केन्द्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण

विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board

Department of Water Resources, River Development and Ganga Rejuvenation,

Ministry of Jal Shakti

Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

In Berla Block, Bemetara District Chhattisgarh

उत्तर मध्य छत्तीसगढ़ क्षेत्र, रायपुर

North Central Chhattigarh Region, Raipur

A REPORT ON

AQUIFER MAPPING & MANAGEMENT PLAN 2020-2021 IN BERLA BLOCK, BEMETARA DISTRICT, CHHATTISGARH

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FOREWORD

Groundwater resources are being developed over years in order to meet domestic, irrigation and industrial requirements. The spatial distribution of availability of ground water resources however, is uneven and is being indiscriminately exploited by various users thereby creating relentless pressure. On the other hand, rapid urbanization, industrialization and land use changes has resulted decline of water levels in many parts of the country.

There is an urgent need for scientific approach for proper management of the available ground water resources for sustainability of this precious natural resource for present and future generation.

Central Ground Water Board has been in the forefront of activities for occurrence, development, and management of this resource through various scientific studies and techniques. Over the last four decades CGWB, NCCR, Raipur has gathered a huge amount of data regarding ground water resources of Chhattisgarh. Based on this experience aquifer mapping of Berla block of Bemetara district was prepared with the vast amount of data generated and available with North Central Chhattisgarh Region. The report embodies all the features of ground water and related aspects of the study area including physiography, meteorological conditions, hydrology, drainage, geomorphology, geology, hydrogeology, ground water resources, hydrochemistry, geophysics, ground water problems etc.

*The report titled "**A Report on Aquifer Mapping and Groundwater Management Plan of Berla Block of Bemetara District, Chhattisgarh**" is prepared by Anusandhya Pradhan, Scientist-B under supervision of Sh. Uddeshya Kumar, Scientist-B. I appreciate the concerted efforts put by the author to make it possible to bring the report in its present shape. I hope this report will no doubt be useful and worthy for the benefit of Berla and would be a useful document for academicians, administrators, planners and all the stakeholders in ground water.*

Though utmost care has been taken to minimize the errors, some errors may have inadvertently crept in. It is expected that these mistakes will be taken in the proper spirit.

Dr. P. K. Naik

(REGIONAL DIRECTOR)

EXECUTIVE SUMMARY

Aquifer mapping is a multidisciplinary scientific process wherein a combination of geological, hydrogeological, geophysical, hydrological and quality data is integrated to characterize the quantity, quality and movement of ground water in aquifers. However, due to paradigm shift in focus from development to management of ground water in last one decade, the need for more reliable and comprehensive aquifer maps on larger scale has been felt for equitable and sustainable management of the ground water resources at local scale. Volumetric assessment of ground water and strategies for future development and management are the primary objectives of aquifer mapping.

Under the aquifer mapping Programme, Berla block of Bemetara District was taken up for study covering an area of 777 sq. km. It falls in the Survey of India's Degree Sheet No. 64 G (2, 5,6,7,9,10,11 &13) between the Latitude 21° 21'0 '' N and 21° 42' 0''N and Longitude 81° 20 '0 ''E and 81° 42' 0''E. The study area is bounded by Bemetara block in the north, Saja block in the north-west, Baloda Bazaar district in North East, Durg district in the south-west, Raipur district in the east. The district has a well-developed road network.

The total population of the study area as per 2011 Census is 182,211. The study area experiences sub-tropical climate. The average annual rainfall for the study area is around 1231.64 mm (Average of the last five years i.e. 2016 to 2020)

Geomorphologically the study area displays Structural Plains and Flood Plain which comes under the physiographic unit belonging to Chhattisgarh basin area.

The net sown area is 56138 Ha, while double-cropped area is 24097 Ha. The gross cropped area of the district is 80235 Ha. The net Irrigated cropped area is 39810 Ha, while the area under groundwater irrigation is 36575 Ha which is about 91.87 % of net cropped area.

Based on the exploratory drilling data generated for the block, the existing aquifer systems in the area may be divided into phreatic and fractured aquifer. The major aquifers present in the study

area are 1. Shale (Maniari and Tarenga), 2. Limestone (Chandi Limestone) and Dolomite (Hirri Dolomite), Discharge varies from 1.5 to 12 lps in fractured aquifer. Higher yields are obtained where thick weathered zones are associated with bedrock fracturing.

As per 2020 ground water resource calculation stage of ground water development in the study area is only 90.85 %. So, there is no broad scope of utilizing more ground water for future irrigation purpose and other purposes. There is a need to check the over exploitation of ground water and focus should me more on sustainable development and management of groundwater. Artificial recharge should be carried out in an extensive scale.

The major ground water issues identified during the survey in the study area are as follows: (i) Drying of Dugwells and handpumps during summer. (ii) Drilling difficulties in limestone terrain (iii) Saline water in some places due to encounter of Gypsiferous Maniari shale. In the study area there may occur serious issue of scarcity of ground water due to over exploitation of it. So, in this area Rain/ Surface water may be conservedand utilized, as more than 90 % of ground water draft is being used in the area which is of serious concern drip irrigation must be followed. High value of Salinity has been reported from several locations which is due to the presence of Gypsiferous shale. The problem of salinity in drinking water may be tackled by setting up of small destillation units, Electrodialysis unit in affected villages or alternate source may be identified. Regular ground water quality monitoring is also required.

So far as Management strategies are concerned for ground water availability, for effective utilization of Ground water existing draft for irrigation may be coupled with micro irrigation system. Change in irrigation pattern, optimum use of available resource, use of ground water potential created after artificial recharge can lead to groundwater savings and increase in gross cropped area of the block.

(Anusandhya Pradhan)
Scientist-B (Hg)

Acknowledgment

I would like to take an opportunity to thank ***Shri Sunil Kumar, Chairman, Central Ground Water Board*** *for giving an opportunity for preparation of Aquifer Map and Management plan of Berla block of Bemetara district of Chhattisgarh* ***and Shri Sateesh Kumar Member (East), CGWB*** *for giving valuable guidance, encouragement and suggestions during the preparation of this report. The author is thankful to* ***Dr. P. K Naik, Regional Director, Central Ground Water Board, NCCR, Raipur*** *for extending valuable guidance and constant encouragement during the preparation of this report. I am very much delighted to express my deep sense of gratitude and regards to* ***Sh. A.K. Biswal, Scientist-E*** *for his continuous guidance and support during preparation of this report. I am also thankful to* ***Dr. P. K Naik, Regional Director (Retd.) and Sh A.K. Patre, Scientist-D*** *for the guidance and suggestions. I am deeply thankful to* ***Sh Uddeshya kumar, Scientist- B, Smt Prachi Gupta, Scientist-B and Shri Sidhanta Kumar Sahu, Scienstist-B*** *for their valuable and meticulous guidance while preparing aquifer maps, 3-d disposition of aquifers and also for their constant encouragement, inspiration, affectionate supervision that I received continuously from them. I am also thankful to* ***Sh Rakesh Dewangan, Scientist-B*** *for the chemical analysis and valuable inputs on quality issues. The efforts made by* ***Sh. T.S. Chouhan, Draftsman*** *for digitization of maps are thankfully acknowledged. The author is also thankful to the state agencies for providing the various needful data. The author is thankful to Technical Section, Data Centre, Chemical Section, Report Processing Section and Library of CGWB, NCCR, Raipur for providing the various needful data. The help and co-operation of staffs of CGWB, NCCR, RAIPUR is greatly recognizable. Their keen devotion and tenacity at work provided the necessary inspiration and courage to stand up to the winds of hope just as a sprouting seedling looks up towards the trees and dreams of becoming one. Last but not least, I would like to acknowledge my family members for their unselfish sacrifices, constant blessing and moral support at every stage.*

(Anusandhya Pradhan)
Scientist-B (Hg)

A Report on Aquifer Mapping, 2020-2021 in Berla Block, Bemetara District, Chhattisgarh

CONTENTS

1. INTRODUCTION

The total volume of fresh groundwater stored on Earth is between 8 and 10 million km3 or 96% of non-frozen freshwater. Groundwater provides almost 50% of all drinking water worldwide and 43% of all consumptive use of water for irrigation in agriculture. Changes in groundwater availability and quality impact human health, livelihoods, food security and national economic development. Many aquatic ecosystems and their biodiversity depend on groundwater. Failure to manage groundwater sustainably puts at risk massive benefits for human well-being, sustainable development and biodiversity conservation. The long-term viability of irrigation-based economies in our country is threatened, creating long-term risks for global food security. Over-exploitation of groundwater and contamination threatens drinking water supply for hundreds of millions of people. Degradation of groundwater reduces resilience of communities and economies to climate change.
However, due to rapid and uneven development, this resource has come under stress in several parts of the country. Central Ground Water Board (CGWB) is involved in Hydrogeological investigations; major part of the country has been covered. CGWB has also carried out ground water exploration in different phases with prime objective of demarcating and identifying the potential aquifers in different terrains for evaluating the aquifer parameters and also for developing them in future. The reports and maps generated from the studies are mostly based on administrative units such as districts and blocks and depict the subsurface disposition of aquifer on regional scale. Volumetric assessments of ground water and strategies for future development and management, these reports are available for most parts the country in different scale. However, due to paradigm shift in focus from development to management of ground water in last one decade, the need for more reliable and comprehensive aquifer maps on larger scale has been felt for equitable and sustainable management of the ground water resources at local scale.

1.1. Purpose and Scope

Abstraction of groundwater has at least tripled over the last 50 years in our country. Groundwater levels have declined significantly in major aquifers, reducing stream flows and causing the degradation of riparian and wetland ecosystems. On the other hand, there are also areas where adequate development of ground water resources has not taken place. These facts underscore the need for micro- level study of the aquifer systems of the country.

The aquifer maps are the maps depicting aquifer disposition, giving lateral and vertical extension. The maps will also provide information on the quantity and quality. Aquifer mapping study is a multidisciplinary scientific process wherein a combination of geological, hydrogeological, geophysical, hydrological and quality data is integrated to characterize the aquifers along with quantity, quality and movement of ground water in it. The purpose of aquifer mapping is to explore the ground water potentiality at depth up to 200m in hard rock area and 300m in soft rock area. The methodology includes historical data collection, compilation, analysis of data gap, data generation and followed by ground water management.

It explains the components of the Aquifer Classification System, outlines the assumptions underlying the map information presented and summarizes the content of an aquifer classification map. The goal is to help the map users understand the strengths and limitations of the information contained on the aquifer classification maps so that they can apply that information appropriately to their particular water and land management needs. The system and maps are designed to be used together and in conjunction with other available information as a screening tool for setting groundwater management priorities. They provide a way of comparing aquifers within a consistent hydrogeological context and prioritizing future actions at various planning levels. The maps may provide some background information for site-specific projects. However, the maps are not to be used for making site-specific decisions. The classification of an aquifer reflects the aquifer as a whole and at a specific time. Groundwater conditions, such as the degree of vulnerability and water quality, can vary locally and over time respectively. This variability in the data sometimes requires subjective decision-making and generalizing of information for an entire aquifer.

Under the aquifer mapping program, Berla Block of Bemetara district covering an area of 777 sq. km was taken up during the first phase of 12th five-year plan. The area is covered in the Survey of India's Topo Sheet Nos. 64G/2, 64G/5, 64G/6, 64G/7, 64G/9, 64G/10, 64G/11 and 64G/13 (1:50000 Scale) and fall lays between latitudes 21° 21'0 '' N & 21° 42' 0''N and between longitudes 81° 20 '0 ''E & 81° 42' 0''E.

1.2 Location, Extent and Accessibility

The study area covers an area of 777 sq. km. It is situated in the western part of Chhattisgarh state. It falls in the Survey of India's Topo Sheet Nos. 64G/2, 64G/5, 64G/6, 64G/7, 64G/9, 64G/10, 64G/11 and 64G/13 (1:50000 Scale) and fall lays between latitudes 21° 21'0 '' N and 21° 42' 0''N and between 81° 20 '0 ''E and 81° 42' 0''E.

The study area is bounded by Bemetara block in the north, Saja block in the north-west, Baloda Bazar district in North East, Durg district in the south-west, Raipur district in the east (**Fig 1**). The district has a well-developed road network.

1.3 Administrative Division

Berla block comes under the study area. Berla is a block situated in Bemetara district in Chhattisgarh. Situated in rural area of Chhattisgarh, it is one of the 4 blocks of Bemetara district. According to the government register, the block code of Berla is 82. The block has 136 villages and there are total 35466 homes in this Block.

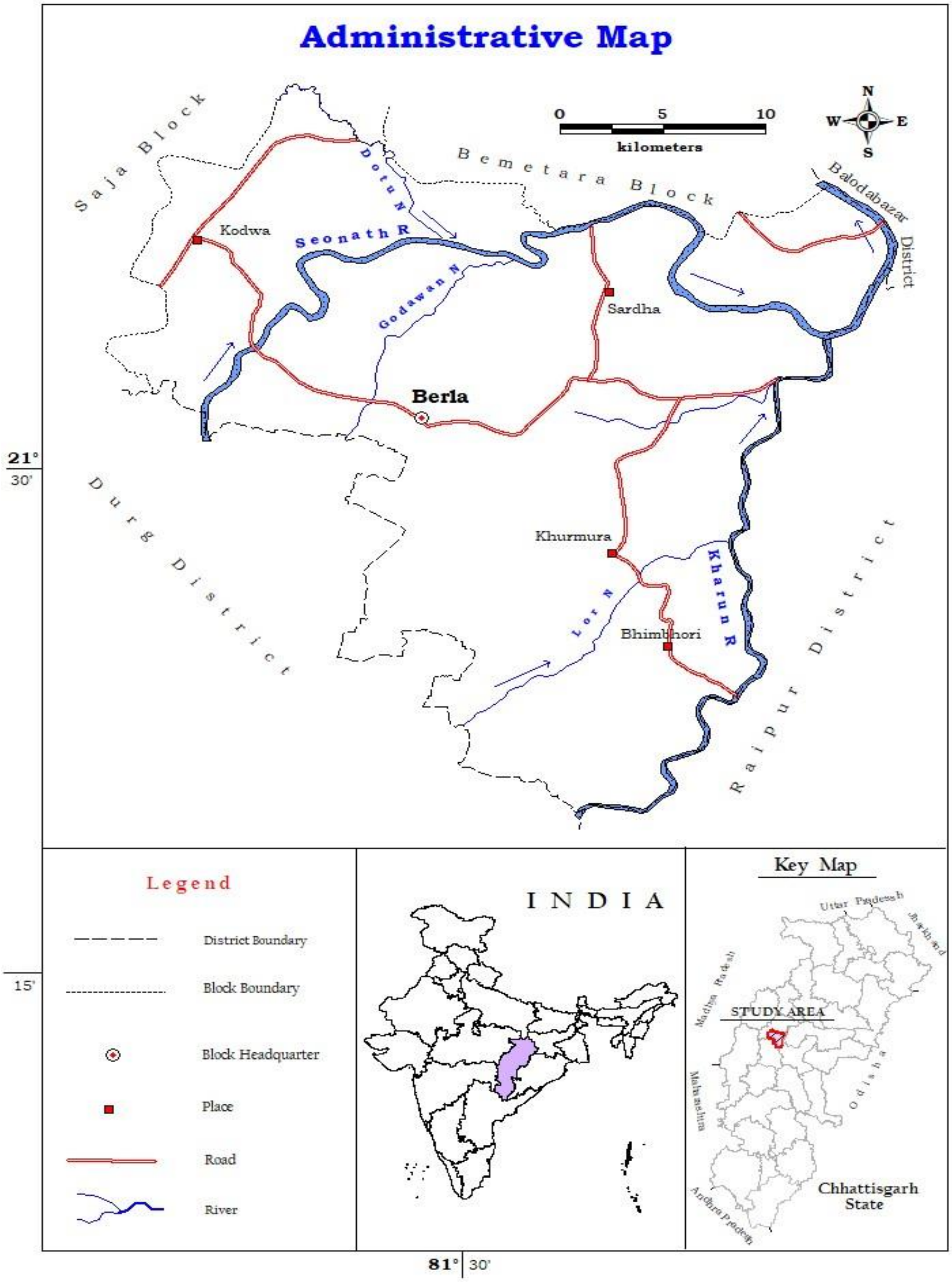
Table 1(A): Geographical location of the study area

Study Area (Blocks)	District	Area (Sq Km)	Latitude		Longitude		Toposheet No (1:50000 Scale)
			From	To	From	To	
Berla Block	Bemetara	777	21° 21'0 ''N	21° 42' 0''N	81° 20 '0''E	81° 42' 0''E	64G/2, 64G/5, 64G/6, 64G/7, 64G/9, 64G/10, 64G/11 and 64G/13

Table 1(B) :Administrative Divisions of the Area

Sl No	Name of Block	District	Area (Sq Km)	No of Tehsils	No of Development Blocks	No of Towns
1	Berla	Bemetara	777	1	1	1

Fig.1 Administrative Map of the Study Area


Administrative Map
0
5
10
kilometers
N
W
E
S
Saja Block
Bemetara Block
Balodabazar District
Kodwa
Seonath R
Dotu N
Godawan N
Sardha
Berla
Durg District
Khurmura
Kharun R
Lor N
Bhimbhori
Raipur District
21°
30'
15'
81°
30'
Legend
District Boundary
Block Boundary
Block Headquarter
Place
Road
River
INDIA
Key Map
Uttar Pradesh
Jharkhand
Madhya Pradesh
STUDY AREA
Maharashtra
Odisha
Andhra Pradesh
Chhattisgarh State

1.4 Demography

According to 2011 census, Total Berla population is 182,211 of which 90,768 are male and 91,443 are female. Expected Population of Berla Tehsil in 2020/2021 is between 176,745 and 225,942. Literate people are 108,156 out of 62,041 are male and 46,115 are female. Total workers are 97,447 depends on multi skills out of which 51,813 are men and 45,634 are women. Total 27,798 Cultivators are depended on agriculture farming out of 17,659 are cultivated by men and 10,139 are women. 32,577 people works in agricultural land as a labour in Berla, men are 17,123 and 15,454 are women. Berla Tehsil sex ratio is 1,007 females per 1000 of males.

The population break up i.e. male- female is given below in **Table 2**.

Table 2: Population break up

Population	**Males**	**Females**	**Households**
187376	93360	94016	35466

**Source: CG Statistical handbook- Census 2011*

1.5 Pedology

Generally, soils are classified based on texture, mineral content and presence of salts and alkalies. However, in present context the classification and distribution are adopted as per the soil orders in US soil taxonomy and their Indian equivalents. There are 12 orders in US soil taxonomy but only two orders are found in study area. They are described below in brief and given in **Table 3**. The distribution of these two different soil types in the study area is presented in **Fig 2**.

Table 3 : Soil Classification

Sl.No.	**US Soil Taxonomy**	**Indian Equivalents**
1	Ultisols	Lateritic soil
2	Vertisols	Medium black soil
		Deep black soil

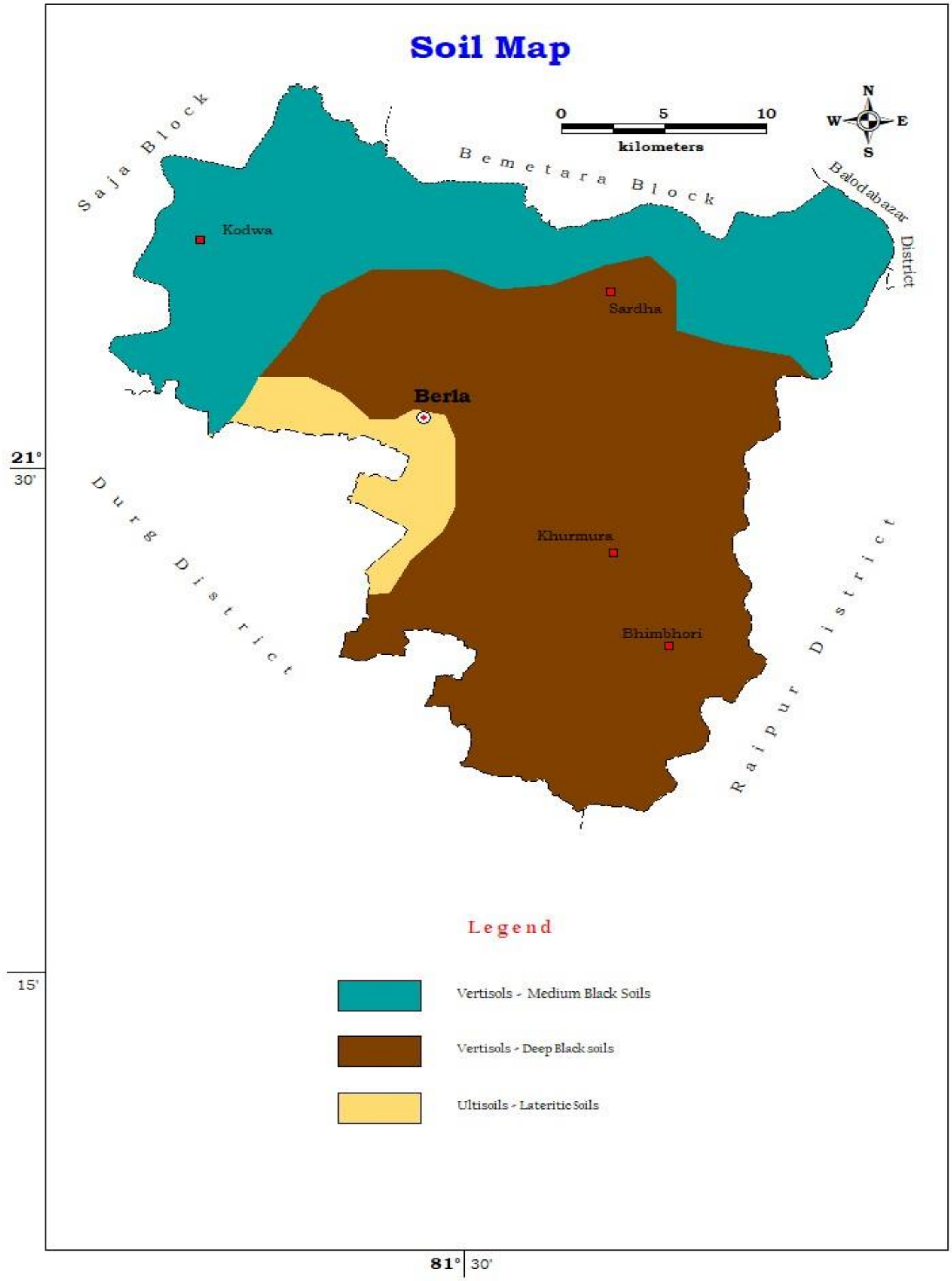
A. Ultisols

The Indian equivalent of this soil found in Berla block is Lateritic soil. It is exposed in western part of the block in patches. It is the ultimate product of continuous weathering of minerals in a humid climate. This is a highly weathered and leached acid soil with high levels of clay below top layer. They are characterized by a humus-rich surface horizon and by a layer of clay that has migrated below the surface horizon. This soil has variety of clay minerals but in many cases the dominant mineral is Kaolinite. This clay has good bearing capacity and no shrink-swell property. They are red to yellow in color and are quite acidic having pH less than 5. The red and yellow color results from the accumulation of iron oxide which is highly insoluble in water.

B. Vertisols

There are two types of Indian equivalent of this soil is found in Berla block namely medium black soil and deep black soil. They are exposed in major part of the block especially in northern,eastern and central part. Vertisol is a soil in which the content of clay size particles is 30% or more by mass in all horizons of the upper half-metre of the soil profile. They are are characterized by a high content of expanding and shrinking clay known as montmorillonite. They may also be characterized by salinity and well defined layers of calcium carbonate or gypsum. Evidence of strong vertical mixing of the soil particles over many periods of wetting and drying can be observed in this type of soil. Vertisols typically form from highly basic rocks such as basalts and are found typically on level or mildly sloping topography in climatic zones that have distinct wet and dry seasons. Depending on the parent material and the climate, they can range from grey or red to the more familiar deep black. Vertisols contain high level of plant nutrients, but, owing to their high clay content, they are not well suited to cultivation without painstaking management. Vertisols are especially suitable for rice because they are almost impermeable when saturated. Rainfed farming is very difficult because vetisols can be worked only under a very narrow range of moisture conditions as they become very hard when dry and become very sticky when wet.

Fig.2 Soil Map of the Study area



1.6 Agriculture, Irrigation, Cropping Pattern

In the study area, ground water related agriculture data has been collected to understand the cropping pattern and thereby the related water requirement and it"s impact on the local ground water regime. Rice is the major crop which is extensively cultivated during both Kharif and Rabi season. Wheat in some parts is also cultivated as Rabi crop.

Commercial Crop and Plantation-Cotton and Banana are commercial plantations mostly taken over every year in the study area. While rain water is the only source during Kharif, the area is irrigated through ground water during Rabi. The relevant data are presented in table 4(A, B, C).

Table 4(A): Agricultural pattern in Berla Block during the year 2018 (in ha)

Tehsil	**Total geographical area**	**Revenue forest area**	**Area not available for cultivation**	**Non agricultural & Fallow land**	**Agricultural Fallow land**	**Net Sown area**	**Double cropped area**	**Gross cropped area**
Berla	777	0	7229	7827	5822	56138	24097	80235

*As per latest data available on State Govt site Directorate of Economics and Statistics, Raipur, Chhattisgarh

Table 4(B): Cropping pattern in Berla district Block during the year 2018(in ha)

Tehsil	Kharif	Rabi	Cereal				Pulses	Tilhan	Fruits / Vegetables	Reshe	Mirch Masala
			Wheat	Rice	Jowra & Maize (Respectively)	Others					
Berla	52374	27861	5123	45140	0 & 12 respectively	3	21128	3538	4635	201	1081

*As per latest data available on State Govt site Directorate of Economics and Statistics, Raipur, Chhattisgarh

Table 4(C) : Area irrigated by various sources in Berla Block during the year 2018 (in ha)

Tehsil	No. of canals (private and Govt.)	Irrigated area	No .of bore wells / Tube wells	Irrigated area	No. of dug wells	Irrigated area	No. of Talabs	Irrigated area	Irrigated area By other sources	Net Irrigated area	Irrigated area more than once	Gross Irrigated Area	% of irrigated area wrt. Net sown area
Berla	4	1478	7986	36568	521	7	143	980	777	24718	15092	39810	49%

*As per latest data available on State Govt site Directorate of Economics and Statistics, Raipur, Chhattisgarh.

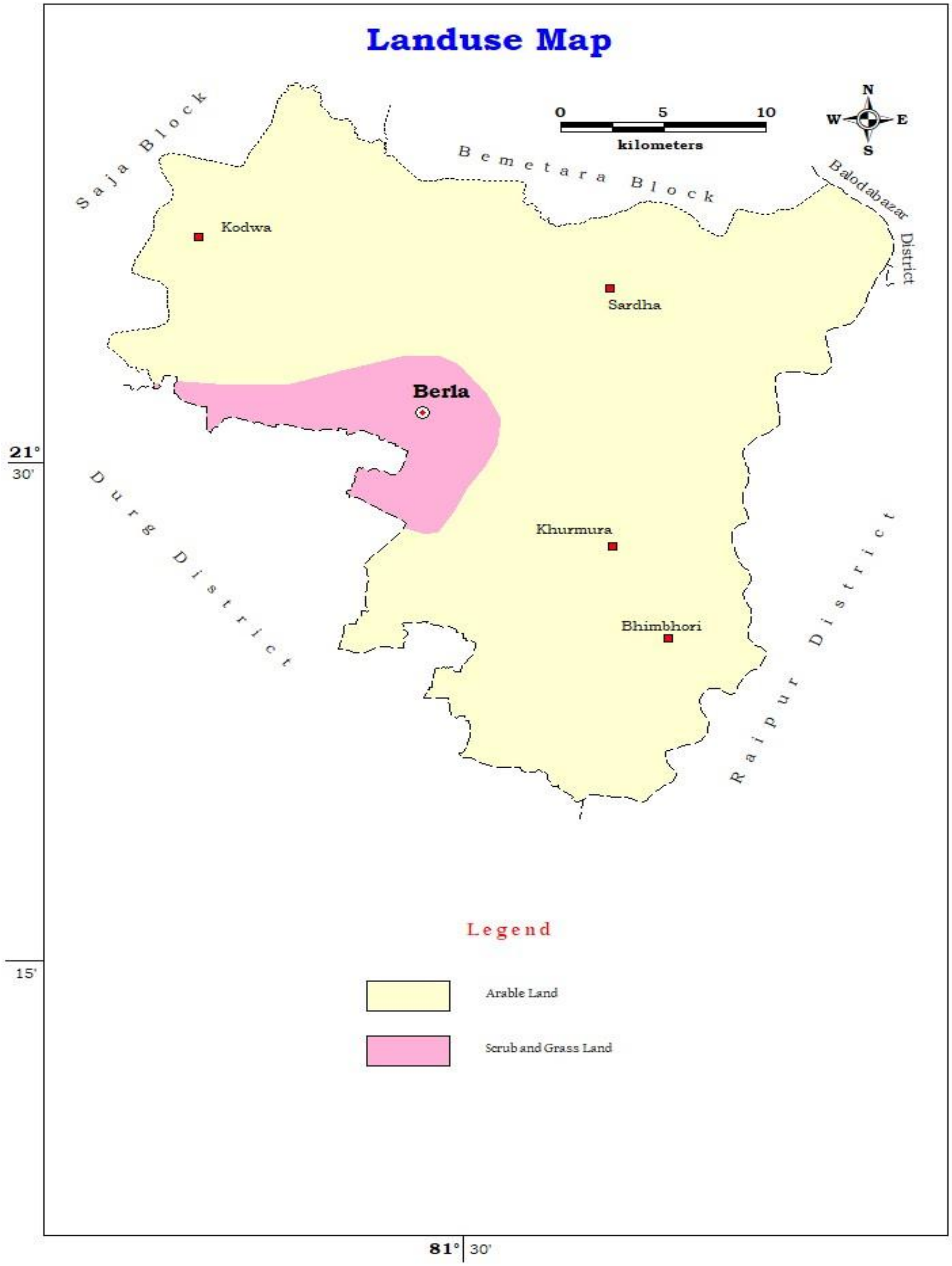
1.7 Land use

The scrub and Grass land and arable land in Berla block is 70.14 and 704.6 sq. km. There is no reserved forest and protected forest, other forest in the district

Table 5: Land Use (Sq. km)

Block	Reserved Forest	Protected Forest	Other Forest	Scrub and Grass Land	Arable Land	Total Area
Berla	NA	NA	NA	70.14	704.6	774.74
Total area						774.74

Fig.3 Land Use Map of the Study Area



1.8. Hydrometeorology

The study area experiences sub-tropical climate and is characterized by extreme summer and winter seasons. The summer months are from March to May and the months of April and May are the hottest. The rainy season extends from the month of June to September with well distributed rainfall through southwest monsoon. Monsoon generally breaks in the third week of June and is maximum in the months of July and August. Winter season is marked by dry and cold weather with intermittent showers during the months of December and January.

1.8.1 Temperature

The temperature in the study area changes continuously with the season and even in day and night. The temperature decreases progressively after October. The winter season lasts till February. January is the coldest month with mean daily maximum temperature at 30°C and the minimum is around 10°C. During winter season, the night temperature sometimes may drop below 10°C. The temperature increases rapidly from mid-February till May and sometimes up to mid-June (summer season). The mean daily maximum temperature in summer season goes up to 46°C and nights are slightly warmer during May and mid-June. The monsoon period is generally pleasant. With the withdrawal of the monsoon by the end of September, day temperature rises a little and then both day and night temperatures begin to drop rapidly.

1.8.2 Evaporation

The evaporation variations are almost sympathetic with the variations of temperature. The evaporation is maximum in the month of May and minimum during the months of December and January.

1.8.3 Humidity

The atmospheric humidity is usually low during summer months around 25%. However humidity slowly starts building up from third week of May and it reaches maximum around 85% during monsoon period. The humidity again decreases in winter season and it varies between 30 to 40% during winter season.

1.8.4 Wind Velocity

The wind flows easterly or westerly during the southwest monsoon period. During post-monsoon and winter seasons the wind directions are between north and east and sometimes westerly. The wind speed of more than 10 km/hr is recorded during the monsoon months (from June to September). In the post-monsoon and winter months (from October to February), the wind speed is less than 5 km/hr and in the summer months (March to May) the wind speed is more than 7 km/hr.

1.8.5 Rainfall

The study area receives rainfall mainly from south-west monsoon. It sets in third/fourth week of June and continues till mid-August/September with heaviest showers in the months of July and August. The average annual rainfall for the study area is around 1231.64 mm (Average of the last three years i.e. 2018 to 2020).

Annual rainfall in Bemetara district for the period of five years from 2016 to 2020 is presented below in **Table 6**.

The months of July and August are the heaviest rainfall months and nearly 95% of the annual rainfall is received during June to September months.

Table 6 : Annual Rainfall (mm) in Bemetara district for the years 2018

District/Tehsil	2016	2017	2018	2019	2020	Average of 3 years for the block
Berla	1147.4	1162.7	1427.3	1039.8	1381	1231.64
Average of 5 years for study area					1231.64	

Source: *IMD*

1.9 Geomorphology and Drainage

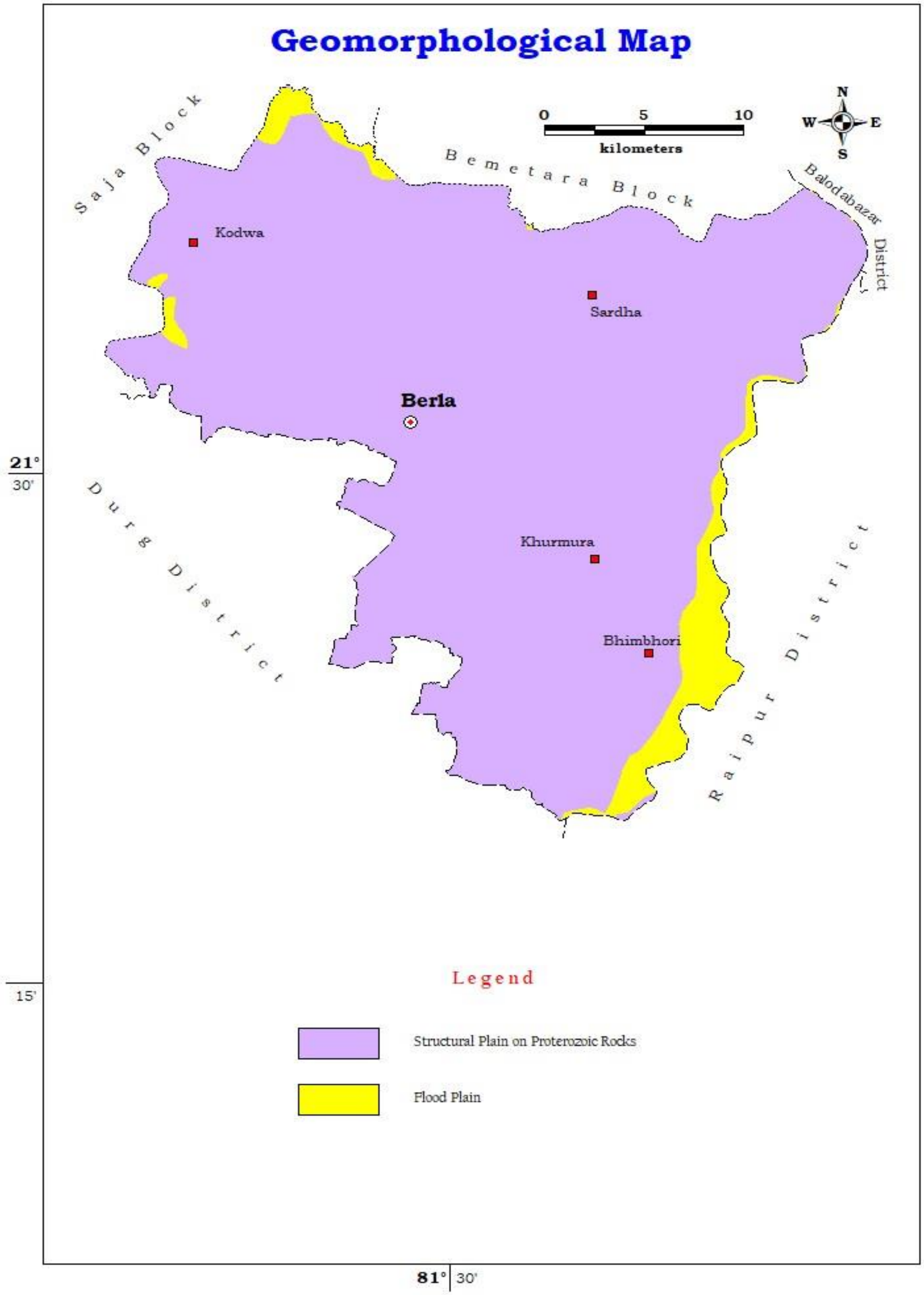
1.9.1 Geomorphology

Geomorphologically the study area displays Structural Plains and Flood Plain which comes under the physiographic unit belonging to Chhattisgarh basin area.

The Central Chhattisgarh Plain is represented by Structural Plain on Proterozoic rocks which cover major area in the northern & central part of the block. This unit is developed over rocks of Purana sedimentary basin of Chhattisgarh. This unit has extensive criss-crossed fractures and joints. They are having gently sloping erosional surfaces and thin to moderate cover of soil.

Along with the above-mentioned geomorphic unit, Flood Plain is also developed in the block especially in norther, north-western, eastern and south-eastern part. It is formed by extensive deposition of alluvium by major river system in the block. This unit is normally flat/gently undulating land surface and located along river courses. This unit is primarily composed of unconsolidated fluvial materials like gravels, sand and silt. **Fig 4** shows the Geomorphology in the study area.

Fig.4 Geomorphology Map of the Study area



1.9.2 Drainage

The study area is mainly drained by Sheonath and Kharun rivers and their distributaries. This river system comes under Mahanadi River basin. Sheonath River, is a tributary to Mahanadi, flows through the upper eastern periphery to central and western part of the district along with its tributaries. Kharun river along with its tributaries flows along the eastern peripheries of the block and also joins Sheonath river in north-eastern part of the block.

The drainage map is prepared and presented in **Fig 4.** From the figure, it may be seen that, the drainage pattern of the area is dendritic to sub-dendritic in nature. Drainage density is more or less same in most of the part of the district except in central part. The drainage density is found comparatively low in the central area which is attributed to plain area indicating somewhat low runoff and higher infiltration.

1.10 Geology

Geologically, the study area comprises of rocks of Meso to Neo-Proterozoic sequence and is represented by the Chhattisgarh Supergroup consisting of the Raipur Group of rocks. Raipur Group comprises Charmuria Formation, Gunderdehi Formation and Chandi formation, Tarenga Formation, Hirri Formation and Maniyari Formation. But the study area is covered predominantly by Tarenga Formation Hirri Dolomite as well as Chandi formations.

The geological map of Berla block is shown in **Fig 5**.

A total of 9 nos. of exploratory wells have been drilled in this Group of rocks. The formation wise drilling results are given below:

Tarenga Formation:

This Formation comprises predominantly an argillite-dolomite sequence. The shales are cherty and calcareous. This formation has good ground water potential at places.

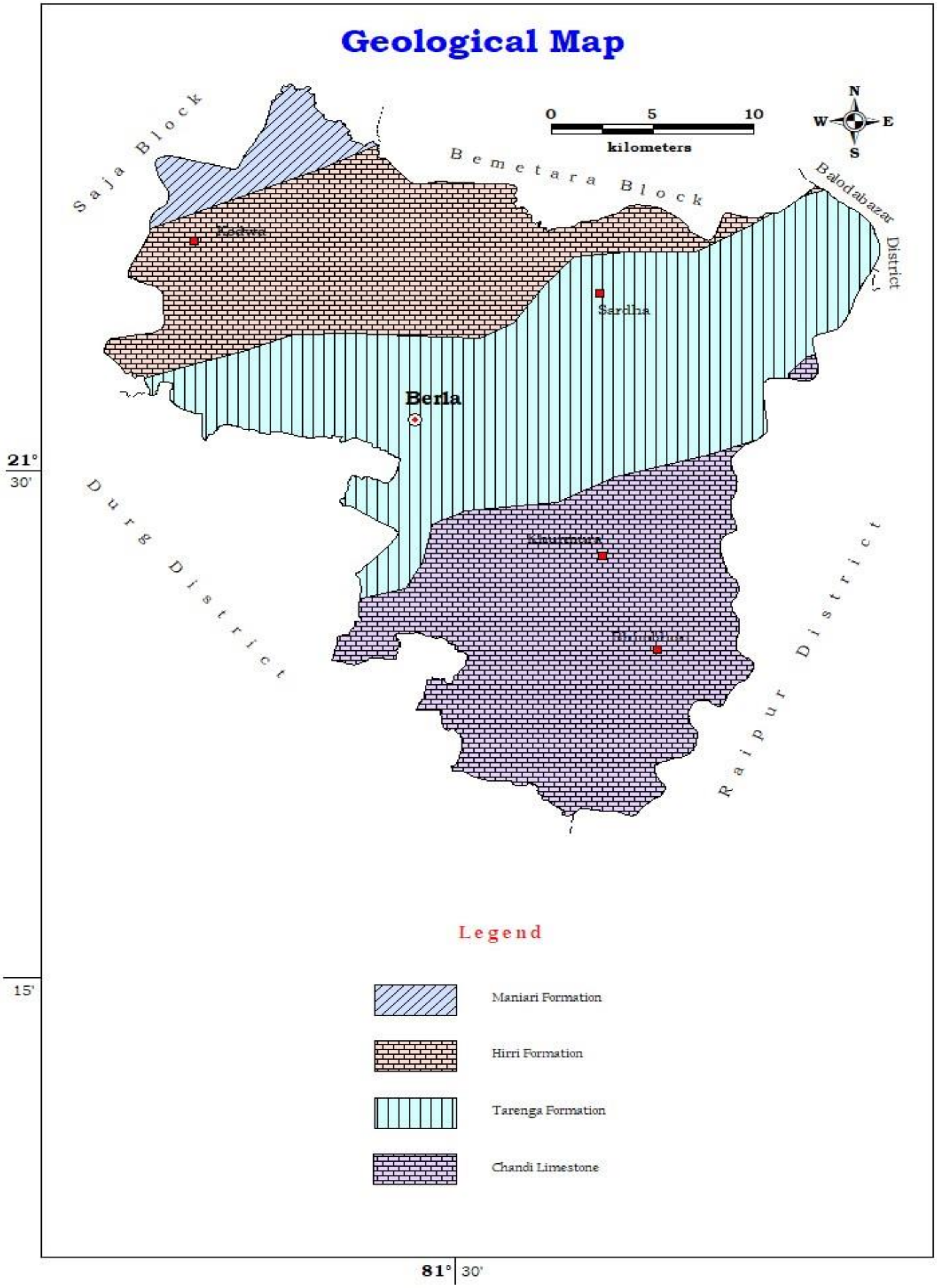
Hirri Formation:

This Formation comprises dark grey, bedded dolomite associated with light grey laminated argillaceous dolomite. This formation has also good ground water potential.

Chandi Formation:

This Formation comprises a dominant stromatolitic limestone sequence. The bottom most (Newari member) comprises of stromatolitic limestone and dolomite which is pink to light grey in colour and thickly bedded followed by dark grey flaggy limestone (Pendri member) with intercalations of calcareous shale and Deodongar sandstone of lensoid shape. The topmost unit (Nipania member) comprises of pink to purple dolomitic limestone. Towards upper part it changes into bedded limestone and purple shale and is devoid of stromatolitic structure. This formation has very good ground water potential due to development of caverns at places.

Fig 5: The geological map of the study area



2. DATA COLLECTION AND GENERATION

2.1 Hydrogeological Data

The semi-consolidated rocks of study area mainly represented by Chhattisgarh Super Group of rocks (Predominantly by Maniyari Formation followed by Hirri, Tarenga and Chandi formations) which consists mainly of shale and limestone. In general two aquifers exist in the area although both are hydraulically connected. The first shallow unconfined/ phreatic aquifer between 0-30 mbgl and the second semi confined to confined aquifer below 30 mbgl.
In the study area, key wells were established during the pre-monsoon period and have been subsequently monitored in the post-monsoon period. The key wells are distributed throughout the study area covering all the geological formations, the details of which are presented in the Table No 8.

Based on the depth to water level periodical monitoring data of the key wells established in the study area, pre-monsoon and post-monsoon depth to water level maps as well as seasonal fluctuation maps have been prepared.

2.1.1 Pre-monsoon period

In the pre-monsoon period, it has been observed that in Berla block, the minimum water level is 2.5 mbgl in Shale formation while the maximum is 12 mbgl. In Limestone formation the minimum water level is 2.1 mbgl while the maximum is 8.6 mbgl.

The detail of aquifer wise Pre-monsoon Water Level is presented in table 10 and in fig 9.

Table 7: Aquifer wise Depth to Water Level (Pre-monsoon)

Block Name	Shale		Limestone	
	Min	Max	Min	Max
Berla	2.5	12	2.1	8.6

*Water Level (in mbgl)

Fig.6 Pre- monsoon Depth to water level Map of Fractured Aquifer

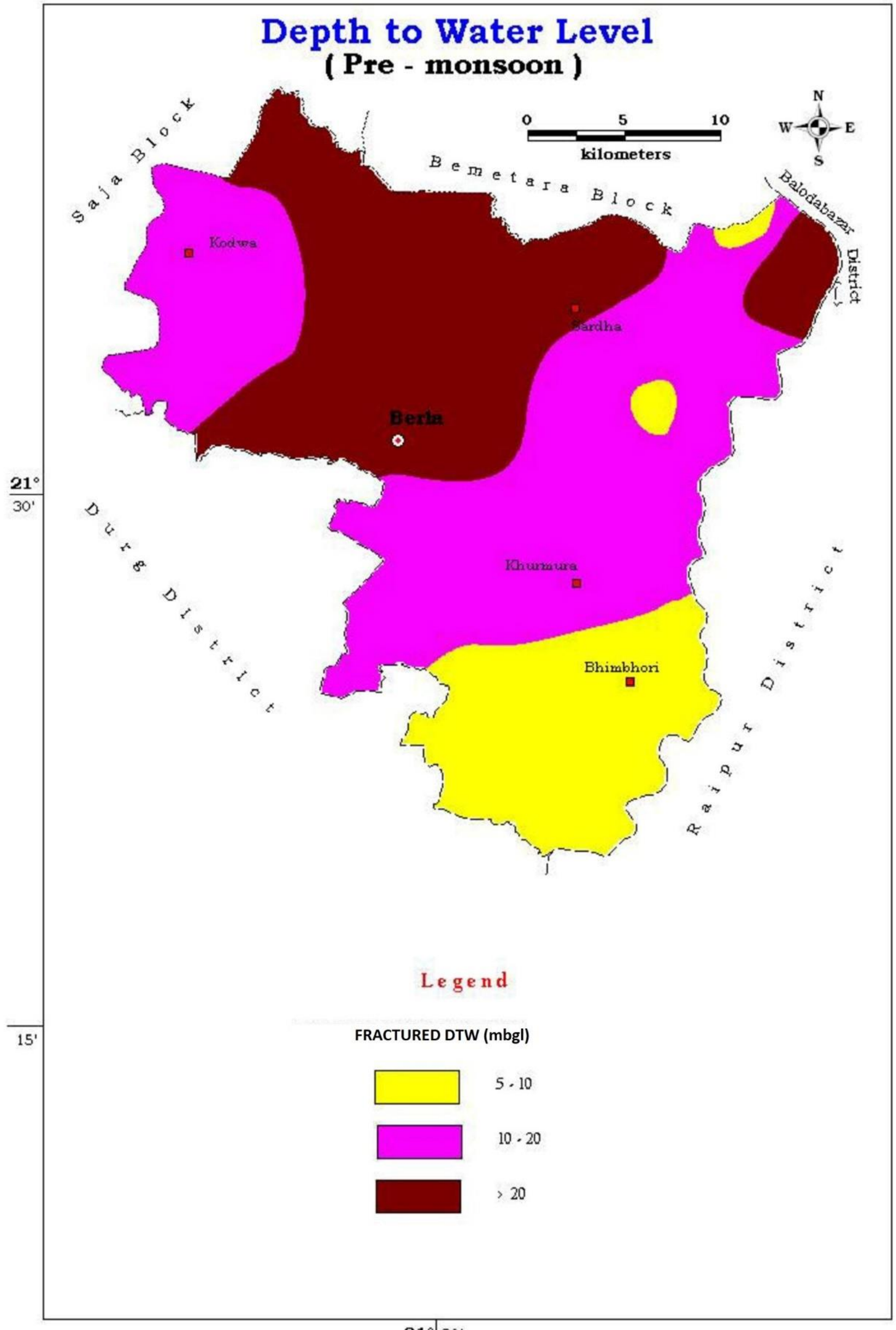
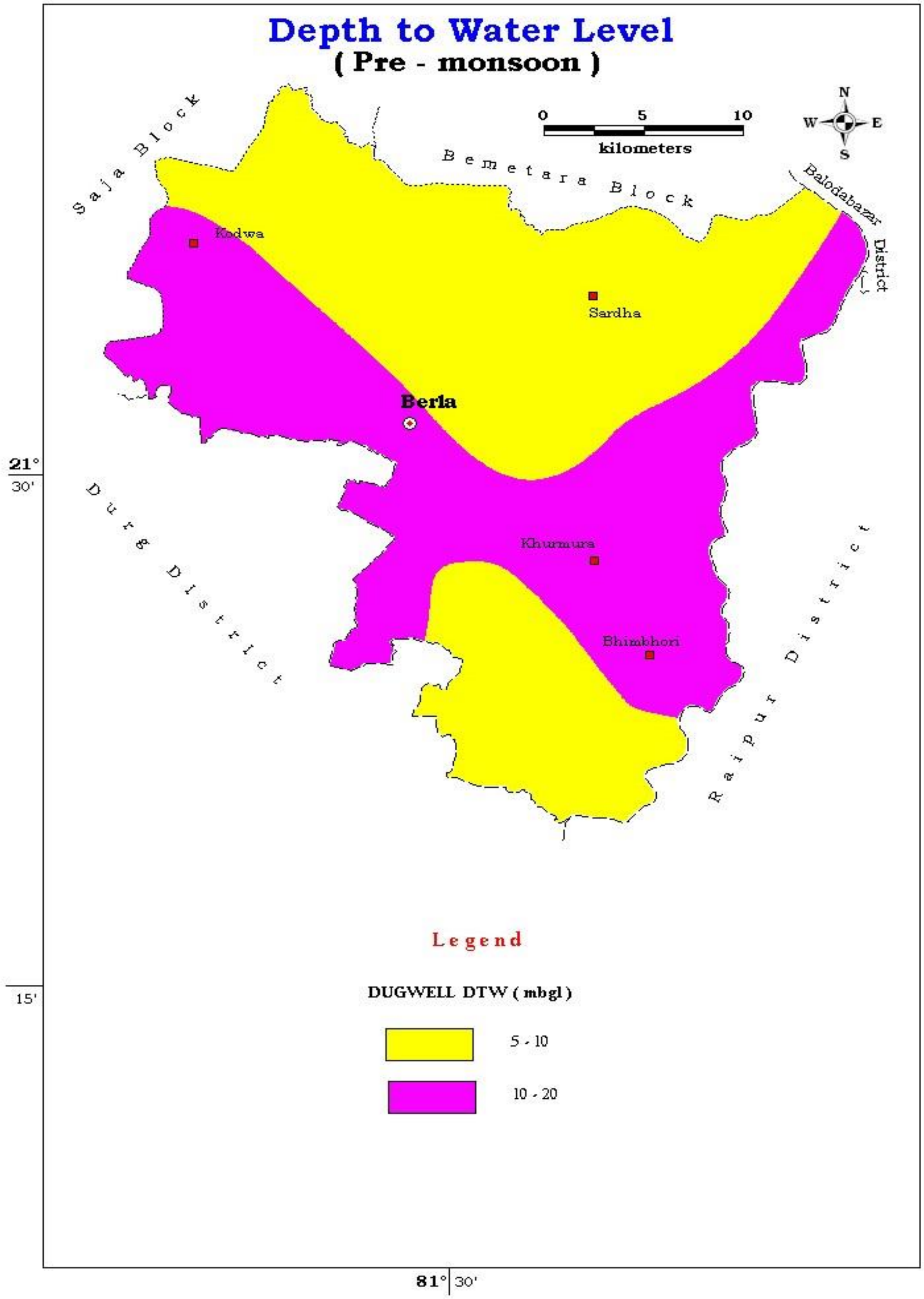


Fig.7 Pre- monsoon Depth to water level Map of Phreatic Aquifer



2.1.2 Post-monsoon period

In the post-monsoon period, it has been observed that in Bemetara block, the minimum water level is 0.82 mbgl in Shale formation while the maximum is 9.02 mbgl. In Dolomite formation the minimum water level is 1.60 mbgl while the maximum is 5.25 mbgl. In Limestone formation, the minimum water level is 1.80 mbgl while the maximum is 7.50 mbgl.

The detail of aquifer wise Post-monsoon Water Level is presented in table 14 and in fig 10.

Table 8: Aquifer wise Depth to Water Level (Post-monsoon)

Block Name	Shale		Dolomite		Limestone	
	Min	Max	Min	Max	Min	Max
Bemetara	0.82	9.02	1.60	5.25	1.80	7.50

*Water Level (in mbgl)

Fig.8 Post- monsoon Depth to water level Map of Fractured Aquifer

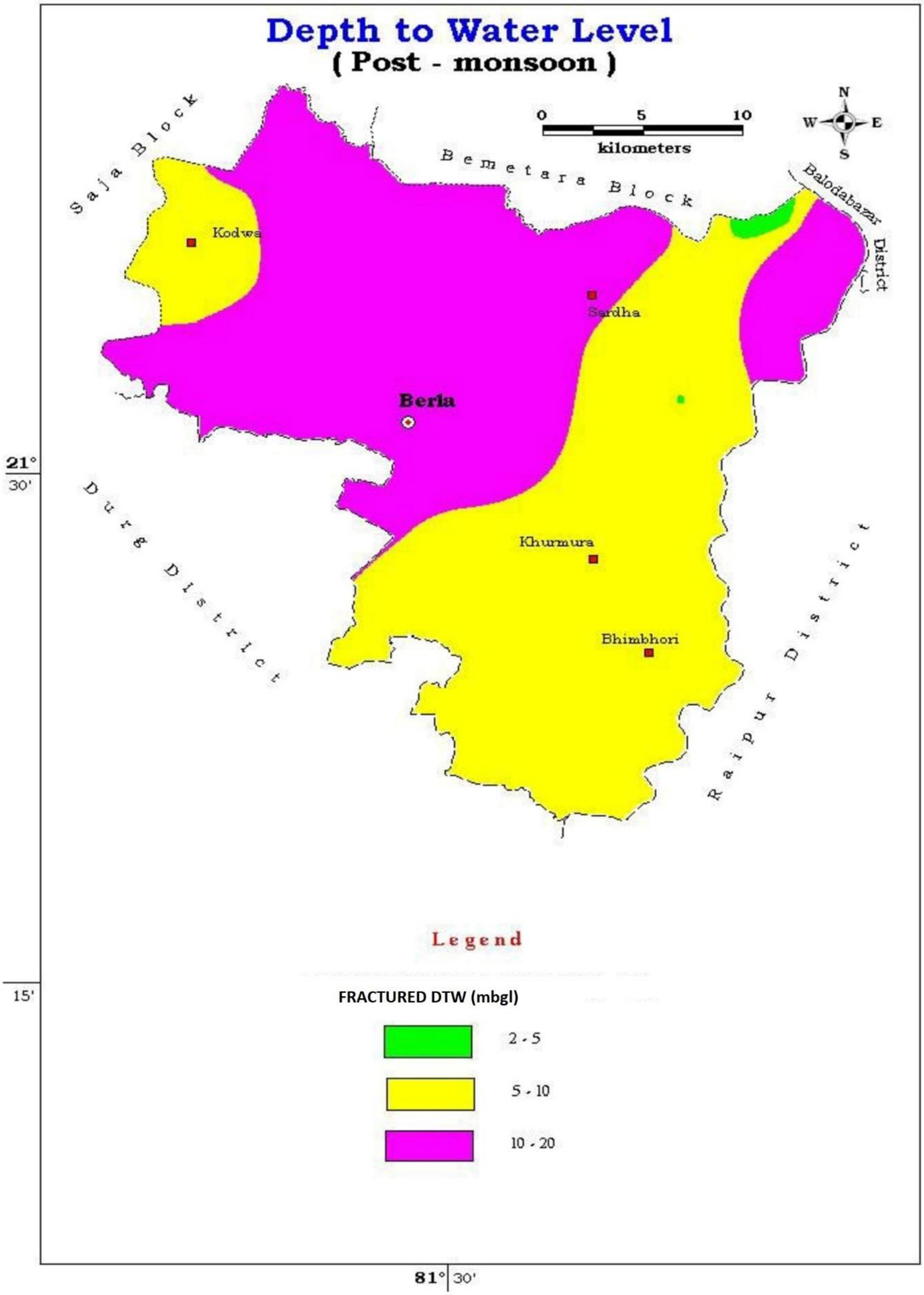
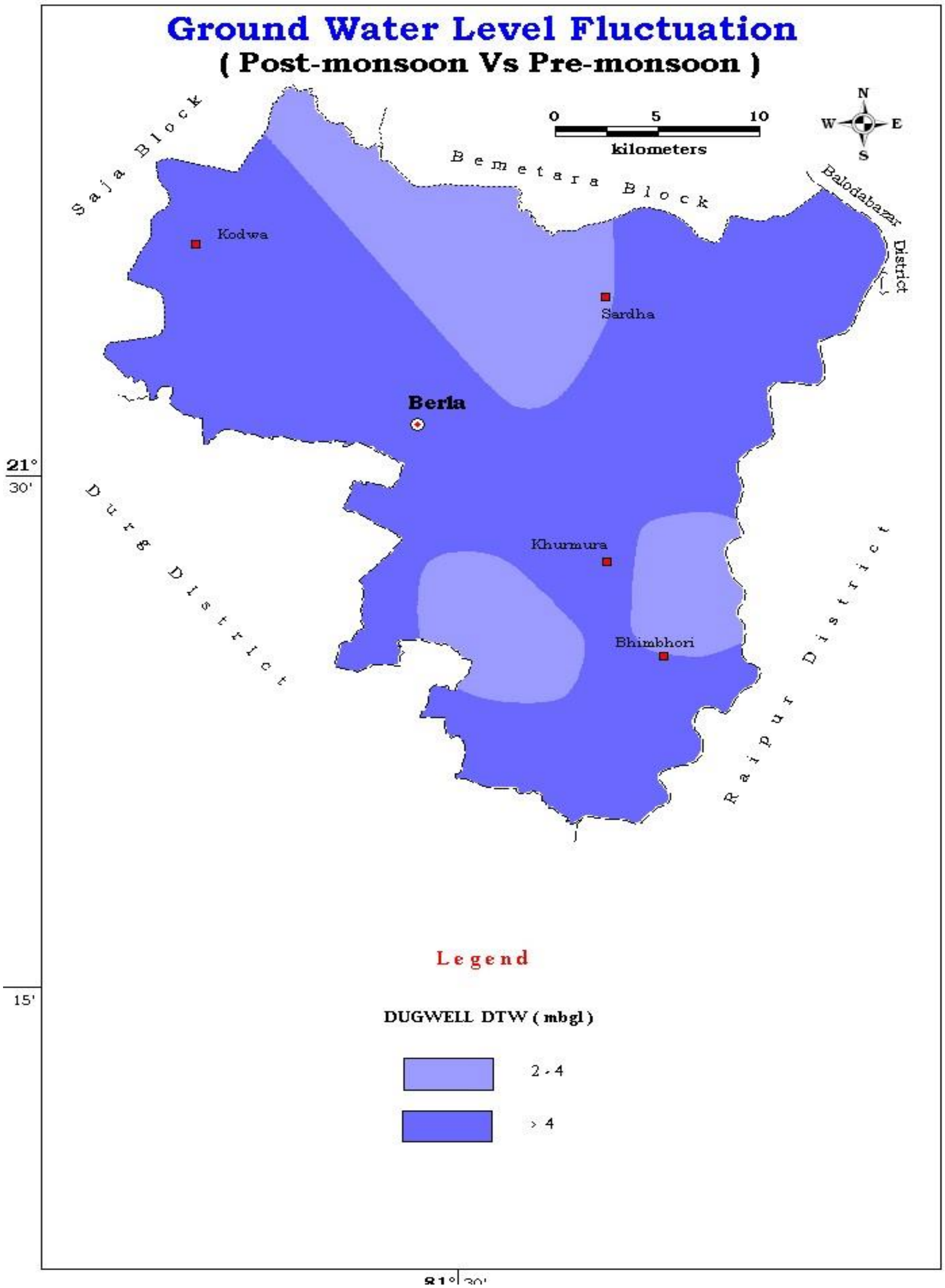


Fig.9 Post- monsoon Depth to water level Map of Phreatic Aquifer



2.1.3 Seasonal water level fluctuation

It has been observed that in Berla block, the minimum water level fluctuation is 1.68 mbgl in Shale formation while the maximum is 2.98 mbgl. In Limestone formation the minimum water level is 0.30 mbgl while the maximum is 1.1 mbgl.

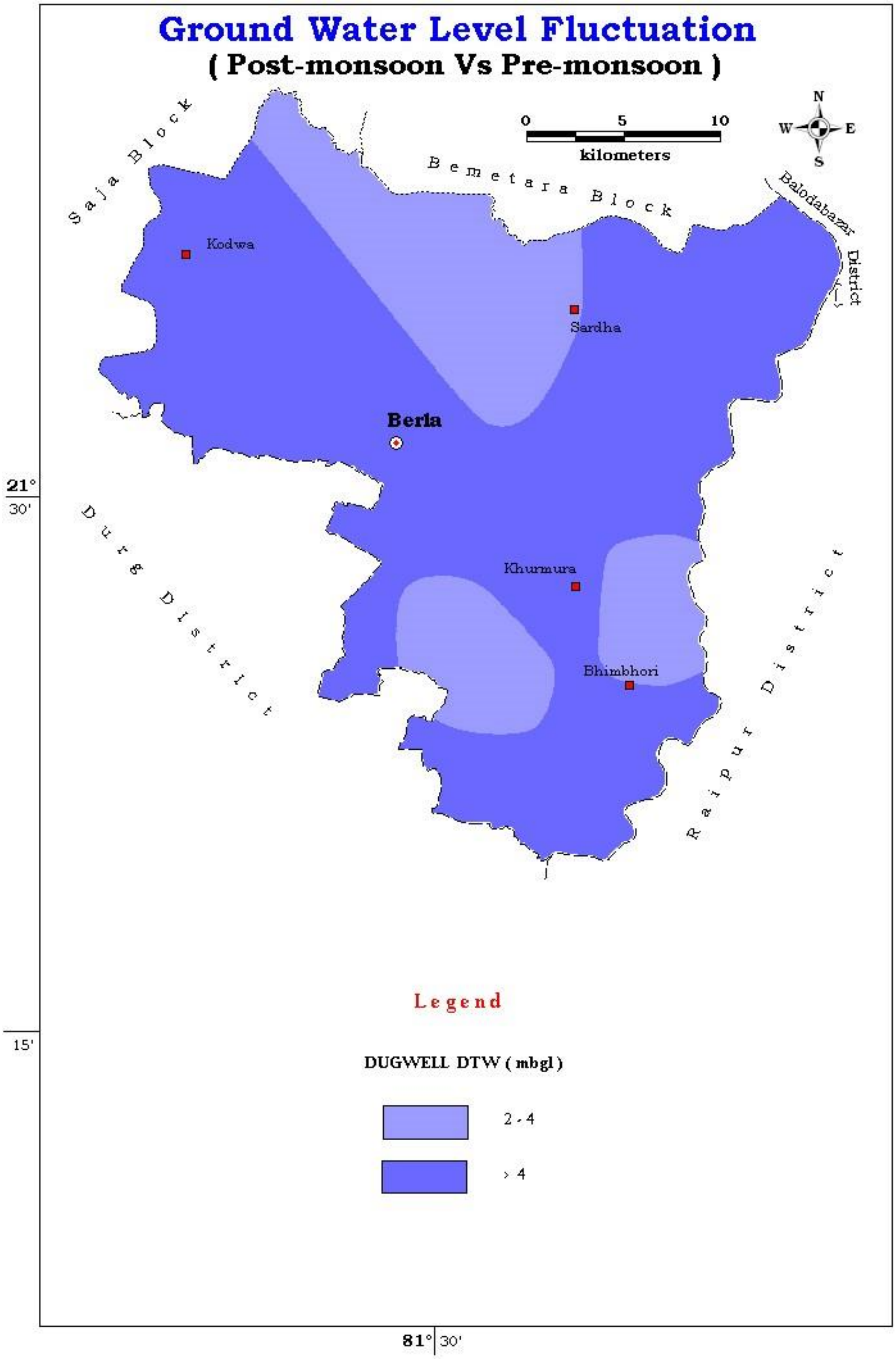
The detail of aquifer wise water level fluctuation is presented in table 12 and in fig 12.

Table 9: Aquifer wise Depth to Water Level Fluctuation (Pre-monsoon vs Post-monsoon)

Block Name	Shale		Limestone	
	Min	Max	Min	Max
Berla	1.68	2.98	0.30	1.1

*Water Level (in mbgl)

Fig.10 Seasonal Fluctuation of Depth to Water Level Map of Phreatic Aquifer



2.2 Hydrochemical Data

To know the hydro chemical behavior of the ground water in the study area, 21 nos. of ground water samples were collected from the key wells during pre-monsoon period of measurement (June 2020). Also, water samples were collected from bore wells during exploration carried out in the area and analyzed in the chemical laboratory of Central Ground Water Board, NCCR, Raipur for determination of various chemical parameters. The results and findings are presented in Table no. 10.

Table 10: Result of chemical analysis of ground water exploration year 2020-21

S.No.	District	Block	Location	latitude	longitude	pH	EC	F	Cl	SO4	CO3	HCO3	TH	Ca	Mg	Na	K
1	Bemetara	Berla	BARSI	21.3515292	81.5854977	7.82	409	0.32	1.8	0.57	0	1.2	4.2	3.2	1	9.57	0.84
2	Bemetara	Berla	BORIYA	21.488236	81.456068	7.22	777	0.29	2	82.88	0	1.5	6.9	6.1	0.8	8.57	0.57
3	Bemetara	Berla	TARALIM	21.555959	81.493897	7.53	360	0.3	0.5	13.36	0	2.9	3.4	1.7	1.7	20.17	0.54
4	Bemetara	Berla	SOND	21.542259	81.441158	7.54	482	0.32	1.5	6.2	0	2.8	3.7	1.7	2	23.35	7.92
5	Bemetara	Berla	KODWA	21.616049	81.369868	7.67	398	0.43	0.7	77.63	0	3.2	3.6	1.1	2.5	23.14	2.15
6	Bemetara	Berla	KHAMARIYA	21.64839	81.438071	7.74	513	0.9	1.1	210.68	0	3.2	2.9	1.2	1.7	61.97	2.39
7	Bemetara	Berla	DEORBIJA	21.664519	81.411728	7.53	1019	0.42	1.2	99.98	0	2.3	7.4	3.1	4.3	78.02	1.13
8	Bemetara	Berla	KANDARKA	21.3515922	81.5854977	7.8	365	0.49	0.6	17.25	0	3	2.7	1	1.7	46.87	0.67
9	Bemetara	Berla	GARAMORA	21.400286	81.512499	7.49	999	0.31	1.6	104.45	0	1.7	6.9	4.2	2.7	75.58	1.7
10	Bemetara	Berla	HASDA	21.434696	81.523826	7.6	615	0.2	1.8	82.73	0	2.1	5.4	2.2	3.2	23.47	5.76
11	Bemetara	Berla	AKOLI	21.447349	81.559061	7.43	1116	0.26	5.2	81.48	0	1.1	9.1	6	3.1	26.27	2.92
12	Bemetara	Berla	SILGHAT	21.443738	81.593442	7.92	395	0.33	1.1	20.21	0	3.1	3.6	0.5	3.1	37.62	0.64
13	Bemetara	Berla	KUMHI	21.425399	81.621016	7.8	476	0.29	1.6	27.48	0	2.7	3.5	1	2.5	47.7	0.79
14	Bemetara	Berla	BHARDA	21.4846	81.616031	7.91	1140	0.43	4.2	97.99	0	3.4	6	1.1	4.9	135.7	1.8
15	Bemetara	Berla	NAWAGAON	21.846486	81.674117	7.9	710	0.48	3	46.16	0	3.1	4.3	0.7	3.6	68.58	1.96
16	Bemetara	Berla	BALODIKALA	21.518001	81.625017	8	737	0.39	3.6	32.93	0	1.5	4.5	1.5	3	69.06	1.62
17	Bemetara	Berla	JAMGAON	21.580464	81.584517	7.75	1445	0.06	3.2	42.14	0	1.8	9.7	5.5	4.2	112.45	6.92
18	Bemetara	Berla	RAKA	21.615103	81.625322	7.62	1072	0.13	3.8	104.63	0	1.9	8.8	4.2	4.6	41.06	2.87
19	Bemetara	Berla	SARDA	21.586932	81.562365	7.61	511	0.27	0.7	95.33	0	1.8	3.7	2.5	1.2	31.29	3.76
20	Bemetara	Berla	TIRAIYAN	21.619477	81.676109	7.89	630	0.35	2.6	35.35	0	3	4	1	3	57.58	1.4
21	Bemetara	Berla	RAWELI	21.628495	81.656597	7.92	597	0.35	1	91.94	0	3.1	4.5	0.8	3.7	47.46	1.96
22	Bemetara	Berla	BUDHAJAUNGA	21.620958	81.598392	7.67	613	0.41	1.6	75.22	0	3.3	4.2	1	3.2	48.38	2.44
23	Bemetara	Berla	KOSPATRA	21.53675	81.611571	7.98	870	0.32	4.8	61.32	0	1.7	5.8	3	2.8	54.21	4.77
24	Bemetara	Berla	JAMGHAT	21.540996	81.656533	7.79	573	0.4	13.4	51.81	0	3.8	4	0.8	3.2	64.61	1.23

2.3 Exploratory Data

Status of Groundwater Exploration

A total of 10 bore wells exist in the study area as on 31-03-2021 out of which 7 nos. are exploratory bore wells and 3 nos are observation bore wells. Table 11 (A, B) summarizes the status of exploratory wells in the study area.

Table 11(A): Detail of Exploration in the study area (old)

Sl No	Location	Block	Lat	Long	Type of well	Drilling Depth (m)	Casing Length (m)	Formation	Zones encountered	Water Level	Draw down (m)	Discharge (lps)
1	Gudheli	Berla	21.3569	81.5417	EW	182.2	19.3	Chandi limestone	11.5-23.5,68.9-72.5,110.5-114.1,140.9-152.5	7.14	7.5	3
2	Raka	Berla	21.6056	81.6222	EW	274.25	8.9	Tarenga Sh and Chandi Lst	14-16,43.3-43.6,48-49.5	15.85	9.26	11
3	Raka OW	Berla	21.6056	81.6222	OW	91.77	8.9	Tarenga Sh and Chandi Lst	14-16,33-33.5,36-36.4,41.-42.5	10.5	7.85	4.5
4	Rampur Bhand	Berla	21.5139	81.5306	EW	300.52	8.5	Tarenga Sh	NO ZONE	8.5		negligible
5	Mohrenga	Berla	21.4489	81.4697	EW	202	7.3	Shale with Limestone	16-20,40-43,113-116	19.65		

Table 11(B): Exploration in the study area (2020-2021)

Sl. No.	Location	Block	Lat	Long	Type of Well	Drilling Depth (m)	Casing length (m)	Formation	Zone encountered (mbgl)	Water level (mbgl)	Drill time discharge (lps)	Draw down (m)	Discharge during Test (lps)
1	Bhimbhori	Berla	21.41428	81.59595	EW	120		Tarenga shale and Hirri limestone	21-23, 30-33, 84-87	6.8	16	15	15.26
2	Bhimbhori	Berla	21.41428	81.59595	OW	201		Tarenga shale and Hirri limestone	35-38	16.60	1.5	12	1.3
3	Hasda	Berla	21.31417	81.19853	EW	201	20.60	Tarenga shale and Hirri limestone	57.70-60.80	13.60	0.4	5.60	0.2
4	Kareli	Berla	21.45291	81.46353	EW	201	33	Tarenga shale and Hirri limestone	33.30-36.40, 60.80-63.80	16.6	4.5	2.4	4.43
5	Kareli	Berla	21.45291	81.46353	OW	97.40	24.20	Tarenga shale and Hirri limestone	94.30-97.40	13.50	6.5	4.80	6.5

3. AQUIFER DISPOSITION

3.1 Number of Aquifers:

There are two major aquifer system viz. Limestone/ Dolomite Aquifer system and Shale Aquifer system. Both the aquifer system has the shallow aquifer and deeper aquifer which occurs in phreatic and fractured condition respectively.

After studying the exploratory well details in aquifer system, it has been envisaged that the rock of the study area comprises alternate beds of limestone/dolomite and shales. Limestone having stromatolitic composition and medium to coarse grained, it is in some places cavernous and hence more porous and permeable and forms good aquifers. Dolomite in study area found is Hirri dolomite which is grey in colour. And the shale is comprised of Dolomitic shale, shale-chert beds, purple shae.

The average thickness of the weathered portion is around 12 m. In general, the discharge varies from 0.2 lps to 15 lps with an average yield of 7 lps. The average drawdown of the F**ormation is around 8** m. Water zone has been encountered up to 152 meters. Transmissivity range observed is 3.74 to 159.1 sq. meter/day.

3.1.1 Basic characteristics of aquifers

Shale aquifer

There are two types of Shale formations namely Maniyari shale and Tarenga Shale which are also most productive aquifers system in Chhattisgarh state

Maniyari Formation**:** This formation consists of gypsiferous grey siltstone and shale and followed upward by reddish brown calcareous and non-calcareous shale with limestone and dolomite. The red shale is less fissile. The laminated grey shale is composed of clay and silt. The alternate clay and silt define the laminated character. The maniyari formation is highly porous and permeable. It also possesses gypsum veins and lenses which easily get dissolved and creating thereby innumerable interconnected cavities/cavernous zones. These interconnected cavities/cavernous zones in this formation are acting as storage reservoirs and conduit system for accumulation and move-ment of ground water and thus making it very high in ground water.

Tarenga Formation**:** This Formation comprises predo-minantly an argillite-dolomite sequence. The shales are cherty and calcareous. This formation has good ground water potential at places.

Limestone aquifer:

Hirri Formation: This Formation comprises dark grey, bedded dolomite associated with light grey laminated argillaceous dolomite. It is less potential formation yielding 1 to 3 lps.

3.2 Geological cross-sections and 3-D disposition of Aquifer

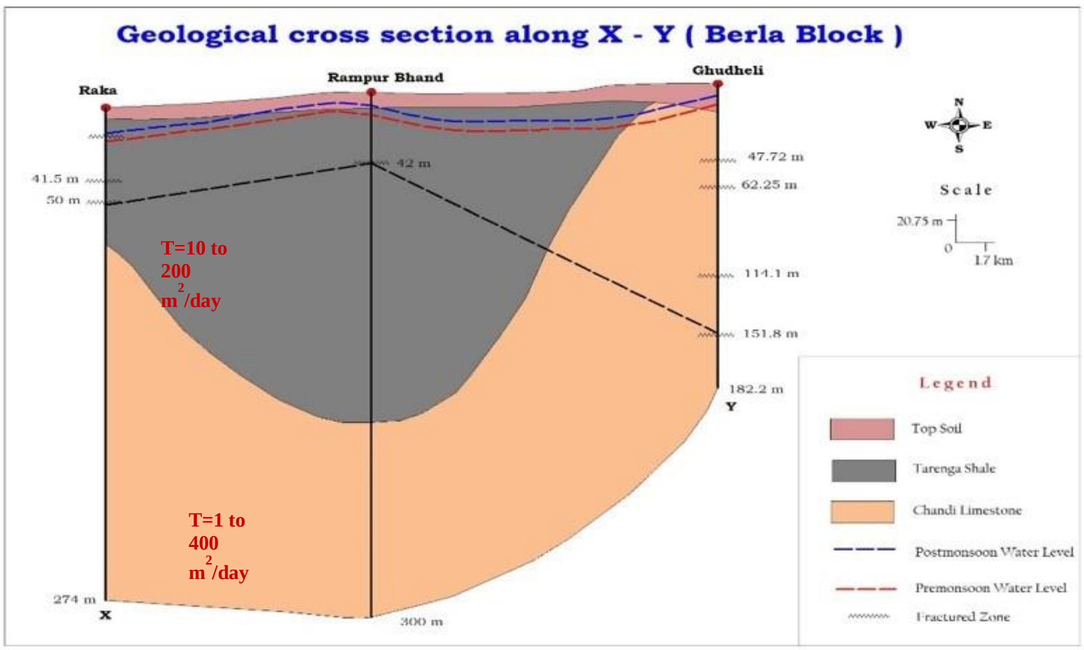
3.2.1 Geological Cross-sections

An attempt has been made to draw geological section along Raka- Gudheli (X-Y). Kareli-Bhimbhori (A-A') in the study area based on available exploration data. The section lines are marked on Map and cross-sections are shown on Figure.

(A) Geological cross-section (X-Y) along Raka -Gudheli

Section X-Y of Berla Block shows a thin soil cover at Raka in the west in which is gradually increasing towards east and is thickest at Gudheli. Below the soil, Tarenga shale formation is encountered in the entire area except at Gudheli where this thick soil cover is underlined by Chandi limestone.

Fig.11 (A) Geological cross-section (X-Y) along Raka- Gudheli

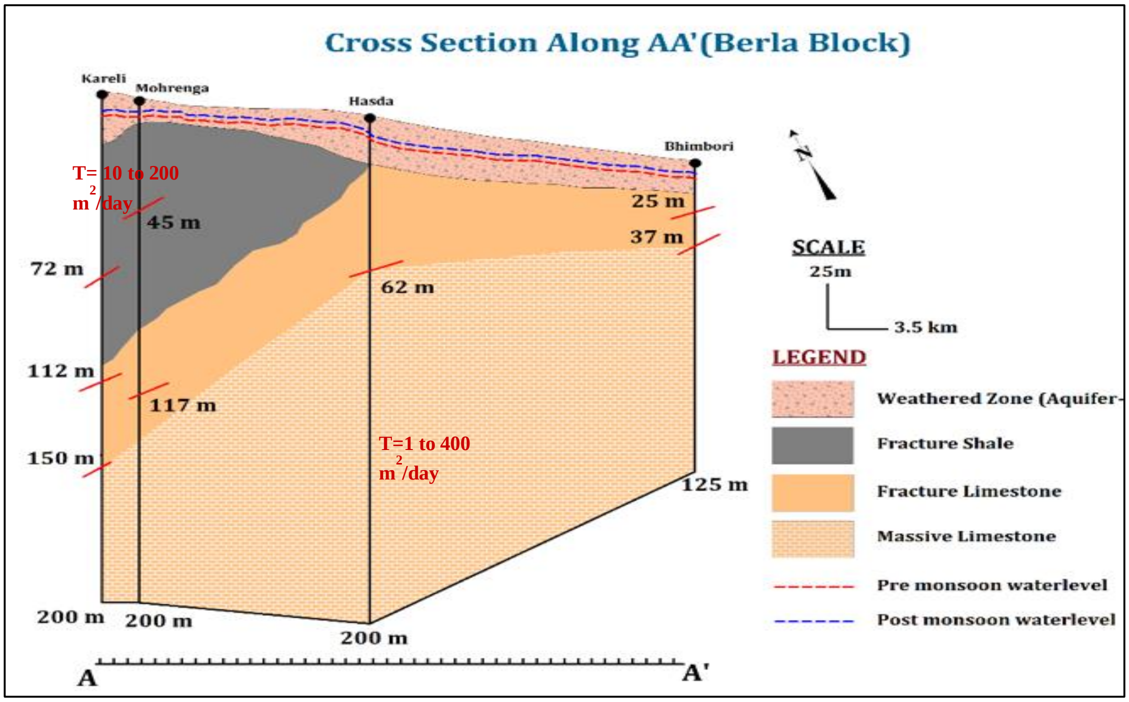


- Shale (Tarenga) – Moderate Potential 1 to 5 lps, T=10 to 200 m^2/day
- Limestone (Chandi) –Moderate Potential 1 to 5 lps, T=1 to 400 m^2/day

(B) Geological cross-section (A-A') along Kareli - Bhimbhori

Section A-B shows a top soil cover followed by shale formation and then Limestone formation.

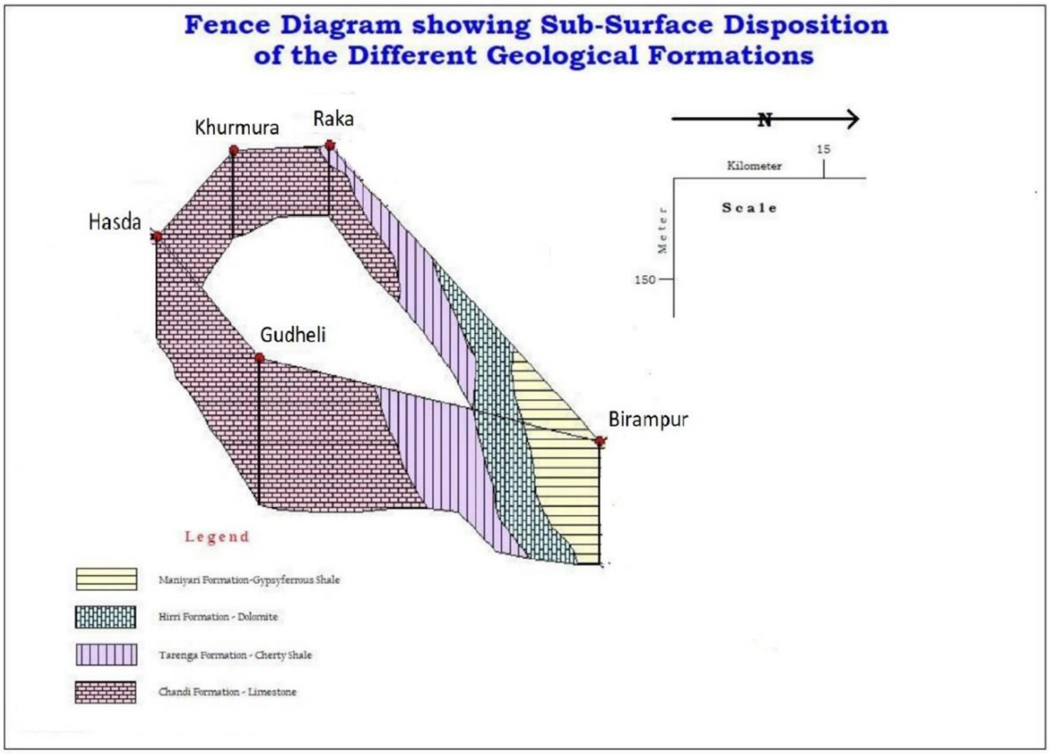
Fig.11 (B) Geological cross-sections (A-A') along Kareli - Bhimbhori



- Shale (Tarenga) – Moderate Potential 1 to 5 lps, T=10 to 200 m^2/day
- Limestone (Chandi) –Moderate Potential 1 to 5 lps, T=1 to 400 m^2/day

3-D disposition of an Aquifer

Fig. 11(C) Ground water resource map of Berla



4. ISSUES

I. During summer, dug wells and Ponds in villages become dry at many locations. Several hand pumps also stop yielding water.

II. Even the canals meant for irrigation purposes get dried in summer days.

III. Gradual deepening of common development depth for ground water withdrawal for tube wells.

IV. Reasons for Excessive ground water draft is for agricultural use: Ground Water Draft for Irrigation is 10341.8 Ham which is 94.68 % of Gross draft (As Total draft is 10921.27 ham).

V. Availability of Power in rural area: In 2020-2021, Chhattisgarh is presently one of the few states that have surplus power. Korba district in Chhattisgarh is known as the power capital of India. It is also among the few profitable states in terms of utility-based electricity. As of April 2021, Chhattisgarh had a total installed power-generation capacity of 13,076.27 MW, comprising 8,229.83 MW under private utilities, 1,971.05 MW (state utilities) and 2,875.39 MW (central utilities). Energy requirement in the state was 27,303 million units in 2019-20. In Chhattisgarh, power available at subsidized cost has been continuously leading to long duration and uncontrolled pumping of ground water withdrawal.

5. GROUND WATER RESOURCE ENHANCEMENT AND MANAGEMENT PLAN

The stage of Ground Water Development stands at 90.85% in Berla block. Hence the block is categorized as "Critical**".** Resource availability of Berla block is given in the table below. Where net ground water availability for future use is 968.31 ham. The various extraction details along with the categorisation are also depicted in the table-12.

Fig. 12 Ground water resource map of Berla

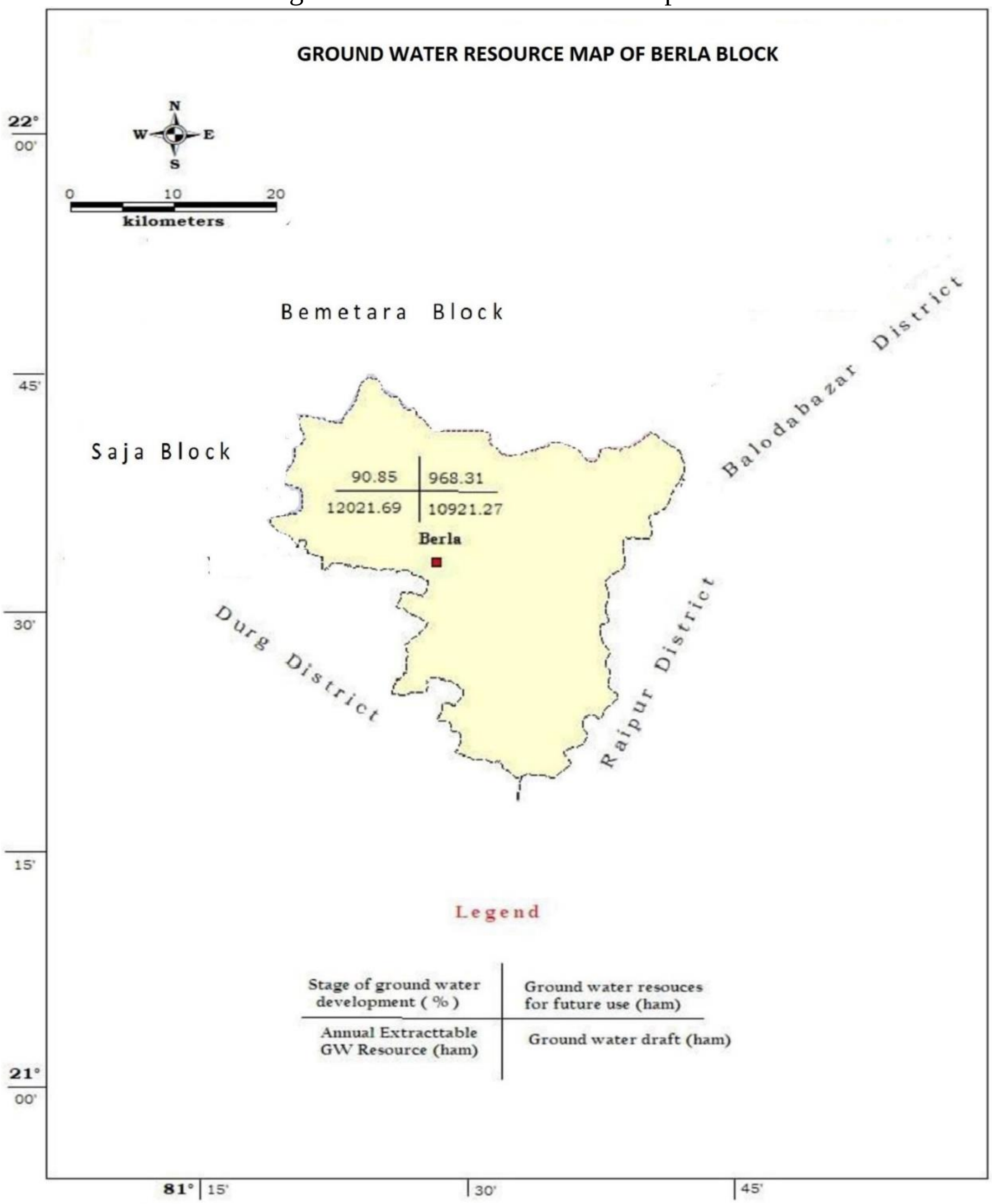


Table 12 : Ground Water Resource Scenario in Berla Block

Assessment Unit Name	Annual Extractable Ground Water Resource (mcm)	Current Annual GW Extraction(mcm) for irrigation	Current Annual GW Extraction (mcm) for IND	Current Annual GW Extraction (mcm) for Domestic	Total Extraction (mcm)	Stage of Ground Water Extraction (%)	Categorization (OE/Critical/ Semicritical/ Safe)
Berla	120.21	103.41	0.36792	5.42	109.21	90.85	Critical

*To Arrest depleting water level, we need to improve the stage of GW extraction of the block from 'Critical' to 'Safe' category.

So, Additional water requirement for improvement;

1	Net GW availability in Berla Block	120.21 ham
2	Gross GW draft	109.21 ham
3	Present status of GW development	90.85%
4	Requirement of water to reaching to stage of GW development by 70%	3581 ham or 35.81 MCM

Fig. 13 Ground Water Development, Potential and Artificial Recharge Prospects

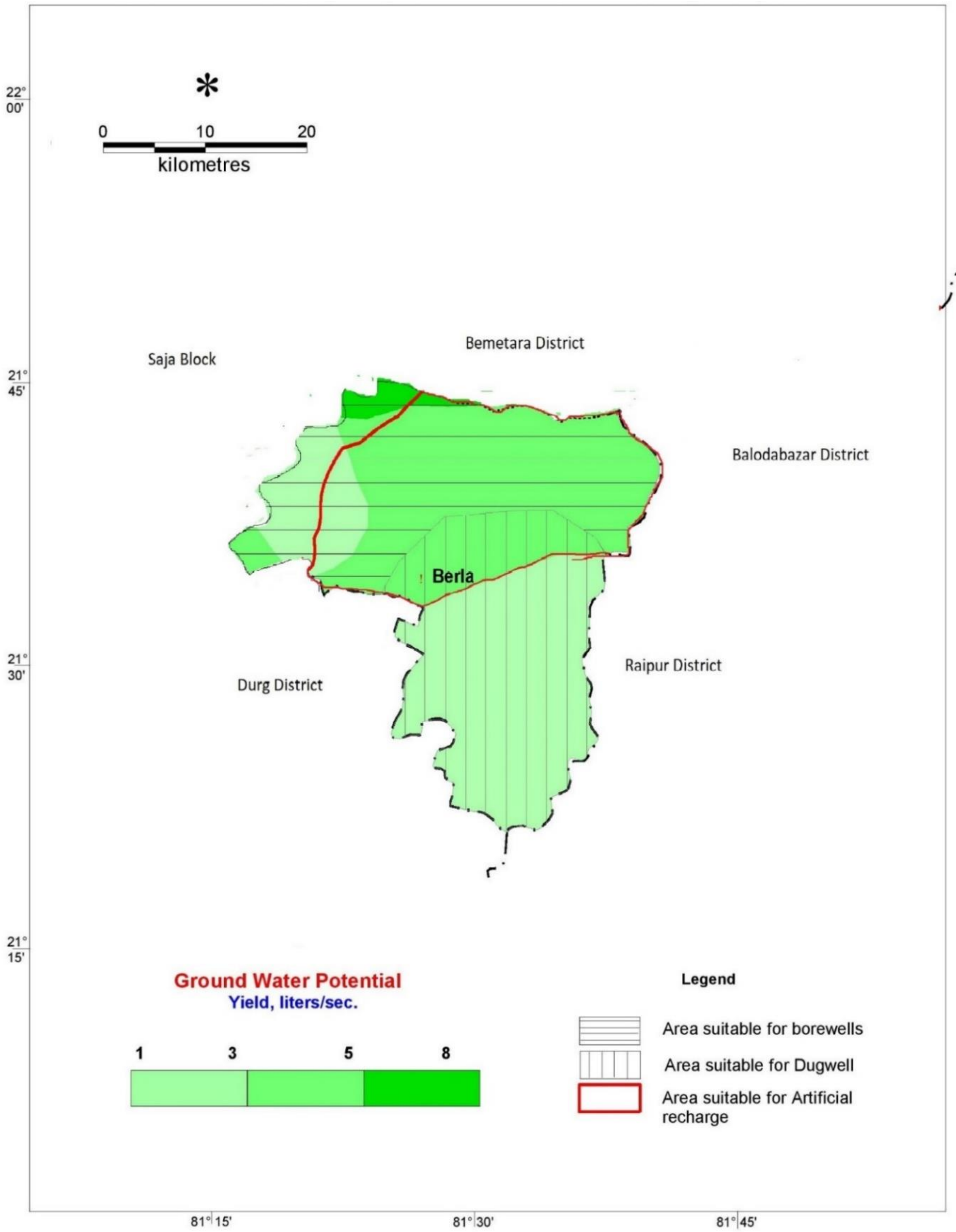
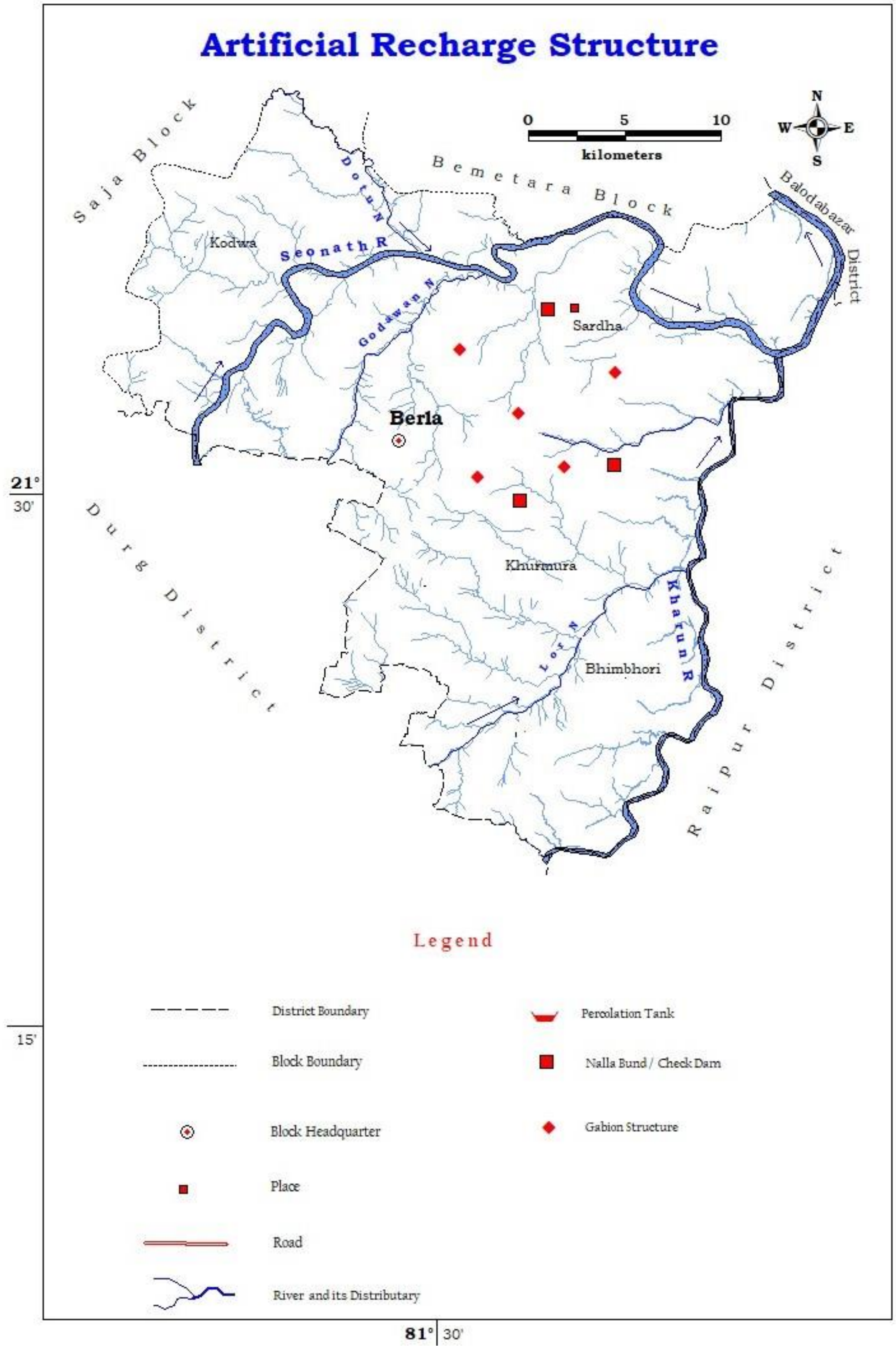


Fig. 14 Map of Artificial Recharge Structure



"FAILURE OF GROUNDWATER MANAGEMENT LEAVES PEOPLE MORE VULNERABLE TO DROUGHT."

The main purposes for ground Water Management is **to arrest depleting water levels** in the block and **to improve it from 'Critical' to 'Safe' category**. To achieve this, following interventions are envisaged. The present ground water scenario in area along with additonal requirement of water is given below:-

Taking Action in Groundwater Management

The strategies can be implemented are:

(i) It has been observed during fieldwork, there is huge wastage of groundwater through private well and public water supply system. So, Information, Education and Communication (IEC) activities need to be organized to sensitize people on the issues of depleting groundwater resource. Massive awareness campaigns are essential to aware people about the importance of community participation in saving water.

(ii) Managing groundwater sustainably requires joint action; A paradigm shift is needed in groundwater management, from technocratic approaches to use of collaborative, participatory knowledge systems. Groundwater users, technical specialists, scientists and policy makers need to work jointly. With the support of facilitators, and backed by demonstration results, learning and communications, they should collaborate to align groundwater knowledge, governance reforms, economic incentives, investment and social organisation.

(iii) Desiltation of existing Tanks and Talabs to be carried out for efficient storage of rainwater. Also Rain water harvesting structures may be constructed in villages to reduce stress on groundwater.

(iv) It has been observed that the demand of ground water is increasing for irrigation, industrial and domestic uses. At locations where water level is declining, we have to go for artificial recharge on a long-term sustainability basis.

Examples of measures for groundwater management and Features Reducing groundwater consumption Promoting higher water productivity in agriculture are;

1. Changing cropping pattern, varieties and agronomic practices
2. Micro-irrigation and root-zone irrigation
3. Improved water conveyance
4. Increasing water-holding capacity of soil
5. Reducing urban groundwater use
6. Leakage detection
7. Reducing domestic water loss and use
8. Urban landscaping Use of economic incentives
9. Pricing of energy supplies
10. Redirecting subsidies to water-saving measures
11. Removing subsidies from water-intensive crops
12. Water-efficiency incentives

13. Smart-card controlled abstraction and quotas Promoting recharge and retention of groundwater Intercepting and retaining surface runoff and floods
14. Field bunding and terracing
15. Contour bunds and gullies
16. Seepage wells and maintaining natural pits
17. Injection wells
18. Water harvesting from roads
19. Recharge ponds, dams and sand-dams
20. Flood water retention Improving infiltration capacity of land surfaces
21. Permeable urban surface
22. Penetration of clay layers
23. Increasing infiltration by burrowing action of animals
24. Sand dams Retaining subsurface flows
25. Gully plugging of drainage canals
26. Subsurface dam's Conjunctive management of surface and groundwater
27. Adjusting surface water delivery to recharge and reuse potential
28. Storage of seasonal excess water Regulating groundwater development Promoting self-regulation
29. Enabling laws
30. Developing and applying local rules
31. Participatory monitoring and assessment
32. Joint crop planning
33. Local investment in recharge Well licensing and well regulation Geographical bans

6. CONCLUSION

For effective utilization of Ground water, existing draft for irrigation may be coupled with micro irrigation system. Change in irrigation pattern, optimum use of available resource, use of ground water potential created after artificial recharge can lead to groundwater savings and increase in gross cropped area of the block.