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 Nawagarh Block, Bemetara District Chhattisgarh

उत्तर मध्य छत्तीसगढ़ क्षेत्र, रायपुर

North Central Chhattigarh Region, Raipur

A REPORT ON

AQUIFER MAPPING
&
GROUND WATER MANAGEMENT PLAN
2020-2021
IN NAWAGARH 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 Nawagarh 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 Nawagarh 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 Nawagarh block 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, Nawagarh block of Bemetara district was taken up for study covering an area of 625 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° 45' 0'' E and 22° 0' 0'' E and between the Longitude 81° 30 '0 '' N and 81° 54' 0''N. The study area is bounded by Bemetara block in the south-west, Mungeli district in the north-east and north, Baloda Bazaar district in south east and east. The blockhas a well-developed road network.
The total population of the study area as per 2011 Census is 197081. The study area experiences sub-tropical climate. The average annual rainfall for the study area is around 760.4 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 50327 Ha, while double-cropped area is 15308 Ha. The gross cropped area of the district is 65635 Ha. The net Irrigated cropped area is 8763 Ha, while the area under groundwater irrigation is 15239 Ha which is about 30.33 % 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 (Maniyari and Tarenga),2. Limestone (Chandi Limestone) and Dolomite (Hirri

Dolomite), Discharge varies from 4.5 to 6.5 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 84.72 %. 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 be 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 Dug wells and hand pumps during summer. (ii) Gradual deepening of common development depth for ground water withdrawal for tube wells. (iii) Drilling difficulties in limestone terrain (iv) Saline water in some places due to encounter of Gypsiferous Maniyari shale. In the study area there may occurs serious issue of scarcity of ground water due to over exploitationof it. So, in this area, rain/surface water may be conserved and utilized. 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 distillation units, Electrodialysis unit in affected villages or alternate source may be identified. Regular ground waterquality 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 Maps and Management plan ofBerla 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* ***Shri. 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.)*** *for the guidance and suggestions. I am deeply thankful to* ***Sh Uddeshya kumar, Scientist- B, Smt PrachiGupta, 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* ***Shri Rakesh Dewangan, Scientist-B*** *for the chemical analysis and valuable inputs on quality issues. The efforts made by* ***Shri. T.S. Chouhan, Draftsman*** *for digitization of maps are thankfully acknowledged. The author is also thankful to the state agenciesfor 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 providingthe various needful data. The help and co-operation of staffs of CGWB, NCCR, Raipur is greatlyrecognizable. 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)

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 are impacting 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 climatechange.

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, Nawagarh Block of Bemetara district covering an area of 625 sq. km was taken up during the first phase of 12th five-year plan. The area is covered in the Survey of India's Toposheet Nos. 64G/2, 64G/5, 64G/7, 64G/9, 64G/10, 64G/11 and 64G/13 (1:50000 Scale).

1.2 Location, Extent and Accessibility

The study area covers an area of 625 sq. km. It is situated in the western part of Chhattisgarh state. It falls in the Survey of India's Toposheet Nos. 64G/2, 64G/5, 64G/6, 64G/7, 64G/9, 64G/10, 64G/11 and 64G/13 (1:50000 Scale).

The study area is bounded by Bemetara block in the west and south-west, Mungeli district in the north-west, Baloda Bazaar district in south-east and east (Fig 1). The block has a well-developed road network.

1.3 Administrative Division

Nawagarh 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 Nawagarh is 03280. The block has 185 villages and there are total 35466 homes in this Block.

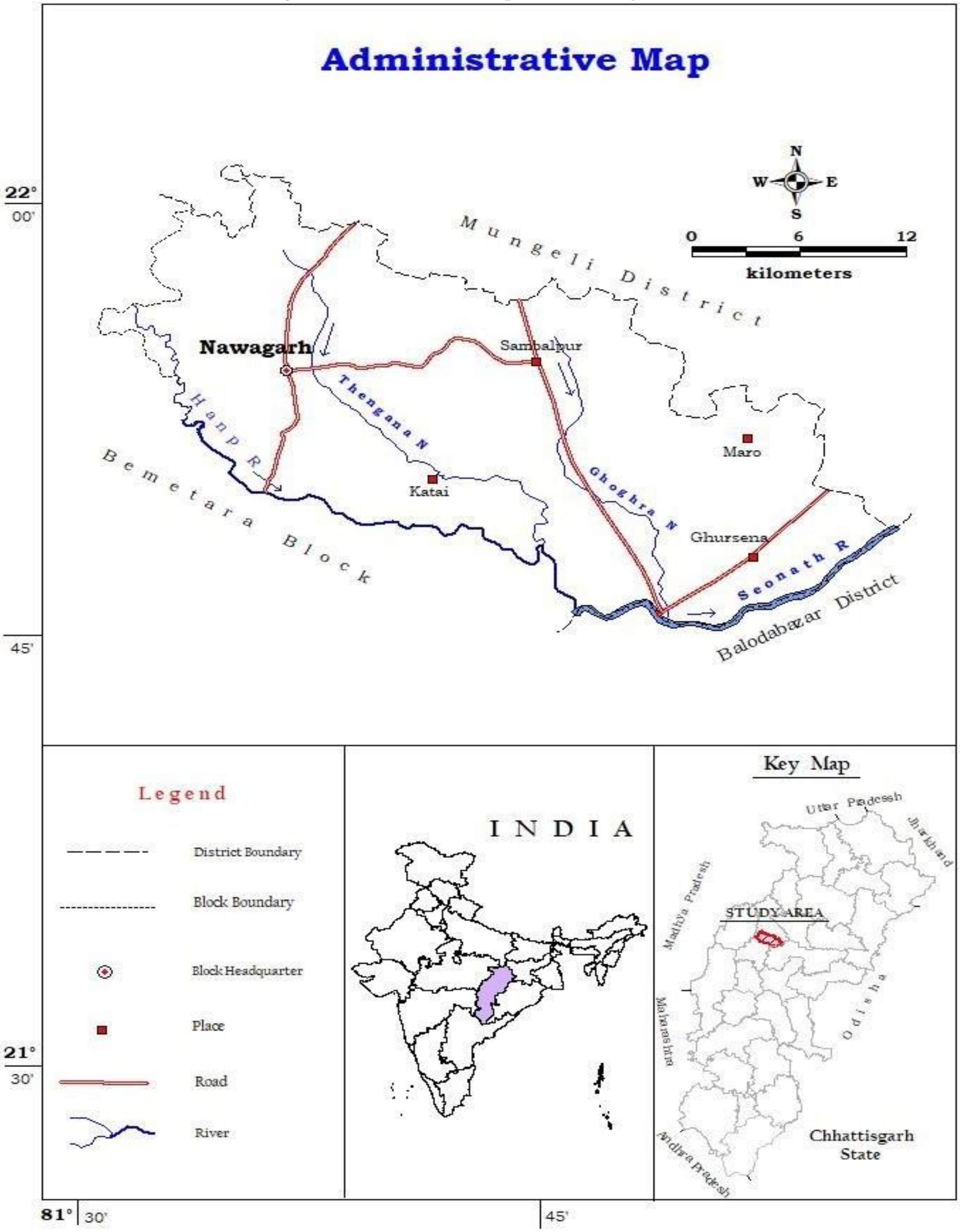
Table 1(A): Geographical location of the study area

Study Area (Block)	District	Area (Sq. Km)	Latitude		Longitude		Toposheet No (1:50000 Scale)
			From	To	From	To	
Berla Block	Bemetara	625	21° 45’ 0‘’ E	22° 0’ 0’’ E	81° 30 ’0 ‘’ N	81° 54’ 0’’N	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

SlNo	Name of Block	District	Area (SqKm)	No of Tehsils	No of Development Blocks	No of Towns
1	Nawagarh	Bemetara	624.98	1	1	1

Fig.1 Administrative Map of the Study Area



1.4 Demography

According to 2011 census, Total Nawagarh population is 197081 of which 98792 are male and 98289 are female. Literate people are 101986 out of 60272 are male and 41714 are female. Total 315317 workers depend on multi skills out of which 182666 are men and 132651 are women. Total 126963 populations depend on agriculture out of which 75166 are men and 51797 are women. 150204 people work in agricultural land labour in Nawagarh out of which 77300 are men and 72904 are women. Nawagarh tehsil sex ratio is 995 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
197081	98792	98289

Source: CG Statistical handbook- Census 2011

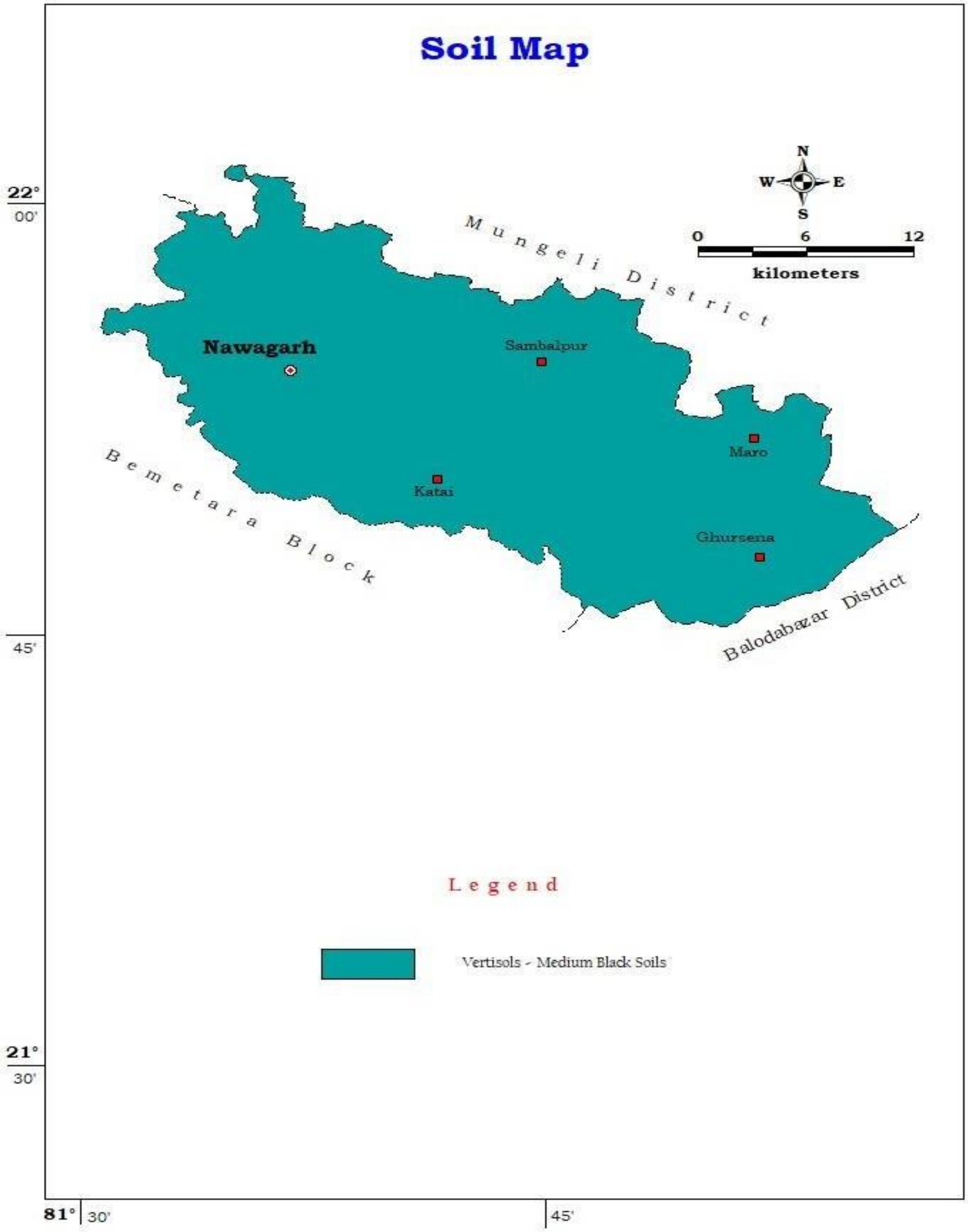
1.5 Pedology Generally soils are classified on the basis of texture, mineral content and presence of salts and alkalis. Howeverin present context the classification and distribution is adopted as per the soil orders in US soil taxonomy and their Indian equivalents. There are 12 orders in US soil taxonomy but only one order is found in study area. Thatis described below in brief and given in Table 3. The distribution of this soil type in the study area is presentedin Fig 2.

Table 3: Soil Classification

Slop.	US Soil Taxonomy	Indian Equivalents
1	Vertisols	Medium black soil

Vertisols- There are two types of Indian equivalent of this soil namely medium black soil and deep black soil. But only one type i.e. medium black soil is found in Nawagarh block. 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-meter of the soil profile. They are characterizedby 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 farmingis very difficult because vertisols can be worked only under a very narrow range of moisture conditions as theybecome 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 there by 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, legumes are also cultivated as Rabi crops. While rain water is the only source during Kharif, the area is irrigated mainly through ground water during Rabi. The relevant data are presented in table 4(A, B, C).

Table 4(A): Agricultural pattern in NAWAGARH block during the year 2018 (in ha)

Tehsil	Total geographical area	Revenue forest area	Area not available for cultivation	Non agricultural & Fallow land	Agricultur e al Fallow land	Net Sown area	Doubl e cropp e d area	Gross crop pe d area
Nawagarh	62498	0	4710	5303	1574	50327	15308	65635

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

Table 4(B): Cropping pattern in NAWAGARH block district during the year 2018(in ha)

Tehsil	Kharif	Rabi	Cereal				Pulses	Tilhan	Fruits / Vegetables	Reshe	Mirch Masala
			Wheat	Rice	Jowra & Maize (Resectively)	Others					
Nawagarh	47888	17747	2698	43782	3 & 0 respectively	97	15410	2348	1011	0	65

*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 Nawagarh 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
Nawagarh	0	352	5010	15239	438	0	3	0	0	8763	6828	15591	24%

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

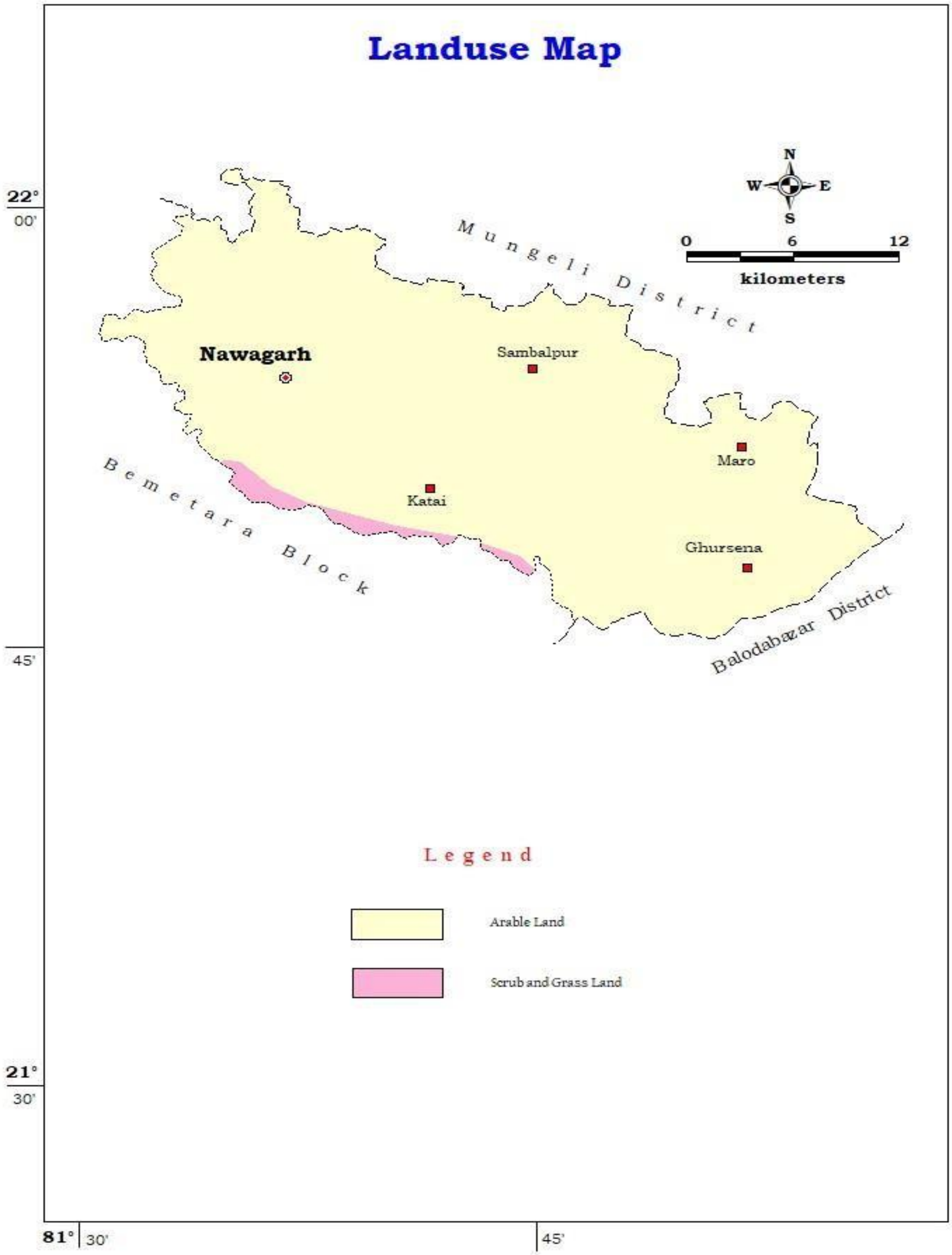
1.7 Land use

The scrub and Grass land and arable land in Nawagarh block is 611.5 and 12.93 sq km. Thereis no reserved forest and protected forest, other forest in the block.

Table 5: Land Use (Sq. Km)

Block	ReservedForest	Protected Forest	Other Forest	Scrub and Grass Land	ArableLand	Total Area
Berla	NA	NA	NA	611.5	12.93	624.43
Total area						624.43

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. Winterseason 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 807.43 mm (Average of the last five years i.e. 2018 to 2020). Annual rainfall in Nawagarh block 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 Nawagarh Block for the year 2020

District/Tehsil	2016	2017	2018	2019	2020	Average of 5 years for the block
Nawagarh	547.7	858	880.30	735	781	760.4
Average of 5 years for study area						760.4

1.9 Geomorphology and Drainage

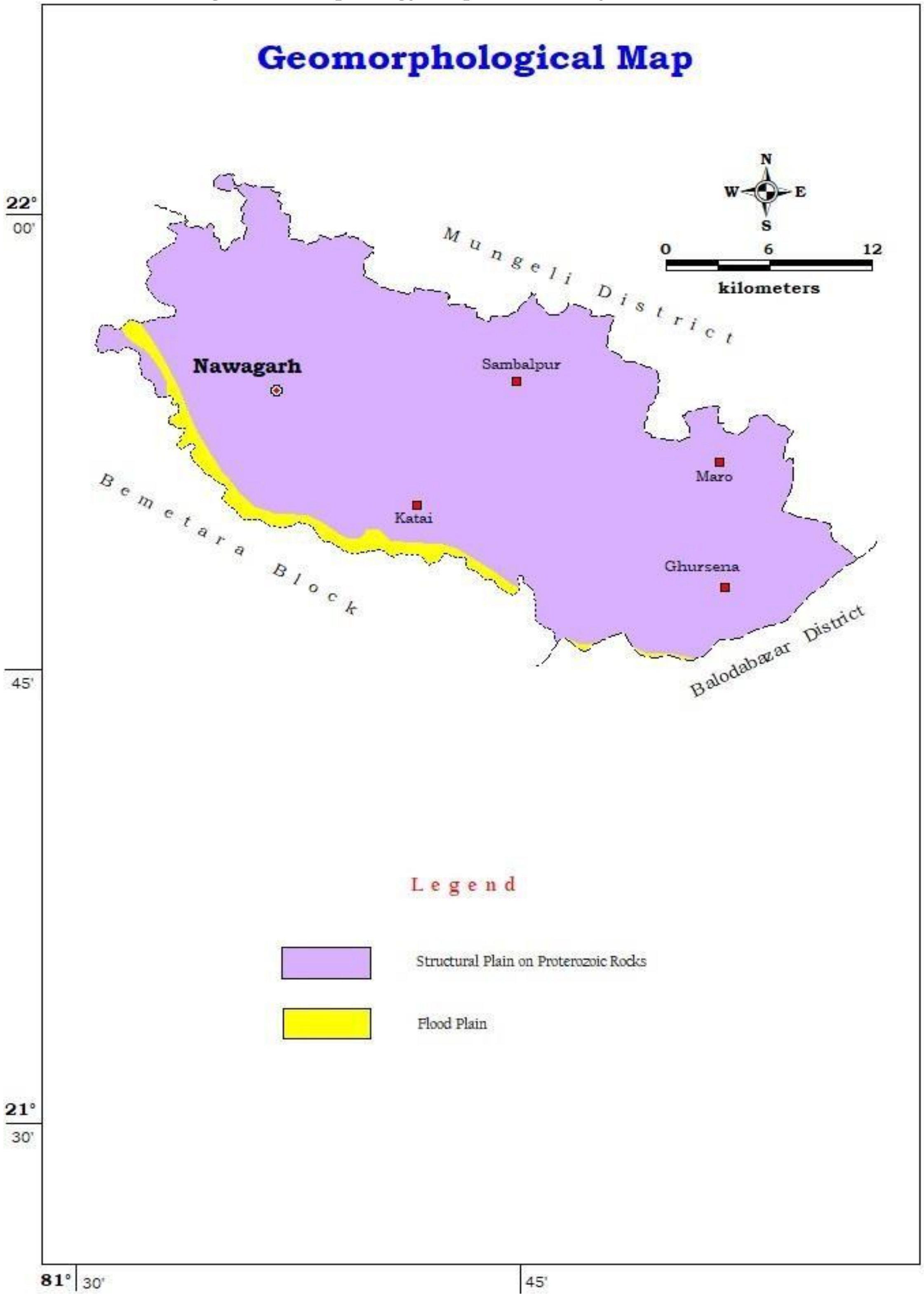
1.9.1 Geomorphology

Geomorphologically the study area displays Structural Plains and Flood Plain which comes under thephysiographic 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 crisscrossed 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 northern, north-western, western and south-western part. It is formed by extensive deposition of alluvium bymajor 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

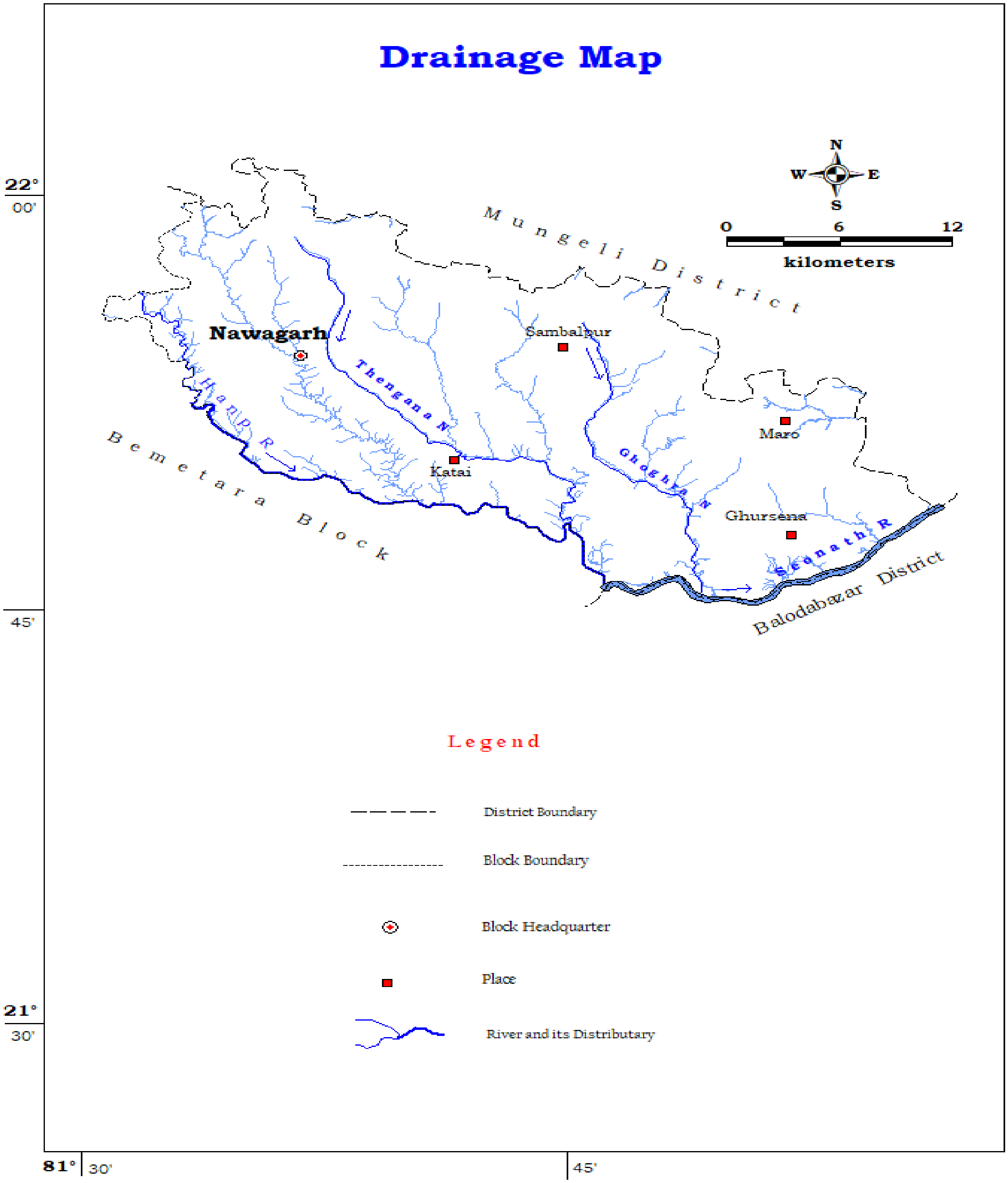


1.9.2 Drainage

The study area is mainly drained by Sheonath river. Thengana river, Hanp River and Ghogra river. Thengana, Ghogra and Hanp are the tributaries of Sheonath river. This river system comes under Mahanadi River basin. Sheonath river,is a tributary to Mahanadi, flows through the upper eastern periphery along with its tributaries. Hanp river along with its tributaries flows along the western peripheries of the block and also joinsSheonath river in South-eastern part of the block.

The drainage map is prepared and presented in **Fig 5.** 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 block. The drainage density is found comparatively low in the north-central and eastern area which is attributed to plain area indicating somewhat low runoff and higher infiltration.

Fig.5 Drainage Map of the Study area

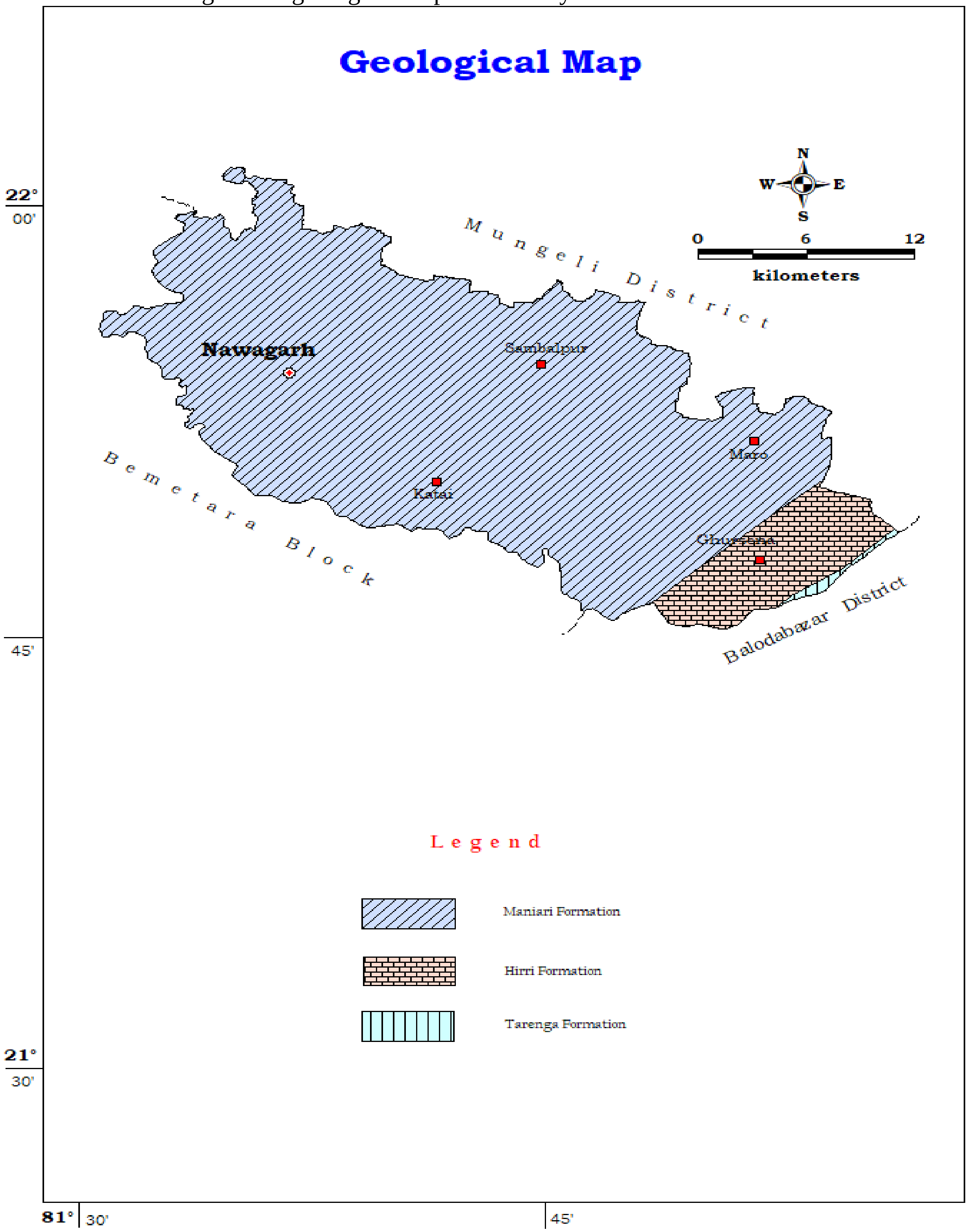


1.10 Geology

Geologically, the study area comprises of rocks of Meso to Neo-Proterozoic sequence and is representedby 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 Maniyari Formation, Hirri Dolomite as well as Tarenga formations.

The geological map of Nawagarh block is shown in **Fig 6**.

Fig 6: 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. It has been found that within the second aquifer, there are 2-3 set of aquifers which are not well connected. The different sets of aquifers are of different thickness as well as of varying horizontal extent.

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 No8.

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 Nawagarh block, the minimum water level is 5 mbgl in Shale formation while the maximum is 6.9 mbgl. In Limestone formation the minimumwater level is 4.5 mbgl while the maximum is 7.8 mbgl.

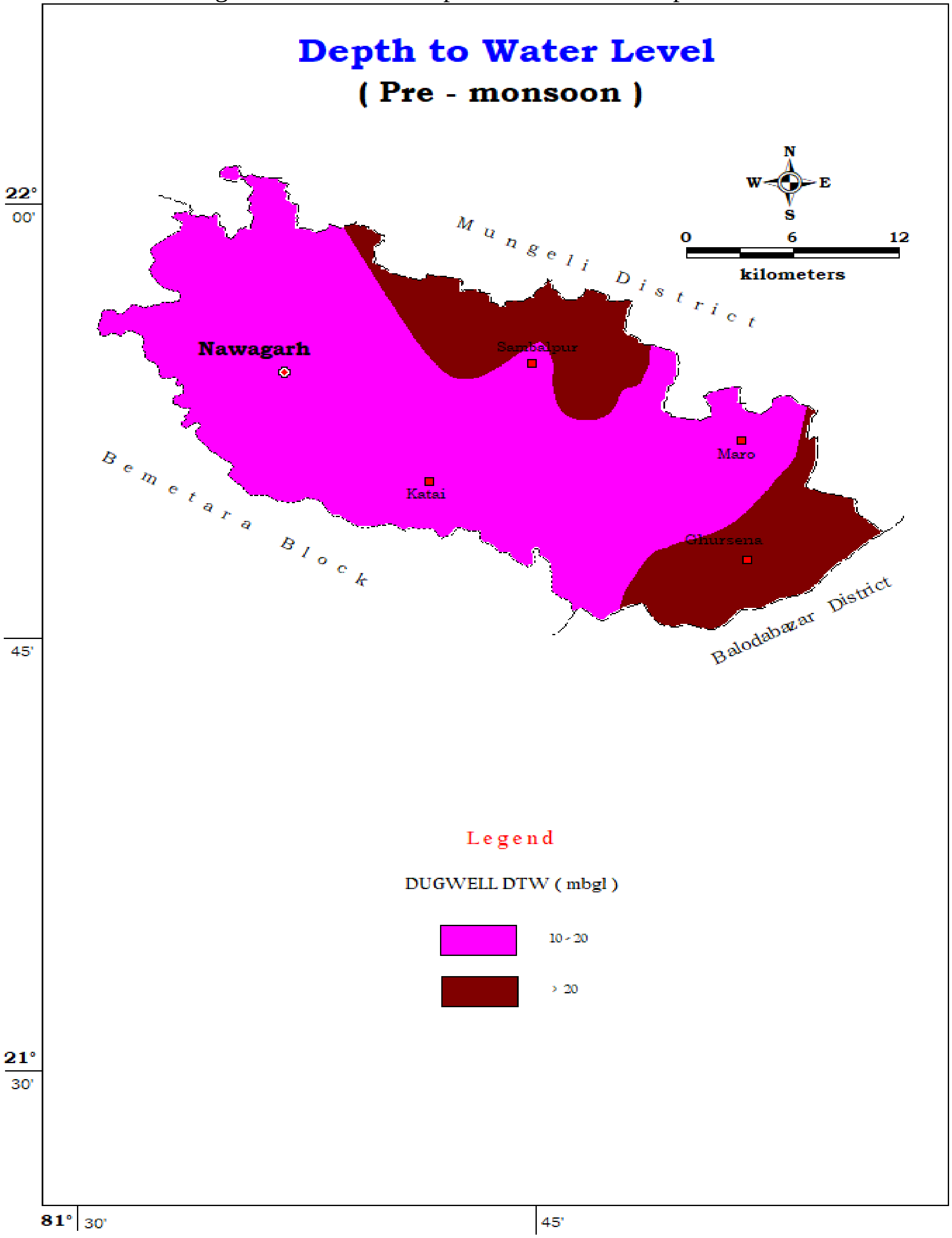
The detail of aquifer wise Pre-monsoon Water Level is presented in table 7 and in fig 7.

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

Block Name	Shale		Dolomite	
	Min	Max	Min	Max
Nawagarh	6.7	8.4	7	9.8

*Water Level (in mbgl)

Fig.7 Pre- monsoon Depth to water level Map



Post-monsoon period

In the post-monsoon period, it has been observed that in Nawagarh block, the minimum water level is 6.7 mbgl in Shale formation while the maximum is 8.4 mbgl. In Limestone formation the minimum water level is 7 mbgl while the maximum is 9.8 mbgl.

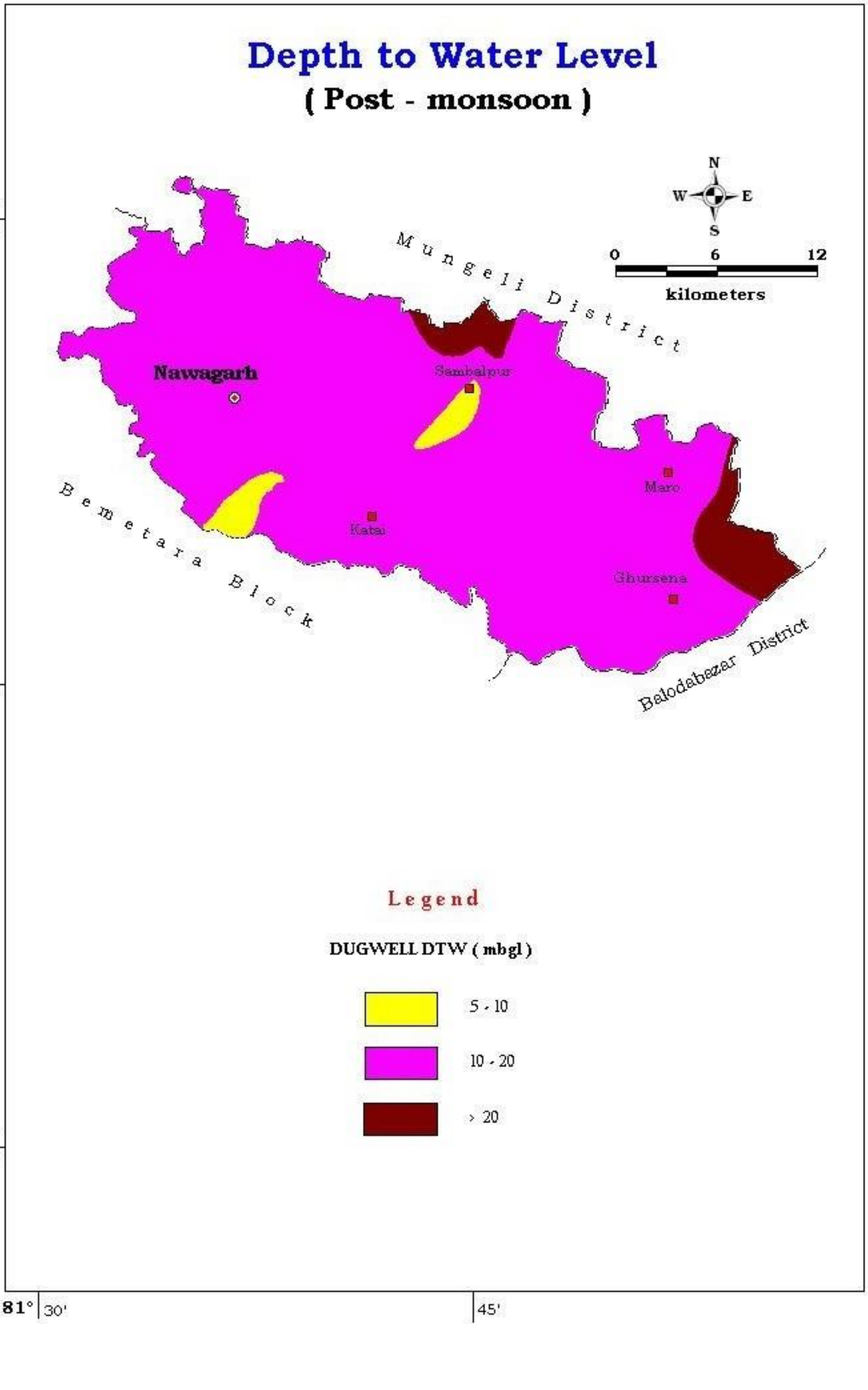
The detail of aquifer wise Post-monsoon Water Level is presented in table 8 and in fig 8.

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

Block Name	Shale		Dolomite	
	Min	Max	Min	Max
Nawagarh	5.0	6.9	4.5	7.8

*Water Level (in mbgl)

Fig.8: Post- monsoon Depth to water level MAP



10.4 Seasonal water level fluctuation

It has been observed that in Nawagarh block, the minimum water level fluctuation is 1.5 mbgl in Shale formation while the maximum is 1.7 mbgl. In Limestone formation the minimum water level is 2 mbgl while the maximum is 2.5 mbgl.

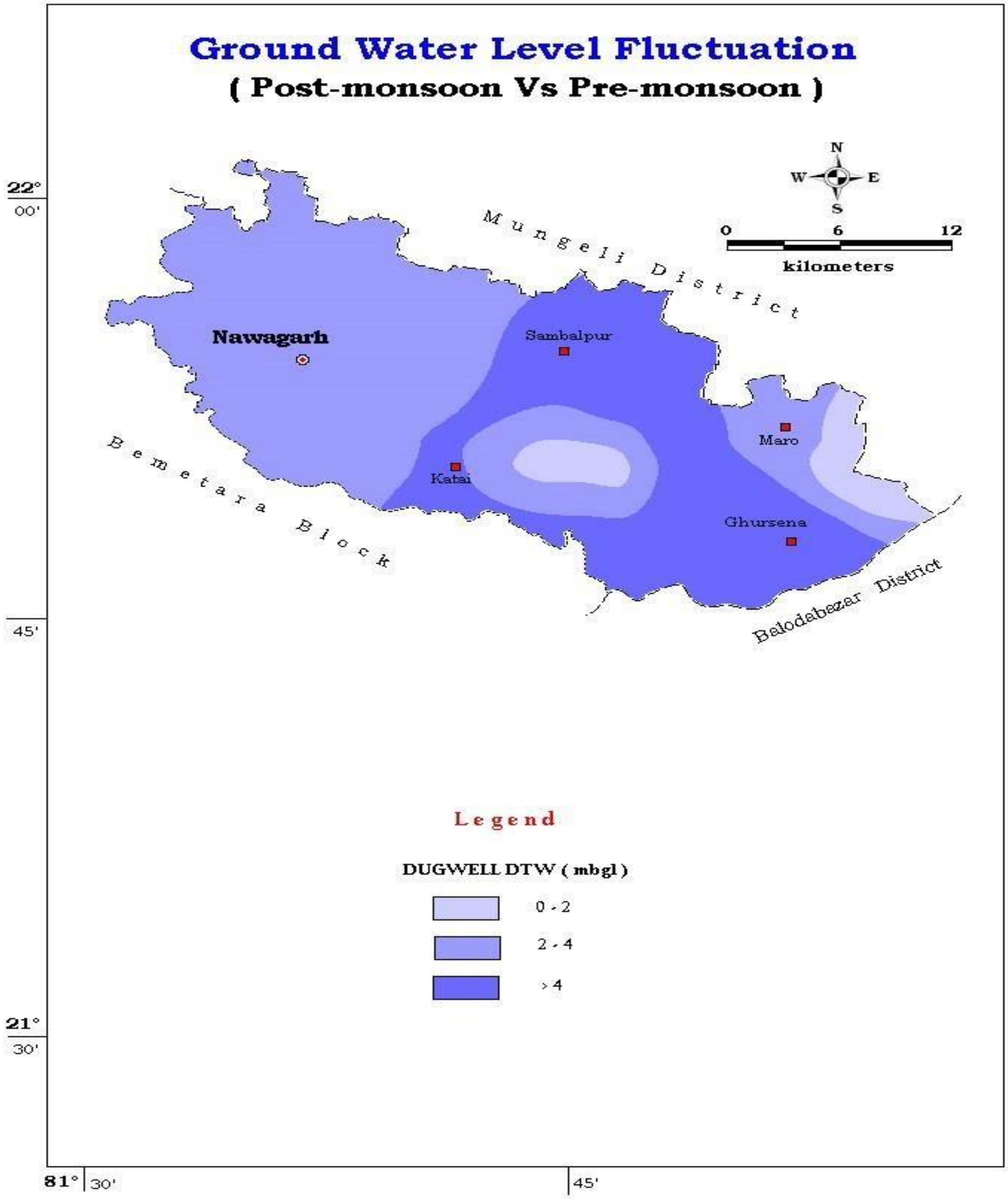
The detail of aquifer wise water level fluctuation is presented in table 9 and in fig 9.

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

Block Name	Shale		Limestone	
	Min	Max	Min	Max
Nawagarh	1.5	1.7	2	2.5

*Water Level (in mbgl)

Fig. 9 Seasonal Water Level Fluctuation Map



Hydrochemical Data

To know the hydro chemical behavior of the ground water in the study area, 20 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 analysed in the chemical laboratory of Central Ground Water Board, NCCR, Raipur for determination of various chemical parameters. The results and findings are presented inTable no. 10.

District	Block	Location	Latitude	Longitude	pH	EC	F	Cl	SO4	CO3	HCO3	TH	Ca	Mg	Na	K
Bemetara	Nawagarh	KHAPRI	21.94001	81.754616	7.82	409	0.32	1.8	0.57	0	1.2	4.2	3.2	1	9.57	0.84
Bemetara	Nawagarh		21.85713 7	81.682378	7.78	678	0.39	1.7	102.07	0	2.6	5.6	1.6	4	34.22	1.56
Bemetara	Nawagarh	CHHERKAPUR	21.85713 7	81.682378	7.77	781	0.35	0.6	106.55	0	2.3	5.8	1.9	3.9	67.99	1.48
Bemetara	Nawagarh	NANDAL	21.86430 2	81.628574	7.59	1254	0.18	1.1	85.2	0	1.8	8.3	3.7	4.6	110.3	1.94
Bemetara	Nawagarh	KIRTA	21.77469 7	81.866272	7.91	1234	0.26	1.2	81.51	0	3.2	5.6	1.3	4.3	161.25	1
Bemetara	Nawagarh	KHERA	21.90517 5	81.772427	7.8	661	0.31	2.2	67.51	0	2.8	4.4	1.8	2.6	44.72	1.29
Bemetara	Nawagarh	SAMBALPUR	21.9096	81.747681	7.62	668	0.31	1.3	106.05	0	1.7	5.2	2.2	3	34.32	1.39
Bemetara	Nawagarh	MORO	21.86609 6	81.854163	7.71	686	0.32	0.9	63.3	0	2.4	5.9	2.2	3.7	55.8	1.39
Bemetara	Nawagarh	BUNDELA	21.87723 3	81.802313	7.41	2061	0.74	3.9	106.54	0	1.1	28. 7	20. 5	8.2	76.84	6.38
Bemetara	Nawagarh	BEORA	21.91384 2	81.7957	7.46	1279	0.31	1.2	67.08	0	1.3	11. 9	7.6	4.3	45.33	1.79
Bemetara	Nawagarh	NARAYANPUR	21.83014	81.904704	7.47	1586	0.47	0.3	66	0	1.4	16. 7	10. 7	6	49.35	2.67
Bemetara	Nawagarh	MGARGH ATA	21.78606 4	81.769191	7.75	637	0.97	0.9	102	0	2.4	5.3	1.7	3.6	32.99	1.88
Bemetara	Nawagarh	KUA	21.81726 2	81.686294	7.47	2040	0.55	1.4	72.59	0	1.2	26. 7	22. 5	4.2	69.12	3.51
Bemetara	Nawagarh	BADNARA	21.84472 4	81.735432	7.79	1271	0.07	1.2	71.6	0	2.1	6.8	3.2	3.6	128.65	1.7
Bemetara	Nawagarh	MURKUTA	21.80977 2	81.816591	7.68	1439	0.19	2.1	68.13	0	1.7	12	5.1	6.9	101.58	3.05

Bemetara	Nawagarh	NAWAGA RH	21.90728	81.611633	7.71	1113	0.3	2	107.41	0	3.2	6.4	2.1	4.3	108.48	1.56
Bemetara	Nawagarh	HARDI	21.94021 6	81.57634	7.54	1161	0.22	2.3	106.94	0	3.5	6.2	2.2	4	1.66	10.5 8
Bemetara	Nawagarh	GARAMOR	21.97172 2	81.629788	7.48	805	0.44	0.6	101.31	0	4.5	3.7	0.9	2.8	102.43	1.21
Bemetara	Nawagarh	ANDHIAR KHOR	21.83539 7	81.597134	7.41	498	0.32	1	17.22	0	2.6	3.1	1.5	1.6	28.15	0.85
Bemetara	Nawagarh	TORA	21.86123 7	81.575503	7.44	821	0.26	0.7	106.3	0	3.6	4.3	2.6	1.7	81.32	1.43

2.3 Exploratory Data

Status of Groundwater Exploration

A total of 12 bore wells exist in the study area as on 31-03-2021 out of which 7 nos. are exploratory bore wells and 5 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	Andhiyarkhor	Nawagarh	21.8361	81.6	EW	269.49	9.7	Maniyari Fm	25-84.09	11.41	8.18	18
2	Andhiyarkhor OW	Nawagarh	21.8361	81.6	OW	84.22	9.9	Maniyari Fm	23.4-76.7	11.66	0.838	
3	Sambalpur	Nawagarh	21.925	81.7333	EW	144.92	20	Maniyari Fm	15-18, 25.92-84.12	8.14	6.58	10.5
4	Sambalpur OW	Nawagarh	21.925	81.7333	OW	300.75	20.5	Maniyari Fm	14-16,25.9-84.1			4.331
5	Amlidih	Nawagarh	21.8331	81.9112	EW	122.12	8	Tarenga shale and Chandi Lst	23.3,27.9,38.5-42.1,67.3-68.9,73.52-74.52,110.5-122.10	1.99	20.05	12.5
6	Nawagarh	Nawagarh	21.9083	81.6	EW	259.06	8.9	Maniyari Fm	22-24, 34.6-53.8,76.6-87.8	4.96	10.17	7.86

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 d (mbgl)	Water level (mbgl)	Drill time discharge (lps)	Draw down (m)	Discharge during Test (lps)
1	Makhanpur	Nawagarh	21.83477	81.6827	EW	201	22.5	Maniyari shale	15-18,33.30-36.40,45.50-48.60,69.90-73.00,88.20-91.30	11.9	6.5	6	6.3
2	Makhanpur OW	Nawagarh	21.83477	81.6827	OW	201	19.5	Maniyari shale	15-18,33.30-36.40,45.50-48.60,69.90-73.00,88.20-91.30	16.89	4.,5		
3	Katai	Nawagarh	21.81566	81.716704	EW	201	12.1	Maniyari shale	18.1-,21.10,39.40-42.50,118.70-121.80	18.19	5.5	2.21	5.13
4	Katai OW	Nawagarh	21.81566	81.716704	OW	201	13.1	Maniyari shale	43-46	19	0.5	7.94	0.5
5	Amora	Nawagarh	21.87862	81.75699	EW	201	14.2	Maniyari shale	33.40-36.50, 71-74.10	14.6	4.5	6.5	4.41
6	Amora OW	Nawagarh	21.87862	81.75699	OW	201	15.1	Maniyari shale			4.5	6.00	4.5

3. AQUIFER DISPOSITION

3.1 Number of Aquifers

There are two major aquifer system viz. Limestone Aquifer system and Shale Aquifer system. Both the aquifersystem has the shallow aquifer and deeper aquifer which occurs in phreatic and semi-confined condition respectively.

After studying the exploratory well details in aquifer system, it has been envisaged that the rock of the study area comprises mainly Maniyari shale with intercalations of Limestone in some places. The shale consists of lower gypsiferous grey siltstone and shale and followed upward by reddish brown calcareous and non- calcareous shale with limestone and dolomite called Hirri Dolomite.

The average thickness of the weathered portion is around 9 m. In general, the discharge varies from 4 lps to 18lps with an average yield of 9 lps. The average drawdown of the f**ormation is around 6** m. Water zone has been encountered up to 122 meters. Transmissivity range observed is 79.11 to 1125.65 sq. meter/day.

3.1.1 Basic Characteristics of AquiferShale aquifer:

There are two types of Shale formations namely Maniyari shale and Tarenga Shale which are also mostproductive 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 defines 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 movement of ground water and thus making it very high in ground water. yield varies from 3 to18 lps, Transmissivity varies between 69 to 1500 m^2/day.

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. Wells have yielded in this formation from 1 to5 lps, Transmissivity varies between 10 to 200 m^2/day.

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. Transmissivity varies between 5 to 100m^2/day. This formation has also yielded 5 lps at places.

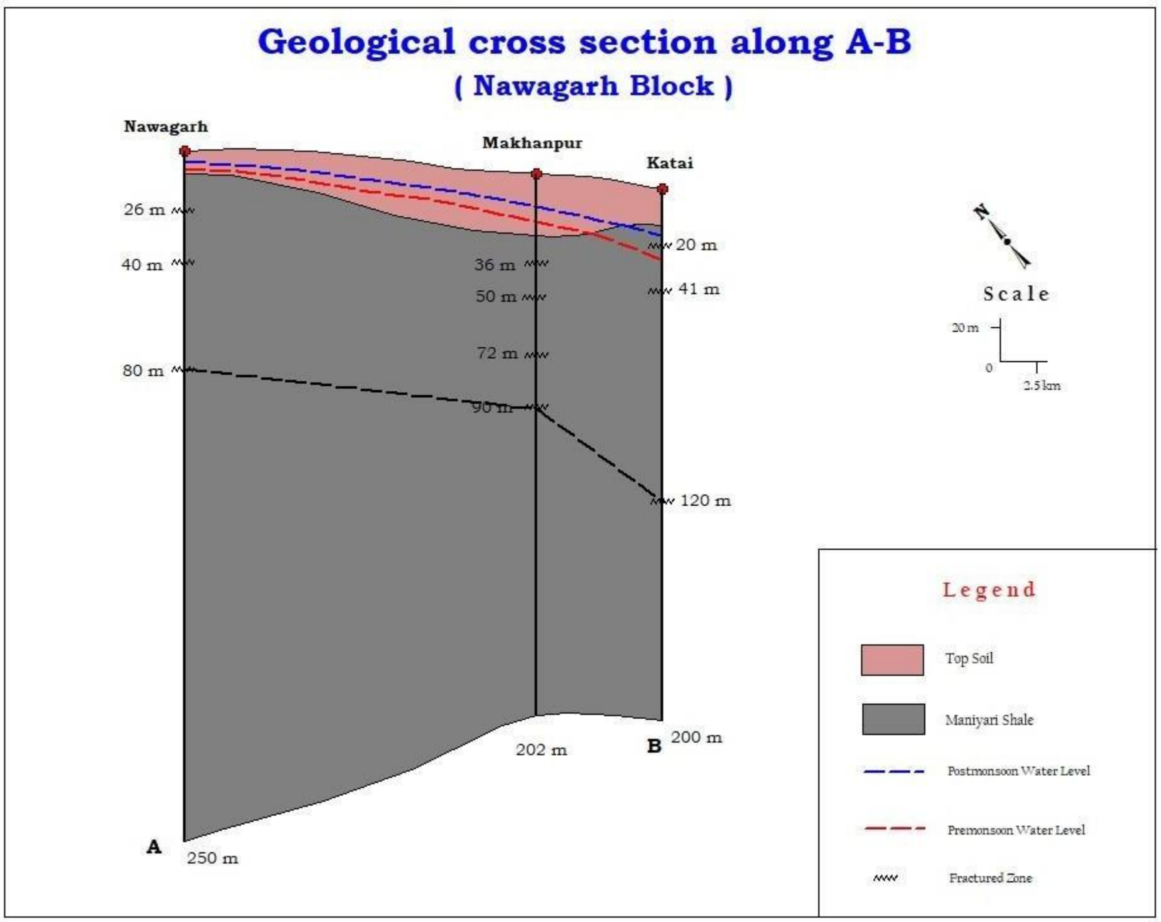
3.2 Geological sections

An attempt has been made to draw geological section along Nawagarh- Katai (A-B) and Sambalpur -Andhiyarkhor (C-D) in the study area based on available exploration data.

(A) Geological cross-section (A-B) along Nawagarh- Katai

Section A-B of Nawagarh Block shows a thin soil cover at Nawagarh in the west in whichis gradually increasing towards center and is thickest at Makhanpur and again its thickness is decreasing towars east. Below the soil, Maniyari shale formation is encountered in the entire area.

Fig. 10(A) Geological cross-sections (A-B) along Nawagarh-Katai

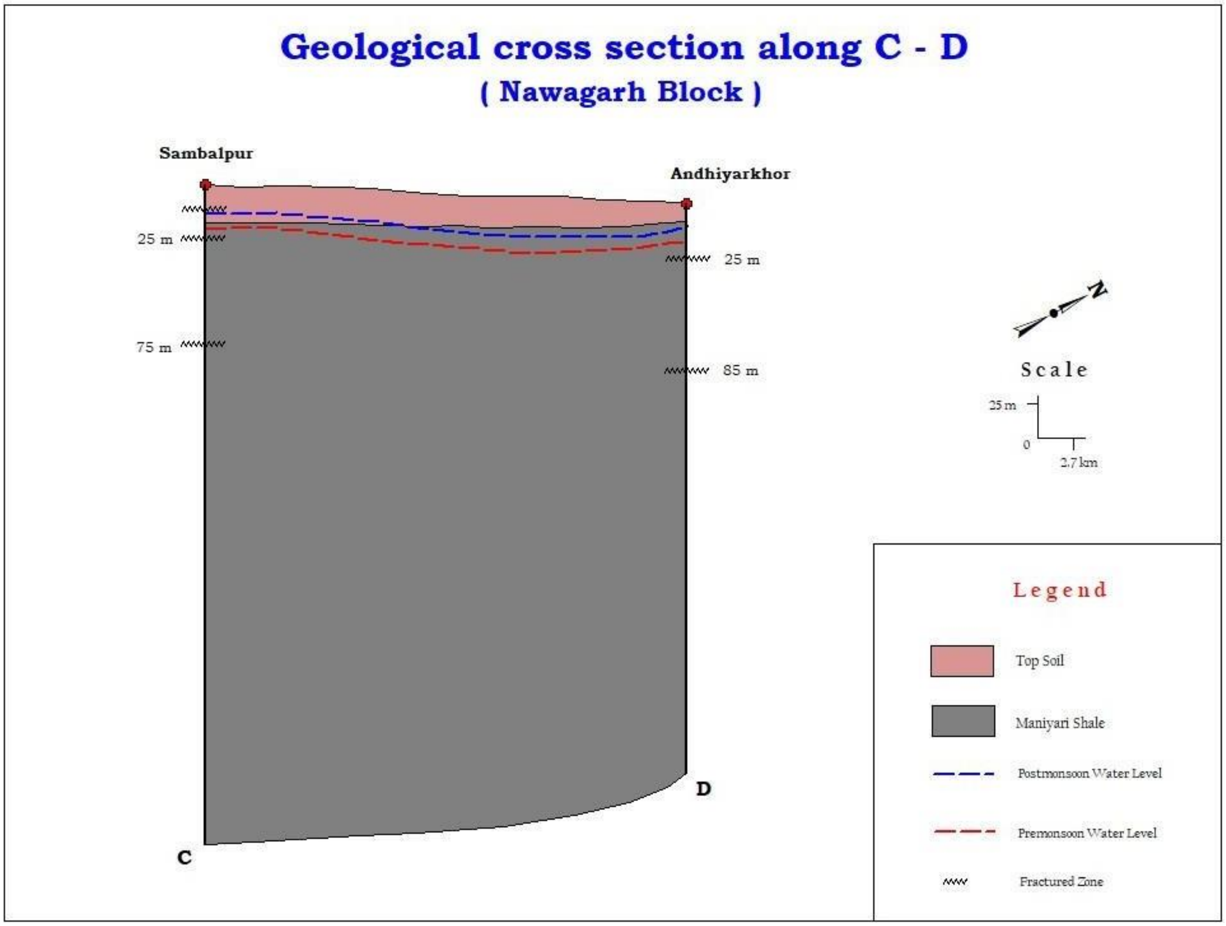


Shale (Maniyari) – Good Potential 3 to18 lps, Transmissivity = 69 to 1500 m^2/day,

10 (B) Geological cross-section (C-D) along Sambalpur-Andhiyarkhor

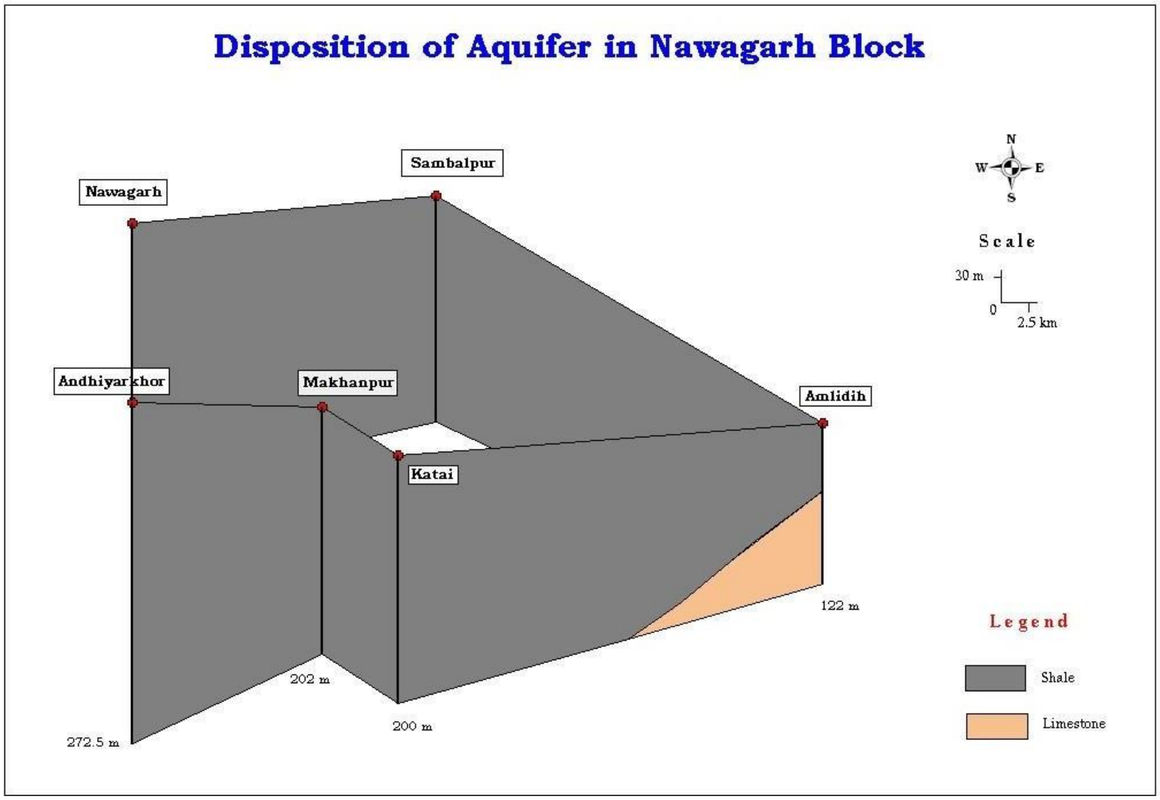
Section C-D shows a top soil cover followed by shale formation.

Fig. 10 (B) Geological cross-sections (C-D) along Sambalpur-Andhiyarkhor



Shale (Maniyari) – Good Potential 3 to18 lps, Transmissivity = 69 to 1500 m^2/day.

Fig. 10 (C) Fence diagram of Nawagarh block



4. ISSUES

(i) During summer, dug wells and Ponds in villages become dry at many locations. Several hand pumps also stopyielding 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 is5291.13 Ham which is 89% of Gross draft (As Total draft is 5935.95 ham)

(v) Availability of Power in rural area: In 2020-2021, Chhattisgarh is presently one of the few states that havesurplus 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 durationand uncontrolled pumping of ground water withdrawal.

5. GROUND WATER ENHANCEMENT AND MANAGEMENT PLAN

The stage of Ground Water Development stands at 84.72 % in Berla block. Hence the block is categorized as"Semi**- Critical"**. Resource availability of Nawagarh block is given in the table below. Where net ground water availability for future use is 1028.08 ham. The various extraction details along with the categorisation are also depicted in the table-12.

Fig. 11 Ground Water Resource Map of Nawagarh block

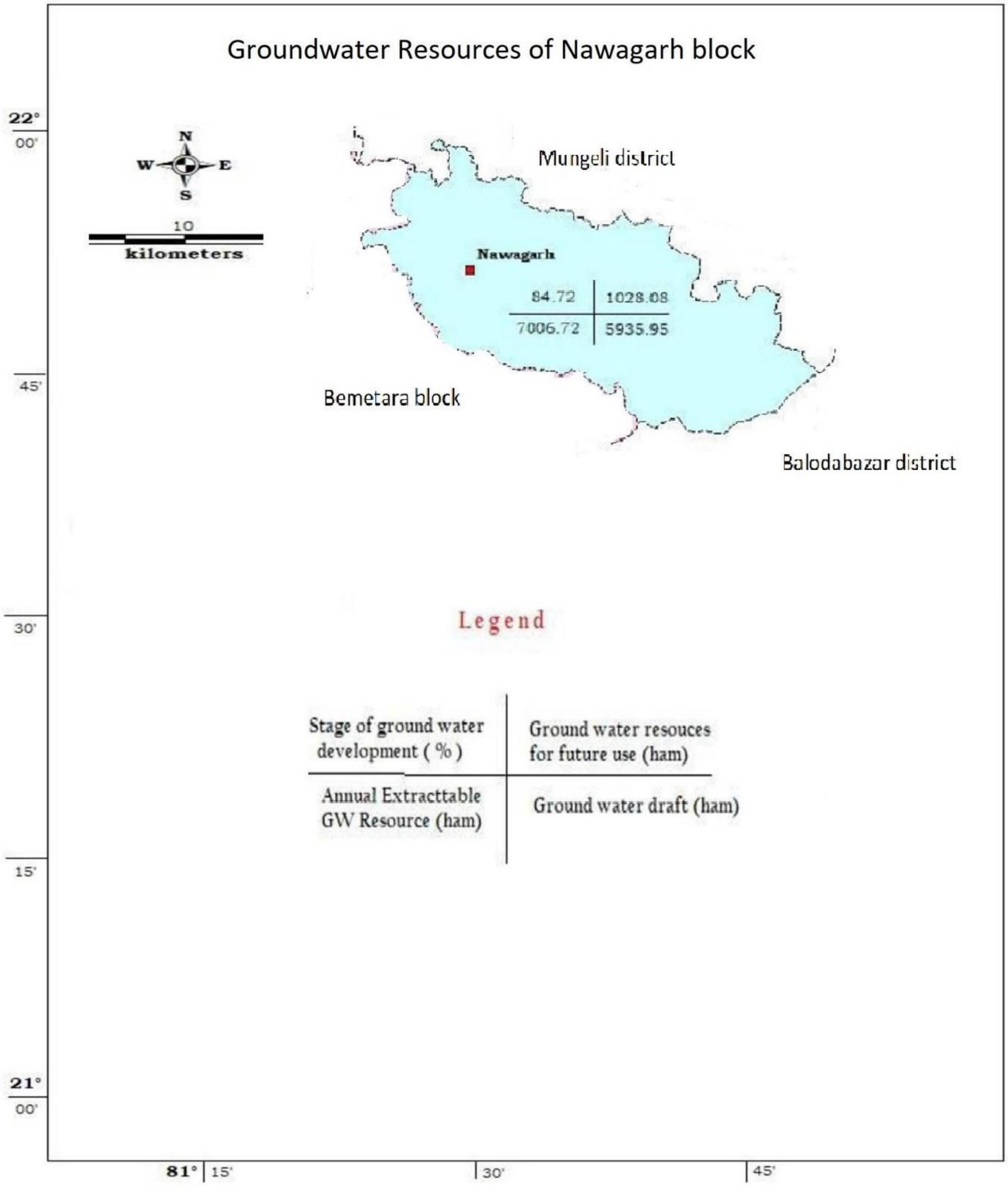


Table 12: Ground Water Resource availability in Nawagarh block

Assessment Unit Name	Annual Extractable e Ground Water Resource (mcm)	Current Annual GW Extraction (mcm) for irrigation	Current Annual GW Extraction (mcm) for IND	Current AnnualGW Extraction (mcm) for Domestic	Total Extraction (mcm)	Stage of Ground Water Extract ionn (%)	Category(OE/ Critical/ Semicritical/Safe)
Berla	70.0672	52.911	0.03	6.4183	59.3595	84.72%	Semi-Critical

To Arrest depleting water level, we need to improve the stage of GW extraction of the block from 'Semi-Critical' to 'Safe' category. So, Additional water requirement for improvement

1. Net GW availability in Nawagarh Block 7006.72 ham
2. Gross GW draft 5935.95 ham
3. Present status of GW development 84.72%
4. Requirement of water to reaching to stage of GW development by 70% 8479.72 ham or 84.79 MCM

Fig. 12 Ground Water Development, Potential and Artificial Recharge

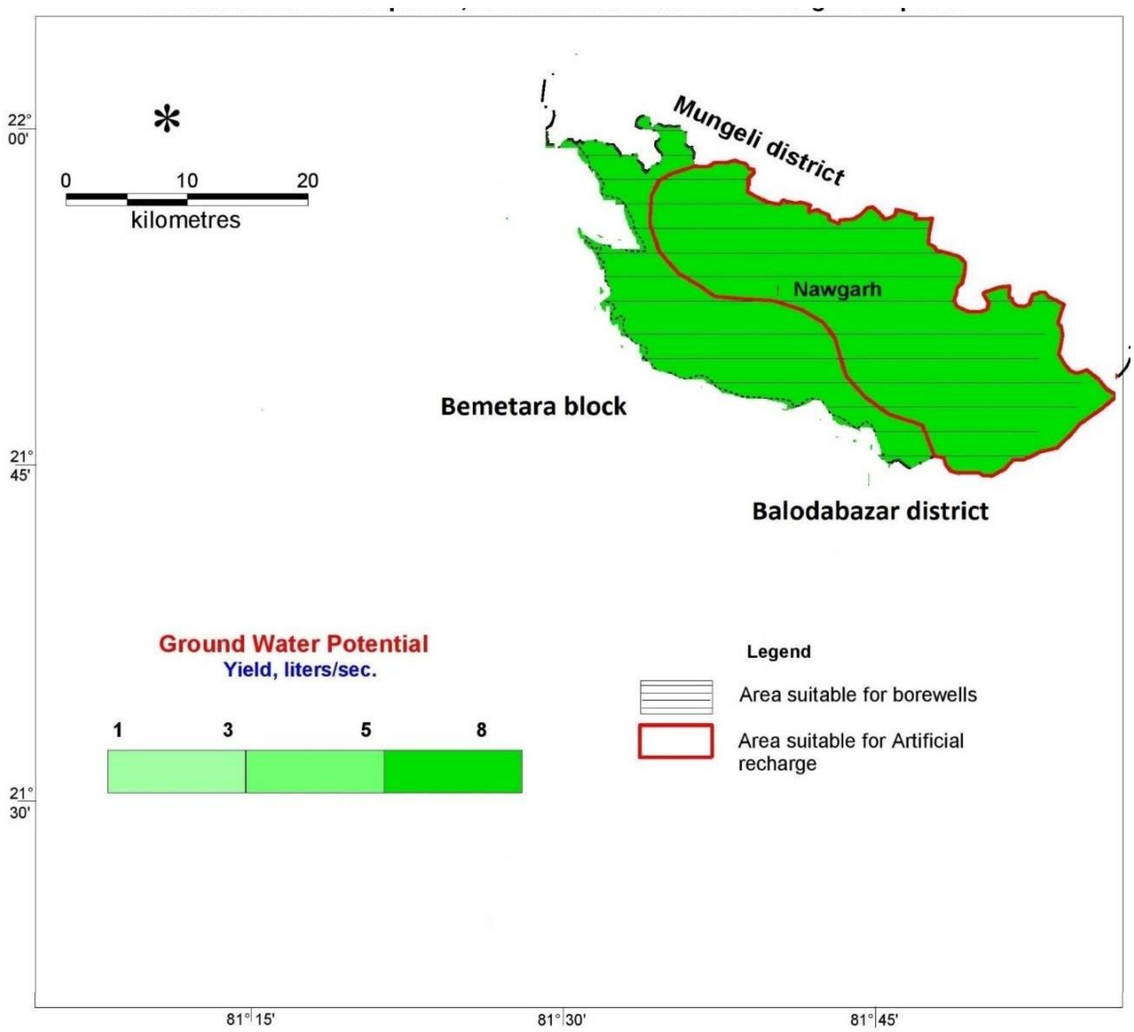
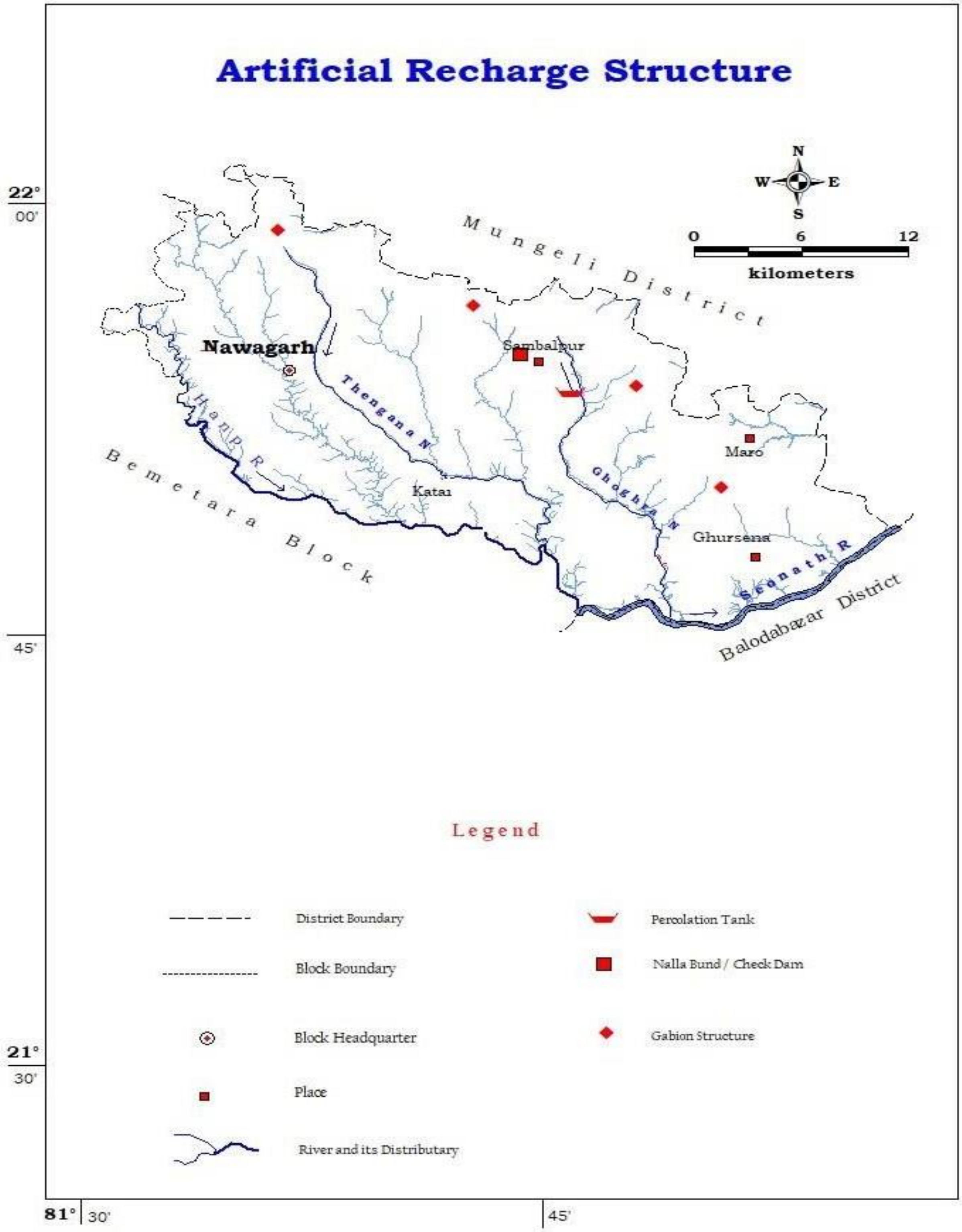


Fig. 13 Artificial Recharge structure Map



“FAILURE OF GROUNDWATER MANAGEMENT LEAVES PEOPLE MORE VULNERABLE TODROUGHT.”

The main purposes for ground Water Management is **to arrest depleting water levels** in the block and **to improve it from ‘Semi-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 ManagementThe 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 organization.

(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 domesticuses. 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 consumptionPromoting 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 groundwaterIntercepting 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 regulationgeographical 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.