2022-23

भारत सरकार

Government of India

जल शक्ति मंत्रालय, जल संसाधन, नदी विकास एवं गंगा संरक्षण बिभाग

Ministry of Jal Shakti, Department of Water Resources, River Development & Ganga Rejuvenation

केन्द्रीय भूमि जल बोर्ड

Central Ground Water Board

गरियाबंद जिला, छत्तीसगढ़ के जलभृत मानचित्रण एवं भूजल प्रबंधन योजना

Aquifer Mapping and Ground Water Management Plan of Gariyaband District, Chhattisgarh

केन्द्रीय भूमि जल बोर्ड

उत्तर मध्य छत्तीसगढ़ क्षेत्र

द्वितीय तल, एल. के. कॉरपोरेट एवं लांजिस्टिक पार्क,

धमतरी रोड, डूमरतराई, रायपुर (छत्तीसगढ़)-492015

फोन-0771-2974405, फैक्स-2974405, ईमैल-rdnccr-cgwb@nic.in

रायपुर

March 2023

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 Gariyaband 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 GARIYABAND DISTRICT, CHHATTISGARH" is prepared by Ms. Gurpreet Kour, Scientist-B under the supervision of Dr. Prabir K. Naik (Regional Director) and Smt. Prachi Gupta (Scientist-C & OIC-NAQUIM). 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 Gariyaband district 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. Prabir K. Naik
(Regional Director)

कार्यकारी सारांश

जलभृत मानचित्रण एक बहु आयामी वैज्ञानिक प्रक्रिया है जिसमें जलभृतों में भूजल की मात्रा, गुणवत्ता और संचलन की विशेषता के लिए भूगर्भीय, जल विज्ञान, भूभौतिकीय, जल विज्ञान और गुणवत्ता जानकारी के संयोजन को एकीकृत किया जाता है। हालांकि, पिछले एक दशक में विकास से भूजल के प्रबंधन पर ध्यान केंद्रित करने के प्रतिमान के कारण, स्थानीय स्तर पर भूजल संसाधनों के न्यायसंगत और टिकाऊ प्रबंधन के लिए बड़े पैमाने पर अधिक विश्वसनीय और व्यापक जलभृत मानचित्रों की आवश्यकता महसूस की गई है। भूजल का वॉल्यूमेट्रिक मूल्यांकन और भविष्य के विकास और प्रबंधन के लिए रणनीतियाँ, जलभृत मानचित्रण के प्राथमिक उद्देश्य हैं।

जलभृत मानचित्रण कार्यक्रम के तहत, गरियाबंद जिले के सभी विकास खंडों अर्थात् गरियाबंद, राजिम, छुरा, देवभोग और मैनपुर को 10863 वर्ग किमी के क्षेत्र में शामिल किया गया था। यह सर्वे ऑफ इंडिया की डिग्री शीट संख्या 64G, 64H, 64K, 64L और 65I भागों में (1:250000 स्केल) पूर्वी देशांतर 82.0160 और 82.7270 के बीच और उत्तरी अक्षांश 21.0840 और 19.7740 के बीच आता है। यह दक्षिण और पूर्व में ओडिशा राज्य, पश्चिम में धमतरी जिले और उत्तर में महासमुंद और रायपुर जिलों से घिरा हुआ है। गरियाबंद जिला मुख्यालय है। जिला आसपास के जिलों से सड़क मार्ग से अच्छी तरह से जुड़ा हुआ है। राज्य के भीतर निकटतम हवाई अड्डा रायपुर की राजधानी है जो गरियाबंद से लगभग 100 किमी दूर है। जिले के भीतर सभी महत्वपूर्ण स्थान राज्य राजमार्गों और अन्य सभी सड़कों के नेटवर्क से अच्छी तरह से जुड़े हुए हैं।

प्रशासन की सुविधा के लिए जिले को 5 नगों में बांटा गया है। सामुदायिक विकास खंड और 690 नं। राजस्व गांवों की जिले में 5 शहरी केंद्र हैं। 2011 की जनगणना के अनुसार जिले की कुल जनसंख्या 597,399 है, जिसमें ग्रामीण जनसंख्या 527630 (88.32%) तथा शेष नगरीय जनसंख्या 69769 (11.68%) है। 2011 की जनगणना के अनुसार जिले की जनसंख्या 597,399 है। जनसंख्या में उच्च दशकीय वृद्धि का श्रेय नगरीय क्षेत्रों में जनसंख्या वृद्धि को दिया जाता है। अध्ययन क्षेत्र उपोष्णकटिबंधीय जलवायु का अनुभव करता है। अध्ययन क्षेत्र के लिए औसत वार्षिक वर्षा लगभग 1219.65 मिमी है (पिछले पांच वर्षों का औसत यानी 2016 से 2021 तक)।

महानदी इस जिले की प्रमुख नदी है। पेयरी और सोंदूर इसकी सहायक नदियाँ हैं। गरियाबंद जिले की भूमि की उर्वरता का श्रेय इन नदियों की उपस्थिति को दिया जा सकता है। सिहावा की पहाड़ियों से निकलकर महानदी उत्तर पूर्व दिशा में बंगाल की खाड़ी में गिरती है। महानदी अपनी उत्तरी सीमाओं के पास तिरछे जिले को पार करती है।

भू-आकृति विज्ञान की दृष्टि से जिले में परिपक्व प्रकार के भू-रूप हैं और इसे मोटे तौर पर दो प्रमुख भू-आकृतिक इकाइयों में विभाजित किया जा सकता है। ये प्रोटेरोज़ोइक चट्टानों द्वारा निर्मित विच्छेदित पेडिप्लेन / पेडिमेंट हैं, प्रोटेरोज़ोइक चट्टानों पर संरचनात्मक मैदान और प्रोटेरोज़ोइक चट्टानों पर डेन्यूडेशनल हिल्स और घाटियाँ हैं।

कुल क्षेत्रफल का लगभग 389053 हेक्टेयर (66.44%) वनों से आच्छादित है। भूमि बहुत उपजाऊ है और ज्यादातर सतही सिंचाई सुविधाओं के साथ कृषि उद्देश्यों के लिए उपयोग की जाती है। वर्ष 2013 के दौरान बोया गया शुद्ध क्षेत्र कुल भौगोलिक क्षेत्र का लगभग 23% है। धान मुख्य फसल (131879 हेक्टेयर) है जिसके बाद गेहूं (431 हेक्टेयर) और उसके बाद दालें (171 हेक्टेयर) हैं।

जिले में वर्ष 2013 में शुद्ध बोया गया क्षेत्रफल 135403 हेक्टेयर है। शुद्ध सिंचित क्षेत्र 56053 हेक्टेयर और सकल सिंचित क्षेत्र 56167 हेक्टेयर है। सिंचाई के लिए भूजल का योगदान शुद्ध सिंचित क्षेत्र का लगभग 26.02% और जिले में सकल सिंचित क्षेत्र का 26.17% है।
जिले में हार्ड रॉक क्षेत्र संभावित एक्वीफर साबित हुए हैं। भूजल अन्वेषण कार्यक्रम के तहत जिले में 40 से 200 मीटर की गहराई में 38 बोरवेल खोदे गए हैं। उन्होंने 0.5 से 10 एलपीएस तक उपज दी है।

2022 के अनुसार अध्ययन क्षेत्र में भूजल विकास का भूजल संसाधन गणना चरण 67.97% है। इसलिए, यह खतरनाक आंकड़ा है और भूजल ड्राफ्ट को संतुलित करने और अध्ययन क्षेत्र में भूजल संरक्षण संरचनाओं के निर्माण पर ध्यान देने की आवश्यकता है क्योंकि चरण अर्ध-महत्वपूर्ण वर्गीकरण की ओर बढ़ रहा है।

क्षेत्र में सिंचाई की मौजूदा मांग 18582.66 हैम है जबकि घरेलू उपयोग के लिए 1603.33 हैम और औद्योगिक क्षेत्र के लिए 21.46 हैम है। भूजल की भविष्य की मांग को पूरा करने के लिए कुल 13187.96 हैम भूजल भविष्य में उपयोग के लिए उपलब्ध है।

अध्ययन क्षेत्र में सर्वेक्षण के दौरान पहचाने गए प्रमुख भूजल मुद्दे इस प्रकार हैं: गर्मियों के दौरान कुओं और हैंडपंपों का सूखना, एक्वीफर का निहित जलभूवैज्ञानिक चरित्र, फ्लोराइड सांद्रता, लौह संदूषण एवं नाइट्रेट संदूषण।

अध्ययन क्षेत्र में जटिल हाइड्रोजियोलॉजिकल परिस्थितियों के कारण जमीन की उपलब्धता बिखरी हुई है। जिन क्षेत्रों में भूमिगत जल की उपलब्धता सीमित है वहां सतही जल का संरक्षण और उपयोग किया जा सकता है। कई स्थानों से फ्लोराइड और आयरन के उच्च मूल्य की सूचना मिली है। ग्रैनाइटिक एक्विफर प्रणाली में कई स्थानों पर भूगर्भिक कारणों से भूजल फ्लोराइड से दूषित होता है। पीने के पानी में फ्लोराइड संदूषण की समस्या का समाधान प्रभावित गांवों में छोटी फ्लोराइडीकरण

इकाइयां स्थापित करके या वैकल्पिक स्रोत की पहचान करके किया जा सकता है। माना जाता है कि भूजल पुनर्भरण पर नीति बनाने से भूजल की वृद्धि में मदद मिलती है। स्मार्ट सिंचाई पद्धतियां, भूजल संसाधनों का विवेकपूर्ण उपयोग, कृत्रिम पुनर्भरण तकनीकें दीर्घावधि में जल के सतत प्रबंधन में मदद कर सकती हैं। समुदाय आधारित दृष्टिकोण आर्थिक विकास के विभिन्न स्तरों पर क्षेत्रों में जल स्थिरता प्राप्त करने का प्रभावी तरीका है।

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, all the development blocks of Gariyaband District namely Gariyaband, Rajim, Chhura, Deobhog and Mainpur were taken up covering an area of 10,863 sq. km. It falls in the Survey of India's Degree Sheet No. 64G, 64H, 64K, 64L & 65I in parts (1:250000 Scale) between East longitudes 82.0160 & 82.7270 and by North latitudes 21.0840 & 19.7740. It is surrounded by Odisha state on the south and east, Dhamtari district in the west and Mahasamund & Raipur districts in the north.Gariyaband is the district headquarters. The district is well connected by all weathered roads. The nearest airport within the state is the capital of Raipur which is around 100 km from Gariyaband. All important places within the district are well connected by a network of the state highways and all-other roads.

For the convenience of administration, the district is divided into 5 nos. of Community Development blocks and 690 number of revenue villages. In the district there are 5 urban centers. According to the 2011 census the total population of the district is 5,97,399 out of which rural population is 5,27,630 (88.32%) and remaining is urban population of 69,769 (11.68 %). The high decadal growth in population is attributed to the growth in population in urban areas. The study area experiences sub-tropical climate. The average annual rainfall for the study area is around 1219.65 mm (Average of the last five years i.e., 2016 to 2021).

Mahanadi is the principal river of this district. Its tributaries are Pairy and Sondur. The fertility of lands of Gariyaband district can be attributed to the presence of these rivers. Mahanadi originating in the hills of Sihava flows in the direction of North East into the Bay of Bengal. Mahanadi crosses the district diagonally near its Northern boundaries

Geomorphologically the district is having matured type of land forms and can be broadly divided into two prominent geomorphic units. These are dissected Pediplain /Pediment made

by Proterozoic rocks, Structural plain on Proterozoic rocks and Denudational hills and valleys on Proterozoic rocks.

Around 3,89,053 hectares (66.44%) of the total area is covered by forest. The land is very fertile and is mostly used for the agriculture purposes with surface irrigation facilities. The net area sown during the year 2013 is around 23% of the total geographical area. Paddy is the main crop (1,31,879 ha) followed by wheat (431 ha) and then by pulses (171ha).

The net sown area in the district in the year 2013 is 1,35,403 hectares. The net irrigated area is 56,053 ha & gross irrigated area is 56,167 ha. The contribution of ground water for irrigation comes to nearly 26.02% of the net irrigated area and 26.17% of the gross irrigated area in the district.

Hard rock areas in the district have been proved to be potential aquifers. Under the ground water exploration programme 38 bore wells have been drilled in the district ranging in depth from 40 to 200 m. They have yielded up to 0.5 to 10 lps.

As per 2022 ground water resource calculation stage of ground water development in the study area is 67.97 %. So, this is alarming figure and need to be focused on to balance the groundwater draft and construct groundwater conservation structures in the study area as stage is increasing towards Semi-critical categorization.

The existing demand for irrigation in the area is 18,582.66 Ham while the same for domestic use is 1,603.33 Ham and for industrial field is 21.46 Ham. To meet the future demand for ground water, a total quantity of 13,187.96 Ham of ground water is available for future use.

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) Inherent hydrogeological character of aquifer. (iii) Fluoride concentration. (iv)Iron contamination. (v) Nitrate contamination.

In study area because of complex hydrogeological conditions ground availability is scattered. In area where ground water availability is limited surface water may be conserved and utilized. High value of Fluoride and Iron has been reported from several locations. In Granitic aquifer system at many places ground water is contaminated with Fluoride because of geogenic reasons. The problem of fluoride contamination in drinking water may be tackled by setting up of small defluorination units in affected villages or alternate source may be identified. Policy making on ground water recharge is believed to help in augmentation of ground water.

Smart irrigation practices, judicious use of ground water resources, artificial recharge techniques can help in the sustainable management of water in the long run. Community based approaches are effective way to achieve water sustainability in areas at different levels of economic development.

Acknowledgement

At the outset the author would like to express sincere gratitude to Shri Sunil Kumar, Chairman, Central Ground Water Board for providing necessary opportunity to carry out Aquifer Map and Management Plan of Gariyaband district. The author express my sincere gratitude to Shri. T.B.N. Singh, Member East for valuable guidance, encouragement and suggestions during the preparation of this report. The author is indebted to Dr. Prabir K. Naik, Regional Director and Shri A. K. Biswal, Scientist-E for their overall guidance and supervision at different stages. The author also express gratitude to Smt. Prachi Gupta, Scientist-C & OIC NAQUIM, for her continuous guidance. I am very thankful to Shri Uddeshya Kumar Sc-C and Shri B. Abhishek, Sc-C for their guidance, critical appraisal and valuable suggestions at different stages. Special thanks to Smt. Priyanka B. Sonbarse (Scientist-C & OIC RODC) for necessary input for the data integration and generation, Dr. A.K. Sinha, Sc-D, Geophysicist for carrying out VET survey at exploratory drilling sites and to Shri Rakesh Dewangan, Sc-C and Dr. Anita Bind, STA for the chemical analysis of ground water samples. The efforts made by Shri T.S. Chouhan, Chief Draftsman, for digitization of maps are thankfully acknowledged. The author is thankful to Technical Section, Geophysical section Data Centre, Chemical Section, Report Processing Section and Library of CGWB, NCCR, Raipur for providing the various needful data.

The Cooperation received from the Water Resources Department, Chhattisgarh is gratefully acknowledged. Lastly the co-operation of innumerable local people received during the work is sincerely appreciated.

Gurpreet Kour/गुरप्रीत कौर

Scientist-B/वैज्ञानिक-ख

AQUIFER MAPPING AND GROUND WATER MANAGEMENT PLAN, GARIYABAND DISTRICT, CHHATTISGARH

(05 BLOCKS-FINGESHWAR, GARIYABAND, CHHURA, MAINPUR & DEOBHOG)

KEY CONTRIBUTORS'

Principal Author		
Gurpreet Kour	:	Scientist-B (Gariyaband, Mainpur & Deobhog/Post Monsoon) AAP 22-23
Mukesh Anand	:	Scientist-B (Gariyaband, Mainpur & Deobhog/Pre Monsoon) AAP 2022-23
Priyanka Patel	:	STA (Fingeshwar and Chhura)
Supervision & Guidance		
Dr. Prabir Kumar Naik	:	Regional Director
Prachi Gupta	:	Scientist-C & OIC NAQUIM
Uddeshya Kumar	:	Scientist-C & OIC GWRA
B. Abhishek	:	Scientist- C
Groundwater Exploration 2022-23, Gariyaband district		
Mukesh Anand	:	Scientist-B
Suvam Prakash Dash	:	Assistant Hydrogeologist
Chemical Analysis		
Rakesh Dewangan	:	Scientist C (Chemist)
Dr. Anita Bind	:	STA(Chemical)
Geophysical Survey		
Dr. A.K. Sinha		Scientist -D, Geophysicist
Section Finalization / Map Digitization	:	
Gurpreet Kour	:	Scientist-B
Mukesh Anand	:	Scientist-B
Prachi Gupta	:	Scientist-C
B. Abhishek	:	Scientist- C
T S Chauhan	:	Draftsman

Contents

List of Tables

List of Figures

.

ABBREVIATIONS **TW** Tube well

a msl	Above mean sea level
BDR	Basic Data Report
BW	Bore well
CGWB	Central Ground Water Board
Dia	Diameter
DTW	Depth to Water level
DW	Dug well
EC	Electrical Conductivity
EW	Exploratory Wells
GS	Gabion structures
GW/ gw	Ground Water
ham	Hectare meter
HP	Hand pump (Shallow)
lpcd	liters per capita per day
lpm	liters per minute
lps	liters per second
m	Meter
mbgl	Meter below ground level
m2/day	Square meter/ day
m3/day	Cubic meter/day
MCM/mcm	Million Cubic Meter
NCCR	North Central Chhattisgarh Region
NHNS/ NHS	National Hydrograph Network Stations
OW	Observation Well
PZ	Piezometer
STP	Sewage Treatment Plan
T	Transmissivity

1. INTRODUCTION

1.1 Objective

Groundwater is the most valuable resource for the country. 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, therefore, involved in hydrogeological investigations for Re-appraisal of ground water regime. 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. 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.

1.2 Scope of study

The demand for ground water for various types of use is increasing day by day; consequently, indiscriminate development of ground water has taken place and the ground water resource has come under stress in several parts of the country. 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 water resource managers and planners to develop and implement effective long term as well as short term aquifer management strategies, a host of scientific questions must be answered. These questions can be best answered through a comprehensive process that integrates the available scientific data.

Aquifer mapping study thus 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. It primarily depends on the existing data that are assembled, analyzed and interpreted from available sources.

The data gap analysis carried out helped to generate data from data newly collected through activities such as exploratory drilling, groundwater level monitoring on a regular basis for a considerable period and groundwater quality analysis. These existing as well as generated data were analyzed in ordered to prepare regional hydrogeological, thematic, water quality maps, cross-sections, 2 D and 3D aquifer disposition maps. 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. 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. These 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, may vary locally and over time respectively. This variability in the data sometimes requires subjective decision-making and generalizing of information for an entire aquifer.

1.3 Approach and Methodology

The activities under the aquifer project can be summarized as follows:

i) ***Data Compilation & Data Gap Analysis:*** One of the important aspects of the aquifer mapping Programme was the synthesis of the large volume of data already collected during specific studies carried out by the Central Ground Water Board and various other government organizations with a new set of data generated that broadly describe an aquifer system. The data were compiled, analyzed, synthesized and interpreted from available sources. These sources were predominantly non-computerized data that were converted into computer-based GIS data sets. On the basis of these available data, Data Gaps were identified.

ii) ***Data Generation:*** It was evident from the data gap that additional data should be generated to fill the data gaps in order to achieve the objective of the aquifer mapping Programme. This was done by multiple activities like exploratory drilling, hydro chemical analysis, use of geophysical techniques as well as detail hydrogeological surveys.

iii) ***Aquifer map Preparation:*** On the basis of integration of data generated through various hydrogeological and geophysical studies, aquifers have been delineated and characterized in terms of quality and potential. Various maps have been prepared bringing out the Characterization of Aquifers. These maps may be termed as Aquifer Maps depicting spatial (lateral and vertical)

variation of the aquifers existing within the study area, quality, water level and vulnerability (quality and quantity).

iv) Aquifer Management Plan: Based on the integration of these generated, compiled, analyzed and interpreted data, the management plan has been prepared for sustainable development of the aquifer existing in the area.

1.4 Area Details

Gariyaband district is located in the eastern part of the Chhattisgarh state and is bounded by East longitudes 82.0160 & 82.7270 and by North latitudes 21.0840 & 19.7740 falling in the Survey of India topo-sheets numbers 64G, 64H, 64K, 64L & 65I. It covers an area of 10.863 sq.km. It is surrounded by Odisha state on the south and east, Dhamtari district in the west and Mahasamund & Raipur districts in the north (**Fig 1**). Gariyaband is the district headquarters. The district is well connected by all weathered roads.

For the convenience of administration, the district is divided into 5 nos. of Community Development blocks and 710 no. of revenue villages. In the district there are 5 urban centers. According to the 2011 census the total population of the district is 5,97,653 out of which 5,57,199 belongs to rural area and 40,454 belongs to urban area. The maximum belongs to the urban area.

Administrative Divisions

District includes 05 blocks and it is further divided in 424 village panchayats and 547 villages. The names of the 6 blocks are given below.

1. Fingeshwar Block
2. Gariyaband Block
3. Chhura Block
4. Mainpur Block
5. Deobhog Block

The administrative map for the study area is given in Figure 1.

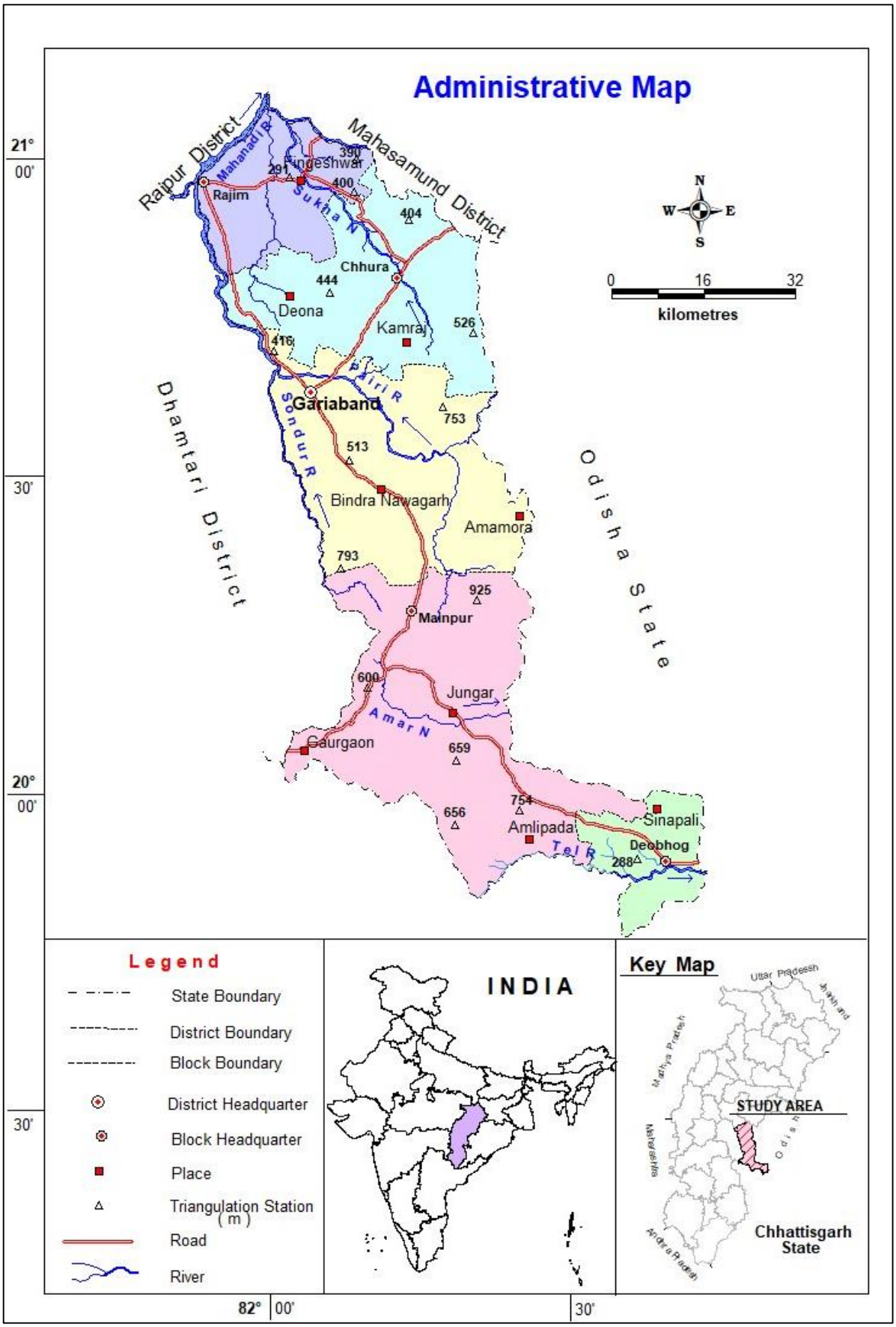

Fig 1: Administrative Map of Gariyaband District

1.5 Data Availability, Data Adequacy and Data gap Analysis

For the fruitful results and successful accomplishment of the task it was necessary to generate the new data to cover up the data gap. It was done with establishing new Key wells, site selection for exploratory drilling, VES nearby exploratory drilling sites and chemical analysis of the samples collected from new EWs and newly established Key Wells. Full details are mentioned in **Table 1 and Fig 2 & 3**.

Table 1: Data integration

Blocks	Existing			Data Generation			
	EW	Chemical	WL	EW	VES	WL	Chemical
Fingeshwar	06	14	19	1	1	00	00
Gariyaband	08	00	04	2	00	16	16
Chhura	09	05	09	4	1	00	02(EW)
Mainpur	04	00	01	00	00	08	08
Deobhog	04	00	09	00	00	13	13
Total	**31**	**19**	**42**	**07**	**02**	**37**	**39**

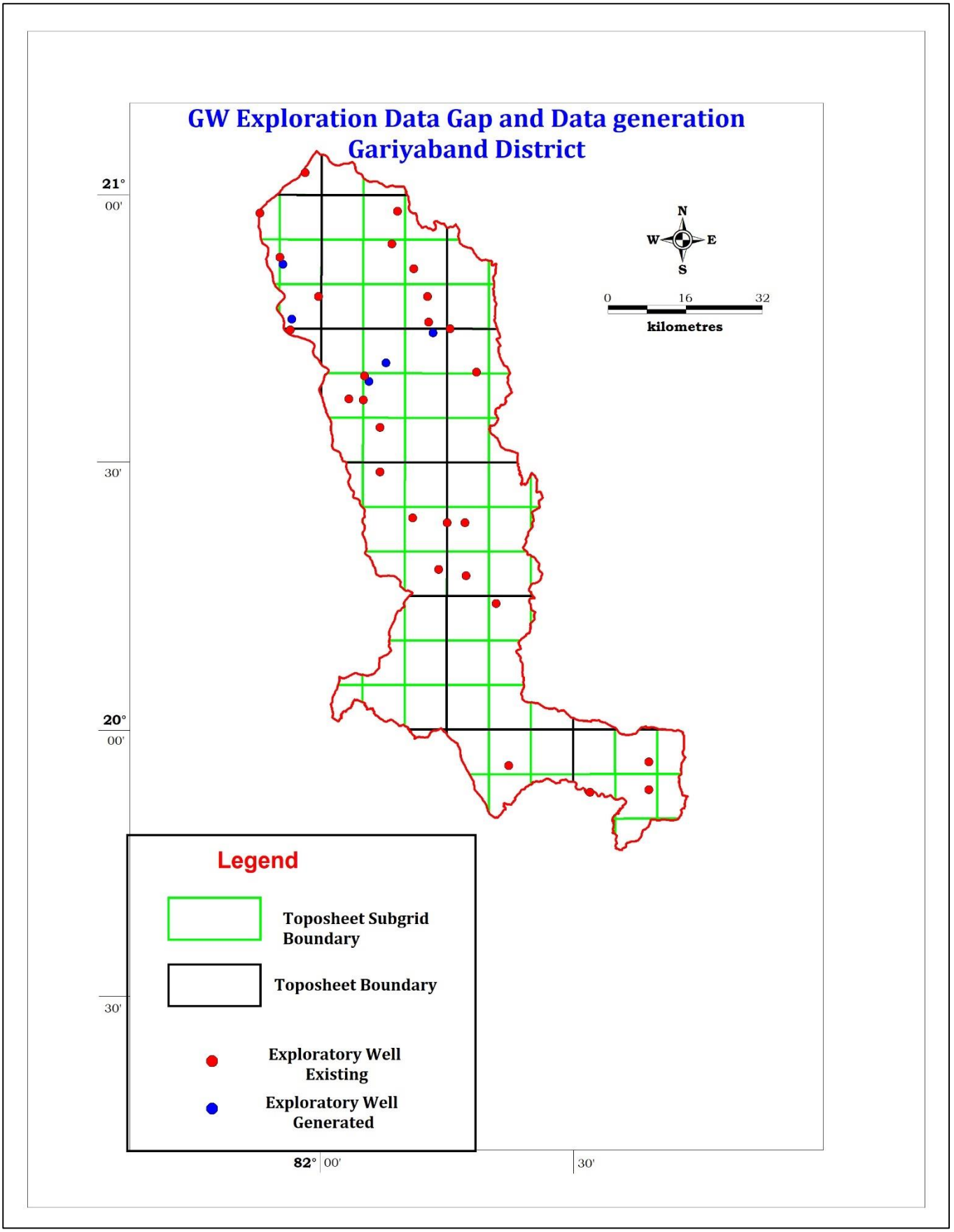

Fig 2: GW Exploration Data Gap & Data Generation Map of Gariyaband District

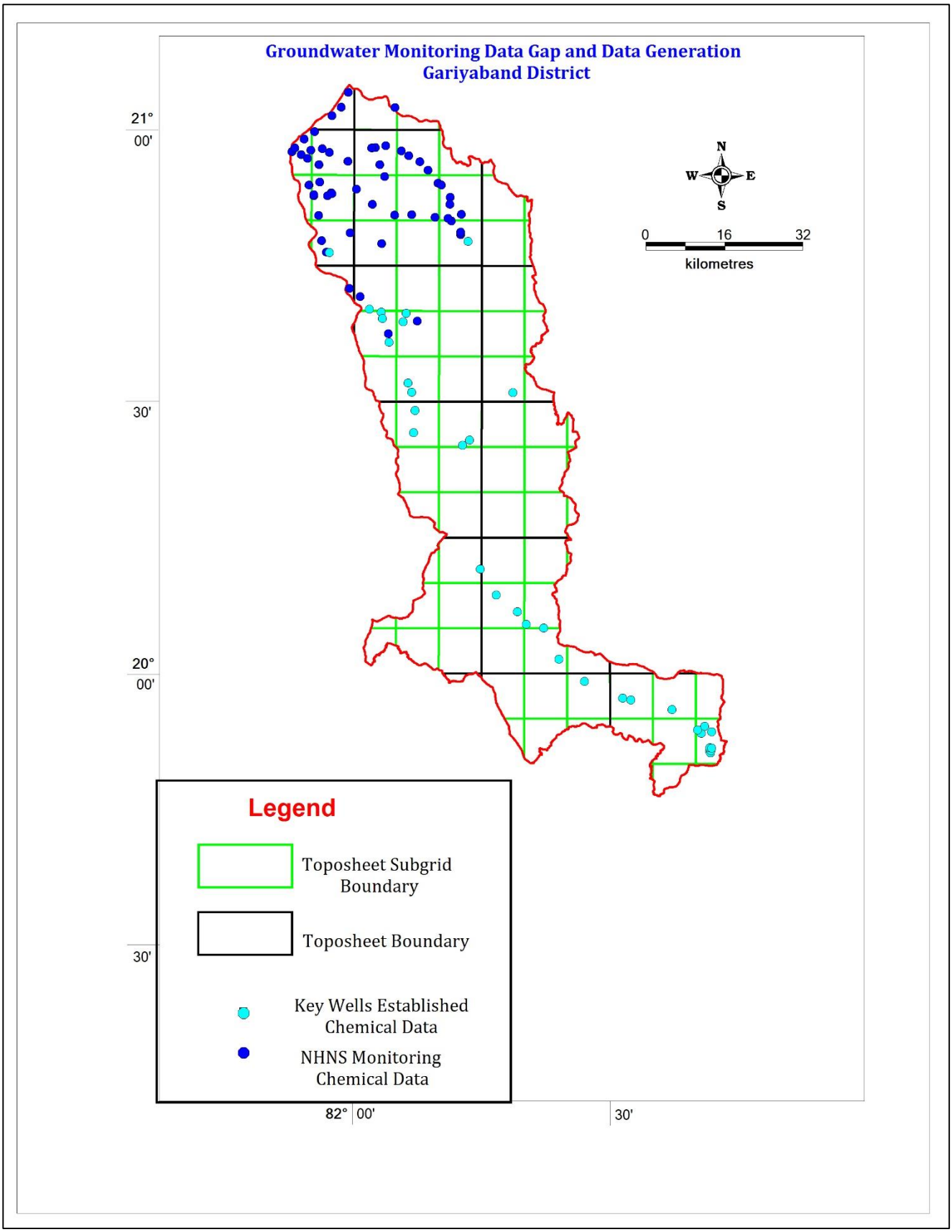

Fig 3: GW Monitoring Data Gap & Data Generation Map of Gariyaband District

1.6 Rainfall

Gariyaband is endowed with high rainfall. Areas of chronic shortfall are few and localized. The district receives its rainfall mainly from the south-west monsoon which usually sets in the third/fourth week of June and spread over a period from late June to early October with heaviest shower in the months of July and August. The normal rainfall in the district is 1193 mm and the average is 1219.65 mm (2016-2021)(**Fig 4**).

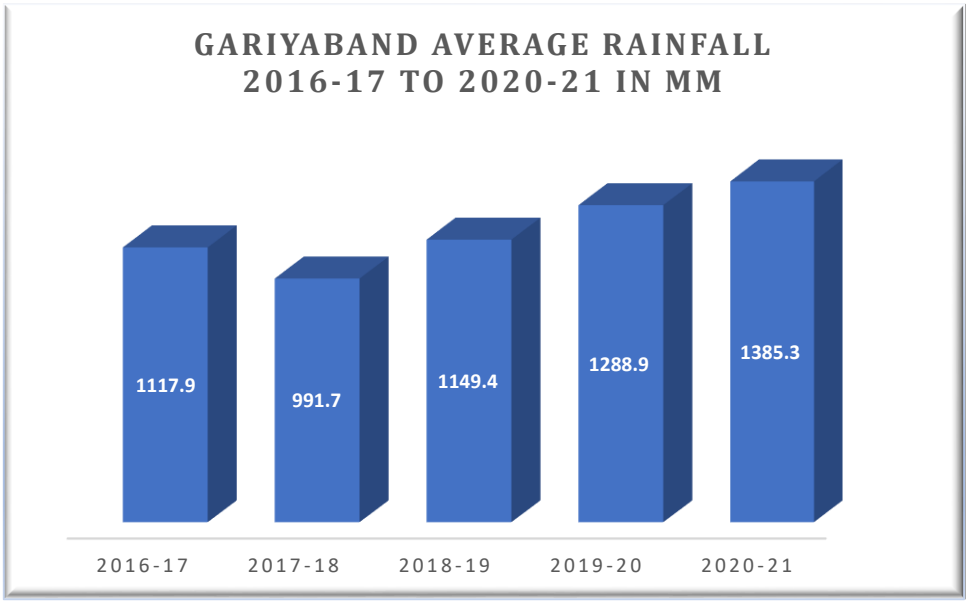

Fig 4: Rainfall in Gariyaband District

Gariyaband district has a tropical wet and dry climate; temperatures remain moderate throughout the year, except from March to June, which can be extremely hot. The highest temperature goes up to 43ºC and observed in the months of May and June. Winters last from November to January and are mild and the lowest falls up to 10 °C and observed in the months of December and January.

1.7 Physiography/Geomorphology

Geomorphologically the district is having matured type of land forms and can be broadly divided into two prominent geomorphic units **(Fig 5)**. These are

1. Dissected Pediplain /Pediment made by Proterozoic rocks
2. Structural plain on Proterozoic rocks
3. Denudational hills and valleys on Proterozoic rocks

The northern part of the district is composed of recent floodplains of Mahanadi River. Just towards the south of the flood plains the region is occupied by structural plains that overlies the rocks of Proterozoic age.

Further towards the south major portion of the district is covered by Pediplains, open fields, hilly terrains and valleys with fairly sloping pediment zone. The plains represents the ancient flood plains of Mahanadi and its tributaries.

The area towards the east of Kurund waterfall are composed of structural plateaus overlying Proterozoic group of Rocks. The structural plateaus are mostly aligned in N-S direction and shares boundary with the state of Odisha towards the east.

Granites and metamorphic rocks towards the south of structural plateaus have undergone prolonged weathering and denudation and in the present day represents denudational slopes and denudational hills.

The southern part of the district is mainly composed of paddy field, flood plains of Tel River and its tributaries with continuation of eroded mountains and slopes. The overall general slope of the study area is towards North.

Physiographically, the northern part of district exhibits mostly the landform of structural plains with structural hills and valleys, denudational slope, denudational hills and valleys, pediments/ pediplains and flood plains along the courses of Mahanadi, Kharun and Seonath rivers. The southern part of district exhibits mostly the landform of Pediment/Pediplain with upper level and lower level structural plateau, structural terrace/rocky bench, denudational slope, denudational hills and valleys and older flood plain. The gradient is towards south-east direction. The maximum elevation in the area is 943 m amsl as recorded at 19 km south-east of Mainpur Khurd in the southern part of district, while the minimum elevation of 236 m amsl is recorded in the north eastern part of district.

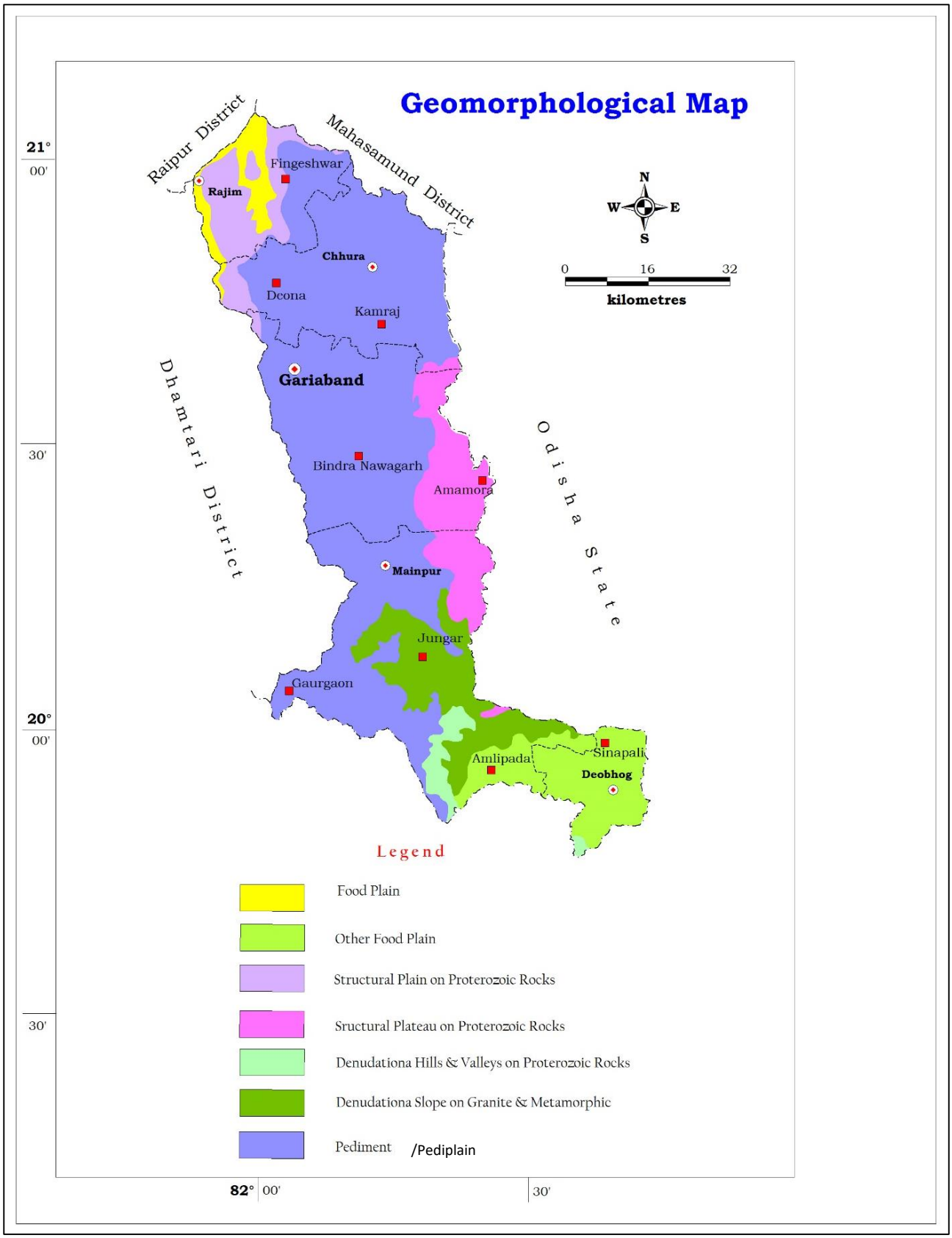

Fig 5: Geomorphological Map of Gariyaband District

1.8 Land use

There is 88,030 ha revenue forest, protected forest and other forest in the district. Area not available for cultivation is 26,648 ha. Details are presented in **Table 2** and **Fig 6** shows the Land use pattern in the study area.

Table 1: Land use pattern 2018-19 (in ha)*

District	Total Geographical Area (In ha)	Revenue forest area (In ha)	Area not available for cultivation (In ha)	Non-agricultural & Fallow land (In ha)	Agricultural Fallow land (In ha)	Net sown area (In ha)	Double cropped area (In ha)	Gross cropped area (In ha)
GARIYA BAND	290494	88030	29239	27858	143225	125857	21762	157872

(*Data Courtesy: District Statistical Handbook 2020-21)

1.9 Soil

As per the US soil taxonomy three soil types namely Alfisol, Vertisol and Ultisol have been found in the district (**Fig 7**). The soil orders in US soil taxonomy and their Indian equivalents, which are found in the district, are:

Table 3: Soil Classification of Gariyaband district

Sl. No.	US soil taxonomy	Indian equivalents
1	Vertisol	Medium black soil
2	Ultisol	Red and yellow soil
3	Alfisol	Red sandy soils

Vertisols:

They are characterized by a high content of expanding and shrinking clay known as montmorillonite that forms deep cracks in certain seasons.

The Indian equivalent of Vertisols which are available in the district is medium black soils. This soil covers only a smaller part of the district and is distributed in the extreme southern part of the district. The word "Ultisol" is derived from *"ultimate"*, because Ultisols were seen as the ultimate product of continuous weathering of minerals in a humid temperate climate.

Ultisols: This is a highly weathered and leached acid soil with high levels of clay below the top layer. They are characterized by a humus-rich surface horizon (the uppermost layer) and by a layer of clay that has migrated below the surface horizon.

The Indian equivalent of Ultisols which is available in the district is red & yellow soils. It mainly occupies the extreme northern part of the district.

Alfisol: This is a fertile leached soil found in humid areas that is alkaline or basic and contains a clay-rich layer. They are less extensively leached of metal ions and develop in cooler climates than the Ultisols, a clay-rich soil of warmer regions. These soils formed where annually dropping leaves form a thick humus layer with the time, under which by decomposition processes the characteristic loam layer are formed, which usually refers to a high age of the soil. They are considered as very fertile soils and are accordingly frequently agriculturally used. Alfisols typically exhibit well-developed, contrasting soil horizons (layers) depleted in calcium carbonate but enriched in aluminum and iron-bearing minerals. Below the surface horizon lies a region with significant accumulation of translocate (migrated) layer silicate clay. This region, called the argillic horizon, is characterized by a relatively high content of available calcium, magnesium, potassium, and sodium ions.

The Indian equivalents of Alfisols which are available in the district are Red gravelly, Red loamy and Red sandy soils. These soils taken together cover more than 70% area of the district.

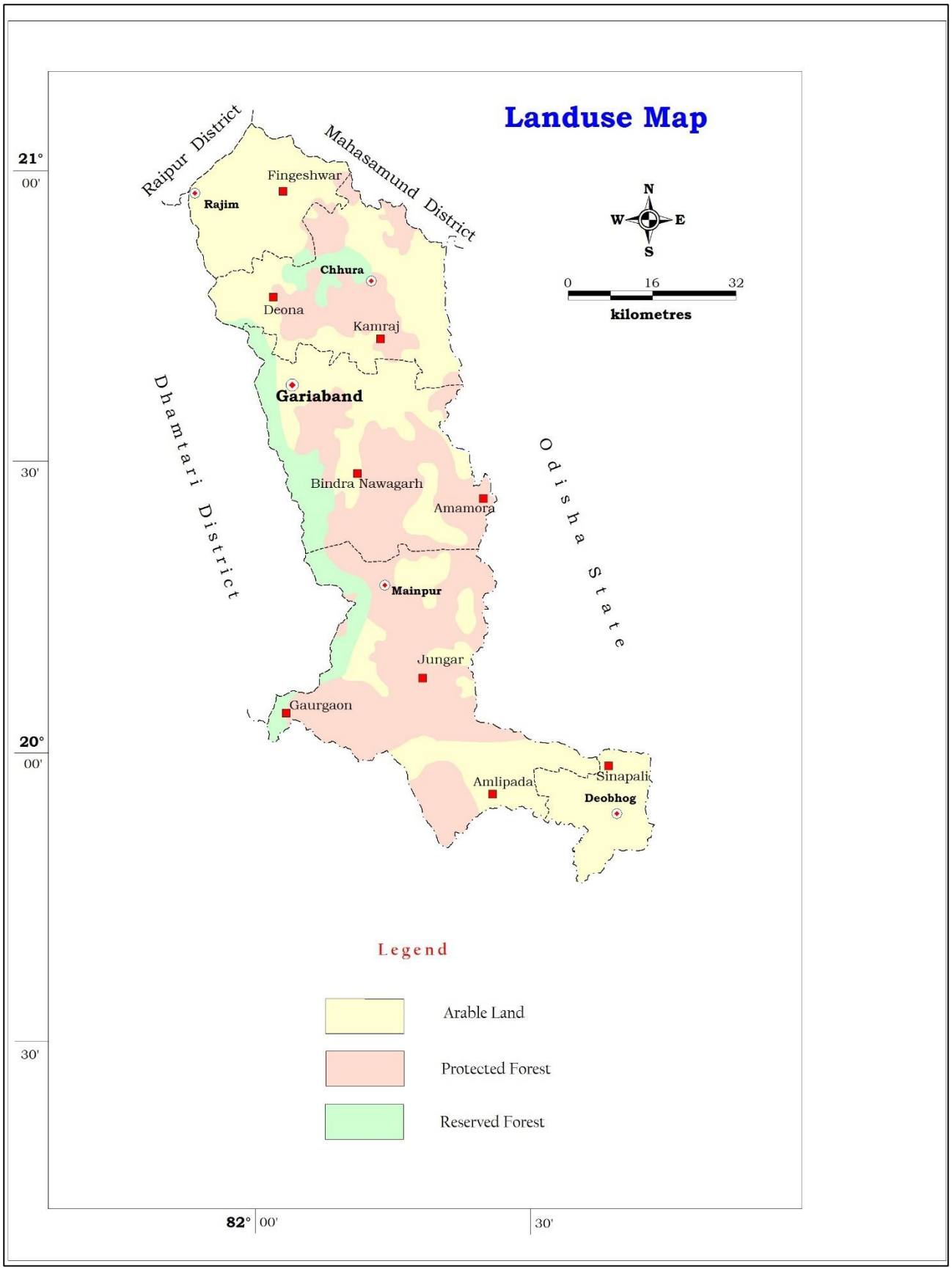

Fig 6: Land use Map of Gariyaband District

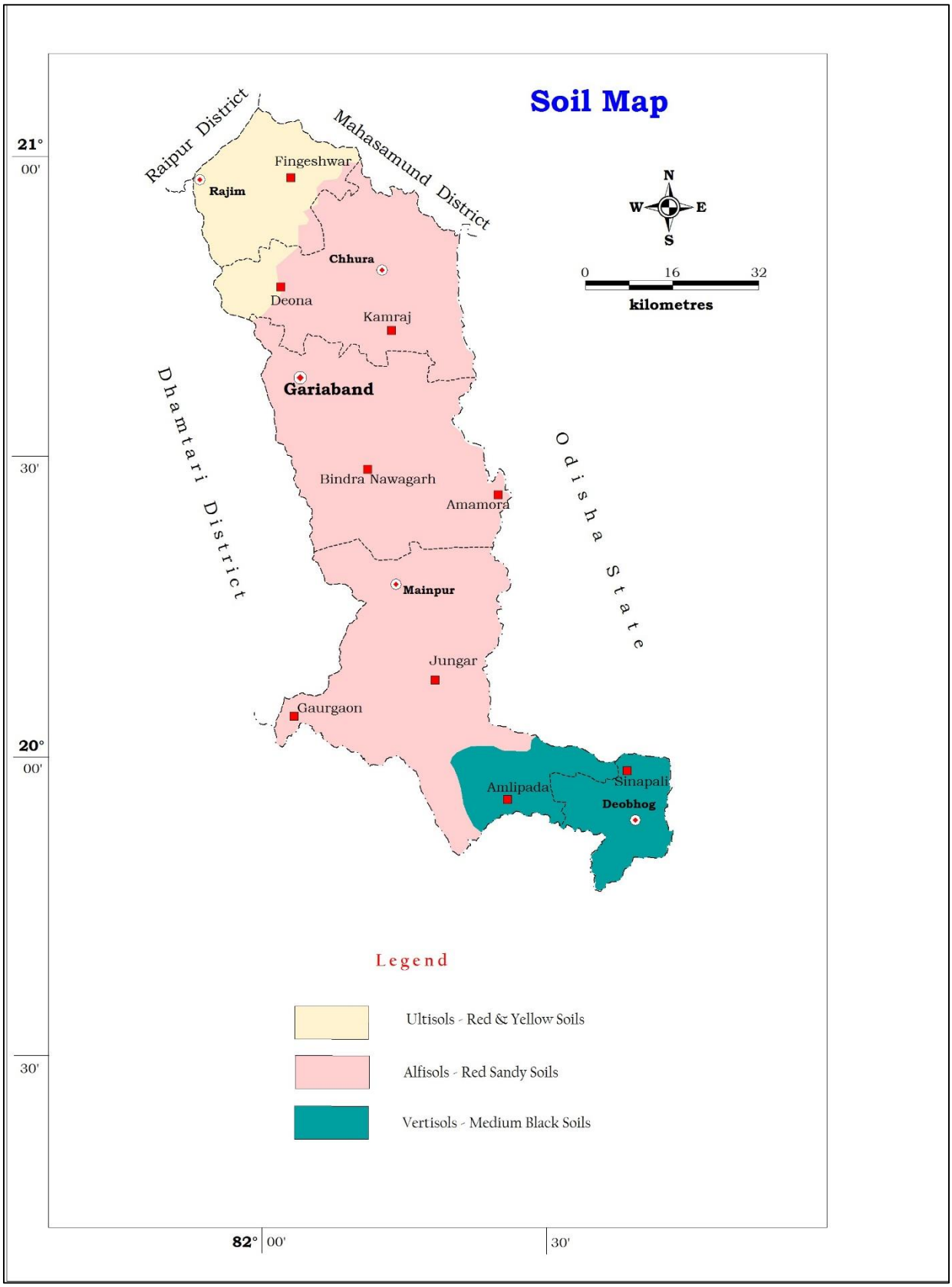

Fig 7: Soil Map of Gariyaband District

1.10 Hydrology and Drainage

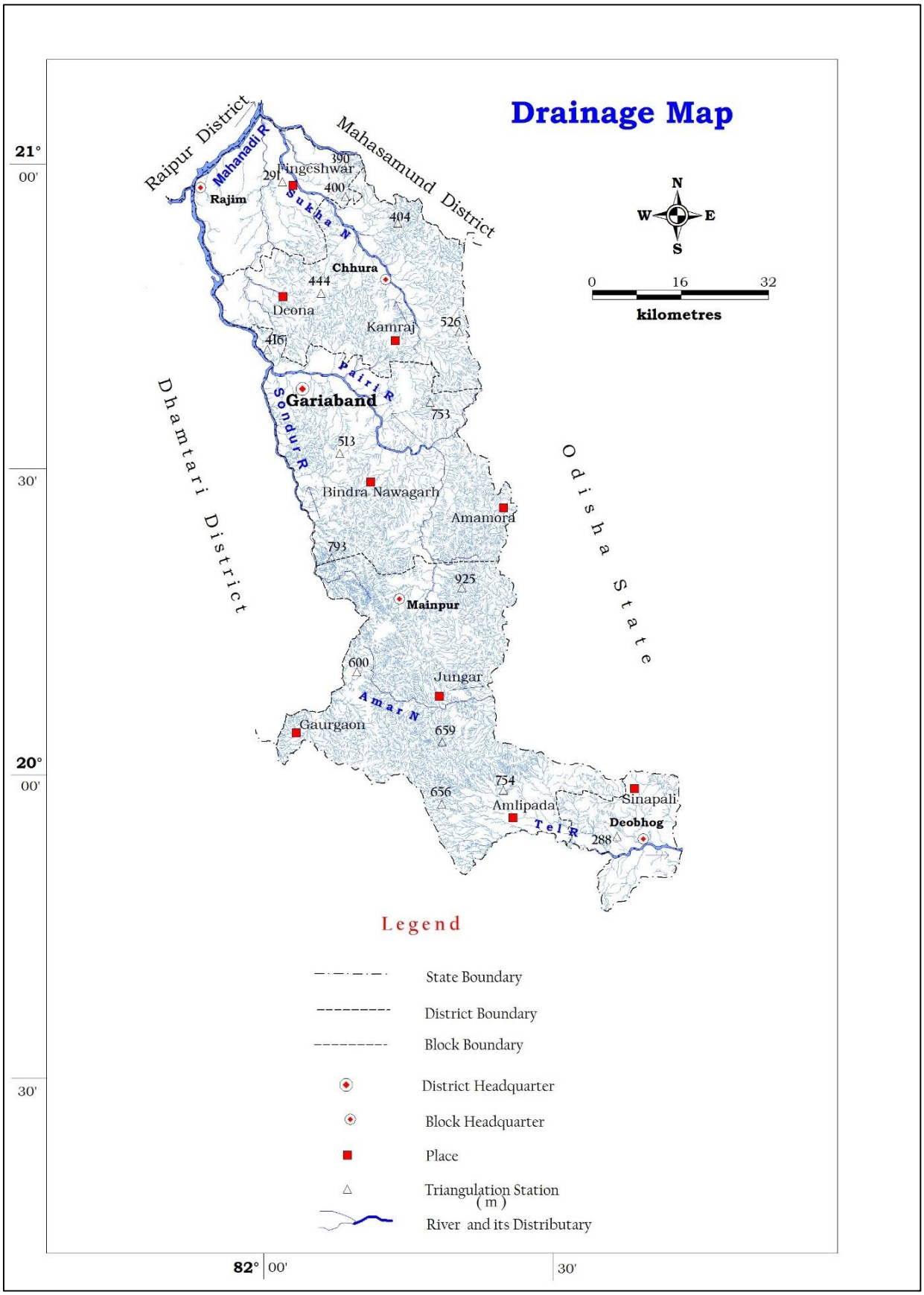

Fig 8: Drainage Map of Gariyaband District

The major rivers that drain the district are Pairi, Sodhur, Telnadi, Sarginala, Sukhanala, Baghnainala and Udant. “Pairi” and “Sodhur” river flows north from here and makes “Triveni Sangam” together at Rajim. By building Orissa state border flows “Tel River” (**Fig 8**).

1.11 Geology

The district is underlain mainly by two distinct geological formations ranging in age from Archean to Recent. The crystalline rocks occupy major parts of the district comprising of granite, granite gneiss, Phyllite, Schist, Charnockite and Khondalite. Granites and Phyllites intruded by quartz veins form the basement of the basin. The Chhattisgarh super group overlies Granite Batholith. The contact between the Archeans and the overlaying sedimentary sequence is faulted along the western margin of the basin, which can be confirmed by the presence of highly sheared and brecciaed rocks in this region. Other part of the basin can be eidenced by the presence of pebbly conglomerate bed at the basal portion of the sedimentary sequence.

The rocks of Chhattisgarh Super group are unconformable overlying the crystalline basement and are represented by the sandstone, limestone and shale sequence occupying the north western part of the district. The rocks of Chhattisgarh super group have been classified into Chandrapur Group and Raipur Group.

The rocks of Chandrapur group are the oldest of Chhattisgarh Supergroup and can be further divided into three formations viz. Lohardih, Choparadih and Kansapathar arranged in the ascending order of superposition. The sequence shows a variable thickness ranging from 20 m to as much as 90 m. The maximum thickness is attained in the SE part, thinning westward as well as in northern side and directly overlying the crystalline basement. Raipur group comprising a predominantly argillite-carbonate sequence conformably overlies the Chandrapur group with a gradational contact. Raipur group has been subdivided into six formations representing three cycles of carbonate-argillite sedimentation viz Charmuria and Gunderdehi, Chandi and Tarenga and Hirri and Maniyari arranged in the ascending order of super position. Of the above formations only two formations namely Charmuria and Gunderdehi are present in the district (**Fig 9**). Generalized Geological Succession of Gariyaband district is represented in **Table 4**.

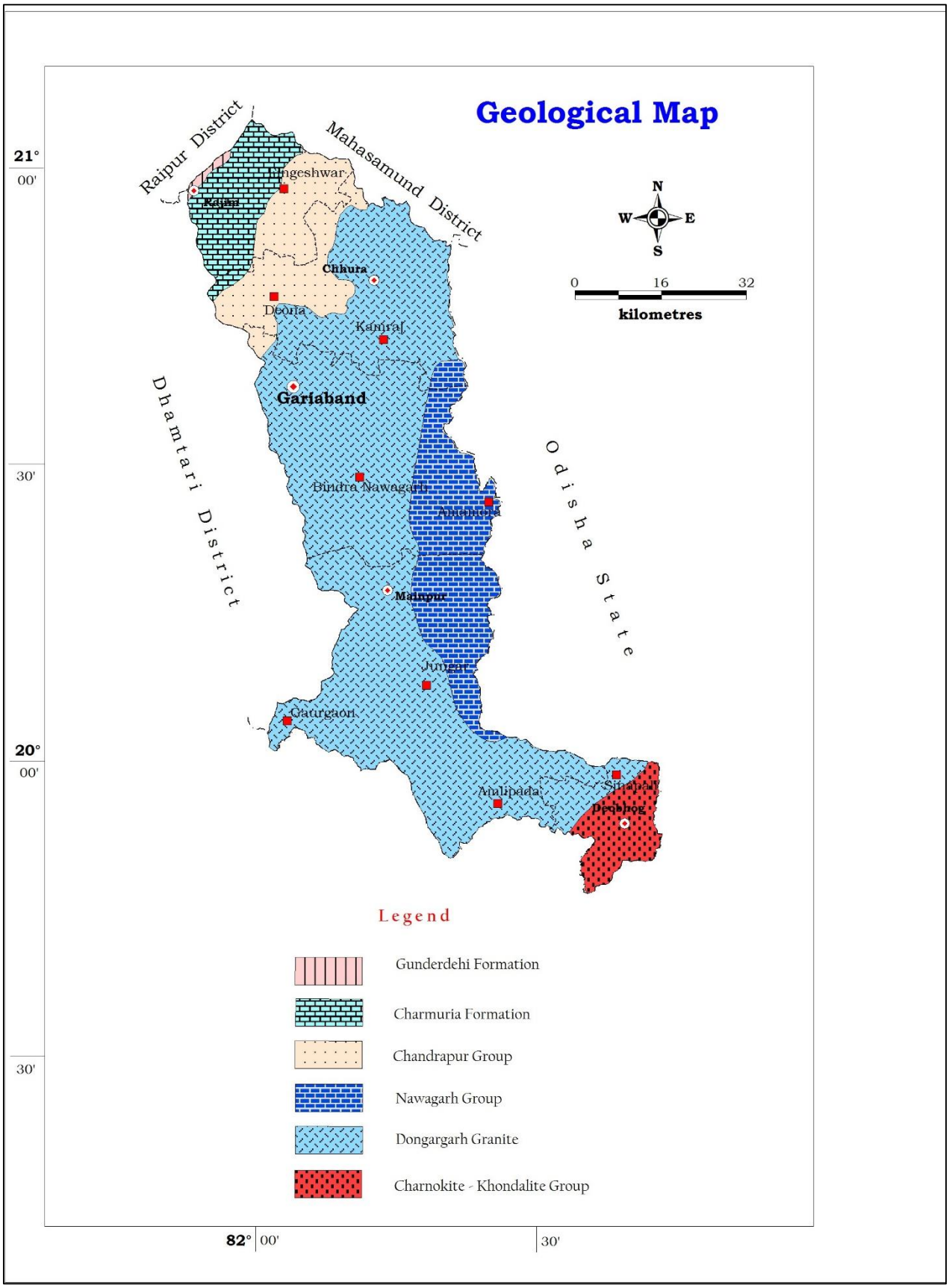

Fig 9: Geological Map of Gariyaband District

Table 4: Generalized Geological Succession of Gariyaband district

<table>
<tr><th>Age</th><th>Super Group</th><th>Group</th><th colspan="2">Formation</th><th>Lithology</th></tr>
<tr><td rowspan="4">Proterozoic</td><td rowspan="3">Chhattisgarh Super Group</td><td rowspan="2">Raipur Group</td><td>Gunderdehi</td><td rowspan="3">Nawagarh Group</td><td>Shale</td></tr>
<tr><td>Charmuria</td><td>Limestone & Shale</td></tr>
<tr><td colspan="2">Chandrapur Group</td><td>Sandstone, Siltstone, Shale & Conglomerate</td></tr>
<tr><td>Dongargarh Super Group</td><td colspan="3">Dongargarh/Kanker Granites</td><td>Granite and Granitic Rocks</td></tr>
<tr><td rowspan="2">Archean</td><td colspan="4">Bengpal & Amgaon Group</td><td>Granite, Gneiss & metasediments</td></tr>
<tr><td colspan="4">Peninsular Gneiss and unclassified sediments</td><td>Granite, Gneiss, Charnockite & Khondalite</td></tr>
</table>

1.12 Agriculture, Irrigation, Cropping Pattern

Agriculture is the prime source of livelihood for majority of the population. Rice, Wheat, Maize, Jaoo, Kodokutki are important Kharif crops grown in the district. In Gariyaband district, rice is grown in 1,34,263 hectares.

Wheat, Rice and Tuwar the main Rabi crops grown in the district. The gross & net irrigated area in the district is 45,544 & 64,336 hectares respectively. The Net irrigated area in the district as on June 2021 by Dug wells is 233 ha, by Tube wells/ Bore wells is 19,771, by Tanks is 357, by canal is 23,683 and by other sources is 1,500 hectares (**Fig 10**).

In the district Pairi and Sondur rivers flows. No major dam is constructed in the Gariyaband district. However, most of the agriculture is rain fed due to limited irrigation infrastructure, lack of multi cropping and reliance on outdated agricultural technology and equipment's. Many farmers are dependent on the rains and dug well/tube wells for irrigation.

Table 5: Cropping pattern (in ha)

Rabi	Kharif	Cereal						Tilhan	Fruits & Vegetables	Reshe/ Fibers	Mirch Masala	Sugarcane
		Paddy	Wheat	Jowar	Maize	Kodo Kutki	Pulses					
	244058	134263	237	21	8856	148	2936	320	456	1	46	38

Table 6: Area irrigated by various sources (in ha)

No. of canal s (private and Govt.)	Irrigated area	No. of bore wells/ Tube wells	Irrigated area	No. Of dug wells	Irrigated area	No. of Ponds	Irrigated area	Irrigated area by other sources	Net Irrigated area	% of irrigated area wrt. Net sown area
47	23683	12104	19771	1629	233	517	357	1500	45544	41.27

Table 7: Contribution of Groundwater in Irrigation Pattern (in ha)

Area Irrigated through Bore wells/Tube wells	Area Irrigated through Dug wells	Area Irrigated through Groundwater	Net Area Irrigated through all sources	% Groundwater contribution in Irrigation wrt. Net Irrigated Area
10684	233	20004	45544	44

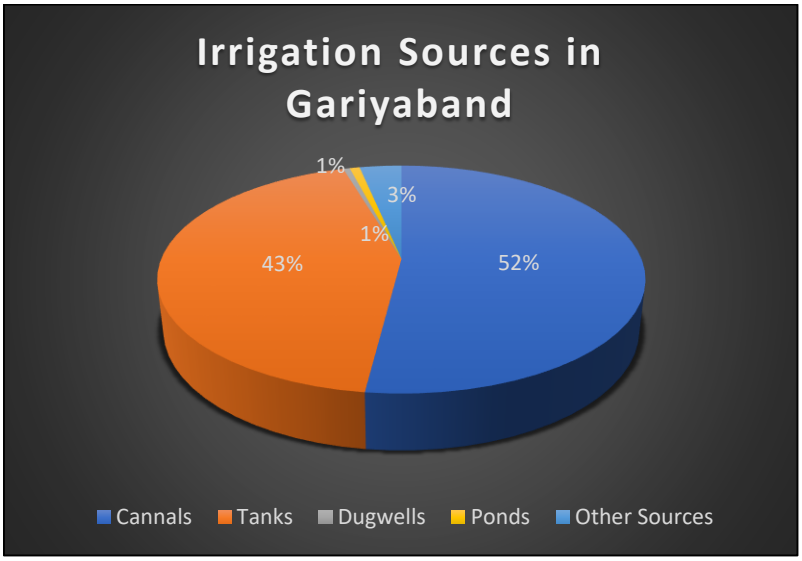

Fig 10: Area Irrigated by groundwater is 20,004 ha i.e., 44% (98.84%-Bore well, 1.16%-Dug well) of the total Irrigated area.

2. DATA GENERATION, DATA INTERPRETATION AND DATA INTEGRATION

2.1 Hydrogeological Data

Both in phreatic and fractured condition in general two aquifers exist in the area although both are hydraulically connected. The first shallow unconfined/ phreatic aquifer between 0-20 m bgl and the second semi confined to confined aquifer below 20 m bgl. 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.

The details of exploration are shown in Annexure II. In the study area, key wells were established during the pre-monsoon period and have been subsequently monitored in the post-monsoon period (Annexure-I). The key wells are distributed throughout the study area (**Figure 11**) covering all the geological formations.

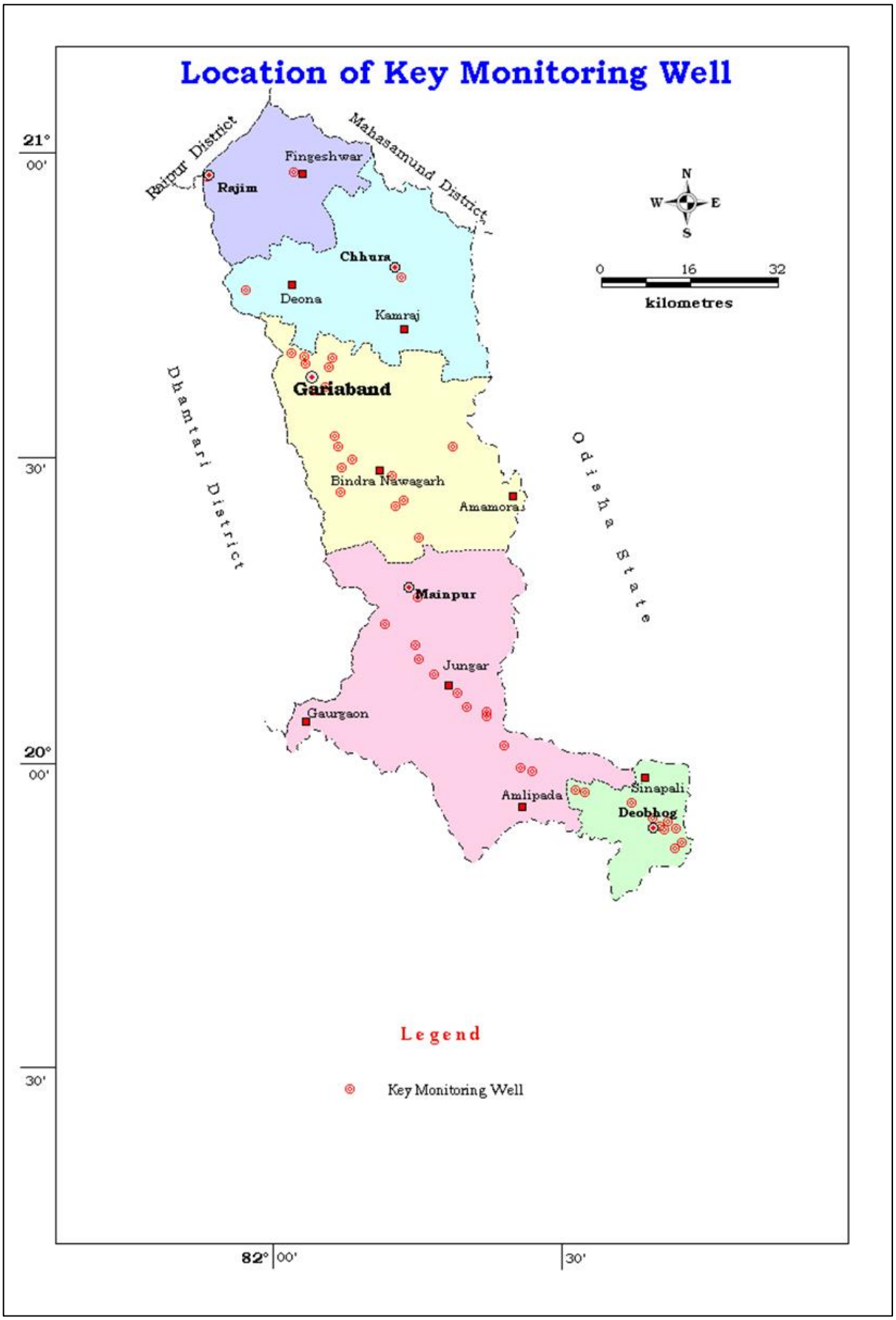

Fig 11: Key Monitoring Wells of the study area

2.2 Water level behavior

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.

i. Pre- monsoon water level (May 2022)

In the pre-monsoon period, it has been observed that in the study area water level in Phreatic aquifer vary between 2.4 to 12.0 mbgl with average water level of 6.34 m bgl. In deeper semi-confined aquifer, water level varies between 2.56 to 32.3 m bgl with average water level of 12.55 m bgl shown in **Table 8** and **Fig 12 & Fig 13**.

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

District	Aquifer Type	Min	Max	Avg
GARIYABAND	Phreatic aquifer	2.45	12.66	6.34
	Semi-confined Aquifer	4.12	22.6	10.23

ii. Post- monsoon water level (Nov 2022)

In the post-monsoon period, it has been observed that in the study area water level in Phreatic aquifer vary between 1 to 10.34 m bgl with average water level of 4.215 m bgl. In deeper semi-confined aquifer, water level varies between 3.41 to 16.79 m bgl with average water level of 8.471 m bgl shown in **Table 9** and **Fig 14 & Fig 15**.

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

District	Aquifer Type	Min	Max	Avg
GARIYABAND	Phreatic aquifer	1	10.34	4.215
	Semi-confined Aquifer	3.41	16.79	8.471

iii. Seasonal Water Level Fluctuation

The water level fluctuation data indicates that in the study area, water level fluctuation in phreatic aquifer varies from 0.75 to 8.45m with an average fluctuation of 2.966m. Water level fluctuation in semi-confined Aquifer in Granite varies from -0.368 to 4.48m. With an average fluctuation of 1.131m (**Fig 16 & Fig 17)**.

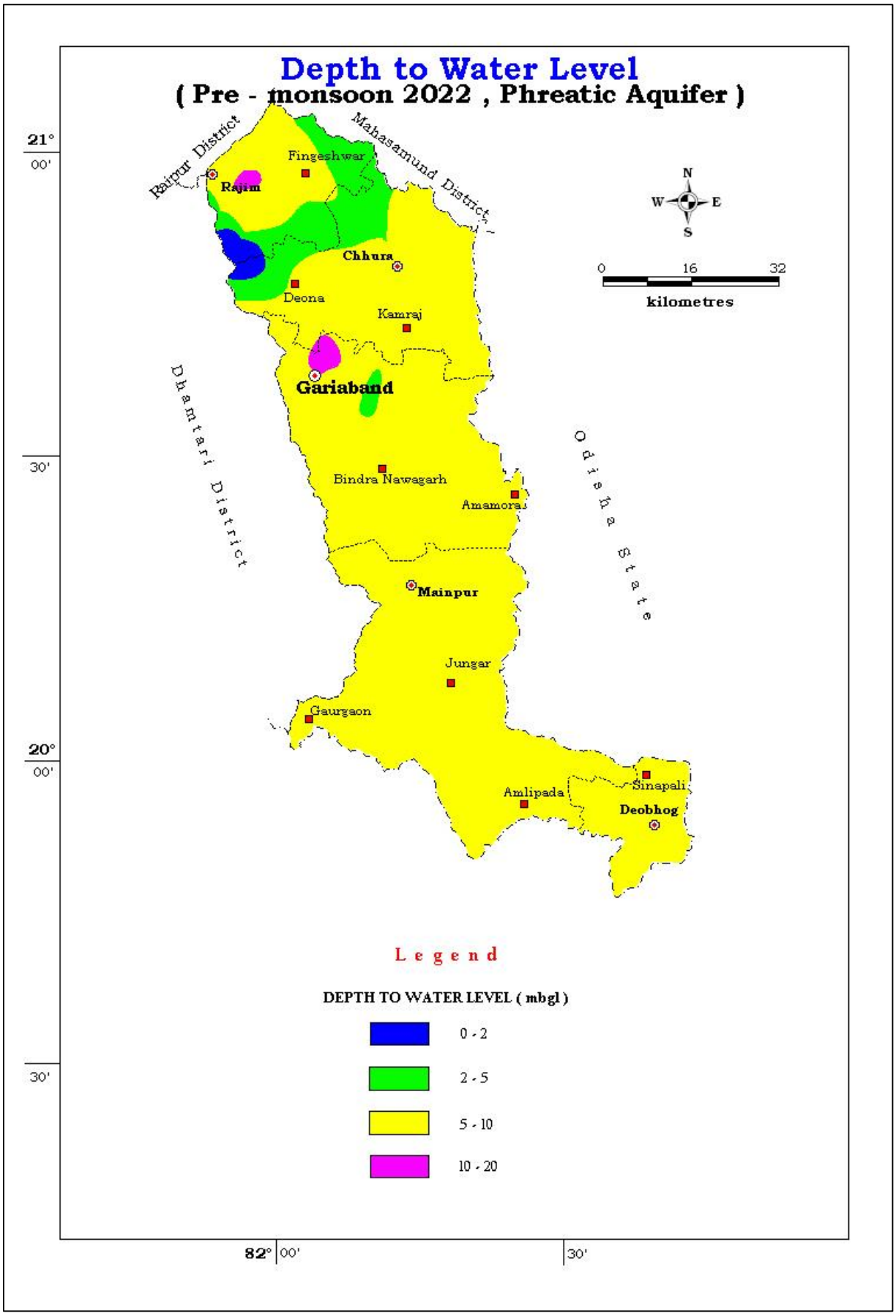

Fig 12: Pre-Monsoon Water Level Map of Gariyaband District for Phreatic Aquifer

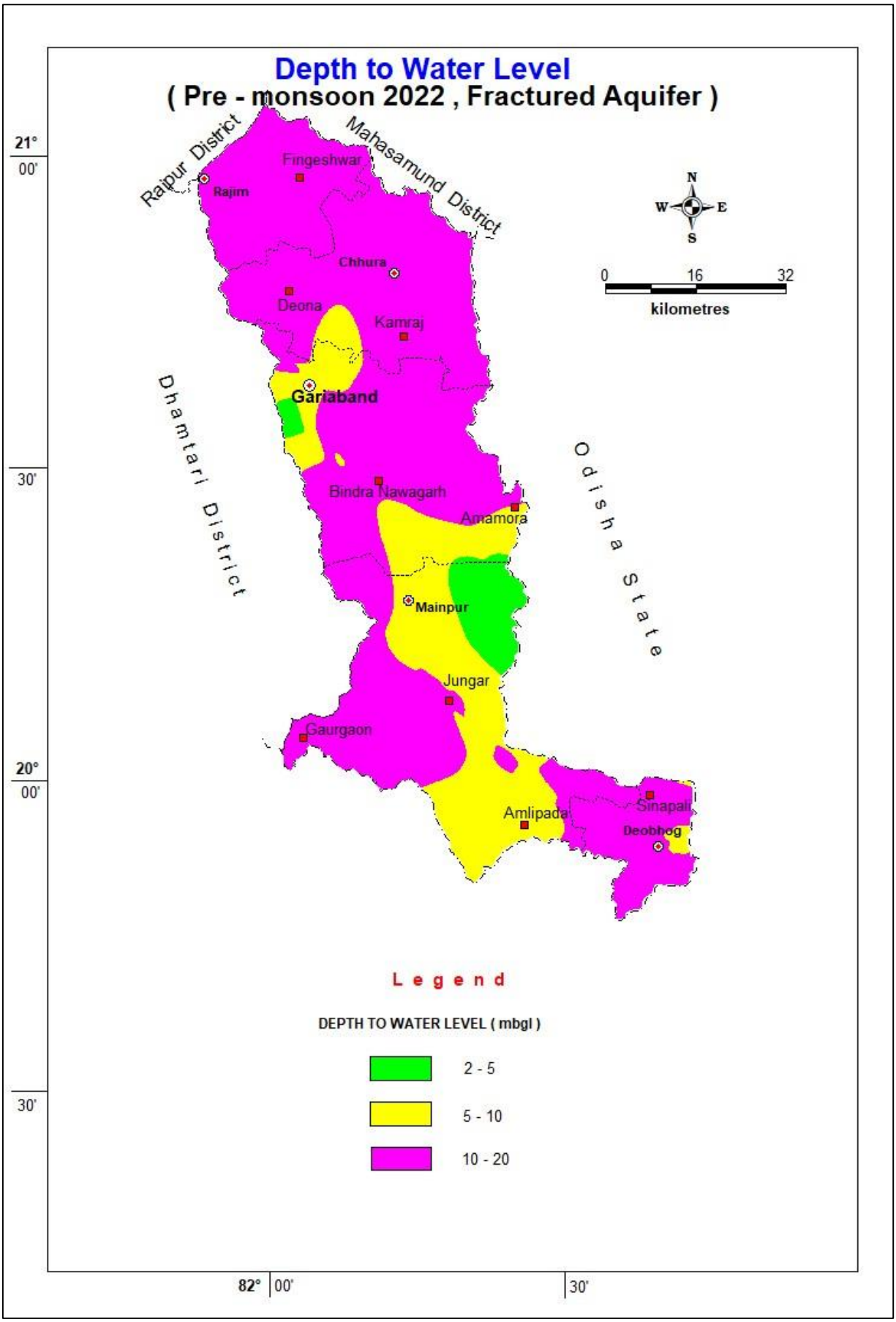

Fig 13: Pre-Monsoon Water Level Map of Gariyaband District for Fractured Aquifer

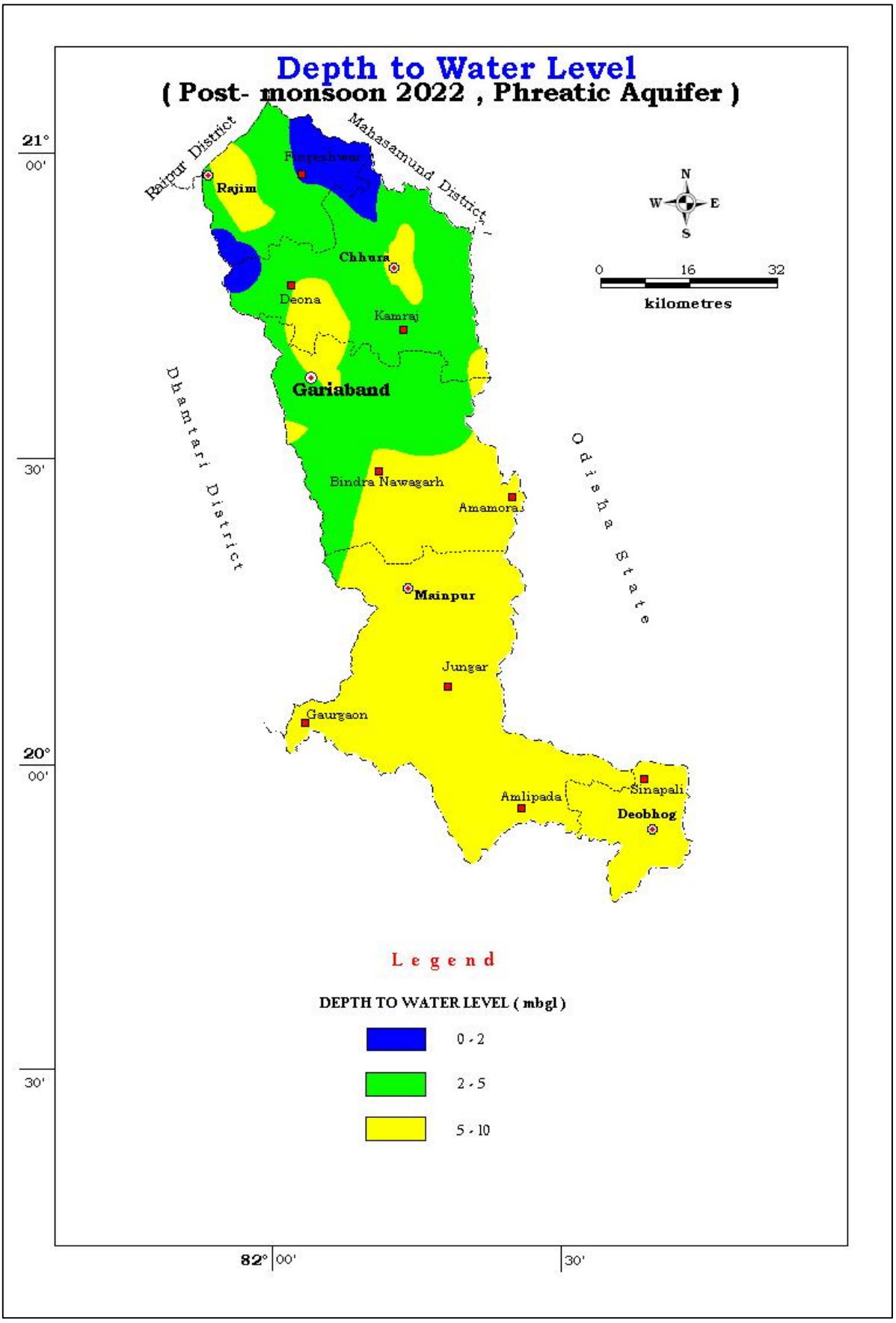

Fig 14: Post Monsoon Water Level Map of Gariyaband District for Phreatic Aquifer

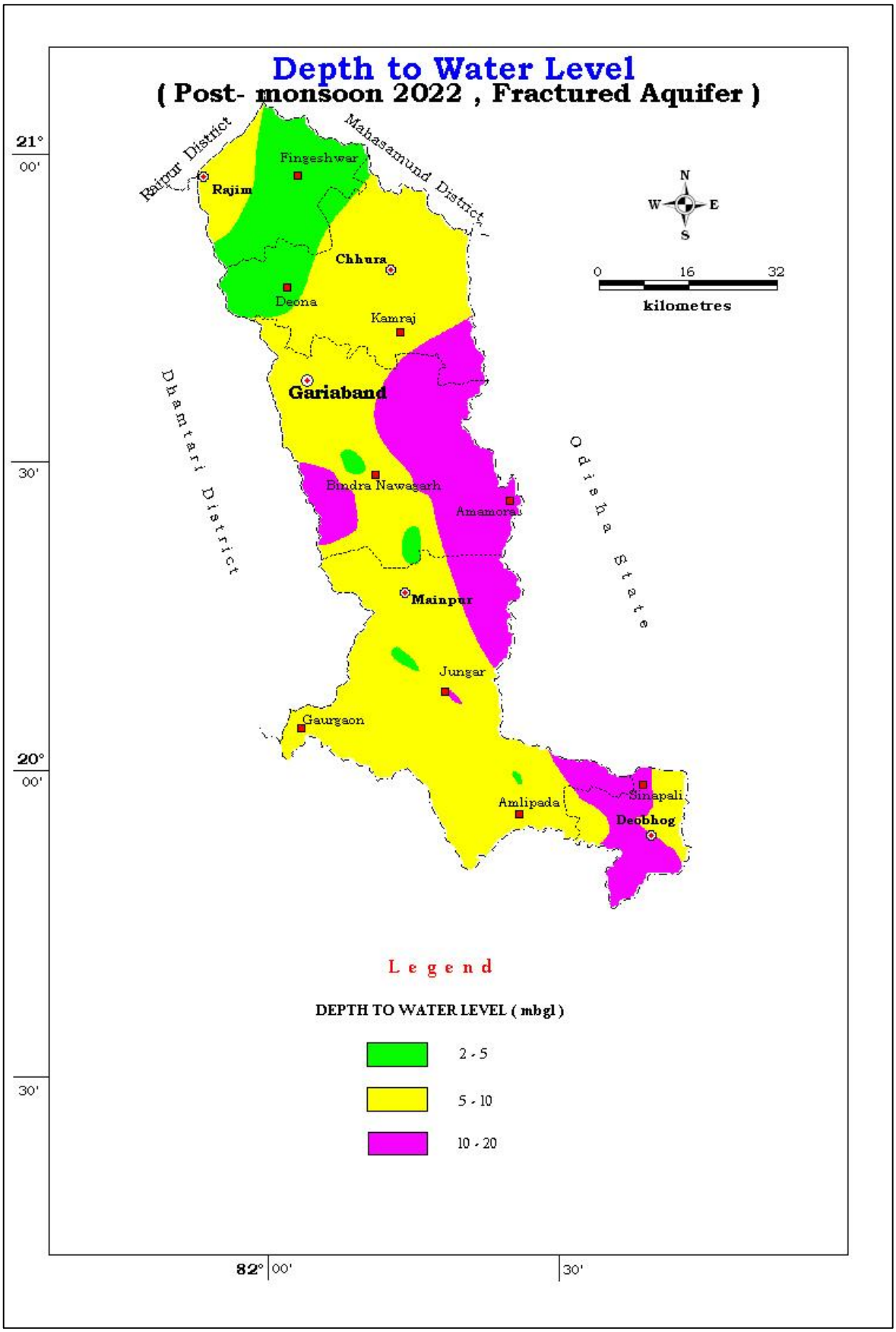

Fig 15: Post monsoon water level map for Gariyaband District Fractured Aquifer

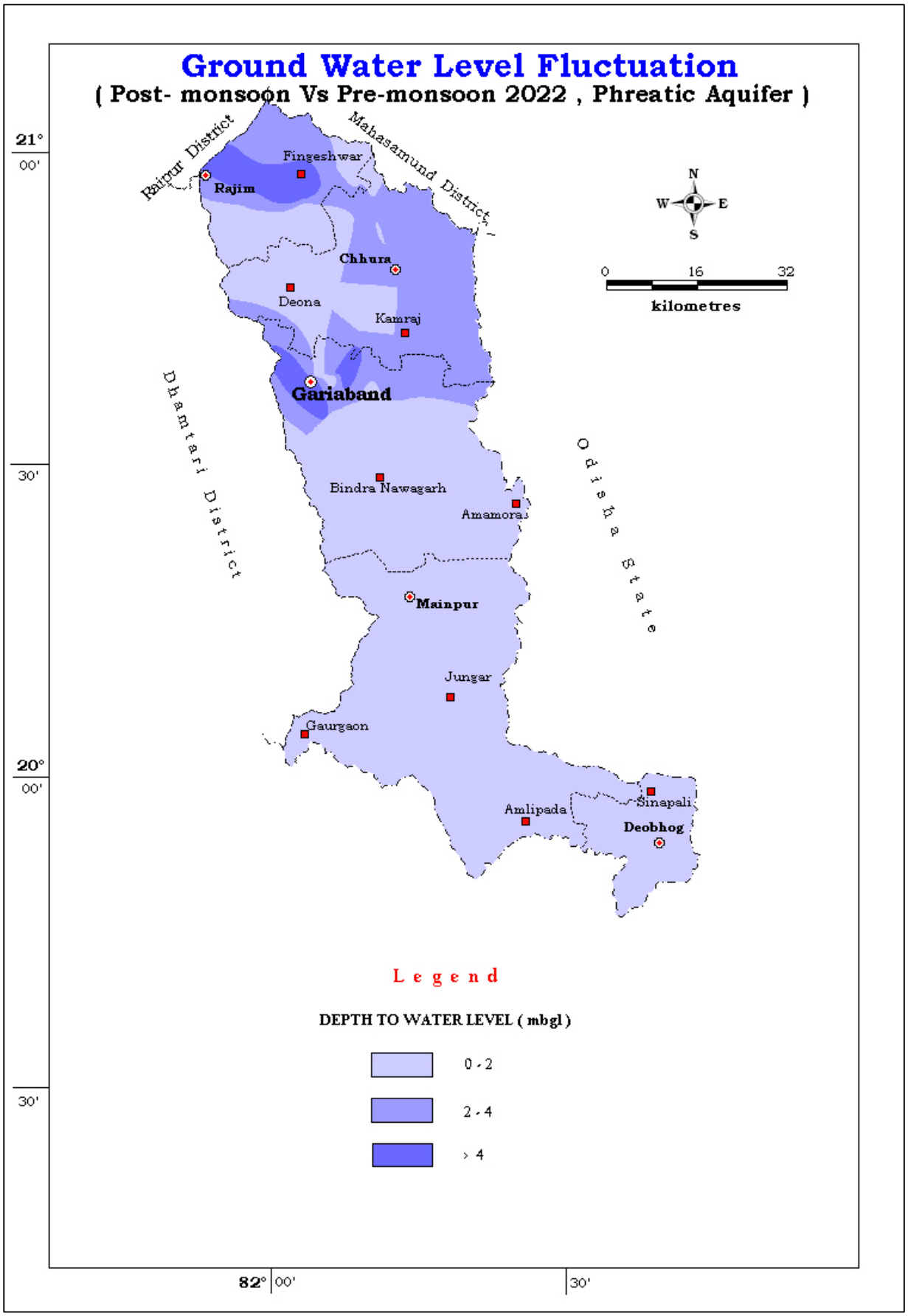

Fig 16: Ground Water Fluctuation Level Map of Gariyaband District for Phreatic Aquifer

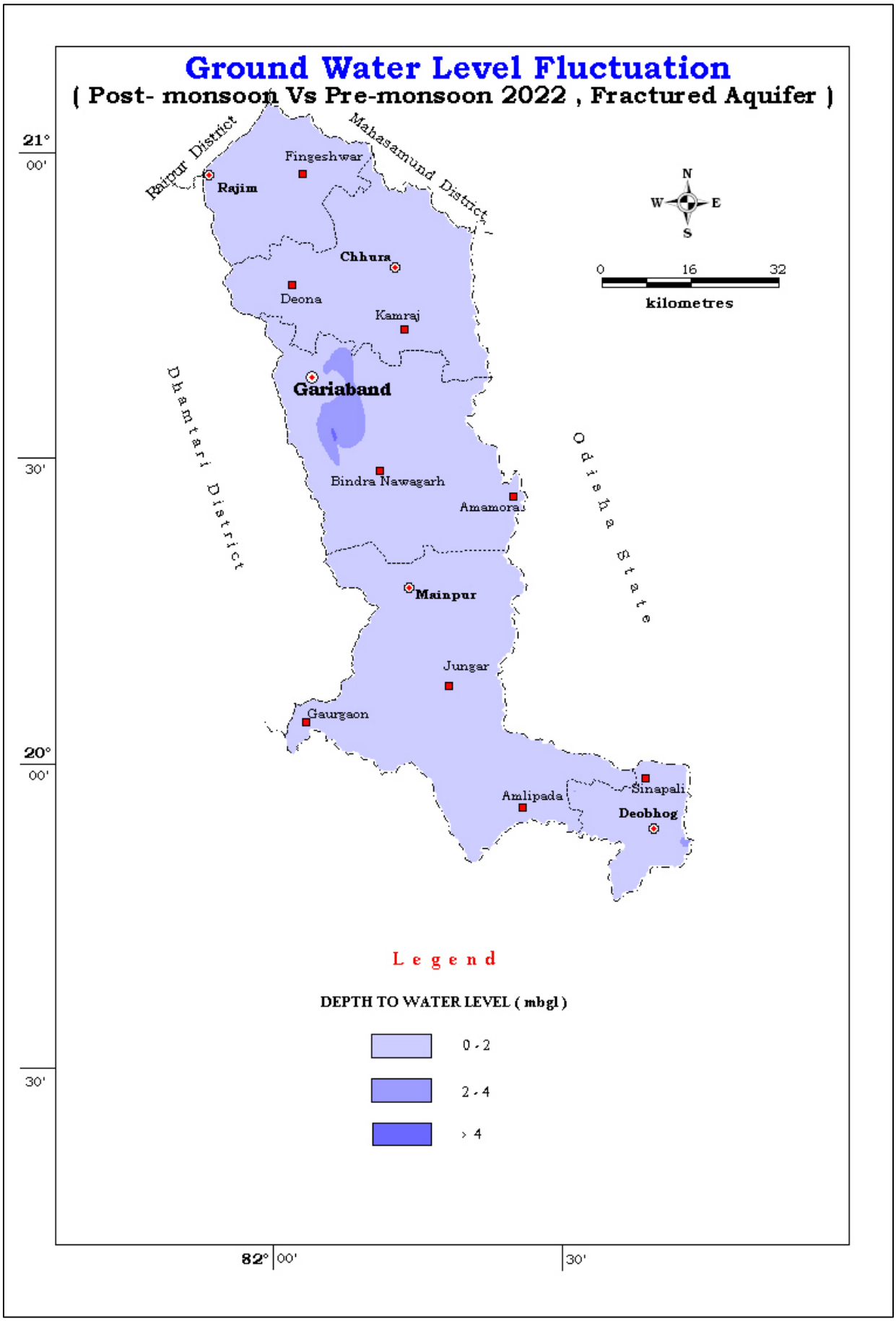

Fig 17: Ground Water Fluctuation Level Map of Gariyaband District for Fractured Aquifer

3. AQUIFER DISPOSITION

3.1 Aquifer Geometry and Characterization

Based on the exploratory drilling data generated for the blocks (Annexure 2), the existing aquifer systems in the area may be divided into two namely phreatic and deeper fractured aquifer. The major aquifers present in the study area is (1) Gondwana formation, (2) Basement Crystalline. Details are represented in **Table 10**.

Table 10: Aquifer Characteristics of Gariyaband District

CHARACTERISTICS	AQUIFER SYSTEM	
	Limestone	**Granite**
Major Geological Formation	Charmuria formation	Dongargarh Supergroup
Major Rock type	Limestone	Granite
Average Weathered Thickness (m)	18.65	19.60
Transmissivity (m^2/day)	1 to 403	1 to 103
Average Range of Transmissivity (m^2/day)	0 to 7	2 to 30
Average Drawdown (m)	18	20.5
Discharge	Negligible to 14 lps	14 lps
No. of Potential Zone	3 to 4 set: up to 50m 1 to 2 set: 50m to 100m (Most potential zone- 10 to 50m)	3 to 4 set: up to 50m 2 to 3 set: 50m to 100m (Most potential zone- 50 to 100m)

The alluvium deposits in the area are mainly confined all along with the flood plains on either side extending 2 km at places. These comprise mostly gravels, coarse to medium sand and silts. It attains a thickness of 10 to 20 m along Mahanadi and Pairi River.

Hard rock mainly consists of granite, gneiss and Charnockite -Khondalite rocks of Proterozoic age and limestone, shale, dolomite and sandstone belong to Chhattisgarh Supergroup of Proterozoic age. Ground water occurs in phreatic condition in the weathered mantle of these rocks, which extends up to a depth of 25 mbgl. The caverns formed in limestone and dolomites holds good amount of ground water which are limited mostly to around 80 meters. Limestone and dolomite form the main aquifer system in the area. Charmuria limestone and Gunderdehi shale are not very good yielding. The alluvium blanket along the major rivers also forms good repository of ground water.

There are 27 no. of permanent observation wells (National Hydrograph Network Stations); out of which 24 no's are dug wells and 3 no's are piezometers. These are established in the district to monitor the water levels four times a year and water quality once in a year. The pre-monsoon ground water level in the district varies from 1.75 to 23.1 mbgl and the post-monsoon water level varies from 0.55 to 16.4 mbgl. The water level trend (for 10 years) for pre-monsoon and post-monsoon period on an average does not show significant change.

Hard rock areas in the district have been proved to be potential aquifers. Underground water exploration programme 38 bore wells have been drilled in the district ranging in depth from 40 to 150 m. They have yielded up to 0.5 to 10 lps. These rocks belong to Dongargarh Supergroup. The average thickness of the weathered portion in the area is around 18 m. Generally, 1 to 2 sets of fractures are encountered within 60 m depth and 2 to 3 sets of fractures are encountered within 60 to 200 m depth. The potential zones are present from 60 to 100 m depth below ground level. In general, the discharge varies from negligible to 3 lps with an average yield of 10 lps. The development in these formations is mostly by way of dug wells. The transmissivity of the formation is around 0.07 -1 m2 per day with an average drawdown of 27 m. The thickness of fractured aquifer is around 0.2 m.

The aquifer parameters determined for various Formations based on preliminary yield test (PYT) results and aquifer performance test in the area shows that the weathered portion of granites has more transmissivity values than Chhattisgarh Group of rocks.

The limestone and shale of Charmuria and Gunderdehi Formations have very low transmissivity values varying between 1 and 2.5m^2/day. The yield of wells in granite complex ranges from negligible to 10 lps with the average value around 2 to 5 lps. The transmissivity value of granite and gneiss varies from 0.15 to 103m^2/day.

The lithological data collected from 25 CGWB Exploratory wells are compiled and fed into Rockworks Software format to prepare 3-Dimensional Stratigraphic model and 2-Dimensional section. The model and section is presented below in the **Fig 19, 23 and 24**. From the cross section and model it is found that the water bearing zones mostly lie in the weathered mantle of the bedrock.

3-D Stratigraphical Model

A 3- dimensional lithological model was prepared for the Gariyaband district after detail analysis of exploratory well log data from the Basic Data Reports of CGWB.

From the 3-D model it is evident that the major lithology of the district is granite. Broadly the lithological classification of the area is Sand, Soil, Weathered Formation, Chandrapur Sandstone and Granite from top to bottom respectively (Fig 18).

Fence Diagram

A fence diagram is also prepared for the district using Rockworks. The diagram is prepared in such a way that it covers maximum area taken up for the study. From the fence diagram it is evident that ground water mostly occurs in the top weathered zones and fracture system in granite(Fig 19).

2-D cross section

Two cross-sections have been one along the N-S direction and the other in the NW-SE directions. The section lines have been selected in such a way that it represents major lithologic variation and distribution in the district. Shallow aquifers mostly lie in the weathered zone while the deeper aquifers are found mostly in the fracture zones present in the granitic terrain (Fig 20, 21 & 22).

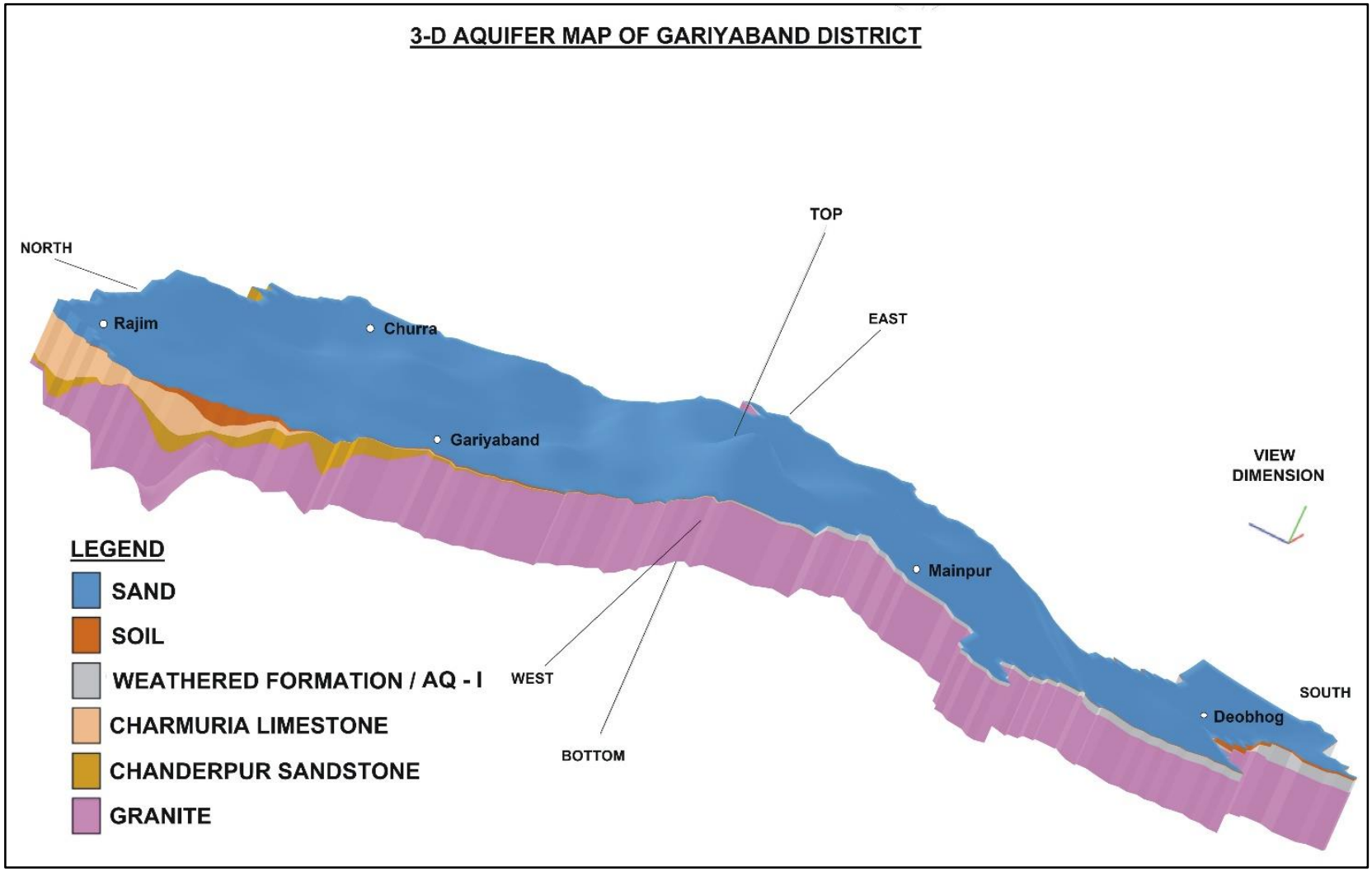

Fig 18: 3D Aquifer map of Gariyaband district

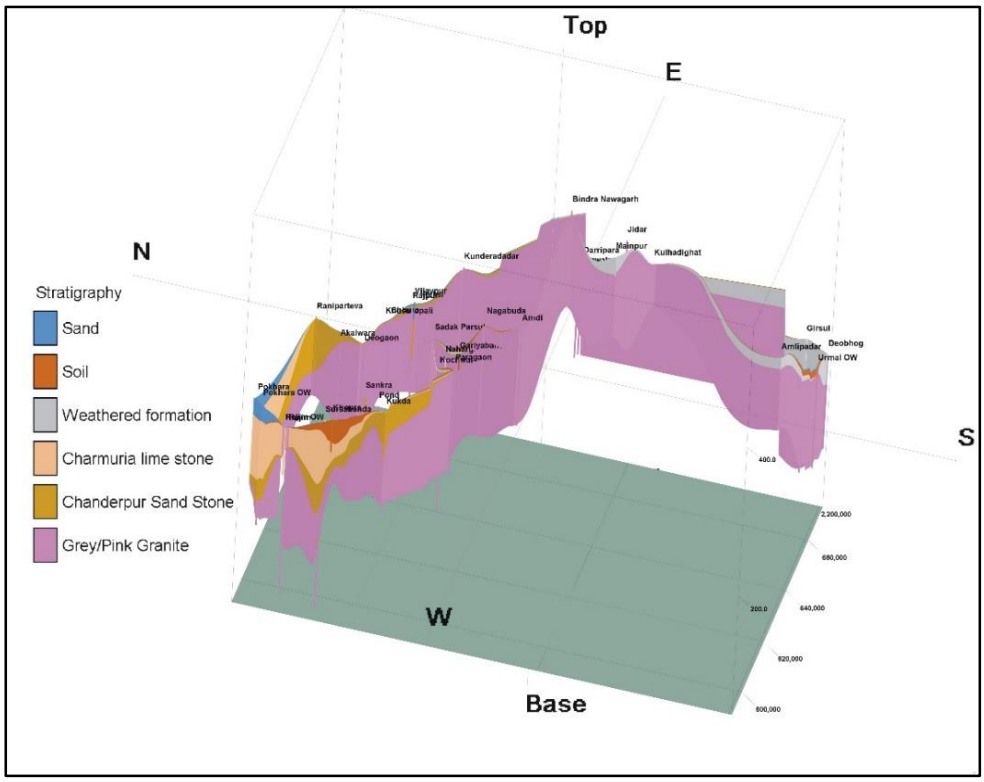

Fig 19: Fence diagram for Aquifer disposition

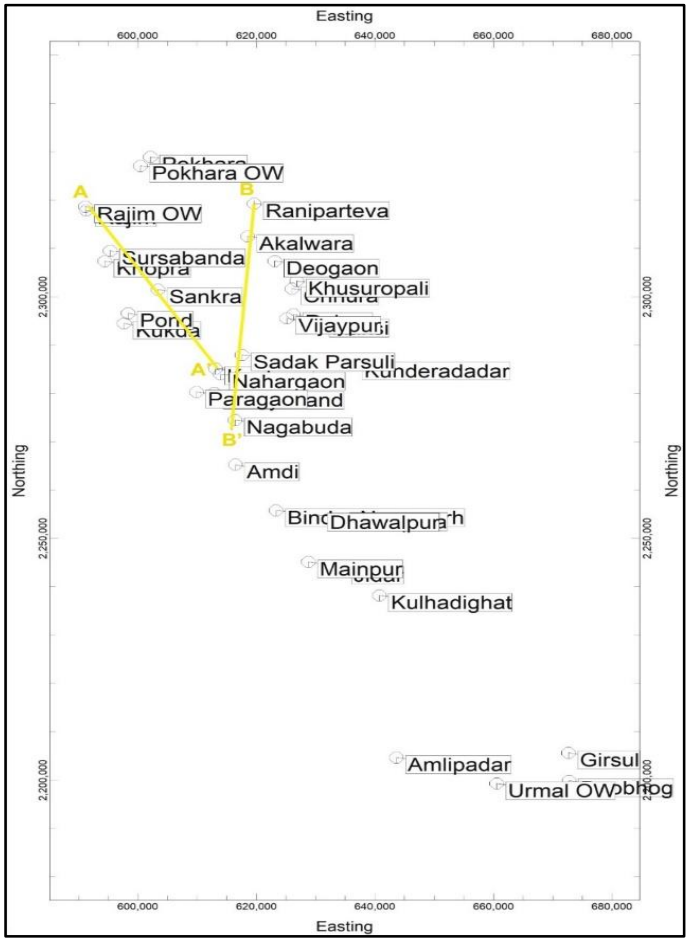

Fig 20: Map showing section line taken for the preparation of 2D section for the Gariyaband

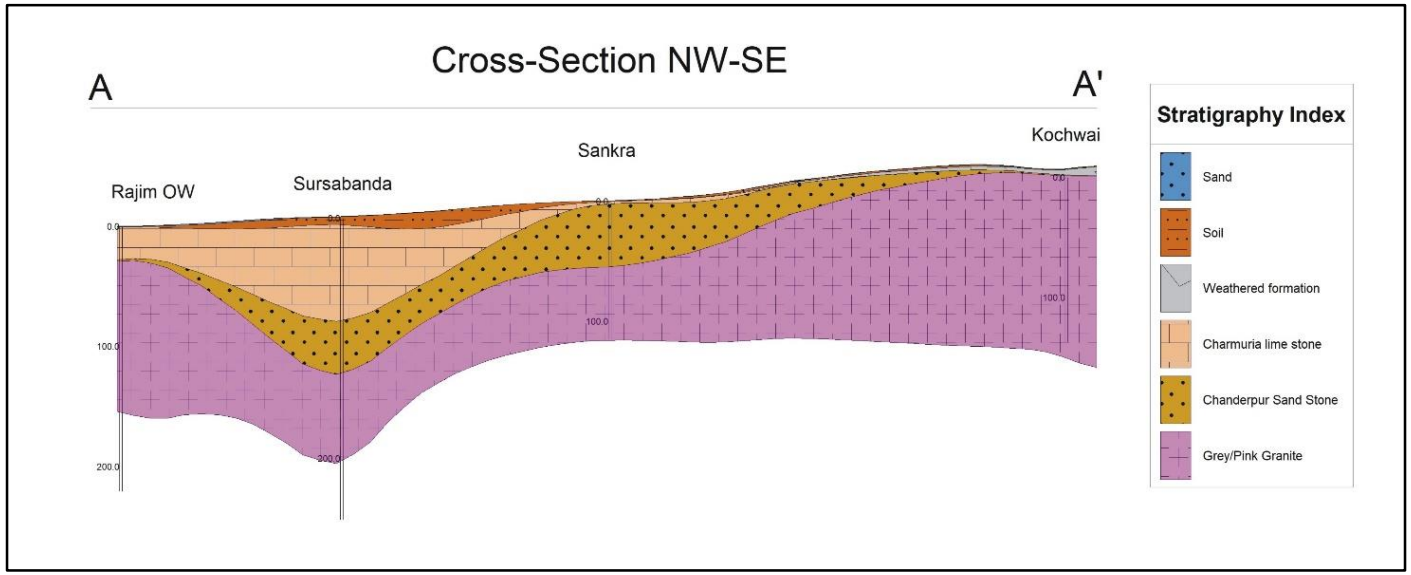

Fig 21: Section AA' for extending from Rajim OW to Kochwai

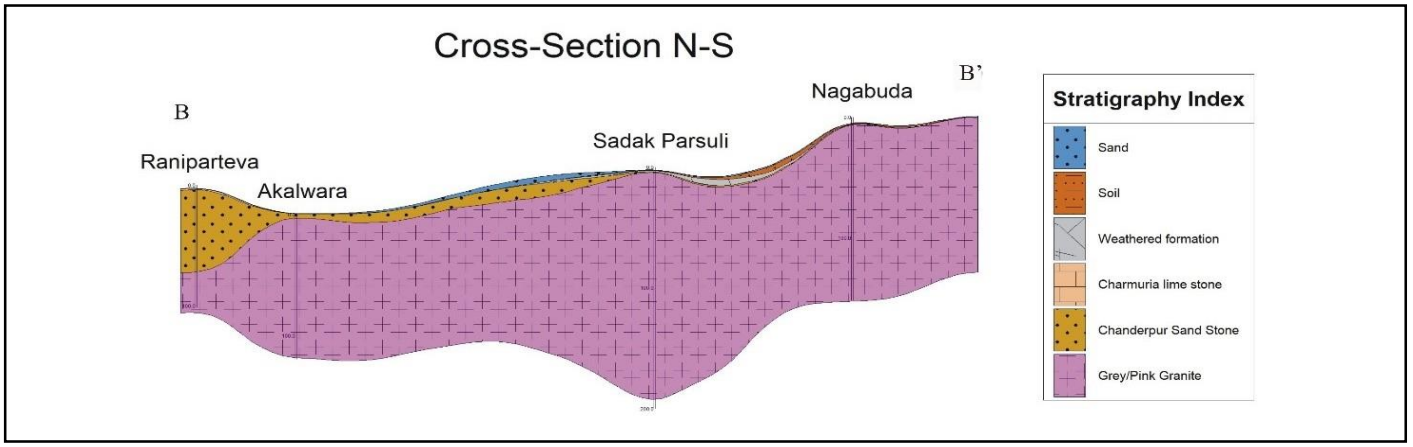

Fig 22: Section AA' for extending from Rajim OW to Kochwai

4. HYDROCHEMICAL ANALYSIS

Hydrochemical studies have been undertaken in the NAQUIM area of Gariyaband district to study the water quality of the area. To know the hydro chemical behavior of the ground water in the study area, 39 numbers of ground water samples were collected from the key wells during pre-monsoon period. The samples were analyzed for chemical data in the NCCR Raipur Chemical Laboratory. Various chemical parameters were calculated and listed in the Annexure III.

4.1 Major Ion Chemistry and Hydrogeochemical Facies of the study area

Piper (1953) and the modified Piper diagram by Chaddha (1999) are used to study the hydrochemical facies prevalent in the phreatic and confined aquifer system of Gariyaband district. The sample plotting falls in different fields of the Plot are as follows:-

i. Piper Trilinear diagram shows that 80% of the samples falls into Category IV and the water type is Na-Mg-HCO_3. Rest 20% falls into mixed type.
ii. Considering the cationic triangular plot 15% Mg type water 36.36% Ca type water and 48.48% belongs to no dominant type.
iii. In the anionic triangular plot majority of the water samples falls in the HCO3 type field while few fall in the No dominant field.
iv. Piper diagram by Chaddha (1999): The water samples chemical analysis data is also been plotted for the Chaddha to have a correlative study with the Piper Plot. From the Chaddha plot, the distribution patterns of the samples fall in the Ca-Mg-HCO_3 type field. Few of the samples shows dispersive trend towards Na-HCO_3 and Ca-Mg-Cl type field.

Inference: From the diamond shaped field it can be concluded that the 80% of the ground water samples falls in the fields of Magnesium bicarbonate type and rest 20% is of mixed type. It can be inferred that the dominant ground water type is Ca-Mg-HCO_3 type i.e. Recharge type of water.

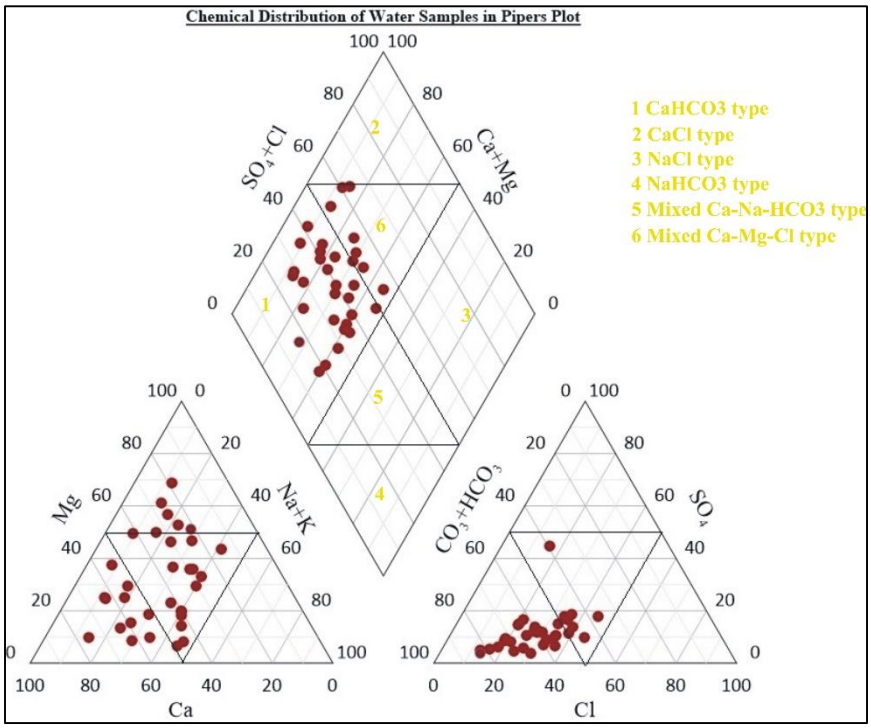

Fig 23: Piper plot for water samples collected during pre-monsoon field survey

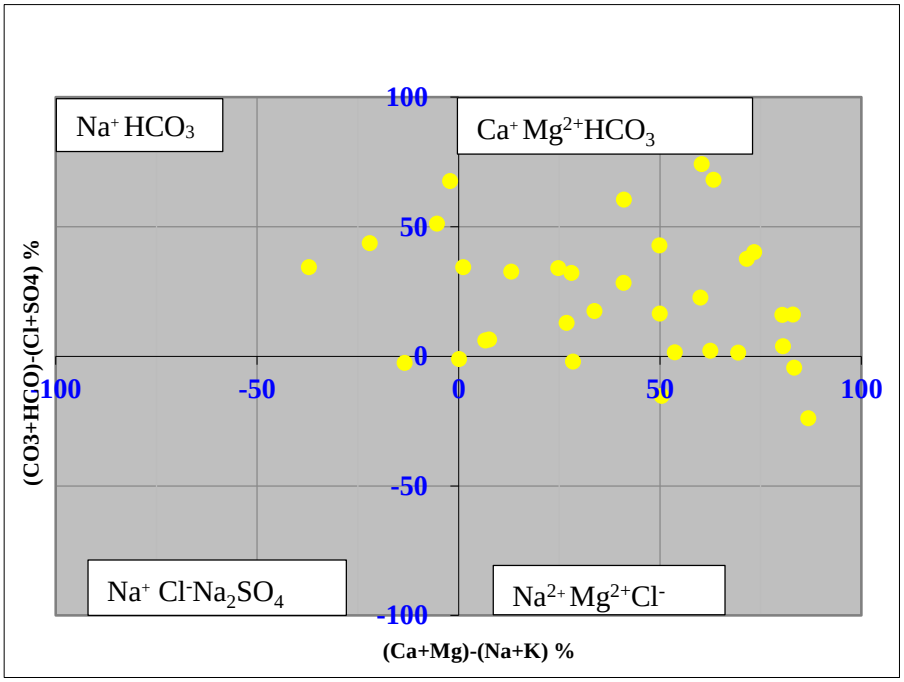

Fig 24: Modified Piper Diagram for ground water samples of Gariyaband District.

4.2 Suitability for Drinking Uses

Hydro chemical parameters of groundwater samples of the Study area were assessed with respect to prescribed limits of Bureau of Indian Standard (BIS, 2012) for drinking water. The details of the samples exceeding the prescribed limit are mentioned in the **Table 11.**

Table 11: Spatial Variation of Ionic Concentration in Study Area

Parameters	Maximum	Minimum	Average	Acceptable Limit	Permissible limit	No of wells above acceptable Limit	No of wells above permissible limit	% of Sample above acceptable Limit	% of Sample above permissible limit	Total No of Samples
pH	8.41	7.06	7.997	6.5	8.5	0	0	0	0	33
EC(µs/cm)	897	202	450.567	--	--	--	--	--	--	33
Cl(mg/l)	147	10.5	38.5	250	1000	0	0	0	0	33
SO4(mg/l)	459.95	4.82	22.357	200	400	0	0	0	0	33
CO3(mg/l)	--	--	--	--	--	--	--	--	--	33
HCO3(mg/l)	335.5	67.1	152.906	--	--	--	--	--	--	33
F(mg/l)	2.1	0.18	0.739	1	1.5	7	3	23.33	10	33
Total Hardness	380	55	151	200	600	0	0	0	0	33
Ca(mg/l)	88	18	33.93	75	200	2	0	6.66	0	33
Mg(mg/l)	44.4	2.4	15.88	30	100	0	0	0	0	33
Na(mg/l)	95.11	7.95	35.746	--	--	--	--	--	--	33
K(mg/l)	40.8	0.21	3.29	--	--	--	--	--	--	33
Si(mg/l)	25.3	5.67	12.23	--	--	--	--	--	--	33
PO4(mg/l)	0.1	0	0.003	--	--	--	--	--	--	33
NO3(mg/l)	70.86	0.3	17.464	--	45	--	--	--	--	33
U(mg/l)	--	--	--	--	--	--	--	--	--	33
TDS(ppm)	600.99	135.34	301.879	--	--	--	--	--	--	33

NOTE — It is recommended that the acceptable limit is to be implemented. Values in excess of those mentioned under 'acceptable' render the water not suitable, but still may be tolerated in the absence of an alternative source but up to the limits indicated under 'permissible limit', above which the sources will have to be rejected.

4.3 Suitability for Irrigation Use

In the present study the suitability of ground water for irrigation is assessed by considering the irrigation indexes like Electrical conductivity (EC), Soluble Sodium Percentage (SSP), Sodium Adsorption Ratio (SAR), Residual Sodium Carbonate (RSC), Magnesium Hazard (MH) and Permeability Index (PI) along with the US salinity assessment and the result has been summarized in the table below.

USSL diagram has been used to study the quality of groundwater suitability for irrigation purpose. The SAR and EC values of water samples of the study area were plotted in the graphical representation Fig: with most of the samples falling in the C2 zone and Sodium Absorption Ratio (SAR) of all the samples fall in the S1 zone. Two samples that fall in the C3 field indicate high salinity hazard. Overall, majority of the representative samples of water imply that salinity hazard in the area ranges within low to moderate category.

Table 12: Summarized result to assess the suitability of the groundwater for irrigation

Parameter	Range	Water Class	Irrigation Suitability Assessment for the study area	
			No of samples	Percentage of samples (%)
SAR	<10	Excellent	33	100
	10-18	Good	--	--
	18-26	Moderate	--	--
	>26	Unsuitable	--	--
SSP	<50	Good	29	87.87
	>50	Unsuitable	4	13
RSC	<1.25	Good	29	87.87
	1.25 -2.50	Moderate	4	13

	>2.50	Unsuitable	0	0
MH	<50	Good	25	75.75
	>50	Unsuitable	8	24.24
PI	>75	Good	11	33.33
	25-75	Moderate	22	66.66
	<25	Unsuitable	0	0

4.4 Major Findings in the Water Quality Assessment of the study area

i. From the Piper plot it is evident that majority of the ground water samples belongs to Ca-Mg-HCO_3 type i.e. Recharge type of water.
ii. Hardness of the samples shows maximum value of 380 while minimum of 55 and hence is less than the permissible limit. (as per BIS standard)
iii. Higher concentration of Fluoride values for 23.33% shows values above acceptable limit while 10% of the samples shows values above the permissible limit.
iv. Majority of the ground water samples are suitable for irrigation purpose as observed from the class range of SAR, SSP, RSC, MH and PI.
v. Overall chemical parameters like EC, Chloride, Total Hardness, alkanity, TDS range falls within the permissible limit and hence suitable for domestic purpose.

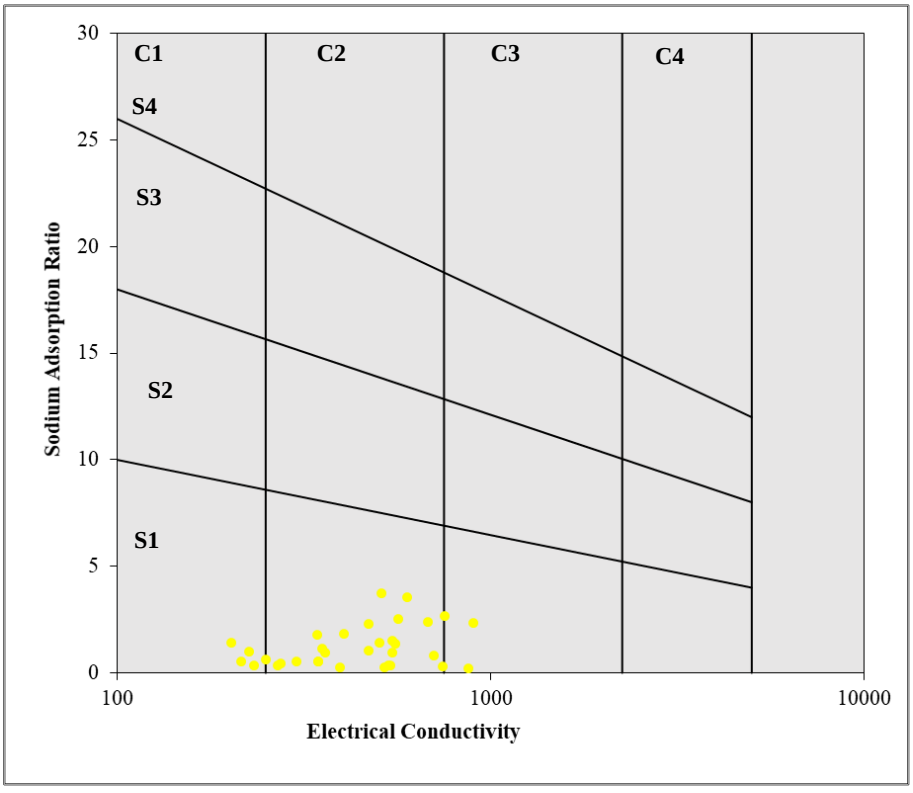

Fig 25: Suitability of water for irrigation use. Adapted from U.S. Salinity Laboratory Staff (1954). S1, S2, S3 and S4 are Low, Medium, High and Very High Sodium Hazards respectively.

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

5. GROUNDWATER RESOURCES

5.1 Ground Water Resource Availability and Extraction

The Gariyaband district is dominantly underlain by Granite with little variation. The dynamic ground water resources of the district have been estimated block wise as per GWRE 2022. The resource availability in Gariyaband up to 200m depth is given in the table below.

Table 13: Ground Water resources of Gariyaband district (Ham)

Sl. No	Block/District	Dynamic Resource Unconfined Aquifer (Ham)	Dynamic Ground Water Resource Confined Aquifer (Ham)	Total Resource (Ham)	Recharge Worthy Area(Ha)	Stage of Ground Water Extraction (%)	Categorization
1	Chhura	5218.49	248.90	39412.61	44880	68.54	Safe
2	Deobhog	2735.79	128.15	27136.06	30000	50.01	Safe
3	Gariaband	8339.74	392.79	71547.47	80280	61.65	Safe
4	Mainpur	4784.55	225.75	43439.7	48450	59.88	Safe
5	Rajim/ Fingeshwar	8744.38	417.61	50368.01	59530	83.70	Semi-Critical
	Total	29822.95	1413.20	231903.8	263140.00	67.97	

5.2 Existing and Future Water Demand (2025)

The existing demand for irrigation in the area 18582.668 Ham while for domestic use is 1666.412Ham. To meet the future demand for ground water, a total quantity of 9393.54 Ham of ground water is available.

Table 14: Ground water Existing and Future Water Demand (2025) Gariyaband district

Sl. No	Assessment Unit Name	Total Area of Assessment Unit (Ha)	Annual Extractable Ground Water Resource (Ham)	Current Annual Ground Water Extraction (Ham)				Annual GW Allocation for Domestic Use as on 2025 (Ham)	Net Ground Water Availability for future use (Ham)
				Ground Water Extraction for Irrigation Use (Ham)	Ground Water Extraction for Industrial Use (Ham)	Ground Water Extraction for Domestic Use (Ham)	Total Extraction (Ham)		
1	Chhura	111127	5218.49	3272.5		304.0549	3576.55	325.31	1620.68
2	Deobhog	39129	2735.79	1110.295	0.216	257.5462	1368.05	283.29	1393.85
3	Gariaband	154517	8339.74	4898.015	1.046	242.7243	5141.78	258.05	3182.63
4	Mainpur	217963	4784.55	2421.843	19.81113	423.2963	2864.94	544.4	1798.51
5	Rajim	59530	8744.38	6880.015	0	438.7906	7318.8	466.5	1397.87
	Total	**582266**	**29822.95**	**18582.668**	**21.07313**	**1666.412**	**20270.12**	**1877.55**	**9393.54**

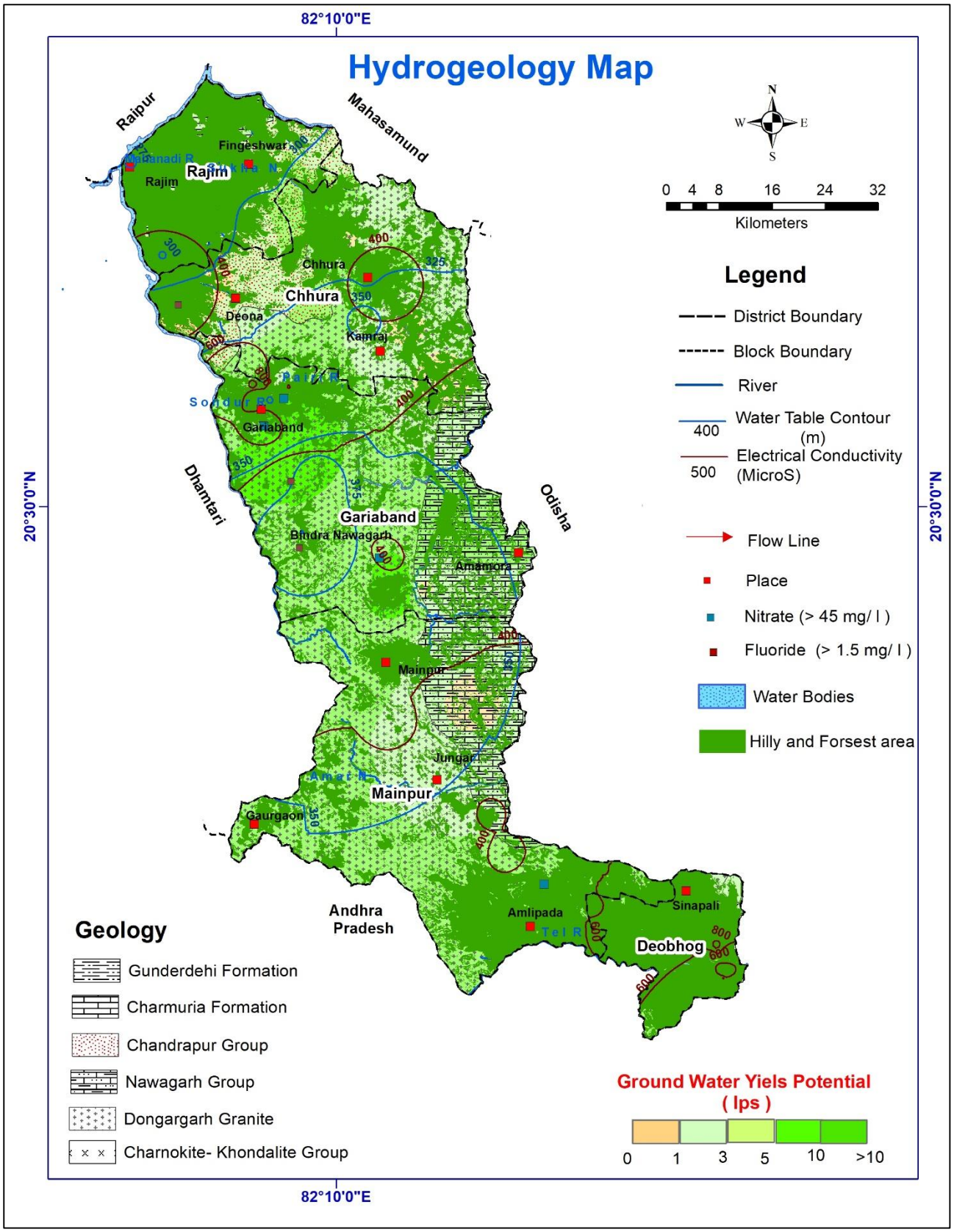

Fig 26: Hydrogeological Map of Gariyaband district

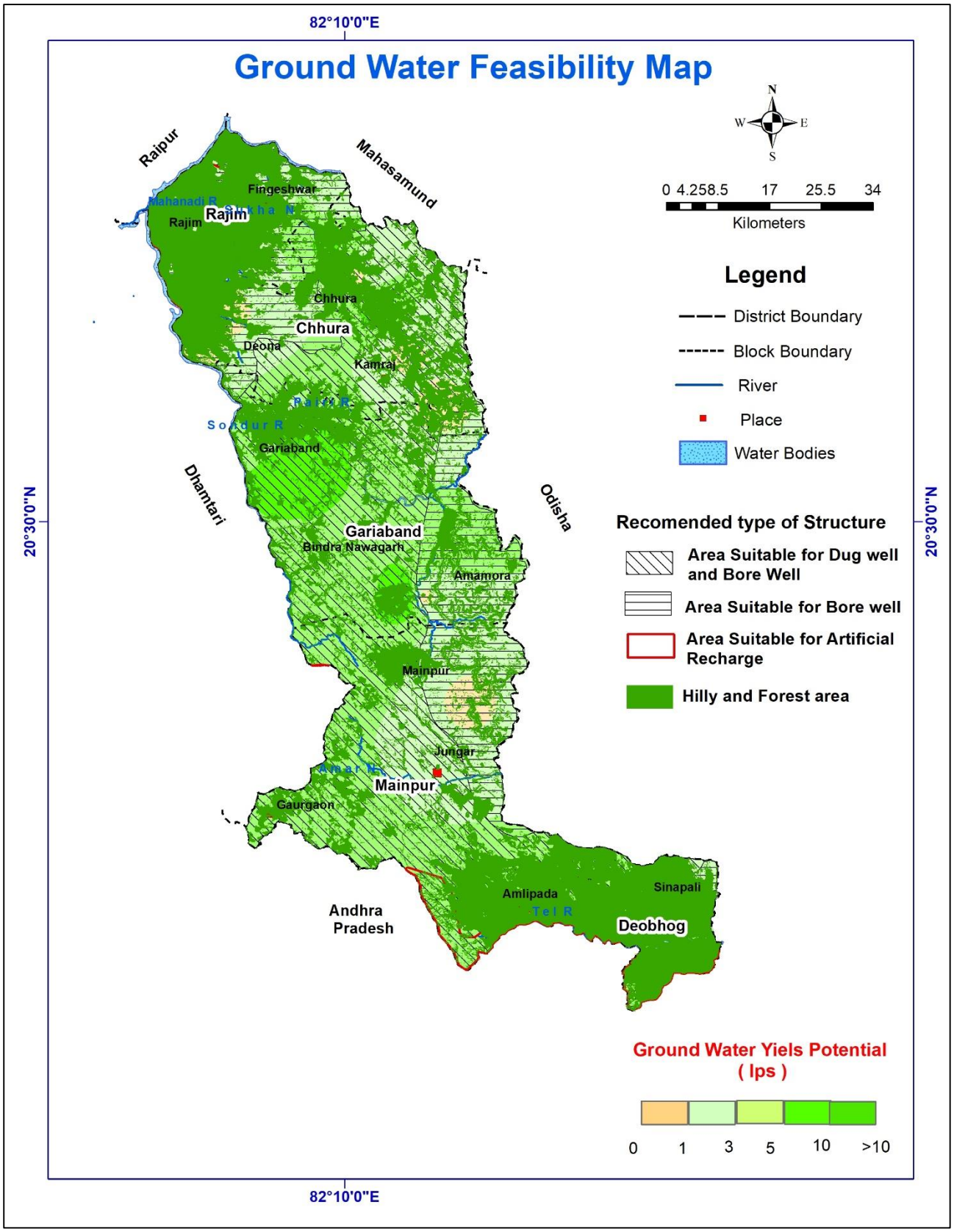

Fig 27: Ground Water Feasility Map for the Gariyaband district

6. Ground Water Related Issues

- **Drying up of Dug wells and hand pumps during summer:** In the summer period, the water level in the dug wells in most villages falls down. There are also cases of handpumps that stop yielding water.
- **Inherent hydrogeological character of aquifer-** The water in the Granitic aquifers mostly encountered in fracture or fracture system with sufficient aperature. There are many cases of failed bores in the area. Proper scientific method of investigation and geophysical exploration can be very useful to delineate potential zones.
- **Fluoride Contamination:** High values of Fluoride contamination is reported from several villages in the district. Most affected villages are Urtuli, Darripara and Pond.
- **Nitrate Contamination:** Nitrate contamination were also
- **Health Hazard in Supabeda:** Supabeda and some villages in the vicinity of Deobhog diamond mine near Odhisha border have been reporting kidney relate ailments since the last decade. Deaths due to chronic kidney disease have been increasing at an alarming rate. The local people points to poor groundwater quality and local mining activities to be the main factors for CKD. As per a study conducted at Supabeda by CGWB, high nitrate, fluoride, iron, magnesium, harness and uranium values are observed at many places in the groundwater samples and hence not suitable for drinking purpose.

7. Social Issues

- In remote areas of Gariaband, people are deprive of basic education, medical and development programmes.
- Literacy rates in such areas is quite low. The people in these areas are not awared of depleting ground water resources and how community participation at the ground level can help to address the crisis.
- People fall trap of traditional psuedoscience techniques like water witching.
- Women carrying heavy loads of water in water deficit areas to meet their basic needs is time consuming and detoriates mental as well as physical well being.
- Most of the people residing in such areas are poverty-stricken. So proper access to clean drinking water and insufficient sanitation affects for making a living.

8. Management Strategy

- Agriculture is the prime source of livlihood of the people residing in rural areas. The demand for groundwater is increasing for irrigation purposes created a prolonged stress on ground water resources. Water savings can be achieved through smart irrigation techniques which will maximize irrigation efficiency by reducing wastage of water that will maintain plant health and quality.
- Desilting and renovation of existing tanks and talabs should be carried out from time to time for increasing the working life of the structure and reducing stress on ground water resources.
- Awareness is the first and foremost domain to be worked on. Proper orientation to people residing in rural areas and to encourage them to come forward for community participation in saving water. IEC activities should be taken up in periodic basis to sensitize people on issues of decling ground water level.

- **Management Strategy for Supabeda Health Crisis:**The following are the themes that proper scientfic study that should be taken up in Supebeda and surrounding villages.

1. Majority of the social community practice agriculture as the main occupation and exposed to chemical pesticides.
2. Lack of proper medical facilities and as such delay in seeking medical treatment and delayed diagnosis.
3. Social practices excessive intake of tobacco is also detrimental to adverse health impacts.
4. Proper scientific study on sampling of soil and water needs to be undertaken for better understanding the root cause of CKD.
5. Maintainance and monitoring of various filtration plant installed at various Kendras in the affected area.
6. Construction of artificial recharge structures to conserve and store rain water for household use is encouraged.

- Recommendation as per study conducted by CGWB in the year 2022 at Supabeda are as follows:-

1. Proper demarcation of areas affected by kidney diseases and detailed investigations is encouraged.
2. Water of Tel river should be used for drinking purpose untill proper soulution to kidney diseases are found.
3. Regular monitoring of chemical quality of ground water.
4. Ground water studies with 3D demarcation of hydrogeology and prediction of spatial and temporal variations of ground water quality in the future.
5. Proper managed aquifer recharge structures should be selected at suitable locations to dilute the concentrations of the chemical parameters.

Table 15: Types of Artificial Recharge Structure feasible

Block/ District	**Area Feasible for recharge(sq km)**	**Volume of sub Surface Potential for Artificial recharge(MCM)**	**Types of Structures Feasible and their Numbers**			
			Percolation Tank	**Nalas Bunding/ Cement plug/ Check dam**	**Gravity head/ Dug well/ Tube Well/ Recharge Shaft**	**Gully plugs/ Gabion Structures**
Recharge Capacity-(MCM)/Structure			**0.2MCM**	**0.03MCM**	**0.008MCM**	**0.007MCM**
Chhura	1.54	2	0	0	1	19
Deobhog	93.27	140	9	31	70	53
Gariaband	15.00	23	1	4	9	7
Mainpur	106.98	160	6	21	48	37
Rajim	231.60	409	25	82	184	140
Total	**448.39**	**734**	**41**	**138**	**312**	**256**

Table 16: Potential of Additional Ground water Abstraction structure creation

Block	Annual Extractable Ground Water Resource (Ham)	Stage of ground water Development (%)	Present ground water draft (Ham)	Ground water draft at 60% stage of development (Ham)	Surplus ground water at present Stage of Development (Ham)	Number of TW Recommended in each block (Assuming unit draft as 1.6 ham/structure/year)	Number of DW Recommended in each block (Assuming unit draft as 0.72 ham/structure/year)
Chhura	5218.49	68.54	3576.55	3131.09	--	--	--
Deobhog	2735.79	50.01	1368.05	1641.47	273.42	103	152
Gariaband	8339.74	61.65	5141.78	5003.84	--	--	--
Mainpur	4784.55	59.88	2864.94	2870.73	--	--	--
Rajim/Fingeshwar	8744.38	83.70	7318.80	5246.63	--	--	--
Total (district)	**29822.95**	**323.77**	**20270.12**	**17893.77**	**--**	**--**	**--**

Table 17: Detail of groundwater saved through change in cropping pattern and other interventions.

Block	Existing Gross Ground Water Draft for Irrigation in Ham	Additional Saving of GW after using Micro Irrigation methods in Ham(Assuming 30 % saving)	Development by new GW abstraction structure	Additional GW irrigation Potential created in Ham	Additional Irrigation potential creation for Maize/ wheat in winter season in Ha (Assuming 500 mm water requirement)	Percent increase in Crop area compare to Gross cropped area	Gross Cropped area
Chhura	3272.5	981.75	--	981.75	1963.50	6.36%	30887
Deobhog	1110.295	333.09	273.42	606.51	1213.02	4.92%	24660
Gariyaband	4898.015	1469.40	--	1469.40	2938.81	12.65%	23232
Mainpur	2421.843	726.55	--	726.55	1453.11	4.48%	32454
Rajim	6880.015	2064.00	--	2064.00	4128.01	8.73%	47293
Total (District)	**18582.67**	**5574.80**	**273.42**	**5848.22**	**11696.44**	**7.38%**	**158526.00**

9. 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 district**.** By making the interventions it is evident that by switching to micro irrigation methods there can be significant increase in the percentage cropped area as compared to gross cropped area with maximum of 12.65 % for Gariyaband block (**Table 16 & 17**).

Annexure I

Sl. No.	District	Block	Location	Latitude	Longitude	Well Type	Pre monsoon	Post Monsoon DTW	Fluctuation
1	Gariyaband	Gariyaband	Behrabuda	20.665	82.053	HP	9.2	9.568	-0.368
2	Gariyaband	Gariyaband	Kochwai	20.6627	82.1015	HP	9.47	7.44	2.03
3	Gariyaband	Gariyaband	Dongrigaon	20.6093	82.0686	HP	9.25	8.25	1
4	Gariyaband	Gariyaband	urtuli	20.5344	82.1053	HP	12.37	7.89	4.48
5	Gariyaband	Gariyaband	Kerabahara	20.5177	82.1129	HP	9.24	8.75	0.49
7	Gariyaband	Gariyaband	Amda	20.484	82.1192	HP	12.23	11.1	1.13
9	Gariyaband	Gariyaband	Darripara	20.4433	82.1168	HP	13.67	12.56	1.11
10	Gariyaband	Gariyaband	Sikasar	20.517	82.3102	HP	17.33	16.79	0.54
11	Gariyaband	Gariyaband	Kamepur	20.4205	82.2121	HP	8.74	7.25	1.49
12	Gariyaband	Gariyaband	Bhaisamunda	20.4301	82.2259	HP	9.8	8.15	1.65
14	Gariyaband	Gariyaband	Nahargaon	20.6468	82.0956	HP	9.87	7.65	2.22
15	Gariyaband	Gariyaband	Bhilai	20.6533	82.0555	HP	10.06	9.45	0.61
17	Gariyaband	Mainpur	Kodomali	20.1923	82.2471	HP	9.6	8.46	1.14
18	Gariyaband	Mainpur	Jugad	20.1448	82.2782	HP	12.45	10.68	1.77
19	Gariyaband	Mainpur	Udanti	20.1139	82.3195	HP	12.34	11.74	0.6
20	Gariyaband	Mainpur	Koyba	20.0905	82.3366	HP	8.94	7.79	1.15
21	Gariyaband	Mainpur	Dhurvagadi	20.0839	82.3705	HP	12.06	10.74	1.32
22	Gariyaband	Mainpur	Budgoltappa	20.0271	82.4001	HP	10.45	10.2	0.25
23	Gariyaband	Mainpur	Sirahlati	19.9857	82.4497	HP	8.93	7.46	1.47
24	Gariyaband	Mainpur	Chichiya	19.952	82.5398	HP	12.05	11.69	0.36
25	Gariyaband	Deobhog	Mudagaon	19.9337	82.6203	HP	14.56	12.66	1.9

Sl. No.	District	Block	Location	Latitude	Longitude	Well Type	Pre monsoon	Post Monsoon DTW	Fluctuation
26	Gariyaband	Deobhog	Khutgaon	19.8925	82.6971	HP	9.45	8.22	1.23
27	Gariyaband	Deobhog	Supabeda	19.8586	82.6953	HP	14.02	13.73	0.29
28	Gariyaband	Deobhog	Selmuda	19.8699	82.7087	HP	10.67	8.49	2.18
29	Gariyaband	Deobhog	Kachariya	19.8902	82.6768	HP	8.98	8.21	0.77
30	Gariyaband	Deobhog	Gohekala	19.9028	82.6836	HP	9.34	8.17	1.17
31	Gariyaband	Deobhog	Fokatpara	19.8964	82.6695	HP	12.45	10.64	1.81
32	Gariyaband	Deobhog	Bahrabali	19.9548	82.5239	HP	11.23	9.28	1.95
33	Gariyaband	Deobhog	Kodobahar	20.6702	82.03	HP	10.89	9.54	1.35
34	Gariyaband	Chhura	Chhura	20.795	82.22222	PZ	9.16	8.45	0.71
35	Gariyaband	Chhura	Pond	20.77417	81.95167	PZ	4.73	3.78	0.95
36	Gariyaband	Deobhog	Deobhog	19.90833	82.65806	PZ	7.82	6.89	0.93
37	Gariyaband	Gariyaband	Dhawalpur	20.36944	82.25278	PZ	5.2	4.76	0.44
38	Gariyaband	Gariyaband	Gariaband	20.61528	82.08917	PZ	6.32	5.33	0.99
39	Gariyaband	Gariyaband	Bindranawagarh	20.46944	82.20611	PZ	9.87	8.34	1.53
40	Gariyaband	Gariyaband	Joba	20.49722	82.1375	PZ	4.12	3.41	0.71
41	Gariyaband	Mainpur	Dhurwagudi	19.99222	82.42917	PZ	5.17	4.88	0.29
42	Gariyaband	Mainpur	Indagaon	20.075	82.37083	PZ	7.2	6.57	0.63
43	Gariyaband	Mainpur	Jheriabahra	20.22722	82.19444	PZ	7.52	6.37	1.15
44	Gariyaband	Mainpur	Mainpur	20.27056	82.25083	PZ	7.98	7.45	0.53
45	Gariyaband	Mainpur	Taurenga	20.16861	82.25361	PZ	4.48	3.76	0.72
46	Gariyaband	Fingeshwar	Fingeshwar	20.96667	82.03333	PZ	4.58	4.29	0.29
47	Gariyaband	Fingeshwar	Rajim	20.95833	81.88333	PZ	9.12	7.44	1.68

Sl. No.	District	Block	Location	Latitude	Longitude	Well Type	DTW	Post Monsoon	Fluctuation
1	Gariyaband	Gariyaband	Daspur	82.1401	20.5439	DW	4.9	3.25	1.65
2	Gariyaband	Gariyaband	Andora	82.1197	20.4652	DW	6.9	5.72	1.18
3	Gariyaband	Gariyaband	Jithidumar	82.1033	20.6374	DW	9.7	8.64	1.06
4	Gariyaband	Gariyaband	Kokdi	82.0762	20.6443	DW	12	10.34	1.66
5	Gariyaband	Chhura	Sorid	82.2081	20.8108	DW	10.5	7	3.5
6	Gariyaband	Fingeswar	Kirwai	81.8774	20.9595	DW	7.1	4.7	2.4
7	Gariyaband	Chhura	Amethi	82.0499	20.9361	DW	10.5	2.05	8.45
9	Gariyaband	Rajim	Mudagaon	82.1704	20.8989	DW	4.16	1.82	2.34
10	Gariyaband	Chhura	Pond	81.7201	20.7987	DW	3.92	2.82	1.1
11	Gariyaband	Fingeswar	Sarkada	82.0594	20.9143	DW	4.7	3	1.7
14	Gariyaband	Rajim	Devri	81.9558	20.8828	DW	7.49	6.74	0.75
15	Gariyaband	Chhura	Gariaband	82.0667	20.625	DW	10.5	3.6	6.9
16	Gariyaband	Rajim	Kanekera	82.0792	21.0417	DW	2.97	1.1	1.87
17	Gariyaband	Chhura	Kaseru	82.1233	20.6486	DW	10.5	3.62	6.88
18	Gariyaband	Rajim	Kashi Bahara	82.1867	20.8638	DW	4.55	2.5	2.05
19	Gariyaband	Chhura	Kharkhara	82.2033	20.7558	DW	5.82	2.85	2.97
20	Gariyaband	Rajim	Kopra	81.9302	20.8427	DW	1.85	1	0.85
23	Gariyaband	Rajim	Parsada Khurd	82.1758	20.8664	DW	5.14	2.6	2.54
24	Gariyaband	Rajim	Rajim	81.8833	20.9667	DW	13.27	6.75	6.52

Annexure II

S. No	District	Block	Location	Latitude	Longitude	Depth (m)	Casing	Formation	Zone encountered	SWL	Discharge (lps)	Drawdown (m)	Transmissivity (m2/day)	Storativity	Stratigraphy	Lithology
1	Gariyaband	Rajim	Pokhara	21.0417	81.9667	104.5	23.45	0.0-23.00 Sand/Alluvium 23-103 Charmuria Fm 103.104.5 Chanderpur Fm	2.3-25 and 103.5	3.25	14	13.5	461	2.24 x 10-4	Charmuria	Limestone
2	Gariyaband	Gariyaband	Gariyaband	20.6167	82.0833	43.45	17.15	0.0-2.3 Soil23.17.0 Weathered granite17.0-43.45 Fractured granite	17-18,19.5-20,21.2-22,23.-23.324-24.4,31-33	8.025	14	6	103.04		Bastar Gneiss	Gneissic Complex
3	Gariyaband	Deobhog	Urmal	19.8833	82.5333	132	11.8	0-2.5 Soil2.5-11.5 Weathered &Fractured Granite11.5-132.0 GraniteTonalite, Granite	12.3 and 15.9-21.9	4.75	1.5	28.87	2.62		Bastar Gneiss	Gneissic Complex
4	Gariyaband	Deobhog	Urmal OW	19.8833	82.5333	49	21.9	Weathered granite	15.9-21.9	6.87	7	13	57.6		Bastar Gneiss	Gneissic Complex
5	Gariyaband	Deobhog	Deobhog	19.8875	82.65	125	14.7	0-40 Weathered Granite 40-125 Massive	14.7-18.8,34.0-37.1,40.5-	5.95	6	23	27.07		Charnockite	Charnockite
6	Gariyaband	Chhura	Deogaon	20.8625	82.1833	141	9.5	0-141 Granite (Archean)	14-14.10,16.5-17.00,18.0-18.20	6.88	0.5				Bastar Gneiss	Gneissic Complex
7	Gariyaband	Deobhog	Girsul	19.9397	82.6497	177	11.3	0-10.7 Weathered ganite 40-125 Massive	6.7-10.7,40	3.73	0.8				Charnockite	Charnockite
8	Gariyaband	Mainpur	Mainpur	20.3	82.2333	103	25.4	0-24.9 Weathered granite24.9-103.0 Granite	20.5-22,24.3-25.4,101.1-103	15	4.5	18			Bastar Gneiss	Gneissic Complex
9	Gariyaband	Mainpur	Amlipadar	19.9333	82.3722	96	14.7	0- 14.7 Weathered Gr 14.7- 96.0 M Granite	13.6-14.70, 17.70						Bastar Gneiss	Gneissic Complex
10	Gariyaband	Rajim	Sursabanda	20.8833	81.9167	251	11.72	0-107Charmuria Fm107-	14-16, 223	8.36	1	30	7.62		Charmuria	Limestone

11	Gariyaband	Rajim	Rajim	20.9661	81.8767	220.84	11.3	Charmuria formation	12--14,40	5.2	1				Charmuria	Limestone
12	Gariyaband	Rajim	Rajim OW	20.9661	81.8767	61.24	11.3	Charmuria formation limestone &	12--14,40	7	1				Charmuria	Limestone
13	Gariyaband	Gariaband	Darripara	20.3878	82.2858	123.58	18.74	Archean Grey granite	25-35,40	-	0.3	-			Nawagarh	Sandstone/Conglomerate
14	Gariyaband	Gariaband	Kochwai	20.6619	82.0858	137.12	23.12	Archean Pink granite	30-35, 65, 77	5.72	1.65	25.41			Bastar Gneiss	Gneissic Complex
15	Gariyaband	Gariaband	Bindra Nawagarh	20.3964	82.1817	119	23.01	Archean Pink granite	19-19.5,38	6.15	3	26.79			Bastar Gneiss	Gneissic Complex
16	Gariyaband	Chhura	Sankra	20.8103	81.9936	114.81	28.1	Chandrapur sandstone Granite	35-36,42	-	0.25	-			Chandarpur	Ferrugineous Sandstone
17	Gariyaband	Gariaband	Nagabuda	20.5658	82.1167	151.7	22.5	Archean Granite	14-18.,32	-	Dry	-			Bastar Gneiss	Gneissic Complex
18	Gariyaband	Mainpur	Jidar	20.2881	82.2881	151.85	31.83	Archean Pink Granite	14-18.,42-43	3.49	1.2	32.44			Bastar Gneiss	Gneissic Complex
19	Gariyaband	Chhura	Akalwara	20.9089	82.1397	119.54	23.11	Archean Granite	23-33	5.9	5.75	21.13			Bastar Gneiss	Gneissic Complex
20	Gariyaband	Chhura	Kukda	20.7475	81.9383	133.11	18.05	Chandrapur sandstone Archean granite	14-20,35	-	Dry	-			Chandarpur	Ferrugineous Sandstone
21	Gariyaband	Chhura	Raniparteva	20.97	82.1506	101.09	19.76	Archean Granite	30-32, 53, 60	6.14	2.6	24.06			Bastar Gneiss	Gneissic Complex
22	Gariyaband	Mainpur	Kulhadighat	20.2364	82.3475	50.2	13.94	Archean Granite	14-18.,25	-	dry	-			Nawagarh	Shale with Sandstone
23	Gariyaband	Gariaband	Dhawalpur	20.3872	82.25	114.6	28.35	Archean Pink granite	14-18., 59, 68, 80, 101	7.93	9.6	15.2			Bastar Gneiss	Gneissic Complex
24	Gariyaband	Chhura	Chhura	20.8106	82.2108	102.1	19.74	Granite	14, 20, 30,79	5.89	6	18.92			Bastar Gneiss	Gneissic Complex
25	Gariyaband	Chhura	Kunderadadar	20.6694	82.3083	146.88	21.54	Archean Pink Granite	18-22, 90	7	0.2	-			Bastar Gneiss	Gneissic Complex
26	Gariyaband	Gariaband	Paragaon	20.6186	82.0547	141.9	6	Archean Granite	14-18.,89-89.6	7.635	1.9	28.02			Bastar Gneiss	Gneissic Complex
27	Gariyaband	Chhura	Rajpur	20.7625	82.2128	96.54	6.05	Archean Granite	9-10, 90-91	8.96	29.69	10.14			Bastar Gneiss	Gneissic Complex
28	Gariyaband	Chhura	Raksi	20.75	82.2561	119.2	10.8	Archean Granite	11-11.5,35	-	0.25	-			Bastar Gneiss	Gneissic Complex

29	Gariyaband	Gariaband	Amdi	20.4825	82.1167	128.46	18.94	Archean Pink granite	25, 63, 81, 115	7	360	17.6			Bastar Gneiss	Gneissic Complex
30	Gariyaband	Rajim	Pokhara OW	21.0417	81.9667	161	25.5	0.0-23.00 Sand/Alluvium 23-103 Charmuria Fm 103.141 Chanderpur Fm 141-161	0-23	21	0.05				Charmuria	Limestone
31	Gariyaband	Rajim	Pokhara OW	21.0417	81.9667	30	21.5	Sand /Alluvium	14-30,38	4.5	10	8			Charmuria	Limestone

Annexure III

Sample No.	District	Block	Location/ Village	Latitude	Longitude	Sample Source	pH	EC	CO 3	HCO3	Cl	SO4	NO3	F	TH	Ca	Mg	Na	K	TDS	Si	PO4	U
								µs/cm	mg/l														µg/l
1	Gariyaband	Gariyaband	Behrabuda	20.66495	82.05305	HP	8.19	874	0	189.1	147	43.25	8.55	0.87	380	78	44.4	10.34	3.3	585.58	10.4	0	0
2	Gariyaband	Gariyaband	Kochwai	20.66273	82.10151	HP	8.3	394	6	103.7	35	18.6	40.55	1	185	62	7.2	8.66	1	263.98	25.3	0	0
3	Gariyaband	Gariyaband	Dongrigaon	20.60931	82.06859	HP	8.01	744	0	219.6	63	39.51	69.1	0.86	325	88	25.2	13.18	1.06	498.48	16.1	0	0
4	Gariyaband	Gariyaband	Urtuli	20.53441	82.10527	HP	7.75	270	0	109.8	21	8.38	2.82	2.1	130	38	8.4	8.74	0.71	180.9	15.9	0	0
5	Gariyaband	Gariyaband	Kerabahara	20.51769	82.11292	HP	8.25	202	0	85.4	14	13.84	7.37	0.28	55	18	2.4	23.77	1.53	135.34	13.5	0	0
6	Gariyaband	Gariyaband	Daspur	82.14006	20.54391	DW	8.12	303	0	73.2	31.5	13.14	34.07	0.36	120	26	13.2	13.14	5.77	203.01	8.6	0	0
7	Gariyaband	Gariyaband	Amda	20.48404	82.11924	HP	8.2	275	6	115.9	10.5	4.82	0.36	0.33	110	22	13.2	10.83	0.8	184.25	8.8	0	0
8	Gariyaband	Gariyaband	Andora	82.11966	20.46516	DW	8.2	532	0	128.1	45.5	31.67	70.8	0.71	260	64	24	12.26	0.96	356.44	17.2	0	0
9	Gariyaband	Gariyaband	Darripara	20.44334	82.11683	HP	8.3	233	0	91.5	14	13.67	0.54	1.8	110	22	13.2	7.95	0.67	156.11	11.01	0	0
10	Gariyaband	Gariyaband	Sikasar	20.51697	82.31024	HP	8.2	250	0	67.1	14	52.75	0.71	0.74	90	30	3.6	13.35	0.44	167.5	7.5	0.1	0
11	Gariyaband	Gariyaband	Bhaisamunda	20.43008	82.22586	HP	8.02	521	0	128.1	56	34.12	47.1	0.19	235	46	28.8	9.44	0.6	349.07	8.5	0	0
12	Gariyaband	Gariyaband	Kamepur	20.42052	82.21205	HP	7.72	215	0	91.5	17.5	5.1	0.39	0.52	80	24	4.8	10.65	2.76	144.05	12.8	0	0
13	Gariyaband	Gariyaband	Nahargaon	20.64684	82.09556	HP	7.82	540	0	122	45.5	31.67	65.05	0.23	230	64	16.8	12.83	10.5	361.8	21.9	0	0
14	Gariyaband	Gariyaband	Jithidumar	82.10332	20.63736	DW	8.01	345	0	73.2	31.5	12.42	46.7	0.18	135	34	12	13.66	1.01	231.15	9.8	0	0
15	Gariyaband	Gariyaband	Bhilai	20.6533	82.05555	HP	8.11	406	0	115.9	38.5	27.9	25.5	0.66	115	26	12	44.7	0.79	272.02	13.94	0	0
16	Gariyaband	Gariyaband	Kokdi	82.07618	20.64428	DW	8.36	503	6	128.1	66.5	24.74	0.56	1.5	170	30	22.8	42.2	1.91	337.01	9.48	0	0
17	Gariyaband	Mainpur	Kodomali	20.19235	82.24713	HP	8.24	345	0	170.8	10.5	5.65	0.45	0.43	140	28	16.8	14.96	1.49	231.15	7.65	0	0
18	Gariyaband	Mainpur	Jugad	20.14475	82.27825	HP	8.21	555	0	183	52.5	29.92	24.7	0.64	200	32	28.8	44.25	1.68	371.85	21.56	0	0
19	Gariyaband	Mainpur	Udanti	20.11392	82.3195	HP	7.71	544	0	170.8	52.5	25.25	28.1	0.87	215	72	8.4	31.92	1.69	364.48	16.51	0	0
20	Gariyaband	Mainpur	Koyba	20.09054	82.33659	HP	7.89	547	0	176.9	56	31.32	1.62	1.2	175	38	19.2	45.78	0.68	366.49	19.67	0	0
21	Gariyaband	Mainpur	Dhurvagadi	20.08391	82.37049	HP	7.61	343	0	97.6	49	12.04	0.3	0.57	90	24	7.2	38.94	3.74	229.81	7.06	0	0
22	Gariyaband	Mainpur	Budgoltappa	20.02711	82.40009	HP	7.06	355	0	128.1	31.5	9.01	1.79	1.3	110	20	14.4	26.82	2.45	237.85	5.76	0	0
23	Gariyaband	Mainpur	Sirahlati	19.98569	82.44972	HP	7.36	470	0	146.4	42	7.44	61.2	0.33	175	30	24	32.26	2.04	314.9	5.67	0	0
24	Gariyaband	Mainpur	Chichiya	19.95196	82.53984	HP	8.17	703	0	250.1	63	38.8	7.39	0.24	290	58	34.8	32.58	0.91	471.01	7.24	0	0

Sample No.	District	Block	Location/ Village	Latitude	Longitude	Sample Source	pH	EC	CO 3	HCO3	Cl	SO4	NO3	F	TH	Ca	Mg	Na	K	TDS	Si	PO4	U
								µs/cm	mg/l														µg/l
25	Gariyaband	Deobhog	Mudagaon	19.93374	82.62034	HP	8.26	681	0	195.2	56	59.95	10.39	0.87	185	32	25.2	73.9	0.21	456.27	7.5	0	0
26	Gariyaband	Deobhog	Khutgaon	19.89249	82.69709	HP	8.12	470	0	201.3	28	13.14	7.33	0.7	115	24	13.2	56.57	3.29	314.9	8.5	0	0
27	Gariyaband	Deobhog	Kachariya	19.89019	82.67679	HP	7.72	510	0	207.4	49	13.14	6.42	0.43	75	18	7.2	73.85	1.91	341.7	12.8	0	0
28	Gariyaband	Deobhog	Gohekala	19.90283	82.68356	HP	8.23	897	0	335.5	66.5	43.69	20.44	0.53	245	26	43.2	84.16	2.81	600.99	21.9	0	0
29	Gariyaband	Deobhog	Fokatpara	19.89645	82.66952	HP	8.24	597	0	268.4	42	25.77	2.06	0.76	135	36	10.8	95.11	2.87	399.99	9.8	0	0
30	Gariyaband	Deobhog	Bahrabali	19.95483	82.52392	HP	7.82	567	0	280.6	24.5	9.34	7.83	1.2	150	26	20.4	70.98	0.84	379.89	13.94	0	0
31	Gariyaband	Deobhog	Kodobahar	20.67019	82.03001	HP	7.47	752	0	213.5	91	53.37	10.62	0.76	175	42	16.8	80.85	40.8	503.84	9.48	0	0
32	Gariyaband	Chhura	Chhura	20.795	82.22222	PZ	8.32	361	6	158.6	17.5	9.34	10.6	0.21	140	42	8.4	26.03	1.35	241.87	7.65	0	0
33	Gariyaband	Chhura	Pond	20.77417	81.95167	PZ	8.41	225	6	73.2	17.5	9.34	20.57	1.54	75	26	2.4	19.9	1.49	150.75	25.3	0	0
34	Gariyaband	Deobhog	Nai Basti Near Hospital	19.85833	82.69288		7.67	346	0	158.6	17.5	9.66	10.43	1.2	165	24	25.2	7.99	1.33	231.82	16.1	0	0
35	Gariyaband	Deobhog	Nishtiguda Talab	19.85388	82.69481		7.73	477	0	195.2	17.5	9.34	30.46	0.67	135	30	14.4	49.27	1.23	319.59	15.9	0	0
36	Gariyaband	Deobhog	Nariapara Arsenic plant	19.85819	82.69593		7.67	550	0	213.5	42	24.24	11.56	0.87	190	32	26.4	48.57	1.14	368.5	13.5	0	0
37	Gariyaband	Deobhog	Supabeda Dug well	19.85857	82.69527		7.72	349	0	176.9	24.5	13.51	16.52	1	150	38	13.2	22.07	0.01	233.83	7.24	0	0
38	Gariyaband	Deobhog	Satnamipara Plant	19.86352	82.69337		7.67	833	0	207.4	126	36.38	25.49	1.2	230	62	18	92.59	1.2	558.11	7.5	0	0
39	Gariyaband	Deobhog	Manjeetpara	19.8625	82.6967		7.83	850	0	311.1	80.5	42.9	14.81	1.5	185	38	21.6	118.4	0.54	569.5	8.5	0	0