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

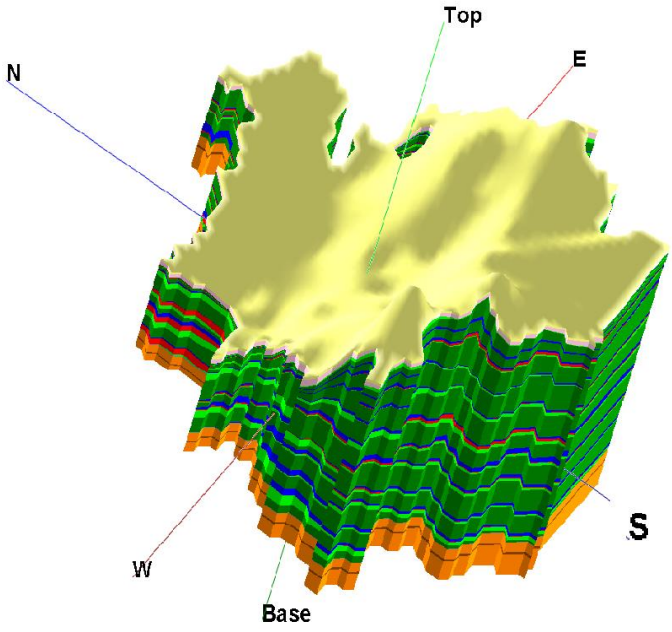
Khargone District
Madhya Pradesh

उत्तर मध्य क्षेत्र, भोपाल

North Central Region, Bhopal

भारतसरकार / Government of India
जल शक्ति मंत्रालय /Ministry of Jal Shakti,
जल संसाधन, नदी विकास और गंगा संरक्षण विभाग
Department of Water Resources, RD&GR
केन्द्रीयभूमिजलबोर्ड / Central Ground Water Board

जलभृतमानचित्रऔरभूजलप्रबंधनयोजना, जिला खारगोन , मध्य प्रदेश
Aquifer Mapping and Ground Water Management Plan, Khargone district, Madhya Pradesh



By
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North Central Region, Bhopal
2020-2021

PREFACE

Aquifer mapping can be defined as a scientific process, wherein a combination of geologic, geophysical, hydrologic, and chemical field and laboratory analyses are applied to characterize the quantity, quality, and sustainability of groundwater in aquifers. Systematic aquifer mapping is expected to improve our understanding of the geologic framework of aquifers, their hydrologic characteristics, water levels in the aquifers and how they change over time, and the occurrence of natural and anthropogenic contaminants that affect the portability of groundwater. Results of these studies will contribute significantly to resource management tools such as long-term aquifer monitoring networks and conceptual and quantitative regional ground-water-flow models used by planners, policymakers, and other stakeholders.

Under the project on National Aquifer Mapping (NAQUIM), Central Ground Water Board (CGWB) North Central Region, Bhopal has taken up Khargone district to prepare the Aquifer Maps for the entire district and formulate Aquifer Management Plan. Khargone district occupies an area of 8030sq km, out of which the groundwater recharge worthy area is 6568.97 sq. km. and the rest is covered by hilly and forest area. Most of the district is drained by the Narmada drainage system. The Tapti drainage system extends in a limited area along the southern boundary of the district. The district is mainly occupied by hard rock; comprising Deccan Traps, Vindhyans, Bijawars, and Archean. The water level in shallow aquifer during pre monsoon ranges from 1.07 -10.32 mbgl and during post monsoon ranges from 0.72 -9.17 mbgl.As per the Dynamic Ground Water Resource Assessment Report (2020), the annual extractable ground water resource 1059.8 MCM and groundwater draft for all uses are457.19 MCM which results in the stage of groundwater extraction being 43.15 % as a whole for the district. After successful implementation of the supply-side and demand-side management plan the stage of extraction in Khargone district is expected toimprove condition of the district in terms of ground water. The interventions suggested in the report will not only have a positive impact on the groundwater regime but would also play a key role in augmenting the net cropping area and would ultimately enhance the agricultural productivity and economy of the district.

I would like to place on record my appreciation of the untiring efforts **Ms. Lata Udsaiya, Scientist-B** for preparing the Aquifer maps and Management plan and compiling this informative report. I fondly hope that this report will serve as a valuable guide for the sustainable development of Ground Water in the Khargone block, Bhopal District, Madhya Pradesh.

Rana Chatterjee
(Regional Director)

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CHAPTER 1

INTRODUCTION

Aquifer mapping is a multi-disciplinary scientific approach for aquifer characterization or it can be defined as a scientific process, wherein a combination of geologic, geophysical, hydrologic and laboratory analyses are applied to characterize the quantity, quality and sustainability of ground water in aquifers. According to the present condition of groundwater related issues there is an urgent need for an accurate and comprehensive picture of groundwater resources available in different hydrogeological settings. Therefore Central Ground Water Board has taken up the **National Aquifer Mapping Projection (NAQUIM)**ona scale of 1:50,000 to formulate sustainable aquifer management plan. Effective and systematic aquifer mapping study is expected to improve our understanding of the geologic framework of aquifers, their hydrologic characteristics, water levels in the aquifers and how they change in a space and time, and the occurrence of natural and anthropogenic contaminants of ground water.This National Water Mission is very helpful in conservation of water, minimizing wastage and ensuring its equitable distribution all over the country (at district and block level also) through **integrated water resources development and management.**Central Ground Water Board extensive study has remarkably brought out comprehensive regional picture of the aquifers in terms of their water quality and yield potential. In CGWB various studies such as ground water monitoring, ground water resource assessment, artificial recharge and ground water exploration is going which is one of the main important tools in this aquifer mapping project all over the country.

1.1 Objectives

The objective of this study is

- Toidentify the accurate geometry of aquifers present in the study area – shallow and deep both.
- Aquifer characterization and their yield potential.
- Quantification of ground water availability and assessment of its quality.
- Aquifer wise assessment of ground water resources.
- Formulation of ground water management plans.

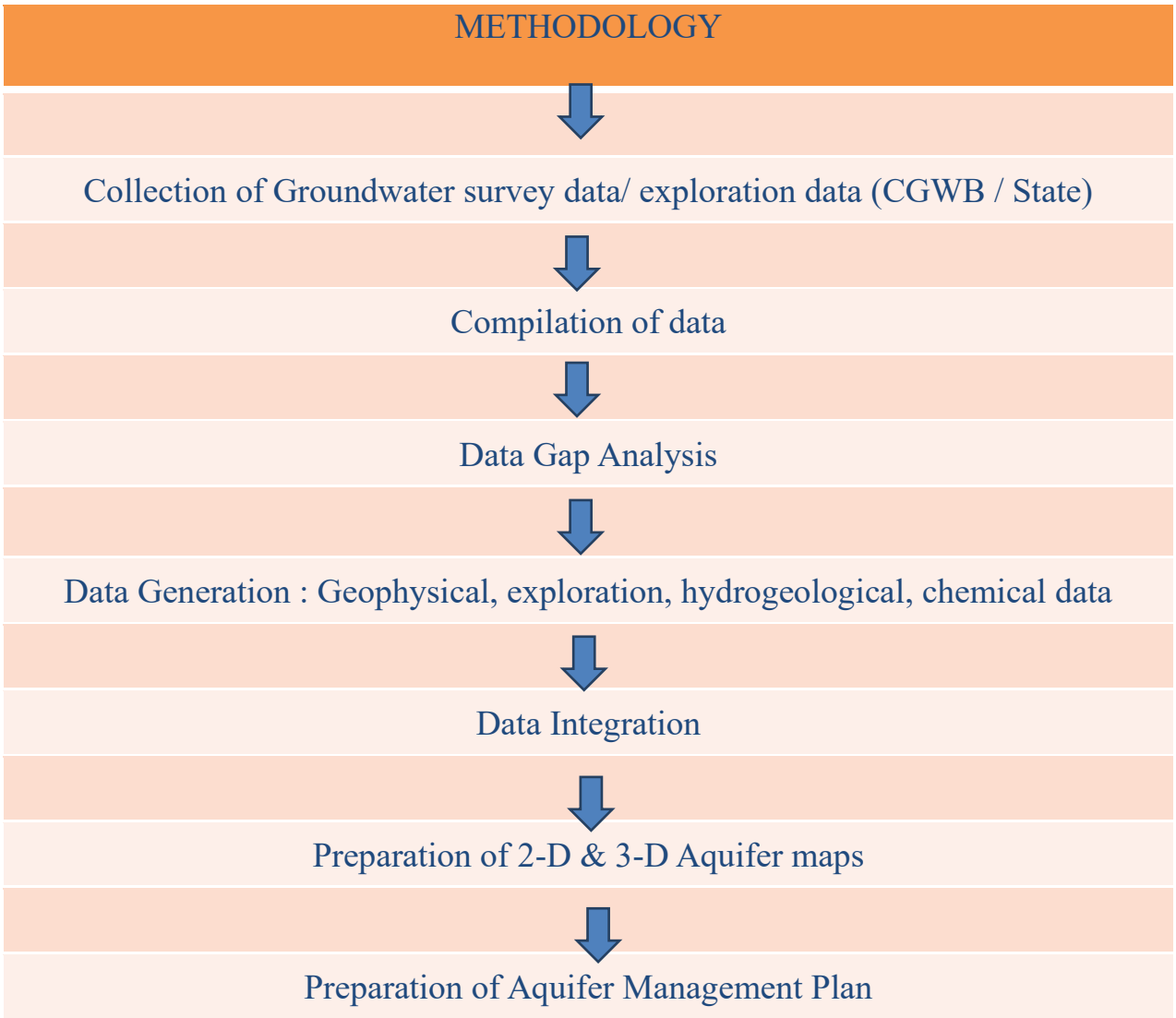
1.2 Scope of Study

To understand the scope of this study it is very important at present time when there is very large scarcity of freshwater even for essential requirement, drought condition, unavailability of drinking water and lack of management of groundwater in Khargonedistrict.This has necessitated for a systematic mapping of aquifers. Further hydro-geological investigation either by geophysical technique or by exploration may be proposed for the aquifer mapping. The study will provide **adequate and precise subsurface information in terms of aquifer lithology and geometry leading to 3-dimensional aquifer dispositions (vertical and lateral extend), their yield, quantification of groundwater, etc.**Also it will establish the most appropriate technique or combination of techniques for identifying the aquifers in

different hydrogeological terrains which will help in management of groundwaterresources in an efficient and equitable manner, for sustainable development of groundwater and for its recharge.

1.3. Approach and Methodology:

To achieve the above objective the following approach has been adopted and given in the methodology flow chart diagram. The major activities involved in this process is compilation of data, data gap analysis, data generation, data integration, preparation of maps and 3-D aquifer model, 2D sections of the district and finally aquifer management plan of the study area.The data acquisition supported by geological, geophysical and hydro-chemical investigation with groundwater exploration to the depth of 200 mt.This study was taken during Covid pandamic period andtherefore because of the restrictions in physical movements, the report is prepared on the basis of existing 29 exploratory/ observation wells and 6 piezometer, drilled by CGWB, Bhopal, Madhya Pradesh.



Methodology flow chart

1.4 Study Area

Khargone district is also called West Nimar which is located in the south west boundary of the state of Madhya Pradesh and lies between north latitudes 22° 47' and 22° 35' and east longitudes 75° 19' and 76° 14' in parts of survey of India Toposheet No. 46N, 460, 55B and 55C &encompasses an area of 8030 sq. km. The district is surrounded by Dhar, Indore and Dewasdistrict in the north, Khandwa &Burhanpur district in the east and Barwani district in the west and Maharashtra state in the south. The district headquater Khargone is well conncted by tar roads to Khandwa in the East, Khalghat and Indore in the North, Dhulia and Manmad in South West.

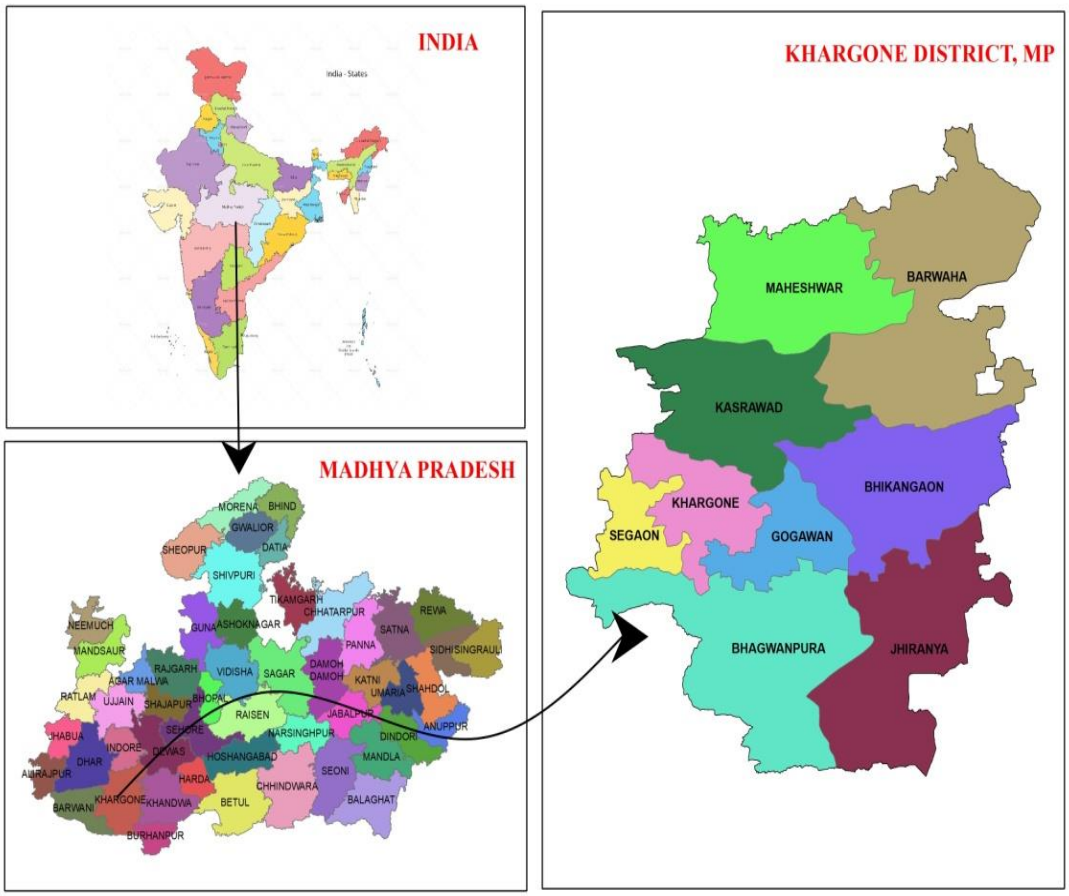


Figure 1: Index Map of Khargone district

The district forms almost central section of Narmada valley which is bordered by Vindhyansescarpment in the north and Satpura hills ranges in the south.

The district is divided into nine administrative blocks namely Kasrawad, Bhagwanpura, Segoan, Badwah, Bhikagon, Jhiranya, Maheshwar, Khargone and Gogaon. For revenue and general administration the district is sub divided into eight tehsils/subdivisions namely Kasrawad, Bhagwanpura, Segaon, Badwah, Bhikangaon, Jhiranya, Maheshwar and Khargone. The main drainage in formed being Narmada River and

various small nalas and rivelutes joins to Narmada. The Tapti drainage system extends in a limited area along the southern boundary of the district. Index map of the district is shown in figure 1. Details of Khargonedistrrict administrative unit is given in Table1.

There are 592 gram panchayat, number of villages 1390in the district. As per census 2011, the total population of the district is 1507403. Total geographical area of the district is 8030sq km of which the gross irrigated area is 376512 ha and net irrigated area (by canal) is 79707 Ha. The net sown area of the district is 400610 Ha, area sown area more than once is 179291 ha, area under waste land is 19594 ha and area under other uses is 40186 ha.

Khargone District	Area (sq km)
Total Geographical Area (sq km)	8030.00
Recharge worthy Area (sq km)	6568.97
Hilly/Forest (sq km)	1461.03
Total number of revenue villages	1390
Total Number of Gram Panchayat	592
Total Number of Blocks	9
Total Population	1507403
Literacy %	63.22

Table 1: Administrative units of Khargone block

Block	Geographical Area (Sq Km)	Recharge Worthy Area (Sq Km)	Total Population (2011 census)	SC Population (2011 census)	ST Population (2011 census)
Barwaha	1470	1332.8	292045	51618	61272
Bhagwanpura	1318	523.98	192996	5419	168282
Bhikangaon	914.8	914.8	175563	12656	85168
Gogawan	407.1	407.1	123512	13570	32284
Kasrawad	1012	1012	219959	30742	52584
Khargone	494.4	494.4	140076	21493	26659
Mahashwar	826.2	826.2	196278	39572	56699
Segaon	398.5	393	83487	3251	62632
Zirniya	1189	664.69	201756	6919	161863
DISTRICT TOTAL	**8030**	**6568.97**	**1625672**	**185240**	**707443**

1.5 RAINFALL AND CLIMATE

RAINFALL

The climate of Khargone district, M. P. characterized by a hot summer and general dryness except during the south west monsoon season. It has four seasons. The cold season(December to February) is followed by the hot season (March to about the middle of June). The period from the middle of June to September is the south west monsoon season. October and November form the post monsoon or transition period.

The normal annual rainfall of Khargone district is 835 mm. The maximum rainfall received during south west monsoon period i.e. June to September about 91 % of the annual rainfall received during monsoon season. Only 9 % of the annual rainfall takes place between October to May period. Thus surplus water for ground water recharge is available only during the south west monsoon period. Blockwise rainfall data of the Khargone District is given in Table2.

Table 2: Blockwise Rainfall data for the Khargone district

Station Name	Year	Rainfall (mm)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Barwah	2011	0	0	0	0	18	151.1	210.0	413.6	44.2	0	0	0
	2012	0	0	0	0	0	17.0	541.8	180.4	241.5	0	0	0
	2013	0	0	0	0	0	250.0	490.2	307.5	141.5	70.20	0	0
	2014	0	0	0	0	0	0.0	446.8	120.9	254.3	16	0	0
	2015	0	0	0	0	0	316.0	261.0	261.0	71.0	0	0	0
	2016	0	0	0	0	0	55.0	244.0	223.0	115.0	62	0	0
	2017	0	0	0	0	0	57.6	305.3	262.2	100.7	79	0	0
	2018	0	0	0	0	0	138.0	127.5	263.3	97.6	0	0	0
	2019	0	0	0	0	0	36.2	173.0	256.7	161.0	54	0	0
	2020	0	0	0	0	0	389.0	155.0	391.0	289.0	0	0	0
BHAGWANPURA	2011	0	0	0	0	0	96.0	446.4	294.0	89.8	0	0	0
	2012	0	0	0	0	0		244.1	206.5	212.0		0	0
	2013	0	0	0	0	0	147.4	433.7	249.5	188.4	34	0	0
	2014	0	0	0	0	0	3.5	315.1	80.3	115.0	3.2	0	0
	2015	0	0	0	38.2	0	116.2	50.6	168.1	131.1	0	0	0
	2016	0	0	0	0	0	146.6	180.3	101.0	193.5	27	0	0
	2017	0	0	0	0	0	77.7	203.9	233.8	218.6	46.4	0	0
	2018	0	0	0	0	0	288.0	172.6	380.3	38.4	0	0	0
	2019	0	0	0	0	0	70.4	311.2	456.6	186.0		0	0
	2020	0	0	0	0	0	289.0	136.0	238.0	140.0	3	0	0
BHIKANGAON	2011	0	0	0	8	0	84	350	415	52	0	0	0
	2012	0	0	0	0	0	55	435	87	280	0	0	0
	2013	0	0	0	0	0	192.6	298	292	68	35	0	0
	2014	13	32	0	0	0	3	582	92	208	0	0	0
	2015	0	0	13	19	0	185.3	183.3	360.3	97	0	0	0
	2016	0	0	0	0	0	73	315	154.30	236	66	0	0

Station Name	Year	Rainfall (mm)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	2017	0	0	0	0	0	149	257.20	231.4	251.8	55	0	0
	2018	0	0	0	0	0	107	116	365	134	0	0	0
	2019	0	0	0	0	0	64	329	527	472	45	0	0
	2020	0	0	0	0	0	158	168	282	138	3	0	0
GOGAWA	2011	0	0	0	0	0	36	288	353	42	0	0	0
	2012	0	0	0	0	0	29	262	78	222	0	0	0
	2013	0	0	0	0	0	87	160	246	42	61	0	0
	2014	0	0	0	0	0	21	461.5	69	196	0	0	0
	2015	0	0	35	25	0	114.9	108	287	77	0	0	0
	2016	0	0	0	0	0	120	325	155	191.9	89	0	0
	2017	0	0	0	0	68	298.6	168.8	150.1	111	0	0	0
	2018	0	0	0	0	0	55	147	300.4	88	0	0	0
	2019	0	0	0	0	0	63	337.1	362	253	28	0	0
	2020	0	0	0	0	0	209	205	233.6	176	0	0	0
KASRAWAD	2011	0	0	0	0	0	63	252	470	75	0	0	0
	2012	0	0	0	0	0	6	268.8	162	143	0	0	0
	2013	0	0	0	0	0	167	405.5	360	97	33.5	0	0
	2014	0	0	0	0	0	33	289	86.7	326	0	0	0
	2015	0	0	37	1	0	102.2	175.5	302.3	92.1	0	0	0
	2016	0	0	0	0	0	120	253.8	170.2	159.2	22	0	0
	2017	0	0	0	0	0	51.4	323.5	182.1	168	23	0	0
	2018	0	0	0	0	0	90	165.1	206	169.2	0	0	0
	2019						91	253	436	196	53		
	2020						188	217	259	157	19		
KHARGONE	2011	0	0	0	0	0	117.6	378.8	235.5	52.9	0	0	0
	2012	0	0	0	0	0	10.7	288.1	137.9	348.1	0	0	0
	2013	0.4	1.8	0	0	0	162.1	231.2	233.4	132.1	89.7	0	0
	2014	0	0	0	0	0	20.4	422.6	105.3	190	0	0	0
	2015	0	0	32.1	24.1	0	67.6	97.4	198	123.2	0	0	0
	2016	0	0	0	0	0	97.7	222.4	130.1	180.3	33.7	0	0
	2017	0	0	0	0	0	105.7	269.2	169.5	120.3	79.4	0	0
	2018	0	0	0	0	0	159.3	142.4	253	46.8	0	0	0
	2019	0	0	0	0	0	85.3	309.7	424.5	336.6	37.7	0	0
	2020	0	0	0	0	0	178.7	231.5	212.6	187	15.4	0	0
MAHESHWAR	2011	0	0	0	0	0	70.6	222.8	421.2	74.4	0	0	0
	2012	0	0	0	0	0	10.7	288.1	153.1	222.4	0	0	0
	2013	0	0	0	0	0	234.2	467	335.2	67.4	45.2	0	0
	2014	0	0	0	0	0	30	342.4	139.8	430	0	0	0
	2015	0	0	0	0	0	140.8	271.2	298.6	153.2	0	0	0
	2016	0	0	0	0	0	39.8	305.8	290.2	182.8	25.4	0	0
	2017	0	0	0	0	0	159	203.3	223.6	125.4	21	0	0

Station Name	Year	Rainfall (mm)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	2018	0	0	0	0	0	172.2	207.8	217.8	126.4	0	0	0
	2019	0	0	0	0	0	118	353.6	436.7	234	46	0	0
	2020	0	0	0	0	0	207.6	221.6	293.4	137.4	0	0	0
SEGAON	2011	0	0	0	0	0	15	149	292	99.1	0	0	0
	2012	0	0	0	0	0	18	197	119	157	0	0	0
	2013	0	0	0	0	0	161	356	254	160	43	0	0
	2014	0	0	0	0	0	25	396	132	189	0	0	0
	2015	0	0	0	0	0	218.5	100	148	135	0	0	0
	2016	0	0	0	0	0	134	180.8	72.7	156	79	0	0
	2017	0	0	0	0	0	75	357	167.8	36	72	0	0
	2018	0	0	0	0	0	288	192	392	49	0	0	0
	2019	0	0	0	0	0	76	218	387	215	0	0	0
	2020	0	0	0	0	0	179	63	271	183	5	0	0
ZIRNIYA	2011	0	0	0	0	0	34	311	368	104	0	0	0
	2012	0	0	0	0	0	53	338	97	408	0	0	0
	2013	0	0	0	0	0	162	181.9	280	105	49	0	0
	2014	0	0	0	0	0	561	200	68.6	268.3	0	0	0
	2015	0	0	15	20	0	133	152.6	666	200	0	0	0
	2016	0	0	0	0	0	199.4	263.4	94	165.8	64.2	0	0
	2017	0	0	0	0	0	146.7	287.6	170.2	210.8	44	0	0
	2018	0	0	0	0	0	294.2	252.4	325.8	103	0	0	0
	2019	0	0	0	0	0	7	277	330.6	189.8	13	0	0
	2020	0	0	0	0	0	212	234	232	167	0	0	0

1.6 TEMPERATURE, HUMIDITY & WIND VELOCITY

The maximum temperature received during the month of May is 43°C and minimum during the month of December16°C.

During the south west monsoon season in 2020 the maximum humidity is observed in the month of September which is 87 % and minimum humidity observed in the month of April is 14 % and the rest of the year is drier. The driest part of the year is the summer season, when relative humidity's is very less. April-May is the driest month of the year.

The depressions which get originated in the Bay of Bengal during the south – west monsoon start moving in WNW direction and passes across the central part of India. The thunderstorm occurs during the April–May months and during southwest monsoon especially during June. Till August frequency of thunderstorms and heavy rains is more.

The wind velocity is higher during the pre-monsoon period as compared to post monsoon period. In 2020 the maximum wind velocity 23.7 kh/hr observed during the month of May and minimum 2.5 km/hrduring the month of December. The average annual wind velocity of Khargone district ranges from 18.1 km/hr to

8.2 km/hr for the year 2020.

1.7 PHYSIOGRAPHY/DEM AND GEOMORPHOLOGY

PHYSIOGRAPHY

The district exhibits varied geomorphic units, the presence of fluvial units showing the occurrences of alluvium in the flood plains of all major stream and rivers, buried Pedi plains showing denudational hills as seen in the north western parts of the district.

Similarly structural hogbacks and Cuesta belonging to VindhayanMeta sedimentary are restricted to northern boundary of the district. Basaltic uplands forming lower belt that extends from west to east in the southern parts of the district. This upland tract also forms major forests in the district.

Physiographically the district area can be broadly divided into three distinct natural divisions. Parallel with the Narmada lie the marked belts of Narmada valley in the center of the Satpura range along the southern margins and in the north a narrow belt of Vindhyan scarp delineating the northern boundary of the district in th north-east. The valley north of the Narmada covers a limited area and forms low lying country about 24.14 km wide and 80.5 km long, drained by several streams. The general height is about 228.6 m which slopes towards the axis of Narmada. The valley south of Narmada slopes gradually and country studded with domes and low hills. This valley is arich tract of old alluvium deposit, intermixed at places and alsodifferent levels of depth, with sandy, gravelly or rocky soils depending upon proximity of the spurs of the Satpura and the history of the drainage in the area. The gradient of the district is towards north in the southern portion varying from 2.5 to 4.8 m per kilometer and towards south in the northern bank of Narmada with gradient varying from 3.5 to 4.9 m per kilometer. The area about 9 to 10 km on either side of Narmada is more or less plain with gentle slope towards west. The general gradient in the part is being 0.4 to 0.7 m per kilometer. Digital elevation model of Khargone District is given in figure 2.

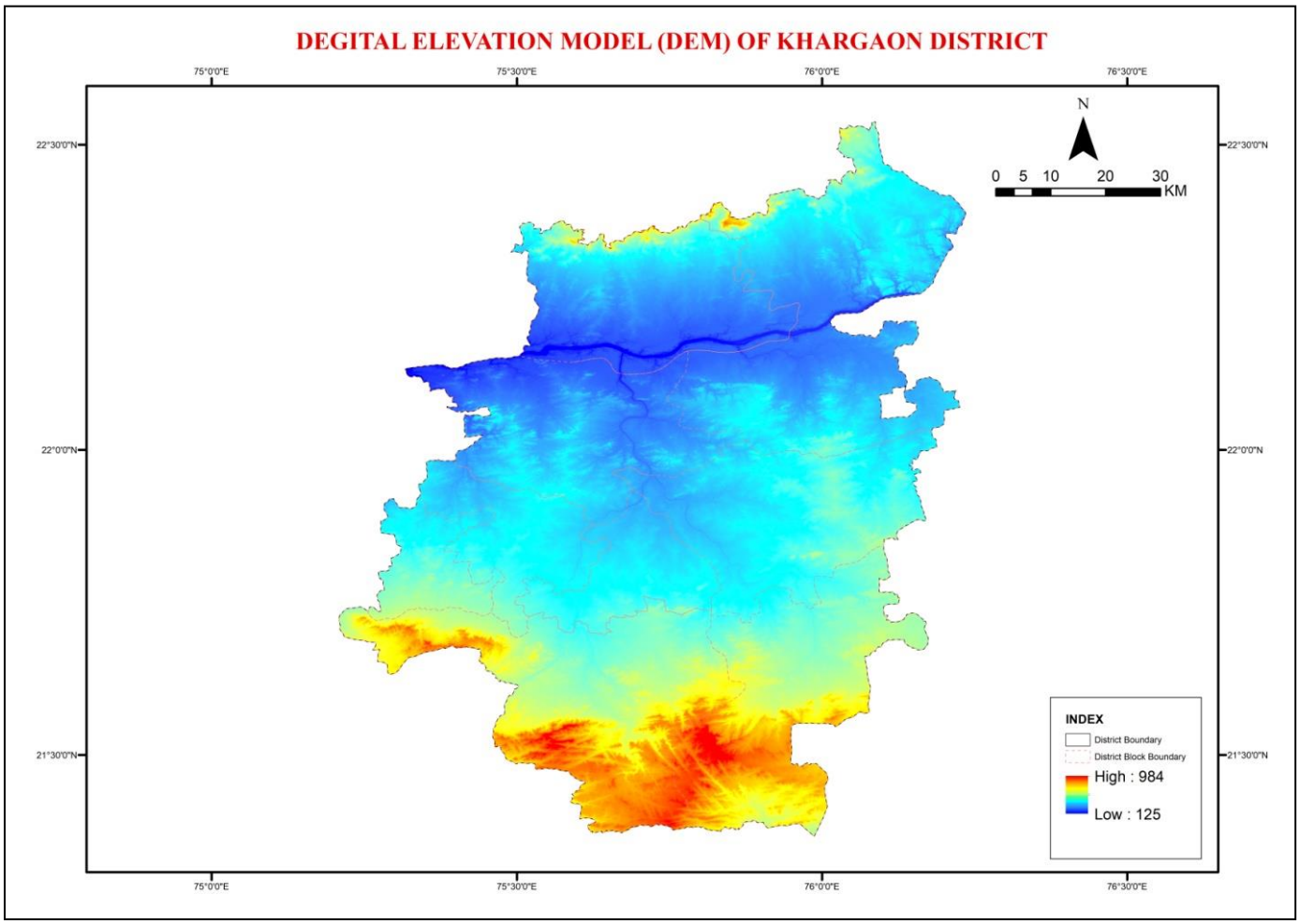


Figure 2: Digital Elevation Model of Khargone district

GEOMORPHOLOGY

The district exihibits varied geomorphic units which give brief and synoptic idea of the general topography of the terrain. The presence of fluvial units showing the occurences of the alluvium in the flood plains of all major streams, rivers and buried pediplainsareshowing denudational hills as seen in the north western parts of the district.

Similarly structural hogbacks and cuesta belonging to Vindhyan Meta sedimentary are restricted to the northern boundary of the district. Basaltic uplands forming the lower belt extending from west to east in the southern part of the district. This upland tract also forms the major forests in the district. Geomorphology of the Khargone District is given in figure 3.

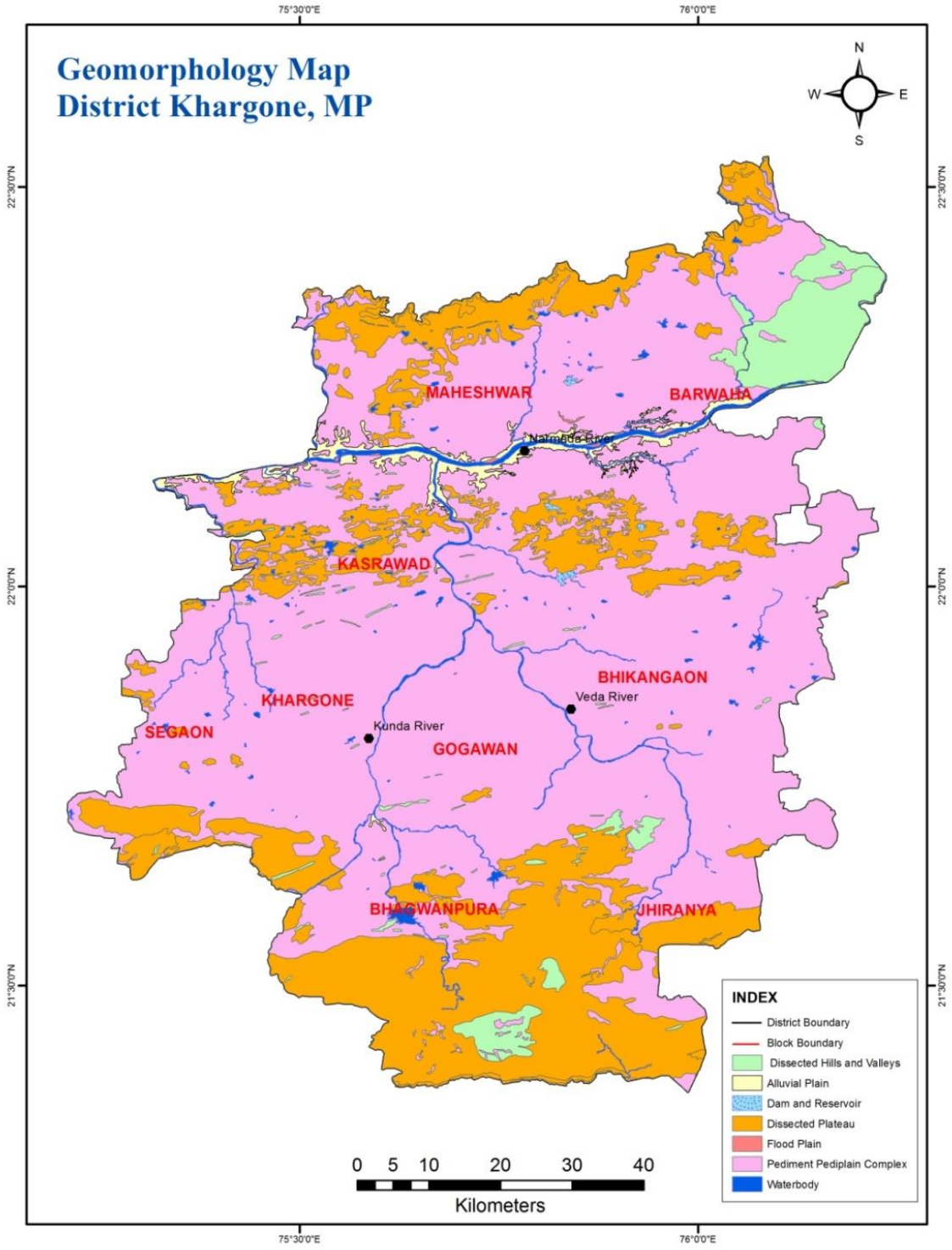


Figure 3: Geomorphology map of Khargone District

1.8.1 HYDROLOGY AND DRAINAGE

In the district Archaen granite and gneisses form pheratic aquifers where ever jointed or weathered. In general these aquifers have a poor potential. Bijawars and vindhyans in this district also have poor potential because of these massive and compactness occurrence of ground water rarely exceeds 12 mbgl.

Bagh beds forms phereaticas well as confined condition at the contact with Deccan trap. They forms good potential aquifers system in phreatic as well as in confined condition.

Most of the district is drained by the Narmada drainage system. The Tapti drainage system extends in a limited area along the southern boundary of the district. Between these two systems runs the water shed line of the Satpuras starting from thvillgeBadla in the South East to Hindoli Bara pass in the south west. Drainage map of Khargone District is shown in figure 4.

The Narmada system represents two majpr types of drainage lines. One is the fault zone linesof Narmada itself flowing much below the adjoining hard masses of the Vindhyans and Satpuras. The other is dentritic pattern shown by Kundi river which is tributarty of the Narmada. The important tributaries of the Narmada in this district are Kundi, Bakar, Borad, Beda etc. All these tributaries flow from south to north. Major rivers are perennial to semi perennial.

The average drainage density of rivers existoing in the southern part of Narmada Basin through Satpura formations and works out to be 2.18 km/sqkm. Rivers flowing in the northern part of Narmada in the Vindhyans having average drainage density 1,72 km/sq.km. Central Water commission has one river discharge gauging station at Mortakka on Narmada River. The maximum river discharge observed during the months from June to August and minimum discharge during the months of November and Decmber for the corresponding year.

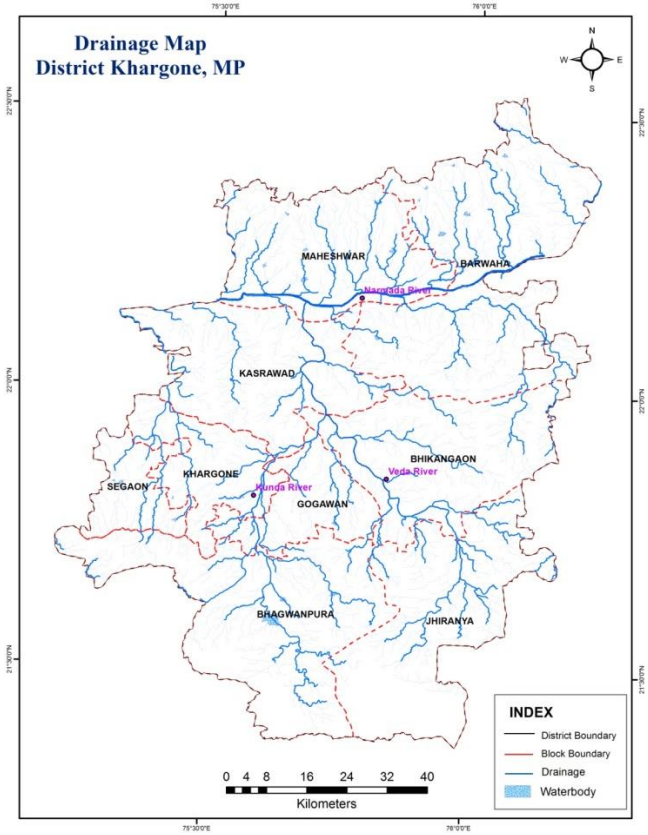


Figure 4: Drainage Map of Khargone district

1.9 SOIL COVER

Generally there are five types of soils namely Kali I, (0-1 mbgl), Kali II (1-2 mbgl), Kali III (2-3 mbgl),Halkikhardri and Bardi. These soils are classified as medium black cotton soils containing 50% silt and clay together (figure 5). Alluvial type of soils is found on both the sides of the river Narmada and is some patches along its tributaries like Kunda, Beda, Goi, Choral and Koram. This type of soil is deep fertile and well drained. The soils of the rest of the tract are mostly shallow and poor in fertility.

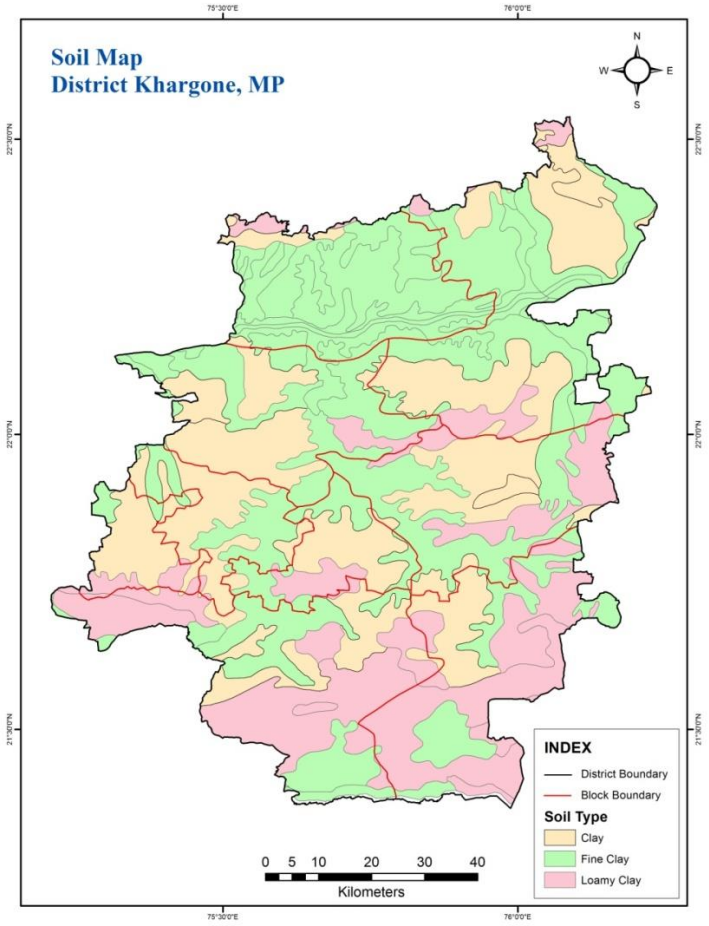


Figure 5: Soil Map of Khargone district

1.10 GEOLOGY

Geologically the district can be broadly grouped under hard rock comprising Deccan Traps, Vindhyans, Bijawars and Archeans. Deccan trap of the district represents a syncline i.e. a super order negative platform underlying it. The Deccan Trap outcrop is surrounded at places with sedimentary rocks e.g.Vindhyans, ArcheansandBijawar. Basaltic rocks of Deccan Trap overlie Bagh beds which in turn rest over the Vindhyansparticukary north of Narmada River from East to West, but South of Narmada, Basakt rocks rests over the Satpura and Vindhyans are absent.Thegelogy of the district is shown in the hydrogeological map (figure 6).

The stratigraphical sequence of the various geological units in this district is as below-

Age	Formation
Recent	Alluvium
Pleistocene	Laterite
Upper cretaceous to Eocene	Deccan Traps and Inter-trappean beds
Upper Cretaceous	Lameta beds
	Bagh Beds
Late Pre- Cambrian to Early Paleozoic	Vidhyan System
Archean	Bijawar series
	Granit and gneisses

A brief description of the different litho units is as follows:

Archeans

The Archeans are represented by -Granitesand gneiss which atre described as more of pink orthoclase, plagioclase and quartz with chlorite and hornblende, occur in the region of the Bawah and thde Knar rivers. They show gneissose and augenstructutes due to metamorphism.

The Bijawar series comprises quartzites, limestones and breccia. The quartzite is sometimes quartzite sandstone and in places becomes soft unaltered sandstone. The limestone is usually banded with chert of hornstone or charged with tubular geode like masses of this mineral.

Vindhyans

The most common constituent of this formation is hard, compact fine grained, purplish rather thin bedded sandstone. White quartzites occur in places conglomerates occasionally extreme corase are not rare. Flags are by n means uncommon. Thinly stratified black or greyish black shales are met with especially towards top of the systems. The sandstones are generally micaceous, very highly so. The rock dips at moderate anglr, generally towards the west and restupon the granite gneisses or on the upturned edges of the Bijawarrocks.The rocks in this region belong it is probable to the Rewa and Kaimur groups the upper Vindhyan system.

Bagh beds

The rocks of this group include the Nimar sandstone, cysterbeds, nodular limestone and coralline limestones. The beds roll about very much knowing to local dislocation.

The Nimar sandstones at Yalam are thin bedded and fine grained. These have a strong resemblance to the Gondwana beds in the lithology and absence of fossils; but in view of the marked unconformity between these two groups and in view of the conformable sequence between the NImar sandstone and cyster bed at Ghatia, which is 0.5 meter (1.6 ft) thick, is described as resting on the eroded surface of the sandstones. The species of the oysters have been identified as OstreaeaLeymerieid or, a form found in the Neocomian.

The nodular limestone is a whitish compact argillaceous rock, through this lacks the peculiar nodular character in this district. Fossils are plentiful and thickness of the bed does not exceed 5 meters. The fossils are characteristic of Gault Horizon.

The coralline limestone is a yellowish or red in color and cosists chiefly of small fragments of bryozoan, shells etc ehich on weathered surface are conspicuous. The freshly broken surface has a somewhat granular mottled appearance. On the strength of the fact that the two of the most characteristic forms of fossils occur in the Ariyalur division of the Cretaceous system in Trichinoply district. These limestones can be assigned th same age as the Ariyalur beds.

Lameta Beds

Near Barwaha some thick bedded rather soft white sandstone which show a strong no fossils except fragments of drift wood in abundance. These are overlain by the Deccan traps but in one or two cases, there intervenes an oyster bed (Cretaceous systems) Bagh beds. In another small inlier ESE of Barwaha the Lameta beds with fresh water shells separate the sandstones. Therte is apparent discordance between the sandstone and Lameta beds. Near Kalikut the basal beds pass insensibly into conglomerates and sandstones indistinguishable form the beds near Barwaha. In most cases beds lie upon the Bijawars but in one or two cases rest directly on the Vindhyan sandstones. These beds at Barwaha and Katkut have been shown to be Lameta age.

Deccan Traps

The Deccan traps belong to the type called " Plateau basalt" and are uniform in composition corresponding to dolerite or basalt. These are dark to dark greenish in colour. These traps are distinguished into vesicular and non vesicular varieties. The non vesicular types are hard, tough compact and medium to fine grained and break with a conchoidal fracture. The vesicular types are comparatively soft and friable and break more easily. Numerous ash beds are common in the upper portion. Thickness of these rocks may be 1200 meters.

Inter-Trappean Beds

Near Barwaha at Rupabani is an inter Trappean bed which consists of limestones with shells of Cyprea and Physa. The shells in the top near the junction with the Traps are considerably flattened.

Laterite

Laterite forms a cover on the Deccan traps in many places, which is of the vesicular type.

Alluvium

Under this area included the Recent alluvium of the Narmada river valley region which is rich & fertile and black cotton soil throughtot the Deccan trap region formed as a result of weathering of the basalts.

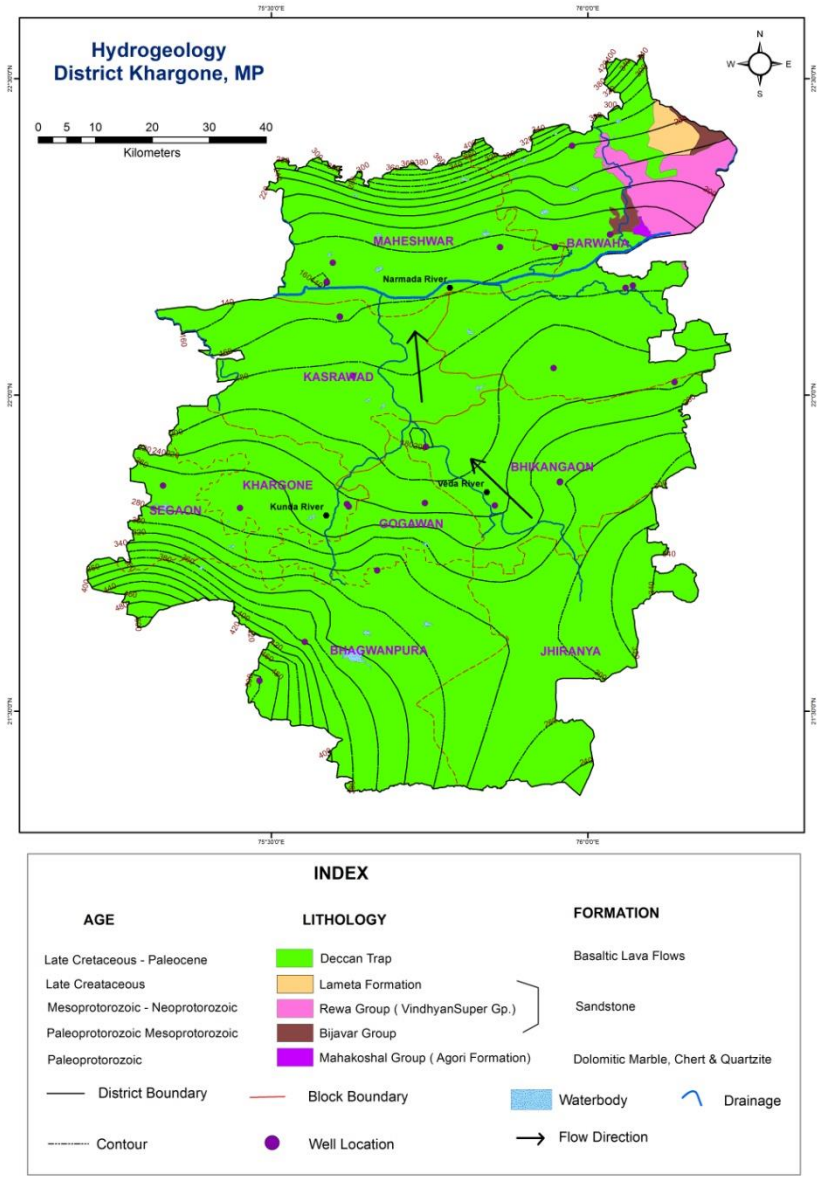


Figure 6: Hydrogeology Map of Khargone district

1.11 LAND USE, IRRIGATION, AND CROPPING PATTERN

The net sown area in the district is 400610 Ha, area sown more than once is 179291 Ha, area under waste land is 19594.40 Ha and area under other uses is 40186.60. The net irrigated area (by canal) in the entire district is 79707 Ha and gross irrigated area (all sources) is 376512 Ha whereas the rainfed area (partially irrigated by borewell,dugwell and ponds) is 296805 ha and unirrigated (totally rainfed area) is 199314 ha. The type of irrigation in the district is by tubewell, open well and borewell. The district is irrigated through groundwater by 89 number of governmenttubewell, by 10226 number of private tubewells and by 80456 number of private open wells.

The principal crops grown during Rabi season are cereals, pulse, oil seed, sugarcane and horticulture

plantation and it is sown in an area of 176688ha.The principal crops during the Kharif season are soyabean, moong and maize and it is sown in an area of 417786 ha. Land use/land cover map of Khargone District is given in figure 7.

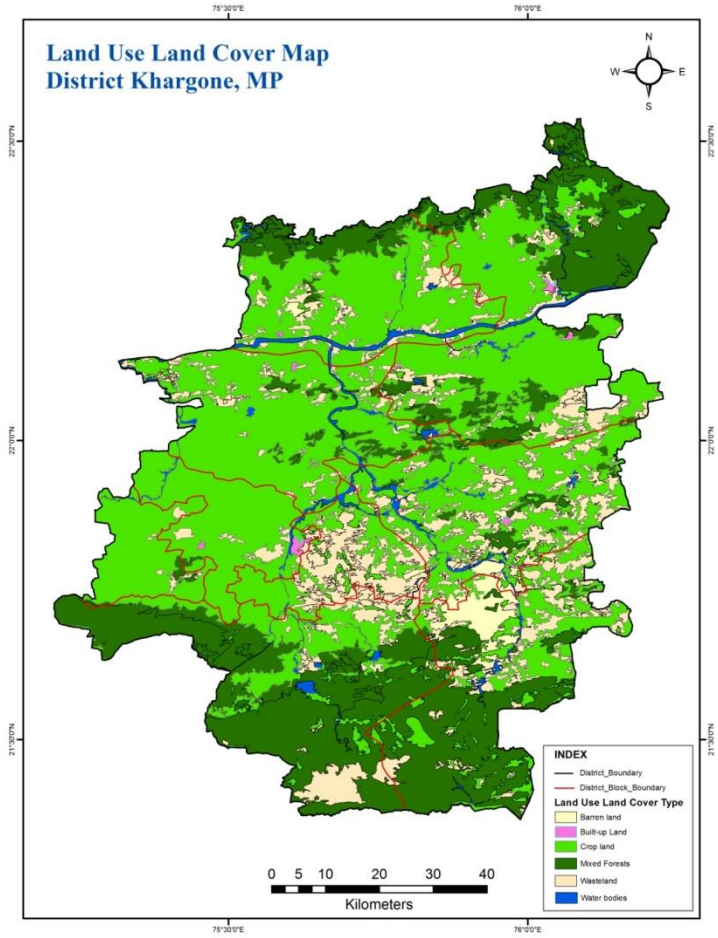


Figure 7: Landuse Map of Khargone district

CHAPTER – 2

DATA COLLECTION AND GENERATION

The data collection and compilation for various components was carried out as given below.

Hydrogeological Data – Current and historical water levels along with water level trend data of monitoring wells representing Aquifer-I (Shallow aquifer) of CGWB. The weathered zone thickness (aquifer-I), lithology and details of deeper aquifers (aquifer-II) of exploratory wells were also collected and compiled.

Hydrochemical Data - Ground water quality data of monitoring wells of CGWB representing shallow aquifer and data from exploratory wells representing deeper aquifer.

Exploratory Drilling – Ground water exploration data of exploratory wells of CGWB.

Hydrometeorological Data - Long term rainfall data for the whole district and for each block from Indian meteorological Department and Water Resource Department.

2.1 Hydrogeology

The entire Khargone district is almost characterized by Deccan Basalt (hard rock). These form the most important aquifers due to the large aerial extent in the district. The weathered, jointed, fractured or vesicular unit of each flow forms moderately potential aquifers. A typical flow unit consist of a lower dense massive, horizon passing upwards into vesicular, amygdaloidal or jointed basalt. At places, top of individual flows are marked by reddish brown clayey material (Red bole) of few cm to 5 – 20 m thickness. Usually the red-bole and vesicular basalt are prone to weathering and give rise extensive black cotton soil. There are different basaltic flows in a vertical column between altitudes of 377.3 to 163 m amslin entire Khargone district. Granite, Sandstone and shale is encountered in the district at a shallower depth towards the northern part of the district. Fractured granite and fractured sandstone form the aquifer of very low potential.

Aquifer System

Almost entire district is occupied by hard rocks (Deccan basalt). An aquifer with the upper surface under atmospheric pressureis called unconfined aquifer and aquifer where the groundwater is under hydrostatic pressure is called confined aquifer.TheseDeccan basalts form the most important aquifers due to the large aerial extent in the district. The district is covered by a large number of basaltic lava flows. The weathered, jointed, fractured or vesicular unit of each flow forms moderately low to medium potential aquifers. The red bole is unproductive but forms a confining layer and also indicated the presence of a productive horizon below. Dug wells in this formation range in depth from 6 -18.25 m having water level 2019 ranges from 0.5 m to 17.6 m approximately. The discharges vary from0.01 to 6.6lps, static water level ranges from 3.21 to 120 m.

Intense jointed basalt layer is sometimes present below the weathered basalts where the basalt is fractured and joints are open therefore the high permeability can be expected in this layer. Massive basalts with minor fractures as a aquifer unit is present as limited isolated pockets relatively on higher ground, where weathered profile thins out and the clay is sometimes absent. This massive basalt present at or very close to the surface and ground water will be restricted to occasional joints and fractures. In this situation the aquifers is likely

to be local patchy. Alluvium soil generally consisting of sandy soil mixed with Kankar and pebbles with a thin band of friable calcareous sandstone at the base occur along major river like Narmada river and along its tributaries. The thickness varies from less than a meter to 15 m. The occurrence of ground water in this zone is good.

2.2. Ground water scenario

Occurrence of Ground Water:

Ground Water occurs in different lava flows having distinctive feature like significant primary porosity in the form of vesicles lava tubes formed due to emanations of gases in weathered lava flows along with fractures, variation vesicles and its vide spatial and temporal with minerals considerable reduced by filling up with minerals like zeolites, calcite, and silica to form amygdule. Alternating sequence of previous and compact horizon acts as a multi aquifer system.

Shallow ground water occurs in the weathered vesicular, jointed fractured zones of basaltic flows generally under unconfined conditions at some places under semi confined to confined condition due to the presence of thickly silty clays overlying the jointed rocks in the cases of deeper aquifer.

Ground Water Levels

Variation of ground water levels in an area is an important component of hydrological cycle because of it is a physical reflection of aquifer system. As the change in ground water level is directly related to ground water balance and its continuous records provide direct information of sub surface geo environmental changes due to withdrawal of ground water. To monitor the seasonal & annual fluctuation, change in quantity and quality of ground water, CGWB has established ground water monitoring wells (Dug wells and Piezometers) in entire Khargone district and ground water levels is four times in a year, in months of May, August, November and January. To study ground water regime of the area pre monsoon and post monsoon maps of the Khargone district has been prepared.

Water level data, including historical data are essential for not only to know the present ground water conditions but also for forecasting future trends in response to ground water reservoir operations. Pre and post monsoon depth to water level is given in figure 8 and figure 9.

Pre MonsoonGround Water Level (May 2020)

Pre-Monsoon depth to water level of the Year 2020 ranges from **1.07mbglat Gogaon site**, Gogawanblockto**10.32mbgl at Divalgaonsite**,Gogawab block. The water level data is presented in Annexure II.

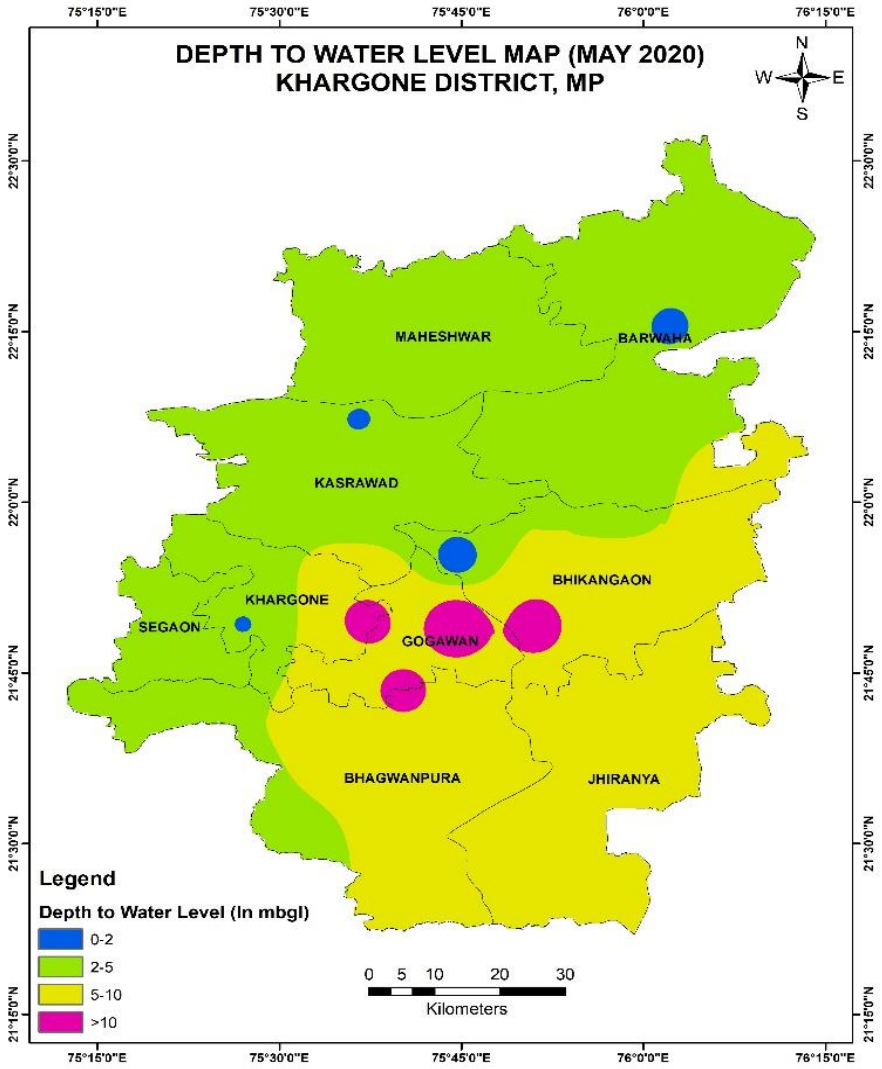


Figure 8: Pre-monsoon Depth to Water Level Map 2020

Post Monsoon Ground Water Level(November 2020)

During post monsoon period, water level ranges from 0.72**mbgl at Sawada site**, Kasrawad block to **9.17 mbglatGogao site, Gogawan** block. The water level data is presented in Annexure III..

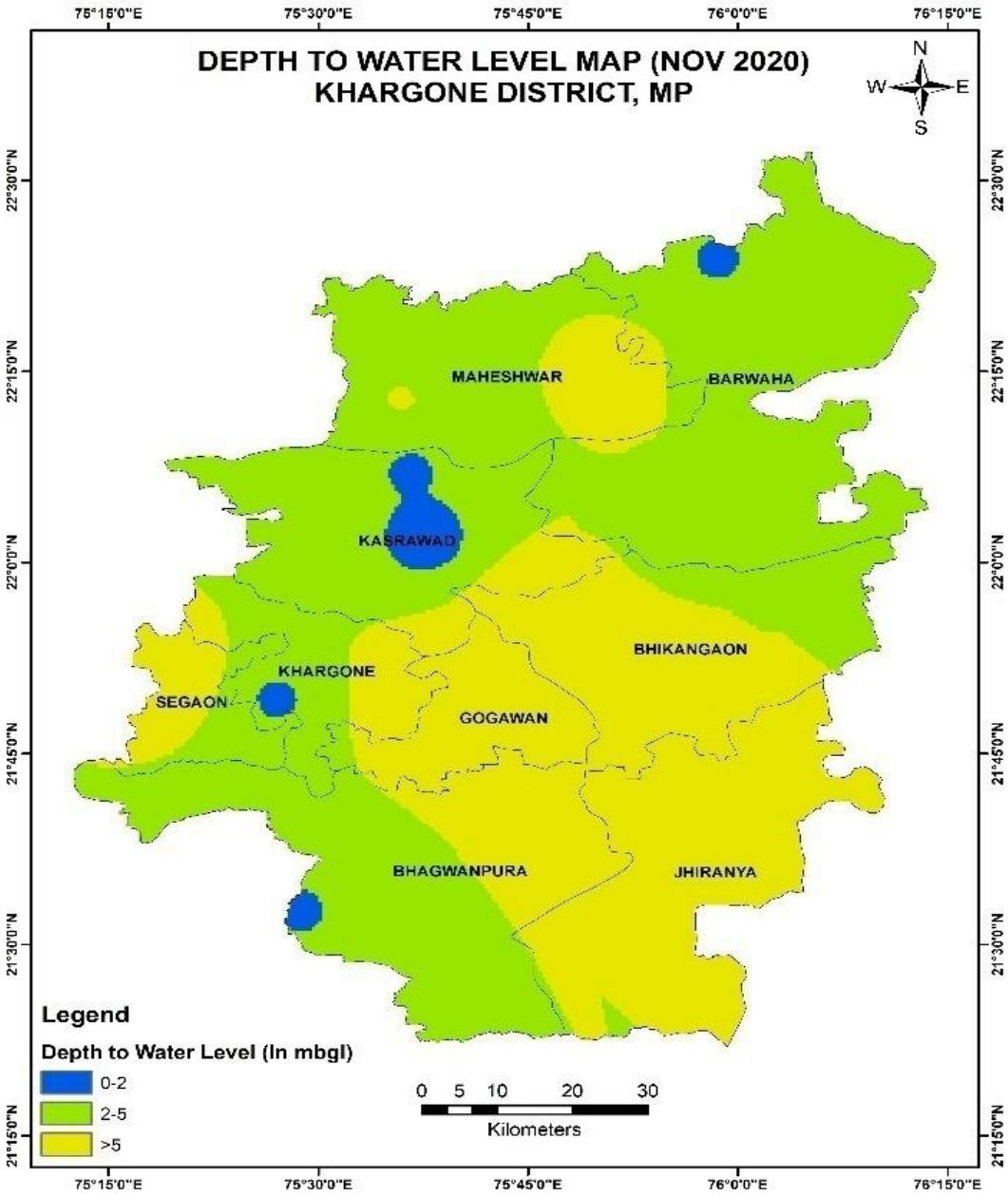


Figure 9: Post monsoon Depth to Water Level Map (Nov 2021)

2.3. Ground water Exploration:

CGWB has drilled 29 exploration borewells and 6 piezometers. On the basis of samples collected during drilling, lithologs have been prepared. The salient details of the some of the drilled bore wells and piezometersare given in Table 3. Locations of exploratory wells are given in figure 10.

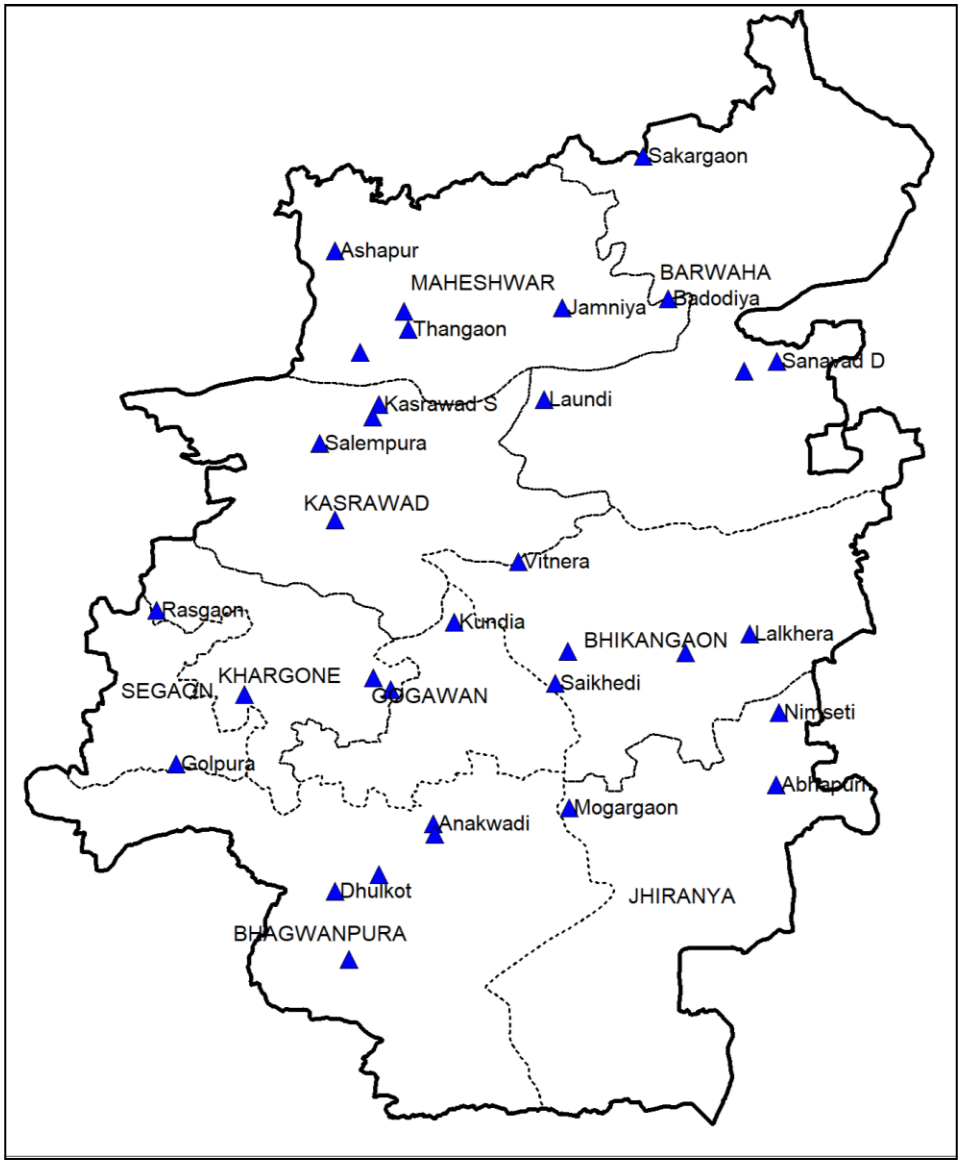


Figure 10: Exploratory wells location Map, Khargone District

Table 3: Salient Features of the constructed Piezometers and Exploratory Wells Khargone District during NAQUIM, CGWB, NCR, Bhopal

Sl. No	District	Block	Location	Longitude	Latitude	Elevation	Years of Construction	Depth of well constructed	Static water level (mbgl)	Discharge (lps)
1	Khargone	Bhikangaon	Amankhedi	75.5745	21.5401	771.7	2020	203.1	120	0.14
2	Khargone	Bhikangaon	Sakargaon	75.8931	22.4056	448.4	1982-83	105.84	dry	
3	Khargone	Bhagwanpura	Dhulkot	75.5590	21.6118	377.3	2020	200.2	59.89	2.8
4	Khargone	Seagaon	Golpura	75.3791	21.7455	375.6	2021	200.2	10.12	Negligible
5	Khargone	Bhikangaon	Abhapuri	76.0586	21.7235	366.9	2020	203.1	9.77	4.4
6	Khargone	Bhagwanpura	Bhagwanpu	75.6089	21.6292	338.7		91.45		
7	Khargone	Bhagwanpura	Anakwadi	75.6703	21.6828	335	2020	200.2	48.2	0.14
8	Khargone	Jhirniya	Nimseti	76.0618	21.7998	333.2	2020	203.1		
9	Khargone	Bhikangaon	Marugarh	75.6717	21.6717	332.9	2020	129.9		
10	Khargone	Bhagwanpura	Mogargaon	75.8245	21.6995	318		203.2		0.01, 0.38,
11	Khargone	Bhagawanpur	Kanjhar	75.8245	21.6995	318	2020	203.1	54	7.8
12	Khargone	Bhikangaon	Lalkhera	76.0290	21.8828	313.8	2020	203.1	6.33	0.9
13	Khargone	Khargone	Un	75.4563	21.8187	282.6	2021	200.2	22.12	Negligible
14	Khargone	Bhikangaon	Bhikhangao	75.9561	21.8631	281.6		120		
15	Khargone	Khargone	Khargone D	75.6222	21.8236	255.1		46.3		
16	Khargone	Khargone	Sukhpuri	75.6019	21.8360	246.1	2020	200.2	5.58	3.32
17	Khargone	Seagaon	Rasgaon	75.3564	21.9073	239.1	2020	200.2	10.2	0.38
18	Khargone	Bhikangaon	Sagur	75.8228	21.8640	237.7	2020	203.2		16
19	Khargone	Gogawan	Kundia	75.6941	21.8947	222.9	2020	200.2	4.25	9.5
20	Khargone	Bhikangaon	Umardad	75.6941	21.8947	222.9	2020	203.1	3.21	4.4
21	Khargone	Kasrawad	Besarkund	75.5585	22.0026	221.3	2020	200.2	5.88	4.4
22	Khargone	Bhikangaon	Vitnera	75.7667	21.9583	217	1982-83	232.45	11.9, 6.95	0.3,1.6,4.3
23	Khargone	Barwaha	Sanavad D	76.0597	22.1694	195.9		120		
24	Khargone	Maheswar	Badodiya	75.9365	22.2352	193.1	2021	203.1		
25	Khargone	Barwaha	Badud	76.0227	22.1590	188	2021	203.1		
26	Khargone	Barwaha	Laundi	75.7958	22.1292	181	1983-84	100.83	dry	dry
27	Khargone	Kasrawad	Kasrawad S	75.6083	22.1239	180.7		68.58		
28	Khargone	Maheswar	Thangaon	75.6417	22.2033	178	1983-84	110.55		negeligible
29	Khargone	Kasrawad	Salempura	75.5417	22.0833	177	1982-83	220.5		0.3
30	Khargone	Maheswar	Maheswar S	75.5875	22.1792	163		48.76		
31	Khargone	Bhikangaon	Saikhedi	75.8085	21.8304	249	2020-2021	203.1	39.65	0.88
32	Khargone	Maheswar	Jamniya	75.8161	22.2258	193	2020-2021	203.1	12.8	2.5
33	Khargone	Maheswar	Ashapur	75.5586	22.2858	222	2020-2021	148.4	136	0.76
34	Khargone	Kasrawad	Kasrawad	75.6016	22.1108	195	2020-2021	200.2	32	1.5
35	Khargone	Maheswar	Nazarpur	75.6368	22.2222	198	2020-2021	200.2	130	3

2.4 Ground Water Quality of Khargone District

2.4.1 Ground Water Quality of Shallow Aquifers

As per chemical analysis of pre-monsoon 2019, the ground water in the area of Kharogne district is slightly acidic to netural in nature and the pH of ground water ranged in between 7.03 to 7.78; the highest value of pH (7.78) has been observed in Balwara dug well. The electrical conductivity of ground water in Kharogne district ranges between 455 to 2325 µS/cm at 25°C and the maximum EC value at Barwah (2325 µS/cm at 25°C). The electrical conductivity shows that the ground water is good to slightly saline in nature and at some locations i.e.Dhargon (1880), Baddiya (1885), Gogaon (1900), PipliyaBuzurg (1985) and Barwah (2325). The fluoride concentration was ranged in between 0.24 to 0.70 mg/l. In the district, fluoride concentration has not been observed more than BIS recommendation of fluoride concentration in drinking water i.e. 1.5 mg/l. The maximum concentration of fluoride has been recorded in the dug well of Balwarai.e. 0.70 mg/l. In the district, nitrate concentration in ground water ranged in between 7 to 102 mg/l. About 38% ground water samples recorded nitrate concentration within the acceptable limit of 45 mg/l and 62% water samples recorded more than 45 mg/l as per BIS recommendation. The high nitrate concentration has been recorded in ground water of Bamnala New (50 mg/l), Bhulwani (55 mg/l), Kasrawad (55 mg/l), Baddiya (57 mg/l), Dhulkot (65 mg/l), Khargone (70 mg/l), Dhargaon (80 mg/l), Gogaon (80 mg/l), Bhikangaon (85 mg/l), Barwah (100 mg/l), Daudwa (100 mg/l), Segaon (100 mg/l) and Piplyabuzrug (102 mg/l). Total hardness of ground water in the study area ranged in between 56 to 545 mg/l. The high concentration has been observed in the dug well of Baddiya (545 mg/l).

As per the piper diagram(Fig 11), water samples are Calcium Bi-carbonate (temporary hardness), Sodium Chloride (Saline) and Mixed Types of water. The US Salinity Diagram (Fig 12),shows the ground water is medium to high salinity classes i.e. C_2S_1, C_3S_1, C_3S_2 and C_4S_2. The C_3S_2 and C_4S_2 classes of water may be used for irrigation purpose with proper soil management. Ground Water Quality of Khargone district of Shallow Aquifer given in (Table 4.1)

Table 4.1: Ground Water Quality of Khargone district of Shallow Aquifer

S. No.	Year	Block	Village	EC	HCO3	Cl	NO3	F	Ca	Mg	Na	K
1	2019	Barwaha	Amba	1220	400	87	40	1	84	41	100	4
2	2019	Maheshwar	Baddiya	1885	406	379	57	1	184	21	185	2
3	2019	Barwaha	Balwara	490	191	32	25	1	60	4	36	1
4	2019	Bhikangaon	Bamnala New	1072	400	84	50	1	120	26	55	1
5	2019	Barwaha	Barwah	2325	455	223	100	1	80	79	285	7
6	2019	Bhikangaon	Bhikangaon1	1285	430	94	85	0	142	10	110	2
7	2019	Bhagwanpura	Bhulwani	830	375	35	55	1	60	12	98	2
8	2019	Bhikangaon	Daudwa	1410	449	136	100	0	148	31	93	3
9	2019	Maheshwar	Dhargaon	1880	566	228	80	0	150	22	212	5
10	2019	Bhagwanpura	Dhulkot	780	252	72	65	0	96	11	45	2
11	2019	Gogawan	Divalgaon	625	105	111	20	0	54	4	72	1
12	2019	Bhagwanpura	Ghatti	855	98	121	29	1	18	3	170	1
13	2019	Bhikangaon	Gogaon	1900	560	265	80	0	180	22	187	3
14	2019	Kasrawad	Kasrawad1	455	123	37	55	0	30	2	64	1
15	2019	Bhikangaon	Khargone	1115	424	92	70	0	62	34	115	3
16	2019	Maheshwar	Maheshwar	1005	350	106	30	0	98	18	75	2
17	2019	Maheshwar	Piplyabuzrug	1985	326	327	102	1	106	38	260	5
18	2019	Barwaha	Sanawad New	1090	486	84	25	0	88	5	139	2
19	2019	Kasrawad	Sawda	510	234	17	7	1	64	5	35	1
20	2019	Segaon	Segaon	1072	314	59	100	0	90	17	110	1
21	2019	Khargone	Un	965	394	94	15	0	84	24	77	2

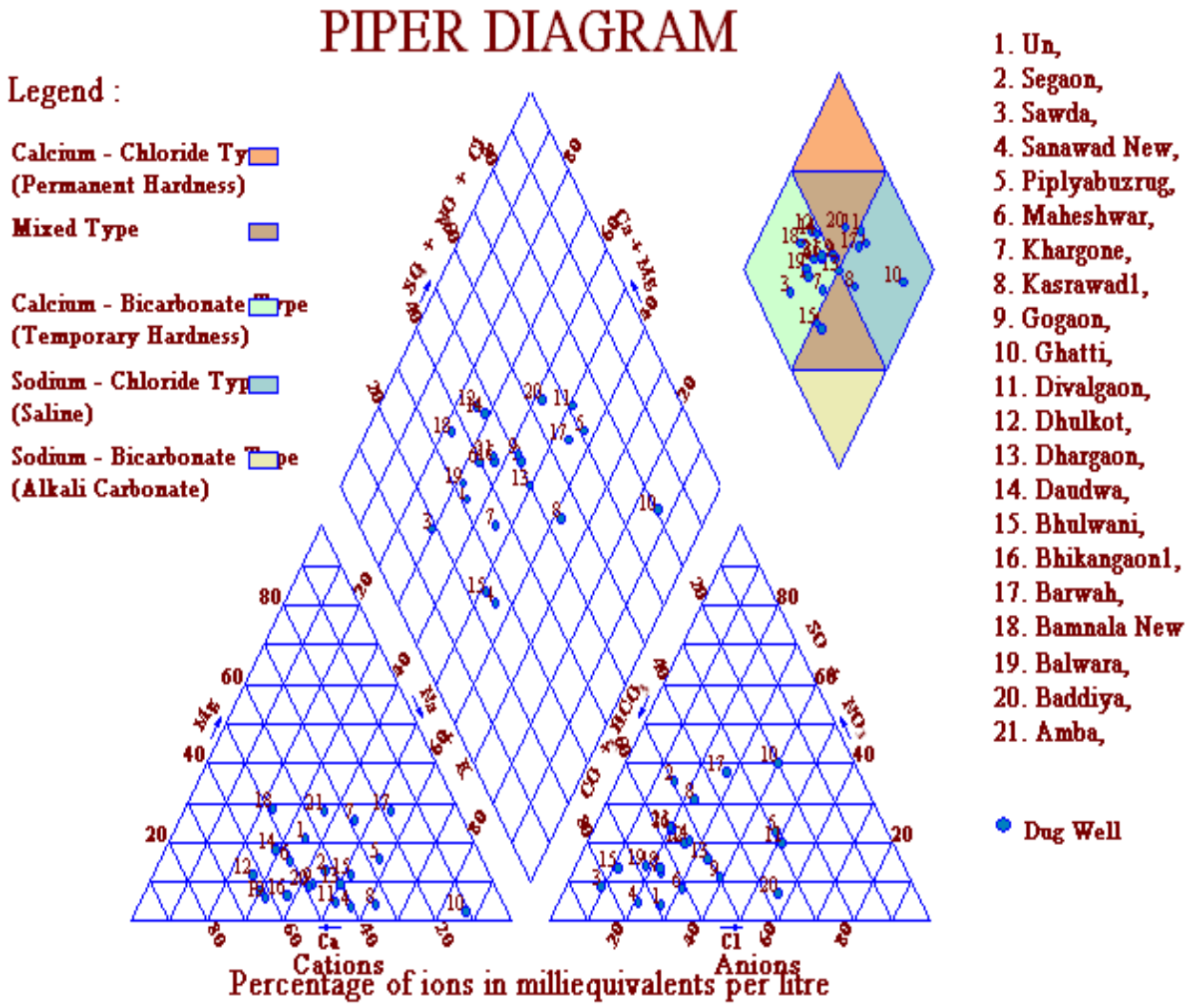


Fig 11: HillPiper diagram for Kharogne district of Shallow Aquifer

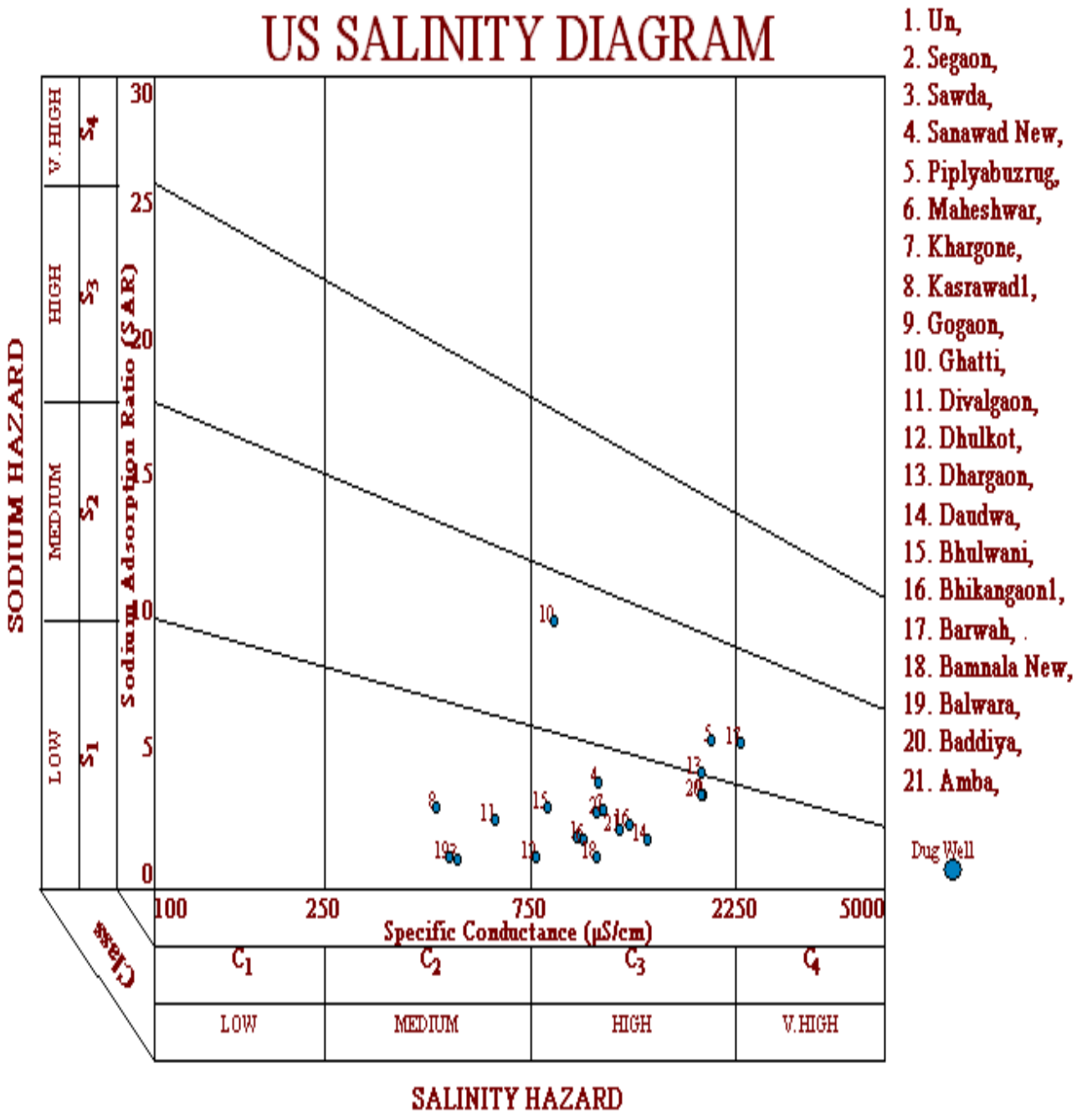


Fig 12: US Salinity diagram for Khargone district of Shallow Aquifer

2.4.2 Ground Water Quality of Deeper Aquifers

As per chemical analysis of samples of exploratory and observatory well, the ground water in the area of Kharogne district is having a good quality of groundwater except in some places where slightly acidic to basic in nature and the pH of ground water ranged in between 6.8 to 8.1; the highest value of pH (8.1) has been observed in Jamniya EW. The electrical conductivity of ground water in deeper aquifers of Kharogne district ranges between 395 to 1502 µS/cm at 25°C and the maximum EC value at Mogargaon (1502 µS/cm at 25°C). The electrical conductivity shows that the ground water is good in quality. The fluoride concentration was ranged in between 0.02 to 3.85 mg/l. In the district, fluoride concentration has not been observed more than BIS recommendation of fluoride concentration in drinking water i.e. 1.5 mg/l. The maximum concentration of fluoride has been recorded in the borewell of Ashapuri.e. 3.85 mg/l.In the district, nitrate concentration in ground water ranged in between 2.8 to 110 mg/l. About 92% ground water samples recorded nitrate concentration within the acceptable limit of 45 mg/l and only 8 % water samples recorded more than 45 mg/l as per BIS recommendation. The high nitrate concentration has been recorded in ground water of Mohargaon(110 mg/l), Golpura (48 mg/l), Saikheda(48 mg/l).Ground Water Quality of Khargone district of Deeper Aquifer given in Table 4.2.

Table 4.2: Ground Water Quality of Khargone district of Deeper Aquifer																			
Block	**Location**	**Source**	**Lat.**	**Long.**	**pH***	**EC***	**CO_3***	**HCO_3**	**Cl**	**SO_4***	**NO_3***	**F***	**PO_4***	**SiO_2***	**TH**	**Ca**	**Mg***	**Na***	**K***	**TDS**
Jhirniya	Abhapuri(EW)	EW	21.43	76.03	7.67	505	0	180.56	27.99	11.74	28.8	0.5	0	40.08	132	7.8	45.04	0.57	43.4	313.1
Barwah	Badod	EW	22.16	76.0	7.6	685	0	280	37	42	12	0.4	BDL	16	258	44	36	37	0.6	445
Barwah	Badod	OW	22.16	76.0	7.7	665	0	268	35	45	16	0.4	BDL	18	268	42	39	28	1.2	432
Barwah	Badod	EW	22.16	76.0	7.5	692	0	305	35	30	12	0.4	BDL	23	263	44	37	36	1.2	450
Kasarwad	Besarkun	EW (1st	22.00	75.5	7.8	753	0	264.4	77.58	20	13	0.2	BDL	28	277.2	77.2	20.46	42	1.6	489.45
Kasarwad	Besarkun	EW	22.00	75.5	7.6	770	0	300.5	75.08	15	9	0.2	BDL	38	202.9	55.4	15.64	82	1.6	500.5
Kasrawad	Besarkund(EW)	EW	22.00	75.56	7.61	548	0	175.68	51.98	24.18	27.8	0.36	0	38.48	104	1.9	71.24	0.52	48.6	339.76
Kasrawad	Besarkund(OW)	OW	22.00	75.56	7.6	939	0	409.92	63.98	37.22	26.6	0.56	0	92.99	368	33.1	52.33	0.25	38.4	582.18
Bhagwanp	Dhulkot	EW	21.61	75.5	6.8	575	0	268	30	15	15	0.6	BDL	32	237	57	23	25	1.5	374
Bhikangao	Kanjhar	EW	21.94	76.0	7.8	725	0	317	40	32	10	0.6	BDL	22	293	53	39	30	0.8	471
Gogaon	Kundiya(EW1)	EW1	21.89	75.69	7.36	554	0	263.52	37.99	12.74	3.4	0.52	0	54.51	164	6.8	46.97	0.87	41.2	343.48
Bhikangao	Lalkhei	EW	21.88	76.0	7.6	719	0	316	15	45	10	1.2	BDL	20	235	38	34	60	1.1	
Jhirnia	Marugarh	OW	21.67	75.9	7.7	460	0	137	25	60	20	0.7	BDL	28	141	40	10	40	1.7	299
Bhagwanp	Mogargao	EW	21.70	75.8	7.8	1502	0	405	175	75	110	0.0	BDL	40	335	48	52	160	74	976
Bhikamgao	Sagur	EW	21.86	75.8	7.9	530	0	260	27	5	7	0.4	BDL	35	185	30	27	35	1.8	345
Bhikamgao	Sagur	EW	21.86	75.8	7.8	650	0	321	35	4	6	0.3	BDL	32	230	36	34	42	1.4	423
Bhikamgao	Sagur	PYT	21.86	75.8	7.8	630	0	309	35	5	5	0.5	BDL	28	225	34	34	40	1.1	410
Bhikangaon	Sagur(EW2)	EW-2	21.86	75.82	7.3	750	0	326.96	27.99	19.76	20.8	0.42	0	72.14	280	24.4	32.06	0.44	44	465
Bhikangaon	Sagur(OW1)	OW1	21.86	75.82	7.19	1182	0	43.92	271.92	50.8	2.8	0.75	0	80.16	228	6.8	129.85	0.97	21	732.84
Bhikangaon	Sagur(OW2)	OW2	21.86	75.82	7.61	665	0	278.16	35.99	22.95	21.4	0.46	0	57.72	232	21.4	45.92	0.32	42.8	412.3
Khargone	Sukhpuri	OW			7.5	1245	0	321.1	187.7	54	15	0.3	BDL	40	267.3	63.3	26.5	158	1.8	809.25
Khargone	Sukhpuri,	EW	21.84	75.6	7.5	900	0	231	160	5	30	1.2	BDL	24	200	62	11	112	1.5	

Table 4.2: Ground Water Quality of Khargone district of Deeper Aquifer																			
Block	**Location**	**Source**	**Lat.**	**Long.**	**pH***	**EC***	**CO_3***	**HCO_3**	**Cl**	**SO_4***	**NO_3***	**F***	**PO_4***	**SiO_2***	**TH**	**Ca**	**Mg***	**Na***	**K***	**TDS**
Bhikangaon	Umardad(EW)	EW	21.48	75.58	7.6	560	0	209.84	31.99	17.46	34	0.44	0	43.29	136	6.8	60.13	0.65	34.2	347.2
Bhikangao	Umardad(	OW	21.48	75.5	7.6	548	0	224.4	25.99	16.05	38	0.3	0	46.	136	4.9	57.43	0.3	32.	339.76
Maheswar	Ashapura(EW)	EW	22.29	75.56	7.57	755	0	203	87	65	15	3.85	BDL	20	75	24	4	138	0.9	491
Seagaon	Golpura(EW)	HP	21.75	75.81	7.89	625	0	302	12	6	48	0.68	BDL	25	300	52	41	5	0.5	406
Maheswar	Jamniya(EW)	EW	22.23	75.82	8.11	410	0	185	22	5	15	0.91	BDL	16	125	26	15	36	0.3	267
Kasrawad	Kasrawad (EW)	EW	22.11	75.61	8.09	395	0	92	50	30	17	1.17	BDL	18	40	12	2	70	0.2	257
Kasrawad	Kasrawad (PYT)	EW	75.61	75.61	7.92	425	0	142	37	22	19	0.83	BDL	22	70	22	4	64	0.5	276
Gogawan	Kundia	EW-2	21.89	75.6	7.9	530	0	224.2	40.04	5	17	0.4	BDL	25	158.4	19.8	26.48	48	1.5	344.5
Block	**Location**	**Source**	**Lat.**	**Long.**	**pH***	**EC***	**CO_3***	**HCO_3**	**Cl**	**SO_4***	**NO_3***	**F***	**PO_4***	**SiO_2***	**TH**	**Ca**	**Mg***	**Na***	**K***	**TDS**
Gogawan	Kundia	OW	21.89	75.69	7.92	590	0	254.525	42.5467	8	15	0.62	BDL	24	193.05	23.76	32.5037	45	1.4	383.5
Jhirnia	Morangarh	OW	21.67	75.99	7.55	487	0	84.84	97.61	12	4	0.38	BDL	29	74.25	13.86	9.6307	70	1.3	316.55
Maheswar	Najarpur	EW	22.22	75.64	7.84	1092	0	367	105	54	19	1.53	BDL	41	305	66	34	108	2.2	710
Maheswar	Nazarpur	OW	22.22	75.6	7.40	675	0	308	25	12	42	0.71	BDL	16	310	54	43	12	0.5	439
Segaon	Rasgaon	EW	21.91	75.3	7.64	671	0	218	70	22	23	0.82	BDL	27	180	44	17	70	1.9	436
Bhikangaon	Saikhedi(EW)	EW	21.83	75.81	7.75	615	0	265	30	5	48	0.71	BDL	23	275	58	32	14	1.0	400
Khargone	Un(EW)	HP	21.82	75.46	7.97	1105	0	450	110	10	19	0.53	BDL	30	110	26	11	202	2.0	718

CHAPTER-3

DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

After the study and analysis of the historical data,lithological data collected from 21 CGWB exploratory borewells and 4 piezometers were compiled and integrated as per Rockworks software format to prepare the 3-Dimensional Stratigraphic model and 2-Dimensional Cross section. It has been interpreted from the 3-D Model and 2-D Section is presented in the figure 11, 12, 13 & 14 that the major water bearing zones has been encountered in weathered/fractured basalts and vesicular basalt. It comprises all the existing litho-units and the zones tapped during the groundwater exploration, forming an aquifer.

3.1 3-D Lithological & 3-D Stratigraphic model

A 3-Dimensional Lithological & Stratigraphic model was prepared for the Khargonedistrict, Madhya Pradesh after detailed analysis of the pre-existing and available bore-log data collected from the Basic Data Reports of CGWB. A comprehensive analysis was made as per lithology and stratigraphy of the area. The lithology of the areaisresentedin the Annexures- I

The 3-D Model results showed that the region is dominantly occupied by alternate layers of different basaltic flows and at the base sandstone, shale and granite. The sandstone, shale and granite encountered at shallow depth as moves towards the north. The sub-surface lithology has been broadly classified into Top soil/Unsaturated zone, underlain by Weathered/fracturedBasalt, vesicular basalt, massive basalt, red bole, sandstone and shale: shallow aquifer (upto a depth of 30 mts) and deeper Aquifer (30-200) mts.

Table 5: Ground Water Quality of Khargone district of Deeper Aquifer

Type of Aquifer	Formation	Aquifers Range (mbgl)	Fractures Encountered (mbgl)	Range of Yield (lps)	Sustainability	Static Water Level	Water Quality Shallow Aquifer
Shallow Aquifer	Weathered / Fractured Basalt	0-30	20.3 – 23.3m, 13- 17 m, 7.9 - 10.5m, 15-18m, 9.15 – 8.5 m	-	2-5 hours	0.5 - 17.6 mbgl	62 % samples having NO_3>45 mg/l
Deeper Aquifer	Fractured / Vesicular Basalt/ Fractured granite	31-200	133 – 140 m, 75.2-78.2m, 123-126.8 m, 108.5 – 111.6m, 99.5-102.5m, 148.2 – 151.2 m	0.01 – 16	6-7 hours	3.21 – 120 mbgl	8 % samples having NO3 >45 mg/l , 5 % samples > 1.5 mg/l concentration

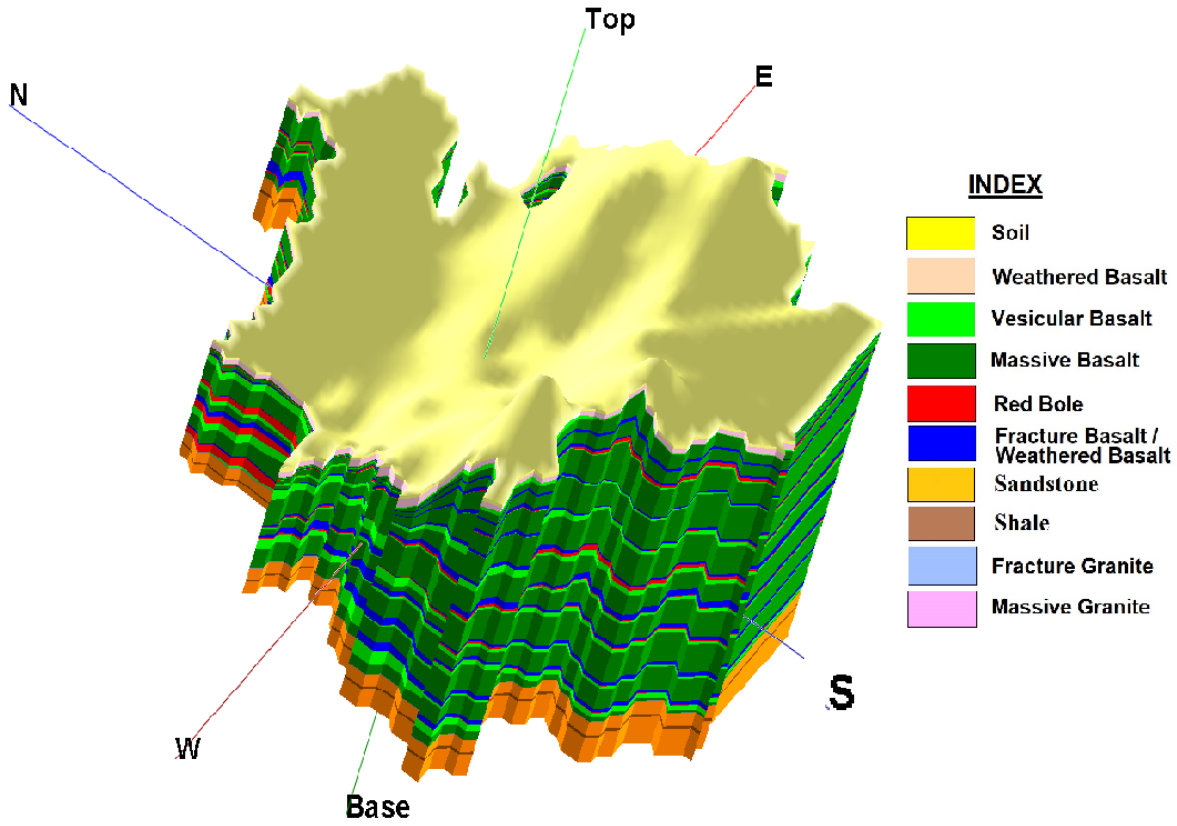


Figure13: 3-D Lithological Model of Khargone District, Madhya Pradesh

3.2 Fence Diagram

Based on the groundwater exploration lithological Fence diagram was also prepared using the Rockworks software. The pattern for the Fence was chosen as such to cover the maximum portion of the region to represent the enhanced picture of the sub-surface as deciphered from the 3-D stratigraphic model.

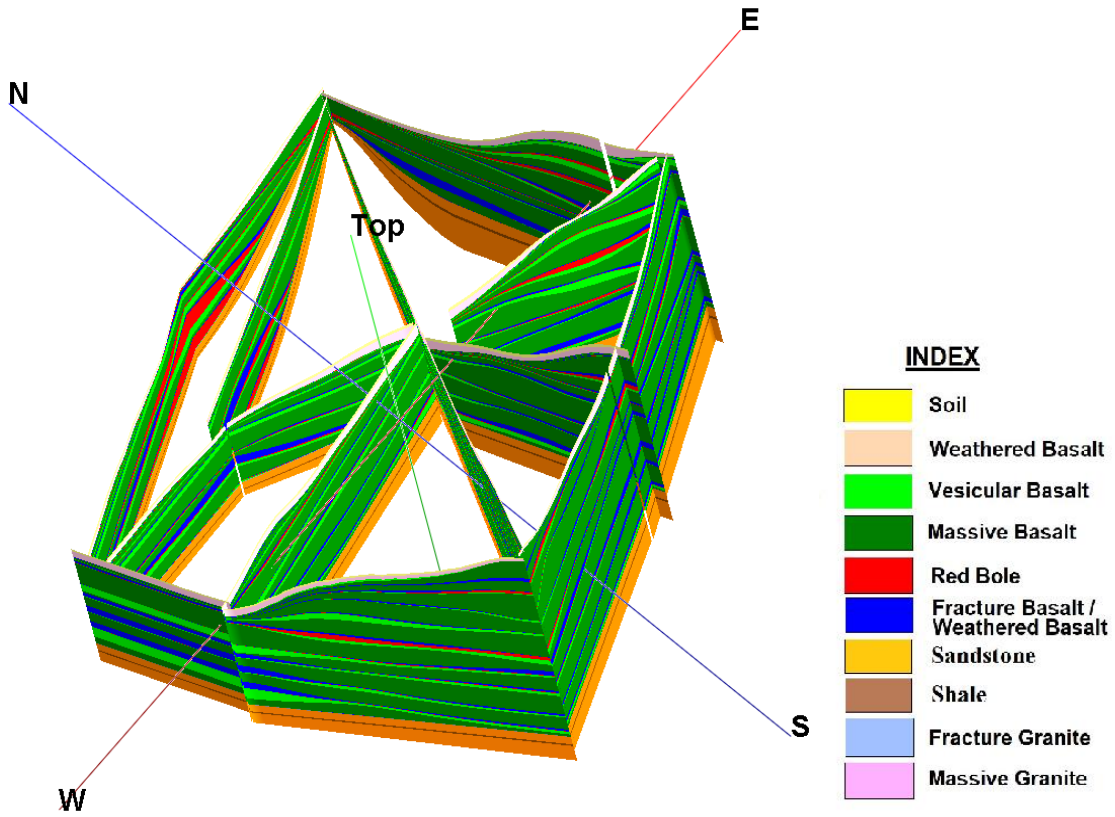


Figure 14: Fence Diagram, Khargone District, Madhya Pradesh

3.3 2-D Cross Section of Khargone District

Sub-surface lithological section has been prepared based on the based on the existing ground water exploration data to know the lithological continuity, its vertical and lateral extent.2-Dimensional cross-section along the section line **A-A'(Dhulkot - Badodiya)**, representing (north – south direction) covering the wells has been prepared using Rockworks. The cross-section shows that the aquifer(vesicular basalt or fracture basalt or weathered basalt) is not continuing for the whole region of Khargone district, massive granite, fracture granite, shale, sandstone and fractured sandstone is encountered at shallower depth towards the northernpart of the district.The basaltic lava flows in the entire district is almost horizontal and followed the topography.The section line **A-A'** represents **Dhulkot – Sukhpuri – Kundia – Vitnera – Laundi – Badodiya** and section line **B-B'**represents**Golpura – Un – Kundia – Vitnera –Badud.**

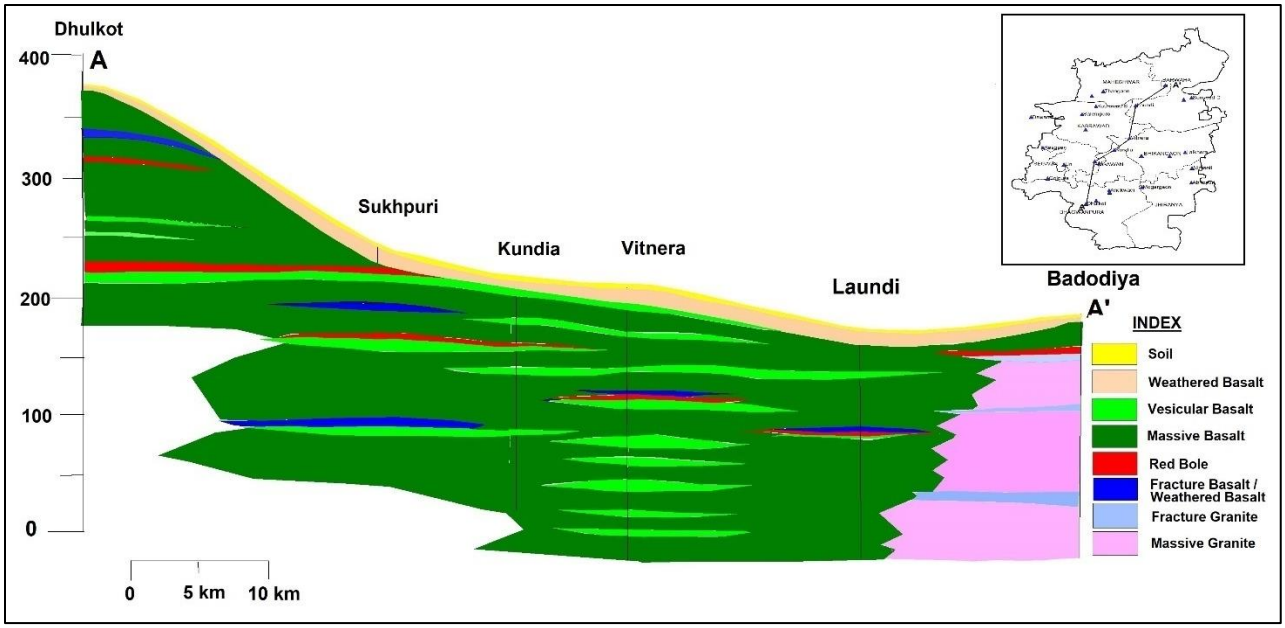


Figure 15: 2-D Cross sections A-A'(Dhulkot - Badodiya) of Khargone district

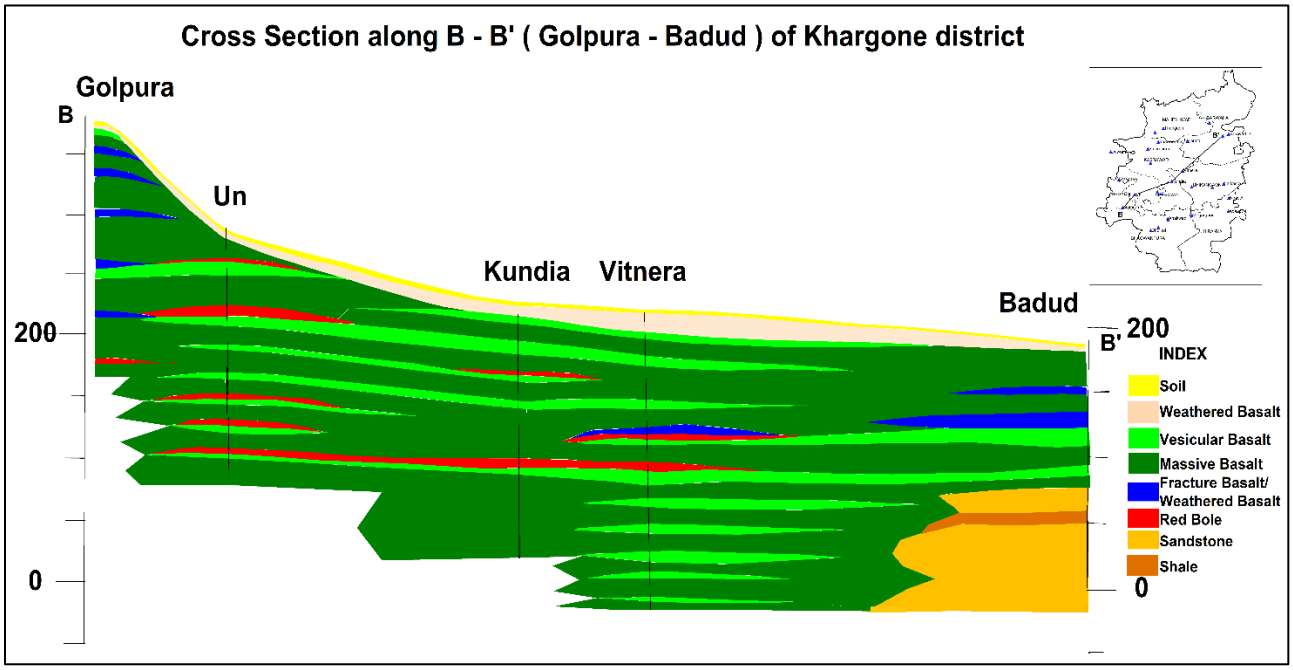


Figure 16: 2-D Cross sections B-B'(Golpura - Badud) of Khargone district

Chapter-4

GROUND WATER RESOURCES

4.1 Dynamic Ground Water Resources:

The dynamic ground water resources of the Madhya Pradesh state assessed jointly by the CGWB and State Ground Water Departments under the supervision of the State Level Committees and have been estimated for the Khargone district for the 2020**on block wise** basis. There are 9 assessment units (blocks) in the districtnamelyBarwah, Bhagwanpura, Bhikangaon, Gogawan, Kasrawad, Khargone,Mahashwar, Segaon and Zirniya. Out of 8030 sq. km of geographical area, 6568.97 sq. km. is ground water recharge worthy area and 1461.03 sq. kmis forest and hilly area.

Out of nine assessment units (blocks) in the district, one blocks fall under semi-critical category namely Khargone and rest 8 block falls under safe category.

Ground water resources have been computed including two components i.e.1)Groundwater recharge during the monsoon season and 2) Groundwater recharge during non-monsoon season.

The resource assessment during the monsoon season is estimated as the sum total of the change in storage and gross ground water draft. The change in storage is computed by using the water level fluctuation method. The other sources of ground water recharge during monsoon season include recharge from rainfall, seepage from canals, surface water irrigation, tanks and ponds, ground water irrigation, water conservation structures. The rainfall recharge during monsoon season computed by Water Level Fluctation (WLF) method is compared with recharge figures from RainFall Infiltration Factor (RIF) method. In case the difference between the two sets of data are more than 20%, then RIF method is considered otherwise monsoon recharge from WLF is adopted.**The resource assessment during non - monsoon season** is computed by using Rainfall Infiltation Factor (RIF) method. Recharge from other sources is then added to get the total non-monsoon recharge. In case of areas receiving less than 10% of the annual rainfall during non-monsoon season, the rainfall recharge is ignored.**The total annual ground water recharge** of the district is the sum of monsoon and non-monsoon recharge. An allowance is kept for ecological flow the rivers by deducting 5% of the total annual ground water recharge, if WLF method is employed to compute rainfall recharge during monsoon season and 10 % of the total annual ground water recharge if RIF method is employed. **Recharge from rainfall and other sources during rainfall** season in the Khargone district is 63404.27 hec and 5658.22 hec respectively. **Recharge from rainfall and other sources during non-monsoon season**are 0 hec and 44762.52 hecrespectively.TheAnnual Extractable Ground Water Resource in the district is 1059.61 MCM and ground water draft for all uses is 457.27 MCM, making stage of ground water extraction to 43.15.45% as a whole for the district.Table6shows the Dynamic Ground Water Resource Assessment estimated by CGWB for the year 2020.

4.2 Static Ground Water resources:

As an outcome of NAQUIM blockwiseGround Water Resource of Khargone District has also been calculated in which the **in-storage resource** for the shallow aquifer below zone of fluctuation (upto 30 mbgl) is computed to be around 628.91MCM and **the static resource** for the deeper aquifer (30-200 mbgl) is computed as 337.79MCM.

4.3 Ground water Draft:

The groundwater draft is the quantity of groundwater withdrawn from the ground reservoirs. The total quantity withdrawn i.e. for irrigation, domestic and industrial purpose is called as gross groundwater draft. Annual groundwater draft is estimated based on the total number of borewell/tubewell/dugwell and unit draft. The draft of dug well and tube well has been calculated separately to assess the ground water draft for irrigation from **shallow and deeper aquifers** that accounts to **414.30 MCM**. The block-wise ground water resources and draft as an outcome of NAQUIM is presented in the Table6&7

Table 6: Dynamic Ground Water Resources of Khargone district (as on March 2020)

Assessment Unit Name	Ground Water Extraction for Irrigation Use (Ham)	Ground Water Extraction for Domestic Use (Ham)	Total Extraction (Ham)	Annual GW Allocation for for Domestic Use as on 2025 (Ham)	Net Ground Water Availability for future use (Ham)	Stage of Ground Water Extraction (%)	Categorization
SEGAON	3171.068	217.4736	3388.54	237.8	2431.13	58.02	safe
BARWAHA	6991.86	735.2776	7727.14	789.33	12239.72	38.60	safe
BHIKANGAON	6353.11	491.6577	6844.77	547	6492.37	51.11	safe
KASRAWAD	5446.45	575.8769	6022.33	624.11	20078.59	23.03	safe
KHARGONE	4357.6416	356.6196	4714.26	382.95	1419.17	76.53	semi_critical
BHAGWANPURA	2218.17	536.3617	2754.53	602.27	4650.6	36.87	safe
GOGAWAN	3070.02	292.2314	3362.25	305.7	2556.47	56.68	safe
MAHASHWAR	5958.61	515.4091	6474.01	556.53	5839.24	52.40	safe
ZIRNIYA	3866.9032	572.5974	4439.5	698.15	4076.46	51.37	safe
DISTRICT TOTAL	**41433.83**	**4293.5**	**45727.33**	**4743.84**	**59783.75**	**43.15**	**safe**

Table 7: Total Ground Water Resources (Outcome of NAQUIM)

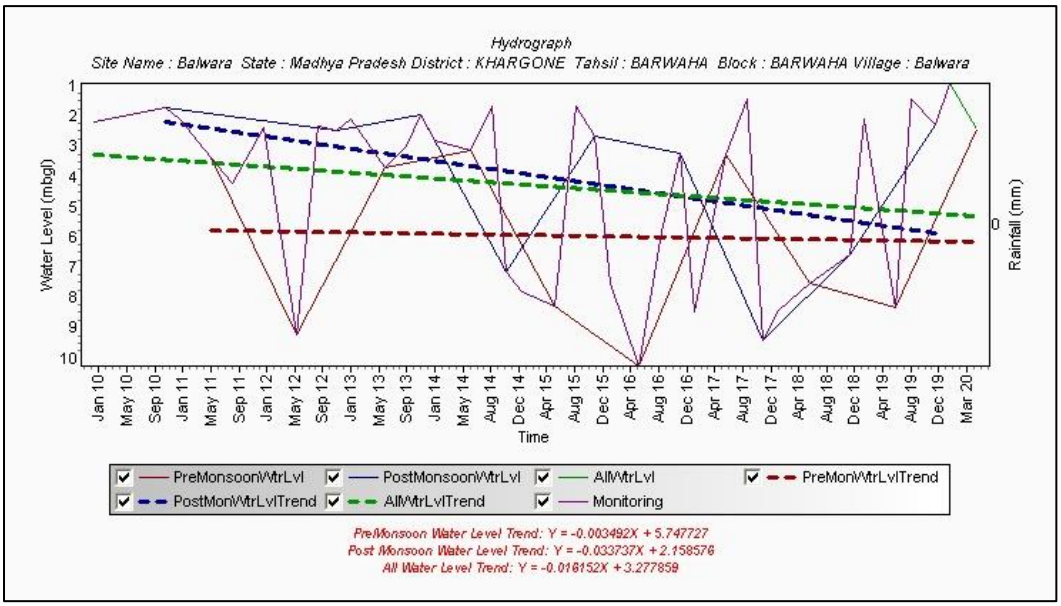
	Barwaha	**Bhagwanpura**	**Bhikangaon**	**Gogawan**	**Kasrawad**	**Khargone**	**Mahashwar**	**Segaon**	**Zirniya**	**Total**
First Aquifer										
Dynamic Resources (MCM)	200.20	74.71	133.92	59.31	261.49	61.59	123.54	58.40	86.41	1059.57
Static Resources (MCM)	148.27	48.03	78.49	22.51	141.17	47.97	85.68	45.59	58.98	628.91
Total Resources (MCM)	**348.47**	**122.74**	**212.41**	**81.82**	**402.66**	**109.56**	**209.22**	**103.99**	**145.39**	**1688.48**
Second Aquifer										
Static Resources (MCM)	81.30	36.68	49.40	19.54	54.65	28.70	30.57	15.25	34.56	337.79
Total GW Resources (MCM)	429.77	159.42	261.81	101.36	457.31	138.26	239.79	119.24	179.95	2026.27

CHAPTER -5
GROUND WATER RELATED ISSUES

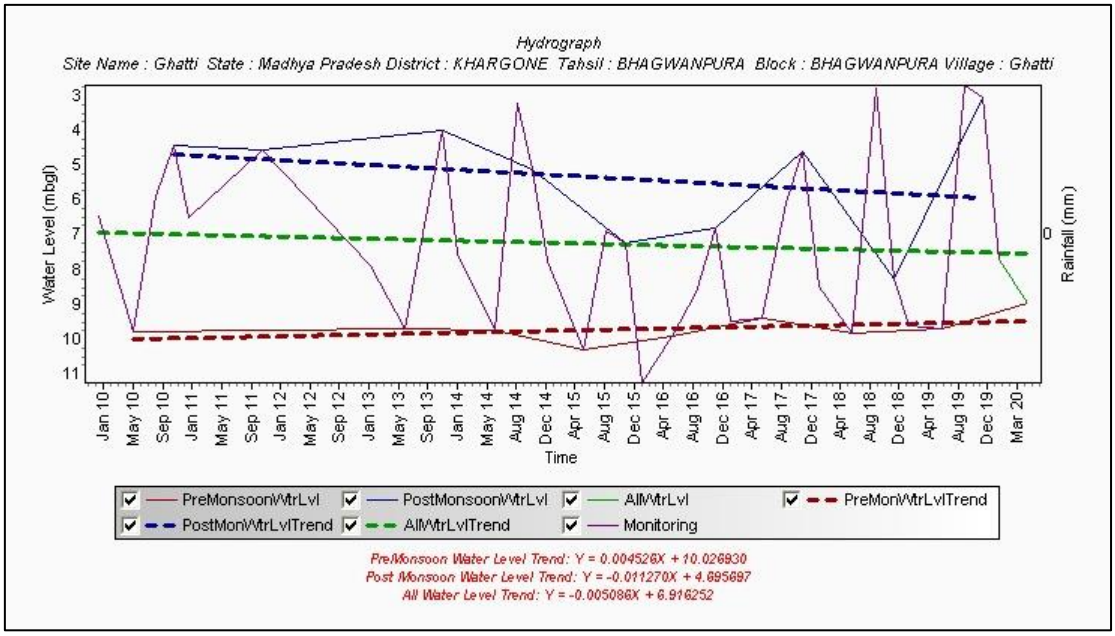
5.1 Ground Water Depletion/ Exploitation of Ground water

In the last 20 years a huge pressure came on utilization of groundwater in the Khargone district for the agriculture and drinking purpose. Almost 30- 40 % agricultural practices in the district are depend upon the rainfall every year. Groundwater is one of the main sources for irrigation. Depth of the borewells and tubewellsareincreasing every year to meet the demand of water for drinking, agriculture and industrial purpose. Shallow aquifers i.e.dugwells yield is reducing due to over development of deep aquifers by the borewell or tubewell. The shallow aquifers in many parts of the district recharge during the monsoon period and sustain only for 3-6 hrs this enforce for over development of deeper aquifers and decline in water level in last few decades. Ground Water Resource Estimation for the year 2020 also reveals that out of 9 blocks of the district 1 block have crossed 70% stage of ground water extraction and other 8 blocks falls under safe category. But this rapid extraction of ground water continues soon the rest of the 8 blocks will come under the semi-critical or critical category. The hydrographs of the Khargone district also shows that the ground water is declining.

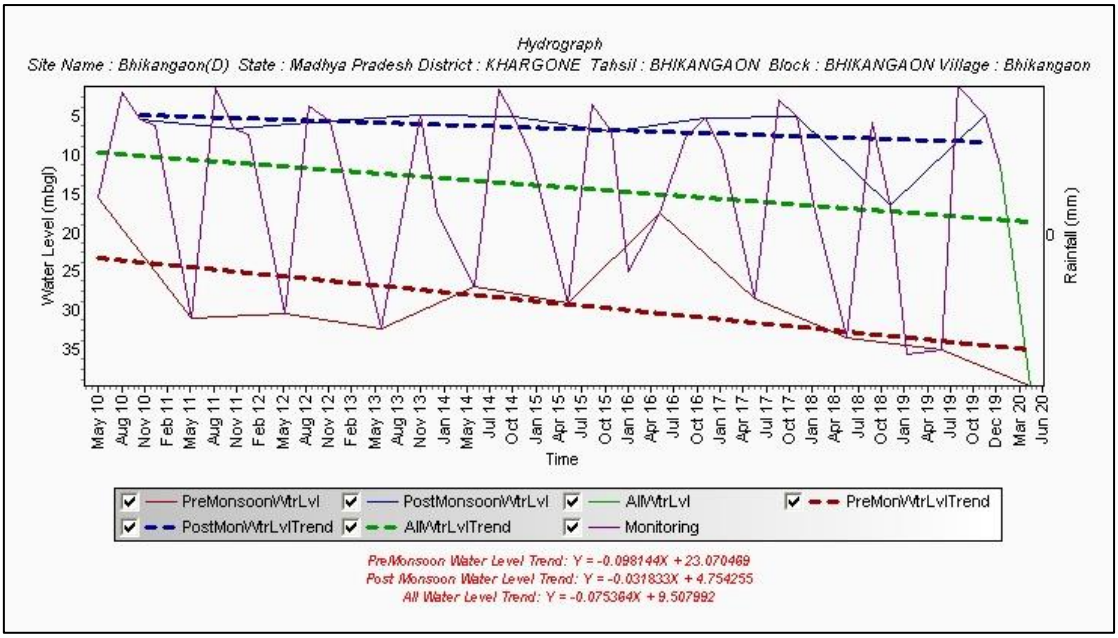
Balwara village, Barwaha Block



Ghatti village, Bhagwanpura Block



Bhikhangaon Village, Bhikangaon block



Khargone site, Khargone block

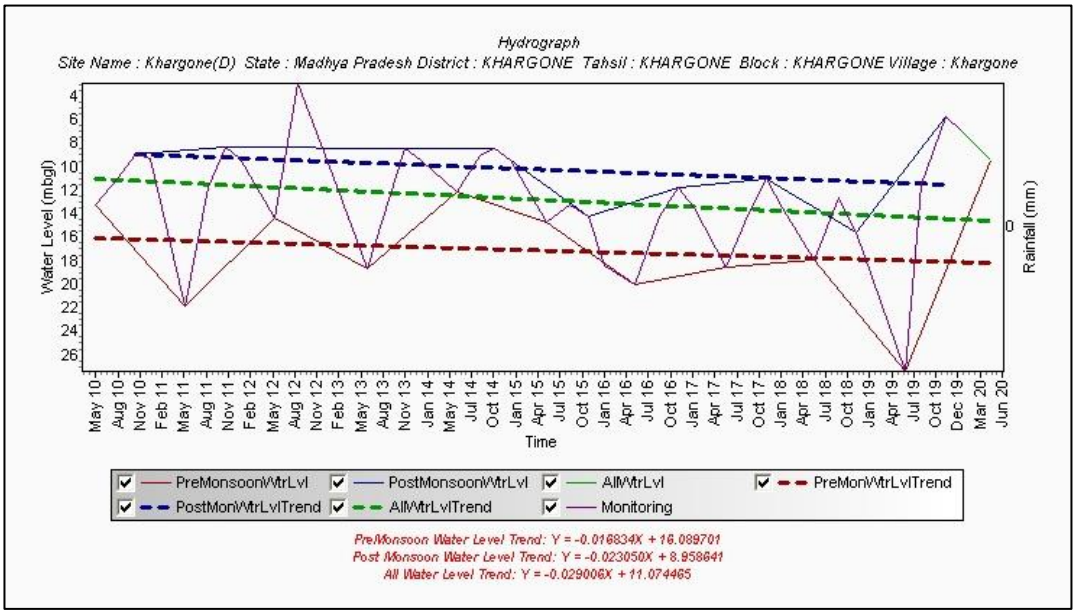


Figure 15:Hydrographs showing declining water level trend at sites Balwara village, Ghatti village, Bhikangaon village and Khargone village, Khargone District, Madhya Pradesh.

5.2 Ground water quality

In Khargone district-

Shallow Aquifer*:*

Nitrate:About62% water samples recorded more than 45 mg/l as per BIS recommendation. The high nitrate concentration has been recorded in ground water of Bamnala New (50 mg/l), Bhulwani (55 mg/l), Kasrawad (55 mg/l), Baddiya (57 mg/l), Dhulkot (65 mg/l), Khargone (70 mg/l), Dhargaon (80 mg/l), Gogaon (80 mg/l), Bhikangaon (85 mg/l), Barwah (100 mg/l), Daudwa (100 mg/l), Segaon (100 mg/l) and Piplyabuzrug (102 mg/l).

Deeper Aquifer:

In deeper aquifers the groundwater is good except in some areas. The nitrateconcentration in 3 samples recorded more than 45 mg/l as per BIS recommendation, at the location Mogargaon (110 mg/l), Golpura (48 mg/l) and Saikheda (48 mg/l).**Fluoride concentration 2 samples is recorded more than 1.5 mg/l as per BIS recommendations i.e. at** Ashapur (3.85 mg/l) and Najarpur (1.53 mg/l)

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5.3 Aquifers having Limited Yield Potential

Hard rock shallow aquifer occupies the first few twenty of meters from the top. Groundwater occurs in weathered zone under the unconfined condition, which has specific hydrodynamic properties from top to bottom. The entire Khargone district is covered by the hard rock i.e. Deccan traps which consists of multiple layers of lava flows.The basaltic flows vary in color as it erupts and solidify under different conditions. Each lava flow consists of an upper vesicular unit and lower massive unit which may or may not be fractured. Deccan traps act as multi aquifer system. Acute shortage of groundwater in hard rock areas such as Deccan traps is well known. Apart from basaltic flows towards northern side the fractured granite and fracture sandstone is also encountered. Ground water available in shallow, weathered mantle under unconfined condition is inadequate to meet the ever-increasing demand of water supply for essential purposes also. In most cases receptiveness of the precipitation is restricted to the degree of weathering and primary porosity if some impervious rock is present below it. As a result, even in high rainfall areas of the district, water scarcity is experienced in the summer months. Hard rock derives its status as an aquifer on the basis of primary porosity (vesicular basalt) and secondary porosity. Red bole that represents the base of a particular flow restricts the downward movement of rainwater as a result aquifer is not able to recharge and cannot be source of fresh water in future. The groundwater in shallow aquifers gets replenished annually as the monsoon rainfall occurs only within 4- month's period and sustain for short period of time.

5.4 Lack of awareness and involvement of stake holders in decision making

Lack of awareness and involvement of stake holders in decision making related to groundwater is also a very important issue. Stakeholders need to participate because management decision taken by the regulatory agency without social consensus is often impossible to implement. Essential management activities (such as monitoring, inspection, etc) can be carried out more effectively and economically through cooperative efforts and shared burdens. Benefits that arise from the stakeholder's participation are-

1) more informed and transparent decision-making
2) Conflict prevention by development of consensus and information sharing.
3) Economic benefits, because it tends to optimize pumping and reduce energy costs.
4) Technical benefits, because it usually involves stakeholders in maintenance and leads to better estimates of water abstraction
5) Management benefits, because the trigger local stakeholder initiatives to implement demand and supply measures and reduce the cost of regulation.

Stakeholder involvement should be seen as on-going, long term process that adapts to the contextual conditions needs and changes therein.

Chapter-6

GROUND WATER MANAGEMENT STRATEGIES

India is the largest user of groundwater in the world and therefore highly dependent on it and it will remain the lifeline for years to come. In the current scenario about 70-80 % water supply for agriculture is from groundwater rather than surface water irrigation. Groundwater is the major source of drinking water, agriculture and industry which is increasing day by day because of increased population growth and socio-economic development in the district. This rapid over-exploitation of groundwater and intensive irrigation has posed serious problems in the districte.g. declining water level, drying of aquifers and groundwater pollution. If this trend continuous unchecked, district is going to face a major water crisis in the near future.In district sufficient and adequate amount of **rainfall** is there each year almost (except for some years) which is **sufficient** to rise the water table and can met the water requirement and demand of the district but because of **lack of awareness**, involvement **of stake holders in decision making, lack of groundwater management and recharge the condition is getting worst with time**. Over a period of time it has been seen that average extraction rate from the aquifers is greater than the average recharge rate. **Groundwater management** is recognised as critical to support the **long term viability of aquifers.** Effective groundwater management is underpinned by sound science that actively engages the wider community and relevant stake holders in the decision making process. Therefore an integrated approach is needed to overcome this major problem, which includes augmentation of groundwater resources through appropriate techniques and adoption of suitable water conservation measures such as **creation of water storage facility, maintenance of existing structures, proposing different structure for recharge.**

6.1 District Ground Water Management Plan (Outcome of NAQUIM)

Groundwater management entails both quality and quantity related groundwater resource management. Quantification of groundwater resources and understanding of hydrogeological processes is a basic pre-requisite for efficient and sustainable management of groundwater resource development and management because **fresh water resource is shrinking** at an alarming rate. For managing the groundwater resource, to control the decline of water level and for sustaining the aquifers, groundwater management plan is to be prepare for the district. As per the directions of **Ministry of Jal Shakti,** Department of Water Resources, River Development and Ganga Rejuvenation preparation of Aquifer Management Plan and its financial layout for the Khargone district in the State has been prepared **blockwise.**

Khargone district has been facing problems of ground water exploitation especially in Khargone block which in turn are depleting the ground water resources in the area and in other blocks if this ground water exploitation will continue with the same rate then district is going to face major problems of water for basic needs also. This needs to evolve sustainable water conservation and management practices through an integrated approach. The ground water management plan for Khargone district has been made keeping in view the area specific details and includes the strategies like enhancing the ground water resources through

construction of artificial recharge structures such as percolation tanks, check dams with recharge shaft, nala bands/cement plugs, village/farm ponds. Also, adoption of micro-irrigation techniques such as sprinkler irrigation/drip irrigation, which would not only conserve ground water resources by reducing the draft, but would also increase the net cropping area thereby, augmenting the agricultural economy of the district.

6.1.1 Supply Side Management Plan

Supply side management plan is propose to overcome the above said major issues through rainwater harvesting and artificial recharge. Recharge to ground water artificially is one of the most efficient, scientifically proven and cost effective technology to mitigate the problems of over exploitation of ground water resources. The artificial recharge aims at augmentation of groundwater reservoir and addresses important things in these crises. It addresses-

1) To enhance the sustainable yield in areas where-development has depleted the aquifer.
2) Conservation and storage of excess surface water for future requirements.
3) Improve the quality of existing groundwater through dilution.

The basic purpose of artificial recharge of ground water is to restore supplies from depleted aquifers due to excessive ground water development.

For Khargone district, the supply side management plan has been formulated using the basic concepts of hydrogeology. Sub-surface storage is calculated by multiplying the total area with the respective specific yield and the unsaturated zone thickness obtained by subtracting 3 mts from the post-monsoon water level. The volume of ground water recharge generated through pre-existing rain water harvesting/water conservation structures is subtracted from the sub-surface storage to assess the available storage potential. Thus, the surface water requirement to completely saturate the sub-surface storage is obtained by multiplying a factor of 1.33 to available storage potential. The volume of unsaturated zone available in the Khargone district is 262.82 MCM. The volume of water required for recharging this much amount of water in the area is 349.56 MCM.

A runoff coefficient factor of 0.23 has been considered for Khargone district to calculate the total surface water runoff, 30% of which accounts to the non-committed runoff which is available to sustain the proposed artificial recharge structures. Further, the number of structures has been calculated by allotting 35%, 45%, 15% and 5% of non-committed runoff to Percolation tanks, check dam with recharge shafts, Nala bund/Cement Plugs and village/farm ponds respectively. Supply Side Ground Water Management given in Table 8 a & b

A financial outlay plan has also been formulated, assuming the cost for the artificial recharge structures to be Rs. 18 lakhs each for percolation tanks, Rs. 5 lakhs each for check dam with recharge shafts/Tube wells, Rs. 1 lakhs each for nala bund/cement plugs and Rs. 2.5 lakhs each village/farm ponds. This accounts to a total of Rs.193.68 crores to successfully implement the supply side management strategy.

Table no. 9 represents the complete financial outlay plan for the district.Financial Outlay Plan- Supply Side Management given in Table 9.

6.1.2 Demand Side Management

Micro-irrigation is a modern method of irrigation and there is scope for increasing areas under this irrigation because of the increasing demand of water especially for the purpose of agriculture. Micro-irrigation is transforming the lives of millions of farmers across the world. **Micro-irrigation** is a slow application of water as discrete or continuous drips, tiny streams or miniature spray on, above or below the soil by surface drip, sub-surface drip, bubbler and micro-sprinkler systems. It is applied through emitters connected to a water delivery line through low pressure delivery. Drip irrigation methods range from simple bucket kit systems for small farms to automated systems linking release of water to soil moisture conditions measured continuously by tension meters. Micro-irrigation is of two types -**drip irrigation and sprinkler irrigation**. Sprinkler irrigation is a system which delivers water for irrigation in a pressurized form. This form of irrigation provides water efficiently. In drip irrigation emitters directly deliver water to the plant root into the soil. These emitters optimize and distribute the pressure from the water source using vents, twisters and convoluted or long flow paths which allows only a limited amount of water to pass through. Emitters can place on the ground or can also be planted deep in the soil.(Figure17)

Micro-irrigation is often promoted by Central and State governments as a way to tackle the **growing water crises** or ground water related issued. Because of the rapid increase in the demand of water especially in agriculture sector this micro-irrigation has become a policy priority in India and technological solutions for achieving water conservation. These micro-irrigation techniques also called as low volume irrigation and have the potential to save water and nutrients by allowing water to drip slowly to the roots of plants. The goal is to place both saves conveyance losses and improves water application efficiency by applying water near the root-zone of the plant. Some benefits of the micro-irrigation have been listed below:

1) The increase in yield for different crops ranges from 27 per cent to 88 per cent and water saving ranges from 36 per cent to 68 per cent vis-à-vis conventional flow irrigation systems (Phansalker and Verma, 2005).
2) It enables farmers to grow crops which would not be possible under conventional systems since it can irrigate adequately with lower water quantities and higher yield.
3) It saves costs of hired labour and other inputs like fertilizer.
4) Joint management of irrigation and fertilization.
5) Reducing pest problem.
6) It reduces the energy needs for pumping, thus reducing energy per ha of irrigation because of its reduced water needs. However, overall energy needs of the agriculture sector may not get reduced because most farmers use the increased water efficiency to bring more area under irrigation.
7) It suits for all type of soils, eg: clay soil requires a slow procedure to avoid surface water collection and runoff and for sandy soils needs higher emitter discharge rates to ensure sufficient wetting of the soil.

Adoption of Sprinkler irrigation techniques would save 8 % of gross ground water draft for irrigation. Also, additional recharge created by construction of artificial recharge structures can be utilized to increase the total cropping area, thereby enhancing the productivity and economy of the district. In Barwaha, Bhagwanpura, Bhikangaon, Gogawan&Segaon block 100%, in Khargone 50%, in Mahashwar 78%, in Zirniya 80% of the additional recharge created by construction of AR structures is utilizing to increase the cropping area and in Kasrawad block 35% of the net groundwaqter available after intervention to increase the cropping area of the block. A summarized table for the demand side management is given in the Table no. 10.

Management Plan for For Ground Water Quality

Higher Concentration of nitrate has been encountered in the district. The use of fertilizers and sewage/ domestic waste is one of the reason for ground water contamination. Therefore it is recommended for proper lining of sewage lines and proper waster management in the district. In agriculture fieldthe use of organic fertilizers instead of the use of harmful fertilizers.

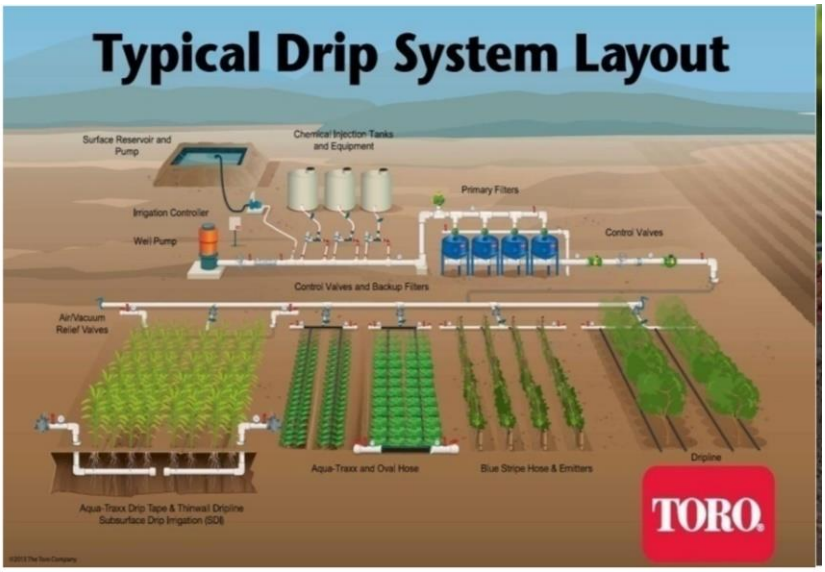


Figure17:Schematic Diagram ofMicro-irrigation (Drip & Micro-irrigation) Drip Irrigation system

(i) Cultivation of cucumbers through drip irrigation

(ii) Cultivation of cauliflower through drip irrigation

(i) Sprinkler Irrigation

(i) Sprinkler system in different farm lands (ii) Automatic Sprinkler system in the garden

Table 8 a: Ground Water Management– Supply Side, Khargone District, Madhya Pradesh

Sl. No	District	Assessment Unit Name	Area (Sq.KM)	Normal Annual Rainfall (mm)	Average Post-monsoon Water Level (m bgl)	Suitable Area for AR (sq.km)	Un Saturated Zone	Specific Yield	Sub-surface storage (mcm)	Surface water required (mcm)	Avaliable water for AR (MCM)
1	2	3	4	5	6	7	8	9	10	11	12
1	Khargone	Barwaha	1470.00	794.60	4.45	1332.80	1.45	0.02	38.52	51.23	51.23
2	Khargone	Bhagwanpura	1318.00	794.60	4.40	523.98	1.40	0.02	14.62	19.44	19.44
3	Khargone	Bhikangaon	914.80	794.60	4.64	914.80	1.64	0.02	30.01	39.91	38.15
4	Khargone	Gogawan	407.10	794.60	6.14	407.10	3.14	0.02	25.57	34.00	16.98
5	Khargone	Kasrawad	1012.00	794.60	4.42	1012.00	1.42	0.02	28.64	38.09	38.09
6	Khargone	Khargone	494.40	794.60	5.17	494.40	2.17	0.02	21.41	28.47	20.62
7	Khargone	Mahashwar	826.20	794.60	4.16	826.20	1.16	0.02	19.17	25.49	25.49
8	Khargone	Segaon	398.50	794.60	3.40	393.00	0.40	0.02	3.14	4.18	4.18
9	Khargone	Zirniya	1189.00	794.60	3.45	664.69	0.45	0.02	5.98	7.96	7.96
	Total		**8030.00**	**794.60**	**4.47**	**6568.97**		**0.02**	**187.05**	**248.78**	**222.14**

Table 8 b: Ground Water Management– Supply Side, Khargone District, Madhya Pradesh

District	Assessment Unit Name	Runoff /sq.km	Runoff MCM	Non-Commuted Runoff	no of percolation tanks	no of Check Dams with Recharge shaft in each CD	no of nala bunds/cement plugs	no of village ponds/ Farm Ponds
2	3	13	14	15	16	17	18	19
Khargone	Barwaha	0.14	204.33	61.30	90.00	768.00	768.00	256.00
Khargone	Bhagwanpura	0.14	183.20	54.96	34.00	292.00	292.00	97.00
Khargone	Bhikangaon	0.14	127.16	38.15	67.00	572.00	572.00	191.00
Khargone	Gogawan	0.14	56.59	16.98	30.00	255.00	255.00	85.00
Khargone	Kasrawad	0.14	140.67	42.20	67.00	571.00	571.00	190.00
Khargone	Khargone	0.14	68.72	20.62	36.00	309.00	309.00	103.00
Khargone	Mahashwar	0.14	114.84	34.45	45.00	382.00	382.00	127.00
Khargone	Segaon	0.14	55.39	16.62	7.00	63.00	63.00	21.00
Khargone	Zirniya	0.14	165.27	49.58	14.00	119.00	119.00	40.00
		0.14	**1116.17**	334.85	**390.00**	**3331.00**	**3331.00**	**1110.00**

Table 9:Financial Outlay Plan- Supply Side Management, Khargone District, Madhya Pradesh

Assessment Unit Name	Sub-surface storage (mcm)	Surface water required (mcm)	Avaliable water for AR (MCM)	no of percolation tanks	cost of percolation tanks in crores @0.2 crores per pt	no of Check Dams	cost of Check Dams in crores @0.06 crores per pt	No of Recharge shaft in each CD	Cost of Recharge shaft in each CD @ 0.01 crores	no of nala bunds/cement plugs	cost of nala bund/cement plugs in crores @0.01 crores per pt	no of village ponds/ Farm Ponds	cost of village pond in crores @0.025 crores per pt	Total cost
Barwaha	38.52	51.23	51.23	90.00	18.00	768.00	46.08	768.00	7.68	768.00	7.68	256.00	6.40	85.84
Bhagwanpura	14.62	19.44	19.44	34.00	6.80	292.00	17.52	292.00	2.92	292.00	2.92	97.00	2.43	32.59
Bhikangaon	30.01	39.91	38.15	67.00	13.40	572.00	34.32	572.00	5.72	572.00	5.72	191.00	4.78	63.94
Gogawan	25.57	34.00	16.98	30.00	6.00	255.00	15.30	255.00	2.55	255.00	2.55	85.00	2.13	28.53
Kasrawad	28.64	38.09	38.09	67.00	13.40	571.00	34.26	571.00	5.71	571.00	5.71	190.00	4.75	63.83
Khargone	21.41	28.47	20.62	36.00	7.20	309.00	18.54	309.00	3.09	309.00	3.09	103.00	2.58	34.50
Mahashwar	19.17	25.49	25.49	45.00	9.00	382.00	22.92	382.00	3.82	382.00	3.82	127.00	3.18	42.74
Segaon	3.14	4.18	4.18	7.00	1.40	63.00	3.78	63.00	0.63	63.00	0.63	21.00	0.53	6.97
Zirniya	5.98	7.96	7.96	14.00	2.80	119.00	7.14	119.00	1.19	119.00	1.19	40.00	1.00	13.32
	187.05	248.78	222.14	390.00	60.00	3331.00	199.86	3331.00	33.31	3331.00	33.31	1110.00	27.75	354.23

6.2

6.2 Post-Intervention Impact

The supply side interventions by implementation of artificial recharge/water conservation will increase the resource by 262.82MCM . These supply side interventions are not sufficient to bring the stage of groundwater extraction under safe category of the Khargoneblock. Therefore demand side interventions are also proposed in which micro-irrigation system is taken up to tackle the issues related to groundwater and bring the district under safe category. Therefore after the supply side and demand side interventions the outcome of the proposed interventions has been described in Table no 10. The Stage of ground water extraction for the entire Khargone district, changed from 43.15 % to 55.09 % with 76114.45 ha additional area irrigated by grounwater after intervention forsustainable ground water management so that district will remain in safe category with more area under irrigation. In Khargone block the stage of groundwater extraction changed from 76.81 % to 65.48 % and on the other hand the stage of groundwater extraction of the district changed from 43.15 % to 55.09 % so that in each block there will be proper balance between groundwater draft and avalaibilty.

6.3 Block-wise Ground Water Management Plan (Outcome of NAQUIM)

As per directions of Ministry of Water Resources, River Development and Ganga Rejuvenation, Government of India, Aquifer Management Plan for district has been prepared block-wise. The plan for each block discusses the broad framework of ground water situation in the block, status of water availability, feasibility of artificial recharge and other water conservation structures and their numbers and cost estimates.

Table 10 : Post-Intervention Impact – Demand side of Khargone District, Madhya Pradesh

Block	Net GW Availability (MCM)	Gross Draft (MCM)	Stage of Development (%)	Saving by microirrigation in (MCM)	Additional recharge created by AR (MCM)	After intervention of AR Structure Net GW AvL. (MCM)	After intervention of AR Structure &utilisation of additional GW created (MCM)/ Utilization of Net Ground Water	After utilization of Net Ground water availabilty (2020 resource)	Draft after sprinkler & additional area created for agricultu re (MCM	Stage of Development W/O GW use for addidtional Area Irrigation(%)	Additional area irrigated by GW after intervention (Ha)
Barwaha	200.20	77.26	38.59	20.97	38.52	238.72	38.52	60.06	154.86	64.87	24644.48
Bhagwanpura	74.71	27.54	36.86	6.65	14.62	89.33	14.62	22.41	57.92	64.84	9258.01
Bhikangaon	133.92	68.44	51.11	19.06	30.01	163.93	30.01	26.78	106.17	64.77	14197.36
Gogawan	59.32	33.62	56.68	9.21	25.57	84.89	25.57	0.00	49.98	58.87	6391.47
Kasrawad	261.49	60.21	23.03	16.34	28.64	290.13	145.06	0.00	188.94	65.12	7159.90
Khargone	61.59	47.13	76.52	13.07	21.41	83.00	14.99	0.00	49.04	59.09	5351.88
Mahashwar	123.54	64.73	52.40	17.87	19.17	142.71	19.17	24.71	90.73	63.58	10968.96
Segaon	58.40	33.88	58.01	9.51	3.14	61.54	3.14	11.68	39.19	63.68	3706.00
Zirniya	86.41	44.38	51.36	11.60	5.98	92.39	5.98	17.28	56.04	60.66	5815.50
Total	**1059.58**	**457.19**	**43.15**	**124.29**	**187.05**	**1246.63**	**297.05**	**162.93**	**792.88**	**63.60**	**87493.56**

Table 11 Quantitative impact on GW Resources after the supply side and demand side interventions

Block	Stage of GW Extraction (%)	Stage of GW Extraction after intervention (%)	Additional area irrigated by GW after intervention (Ha)
Barwaha	38.59	64.87	24644.48
Bhagwanpura	36.86	64.84	9258.01
Bhikangaon	51.11	64.77	14197.36
Gogawan	56.68	58.87	6391.47
Kasrawad	23.03	65.12	7159.90
Khargone	76.52	59.09	5351.88
Mahashwar	52.40	63.58	10968.96
Segaon	58.01	63.68	3706.00
Zirniya	51.36	60.66	5815.50
Total	43.15	63.60	87493.56

6.4 Blockwise Groundwater Management Plan

Management Plan: Barwaha Block

GROUND WATER RESOURCE OF BARWAHA BLOCK	
Shallow Aquifer	
Dynamic Resources (MCM)	200.20
Static Resources (MCM)	148.27
Total Resources (MCM)	**348.47**
Deeper Aquifer	
Static Resources (MCM)	81.30
Total GW Resources (MCM)	429.77
Irrigation GW Draft (MCM)	**69.91**
Domestic+Industries	**7.35**
Gross Ground Water Draft (MCM)	**77.26**
Stage of Ground Water Extraction (%)	**38.59**
Category	**safe**

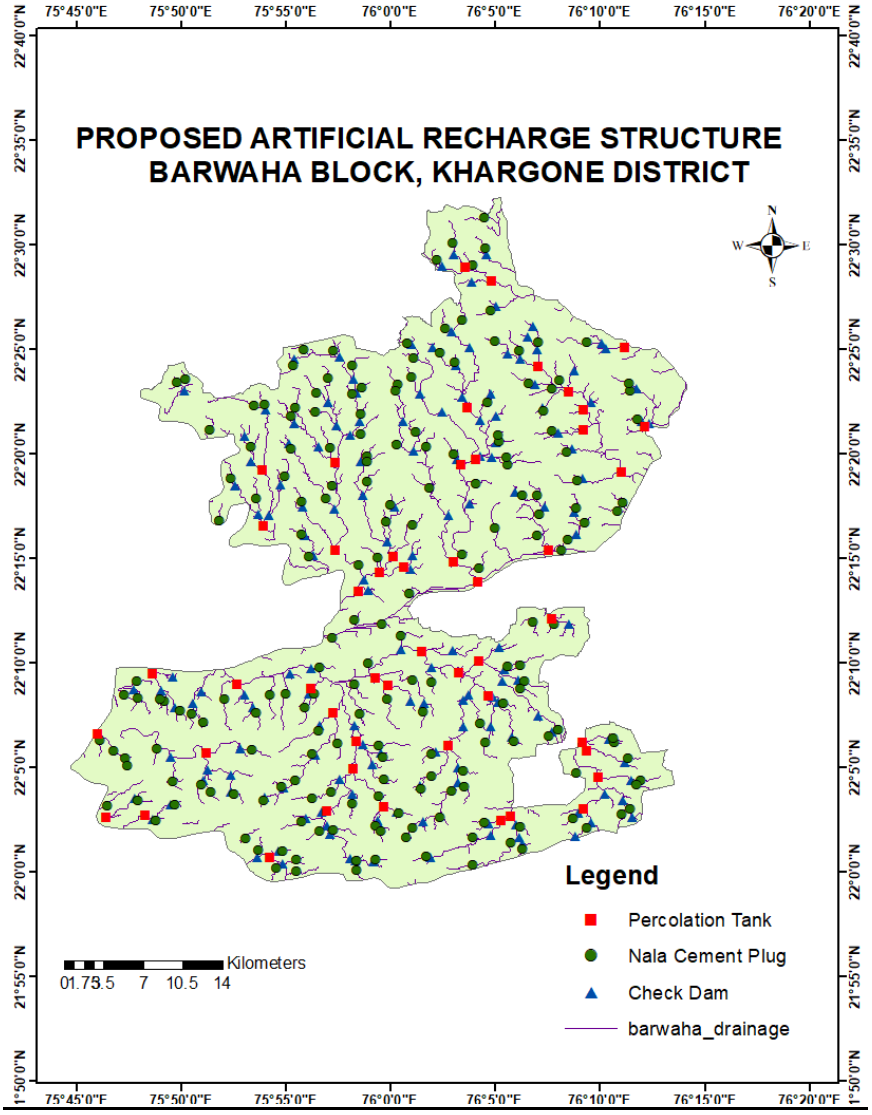
Supply Side Mangement Plan

The supply side management plan has been formulated for the Barwah block.

1. The volume of unsaturated zone available for AR in the Barwaha block is 38.52 MCM.
2. The volume of water required for recharging this much amount of water in the block is 51.23 MCM.
3. The number of artificial recharge structures proposed in the block – 90 percolation tanks, 768 check dams with recharge shaft/ tubewell, 768 nala bunds/cement plugs, 256 villages' ponds/farm ponds and the estimated cost of the recharge structures proposed –18 crore, 53.76 crore, 7.68 crore and 6.40 crore respectively. The cost for all structures of the block is 85.84 MCM

Area (Sq Km)	Sq km	1470.00
Rainfall (m)	M	7.94
Water level (pre-monsoon)	M	2.0 – 5.58
Water level (post-monsoon)	M	1.99 – 4.92
Net. Sown Area	**Hec**	71596.40
Area sown more than once	**Hec**	41770.00
Area under Wasteland	**Hec**	4306.10
Area under othdr uses	**Hec**	8271.50
Area suitable for recharge (Sq Km)	Sq km	1332.80
Average post-monsoon water level (m)	M	4.45
Unsaturated zone (m)	M	1.45
Average SP Yield (%)	%	0.02
Sub-surface storage (mcm)	Mcm	38.52
Surface water required (mcm)	Mcm	51.23
Surface water (Run-off) available (mcm) for	Mcm	51.23
Non-committed Run-off (mcm)	Mcm	61.30
Percolation tank	No.	90
Check dam with Recharge shaft/ Tube well	No.	768
Nala Bunds/ Cement Plugs	No.	768
no of village ponds/ Farm Ponds	No.	256

ype of Structure Proposed	Number	Cost in crores
Percolation tanks	90	18 (0.2 crore per structure)
Check Dams with recharge shaft	768	53.76 (0.07 crore per structure)
Nala bunds/cement plugs	768	7.68 (0.01 crore per structure)
Village ponds/ Farm Ponds	256	6.40 (0.025 crore per structure)
Total Cost		85.84 crore


PROPOSED ARTIFICIAL RECHARGE STRUCTURE
BARWAHA BLOCK, KHARGONE DISTRICT
N
W
E
S
Legend
Percolation Tank
Nala Cement Plug
Check Dam
barwaha_drainage
Kilometers
0 1.75 3.5 7 10.5 14
75°45'0"E
75°50'0"E
75°55'0"E
76°0'0"E
76°5'0"E
76°10'0"E
76°15'0"E
76°20'0"E
22°40'0"N
22°35'0"N
22°30'0"N
22°25'0"N
22°20'0"N
22°15'0"N
22°10'0"N
22°5'0"N
22°0'0"N
21°55'0"N
21°50'0"N

Impact after Intervention: Barwaha Block

Demand Side Management Plan

4. Demand side management plan has also been formulated in which saving of groundwater by micro-irrigation (drip or sprinkler) in the Barwaha block is 20.97 MCM.
5. After the intervention of supply side and demand side management plan successfully making the Stage of Ground Water Extraction of the Barwaha block from 38.59 % to 64.87 % and the block remains under safe category.
6. The additional area irrigated by Ground water after the intervention is 24644.48 ha.

Block	Net GW Availability (MCM)	GW Draft for Irrigation (MCM)	GW Draft for Domestic & Industrial (MCM)	Gross Draft (MCM)	Stage of Development (%)	Saving by microirrigation in (MCM)	Additional recharge created by AR (MCM)	After intervention of AR Structure Net GW AvL. (MCM)	After intervention of AR Structure & utilisation of additional GW created (MCM)/ Utilization of Net Ground Water Availabilty	After utilization of Net Ground water availability (2020 resource)	Draft after sprinkler & additional area created for agriculture (MCM	Stage of Development W/O GW use for addidtional Area Irrigation(%)	Additional area irrigated by GW after intervention (Ha)
Barwaha	200.20	69.91	7.35	77.26	38.59	20.97	38.52	238.72	38.52	60.06	154.86	64.87	24644.48

Management Plan: Bhagwanpura Block

GROUND WATER RESOURCE OF BHAGWANPURA BLOCK	
Shallow Aquifer	
Dynamic Resources (MCM)	74.71
Static Resources (MCM)	48.03
Total Resources (MCM)	**122.74**
Deeper Aquifer	
Static Resources (MCM)	36.68
Total GW Resources (MCM)	159.42
Irrigation GW Draft (MCM)	**22.18**
Domestic+Industries	**5.36**
Gross Ground Water Draft (MCM)	**27.54**
Stage of Ground Water Extraction (%)	**36.86**
Category	**safe**

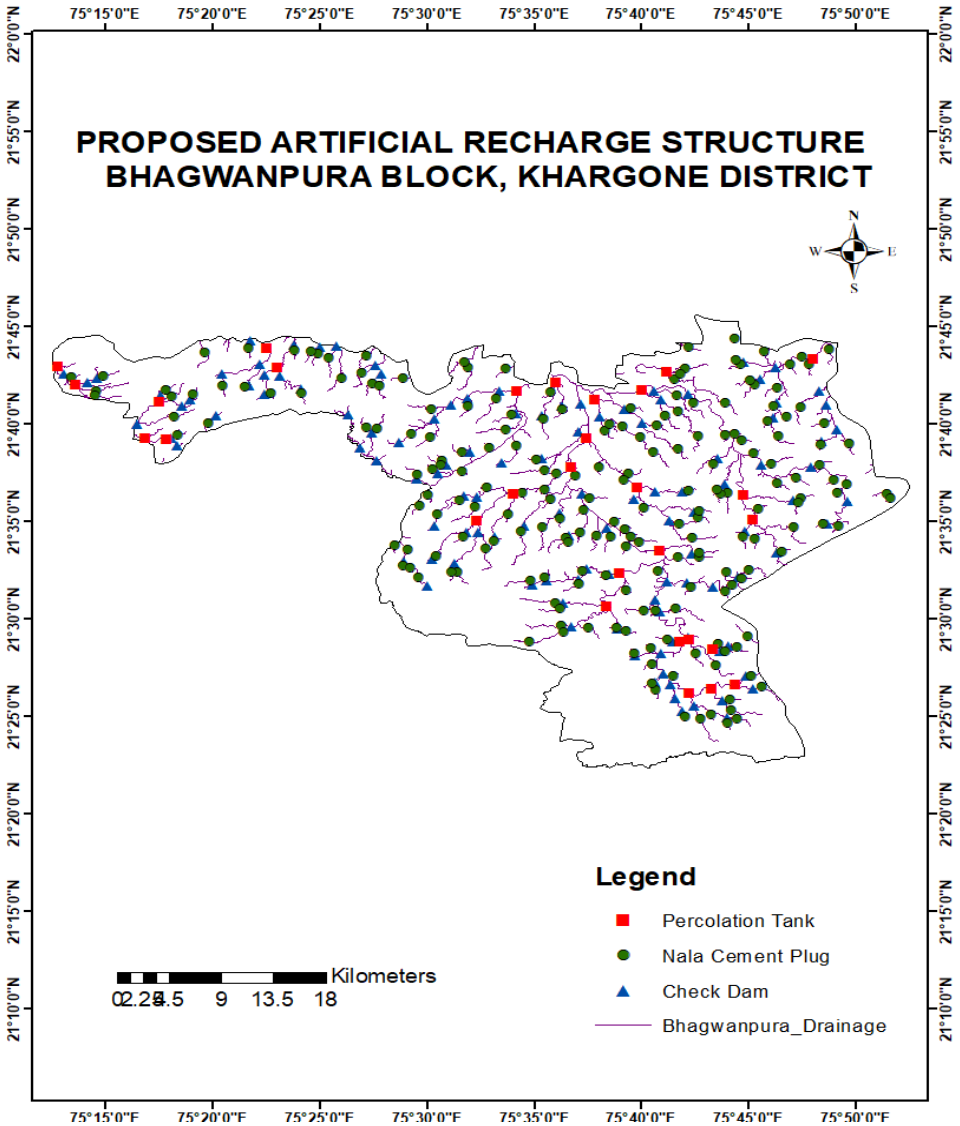
Supply Side Mangement Plan

1. The supply side management plan has been formulated for the Bhagwanpura block. The volume of unsaturated zone available for AR in the Bhagwanpurablock is 14.62 MCM
2. The volume of water required for recharging this much amount of water in the block is 19.44 MCM.
3. The number of artificial recharge structures proposed in the block – 34 percolation tanks, 292 check dams with recharge shaft/ tubewell, 292 nala bunds/cement plugs, 97 villages' ponds/farm ponds and the estimated cost of the recharge structures proposed – 6.8 crore, 20.44 crore, 2.92 crore and 2.43 crore respectively. The cost for all structures of the block is 32.59 MCM.

Area (Sq Km)	**Sq km**	**1318.00**
Rainfall (m)	m	7.94
Water level (pre-monsoon)	m	2.0 – 8.95
Water level (post-monsoon)	m	1.9 – 5.03

Net. Sown Area	hec	35199.30
Area sown more than once	hec	8695.00
Area under Wasteland	hec	2431.20
Area under othdr uses	hec	3655.60
Area suitable for recharge (Sq Km)	Sq km	523.98
Average post-monsoon water level (m)	m	4.40
Unsaturated zone (m)	m	1.40
Average SP Yield (%)	%	0.02
Sub-surface storage (mcm)	mcm	14.62
Surface water required (mcm)	mcm	19.44
Surface water (Run-off) available (mcm) for AR	mcm	19.44
Non-committed Run-off (mcm)	mcm	54.96
Percolation tank	No.	34
Check dam with Recharge shaft/ Tube well	No.	292
Nala Bunds/ Cement Plugs	No.	292
no of village ponds/ Farm Ponds	No.	97

Type of Structure Proposed	Number	Cost in crores
Percolation tanks	90	6.80 (0.2 crore per structure)
Check Dams with recharge shaft	768	20.44 (0.07 crore per structure)
Nala bunds/cement plugs	768	2.92 (0.01 crore per structure)
Village ponds/ Farm Ponds	256	2.43 (0.025 crore per structure)
Total Cost		32.59 crore


PROPOSED ARTIFICIAL RECHARGE STRUCTURE
BHAGWANPURA BLOCK, KHARGONE DISTRICT
N
W
E
S
75°15'0"E
75°20'0"E
75°25'0"E
75°30'0"E
75°35'0"E
75°40'0"E
75°45'0"E
75°50'0"E
22°0'0"N
21°55'0"N
21°50'0"N
21°45'0"N
21°40'0"N
21°35'0"N
21°30'0"N
21°25'0"N
21°20'0"N
21°15'0"N
21°10'0"N
Legend
Percolation Tank
Nala Cement Plug
Check Dam
Bhagwanpura_Drainage
Kilometers
0 2.25 4.5 9 13.5 18

Impact after Intervention: Bhagwanpura Block

Demand Side Mangement

1. Demand side management plan has also been formulated in which saving of groundwater by micro-irrigation (drip or sprinkler) in the Bhagwanpura block is 6.65 MCM.

2. After the intervention of supply side and demand side management plan successfully making the Stage of Ground Water Extraction of the Bhagwanpura block from **36.86 % to 64.84 %** and the block remains under safe category.

3.The additional area irrigated by Ground water after the intervention is9258.01ha.

Block	Net GW Availability (MCM)	GW Draft for Irrigation (MCM)	GW Draft for Domestic & Industrial (MCM)	Gross Draft (MCM)	Stage of Development (%)	Saving by microirrigation in (MCM)	Additional recharge created by AR (MCM)	After intervention of AR Structure Net GW AvL. (MCM)	After intervention of AR Structure & utilisation of additional GW created (MCM)/ Utilization of Net Ground Water Availabilty	After utilization of Net Ground water availabilty (2020 resource)	Draft after sprinkler & additional area created for agriculture (MCM	Stage of Development W/O GW use for addidtional Area Irrigation(%)	Additional area irrigated by GW after intervention (Ha)
Bhagwanpura	74.71	22.18	5.36	27.54	36.86	6.65	14.62	89.33	14.62	22.41	57.92	64.84	9258.01

Management Plan: Bhikangaon Block

GROUND WATER RESOURCE OF BHIKANGAON BLOCK	
Shallow Aquifer	
Dynamic Resources (MCM)	133.92
Static Resources (MCM)	78.49
Total Resources (MCM)	**212.41**
Deeper Aquifer	
Static Resources (MCM)	49.40
Total GW Resources (MCM)	261.81
Irrigation GW Draft (MCM)	**63.53**
Domestic+Industries	**4.91**
Gross Ground Water Draft (MCM)	**69.44**
Stage of Ground Water Extraction (%)	**51.10**
Category	**safe**

Supply Side Mangement Plan

1. The supply side management plan has been formulated for the Bhikangaon block. The volume of unsaturated zone available for AR in theBhikangaon block is 30.01 MCM.

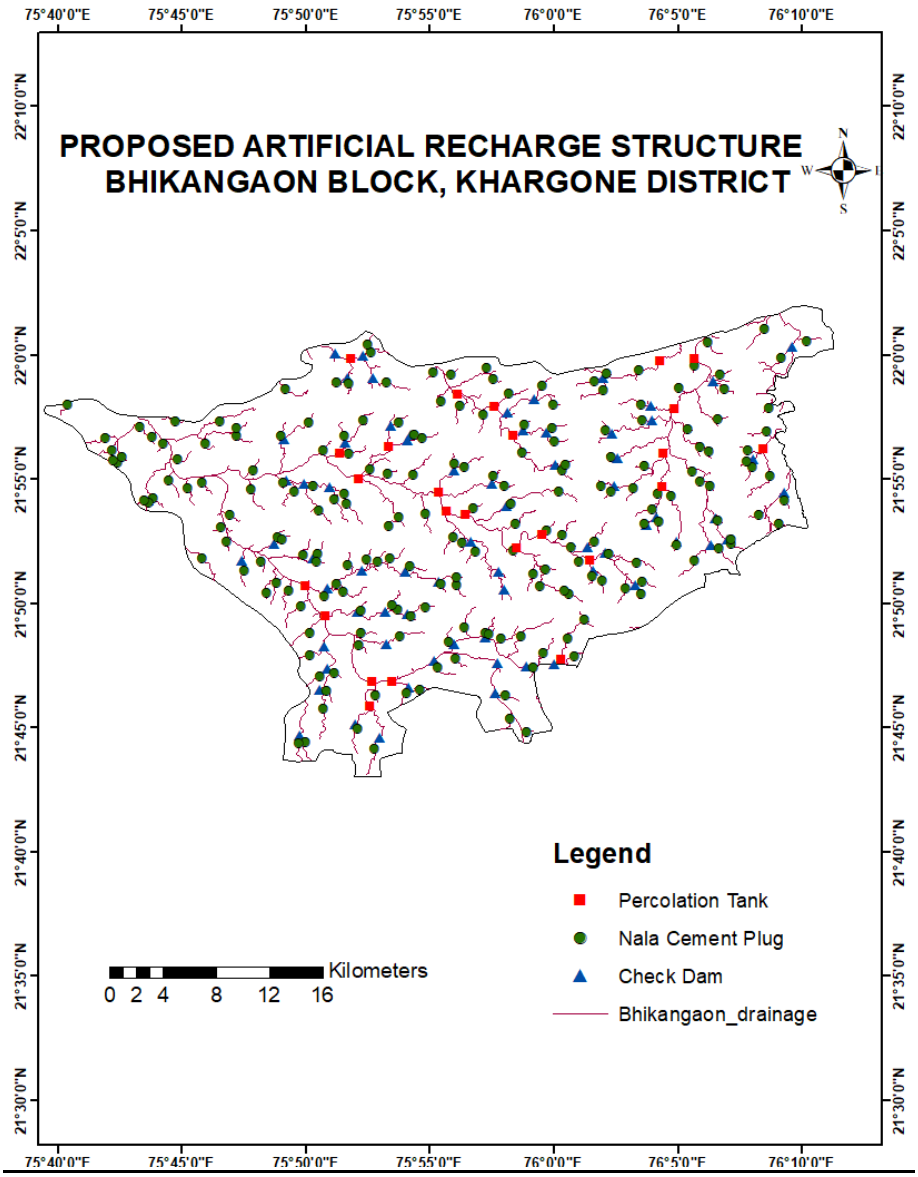
2. The volume of water required for recharging this much amount of water in the block is 39.91 MCM but water available for recharge is 38.15 MCM.

3. The number of artificial recharge structures proposed in the block – 67 percolation tanks, 572 check dams with recharge shaft/ tubewell, 572 nala bunds/cement plugs, 191 villages' ponds/farm ponds and the estimated cost of the recharge structures proposed – 13.40 crore,40.04 crore, 5.72 crore and 4.78 crore respectively. The cost for all structures of the block is 63.94 MCM.

Area (Sq Km)	**Sq km**	**914.80**
Rainfall (m)	M	7.94
Water level (pre-monsoon)	M	5.86 – 9.5
Water level (post-monsoon)	M	3.52 – 6.6
Net. Sown Area	**Hec**	56641.80

Area sown more than once	**Hec**	21462.00
Area under Wasteland	**Hec**	2916.20
Area under othdr uses	**Hec**	4978.90
Area suitable for recharge (Sq Km)	Sq km	914.80
Average post-monsoon water level (m)	M	4.64
Unsaturated zone (m)	M	1.64
Average SP Yield (%)	%	0.02
Sub-surface storage (mcm)	Mcm	30.01
Surface water required (mcm)	Mcm	39.91
Surface water (Run-off) available (mcm) for	Mcm	38.15
Non-committed Run-off (mcm)	Mcm	38.15
Percolation tank	No.	67
Check dam with Recharge shaft/ Tube well	No.	572
Nala Bunds/ Cement Plugs	No.	572
no of village ponds/ Farm Ponds	No.	191

Type of Structure Proposed	Number	Cost in crores
Percolation tanks	90	13.40 (0.2 crore per structure)
Check Dams with recharge shaft	768	40.04 (0.07 crore per structure)
Nala bunds/cement plugs	768	5.72 (0.01 crore per structure)
Village ponds/ Farm Ponds	256	4.78 (0.025 crore per structure)
Total Cost		63.94 crore


PROPOSED ARTIFICIAL RECHARGE STRUCTURE
BHIKANGAON BLOCK, KHARGONE DISTRICT
N
W
E
S
75°40'0"E
75°45'0"E
75°50'0"E
75°55'0"E
76°0'0"E
76°5'0"E
76°10'0"E
22°10'0"N
22°5'0"N
22°0'0"N
21°55'0"N
21°50'0"N
21°45'0"N
21°40'0"N
21°35'0"N
21°30'0"N
Legend
Percolation Tank
Nala Cement Plug
Check Dam
Bhikangaon_drainage
Kilometers
0 2 4 8 12 16

Impact after Intervention: Bhikangaon Block

Demand Side Management Plan

1. Demand side management plan has also been formulated in which saving of groundwater by micro-irrigation (drip or sprinkler) in the Bhikangaon block is 19.06 MCM.
2. After the intervention of supply side and demand side management plan successfully making the Stage of Ground Water Extraction of the Bhikangaon block from **51.11 % to 64.77 %** and the block remains under safe category.
3. The additional area irrigated by Ground water after the intervention is 14197.36 ha.

Block	Net GW Availability (MCM)	GW Draft for Irrigation (MCM)	GW Draft for Domestic & Industrial (MCM)	Gross Draft (MCM)	Stage of Development (%)	Saving by microirrigation in (MCM)	Additional recharge created by AR (MCM)	After intervention of AR Structure Net GW AvL. (MCM)	After intervention of AR Structure & utilisation of additional GW created (MCM)/ Utilization of Net Ground Water Availabilty	After utilization of Net Ground water availabilty (2020 resource)	Draft after sprinkler & additional area created for agriculture (MCM	Stage of Development W/O GW use for addidtional Area Irrigation(%)	Additional area irrigated by GW after intervention (Ha)
Bhikangaon	133.92	63.53	4.91	68.44	51.11	19.06	30.01	163.93	30.01	26.78	106.17	64.77	14197.36

Management Plan: Gogawan Block

GROUND WATER RESOURCE OF GOGAWAN BLOCK	
Shallow Aquifer	
Dynamic Resources (MCM)	59.31
Static Resources (MCM)	22.51
Total Resources (MCM)	**81.82**
Deeper Aquifer	
Static Resources (MCM)	19.54
Total GW Resources (MCM)	101.36
Irrigation GW Draft (MCM)	**30.70**
Domestic+Industries	**2.92**
Gross Ground Water Draft (MCM)	**33.62**
Stage of Ground Water Extraction (%)	**56.69**
Category	**safe**

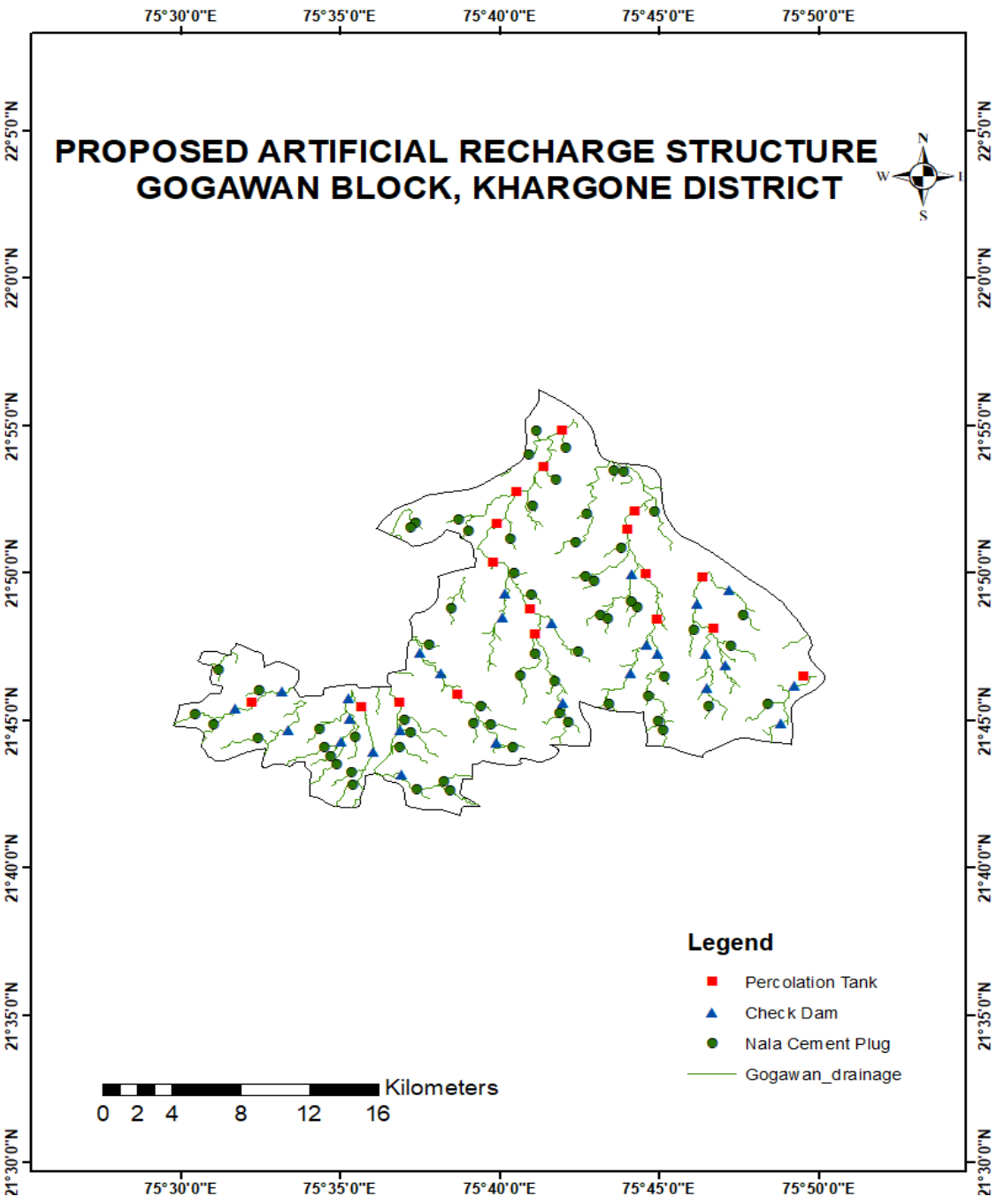
Supply Side Management Plan

1. The supply side management plan has been formulated for the Gogawan block. The volume of unsaturated zone available for AR in the Gogawan block is 25.57 MCM.
2. The volume of water required for recharging this much amount of water in the block is 34 MCM but water available for artificial recharge is 16.98 MCM.
3. The number of artificial recharge structures proposed in the block – 30 percolation tanks, 255 check dams with recharge shaft/ tubewell, 255 nala bunds/cement plugs, 85 villages' ponds/farm ponds and the estimated cost of the recharge structures proposed – 6crore, 17.87crore, 2.55 crore and 2.13 crore respectively. The cost for all structures of the block is 28.53MCM.

Area (Sq Km)	**Sq km**	**407.10**
Rainfall (m)	M	7.94
Water level (pre-monsoon)	M	10.7 – 10.32
Water level (post-monsoon)	M	6.4 – 9.17
Net. Sown Area	**Hec**	31490.10
Area sown more than once	**Hec**	13137.00
Area under Wasteland	**Hec**	1009.30
Area under othdr uses	**Hec**	2042.00

Area suitable for recharge (Sq Km)	Sq km	407.10
Average post-monsoon water level (m)	M	6.14
Unsaturated zone (m)	M	3.14
Average SP Yield (%)	%	0.02
Sub-surface storage (mcm)	Mcm	25.57
Surface water required (mcm)	Mcm	34
Surface water (Run-off) available (mcm) for AR	Mcm	16.98
Non-committed Run-off (mcm)	Mcm	16.98
Percolation tank	No.	30
Check dam with Recharge shaft/ Tube well	No.	255
Nala Bunds/ Cement Plugs	No.	255
no of village ponds/ Farm Ponds	No.	85

Type of Structure Proposed	Number	Cost in crores
Percolation tanks	90	6 (0.2 crore per structure)
Check Dams with recharge shaft	768	17.87 (0.07 crore per structure)
Nala bunds/cement plugs	768	2.55 (0.01 crore per structure)
Village ponds/ Farm Ponds	256	2.13 (0.025 crore per structure)
Total Cost		28.53 crore


PROPOSED ARTIFICIAL RECHARGE STRUCTURE
GOGAWAN BLOCK, KHARGONE DISTRICT
N
W
E
S
75°30'0"E
75°35'0"E
75°40'0"E
75°45'0"E
75°50'0"E
22°5'0"N
22°0'0"N
21°55'0"N
21°50'0"N
21°45'0"N
21°40'0"N
21°35'0"N
21°30'0"N
Legend
Percolation Tank
Check Dam
Nala Cement Plug
Gogawan_drainage
Kilometers
0 2 4 8 12 16

Impact after Intervention: Gogawan Block

Demand Side Management Plan

1. Demand side management plan has also been formulated in which saving of groundwater by micro-irrigation (drip or sprinkler) in the Gogawan block is 9.21 MCM.
2. After the intervention of supply side and demand side management plan successfully making the Stage of Ground Water Extraction of the Gogawan block from **56.68 % to 58.87 %** and the block remains under safe category.
3. The additional area irrigated by Ground water after the intervention is 6391.47 ha.

Block	Net GW Availability (MCM)	GW Draft for Irrigation (MCM)	GW Draft for Domestic & Industrial (MCM)	Gross Draft (MCM)	Stage of Development (%)	Saving by microirrigation in (MCM)	Additional recharge created by AR (MCM)	After intervention of AR Structure Net GW AvL. (MCM)	After intervention of AR Structure & utilisation of additional GW created (MCM)/ Utilization of Net Ground Water Availabilty	After utilization of Net Ground water availabilty (2020 resource)	Draft after sprinkler & additional area created for agriculture (MCM	Stage of Development W/O GW use for addidtional Area Irrigation(%)	Additional area irrigated by GW after intervention (Ha)
Gogawan	59.32	30.70	2.92	33.62	56.68	9.21	25.57	84.89	25.57	0.00	49.98	58.87	6391.47

Management Plan: Kasrawad Block

GROUND WATER RESOURCE OF KASRAWAD BLOCK	
Shallow Aquifer	
Dynamic Resources (MCM)	261.49
Static Resources (MCM)	141.17
Total Resources (MCM)	**402.66**
Deeper Aquifer	
Static Resources (MCM)	54.65
Total GW Resources (MCM)	457.31
Irrigation GW Draft (MCM)	**54.46**
Domestic+Industries	**5.75**
Gross Ground Water Draft (MCM)	**60.21**
Stage of Ground Water Extraction (%)	**23.03**
Category	**safe**

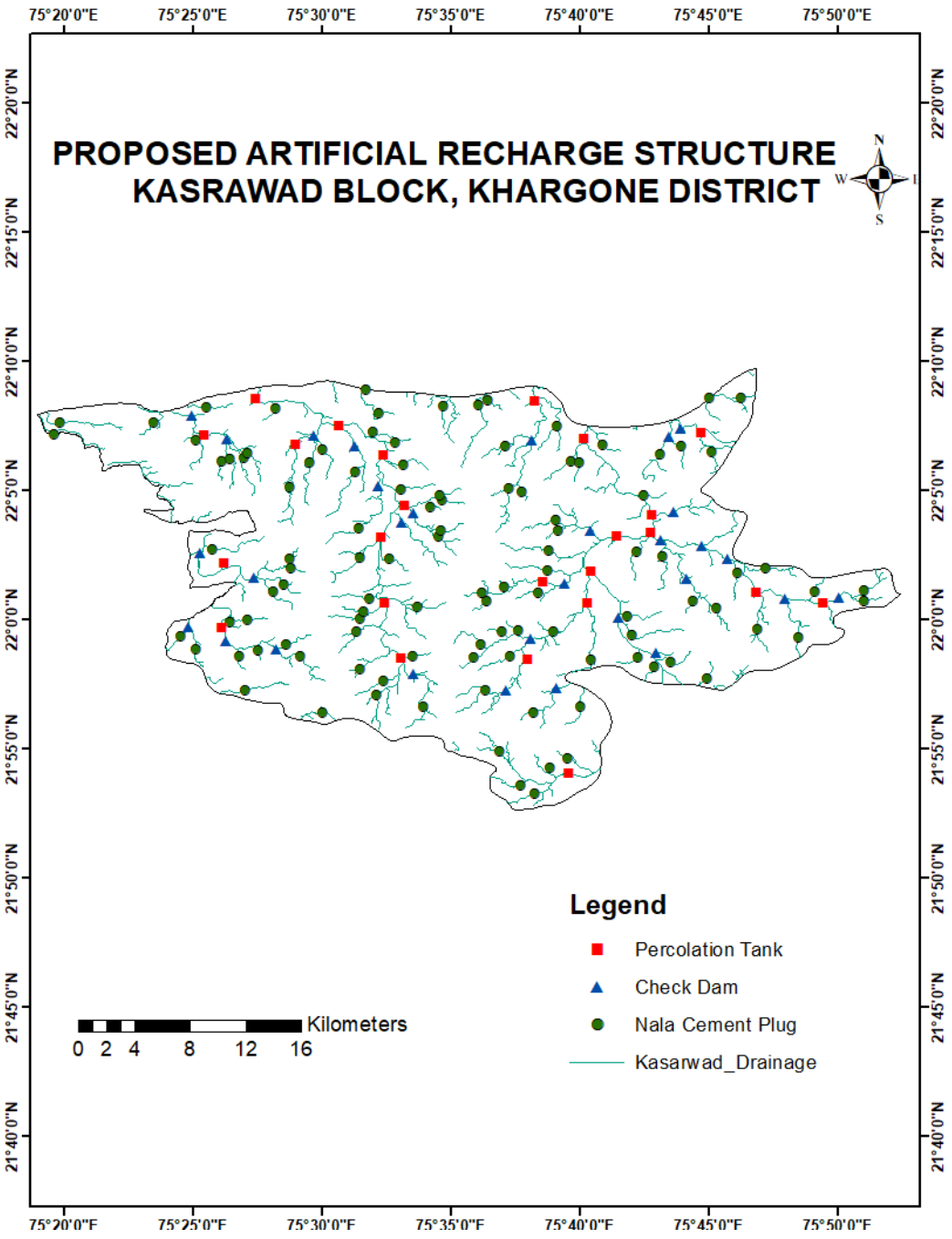
Supply Side Management Plan

1. The supply side management plan has been formulated for the Kasrawad block. The volume of unsaturated zone available for AR in the Kasrawadblock is 28.64 MCM.
2. The volume of water required for recharging this much amount of water in the block is 38.09 MCM.
3. The number of artificial recharge structures proposed in the block – 67 percolation tanks, 571 check dams with recharge shaft/ tubewell, 571 nala bunds/cement plugs, 190 villages' ponds/farm ponds and the estimated cost of the recharge structures proposed – 13.40 crore, 39.97 crore, 5.71 crore and 4.75 crore respectively. The cost for all structures of the block is 63.83 MCM.

Area (Sq Km)	**Sq km**	**1012.00**
Rainfall (m)	M	7.94
Water level (pre-monsoon)	M	10.3 - 13
Water level (post-monsoon)	M	0.72 – 1.67
Net. Sown Area	**Hec**	58109.20
Area sown more than once	**Hec**	30796.00

Area under Wasteland	**Hec**	8212.50
Area under othdr uses	**Hec**	2951.80
Area suitable for recharge (Sq Km)	Sq km	1012
Average post-monsoon water level (m)	M	4.42
Unsaturated zone (m)	M	1.42
Average SP Yield (%)	%	0.02
Sub-surface storage (mcm)	Mcm	28.64
Surface water required (mcm)	Mcm	38.09
Surface water (Run-off) available (mcm) for AR	Mcm	38.64
Non-committed Run-off (mcm)	Mcm	42.20
Percolation tank	No.	67
Check dam with Recharge shaft/ Tube well	No.	571
Nala Bunds/ Cement Plugs	No.	571
no of village ponds/ Farm Ponds	No.	190

Type of Structure Proposed	Number	Cost in crores
Percolation tanks	90	13.400.2 crore per structure)
Check Dams with recharge shaft	768	39.97 (0.07 crore per structure)
Nala bunds/cement plugs	768	5.71 (0.01 crore per structure)
Village ponds/ Farm Ponds	256	4.75 (0.025 crore per structure)
Total Cost		63.83 crore


PROPOSED ARTIFICIAL RECHARGE STRUCTURE
KASRAWAD BLOCK, KHARGONE DISTRICT
N
W
E
S
75°20'0"E
75°25'0"E
75°30'0"E
75°35'0"E
75°40'0"E
75°45'0"E
75°50'0"E
22°20'0"N
22°15'0"N
22°10'0"N
22°5'0"N
22°0'0"N
21°55'0"N
21°50'0"N
21°45'0"N
21°40'0"N
Legend
Percolation Tank
Check Dam
Nala Cement Plug
Kasarwad_Drainage
Kilometers
0 2 4 8 12 16

Impact after Intervention: Kasrawad Block

Demand Side Management Plan

1. Demand side management plan has also been formulated in which saving of groundwater by micro-irrigation (drip or sprinkler) in the Kasrawad block is 16.34 MCM.
2. After the intervention of supply side and demand side management plan successfully making the Stage of Ground Water Extraction of the Kasrawad block from 23.03 **% to 65.12%** and the block remains under safe category.
3. The additional area irrigated by Ground water after the intervention is 7159 ha.

Block	Net GW Availability (MCM)	GW Draft for Irrigation (MCM)	GW Draft for Domestic & Industrial (MCM)	Gross Draft (MCM)	Stage of Development (%)	Saving by microirrigation in (MCM)	Additional recharge created by AR (MCM)	After intervention of AR Structure Net GW AvL. (MCM)	After intervention of AR Structure & utilisation of additional GW created (MCM)/ Utilization of Net Ground Water Availabilty	After utilization of Net Ground water availabilty (2020 resource)	Draft after sprinkler & additional area created for agriculture (MCM	Stage of Development W/O GW use for addidtional Area Irrigation(%)	Additional area irrigated by GW after intervention (Ha)
Kasrawad	261.49	54.46	5.75	60.21	23.03	16.34	28.64	290.13	145.06	0.00	188.94	65.12	7159.90

Management Plan: Khargone Block

GROUND WATER RESOURCE OF KHARGONE BLOCK	
First Aquifer	
Dynamic Resources (MCM)	61.59
Static Resources (MCM)	47.97
Total Resources (MCM)	**109.56**
Second Aquifer	
Static Resources (MCM)	28.70
Total GW Resources (MCM)	138.26
Irrigation GW Draft (MCM)	**43.57**
Domestic+Industries	**3.56**
Gross Ground Water Draft (MCM)	**47.13**
Stage of Ground Water Extraction (%)	**76.52**
Category	**semi-critical**

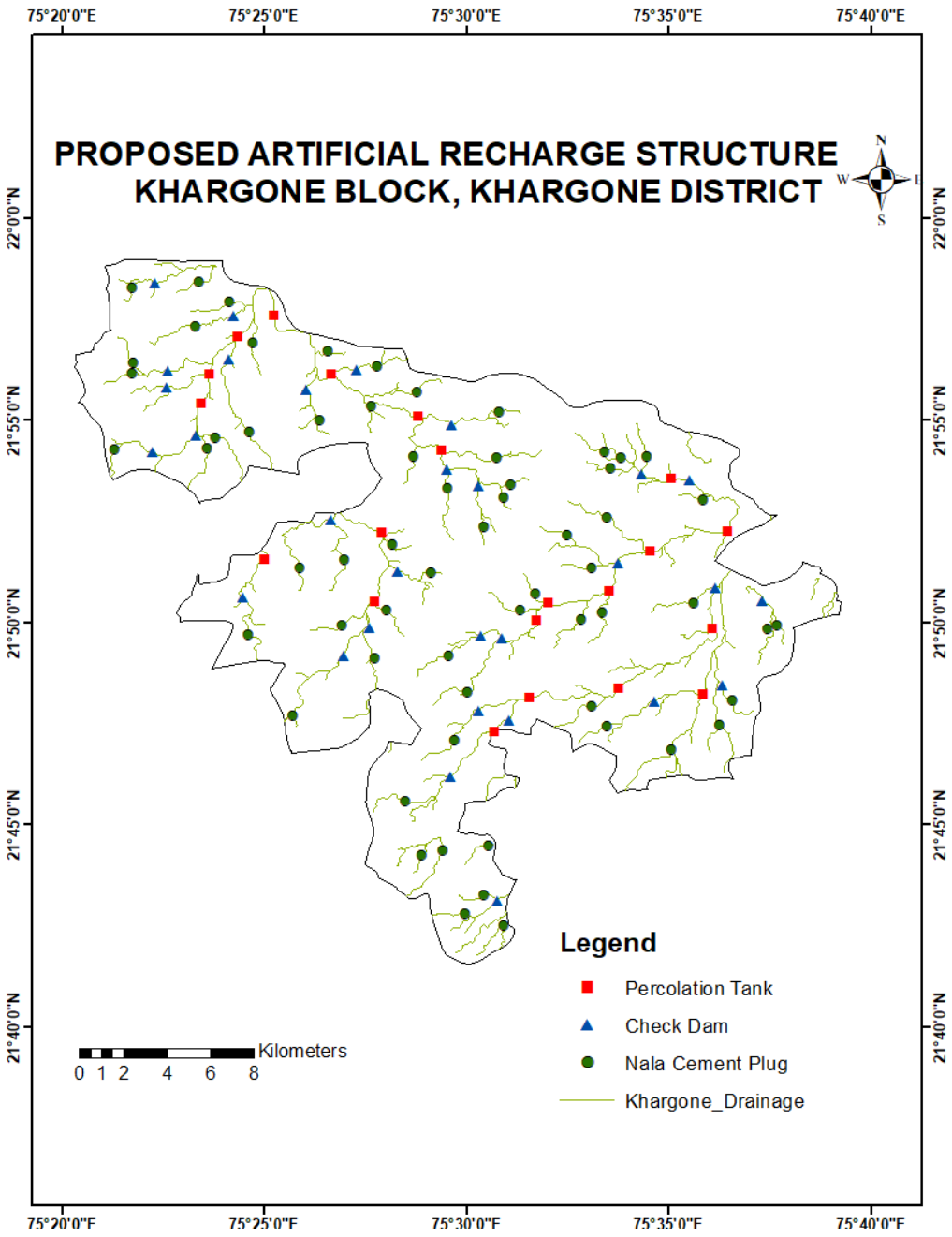
Supply Side Management

1. **The supply side management plan** has been formulated for the Khargone block. The volume of unsaturated zone available for AR in the Khargone block is 21.41 MCM.
2. The volume of water required for recharging this much amount of water in the block is 28.47 MCM but water available for recharge is 20.62 MCM.
3. The number of artificial recharge structures proposed in the block – 36 percolation tanks, 309 check dams with recharge shaft/ tubewell, 309 nala bunds/cement plugs, 103 villages' ponds/farm ponds and the estimated cost of the recharge structures proposed – 7.20 crore, 21.63 crore, 3.09 crore and 2.58 crore respectively. The cost for all structures of the block is 34.50 MCM.

Area (Sq Km)	**Sq km**	**494.00**
Rainfall (m)	m	7.94
Water level (pre-monsoon)	m	2.29 – 9.28
Water level (post-monsoon)	m	1.84 – 7.88
Net. Sown Area	**hec**	36434.00
Area sown more than once	**hec**	17820.00
Area under Wasteland	**hec**	1676.80

Area under othdr uses	**hec**	2989.90
Area suitable for recharge (Sq Km)	Sq km	1332.80
Average post-monsoon water level (m)	m	5.17
Unsaturated zone (m)	m	2.17
Average SP Yield (%)	%	0.02
Sub-surface storage (mcm)	mcm	21.41
Surface water required (mcm)	mcm	28.47
Surface water (Run-off) available (mcm) for AR	mcm	20.62
Non-committed Run-off (mcm)	mcm	20.62
Percolation tank	No.	36
Check dam with Recharge shaft/ Tube well	No.	309
Nala Bunds/ Cement Plugs	No.	309
no of village ponds/ Farm Ponds	No.	103

Type of Structure Proposed	Number	Cost in crores
Percolation tanks	90	7.20 (0.2 crore per structure)
Check Dams with recharge shaft	768	21.63 (0.07 crore per structure)
Nala bunds/cement plugs	768	3.09 (0.01 crore per structure)
Village ponds/ Farm Ponds	256	2.58 (0.025 crore per structure)
Total Cost		34.50 crore


PROPOSED ARTIFICIAL RECHARGE STRUCTURE
KHARGONE BLOCK, KHARGONE DISTRICT
N
W
E
S
75°20'0"E
75°25'0"E
75°30'0"E
75°35'0"E
75°40'0"E
22°0'0"N
21°55'0"N
21°50'0"N
21°45'0"N
21°40'0"N
Legend
Percolation Tank
Check Dam
Nala Cement Plug
Khargone_Drainage
Kilometers
0 1 2 4 6 8

Impact after Intervention: Khargone Block

Demand Side Management

1. Demand side management plan has also been formulated in which saving of groundwater by micro-irrigation (drip or sprinkler) in the Khargone block is 13.07 MCM.
2. After the intervention of supply side and demand side management plan successfully making the Stage of Ground Water Extraction of the Khargone block from **76.52 % to 59.09 %** and the block changed from semi critical to safe category.
3. The additional area irrigated by Ground water after the intervention is 5351.88 ha.

Block	Net GW Availability (MCM)	GW Draft for Irrigation (MCM)	GW Draft for Domestic & Industrial (MCM)	Gross Draft (MCM)	Stage of Development (%)	Saving by microirrigation in (MCM)	Additional recharge created by AR (MCM)	After intervention of AR Structure Net GW AvL. (MCM)	After intervention of AR Structure & utilisation of additional GW created (MCM)/ Utilization of Net Ground Water Availabilty	After utilization of Net Ground water availabilty (2020 resource)	Draft after sprinkler & additional area created for agriculture (MCM	Stage of Development W/O GW use for addidtional Area Irrigation(%)	Additional area irrigated by GW after intervention (Ha)
Khargone	61.59	43.57	3.56	47.13	76.52	13.07	21.41	83.00	14.99	0.00	49.04	59.09	5351.88

Management Plan: Mahashwar Block

GROUND WATER RESOURCE OF MAHASHWAR BLOCK	
Shallow Aquifer	
Dynamic Resources (MCM)	123.54
Static Resources (MCM)	85.68
Total Resources (MCM)	**209.22**
Deeper Aquifer	
Static Resources (MCM)	30.57
Total GW Resources (MCM)	239.79
Irrigation GW Draft (MCM)	**59.58**
Domestic+Industries	**5.15**
Gross Ground Water Draft (MCM)	**64.73**
Stage of Ground Water Extraction (%)	**52.40**
Category	**Safe**

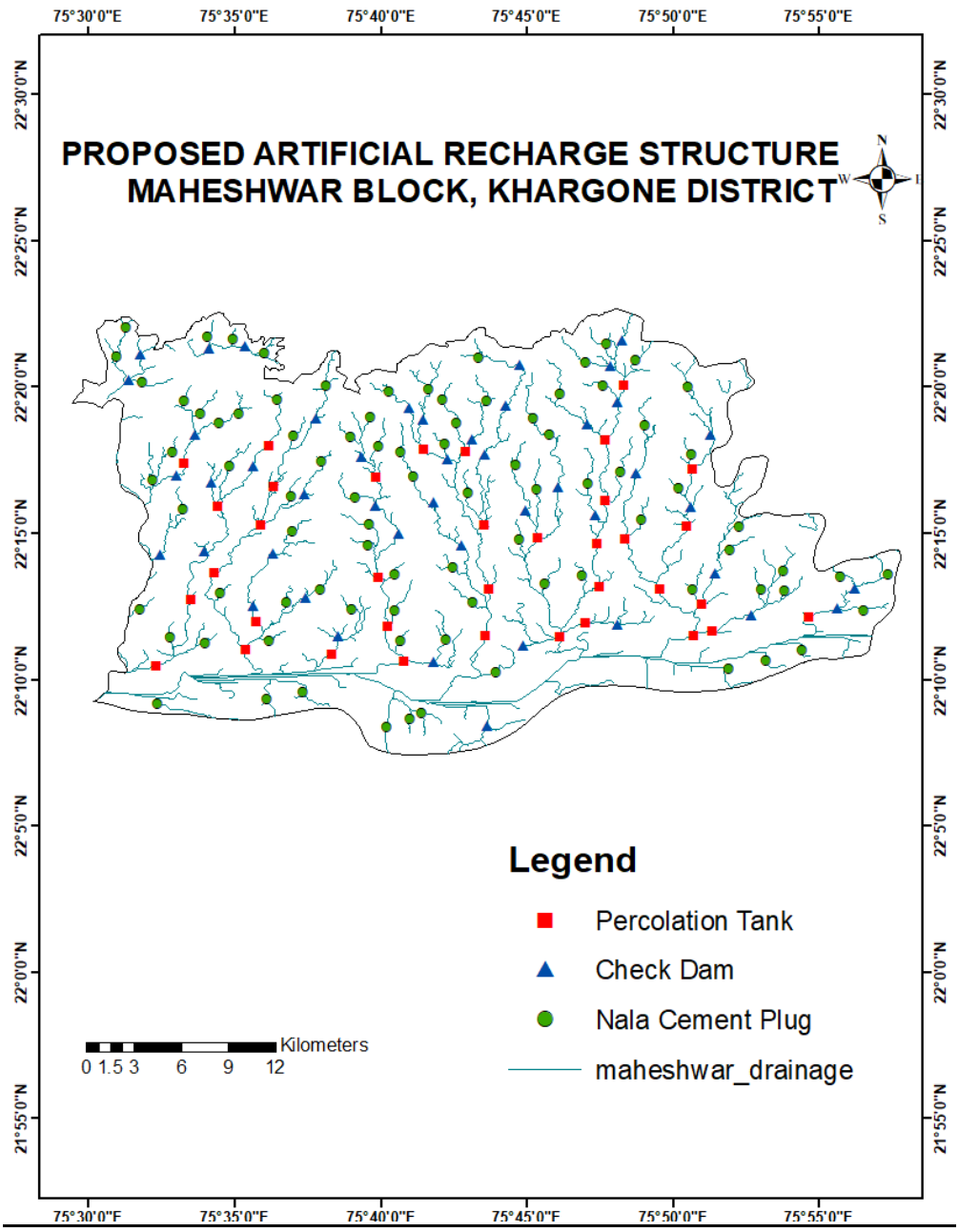
Supply Side Management

1. The supply side management plan has been formulated for the Mahashwar block. The volume of unsaturated zone available for AR in the Mahashwar block is 19.17 MCM.
2. The volume of water required for recharging this much amount of water in the block is 25.49 MCM.
3. The number of artificial recharge structures proposed in the block – 45 percolation tanks, 382 check dams with recharge shaft/ tubewell, 382 nala bunds/cement plugs, 127 villages' ponds/farm ponds and the estimated cost of the recharge structures proposed – 9 crore, 26.94 crore, 3.82 crore and 3.18 crore respectively. The cost for all structures of the block is 42.74 MCM.

Area (Sq Km)	**Sq km**	**826.20**
Rainfall (m)	M	7.94
Water level (pre-monsoon)	M	3.72 – 4.37
Water level (post-monsoon)	M	3.47 – 7.25
Net. Sown Area	**hec**	44287.40
Area sown more than once	**hec**	18017.00

Area under Wasteland	**hec**	1337.40
Area under othdr uses	**hec**	5643.10
Area suitable for recharge (Sq Km)	Sq km	826.20
Average post-monsoon water level (m)	M	4.16
Unsaturated zone (m)	M	1.16
Average SP Yield (%)	%	0.02
Sub-surface storage (mcm)	mcm	19.17
Surface water required (mcm)	mcm	25.49
Surface water (Run-off) available (mcm) for AR	mcm	25.49
Non-committed Run-off (mcm)	mcm	34.45
Percolation tank	No.	45
Check dam with Recharge shaft/ Tube well	No.	382
Nala Bunds/ Cement Plugs	No.	382
no of village ponds/ Farm Ponds	No.	127

Type of Structure Proposed	Number	Cost in crores
Percolation tanks	90	9 (0.2 crore per structure)
Check Dams with recharge shaft	768	26.94 (0.07 crore per structure)
Nala bunds/cement plugs	768	3.82 (0.01 crore per structure)
Village ponds/ Farm Ponds	256	3.18 (0.025 crore per structure)
Total Cost		42.74 crore


PROPOSED ARTIFICIAL RECHARGE STRUCTURE
MAHESHWAR BLOCK, KHARGONE DISTRICT
N
S
W
75°30'0"E
75°35'0"E
75°40'0"E
75°45'0"E
75°50'0"E
75°55'0"E
22°30'0"N
22°25'0"N
22°20'0"N
22°15'0"N
22°10'0"N
22°5'0"N
22°0'0"N
21°55'0"N
Legend
Percolation Tank
Check Dam
Nala Cement Plug
maheshwar_drainage
Kilometers
0 1.5 3 6 9 12

Impact after Intervention: Mahashwar Block

Demand Side Mangement

1. Demand side management plan has also been formulated in which saving of groundwater by micro-irrigation (drip or sprinkler) in the Mahashwar block is 17.87 MCM.
2. After the intervention of supply side and demand side management plan successfully making the Stage of Ground Water Extraction of the Mahashwar block from **52.40 % to 63.58 %** and the block remains under safe category.
3. The additional area irrigated by Ground water after the intervention is 10968.96 ha.

Block	Net GW Availability (MCM)	GW Draft for Irrigation (MCM)	GW Draft for Domestic & Industrial (MCM)	Gross Draft (MCM)	Stage of Development (%)	Saving by microirrigation in (MCM)	Additional recharge created by AR (MCM)	After intervention of AR Structure Net GW AvL. (MCM)	After intervention of AR Structure & utilisation of additional GW created (MCM)/ Utilization of Net Ground Water Availabilty	After utilization of Net Ground water availabilty (2020 resource)	Draft after sprinkler & additional area created for agriculture (MCM	Stage of Development W/O GW use for addidtional Area Irrigation(%)	Additional area irrigated by GW after intervention (Ha)
Mahashwar	123.54	59.58	5.15	64.73	52.40	17.87	19.17	142.71	19.17	24.71	90.73	63.58	10968.96

Management Plan:Segaon Block

GROUND WATER RESOURCE OF SEGAON BLOCK	
Shallow Aquifer	
Dynamic Resources (MCM)	58.40
Static Resources (MCM)	45.59
Total Resources (MCM)	**103.99**
Deeper Aquifer	
Static Resources (MCM)	15.25
Total GW Resources (MCM)	119.24
Irrigation GW Draft (MCM)	**31.71**
Domestic+Industries	**2.17**
Gross Ground Water Draft (MCM)	**33.88**
Stage of Ground Water Extraction (%)	**58.01**
Category	**Safe**

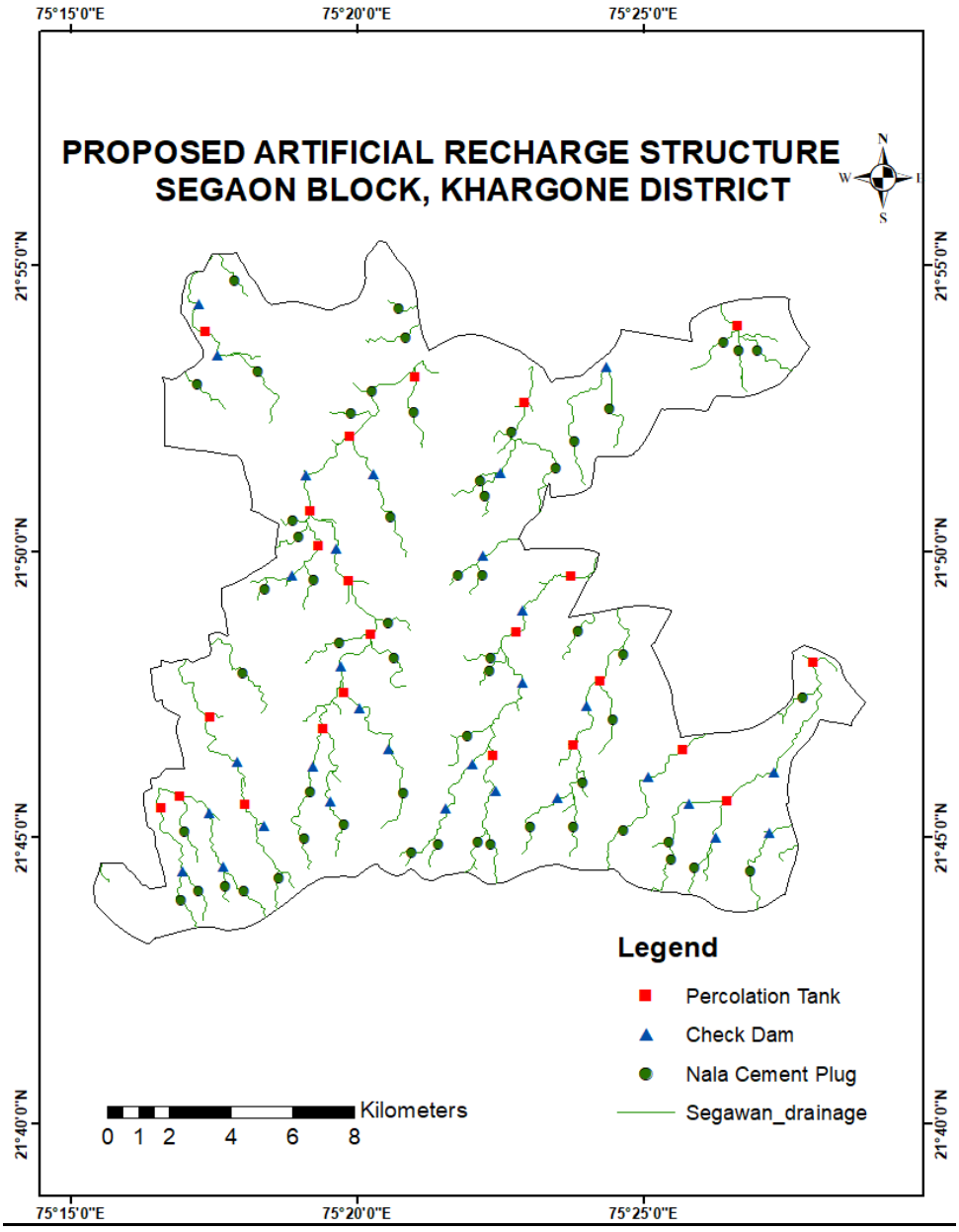
Supply Side Management Plan

1. The supply side management plan has been formulated for the Segaon block. The volume of unsaturated zone available for AR in the Segaon block is 3.14 MCM.
2. The volume of water required for recharging this much amount of water in the block is 4.18 MCM.
3. The number of artificial recharge structures proposed in the block – 7 percolation tanks, 63 check dams with recharge shaft/ tubewell, 63 nala bunds/cement plugs, 21 villages' ponds/farm ponds and the estimated cost of the recharge structures proposed – 1.40 crore, 4.41 crore, 0.63 crore and 0.53 crore respectively. The cost for all structures of the block is 6.97 MCM.

Area (Sq Km)	**Sq km**	**398.50**
Rainfall (m)	m	7.94
Water level (pre-monsoon)	m	3.6 – 4.8
Water level (post-monsoon)	m	7.01 – 9.10
Net. Sown Area	**hec**	24482.40
Area sown more than once	**hec**	8333.00
Area under Wasteland	**hec**	1616.00
Area under othdr uses	**hec**	2433.80

Area suitable for recharge (Sq Km)	Sq km	398.00
Average post-monsoon water level (m)	m	3.40
Unsaturated zone (m)	m	0.40
Average SP Yield (%)	%	0.02
Sub-surface storage (mcm)	mcm	3.14
Surface water required (mcm)	mcm	4.18
Surface water (Run-off) available (mcm) for AR	mcm	4.18
Non-committed Run-off (mcm)	mcm	16.62
Percolation tank	No.	7
Check dam with Recharge shaft/ Tube well	No.	63
Nala Bunds/ Cement Plugs	No.	63
no of village ponds/ Farm Ponds	No.	21

Type of Structure Proposed	Number	Cost in crores
Percolation tanks	90	1.4 (0.2 crore per structure)
Check Dams with recharge shaft	768	4.41 (0.07 crore per structure)
Nala bunds/cement plugs	768	0.63 (0.01 crore per structure)
Village ponds/ Farm Ponds	256	0.53 (0.025 crore per structure)
Total Cost		6.97 crore


PROPOSED ARTIFICIAL RECHARGE STRUCTURE
SEGAON BLOCK, KHARGONE DISTRICT
N
W
E
S
75°15'0"E
75°20'0"E
75°25'0"E
21°55'0"N
21°50'0"N
21°45'0"N
21°40'0"N
Legend
Percolation Tank
Check Dam
Nala Cement Plug
Segawan_drainage
Kilometers
0 1 2 4 6 8

Impact after Intervention: Segaon Block

Demand Side Management Plan

1. Demand side management plan has also been formulated in which saving of groundwater by micro-irrigation (drip or sprinkler) in the Segaon block is 9.51 MCM.
2. After the intervention of supply side and demand side management plan successfully making the Stage of Ground Water Extraction of the Segaon block from **58.01 % to 63.68%** and the block remains under safe category.
3. The additional area irrigated by Ground water after the intervention is 3706 ha.

Block	Net GW Availability (MCM)	GW Draft for Irrigation (MCM)	GW Draft for Domestic & Industrial (MCM)	Gross Draft (MCM)	Stage of Development (%)	Saving by microirrigation in (MCM)	Additional recharge created by AR (MCM)	After intervention of AR Structure Net GW AvL. (MCM)	After intervention of AR Structure & utilisation of additional GW created (MCM)/ Utilization of Net Ground Water Availabilty	After utilization of Net Ground water availability (2020 resource)	Draft after sprinkler & additional area created for agriculture (MCM	Stage of Development W/O GW use for addidtional Area Irrigation(%)	Additional area irrigated by GW after intervention (Ha)
Segaon	58.40	31.71	2.17	33.88	58.01	9.51	3.14	61.54	3.14	11.68	39.19	63.68	3706.00

Management Plan: Zirniya Block

GROUND WATER RESOURCE OF ZIRNIYA BLOCK	
Shallow Aquifer	
Dynamic Resources (MCM)	86.41
Static Resources (MCM)	58.98
Total Resources (MCM)	**145.39**
Deeper Aquifer	
Static Resources (MCM)	34.56
Total GW Resources (MCM)	179.95
Irrigation GW Draft (MCM)	**38.66**
Domestic+Industries	**5.72**
Gross Ground Water Draft (MCM)	**44.38**
Stage of Ground Water Extraction (%)	**51.36**
Category	**safe**

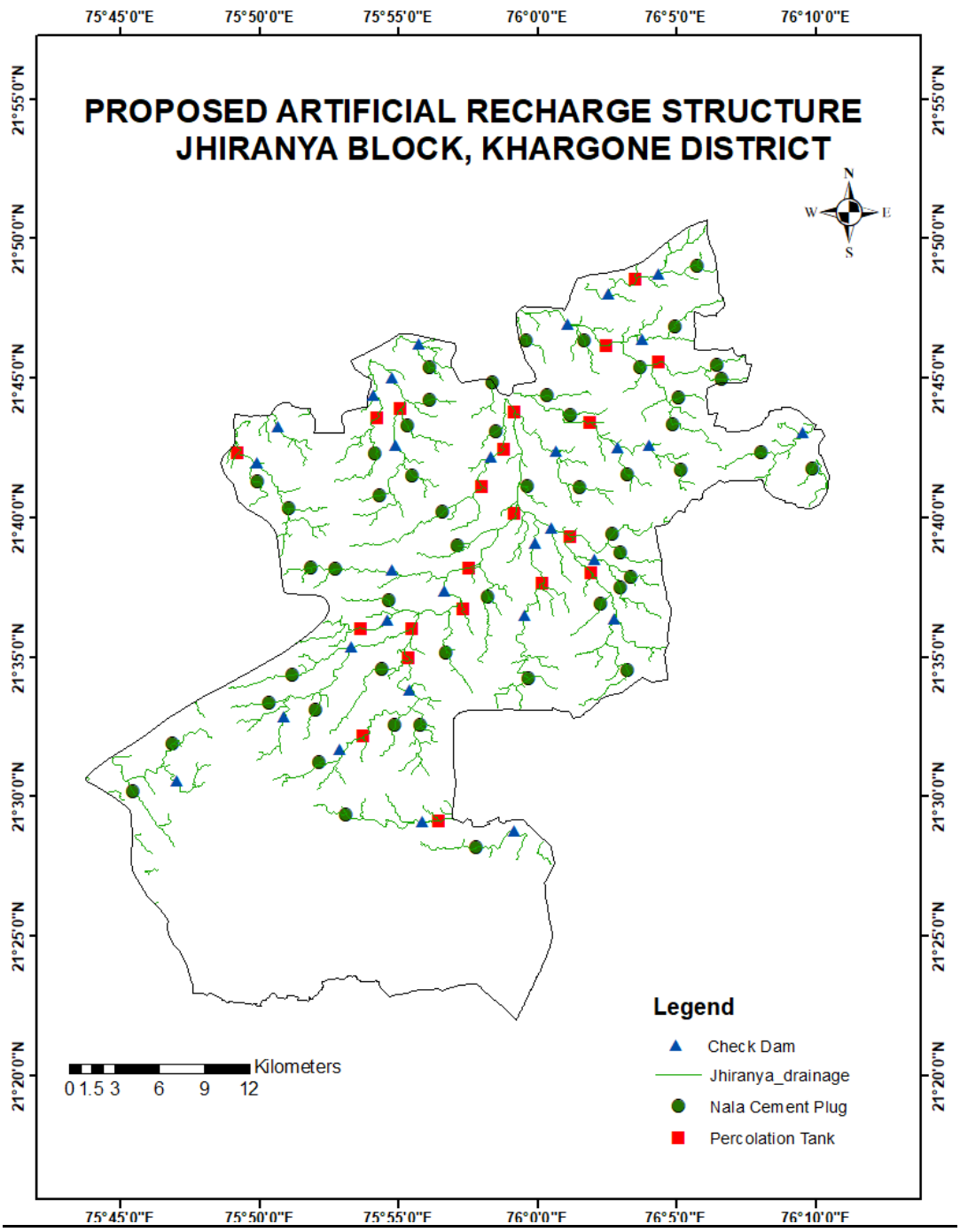
Supply Side Managemnt Plan

1. The supply side management plan has been formulated for theZirniya block. The volume of unsaturated zone available for AR in the Zirniya block is 5.98 MCM.
2. The volume of water required for recharging this much amount of water in the block is 7.96 MCM.
3. The number of artificial recharge structures proposed in the block –14 percolation tanks, 119 check dams with recharge shaft/ tubewell, 119 nala bunds/cement plugs, 40 villages' ponds/farm ponds and the estimated cost of the recharge structures proposed – 2.8 crore, 8.33 crore, 1.19 crore and 1 crore respectively. The cost for all structures of the block is 13.32 MCM.

Area (Sq Km)	**Sq km**	**1189.00**
Rainfall (m)	m	7.94
Net. Sown Area	**hec**	42370.20
Area sown more than once	**hec**	19261.00
Area under Wasteland	**hec**	2916.20
Area under othdr uses	**hec**	4978.90
Area suitable for recharge (Sq Km)	Sq km	664.69

Average post-monsoon water level (m)	m	915
Unsaturated zone (m)	m	6.15
Average SP Yield (%)	%	0.02
Sub-surface storage (mcm)	mcm	81.76
Surface water required (mcm)	mcm	108.74
Surface water (Run-off) available (mcm) for AR	mcm	49.58
Non-committed Run-off (mcm)	mcm	49.58
Percolation tank	No.	87
Check dam with Recharge shaft/ Tube well	No.	744
Nala Bunds/ Cement Plugs	No.	744
no of village ponds/ Farm Ponds	No.	248

Type of Structure Proposed	Number	Cost in crores
Percolation tanks	14	2.8 (0.2crore per structure)
Check Dams with recharge shaft	119	8.33 (0.07 crore per structure)
Nala bunds/cement plugs	119	1.19(0.01 crore per structure)
Village ponds/ Farm Ponds	40	1(0.025 crore per structure)
Total Cost		13.32 crore


PROPOSED ARTIFICIAL RECHARGE STRUCTURE
JHIRANYA BLOCK, KHARGONE DISTRICT
75°45'0"E
75°50'0"E
75°55'0"E
76°0'0"E
76°5'0"E
76°10'0"E
21°55'0"N
21°50'0"N
21°45'0"N
21°40'0"N
21°35'0"N
21°30'0"N
21°25'0"N
21°20'0"N
N
W
E
S
Kilometers
0 1.5 3 6 9 12
Legend
Check Dam
Jhiranya_drainage
Nala Cement Plug
Percolation Tank

Impact after Intervention: Zirniya Block

Demand Side Management Plan

1. Demand side management plan has also been formulated in which saving of groundwater by micro-irrigation (drip or sprinkler) in the Zirniya block is 11.60 MCM.
2. After the intervention of supply side and demand side management plan successfully making the Stage of Ground Water Extraction of the Zirniya block from **51.36 % to 60.66 %** and the block remains under safe category.
3. The additional area irrigated by Ground water after the intervention is5815.50 ha

Block	Net GW Availability (MCM)	GW Draft for Irrigation (MCM)	GW Draft for Domestic & Industrial (MCM)	Gross Draft (MCM)	Stage of Development (%)	Saving by microirrigation in (MCM)	Additional recharge created by AR (MCM)	After intervention of AR Structure Net GW AvL. (MCM)	After intervention of AR Structure & utilisation of additional GW created (MCM)/ Utilization of Net Ground Water Availabilty	After utilization of Net Ground water availabilty (2020 resource)	Draft after sprinkler & additional area created for agriculture (MCM	Stage of Development W/O GW use for addidtional Area Irrigation(%)	Additional area irrigated by GW after intervention (Ha)
Zirniya	86.41	38.66	5.72	44.38	51.36	11.60	5.98	92.39	5.98	17.28	56.04	60.66	5815.50

Chapter-7
CONCLUSIONS AND RECOMMENDATIONS

Based on the study of data gap analysis, data generated, exploration data and data acquired from the State Government an integrated approach was adopted foe the preparation of aquifer maps and blockwise aquifer management plan for the Khargone district.

- Khargone district occupies an area of sq km out of which the ground water recharge worthy area is 8030 sq. km. and 6568.97 sq. km. is covered by hilly and forest area. It comprises 9 blocks namely – Barwaha, Bhagwanpura, Bhikangaon, Gogawan, Kasrawad, Khargone, Mahashwar, Segaon and Zirniya block.

- The Narmada system represents two major types of drainage lines. First is the fault zone line and second is dentritic pattern shown by Kundi River. The important tributaries of the Narmada in this district are Kundi, Bakar, Borad, Beda etc. All these tributaries flow from south to north. Major rivers are perennial to semi perennial.
- The major part of the district is covered by the Deccan Basalt and as moves towards northern and northe eastern part number of flows encountered is less and sandston, shale and granite is also encountered at a shallow depth. The district is characterised by different number of lava. These flows occur in a layered sequence and act as multi-aquifer system. Each flow is characterised by the massive basalt at the bottom followed by vesicular basalt and marker horizon bed called as red bole.The alluvium of recent age found along the river course of Narmada River and along the tributaries of the Narmadain the district.

- The phreatic aquifer is recharged during monsoon and sustains for 3 to 5 months.

- More stress on Groundwater for irrigation in comparision to irrigation from surface water.

- Pre-Monsoon depth to water level in the year 2020 range from **1.07 mbgl at Gogaon site**, Gogawan block (minimum) to **10.32 mbgl at Divalgaon site**, Gogawab block (maximum).

- Post monsoon period, water level ranges from 0.72**mbgl at Sawada site**, Kasrawad block (minimum) to **9.17 mbgl (maximum) at Gogao site, Gogawan** block.
- **Higher concentration of Nitrate In the shallow aquifer i.e.** About62% water samples recorded more than 45 mg/l as per BIS recommendation. The high nitrate concentration has been recorded in ground water of Bamnala New (50 mg/l), Bhulwani (55 mg/l), Kasrawad (55 mg/l), Baddiya (57 mg/l), Dhulkot (65 mg/l), Khargone (70 mg/l), Dhargaon (80 mg/l), Gogaon (80 mg/l), Bhikangaon(85 mg/l), Barwah(100 mg/l), Daudwa (100 mg/l), Segaon (100 mg/l) and

Piplyabuzrug (102 mg/l).**In the deeper aquifer i.e. only 3 samples recorded more than 45** mg/l as per BIS recommendation, at the location Mogargaon (110 mg/l), Golpura (48 mg/l) and Saikheda (48 mg/l). **Fluoride concentration found in 2 samplesis more than 1.5 mg/l as per BIS recommendations and the sites are**Ashapur (3.85 mg/l) and Najarpur (1.53 mg/l)

- Higher Concentration of nitrate has been encountered in the district. The use **of fertilizers and sewage/ domestic waste** is one of the reason for ground water contamination. Therefore it is recommended for proper lining of sewage lines and proper waste management in the district. In agriculture field the use of **organic fertilizers** instead of the use of harmful fertilizers is suggested.

- On the basis of the 29 exploratory borewells drilled by CGWB, NCR under its Exploratory/NAQUIM program and 6 piezometers, it has been observed that the yield of the wells varies from 0.01lps to 16lps.

- As per the Dynamic Ground Water Resource Assessment Report (2020), the annual extractable ground water availability in the district is 1059.8MCM and ground water draft for all uses is 457.19 MCM which results the stage of ground water extraction to be 43.15% as a whole for district. The Khargone district falls under safe category.

- There are 1 semi-critical block namely Khargone having stage of GW extraction is 76.52 %andrest 8 blocks are safe namely Barwaha, Bhagwanpura, Bhikangaon, Gogawan, Kasrawad, Mahashwar, Segaon and Zirniyahaving Stage of Ground Water Extraction are 38.59 %, 36.86 %, 51.11 %, 56.68 %, 23.03 %, 52.40 %, 58.01 % and 51.36 % respectively.

- After the supply side interventions i.e. construction of artificial recharge structures groundwater resource will increase by **38.52 MCM** in Barwaha block, **14.62 MCM** in Bhagwanpura block, **30.01 MCM** in Bhikangaonblock, 25.57 MCM in Gogawan block, 28.64 MCM in Kasrawad block, 21.41 MCM in Khargone block, 19.17 MCM in Mahashwar block, 3.14 MCM in Segaonblockand**5.98 MCM** in Zirniya block. As a whole ground water resource will increase by **187.05 MCM** in Khargonedistrct.

- As per the Management plan prepared under NAQUIM of all the Block of Khargonedistrict , a total number of 390 Percolation Tanks, 3331 Check dams with recharge shafts, 3331 Nala Bunds/Cement Plugs and 1110 village ponds/ farm ponds have been proposed and financial expenditure is expected to be60 crores, 233.17 crores, 33.31 crores and 27.75 crores respectively (as a whole the total expenditure for whole district is expected to be Rs 354.23 crores in the district) for sustainable extraction and management of ground water resources.

- The number of artificial recharge structure and financial estimation has been proposed based on the methodology recommended in **CGWB Master plan 2020**. It may be differ from the field condition as well as changes in dynamic Ground water resources.

- These above supply side interventions are not enough to bring the stage of ground water extraction less than or equal to 70 %. Hence a demand side intervention ispropsed for all four blocks in which micro-irrigation system is adopting instead of conventional old methods. The saving by micro-irrigation (drip and sprinkler) in the Barwaha block is20.97MCM, in the Bhagwanpura block is 6.65 MCM, in the Bhikangaon block is 19.06 MCM, in the Gogawanblock is 9.21 MCM, in the Kasrawad block is 16.34 MCM, in the Khargone block is 13.07 MCM, in the Mahashwar block is 17.87MCM, in the Segaon block is 9.51 MCM and in the Zirniyablock is 11.60MCM**.** As a whole saving by micro-irrigtaion is **124.29MCM** in the entire Khargone district.

- After the implemention of project interventions in the report, the stage of ground water extraction is expected to change by **20.45 % i.e. from 43.15% to 63.60%** for the Khargone district and additional area for the irrigation will be 87493.56 Ha. The block wise stage of groundwater extraction expected to improve is given in table 10 with additional area irrigated after the intervention is 24644.48 ha in Barwaha block, 9258.01 ha in Bhagwanpura block, 14197.36 ha in Bhikangaon block, 6391.47 ha in Gogawan block, 7159.90 ha in Kasrawad block, 5351.88 ha in Khargone block, 10968.96 ha in Mahashwar block, 3706ha in Segaon block and 5815.50 ha in Zirniya block.

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LithologAnnexure I

1. Amankhedi

Amankhedi				
Depth range (m)		Thickness (m)	Lithology	
From	To			
0	3	3	Top Soil	
3	20.1	17.1	Weathered Basalt	
20.1	44	23.9	Massive Basalt	
44	47.5	3.5	Red Bole	
47.5	62.5	15	Massive Basalt	
62.5	75	12.5	Fracture Basalt/Weathered Basalt	62.8-75
75	102.4	27.4	Massive Basalt	
102.4	108.5	6.1	Fracture Basalt/Weathered Basalt	
108.5	123.8	15.3	Massive Basalt	
123.8	129.9	6.1	Fracture Basalt/Weathered Basalt	
129.9	145.1	15.2	Vesicular Basalt	
145.1	172.6	27.5	Massive Basalt	
172.6	178.7	6.1	Red Bole	
178.7	184.8	6.1	Fracture Basalt/Weathered Basalt	
184.8	203.1	18.3	Vesicular Basalt	

2. Sakargaon

Sakargaon				
Depth range (m)		Thickness (m)	Lithology	
From	To			
0	1.7	1.7	Top Soil	
1.7	8.3	6.6	Weathered Basalt	
8.3	11.3	3	Massive Basalt	
11.3	17.5	6.2	Vesicular Basalt	
17.5	34.7	17.2	Massive Basalt	
34.7	53	18.3	Vesicular Basalt	INTERFLOW CONTACT
53	69.3	16.3	Massive Basalt	
69.3	77.4	8.1	Vesicular Basalt	
77.4	91.6	14.2	Massive Basalt	
91.6	100.8	9.2	Vesicular Basalt	
100.8	105.84	5.04	Massive Basalt	

3. Dhulkot

Dhulkot				
Depth range (m)		Thickness (m)	Lithology	
From	To			
0	2	2	Top Soil	
2	5.5	3.5	Weathered Basalt	
5.5	37	31.5	Massive Basalt	
37	43	6	Fracture Basalt/Weathered Basalt	
43	59.9	16.9	Massive Basalt	
59.9	63	3.1	Red Bole	
63	108.6	45.6	Massive Basalt	
108.6	111.7	3.1	Vesicular Basalt	105.6-111.7
111.7	121	9.3	Massive Basalt	
121	123.9	2.9	Vesicular Basalt	
123.9	155	31.1	Massive Basalt	
155	160	5	Red Bole	
160	167	7	Vesicular Basalt	133-140
167	200	33	Massive Basalt	

4. Golpura

Golpura				
Depth range (m)		Thickness (m)	Lithology	
From	To			
0	3	3	Top Soil	
3	11.1	8.1	Vesicular Basalt	
11.1	20.3	9.2	Massive Basalt	
20.3	23.3	3	Fracture Basalt/Weathered Basalt	20.3-23.3
23.3	38.6	15.3	Massive Basalt	
38.6	44.7	6.1	Fracture Basalt/Weathered Basalt	
44.7	72.1	27.4	Massive Basalt	
72.1	78.2	6.1	Fracture Basalt/Weathered Basalt	75.2-78.2
78.2	114.8	36.6	Massive Basalt	
114.8	120.9	6.1	Fracture Basalt/Weathered Basalt	
120.9	130	9.1	Vesicular Basalt	
130	154	24	Massive Basalt	
154	163.6	9.6	Fracture Basalt/Weathered Basalt	
163.6	195	31.4	Massive Basalt	
195	198	3	Red Bole	
198	202.3	4.3	Massive Basalt	

5. Abhapuri

Abhapuri				
Depth range (m)		Thickness (m)	Lithology	
From	To			
0	7.9	7.9	Top Soil	
7.9	14	6.1	Weathered Basalt	13-17
14	23.1	9.1	Vesicular Basalt	13-17
23.1	41.4	18.3	Massive Basalt	
41.4	44.5	3.1	Fracture Basalt/Weathered Basalt	
44.5	62	17.5	Massive Basalt	
62	67	5	Red Bole	
67	102.5	35.5	Massive Basalt	
102.5	108.5	6	Vesicular Basalt	105-108
108.5	140	31.5	Massive Basalt	
140	149	9	Fracture Basalt/Weathered Basalt	
149	158	9	Vesicular Basalt	
158	203.1	45.1	Massive Basalt	

6. Bhagwanpura D

Bhagwanpura D				
Depth range (m)		Thickness (m)	Lithology	
From	To			
0	0.45	0.45	Top Soil	
0.45	9.15	8.7	Massive Basalt	
9.15	10.65	1.5	Fracture Basalt/Weathered Basalt	9.15-8.5
10.65	18.5	7.85	Red Bole	
18.5	25.6	7.1	Vesicular Basalt	
25.6	26.3	0.7	Red Bole	
26.3	28	1.7	Vesicular Basalt	
28	30.15	2.15	Massive Basalt	

7. Anakwadi

Anakwadi				
Depth range (m)		Thickness (m)	Lithology	
From	To			
0	2	2	Top Soil	

2	8.1	6.1	Weathered Basalt	
8.1	20.3	12.2	Massive Basalt	
20.3	29.4	9.1	Fracture Basalt/Weathered Basalt	
29.4	45	15.6	Massive Basalt	
45	49	4	Fracture Basalt/Weathered Basalt	
49	75	26	Massive Basalt	
75	78	3	Vesicular Basalt	59.9-60.5
78	115	37	Massive Basalt	
115	118	3	Fracture Basalt/Weathered Basalt	
118	200	82	Massive Basalt	

8. Nimseti

Nimseti				
Depth range (m)		Thickness (m)	Lithology	
From	To			
0	0.5	0.5	Top Soil	
0.5	1.8	1.3	Weathered Basalt	
1.8	14	12.2	Vesicular Basalt	
14	23.1	9.1	Massive Basalt	
23.1	26.2	3.1	Fracture Basalt/Weathered Basalt	
26.2	62.8	36.6	Massive Basalt	
62.8	68.9	6.1	Fracture Basalt/Weathered Basalt	
68.9	75	6.1	Vesicular Basalt	68.9-71.9
75	87.2	12.2	Fracture Basalt/Weathered Basalt	
87.2	145.1	57.9	Massive Basalt	
145.1	151.3	6.2	Fracture Basalt/Weathered Basalt	
151.3	160.5	9.2	Massive Basalt	
160.5	166.6	6.1	Fracture Basalt/Weathered Basalt	
166.6	203.2	36.6	Massive Basalt	

9. Marugarh

Marugarh				
Depth range (m)		Thickness (m)	Lithology	
From	To			
0	2	2	Top Soil	
2	7.9	5.9	Weathered Basalt	
7.9	31	23.1	Masssive Basalt	
31	35	4	Fracture Basalt/Weathered Basalt	32.3-35

35	68.9	33.9	Masssive Basalt	
68.9	75	6.1	Fracture Basalt/Weathered Basalt	
75	93.3	18.3	Masssive Basalt	
93.3	96.3	3	Fracture Basalt/Weathered Basalt	
96.3	123.8	27.5	Masssive Basalt	
123.8	127.5	3.7	Fracture Basalt/Weathered Basalt	123.8-126.8

10. Mogargaon

Mogargaon				
Depth range (m)		Thickness (m)	Lithology	
From	To			
0	4.8	4.8	Top Soil	
4.8	10.9	6.1	Weathered Basalt	4.8m
10.9	43	32.1	Massive Basalt	
43	55	12	Fracture Basalt/Weathered Basalt	
55	61	6	Vesicular Basalt	47.5m
61	81.1	20.1	Massive Basalt	
81.1	84.1	3	Fracture Basalt/Weathered Basalt	81.1 m
84.1	93.3	9.2	Massive Basalt	
93.3	99.4	6.1	Fracture Basalt/Weathered Basalt	
99.4	139	39.6	Massive Basalt	
139	148.2	9.2	Fracture Basalt/Weathered Basalt	
148.2	166.6	18.4	Massive Basalt	
166.6	173	6.4	Fracture Basalt/Weathered Basalt	
173	203.2	30.2	Massive Basalt	

11. Kanjhar

Kanjhar				
Depth range (m)		Thickness (m)	Lithology	
From	To			
0	2	2	Top Soil	
2	18	16	Weathered Basalt	14-17
18	55	37	Massive Basalt	
55	69.4	14.4	Red Bole	
69.4	81.1	11.7	Massive Basalt	
81.1	84.1	3	Fracture Basalt/Weathered Basalt	81-83
84.1	203.1	119	Massive Basalt	

12. Lalkhera

Lalkhera				
Depth range (m)		Thickness (m)	Lithology	
From	To			
0	3	3	Top Soil	
3	23	20	Weathered Basalt	14-17
23	33	10	Vesicular Basalt	
33	50.6	17.6	Massive Basalt	
50.6	56.7	6.1	Red Bole	
56.7	68.9	12.2	Vesicular Basalt	
68.9	81.1	12.2	Massive Basalt	
81.1	87.2	6.1	Red Bole	
87.2	125	37.8	Massive Basalt	
125	135.6	10.6	Fracture Basalt/Weathered Basalt	108.5-111.16
135.6	139	3.4	Red Bole	
139	148.2	9.2	Massive Basalt	
148.2	154.3	6.1	Fracture Basalt/Weathered Basalt	
154.3	190.9	36.6	Massive Basalt	
190.9	197	6.1	Fracture Basalt/Weathered Basalt	
197	203.1	6.1	Massive Basalt	

13. Un

Un				
Depth range (m)		Thickness (m)	Lithology	
From	To			
0	2	2	Top Soil	
2	7.9	5.9	Weathered Basalt	
7.9	23.1	15.2	Massive Basalt	
23.1	23.6	0.5	Red Bole	
23.6	35	11.4	Vesicular Basalt	32.5-35.5
35	58	23	Massive Basalt	
58	69	11	Red Bole	
69	75	6	Vesicular Basalt	
75	90.2	15.2	Massive Basalt	
90.2	95.3	5.1	Vesicular Basalt	
95.3	112.6	17.3	Massive Basalt	
112.6	114.6	2	Vesicular Basalt	
114.6	132.9	18.3	Massive Basalt	
132.9	133.4	0.5	Red Bole	
133.4	139	5.6	Vesicular Basalt	

139	157.3	18.3	Massive Basalt	
157.3	157.8	0.5	Red Bole	
157.8	159	1.2	Vesicular Basalt	
159	175.6	16.6	Massive Basalt	
175.6	180.5	4.9	Red Bole	
180.5	181.5	1	Vesicular Basalt	
181.5	203.1	21.6	Massive Basalt	

14. Bhikhangaon D

Bhikhangaon D				
Depth range (m)		Thickness (m)	Lithology	
From	To			
0	0.15	0.15	Top Soil	
0.15	15	14.85	Massive Basalt	
15	15.5	0.5	Red Bole	
15.5	22.75	7.25	Vesicular Basalt	
22.75	55.4	32.65	Massive Basalt	
55.4	65.6	10.2	Red Bole	
65.6	73	7.4	Vesicular Basalt	
73	82.3	9.3	Massive Basalt	
82.3	96	13.7	Vesicular Basalt	
96	114.5	18.5	Massive Basalt	
114.5	118.5	4	Red Bole	
118.5	119.5	1	Vesicular Basalt	
119.5	120	0.5	Massive Basalt	

15.Khargone D

Khargone D				
Depth range (m)		Thickness (m)	Lithology	
From	To			
0	6.7	6.7	Top Soil	
6.7	15.5	8.8	Weathered Basalt	
15.5	35.5	20	Massive Basalt	
35.5	39	3.5	Vesicular Basalt	
39	46.3	7.3	Massive Basalt	

Sukhpuri

Sukhpuri(Mela Ground)				
Depth range (m)		Thickness (m)	Lithology	
From	To			
0	2.54	2.54	Top Soil	
2.54	17.2	14.66	Weathered Basalt	
17.2	23.3	6.1	Red Bole	
23.3	29.4	6.1	Vesicular Basalt	
29.4	48.6	19.2	Massive Basalt	
48.6	54.6	6	Fracture Basalt/Weathered Basalt	
54.6	75.2	20.6	Massive Basalt	
75.2	78.2	3	Red Bole	
78.2	87.4	9.2	Vesicular Basalt	84.3-87.4
87.4	145.3	57.9	Massive Basalt	
145.3	153.6	8.3	Fracture Basalt/Weathered Basalt	148.4-157.5
153.6	158.6	5	Vesicular Basalt	
158.6	200.2	41.6	Massive Basalt	

16. Rasgaon

Rasgaon				
Depth range (m)		Thickness (m)	Lithology	
From	To			
0	2	2	Top Soil	
2	11.1	9.1	Weathered Basalt	
11.1	14.2	3.1	Fracture Basalt/Weathered Basalt	
14.2	47.7	33.5	Massive Basalt	
47.7	59.9	12.2	Vesicular Basalt	
59.9	66	6.1	Fracture Basalt/Weathered Basalt	63-66
66	76	10	Massive Basalt	
76	86.5	10.5	Fracture Basalt/Weathered Basalt	
86.5	87.3	0.8	Vesicular Basalt	
87.3	100.5	13.2	Massive Basalt	
100.5	110.5	10	Fracture Basalt/Weathered Basalt	
110.5	127	16.5	Vesicular Basalt	
127	136.2	9.2	Massive Basalt	
136.2	139.2	3	Fracture Basalt/Weathered Basalt	
139.2	145.3	6.1	Vesicular Basalt	
145.3	200.2	54.9	Massive Basalt	

17. Sagur

Sagur				
Depth range (m)		Thickness (m)	Lithology	
From	To			
0	4.8	4.8	Top Soil	
4.8	7.9	3.1	Weathered Basalt	
7.9	14	6.1	Massive Basalt	
14	17	3	Fracture Basalt/Weathered Basalt	14-17
17	65.9	48.9	Massive Basalt	
65.9	69	3.1	Fracture Basalt/Weathered Basalt	
69	78.1	9.1	Massive Basalt	
78.1	81.2	3.1	Fracture Basalt/Weathered Basalt	78-80
81.2	104.7	23.5	Massive Basalt	
104.7	115	10.3	Fracture Basalt/Weathered Basalt	
115	122	7	Vesicular Basalt	120-123
122	135.7	13.7	Massive Basalt	
135.7	141.7	6	Fracture Basalt/Weathered Basalt	
141.7	203.2	61.5	Massive Basalt	

18. Kundia

Kundia				
Depth range (m)		Thickness (m)	Lithology	
From	To			
0	5	5	Top Soil	
5	11.5	6.5	Weathered Basalt	
11.5	17.2	5.7	Vesicular Basalt	
17.2	35.4	18.2	Massive Basalt	
35.4	41.5	6.1	Vesicular Basalt	
41.5	56.8	15.3	Massive Basalt	
56.8	59.8	3	Red Bole	
59.8	63.5	3.7	Vesicular Basalt	
63.5	78.3	14.8	Massive Basalt	
78.3	84.3	6	Vesicular Basalt	
84.3	126.8	42.5	Massive Basalt	
126.8	130	3.2	Red Bole	
130	135.2	5.2	Vesicular Basalt	
135.2	200.2	65	Massive Basalt	

19. Umardad

Umardad				
Depth range (m)		Thickness (m)	Lithology	
From	To			
0	4.8	4.8	Top Soil	
4.8	10.9	6.1	Weathered Basalt	
10.9	23.1	12.2	Massive Basalt	
23.1	29.2	6.1	Fracture Basalt/Weathered Basalt	20.123.1
29.2	44.5	15.3	Massive Basalt	
44.5	47.5	3	Fracture Basalt/Weathered Basalt	
47.5	53.6	6.1	Vesicular Basalt	
53.6	99.4	45.8	Massive Basalt	
99.4	102.4	3	Fracture Basalt/Weathered Basalt	
102.4	105.5	3.1	Vesicular Basalt	
105.5	129.5	24	Massive Basalt	
129.5	132.9	3.4	Fracture Basalt/Weathered Basalt	129.9-133
132.9	142.1	9.2	Massive Basalt	

21.Besarkund

Besarkund				
Depth range (m)		Thickness (m)	Lithology	
From	To			
0	2	2	Top Soil	
2	5	3	Weathered Basalt	
5	17.2	12.2	Massive Basalt	
17.2	22.5	5.3	Vesicular Basalt	
22.5	44.7	22.2	Massive Basalt	
44.7	50.8	6.1	Fracture Basalt/Weathered Basalt	
50.8	56.9	6.1	Vesicular Basalt	
56.9	69.1	12.2	Massive Basalt	
69.1	75.2	6.1	Fracture Basalt/Weathered Basalt	70-75.2
75.2	124	48.8	Massive Basalt	
124	130.1	6.1	Vesicular Basalt	127-130.1
130.1	200.2	70.1	Massive Basalt	

22.Vitnera

Vitnera				
Depth range (m)		Thickness (m)	Lithology	
From	To			
0	3.85	3.85	Top Soil	
3.85	18	14.15	Weathered Basalt	7.9
18	24	6	Vesicular Basalt	
24	40	16	Massive Basalt	
40	44.5	4.5	Vesicular Basalt	40.45
44.5	70.4	25.9	Massive Basalt	
70.4	76.2	5.8	Vesicular Basalt	
76.2	93.15	16.95	Massive Basalt	
93.15	95.2	2.05	Fracture Basalt/Weathered Basalt	
95.2	98	2.8	Red Bole	
98	108	10	Vesicular Basalt	
108	125.7	17.7	Massive Basalt	
125.7	127.7	2	Red Bole	
127.7	140.95	13.25	Vesicular Basalt	
140.95	147.05	6.1	Massive Basalt	
147.05	156.2	9.15	Vesicular Basalt	
156.2	166.35	10.15	Massive Basalt	
166.35	180.65	14.3	Vesicular Basalt	
180.65	191.75	11.1	Massive Basalt	
191.75	198.9	7.15	Vesicular Basalt	
198.9	207	8.1	Massive Basalt	
207	214	7	Vesicular Basalt	
214	218	4	Massive Basalt	
218	221.25	3.25	Vesicular Basalt	
221.25	225.3	4.05	Massive Basalt	
225.3	231.4	6.1	Vesicular Basalt	
231.4	232.45	1.05	Massive Basalt	

23. Sanavad D

Sanavad D				
Depth range (m)		Thickness (m)	Lithology	
From	To			
0	2	2	Top Soil	
2	41.15	39.15	Masssive Basalt	
41.15	44.2	3.05	Fracture Basalt/Weathered Basalt	
44.2	68.6	24.4	Masssive Basalt	
68.6	70.1	1.5	Fracture Basalt/Weathered Basalt	
70.1	97.5	27.4	Masssive Basalt	
97.5	106.7	9.2	Vesicular Basalt	
9.2	120	110.8	Masssive Basalt	

24. Badodiya

Badodiya				
Depth range (m)		Thickness (m)	Lithology	
From	To			
0	1.5	1.5	Top Soil	
1.5	4.5	3	Weathered Basalt	
4.5	26.2	21.7	Massive Basalt	
26.2	32	5.8	Red Bole	26.2-29.2
32	35.3	3.3	Fracture Granite/Weathered Granite	
35.3	75	39.7	Massive Granite	
75	81.1	6.1	Fracture Granite/Weathered Granite	
81.1	150.2	69.1	Massive Granite	
150.2	159.4	9.2	Fracture Granite/Weathered Granite	
159.4	203.1	43.7	Massive Granite	163.4-166.5

25. Laundi

Laundi				
Depth range (m)		Thickness (m)	Lithology	
From	To			
0	1.7	1.7	Top Soil	
1.7	14.47	12.77	Weathered Basalt	
14.47	35.6	21.13	Massive Basalt	
35.6	42.88	7.28	Vesicular Basalt	
42.88	82.53	39.65	Massive Basalt	
82.53	93.68	11.15	Fracture Basalt/Weathered Basalt	
93.68	94.73	1.05	Red Bole	
94.73	97.98	3.25	Vesicular Basalt	
97.98	100.83	2.85	Massive Basalt	

26.Kasrawad S

Kasrawad S				
Depth range (m)		Thickness (m)	Lithology	
From	To			
0	5.18	5.18	Top Soil	
5.18	7.77	2.59	Weathered Basalt	
7.77	28.65	20.88	Massive Basalt	
28.65	28.95	0.3	Red Bole	
28.95	32.61	3.66	Vesicular Basalt	
32.61	50.9	18.29	Fracture Basalt/Weathered Basalt	
50.9	63.1	12.2	Massive Basalt	

27. Thangaon

Thangaon				
Depth range (m)		Thickness (m)	Lithology	
From	To			
0	2	2	Top Soil	
2	3.8	1.8	Red Bole	
3.8	10.5	6.7	Fracture Basalt/Weathered Basalt	
10.5	11.5	1	Red Bole	
11.5	18	6.5	Vesicular Basalt	15-18.05
18	25	7	Massive Basalt	
25	35	10	Vesicular Basalt	
35	61.75	26.75	Red Bole	
61.75	72.6	10.85	Vesicular Basalt	
72.6	89.2	16.6	Red Bole	
89.2	90.2	1	Limestone	
90.2	98.35	8.15	Sandstone	
98.35	99.35	1	Shale	
99.35	101.4	2.05	Sandstone	
101.4	102.4	1	Limestone	
102.4	105.45	3.05	Sandstone	
105.45	110.55	5.1	Limestone	

28. Dawana

Dawana				
Depth range (m)		Thickness (m)	Lithology	
From	To			
0	6	6	Top Soil	
6	10	4	Weathered Basalt	
10	12	2	Massive Basalt	
12	22	10	Vesicular Basalt	
22	48.7	26.7	Massive Basalt	
48.7	58	9.3	Vesicular Basalt	48.7-52.0
58	78	20	Massive Basalt	
78	82	4	Vesicular Basalt	
82	98	16	Massive Basalt	
98	105	7	Vesicular Basalt	
105	114	9	Massive Basalt	

114	126	12	Vesicular Basalt	
126	129	3	Fracture Basalt/Weathered Basalt	125-129

29. Salempura

Salempura				
Depth range (m)		Thickness (m)	Lithology	
From	To			
0	1	1	Top Soil	
1	6.1	5.1	Weathered Basalt	
6.1	9.15	3.05	Massive Basalt	
9.15	15.25	6.1	Vesicular Basalt	
15.25	40	24.75	Massive Basalt	
40	52	12	Fracture Basalt/Weathered Basalt	37.65-42.75
52	56	4	Vesicular Basalt	
56	77.55	21.55	Massive Basalt	
77.55	83.55	6	Vesicular Basalt	
83.55	93.6	10.05	Massive Basalt	
93.6	102.75	9.15	Vesicular Basalt	
102.75	110.9	8.15	Massive Basalt	
110.9	121	10.1	Vesicular Basalt	
121	135.25	14.25	Massive Basalt	
135.25	147.45	12.2	Vesicular Basalt	
147.45	178	30.55	Massive Basalt	
178	180	2	Vesicular Basalt	
180	187	7	Massive Basalt	
187	197.25	10.25	Vesicular Basalt	
197.25	209.65	12.4	Massive Basalt	
209.65	215.55	5.9	Vesicular Basalt	
215.55	220.5	4.95	Massive Basalt	

30. Maheswar S

Maheswar S				
Depth range (m)		Thickness (m)	Lithology	
From	To			
0	0.6	0.6	Top Soil	
0.6	4.87	4.27	Weathered Basalt	
4.87	2.05	-2.82	Red Bole	
2.05	10	7.95	Vesicular Basalt	
10	20.5	10.5	Massive Basalt	

20.5	35	14.5	Red Bole	
35	43.28	8.28	Vesicular Basalt	
43.28	48.76	5.48	Massive Basalt	

31. Saikheda

Saikheda				
Depth range (m)		Thickness (m)	Lithology	
From	To			
0	4.8	4.8	Top Soil	
4.8	8.9	4.1	Weathered Basalt	
8.9	20.1	11.2	Massive Basalt	
20.1	25	4.9	Red Bole	
25	28	3	Fracture Basalt/Weathered Basalt	
28	56.7	28.7	Massive Basalt	
56.7	62.8	6.1	Red Bole	
62.8	69	6.2	Fracture Basalt/Weathered Basalt	
69	75.2	6.2	Vesicular Basalt	
75.2	117.7	42.5	Massive Basalt	
117.7	126.8	9.1	Fracture Basalt/Weathered Basalt	
126.8	145	18.2	Massive Basalt	
145	148	3	Fracture Basalt/Weathered Basalt	
148	160.3	12.3	Massive Basalt	
160.3	166.4	6.1	Fracture Basalt/Weathered Basalt	
166.4	172.5	6.1	Vesicular Basalt	
172.5	203.1	30.6	Massive Basalt	

32. Ashapur

Ashapur				
Depth range (m)		Thickness (m)	Lithology	
From	To			
0	2	2	Top Soil	
2	38.6	36.6	Massive Basalt	
38.6	47.7	9.1	Vesicular Basalt	
47.7	87.4	39.7	Massive Basalt	
87.4	93.5	6.1	Fracture Basalt/Weathered Basalt	
93.5	117.9	24.4	Massive Basalt	
117.9	120.9	3	Vesicular Basalt	
120.9	124	3.1	Limestone	

124	139.2	15.2	Sandstone	
139.2	148.4	9.2	Granite	

33. Nazarpur

Nazarpur				
Depth range (m)		Thickness (m)	Lithology	
From	To			
0	1	1	Top Soil	
1	5	4	Weathered Basalt	
5	11.1	6.1	Vesicular Basalt	
11.1	29.4	18.3	Massive Basalt	
29.4	32.5	3.1	Fracture Basalt/Weathered Basalt	
32.5	59.9	27.4	Massive Basalt	
59.9	65	5.1	Fracture Basalt/Weathered Basalt	
65	69.1	4.1	Vesicular Basalt	
69.1	87.4	18.3	Massive Basalt	
87.4	96.5	9.1	Fracture Basalt/Weathered Basalt	
96.5	99.6	3.1	Vesicular Basalt	
99.6	120.9	21.3	Massive Basalt	
120.9	124.1	3.2	Limestone	
124.1	169.7	45.6	Sandstone	
169.7	181.9	12.2	Shale	
181.9	194.1	12.2	Sandstone	
194.1	200.2	6.1	Granite	

34. Kasrawad

Kasrawad				
Depth range (m)		Thickness (m)	Lithology	
From	To			
0	5	5	Top Soil	
5	8.1	3.1	Weathered Basalt	
8.1	14.2	6.1	Vesicular Basalt	
14.2	32.5	18.3	Massive Basalt	
32.5	35.5	3	Fracture Basalt/Weathered Basalt	
35.5	41.6	6.1	Massive Basalt	
41.6	44.7	3.1	Vesicular Basalt	
44.7	50.8	6.1	Vesicular Basalt	
50.8	105.7	54.9	Massive Basalt	
105.7	111.8	6.1	Fracture Basalt/Weathered Basalt	

111.8	200.2	88.4	Massive Basalt	

35. Jamniya

Jamniya				
Depth range (m)		Thickness (m)	Lithology	
From	To			
0	1.8	1.8	Top Soil	
1.8	4.8	3	Weathered Basalt	
4.8	12.8	8	Vesicular Basalt	
12.8	47.7	34.9	Massive Basalt	
47.7	57.4	9.7	Fracture Basalt/Weathered Basalt	
57.4	114.2	56.8	Massive Basalt	
114.2	117.9	3.7	Fracture Basalt/Weathered Basalt	
117.9	120.9	3	Vesicular Basalt	
120.9	124	3.1	Limestone	
124	152.2	28.2	Sandstone	
152.2	203.1	50.9	Granite	

Annexure II

Premonsoon Depth to Water Level 2020

DISTRICT_NAME	BLOCK_NAME	SITE_NAME	LATITUDE	LONGITUDE	SITE_TYPE	Premonsoon 2020-WaterLevel_mbgl
KHARGONE	BARWAHA	Amba	22°2'34" N	75°56'45" E	Dug Well	2.85
KHARGONE	BARWAHA	Balwara	22°23'39" N	75°58'30" E	Dug Well	2.4
KHARGONE	BARWAHA	Barwah	22°15'14" N	76°2'6" E	Dug Well	2
KHARGONE	BARWAHA	Sanawad(D)	22°10'10" N	76°3'35" E	Bore Well	5.58
KHARGONE	BARWAHA	Sanawad New	22°10'24" N	76°4'16" E	Dug Well	3.97
KHARGONE	BHAGWANPURA	Bhulwani	21°32'54" N	75°28'53" E	Dug Well	2.85
KHARGONE	BHAGWANPURA	Dhulkot	21°36'35" N	75°33'10" E	Dug Well	5.95
KHARGONE	BHAGWANPURA	Ghatti	21°43'22" N	75°40'2" E	Dug Well	8.95
KHARGONE	BHIKANGAON	Bamnala New	21°49'31" N	75°51'11" E	Dug Well	9.5
KHARGONE	BHIKANGAON	Bhikangaon(D)	21°51'47" N	75°57'22" E	Bore Well	39.65
KHARGONE	BHIKANGAON	Bhikangaon1	21°51'43" N	75°57'21" E	Dug Well	5.86
KHARGONE	BHIKANGAON	Daudwa	22°1'14" N	76°8'13" E	Dug Well	7.84
KHARGONE	GOGAWAN	Divalgaon	21°49'45" N	75°44'34" E	Dug Well	10.32
KHARGONE	GOGAWAN	Gogaon	21°55'5" N	75°44'40" E	Dug Well	1.07
KHARGONE	KASRAWAD	Kasrawad1	22°7'25" N	75°36'30" E	Dug Well	2.15
KHARGONE	KASRAWAD	Sawda	22°1'50" N	75°37'44" E	Dug Well	3.55
KHARGONE	KHARGONE	Khargone	21°49'40" N	75°37'10" E	Dug Well	9.28
KHARGONE	KHARGONE	Khargone(D)	21°49'25" N	75°37'20" E	Bore Well	9.4
KHARGONE	KHARGONE	Un	21°49'17" N	75°27'2" E	Dug Well	2.29
KHARGONE	MAHESHWAR	Baddiya	22°14'2" N	75°56'54" E	Dug Well	3.72
KHARGONE	MAHESHWAR	Maheshwar	22°10'40" N	75°35'15" E	Dug Well	4.37
KHARGONE	MAHESHWAR	Maheswar(S)	22°10'45" N	75°35'15" E	Bore Well	10.11
KHARGONE	MAHESHWAR	Piplyabuzrug	22°14'2" N	75°51'41" E	Dug Well	4.1
KHARGONE	SEGAON	Segaon	21°51'25" N	75°19'44" E	Dug Well	3.6

Annexure III

Postmonsoon Depth to Water Level 2020

DISTRICT_NAME	BLOCK_NAME	SITE_NAME	LATITUDE	LONGITUDE	SITE_TYPE	Postmonsoon 2020-Waterlevel_mbgl
KHARGONE	BARWAHA	Amba	22°2'34" N	75°56'45" E	Dug Well	3.23
KHARGONE	BARWAHA	Balwara	22°23'39" N	75°58'30" E	Dug Well	1.99
KHARGONE	BARWAHA	Barwah	22°15'14" N	76°2'6" E	Dug Well	4.92
KHARGONE	BARWAHA	Sanawad(D)	22°10'10" N	76°3'35" E	Bore Well	5.41
KHARGONE	BARWAHA	Sanawad New	22°10'24" N	76°4'16" E	Dug Well	3
KHARGONE	BHAGWANPURA	Bhulwani	21°32'54" N	75°28'53" E	Dug Well	1.9
KHARGONE	BHAGWANPURA	Dhulkot	21°36'35" N	75°33'10" E	Dug Well	4.55
KHARGONE	BHAGWANPURA	Ghatti	21°43'22" N	75°40'2" E	Dug Well	5.03
KHARGONE	BHIKANGAON	Bamnala New	21°49'31" N	75°51'11" E	Dug Well	6.6
KHARGONE	BHIKANGAON	Bhikangaon(D)	21°51'47" N	75°57'22" E	Bore Well	6.09
KHARGONE	BHIKANGAON	Bhikangaon1	21°51'43" N	75°57'21" E	Dug Well	5.38
KHARGONE	BHIKANGAON	Daudwa	22°1'14" N	76°8'13" E	Dug Well	3.52
KHARGONE	GOGAWAN	Divalgaon	21°49'45" N	75°44'34" E	Dug Well	6.4
KHARGONE	GOGAWAN	Gogaon	21°55'5" N	75°44'40" E	Dug Well	9.17
KHARGONE	KASRAWAD	Kasrawad(S)	22°7'26" N	75°36'30" E	Bore Well	4.99
KHARGONE	KASRAWAD	Kasrawad1	22°7'25" N	75°36'30" E	Dug Well	1.67
KHARGONE	KASRAWAD	Sawda	22°1'50" N	75°37'44" E	Dug Well	0.72
KHARGONE	KHARGONE	Khargone	21°49'40" N	75°37'10" E	Dug Well	7.88
KHARGONE	KHARGONE	Khargone(D)	21°49'25" N	75°37'20" E	Bore Well	7.68
KHARGONE	KHARGONE	Un	21°49'17" N	75°27'2" E	Dug Well	1.84
KHARGONE	MAHESHWAR	Baddiya	22°14'2" N	75°56'54" E	Dug Well	4.25
KHARGONE	MAHESHWAR	Dhargaon	22°12'33" N	75°35'50" E	Dug Well	5.3
KHARGONE	MAHESHWAR	Maheshwar	22°10'40" N	75°35'15" E	Dug Well	3.47
KHARGONE	MAHESHWAR	Maheswar(S)	22°10'45" N	75°35'15" E	Bore Well	11.97
KHARGONE	MAHESHWAR	Piplyabuzrug	22°14'2" N	75°51'41" E	Dug Well	7.25
KHARGONE	SEGAON	Segaon	21°51'25" N	75°19'44" E	Dug Well	7.01