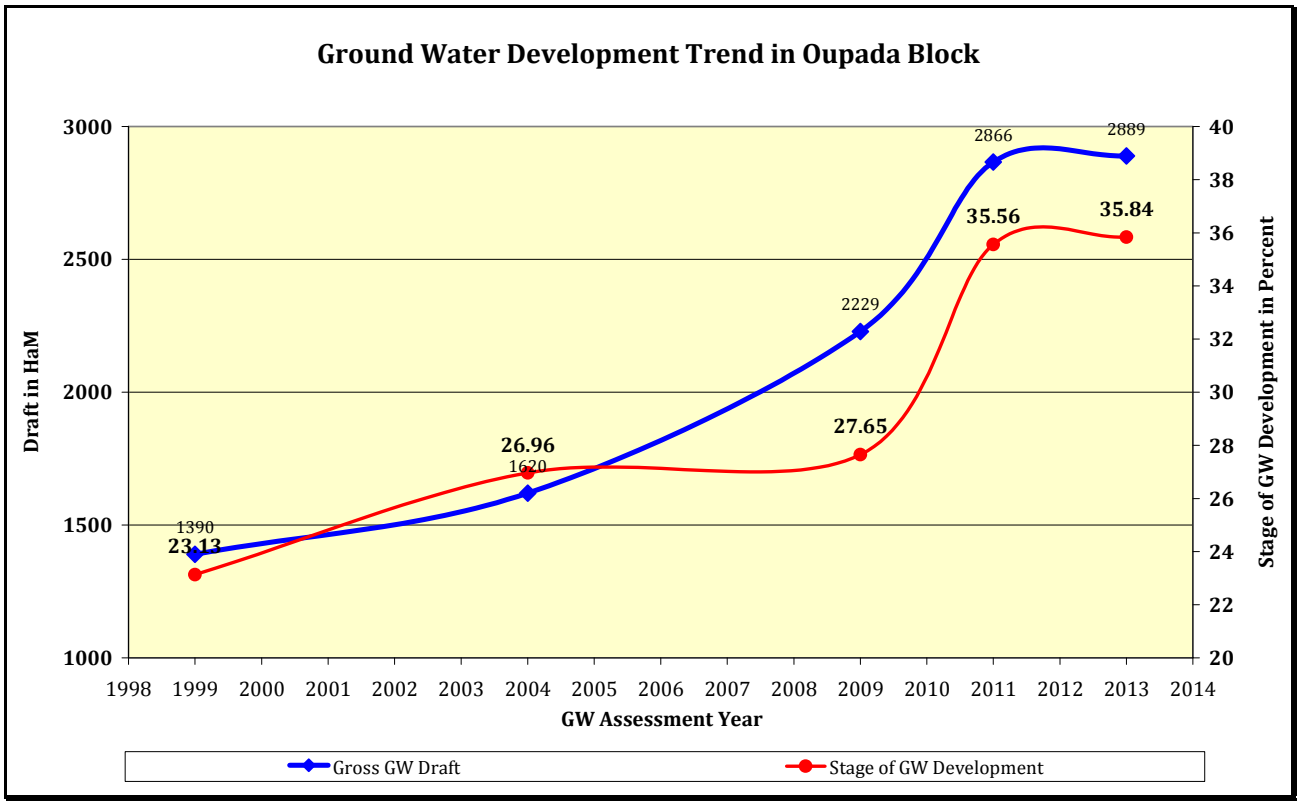
Parameters	1999	2004	2009	2011	2013
Net Ground Water Availability(HaM)	5026	5024	8306.00	8306.00	8306.00
Gross Ground Water Draft(HaM)	1312	1682	2378.00	2673.36	2692.57
Stage of Ground Water Development(%)	**26.10**	**33.48**	**28.63**	**32.19**	**32.42**
Category	**Safe**	**Safe**	**Safe**	**Safe**	**Safe**



ANNEXURE – 5: Blockwise Dynamic Ground Water Resource Trend

Dynamic Ground Water Resiources Trend – Oupada Block, Balasore District

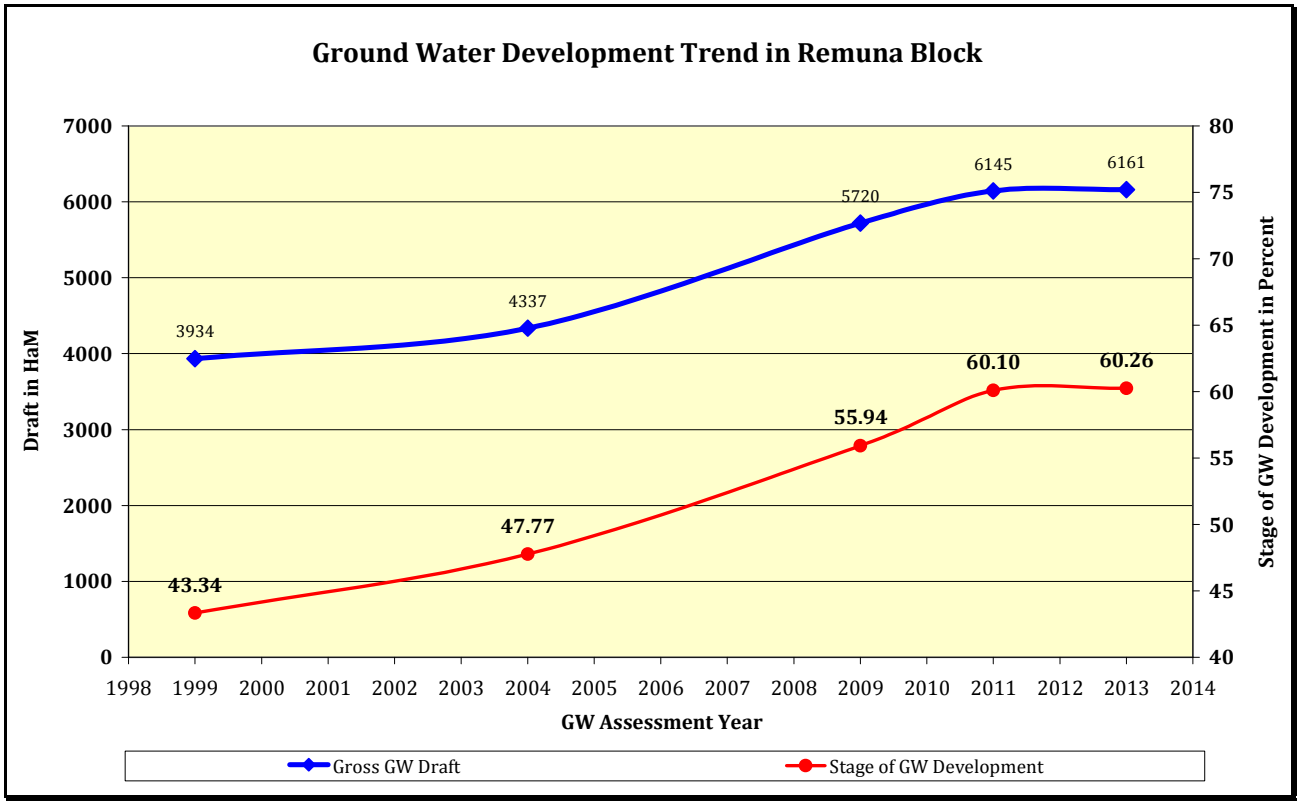
Parameters	1999	2004	2009	2011	2013
Net Ground Water Availability(HaM)	6010	6009	8061.00	8061.00	8061.00
Gross Ground Water Draft(HaM)	1390	1620	2229.00	2866.13	2888.95
Stage of Ground Water Development(%)	**23.13**	**26.96**	**27.65**	**35.56**	**35.84**
Category	**Safe**	**Safe**	**Safe**	**Safe**	**Safe**



ANNEXURE – 5: Blockwise Dynamic Ground Water Resource Trend

Dynamic Ground Water Resiources Trend – Remuna Block, Balasore District

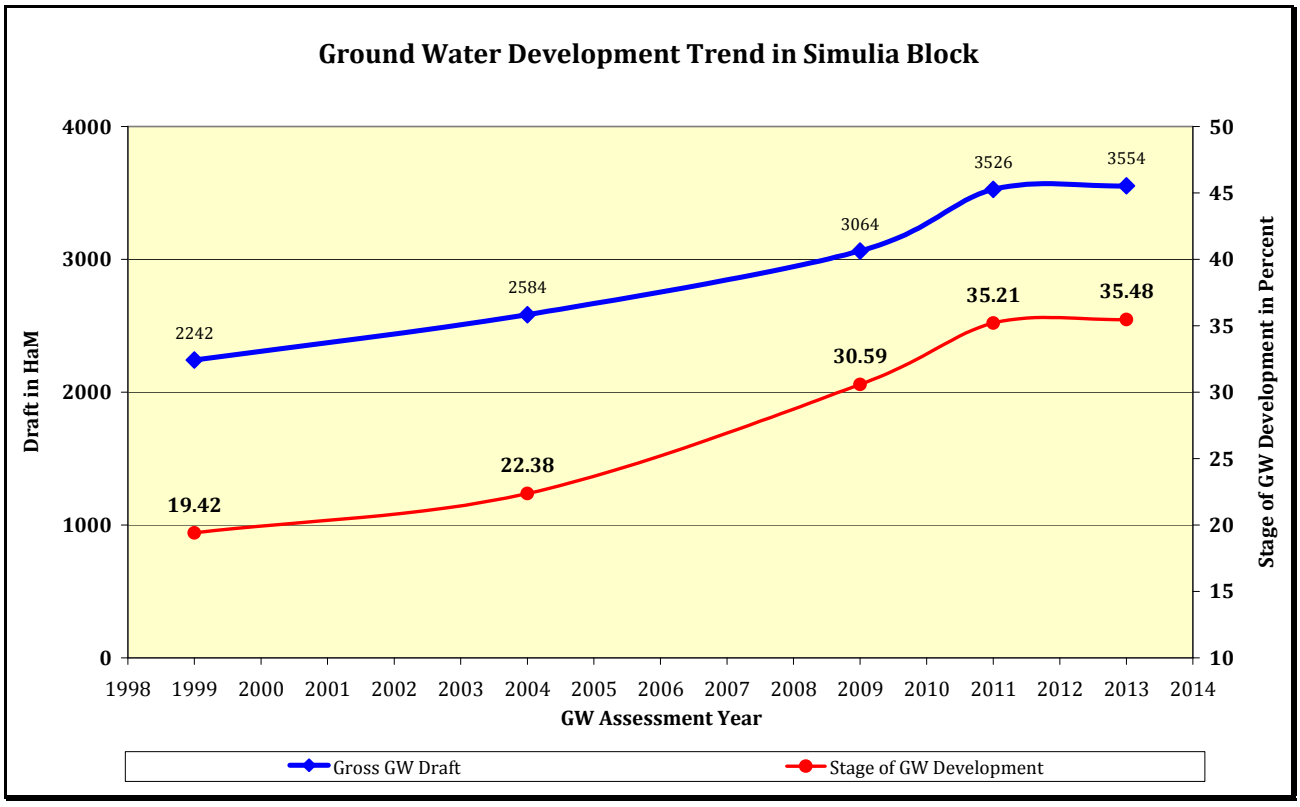
Parameters	1999	2004	2009	2011	2013
Net Ground Water Availability(HaM)	9078	9078	10225.00	10225.00	10225.00
Gross Ground Water Draft(HaM)	3934	4337	5720.00	6144.86	6161.30
Stage of Ground Water Development(%)	**43.34**	**47.77**	**55.94**	**60.10**	**60.26**
Category	**Safe**	**Safe**	**Safe**	**Safe**	**Safe**



ANNEXURE – 5: Blockwise Dynamic Ground Water Resource Trend

Dynamic Ground Water Resiources Trend – Simulia Block, Balasore District

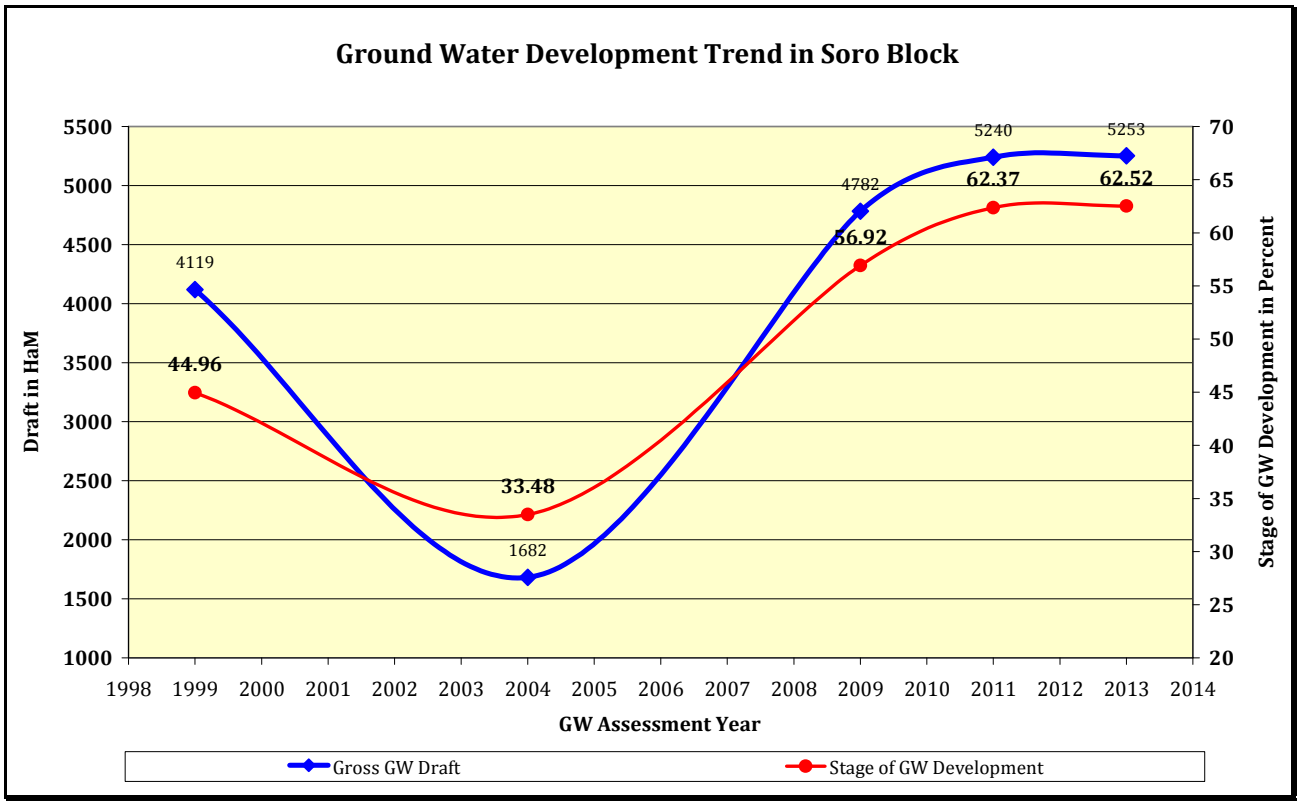
Parameters	1999	2004	2009	2011	2013
Net Ground Water Availability(HaM)	11545	11544	10016.00	10016.00	10016.00
Gross Ground Water Draft(HaM)	2242	2584	3064.00	3526.34	3553.64
Stage of Ground Water Development(%)	**19.42**	**22.38**	**30.59**	**35.21**	**35.48**
Category	**Safe**	**Safe**	**Safe**	**Safe**	**Safe**



ANNEXURE – 5: Blockwise Dynamic Ground Water Resource Trend

Dynamic Ground Water Resiources Trend – Soro Block, Balasore District

Parameters	1999	2004	2009	2011	2013
Net Ground Water Availability(HaM)	9161	5024	8402.00	8402.00	8402.00
Gross Ground Water Draft(HaM)	4119	1682	4782.00	5240.14	5252.99
Stage of Ground Water Development(%)	**44.96**	**33.48**	**56.92**	**62.37**	**62.52**
Category	**Safe**	**Safe**	**Safe**	**Safe**	**Safe**



ANNEXURE – 6: Suggested Locations of Water Conservation Structures

Sl No	Block	Latitude (dd°mm′ss″N)	Longitude (dd°mm′ss″E)
A	**CHECK WEIRS**		
1	BAHANAGA	21°20'41"	86°49'39"
2	BASTA	21°41'18"	87°03'43"
3	KHAIRA	21°16'56"	86°26'50"
4	KHAIRA	21°15'55"	86°27'57"
5	KHAIRA	21°14'21"	86°33'19"
6	KHAIRA	21°15'58"	86°31'15"
7	KHAIRA	21°14'34"	86°33'49"
8	KHAIRA	21°13'25"	86°31'41"
9	NILGIRI	21°36'06"	86°46'27"
10	NILGIRI	21°34'12"	86°46'52"
11	NILGIRI	21°33'46"	86°47'55"
12	NILGIRI	21°34'10"	86°41'57"
13	NILGIRI	21°33'40"	86°44'56"
14	NILGIRI	21°34'52"	86°42'07"
15	NILGIRI	21°35'09"	86°41'28"
16	NILGIRI	21°31'58"	86°45'06"
17	OUPADA	21°25'59"	86°46'28"
18	REMUNA	21°34'53"	86°52'43"
19	REMUNA	21°33'00"	86°50'03"
20	REMUNA	21°26'21"	86°52'03"
21	REMUNA	21°21'01"	86°51'23"
22	REMUNA	21°25'11"	86°49'28"
23	SIMULIA	21°12'53"	86°39'38"
24	SIMULIA	21°13'38"	86°35'35"
25	SORO	21°15'21"	86°38'12"
26	SORO	21°16'35"	86°36'59"
B	**GABION STRUCTURES**		
1	KHAIRA	21°17'16"	86°21'32"
2	KHAIRA	21°16'35"	86°21'57"
3	KHAIRA	21°18'00"	86°21'45"
4	KHAIRA	21°17'49"	86°22'12"
5	KHAIRA	21°18'02"	86°22'16"
6	KHAIRA	21°17'55"	86°22'29"
7	KHAIRA	21°18'08"	86°22'23"
8	KHAIRA	21°18'16"	86°22'39"
9	KHAIRA	21°18'00"	86°22'57"
10	KHAIRA	21°18'43"	86°23'31"
11	KHAIRA	21°18'40"	86°23'38"
12	KHAIRA	21°18'16"	86°23'41"
13	KHAIRA	21°18'38"	86°23'59"
14	KHAIRA	21°18'35"	86°24'12"
15	KHAIRA	21°18'42"	86°24'09"
16	KHAIRA	21°18'55"	86°24'13"
17	KHAIRA	21°19'06"	86°24'14"
18	KHAIRA	21°19'02"	86°24'33"
19	KHAIRA	21°19'01"	86°24'46"
20	KHAIRA	21°18'59"	86°24'49"
21	KHAIRA	21°19'35"	86°25'21"
22	KHAIRA	21°19'31"	86°25'08"
23	KHAIRA	21°19'27"	86°25'34"
24	KHAIRA	21°17'20"	86°21'28"
25	KHAIRA	21°16'09"	86°22'04"
26	KHAIRA	21°15'55"	86°22'20"
27	KHAIRA	21°17'50"	86°23'50"
28	KHAIRA	21°17'45"	86°23'49"
29	KHAIRA	21°17'36"	86°23'23"
30	KHAIRA	21°17'30"	86°24'23"
31	KHAIRA	21°17'14"	86°23'10"

ANNEXURE – 6: Suggested Locations of Water Conservation Structures

Sl No	Block	Latitude (dd°mm′ss″N)	Longitude (dd°mm′ss″E)
32	KHAIRA	21°17'21"	86°23'34"
33	KHAIRA	21°17'24"	86°25'22"
34	KHAIRA	21°17'50"	86°29'12"
35	KHAIRA	21°19'44"	86°31'20"
36	KHAIRA	21°19'42"	86°31'24"
37	KHAIRA	21°19'15"	86°34'30"
38	NILGIRI	21°24'42"	86°37'57"
39	NILGIRI	21°24'38"	86°37'49"
40	NILGIRI	21°24'31"	86°37'36"
41	NILGIRI	21°24'24"	86°37'48"
42	NILGIRI	21°24'09"	86°37'54"
43	NILGIRI	21°25'34"	86°36'01"
44	NILGIRI	21°25'38"	86°35'60"
45	NILGIRI	21°25'06"	86°37'21"
46	NILGIRI	21°25'10"	86°37'15"
47	NILGIRI	21°24'51"	86°37'00"
48	NILGIRI	21°24'46"	86°37'19"
49	NILGIRI	21°24'44"	86°37'29"
50	NILGIRI	21°24'57"	86°38'29"
51	NILGIRI	21°24'37"	86°38'43"
52	NILGIRI	21°27'13"	86°33'34"
53	NILGIRI	21°27'30"	86°33'24"
54	NILGIRI	21°27'40"	86°33'33"
55	NILGIRI	21°27'21"	86°33'42"
56	NILGIRI	21°27'30"	86°33'46"
57	NILGIRI	21°27'37"	86°34'06"
58	NILGIRI	21°26'55"	86°34'23"
59	NILGIRI	21°27'14"	86°34'27"
60	NILGIRI	21°26'25"	86°34'57"
61	NILGIRI	21°26'32"	86°35'10"
62	NILGIRI	21°26'45"	86°35'05"
63	NILGIRI	21°28'22"	86°34'03"
64	NILGIRI	21°28'38"	86°34'10"
65	NILGIRI	21°28'45"	86°34'16"
66	NILGIRI	21°28'54"	86°34'32"
67	NILGIRI	21°28'14"	86°35'02"
68	NILGIRI	21°28'12"	86°35'05"
69	NILGIRI	21°28'05"	86°35'07"
70	NILGIRI	21°28'02"	86°35'09"
71	NILGIRI	21°26'34"	86°36'03"
72	NILGIRI	21°26'11"	86°35'45"
73	NILGIRI	21°26'08"	86°36'32"
74	NILGIRI	21°26'03"	86°36'17"
75	NILGIRI	21°26'37"	86°36'42"
76	NILGIRI	21°24'55"	86°36'31"
77	NILGIRI	21°25'13"	86°36'42"
78	NILGIRI	21°25'03"	86°36'54"
79	NILGIRI	21°25'54"	86°36'08"
80	NILGIRI	21°25'38"	86°36'57"
81	NILGIRI	21°25'44"	86°37'23"
82	NILGIRI	21°25'39"	86°37'27"
83	NILGIRI	21°25'38"	86°37'35"
84	NILGIRI	21°25'33"	86°37'41"
85	NILGIRI	21°25'30"	86°38'07"
86	NILGIRI	21°25'27"	86°38'25"
87	NILGIRI	21°25'36"	86°38'21"
88	NILGIRI	21°25'47"	86°38'15"
89	NILGIRI	21°24'44"	86°38'52"
90	NILGIRI	21°24'46"	86°39'03"

ANNEXURE – 6: Suggested Locations of Water Conservation Structures

Sl No	Block	Latitude (dd°mm′ss″N)	Longitude (dd°mm′ss″E)
91	NILGIRI	21°24'50"	86°39'09"
92	NILGIRI	21°24'56"	86°39'12"
93	NILGIRI	21°25'06"	86°39'13"
94	NILGIRI	21°24'57"	86°38'48"
95	NILGIRI	21°24'54"	86°38'37"
96	NILGIRI	21°25'07"	86°39'04"
97	NILGIRI	21°25'16"	86°39'14"
98	NILGIRI	21°25'15"	86°39'18"
99	NILGIRI	21°24'50"	86°39'38"
100	NILGIRI	21°24'53"	86°39'43"
101	NILGIRI	21°25'13"	86°39'46"
102	NILGIRI	21°25'11"	86°39'49"
103	NILGIRI	21°25'10"	86°40'05"
104	NILGIRI	21°25'08"	86°40'07"
105	NILGIRI	21°25'49"	86°38'30"
106	NILGIRI	21°25'52"	86°38'38"
107	NILGIRI	21°25'57"	86°38'49"
108	NILGIRI	21°26'03"	86°38'52"
109	NILGIRI	21°26'06"	86°38'57"
110	NILGIRI	21°26'10"	86°39'11"
111	NILGIRI	21°26'12"	86°39'15"
112	NILGIRI	21°26'13"	86°39'29"
113	NILGIRI	21°25'49"	86°39'40"
114	NILGIRI	21°25'30"	86°39'14"
115	NILGIRI	21°25'48"	86°39'54"
116	NILGIRI	21°25'57"	86°40'08"
117	NILGIRI	21°25'57"	86°40'17"
118	NILGIRI	21°25'56"	86°40'18"
119	NILGIRI	21°25'57"	86°40'16"
120	NILGIRI	21°25'48"	86°40'23"
121	NILGIRI	21°26'02"	86°40'08"
122	NILGIRI	21°26'03"	86°40'07"
123	NILGIRI	21°26'15"	86°39'38"
124	NILGIRI	21°26'17"	86°39'58"
125	NILGIRI	21°26'28"	86°40'01"
126	NILGIRI	21°26'19"	86°39'51"
127	NILGIRI	21°26'19"	86°39'43"
128	NILGIRI	21°26'45"	86°38'25"
129	NILGIRI	21°26'24"	86°38'15"
130	NILGIRI	21°26'07"	86°38'01"
131	NILGIRI	21°26'00"	86°37'55"
132	NILGIRI	21°25'49"	86°37'27"
133	NILGIRI	21°26'39"	86°37'12"
134	NILGIRI	21°26'48"	86°37'41"
135	NILGIRI	21°26'55"	86°38'47"
136	NILGIRI	21°26'43"	86°38'43"
137	NILGIRI	21°26'43"	86°38'56"
138	NILGIRI	21°26'45"	86°39'12"
139	NILGIRI	21°26'50"	86°39'21"
140	NILGIRI	21°26'45"	86°39'25"
141	NILGIRI	21°26'41"	86°39'39"
142	NILGIRI	21°26'34"	86°39'31"
143	NILGIRI	21°27'12"	86°39'42"
144	NILGIRI	21°27'15"	86°39'50"
145	NILGIRI	21°26'59"	86°40'02"
146	NILGIRI	21°26'54"	86°40'15"
147	NILGIRI	21°26'54"	86°40'11"
148	NILGIRI	21°26'47"	86°40'39"
149	NILGIRI	21°26'43"	86°40'37"

ANNEXURE – 6: Suggested Locations of Water Conservation Structures

Sl No	Block	Latitude (dd°mm′ss″N)	Longitude (dd°mm′ss″E)
150	NILGIRI	21°27'13"	86°40'35"
151	NILGIRI	21°27'12"	86°40'37"
152	NILGIRI	21°27'03"	86°40'42"
153	NILGIRI	21°27'07"	86°40'53"
154	NILGIRI	21°27'05"	86°41'16"
155	NILGIRI	21°26'54"	86°41'25"
156	NILGIRI	21°26'49"	86°41'13"
157	NILGIRI	21°26'50"	86°41'06"
158	NILGIRI	21°26'36"	86°40'57"
159	NILGIRI	21°26'22"	86°40'59"
160	NILGIRI	21°26'40"	86°40'60"
161	NILGIRI	21°26'27"	86°41'27"
162	NILGIRI	21°26'20"	86°41'34"
163	NILGIRI	21°26'15"	86°41'26"
164	NILGIRI	21°26'17"	86°41'32"
165	NILGIRI	21°26'21"	86°41'49"
166	NILGIRI	21°26'25"	86°42'03"
167	NILGIRI	21°26'47"	86°42'06"
168	NILGIRI	21°26'53"	86°42'05"
169	NILGIRI	21°26'55"	86°42'08"
170	NILGIRI	21°26'59"	86°42'11"
171	NILGIRI	21°27'03"	86°42'14"
172	NILGIRI	21°27'43"	86°41'34"
173	NILGIRI	21°27'32"	86°41'44"
174	NILGIRI	21°27'24"	86°41'53"
175	NILGIRI	21°27'13"	86°41'54"
176	NILGIRI	21°27'06"	86°41'46"
177	NILGIRI	21°27'17"	86°42'00"
178	NILGIRI	21°27'40"	86°38'35"
179	NILGIRI	21°27'49"	86°38'23"
180	NILGIRI	21°27'46"	86°39'05"
181	NILGIRI	21°27'50"	86°39'03"
182	NILGIRI	21°27'54"	86°39'02"
183	NILGIRI	21°27'50"	86°39'40"
184	NILGIRI	21°27'48"	86°39'48"
185	NILGIRI	21°27'44"	86°39'48"
186	NILGIRI	21°27'54"	86°39'46"
187	NILGIRI	21°28'00"	86°39'48"
188	NILGIRI	21°28'04"	86°39'53"
189	NILGIRI	21°28'07"	86°39'57"
190	NILGIRI	21°28'03"	86°39'32"
191	NILGIRI	21°28'06"	86°38'56"
192	NILGIRI	21°27'17"	86°38'08"
193	NILGIRI	21°27'33"	86°38'01"
194	NILGIRI	21°27'41"	86°37'53"
195	NILGIRI	21°27'44"	86°37'52"
196	NILGIRI	21°27'49"	86°37'36"
197	NILGIRI	21°27'36"	86°37'32"
198	NILGIRI	21°27'11"	86°37'45"
199	NILGIRI	21°27'00"	86°37'23"
200	NILGIRI	21°27'04"	86°37'19"
201	NILGIRI	21°27'18"	86°37'02"
202	NILGIRI	21°27'22"	86°36'56"
203	NILGIRI	21°27'08"	86°36'46"
204	NILGIRI	21°26'58"	86°36'42"
205	NILGIRI	21°27'20"	86°36'48"
206	NILGIRI	21°27'26"	86°36'52"
207	NILGIRI	21°27'41"	86°36'57"
208	NILGIRI	21°27'45"	86°36'57"

ANNEXURE – 6: Suggested Locations of Water Conservation Structures

Sl No	Block	Latitude (dd°mm′ss″N)	Longitude (dd°mm′ss″E)
209	NILGIRI	21°28'07"	86°37'15"
210	NILGIRI	21°27'05"	86°35'19"
211	NILGIRI	21°26'45"	86°35'13"
212	NILGIRI	21°26'23"	86°35'41"
213	NILGIRI	21°27'18"	86°35'15"
214	NILGIRI	21°27'21"	86°35'23"
215	NILGIRI	21°29'32"	86°34'40"
216	NILGIRI	21°29'50"	86°34'44"
217	NILGIRI	21°30'04"	86°34'51"
218	NILGIRI	21°29'50"	86°35'05"
219	NILGIRI	21°30'02"	86°35'09"
220	NILGIRI	21°29'16"	86°35'50"
221	NILGIRI	21°29'00"	86°34'42"
222	NILGIRI	21°29'21"	86°35'56"
223	NILGIRI	21°28'51"	86°34'56"
224	NILGIRI	21°28'50"	86°35'06"
225	NILGIRI	21°28'12"	86°35'39"
226	NILGIRI	21°28'25"	86°36'10"
227	NILGIRI	21°28'31"	86°36'22"
228	NILGIRI	21°28'32"	86°36'26"
229	NILGIRI	21°28'37"	86°36'27"
230	NILGIRI	21°28'39"	86°36'28"
231	NILGIRI	21°28'43"	86°36'32"
232	NILGIRI	21°28'46"	86°36'35"
233	NILGIRI	21°28'50"	86°36'40"
234	NILGIRI	21°28'57"	86°36'46"
235	NILGIRI	21°28'17"	86°37'14"
236	NILGIRI	21°28'24"	86°37'16"
237	NILGIRI	21°28'42"	86°37'27"
238	NILGIRI	21°28'46"	86°37'16"
239	NILGIRI	21°29'04"	86°36'49"
240	NILGIRI	21°28'26"	86°37'43"
241	NILGIRI	21°28'31"	86°37'35"
242	NILGIRI	21°28'04"	86°37'44"
243	NILGIRI	21°28'21"	86°37'55"
244	NILGIRI	21°28'11"	86°38'36"
245	NILGIRI	21°28'10"	86°38'24"
246	NILGIRI	21°28'12"	86°38'16"
247	NILGIRI	21°28'37"	86°38'39"
248	NILGIRI	21°28'34"	86°38'50"
249	NILGIRI	21°28'35"	86°38'49"
250	NILGIRI	21°28'49"	86°38'51"
251	NILGIRI	21°28'58"	86°38'48"
252	NILGIRI	21°28'56"	86°38'37"
253	NILGIRI	21°29'02"	86°38'03"
254	NILGIRI	21°29'20"	86°37'53"
255	NILGIRI	21°29'16"	86°37'46"
256	NILGIRI	21°29'46"	86°38'48"
257	NILGIRI	21°29'20"	86°38'51"
258	NILGIRI	21°29'28"	86°39'07"
259	NILGIRI	21°29'27"	86°39'31"
260	NILGIRI	21°29'18"	86°39'46"
261	NILGIRI	21°29'33"	86°39'48"
262	NILGIRI	21°29'37"	86°39'45"
263	NILGIRI	21°29'32"	86°39'40"
264	NILGIRI	21°29'45"	86°39'40"
265	NILGIRI	21°28'10"	86°39'40"
266	NILGIRI	21°28'27"	86°39'53"
267	NILGIRI	21°28'34"	86°39'51"

ANNEXURE – 6: Suggested Locations of Water Conservation Structures

Sl No	Block	Latitude (dd°mm′ss″N)	Longitude (dd°mm′ss″E)
268	NILGIRI	21°28'36"	86°40'00"
269	NILGIRI	21°28'49"	86°40'04"
270	NILGIRI	21°28'01"	86°40'06"
271	NILGIRI	21°28'19"	86°40'20"
272	NILGIRI	21°28'07"	86°40'34"
273	NILGIRI	21°28'21"	86°40'43"
274	NILGIRI	21°28'25"	86°40'23"
275	NILGIRI	21°28'47"	86°40'29"
276	NILGIRI	21°27'51"	86°40'43"
277	NILGIRI	21°28'00"	86°40'56"
278	NILGIRI	21°28'01"	86°41'09"
279	NILGIRI	21°28'10"	86°41'24"
280	NILGIRI	21°28'07"	86°41'27"
281	NILGIRI	21°28'20"	86°41'19"
282	NILGIRI	21°28'38"	86°41'37"
283	NILGIRI	21°29'11"	86°36'45"
284	NILGIRI	21°29'29"	86°36'38"
285	NILGIRI	21°29'38"	86°36'43"
286	NILGIRI	21°30'02"	86°37'06"
287	NILGIRI	21°29'21"	86°37'15"
288	NILGIRI	21°29'52"	86°38'27"
289	NILGIRI	21°29'50"	86°38'38"
290	NILGIRI	21°30'06"	86°38'44"
291	NILGIRI	21°30'58"	86°35'41"
292	NILGIRI	21°30'51"	86°35'29"
293	NILGIRI	21°30'51"	86°35'14"
294	NILGIRI	21°30'44"	86°35'24"
295	NILGIRI	21°30'09"	86°35'41"
296	NILGIRI	21°30'59"	86°36'14"
297	NILGIRI	21°31'03"	86°36'60"
298	NILGIRI	21°30'16"	86°36'51"
299	NILGIRI	21°30'35"	86°37'14"
300	NILGIRI	21°30'18"	86°37'37"
301	NILGIRI	21°30'21"	86°37'11"
302	NILGIRI	21°31'08"	86°37'23"
303	NILGIRI	21°31'01"	86°38'25"
304	NILGIRI	21°31'24"	86°38'28"
305	NILGIRI	21°31'28"	86°38'29"
306	NILGIRI	21°31'33"	86°38'29"
307	NILGIRI	21°31'43"	86°38'26"
308	NILGIRI	21°31'47"	86°38'19"
309	NILGIRI	21°31'18"	86°39'45"
310	NILGIRI	21°30'33"	86°39'28"
311	NILGIRI	21°30'46"	86°39'23"
312	NILGIRI	21°30'18"	86°38'55"
313	NILGIRI	21°29'52"	86°40'16"
314	NILGIRI	21°29'42"	86°40'43"
315	NILGIRI	21°29'41"	86°40'46"
316	NILGIRI	21°30'17"	86°41'07"
317	NILGIRI	21°30'27"	86°41'15"
318	NILGIRI	21°30'40"	86°41'21"
319	NILGIRI	21°28'48"	86°41'02"
320	NILGIRI	21°28'49"	86°41'01"
321	NILGIRI	21°29'12"	86°41'29"
322	NILGIRI	21°29'19"	86°41'16"
323	NILGIRI	21°29'10"	86°41'48"
324	NILGIRI	21°29'12"	86°42'01"
325	NILGIRI	21°29'11"	86°42'11"
326	NILGIRI	21°29'12"	86°42'14"

ANNEXURE – 6: Suggested Locations of Water Conservation Structures

Sl No	Block	Latitude (dd°mm′ss″N)	Longitude (dd°mm′ss″E)
327	NILGIRI	21°29'12"	86°42'22"
328	NILGIRI	21°29'12"	86°42'30"
329	NILGIRI	21°29'09"	86°42'46"
330	NILGIRI	21°29'01"	86°42'44"
331	NILGIRI	21°29'02"	86°42'43"
332	NILGIRI	21°28'47"	86°42'47"
333	NILGIRI	21°28'50"	86°42'60"
334	NILGIRI	21°28'21"	86°42'20"
335	NILGIRI	21°28'17"	86°42'28"
336	NILGIRI	21°28'06"	86°42'28"
337	NILGIRI	21°28'33"	86°42'48"
338	NILGIRI	21°27'47"	86°42'01"
339	NILGIRI	21°27'44"	86°42'09"
340	NILGIRI	21°27'50"	86°42'18"
341	NILGIRI	21°27'05"	86°42'21"
342	NILGIRI	21°27'08"	86°42'28"
343	NILGIRI	21°27'14"	86°42'40"
344	NILGIRI	21°27'17"	86°42'41"
345	NILGIRI	21°27'06"	86°43'04"
346	NILGIRI	21°26'55"	86°43'08"
347	NILGIRI	21°27'02"	86°43'14"
348	NILGIRI	21°27'11"	86°43'24"
349	NILGIRI	21°27'27"	86°43'30"
350	NILGIRI	21°26'29"	86°42'09"
351	NILGIRI	21°26'29"	86°42'13"
352	NILGIRI	21°26'28"	86°42'17"
353	NILGIRI	21°26'27"	86°42'20"
354	NILGIRI	21°26'22"	86°42'25"
355	NILGIRI	21°26'19"	86°42'23"
356	NILGIRI	21°26'13"	86°42'20"
357	NILGIRI	21°26'30"	86°43'02"
358	NILGIRI	21°26'34"	86°43'09"
359	NILGIRI	21°26'19"	86°43'38"
360	NILGIRI	21°26'48"	86°43'51"
361	NILGIRI	21°26'45"	86°43'60"
362	NILGIRI	21°26'55"	86°44'12"
363	NILGIRI	21°26'51"	86°44'14"
364	NILGIRI	21°26'23"	86°44'02"
365	NILGIRI	21°25'04"	86°40'12"
366	NILGIRI	21°25'15"	86°40'21"
367	NILGIRI	21°25'14"	86°40'21"
368	NILGIRI	21°25'28"	86°40'42"
369	NILGIRI	21°25'09"	86°41'15"
370	NILGIRI	21°25'33"	86°41'25"
371	NILGIRI	21°25'42"	86°41'05"
372	NILGIRI	21°25'36"	86°41'33"
373	NILGIRI	21°25'40"	86°41'27"
374	NILGIRI	21°25'48"	86°41'44"
375	NILGIRI	21°25'47"	86°41'40"
376	NILGIRI	21°25'34"	86°42'05"
377	NILGIRI	21°25'39"	86°42'09"
378	NILGIRI	21°25'52"	86°42'19"
379	NILGIRI	21°24'32"	86°43'29"
380	NILGIRI	21°24'40"	86°43'10"
381	NILGIRI	21°24'55"	86°43'01"
382	NILGIRI	21°25'23"	86°43'17"
383	NILGIRI	21°25'27"	86°44'03"
384	NILGIRI	21°25'31"	86°44'10"
385	NILGIRI	21°25'32"	86°44'11"

ANNEXURE – 6: Suggested Locations of Water Conservation Structures

Sl No	Block	Latitude (dd°mm′ss″N)	Longitude (dd°mm′ss″E)
386	NILGIRI	21°25'39"	86°44'21"
387	NILGIRI	21°25'31"	86°43'16"
388	NILGIRI	21°25'45"	86°42'57"
389	NILGIRI	21°25'53"	86°42'53"
390	NILGIRI	21°26'01"	86°42'56"
391	NILGIRI	21°26'07"	86°43'09"
392	NILGIRI	21°26'10"	86°43'15"
393	NILGIRI	21°26'12"	86°43'18"
394	NILGIRI	21°26'21"	86°42'43"
395	NILGIRI	21°26'16"	86°44'37"
396	NILGIRI	21°26'59"	86°44'47"
397	NILGIRI	21°27'08"	86°45'14"
398	NILGIRI	21°27'17"	86°44'32"
399	NILGIRI	21°27'17"	86°44'42"
400	NILGIRI	21°27'52"	86°45'23"
401	NILGIRI	21°31'02"	86°40'08"
402	NILGIRI	21°31'15"	86°40'36"
403	NILGIRI	21°31'09"	86°41'27"
404	NILGIRI	21°31'27"	86°41'29"
405	NILGIRI	21°31'39"	86°41'28"
406	NILGIRI	21°31'59"	86°40'41"
407	NILGIRI	21°31'50"	86°41'35"
408	NILGIRI	21°32'01"	86°41'39"
409	NILGIRI	21°32'10"	86°41'37"
410	NILGIRI	21°32'06"	86°41'38"
411	NILGIRI	21°31'54"	86°43'20"
412	NILGIRI	21°30'21"	86°42'04"
413	NILGIRI	21°30'03"	86°41'57"
414	NILGIRI	21°30'00"	86°41'55"
415	NILGIRI	21°30'47"	86°42'48"
416	NILGIRI	21°30'39"	86°43'14"
417	NILGIRI	21°30'44"	86°43'26"
418	NILGIRI	21°31'56"	86°43'35"
419	NILGIRI	21°32'17"	86°43'45"
420	NILGIRI	21°29'27"	86°45'04"
421	NILGIRI	21°29'51"	86°45'03"
422	NILGIRI	21°30'09"	86°44'49"
423	NILGIRI	21°30'11"	86°45'05"
424	NILGIRI	21°30'17"	86°45'12"
425	NILGIRI	21°29'60"	86°45'22"
426	NILGIRI	21°29'57"	86°45'36"
427	NILGIRI	21°29'57"	86°45'45"
428	NILGIRI	21°30'00"	86°45'49"
429	NILGIRI	21°29'55"	86°46'26"
430	NILGIRI	21°29'41"	86°46'37"
431	NILGIRI	21°29'40"	86°46'32"
432	NILGIRI	21°30'23"	86°46'27"
433	NILGIRI	21°30'25"	86°46'32"
434	NILGIRI	21°30'28"	86°46'36"
435	NILGIRI	21°30'46"	86°45'49"
436	NILGIRI	21°30'49"	86°45'39"
437	NILGIRI	21°30'45"	86°44'52"
438	NILGIRI	21°30'50"	86°44'51"
439	NILGIRI	21°30'52"	86°44'49"
440	NILGIRI	21°30'55"	86°44'45"
441	NILGIRI	21°29'58"	86°47'14"
442	NILGIRI	21°31'23"	86°45'05"
443	NILGIRI	21°31'14"	86°45'38"
444	NILGIRI	21°31'20"	86°45'32"

ANNEXURE – 6: Suggested Locations of Water Conservation Structures

Sl No	Block	Latitude (dd°mm′ss″N)	Longitude (dd°mm′ss″E)
445	NILGIRI	21°31'33"	86°45'18"
446	NILGIRI	21°31'26"	86°46'04"
447	NILGIRI	21°31'39"	86°46'10"
448	NILGIRI	21°31'42"	86°46'10"
449	NILGIRI	21°31'06"	86°46'35"
450	NILGIRI	21°31'09"	86°46'41"
451	NILGIRI	21°33'22"	86°40'44"
452	NILGIRI	21°33'31"	86°40'39"
453	NILGIRI	21°33'35"	86°40'32"
454	NILGIRI	21°32'51"	86°39'36"
455	NILGIRI	21°32'53"	86°39'36"
456	NILGIRI	21°32'56"	86°39'33"
457	NILGIRI	21°33'03"	86°39'28"
458	NILGIRI	21°33'07"	86°39'20"
459	NILGIRI	21°33'09"	86°38'57"
460	NILGIRI	21°32'38"	86°40'06"
461	NILGIRI	21°32'45"	86°42'36"
462	NILGIRI	21°32'46"	86°41'25"
463	NILGIRI	21°33'14"	86°41'04"
464	NILGIRI	21°33'13"	86°41'43"
465	NILGIRI	21°32'50"	86°43'19"
466	NILGIRI	21°32'55"	86°43'22"
467	NILGIRI	21°33'08"	86°43'35"
468	NILGIRI	21°33'12"	86°43'44"
469	NILGIRI	21°33'13"	86°43'56"
470	NILGIRI	21°32'54"	86°44'22"
471	NILGIRI	21°33'46"	86°43'00"
472	NILGIRI	21°33'17"	86°44'14"
473	NILGIRI	21°34'05"	86°39'29"
474	NILGIRI	21°34'34"	86°40'19"
475	NILGIRI	21°34'33"	86°40'21"
476	NILGIRI	21°34'14"	86°40'37"
477	NILGIRI	21°34'24"	86°40'46"
478	NILGIRI	21°34'52"	86°41'10"
479	NILGIRI	21°34'55"	86°41'18"
480	NILGIRI	21°35'15"	86°40'54"
481	NILGIRI	21°32'02"	86°46'18"
482	NILGIRI	21°32'02"	86°46'22"
483	NILGIRI	21°31'54"	86°46'03"
484	NILGIRI	21°31'58"	86°46'02"
485	NILGIRI	21°32'28"	86°45'57"
486	NILGIRI	21°32'47"	86°45'57"
487	NILGIRI	21°32'57"	86°46'13"
488	NILGIRI	21°32'30"	86°47'23"
489	NILGIRI	21°32'51"	86°47'32"
490	NILGIRI	21°33'19"	86°47'01"
491	NILGIRI	21°29'26"	86°46'38"
492	NILGIRI	21°28'52"	86°46'33"
493	NILGIRI	21°28'47"	86°46'52"
494	NILGIRI	21°28'34"	86°46'16"
495	NILGIRI	21°28'35"	86°46'21"
496	NILGIRI	21°28'35"	86°46'25"
497	NILGIRI	21°28'33"	86°46'30"
498	NILGIRI	21°28'32"	86°46'36"
499	NILGIRI	21°28'30"	86°46'41"
500	NILGIRI	21°27'37"	86°46'38"
501	OUPADA	21°20'23"	86°27'44"
502	OUPADA	21°19'54"	86°25'46"
503	OUPADA	21°20'06"	86°26'20"

ANNEXURE – 6: Suggested Locations of Water Conservation Structures

Sl No	Block	Latitude (dd°mm′ss″N)	Longitude (dd°mm′ss″E)
504	OUPADA	21°20'21"	86°26'24"
505	OUPADA	21°20'34"	86°26'16"
506	OUPADA	21°20'18"	86°26'44"
507	OUPADA	21°19'47"	86°27'36"
508	OUPADA	21°20'50"	86°26'30"
509	OUPADA	21°20'54"	86°26'27"
510	OUPADA	21°20'43"	86°27'54"
511	OUPADA	21°20'50"	86°27'49"
512	OUPADA	21°21'08"	86°28'18"
513	OUPADA	21°21'08"	86°28'07"
514	OUPADA	21°21'34"	86°27'33"
515	OUPADA	21°21'30"	86°27'32"
516	OUPADA	21°21'30"	86°27'17"
517	OUPADA	21°21'28"	86°27'18"
518	OUPADA	21°21'12"	86°27'20"
519	OUPADA	21°21'17"	86°27'49"
520	OUPADA	21°21'37"	86°28'19"
521	OUPADA	21°21'59"	86°28'29"
522	OUPADA	21°22'21"	86°28'42"
523	OUPADA	21°22'09"	86°28'43"
524	OUPADA	21°22'05"	86°28'42"
525	OUPADA	21°21'38"	86°28'23"
526	OUPADA	21°21'38"	86°28'30"
527	OUPADA	21°21'18"	86°28'07"
528	OUPADA	21°22'01"	86°28'33"
529	OUPADA	21°21'40"	86°28'44"
530	OUPADA	21°21'32"	86°29'05"
531	OUPADA	21°21'58"	86°29'15"
532	OUPADA	21°22'14"	86°29'23"
533	OUPADA	21°22'22"	86°29'26"
534	OUPADA	21°22'44"	86°29'36"
535	OUPADA	21°22'55"	86°29'40"
536	OUPADA	21°22'57"	86°29'42"
537	OUPADA	21°22'43"	86°30'12"
538	OUPADA	21°22'50"	86°30'22"
539	OUPADA	21°22'53"	86°30'26"
540	OUPADA	21°22'58"	86°30'33"
541	OUPADA	21°22'39"	86°30'25"
542	OUPADA	21°22'35"	86°29'33"
543	OUPADA	21°23'16"	86°30'04"
544	OUPADA	21°23'15"	86°30'03"
545	OUPADA	21°23'48"	86°30'18"
546	OUPADA	21°23'46"	86°30'24"
547	OUPADA	21°23'44"	86°30'35"
548	OUPADA	21°23'43"	86°30'42"
549	OUPADA	21°23'45"	86°30'57"
550	OUPADA	21°23'47"	86°30'59"
551	OUPADA	21°23'23"	86°31'10"
552	OUPADA	21°23'20"	86°31'13"
553	OUPADA	21°23'09"	86°31'14"
554	OUPADA	21°22'36"	86°30'49"
555	OUPADA	21°23'55"	86°31'50"
556	OUPADA	21°24'03"	86°31'54"
557	OUPADA	21°24'09"	86°31'59"
558	OUPADA	21°24'13"	86°32'02"
559	OUPADA	21°24'23"	86°32'07"
560	OUPADA	21°24'37"	86°32'02"
561	OUPADA	21°24'40"	86°31'59"
562	OUPADA	21°24'43"	86°31'58"

ANNEXURE – 6: Suggested Locations of Water Conservation Structures

Sl No	Block	Latitude (dd°mm′ss″N)	Longitude (dd°mm′ss″E)
563	OUPADA	21°24'47"	86°31'57"
564	OUPADA	21°23'15"	86°31'34"
565	OUPADA	21°23'18"	86°32'09"
566	OUPADA	21°23'43"	86°32'38"
567	OUPADA	21°23'45"	86°32'41"
568	OUPADA	21°23'55"	86°32'50"
569	OUPADA	21°24'19"	86°32'50"
570	OUPADA	21°24'08"	86°33'39"
571	OUPADA	21°24'18"	86°33'22"
572	OUPADA	21°24'30"	86°33'11"
573	OUPADA	21°24'25"	86°33'12"
574	OUPADA	21°24'39"	86°33'08"
575	OUPADA	21°25'11"	86°32'38"
576	OUPADA	21°24'26"	86°34'13"
577	OUPADA	21°23'47"	86°34'42"
578	OUPADA	21°23'46"	86°34'38"
579	OUPADA	21°23'45"	86°34'35"
580	OUPADA	21°23'42"	86°34'20"
581	OUPADA	21°23'23"	86°34'19"
582	OUPADA	21°23'25"	86°33'03"
583	OUPADA	21°23'24"	86°33'44"
584	OUPADA	21°22'52"	86°34'13"
585	OUPADA	21°22'47"	86°34'02"
586	OUPADA	21°22'56"	86°34'02"
587	OUPADA	21°23'18"	86°33'58"
588	OUPADA	21°23'25"	86°34'30"
589	OUPADA	21°23'12"	86°34'42"
590	OUPADA	21°23'15"	86°34'42"
591	OUPADA	21°22'43"	86°35'14"
592	OUPADA	21°22'39"	86°35'18"
593	OUPADA	21°23'12"	86°33'08"
594	OUPADA	21°23'09"	86°33'04"
595	OUPADA	21°23'03"	86°32'54"
596	OUPADA	21°22'59"	86°32'47"
597	OUPADA	21°22'43"	86°32'27"
598	OUPADA	21°23'14"	86°32'11"
599	OUPADA	21°23'48"	86°34'45"
600	OUPADA	21°23'54"	86°35'04"
601	OUPADA	21°24'05"	86°35'18"
602	OUPADA	21°24'09"	86°34'48"
603	OUPADA	21°24'10"	86°35'06"
604	OUPADA	21°24'18"	86°35'03"
605	OUPADA	21°24'21"	86°35'34"
606	OUPADA	21°23'20"	86°35'38"
607	OUPADA	21°23'29"	86°35'56"
608	OUPADA	21°23'36"	86°36'28"
609	OUPADA	21°23'51"	86°36'19"
610	OUPADA	21°24'04"	86°36'01"
611	OUPADA	21°23'57"	86°35'45"
612	OUPADA	21°23'40"	86°35'36"
613	OUPADA	21°24'10"	86°35'25"
614	OUPADA	21°23'02"	86°36'16"
615	OUPADA	21°22'58"	86°36'18"
616	OUPADA	21°22'41"	86°35'35"
617	OUPADA	21°22'29"	86°35'53"
618	OUPADA	21°22'26"	86°35'33"
619	OUPADA	21°22'06"	86°35'28"
620	OUPADA	21°22'41"	86°36'43"
621	OUPADA	21°22'38"	86°36'45"

ANNEXURE – 6: Suggested Locations of Water Conservation Structures

Sl No	Block	Latitude (dd°mm′ss″N)	Longitude (dd°mm′ss″E)
622	OUPADA	21°22'34"	86°36'48"
623	OUPADA	21°22'16"	86°37'04"
624	OUPADA	21°22'42"	86°37'24"
625	OUPADA	21°23'11"	86°37'12"
626	OUPADA	21°24'45"	86°35'27"
627	OUPADA	21°24'48"	86°35'19"
628	OUPADA	21°24'44"	86°34'52"
629	OUPADA	21°24'49"	86°34'35"
630	OUPADA	21°24'14"	86°37'11"
631	OUPADA	21°24'37"	86°35'59"
632	OUPADA	21°25'03"	86°31'57"
633	OUPADA	21°25'30"	86°31'60"
634	OUPADA	21°25'01"	86°32'28"
635	OUPADA	21°24'56"	86°32'31"
636	OUPADA	21°24'24"	86°32'39"
637	OUPADA	21°25'10"	86°32'33"
638	OUPADA	21°25'28"	86°32'23"
639	OUPADA	21°25'40"	86°32'37"
640	OUPADA	21°25'51"	86°32'60"
641	OUPADA	21°25'54"	86°33'05"
642	OUPADA	21°26'08"	86°33'15"
643	OUPADA	21°26'12"	86°33'14"
644	OUPADA	21°25'52"	86°33'23"
645	OUPADA	21°25'36"	86°32'12"
646	OUPADA	21°26'40"	86°33'09"
647	OUPADA	21°26'53"	86°33'55"
648	OUPADA	21°26'07"	86°34'16"
649	OUPADA	21°25'56"	86°34'25"
650	OUPADA	21°24'46"	86°36'20"
651	OUPADA	21°23'49"	86°37'04"
652	OUPADA	21°23'60"	86°36'55"
653	OUPADA	21°23'29"	86°37'30"
654	OUPADA	21°23'36"	86°37'44"
655	OUPADA	21°23'29"	86°37'46"
656	OUPADA	21°23'27"	86°37'47"
657	OUPADA	21°23'25"	86°37'48"
658	OUPADA	21°23'18"	86°37'50"
659	OUPADA	21°22'49"	86°38'01"
660	OUPADA	21°23'41"	86°38'30"
661	OUPADA	21°23'25"	86°38'56"
662	OUPADA	21°23'54"	86°39'10"
663	OUPADA	21°24'02"	86°39'03"
664	OUPADA	21°23'56"	86°39'07"
665	OUPADA	21°24'06"	86°39'07"
666	OUPADA	21°23'52"	86°39'49"
667	OUPADA	21°24'46"	86°40'07"
668	OUPADA	21°24'13"	86°39'30"
669	OUPADA	21°24'04"	86°39'27"
670	OUPADA	21°24'05"	86°39'45"
671	OUPADA	21°20'41"	86°28'22"
672	OUPADA	21°20'55"	86°28'54"
673	OUPADA	21°20'57"	86°28'54"
674	OUPADA	21°20'52"	86°29'27"
675	OUPADA	21°20'39"	86°28'54"
676	OUPADA	21°21'45"	86°29'44"
677	OUPADA	21°21'57"	86°29'43"
678	OUPADA	21°22'02"	86°29'41"
679	OUPADA	21°21'23"	86°30'31"
680	OUPADA	21°21'41"	86°30'28"

ANNEXURE – 6: Suggested Locations of Water Conservation Structures

Sl No	Block	Latitude (dd°mm′ss″N)	Longitude (dd°mm′ss″E)
681	OUPADA	21°21'00"	86°30'51"
682	OUPADA	21°20'30"	86°30'31"
683	OUPADA	21°20'43"	86°31'46"
684	OUPADA	21°20'25"	86°31'26"
685	OUPADA	21°20'46"	86°31'21"
686	OUPADA	21°21'32"	86°31'23"
687	OUPADA	21°20'51"	86°31'12"
688	OUPADA	21°20'53"	86°31'09"
689	OUPADA	21°22'32"	86°30'50"
690	OUPADA	21°22'24"	86°30'45"
691	OUPADA	21°22'29"	86°31'17"
692	OUPADA	21°22'29"	86°31'26"
693	OUPADA	21°22'40"	86°31'31"
694	OUPADA	21°22'45"	86°31'43"
695	OUPADA	21°22'38"	86°32'12"
696	OUPADA	21°22'32"	86°32'41"
697	OUPADA	21°21'49"	86°31'42"
698	OUPADA	21°21'34"	86°31'24"
699	OUPADA	21°21'35"	86°32'30"
700	OUPADA	21°21'18"	86°32'26"
701	OUPADA	21°21'30"	86°33'01"
702	OUPADA	21°21'52"	86°33'05"
703	OUPADA	21°21'38"	86°33'12"
704	OUPADA	21°21'26"	86°33'10"
705	OUPADA	21°21'32"	86°33'27"
706	OUPADA	21°21'39"	86°33'32"
707	OUPADA	21°22'09"	86°33'33"
708	OUPADA	21°22'07"	86°33'36"
709	OUPADA	21°22'00"	86°33'41"
710	OUPADA	21°21'51"	86°33'47"
711	OUPADA	21°22'29"	86°33'08"
712	OUPADA	21°22'56"	86°33'12"
713	OUPADA	21°23'01"	86°33'25"
714	OUPADA	21°21'24"	86°34'10"
715	OUPADA	21°22'09"	86°34'00"
716	OUPADA	21°22'08"	86°34'25"
717	OUPADA	21°22'03"	86°34'40"
718	OUPADA	21°21'45"	86°35'07"
719	OUPADA	21°22'03"	86°34'59"
720	OUPADA	21°21'57"	86°35'17"
721	OUPADA	21°22'03"	86°35'17"
722	OUPADA	21°21'36"	86°35'29"
723	OUPADA	21°21'42"	86°36'10"
724	OUPADA	21°22'00"	86°37'03"
725	OUPADA	21°22'06"	86°36'23"
726	OUPADA	21°22'01"	86°36'23"
727	OUPADA	21°21'50"	86°36'21"
728	OUPADA	21°21'32"	86°36'21"
729	OUPADA	21°21'18"	86°36'16"
730	OUPADA	21°21'46"	86°36'09"
731	OUPADA	21°22'12"	86°37'08"
732	OUPADA	21°22'47"	86°40'29"
733	OUPADA	21°23'17"	86°40'07"
734	OUPADA	21°23'26"	86°40'37"
735	OUPADA	21°23'33"	86°40'11"
736	OUPADA	21°23'56"	86°40'28"
737	OUPADA	21°24'09"	86°40'34"
738	OUPADA	21°24'14"	86°40'34"
739	OUPADA	21°24'10"	86°40'43"

ANNEXURE – 6: Suggested Locations of Water Conservation Structures

Sl No	Block	Latitude (dd°mm′ss″N)	Longitude (dd°mm′ss″E)
740	OUPADA	21°24'06"	86°41'01"
741	OUPADA	21°23'53"	86°41'27"
742	OUPADA	21°23'55"	86°41'34"
743	OUPADA	21°23'49"	86°41'49"
744	OUPADA	21°23'33"	86°41'36"
745	OUPADA	21°23'33"	86°42'01"
746	OUPADA	21°24'32"	86°41'42"
747	OUPADA	21°24'27"	86°41'42"
748	OUPADA	21°23'02"	86°41'58"
749	OUPADA	21°24'18"	86°42'10"
750	OUPADA	21°24'13"	86°42'18"
751	OUPADA	21°24'09"	86°42'21"
752	OUPADA	21°25'08"	86°40'58"
753	OUPADA	21°25'07"	86°41'03"
754	OUPADA	21°24'59"	86°41'28"
755	OUPADA	21°25'04"	86°41'03"
756	OUPADA	21°25'11"	86°42'34"
757	OUPADA	21°24'58"	86°41'60"
758	OUPADA	21°24'49"	86°42'05"
759	OUPADA	21°24'37"	86°42'22"
760	OUPADA	21°24'12"	86°42'32"
761	OUPADA	21°20'19"	86°34'11"
762	OUPADA	21°19'58"	86°34'16"
763	OUPADA	21°19'39"	86°34'24"
764	OUPADA	21°20'52"	86°36'12"
765	OUPADA	21°21'55"	86°40'23"
766	OUPADA	21°22'00"	86°41'17"
767	OUPADA	21°22'03"	86°41'52"
768	OUPADA	21°22'47"	86°41'19"
769	OUPADA	21°22'51"	86°41'35"
770	OUPADA	21°22'53"	86°41'43"
771	OUPADA	21°22'51"	86°41'41"
772	OUPADA	21°22'56"	86°41'52"
773	OUPADA	21°22'58"	86°42'04"
774	OUPADA	21°22'39"	86°42'18"
775	OUPADA	21°22'33"	86°42'21"
776	OUPADA	21°22'33"	86°42'39"
777	OUPADA	21°23'17"	86°42'33"
778	OUPADA	21°23'13"	86°42'41"
779	OUPADA	21°23'18"	86°43'01"
780	OUPADA	21°24'24"	86°42'48"
781	OUPADA	21°24'23"	86°42'46"
782	OUPADA	21°23'51"	86°42'58"
783	OUPADA	21°24'07"	86°43'21"
784	OUPADA	21°23'46"	86°43'47"
785	OUPADA	21°23'51"	86°43'38"
786	OUPADA	21°23'34"	86°43'33"
787	OUPADA	21°23'23"	86°43'45"
788	OUPADA	21°23'18"	86°43'31"
789	OUPADA	21°23'25"	86°44'24"
790	OUPADA	21°24'31"	86°43'51"
791	OUPADA	21°24'16"	86°43'52"
792	OUPADA	21°23'52"	86°44'43"
793	OUPADA	21°25'06"	86°42'49"
794	OUPADA	21°24'45"	86°44'04"
795	OUPADA	21°24'48"	86°44'18"
796	OUPADA	21°25'09"	86°44'38"
797	OUPADA	21°25'06"	86°44'47"
798	OUPADA	21°25'22"	86°44'50"

ANNEXURE – 6: Suggested Locations of Water Conservation Structures

Sl No	Block	Latitude (dd°mm′ss″N)	Longitude (dd°mm′ss″E)
799	OUPADA	21°25'52"	86°44'53"
800	OUPADA	21°26'16"	86°45'05"
801	OUPADA	21°26'35"	86°45'06"
802	OUPADA	21°26'27"	86°45'19"
803	OUPADA	21°26'20"	86°45'26"
804	SORO	21°23'32"	86°39'26"
805	SORO	21°23'38"	86°39'26"
806	SORO	21°21'42"	86°37'08"
807	SORO	21°21'33"	86°37'48"
808	SORO	21°22'52"	86°39'10"
809	SORO	21°22'45"	86°39'07"
810	SORO	21°21'54"	86°39'23"
811	SORO	21°21'51"	86°39'21"
812	SORO	21°22'57"	86°39'57"
813	SORO	21°20'47"	86°39'11"
814	SORO	21°20'37"	86°38'44"
815	SORO	21°20'14"	86°38'24"
816	SORO	21°19'36"	86°38'35"
817	SORO	21°21'46"	86°40'51"
818	SORO	21°21'13"	86°39'58"