केंद्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण

विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board

Department of Water Resources, River Development and Ganga Rejuvenation,

Ministry of Jal Shakti

Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

JHABUA DISTRICT, MADHYA PRADESH

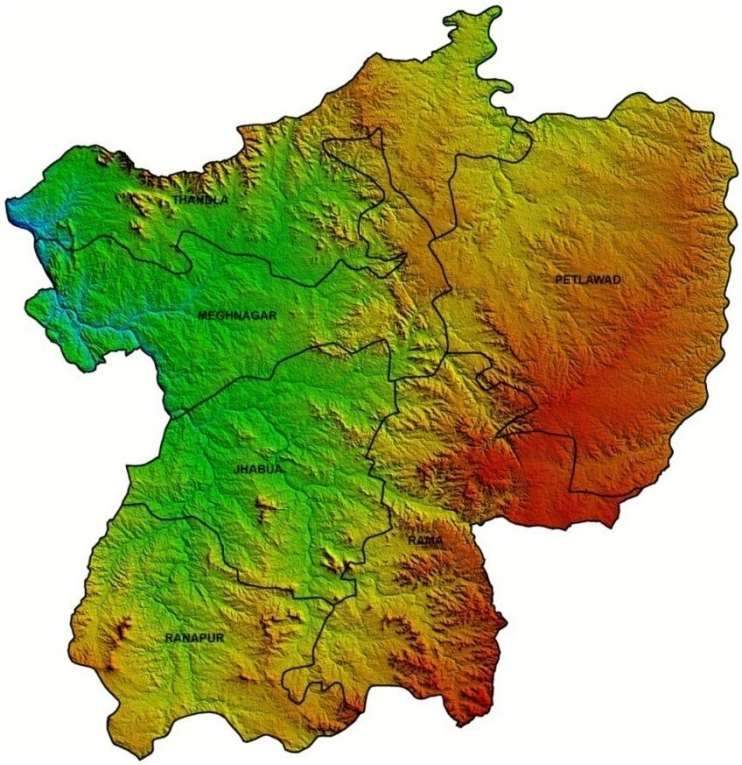
उत्तर मध्य क्षेत्र, भोपाल

North Central Region, Bhopal

Central Ground Water Board

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

Aquifer Mapping and Ground Water Management Plan of Jhabua District, Madhya Pradesh



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NORTH CENTRAL REGION
BHOPAL
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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 ground water 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 ground water. 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 planners, policy makers and other stakeholders.

Under the project on National Aquifer Mapping (NAQUIM), Central Ground Water Board (CGWB) North Central Region, Bhopal has taken up Jhabua district to prepare the Aquifer Maps for the entire district as well as block wise and formulate Block-wise Aquifer Management Plan. Jhabua district occupies an area of 3460 sq km out of which the ground water recharge worthy area is 3112 sq. km. and the rest is covered by hilly and forest area. Almost entire district is falling under Narmada Basin. The major rivers flowing in the district are Mahi and Narmada. The district is mainly occupied by Deccan Trap basalt, rock formations of Vindhyan Super Group. Both in shallow and deep aquifers the water levels between 5 to 10 mbgl in the pre-monsoon and between 2 to 10 mbgl in post-monsoon are observed in major parts of the district. As per the Dynamic Ground Water Resource Assessment Report (2022), the annual Ground Water Extractable Resource in the district is 233.49 mcm and the total ground water extraction for all uses is 108.13 mcm, resulting the stage of ground water development to be 46.31 % as a whole for district. After successful implementation of supply side and demand side management plan the groundwater levels in Jhabua district is expected to rise. The interventions suggested in the report will not only have a positive impact on the ground water 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 of **Shri J.Sreemannarayana, STA (HG)** 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 sustainable development of Ground Water in the Jhabua District, Madhya Pradesh.

A.K.Biswal
(Head of Office)

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CHAPTER 1
INTRODUCTION

National Aquifer Mapping (NAQUIM) has been taken up in XII five-year plan by CGWB to carry out detailed hydrogeological investigation on 1:50,000 scale. The NAQUIM has been prioritized to study Over-exploited, Critical and Semi-Critical blocks as well as the other stress areas recommended by the State Govt. Aquifer mapping is a process wherein a combination of geologic, geophysical, hydrologic and chemical analyses is applied to characterize the quantity, quality and sustainability of ground water in aquifers.

The vagaries of rainfall, inherent heterogeneity & poor sustainability of hard rock aquifers, over exploitation of once copious alluvial aquifers, lack of regulatory mechanism has a detrimental effect on ground water scenario of the Country in last decade or so. Thus, prompting the paradigm shift from "**traditional groundwater development concept**" to "**modern groundwater management concept**".

Varied and diverse hydrogeological settings demand precise and comprehensive mapping of aquifers down to the optimum possible depth at appropriate scale to arrive at the robust and implementable ground water management plans. The proposed management plans will provide the **"Road Map"** for ensuring sustainable management and equitable distribution of ground water resources, thereby primarily improving drinking water security and irrigation coverage. Thus, the crux of NAQUIM is not merely mapping, but reaching the goal-that of ground water management through community participation. The aquifer maps and management plans will be shared with the administration of Jhabua district, Madhya Pradesh for its effective implementation.

The activities under NAQUIM are aimed at:

- Identifying the aquifer geometry
- Aquifer characteristics and their yield potential
- Quality of water occurring at various depths
- Aquifer wise assessment of ground water resources
- Preparation of aquifer maps and
- Formulate ground water management plan

1.1 Background of Aquifer Mapping

'Aquifer mapping' is a holistic approach for aquifer-based groundwater management. It may not be construed as aquifer geometry mapping only. In a broader perspective it can be defined as understanding the aquifers, ascertaining and establishing their quantity and quality sustainability through multi-disciplinary scientific approach integrating the techniques of geology, remote sensing, hydrogeology, geophysics, borehole drilling, hydrochemistry, hydrology, hydrometeorology, mathematical modelling, agriculture and soil science, water treatment and remediation, economics and social and environmental sciences. Out of these the Geophysical technique will help as a strong tool to identify the aquifer geometry precisely.

1.2 Scope of Study

At present a generalized picture of aquifer-dispositions and their characteristics are known from the existing hydrogeological and surface geophysical data, the borehole lithological and geophysical logs and the aquifer performance tests conducted by CGWB and other central and state agencies. But it is not enough to prepare aquifer maps because of the inadequate density of data vis-à-vis geological heterogeneities. The extrapolation and interpolation within the existing boreholes may not yield accurate information on aquifer disposition unless they are tied up further by close-grid geophysical measurements conducted in between. This has necessitated in a systematic mapping of aquifers. Further hydro-geological investigation either by geophysical technique or by exploration is proposed for the aquifer mapping. It is to provide adequate and precise subsurface information in terms of aquifer lithology and geometry leading to 3-dimensional aquifer dispositions. Also, it is to establish the most appropriate technique or combination of techniques for identifying the aquifers in different hydrogeological terrains.

1.3 Objectives

The objective of applying the hydrogeological and geophysical techniques is to provide more adequate and more precise (reduced uncertainty and ambiguity) information on aquifers – shallow and deep including dry and saturated zones with their geometry at reasonable scale (1:50,000) in the area. The tentative depth of the hydrogeological and geophysical exploration will be 200 m in hard rock area. However, the depth of exploration may vary depending on the geological conditions and requirements. Additional exploratory wells shall be drilled for validations of aquifer parameter estimations where borehole data are not available.

The information thus generated through additional drilling of boreholes shall be used for refinement of hydrogeological data base in terms of aquifer characterization, yield capacity, chemical quality, selecting areas for artificial recharge and sustainability under varied future demand scenario leading to preparations of aquifer-management plans and recommendations to mitigate mining of aquifer.

1.4 Approach and Methodology

National Aquifer Mapping Programme basically aims at characterizing the geometry, parameters, behavior of ground water levels and status of ground water development in various aquifer systems to facilitate Major Aquifers planning of their sustainable management. The major activities involved in this process include compilation of existing data, identification of data gaps and generation of data for filling data gaps and preparation of aquifer maps. The overall methodology of aquifer mapping is presented **(Fig:1.1)** once the maps are prepared, plans for sustainable management of ground water resources in the aquifers mapped shall be formulated and implemented through participatory approach involving all stakeholders.

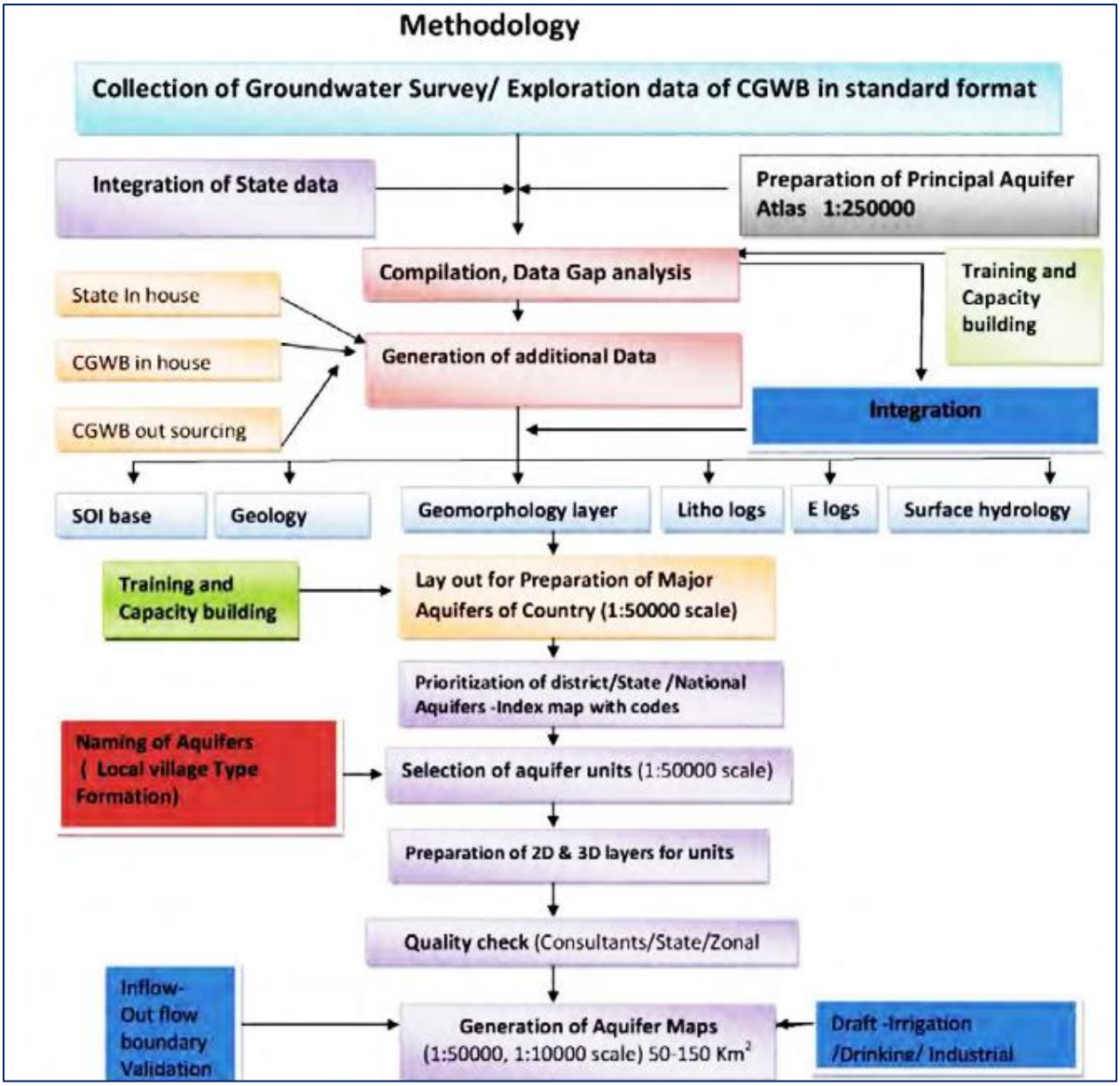


Fig: 1.1 Flow Chart of Methodology.

1.5 Study Area

Jhabua district is situated in the extreme south- western part of the Madhya Pradesh state. It occupies the hilly tract along the western margins of Malwa plateau. The district extends between the parallels of latitude 22.525886 N and 23.242257 N, and meridians of longitude 74.319641 E and 75.016647 E. Jhabua district lies in the western part of Madhya Pradesh. It is surrounded by Panchmahal and Baroda districts of Gujarat, Banswara district of Rajasthan and Alirajpur, Dhar and Ratlam districts of Madhya Pradesh **(Fig:1.2)**. The total geographical area of the district is 3460 sq.km (**As per GWRA-2022)**. The shape of Jhabua district resembles a rough parallelogram with its length extending from south-west to north-east.

The district is sub divided into 05 Tehsils and 06 blocks. There are 813 Villages, 375 Panchayats & 04 revenue sub divisions viz. Jhabua, Thadla, Meghnagr and Petlawad, 04 Nagar panchayats and 01 Town Municipalities. As per census 2011, the total population of the district 10,25,408. **(Table: 1.1 & 1.2)**

Table: 1.1 Statistical data of Jhabua district, MP.

S No.	Tehsils	Geographical Area (Sq.km)	Rural	Urban	Total
1	Jhabua	440.00	2,87,451	35,753	3,23,204
2	Rama	594.00			
3	Meghnagar	502.00	1,59,015	12,929	1,71,944
4	Petlawad	977.00	2,17,626	15,174	2,32,800
5	Ranapur	404.00	1,02,367	12,371	1,14,738
6	Thandla	543.00	1,66,606	15,756	1,82,362
Total		3460.00	9,33,065	91,983	10,25,048

(Source: Census handbook- 2011)

Table: 1.2: Administrative units of Jhabua district, MP.

Total Blocks	Area (sq km)
Total Geographical Area (sq km)	3460.00
Recharge worthy Area (sq km)	3112.53 (89.96%)
Hilly/Forest (sq km)	347.47 (10.04%)

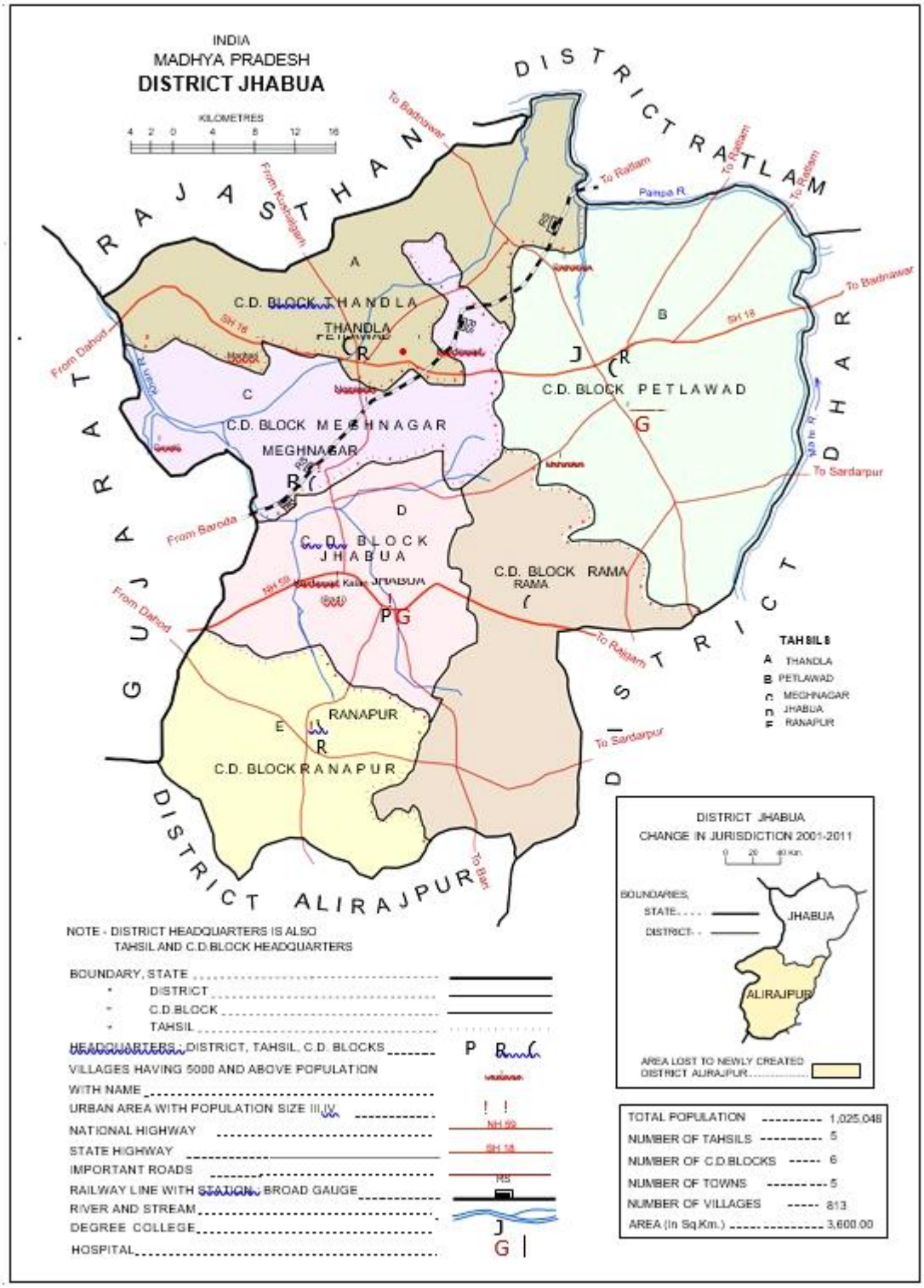


Fig: 1.2 Administrative Map of Jhabua district, M.P.

1.6 AGRICULTURE/IRRIGATION/CROPPING PATTERN

Jhabua is developing district of the state & important district for agriculture point of view. Here major crops grown in the district in kharif are Maize, Soybean, cotton, paddy, Groundnut, Urd. Arhar, Jowar, Wheat and Gram in Rabi season. The prominent cropping system prevails in the district are Soyabean – Wheat, Maize –Gram, Cotton – Wheat and Tomato/Chilly - Wheat. The productivity of the major crop is not better since the crops are dependent on rains and light soil. Maize and wheat are mainly used as a staple food in the district.

A total around 35% of cultivable land is under irrigation. Average rainfall of the district is 835.10 mm with the average 30 raining days was last year. The much sources of irrigation are Canal, Tube well, Dug wells and Ponds. Area under command is only 5549 ha. where canal irrigation system is followed. The irrigated area under Tube wells, Dug wells, and Ponds, mainly depended on rains.

Table: 1.3 Land Use pattern of Jhabua district, MP.

S. No.	Block	Area under Agriculture (ha)				Area under Forest (ha.)	Area under waste Land (ha.)	Area under other Uses (ha.)
		Gross Cropped Area (1)	Net sown Area(2)	Area sown more than once (1-2)	Cropping Intensity (%)			
1	Jhabua	35797	27985	7812	127.91	21684	2582	2040
2	Rama	40724	30457	10267	133.71	0	3038	2010
3	Ranapur	35989	28688	7301	125.45	462	2426	1300
4	Thandla	34429	27754	6675	124.05	12501	6147	2281
5	Petlawad	74364	51645	22719	143.99	12615	5395	5282
6	Meghnagar	29813	23155	6658	128.75	18104	2920	1685
Total		**251116**	**189684**	**61432**	**132.39**	**65366**	**22508**	**14598**

Table: 1.4 Area under Irrigated & Rainfed, Jhabua district, MP.

S. No	Name of Block	Irrigated Area (ha.)		Rainfed Area (ha.)	
		Gross Irrigated	Net Irrigated	Partially Irrigation	Un -irrigated/ totally Rainfed
1	Jhabua	6621	6523	3054	18610
2	Rama	11805	11677	2778	15874
3	Ranapur	5785	5785	1206	21997
4	Thandla	9517	9426	1930	16607
5	Petlawad	29475	8721	3247	18923
6	Meghnagar	5665	5558	2687	15081
	Total	**68868**	**67690**	**14902**	**107092**

(*Source-DIP, Sheopur)

1.7 RAINFALL AND CLIMATE

Climate is generally moderate and seasons are well defined. The summers are hot, winters are short and the monsoon season is generally pleasant. The average annual rainfall in the district is **835.10** mm. Most of the rainfall occurs in monsoon season while there is also a little of rainfall in winter season

A hot summer and general dryness characterize the climate of Jhabua district, except during the southwest monsoon season. The year can be divided in to four seasons. The winter commences from middle of November and lasts till the end of February. The period from March to about middle of June is the hot summer season. May is the hottest month of the year. The southwest monsoon starts from middle of June and lasts till end of September. October and middle of November constitute the post monsoon or retreating monsoon season.

The temperature starts rising from the beginning of February and reaching maximum in the month of May. The normal annual mean maximum temperature is 32.8^0C and normal annual mean minimum temperature is 19.1^0C.The individual day maximum temperature in May goes up to 39.5^0C. The individual day minimum temperature is recorded 11^0C in the month of January. The march is the driest month of the year. The humidity comes down lowest in April. It varies between 41 % and 89 % at different during April and August. The wind velocity is high during the pre monsoon period as compared to post monsoon period. The wind velocity is highest in June around 15.9 km/hr and lowest is 3.2 km/hr in November. The average normal annual wind velocity of Jhabua district is 7.8 km/hr.

The normal annual rainfall of Jhabua district is **835.10** mm. Jhabua district receive maximum rainfall during southwest monsoon period i.e. June to November. About 92.8% of annual rainfall is received during monsoon season. Only 7.2% of annual rainfall takes place between Octobers to May period. The surplus water for ground water recharge is available only during the southwest monsoon period.

Table: 1.5 Rainfall data of Jhabua district, MP.

Year	Monsoon (mm)	Non-Monsoon (mm)	Total (mm)
2017-2018	838.00	7.60	845.60
2018-2019	774.50	0.0	774.50
2019-2020	1424.55	124.50	1549.05
2020-2021	1010.80	21.90	1032.70
2021-2022	829.00	47.56	876.56

1.8 DRAINAGE

Jhabua district lies in the major basin, the Mahi in the north. The Mahi River forms northern and northeastern boundary of the district. It has a length of 67 Km. Within the district limits and along with its left bank tributaries. The Mahi and Pampawati drains 52% of the geographical area of the district. The Anas river with its tributaries like Mod, Sapan, Sunar, Negaria and Pat covers 38% of the geographical area of the district. The drainage basins found vary from one place to another. The Drainage map of Jhabua district is shown in the (**Fig: 1.3).**

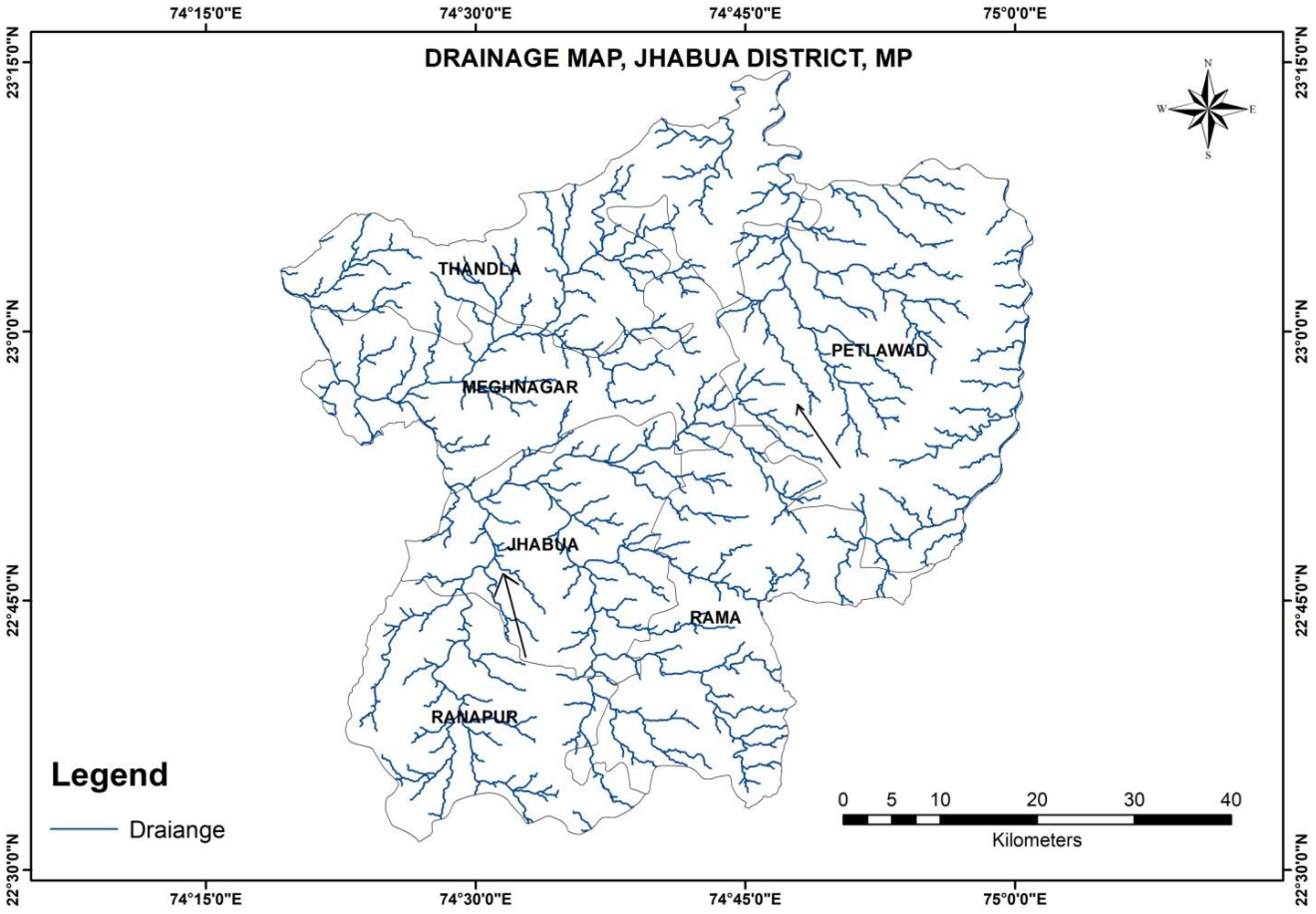


Fig: 1.3 Drainage Map of Jhabua District, MP.

1.9 PHYSIOGRAPHY/DEM

Jhabua district is mainly a hilly region covered with a chain of hills known as "The Vindhyachal" which extends northwards towards Udaipur in Rajasthan. The maximum elevation of 569 mamsl is recorded in Petlawad block. The general trends of the hills are in east-west direction. The Physiography map of Jhabua district is shown in the **(Fig: 1.4).**

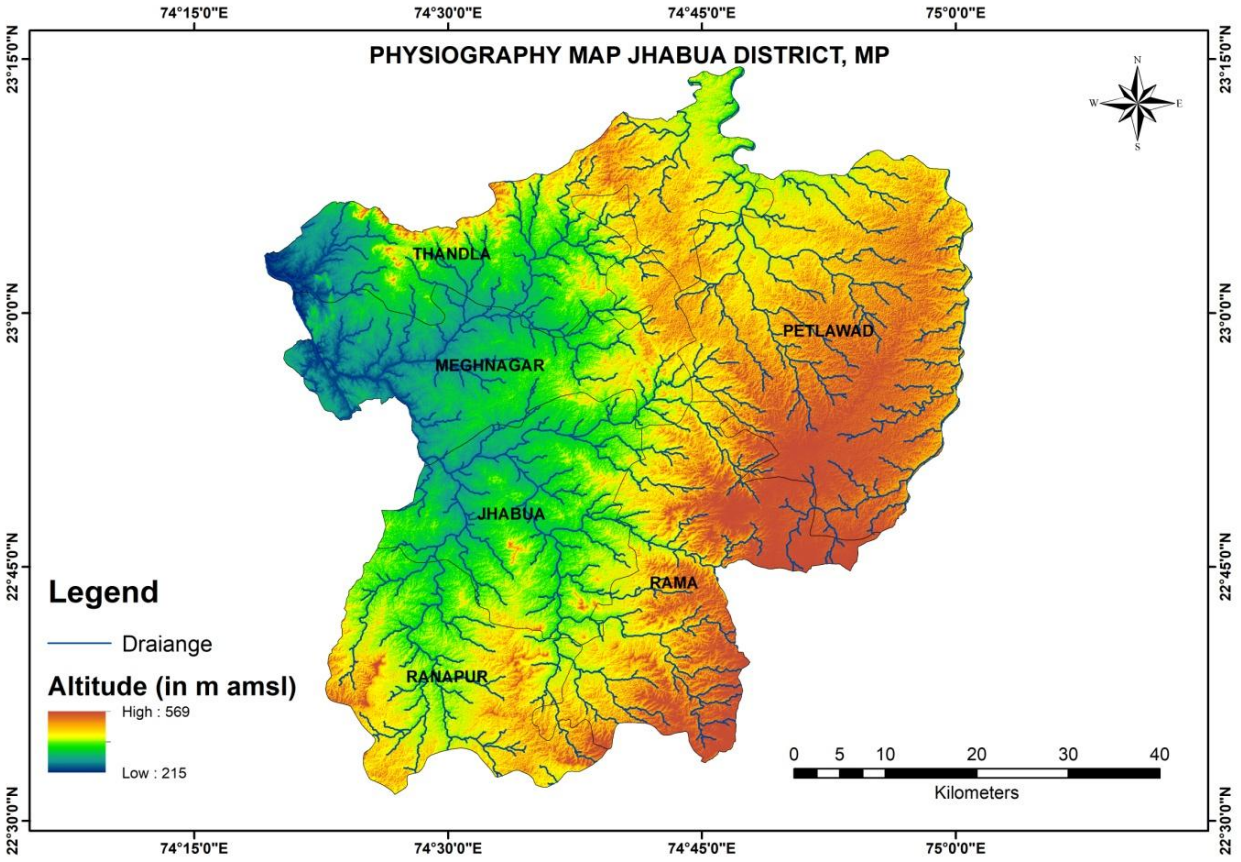


Fig: 1.4 Physiography Map of Jhabua District, MP.

1.10 GEOMORPHOLOGY

S.No	Geomorphic Unit	Description
1	Highly Dissected Plateau	High relief. Steep slope. Sharp crested. Highly dissected hills
2	Moderately Dissected Plateau	Moderate relief and slope rolling topography
3	Burried pediment over traps	Gently undulating shallow burried pediplain
4	Pediments over Lameta/Bagh beds	Thin soil cover sparsely vegetated landforms developed over sandstones
5	Pediplain over granite/Gneissic granite	Moderate erosional surface with thin soil cover. Low relief. Gentle to moderate slopes. Sparsely vegetated.
6	Denudational hills over granite/Gneissic granite	Thin soil cover. Gently sloping. Isolated residual hills present in vast granite pediplain.
7	Pediment over Chlorite Schist/Phyllites Gneissic granite	Vertically foliated. Undulating topography thin erosional surface locally folded and criss crossed by fractures.
8	Pediment over Calcareous rocks	Highly eroded siliceous limestone showing elephant skin weathering low relief. Sparsely vegetated.
9	Valley fills	Unconsolidated sediments. Forming depressions sometimes controlled by lineaments supports cultivation

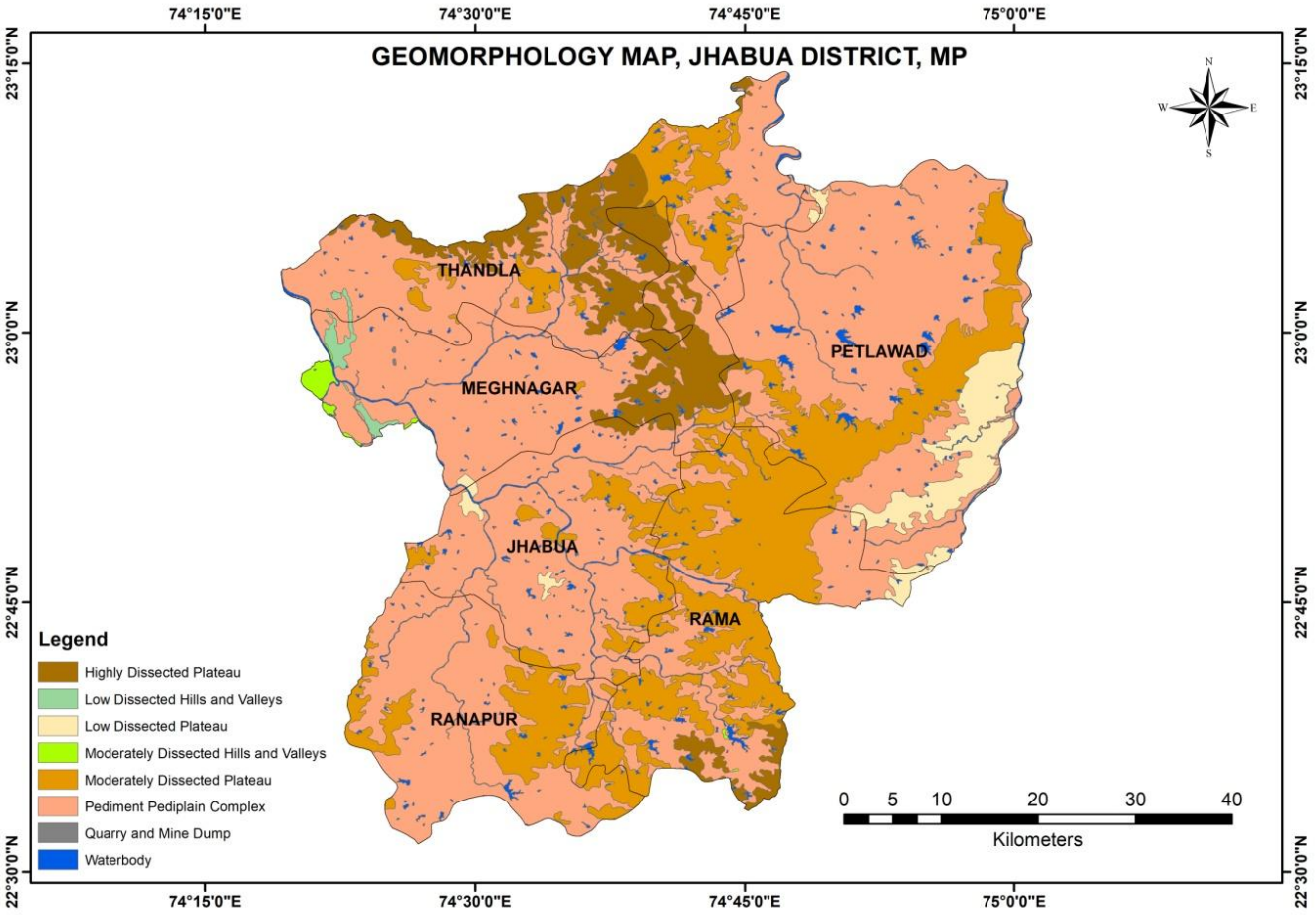


Fig: 1.5 Geomorphological Map of Jhabua District, MP.

1.11 LAND USE AND LAND COVER

Land use denotes how humans use the biophysical or ecological properties of land. Land use include the modification and/or management of land for agriculture, settlements, forestry and other uses including those that exclude humans from land, as in the designation of nature reserves for conservation.

The analysis of land use in the present study is based on district land record, data available at block level and revenue office. Following categories of land use have been recognized in the study area. In the analysis of land use pattern study has adopted at block level: Forest Cover, Barren and cultivable waste land, Current Fallow land, Other Fallow land, Barren & uncultivable Land, Land put to non-agricultural Use, Pastures and Grazing Land, Area under bush, forest & garden, Net area sown. The land use / land cover map of Jhabua district is shown in the (**Fig: 1.6**).

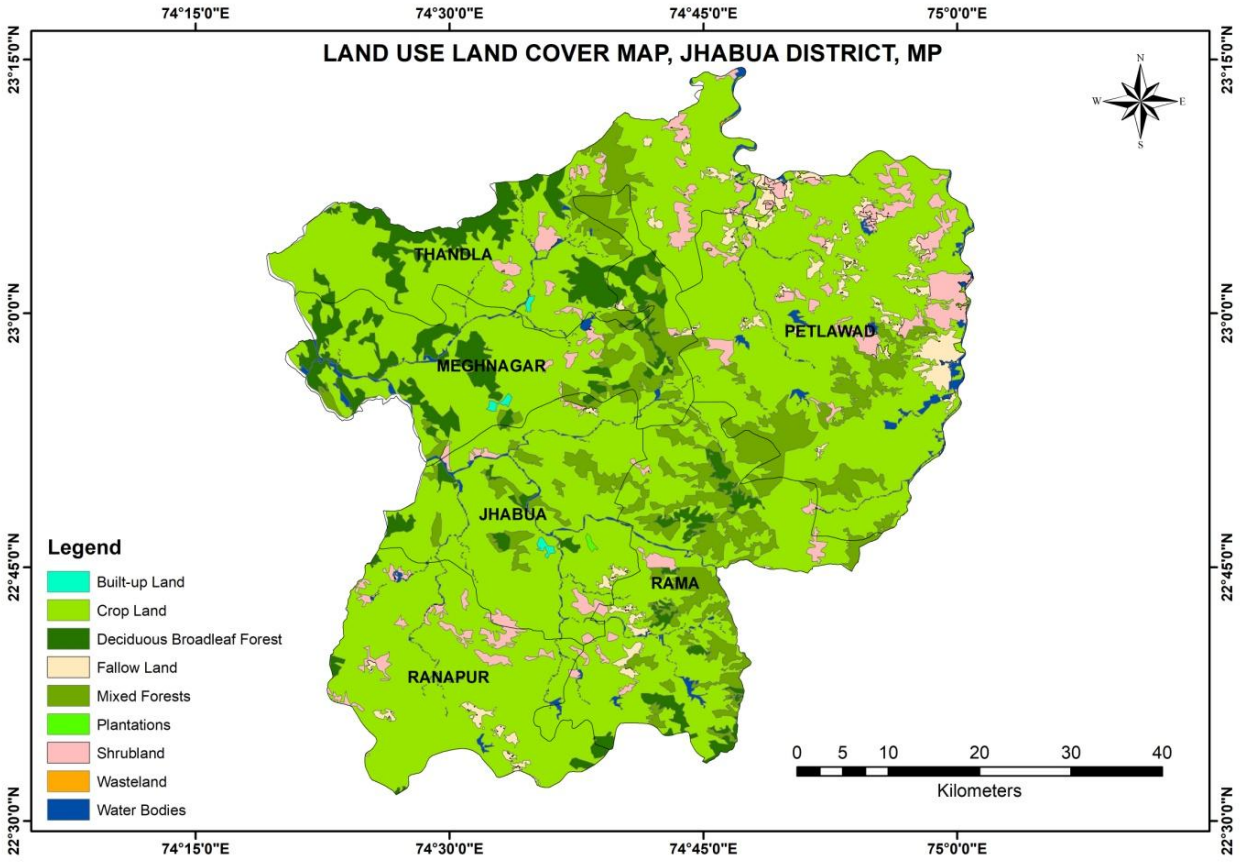


Fig: 1.6 Land Use and Land Cover Map of Jhabua district, MP.

1.12 SOIL

The variation in climatic condition, topography and lithology in Jhabua district has played a significant role in the formation of soil which has resulted from the physical and chemical weathering of the parent rock. Black cotton soil has been derived from the parent basaltic rock under semi-arid conditions. These soils are clay to loamy clay in texture, having clay contents of 40% to 60% mixed with red and yellow soil. The soil generally occurs in slopes and uplands are sandy-to-sandy loam and their colour varies from reddish yellow yellowish brown. The Soil map of the district is shown in the **(Fig: 1.7).**

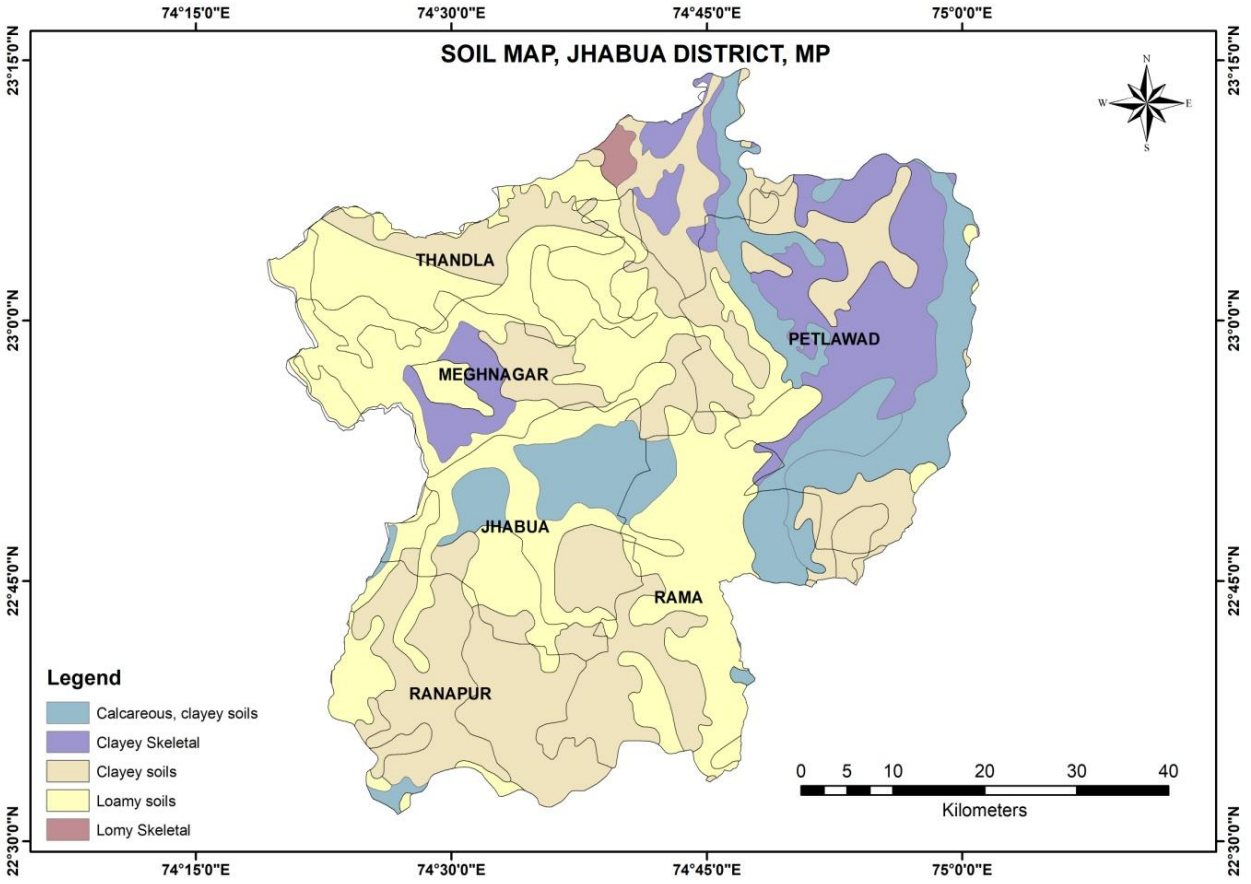


Fig: 1.7 Soil Map of Jhabua district, MP.

1.13 GEOLOGY

The general geological successions in the district are given in **Table: 1.6** and shown in **(Fig: 1.8).**

Table: 1.6 Geological Successions of Jhabua district, MP.

Age	Stratigraphic Unit	Lithology
Quaternary to Recent	Recent Alluvium	Alluvium and Laterite
---------- Unconformity ----------		
Upper Cretaceous to Lower Eocene	Deccan trap	Basalt with inter trappean clays
Upper Cretaceous	Lameta and Bagh Beds	Limestone and shale
Archaeans	Aravali Super Group	Granites, Phyllites, Schist and Dolomitic Marble

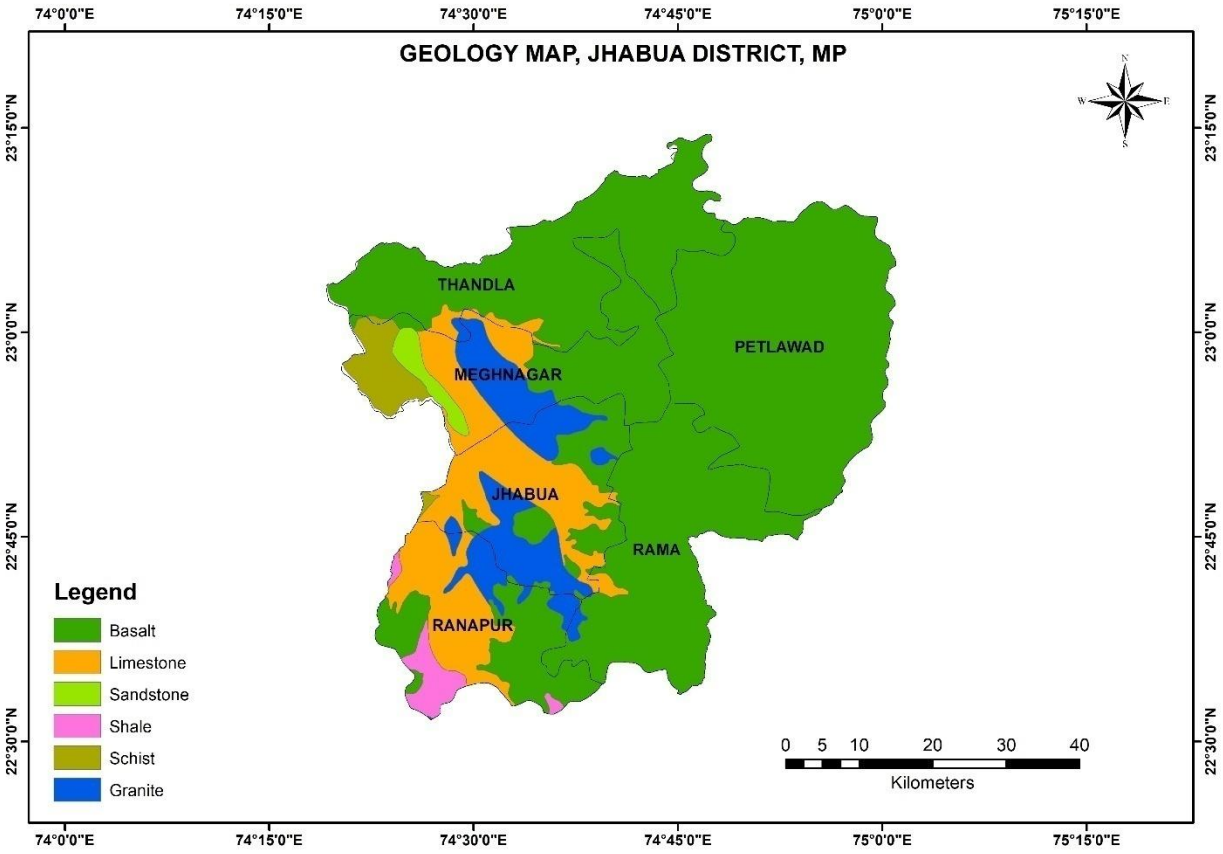


Fig: 1.8 Geological Map of Jhabua district, MP.

1.13.1 *Archaeans*

The Archaean groups of rocks are exposed in the central, northwestern parts of the district. The groundwater generally occurs under phreatic conditions in the weathered, jointed and fractured horizons of different rock units. The pink and grey granites are exposed mainly in Jhabua and Meghnagar blocks, are generally hard and compact and are poorly permeable. The gneissic granites are susceptible to weathering with jointed and fractured zones extending about 5 to 15 m below ground level. The occurrence of groundwater in the granites and gneissic granites depend on the depth of weathering. The schist which is exposed in Meghnagar block is moderately permeable. The occurrence of groundwater is dependent on the intensity of fractures and disposition of foliation planes. The limestone occurring as bands, generally occurring occupy small hill ranges and as such their geographic locations are unfavorable for ground water development in parts of Meghnagar, Thandla and Ranapur blocks.

1.13.2 *Lameta and Bagh Beds*

Overlying unconformably the Archaeans, are the infra-trappean represented by the Lameta and the Bagh beds. The main exposures are seen in the southeastern and central parts of the district. The outcrops occur in widely separated patches and the lithostratigraphy differs from place to place. In general the rock unit lowers arenaceous and upper calcareous facies. Nimar sandstone, the basal units of the Bagh beds in the area are horizontally bedded and compact in nature with an average thickness of 12 to 18 meters. Though hard and compact, they are well jointed and fractured and act as groundwater repository. Nimar sandstone is overlain by nodular limestone and coralline limestone. The groundwater occurs generally under phreatic conditions in the Infra-trappean sandstone and limestone. Limestone Solution activities these rocks act as promising horizons for groundwater storage. Dug wells tapping the Bagh beds in the lower elevation generally gild good discharge. The Infra-trappean beds underlying the Deccan traps when encountered during drilling exhibits confined /semi confined conditions.

1.13.3 *Deccan Traps*

The northern and north western parts of the district covering mainly Thandla, Petlawad and Rama blocks are occupied by the basaltic lava flows of Cretaceous to Eocene age. More than 12 number lava flows have been demarcated in the district with average thickness of flow being 25-30 m. The bottom most parts of the flows are generally massive, hard and compact in nature. They often show columnar jointing and spheroidal weathering. The overlying vesicular basalts comprise has rounded to oval shaped vesicle, which is generally filled, with zeolites, calcite and quartz. Vesicular horizons are limited in thickness or absent there by reducing the chances of the good aquifer for the storage of groundwater. The weathered zones, joints, fracture and vesicular zones form the main water bearing horizons. The open dug well located in the geographic low often yields 50-100 m^3/day. The bore well tapping different vesicular horizons yield moderate quantity of water (100-200 m^3/day).

1.13.4 *Alluvium and Laterite*

Localized patches of alluvium cover occur along the banks of major and minor rivers and streams in the district. In general it is difficult to differentiate between alluvium and product of black cotton soil underlain by yellow clay with kankar. The thickness of alluvium varies from few meters to 15 m. Laterite capping on top of Deccan trap basalt are seen in localized patches. The rocks are generally bouldery in nature, highly ferruginous and weathered to yellowish red soil.

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), lithological details of deeper aquifers (aquifer- II) of exploratory wells were also collected and compiled.

- Hydro chemical Data - Ground water quality data of monitoring wells of CGWB & State (WRD) representing shallow aquifer and data from exploratory wells representing deeper aquifer.

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

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

- Cropping Pattern Data – Data on prevailing cropping pattern from District Irrigation Plan, Jhabua district.

- For data generation 23 no's of key wells have been established throughout the district and collected Pre-monsoon water sample.

- Again, for data generation 100 no's of Key observation wells Water level data collected from State Water Resource Department.

2.1 DATA AVAILABILITY

The compiled data were plotted on a 1:50000 scale map, and analysis of the data gap was carried out. The summarized table comprising the data requirement and data availability is represented in the following **Table: 2.1**

Table: 2.1 various data for NAQUIM Study.

S. No	Items	Data Requirement	Data Availability
1	Rainfall Data	Meteorological stations spread over the project area.	India-Wris
2	Soil	Soil map	Prepared
3	Land Use	Latest Land UsePattern	Prepared from Land Sat 8 Imagery in GIS
4	Geomorphology	Digitized Geomorphological Map	Bhukosh
5	Exploration Data	EW in each Quadrant with Aquifer Parameters	26 exploratory wells drilled
6	Aquifer Parameters	Aquifer parameters for all the quadrants	Available
7	Groundwater Level	Decadal water level data	CGWB monitoring wells data

2.2 DATA COLLECTION AND GENERATION

Data on all the attributes of Aquifer Mapping has been generated based on the data availability and data gap analysis. The data generated and data collected from various state governments agencies are summarized in the following **Table: 2.2**

Table: 2.2 Data Generated and Data collected for Aquifer Mapping Area.

S.No	Items	Data Generated	Data Collected
1	GW Regime Monitoring	23 Key observation wells established & 100 Key observation wells of WRD	Pre & Post monsoon depth to water level
2	Chemical Quality	23 Samples collected during June, 2022 for Basic element analysis & Heavy metal analysis	GW Samples submitted for chemical analysis to generate the quality data
3	Exploration	26 Exploratory wells drilled	Lithologs, Aquifer geometry and aquifer parameters measured

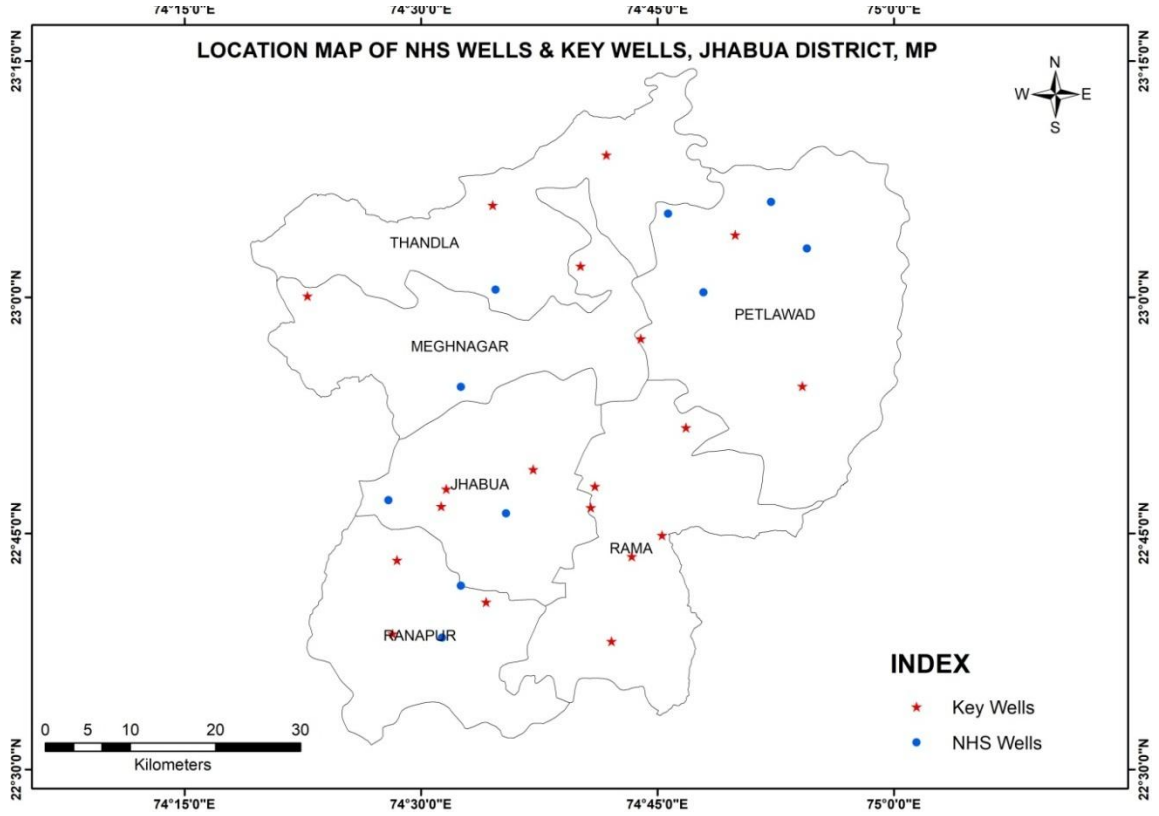


Fig: 2.1 Location of NHS& KEY Wells in Jhabua district, M.P.

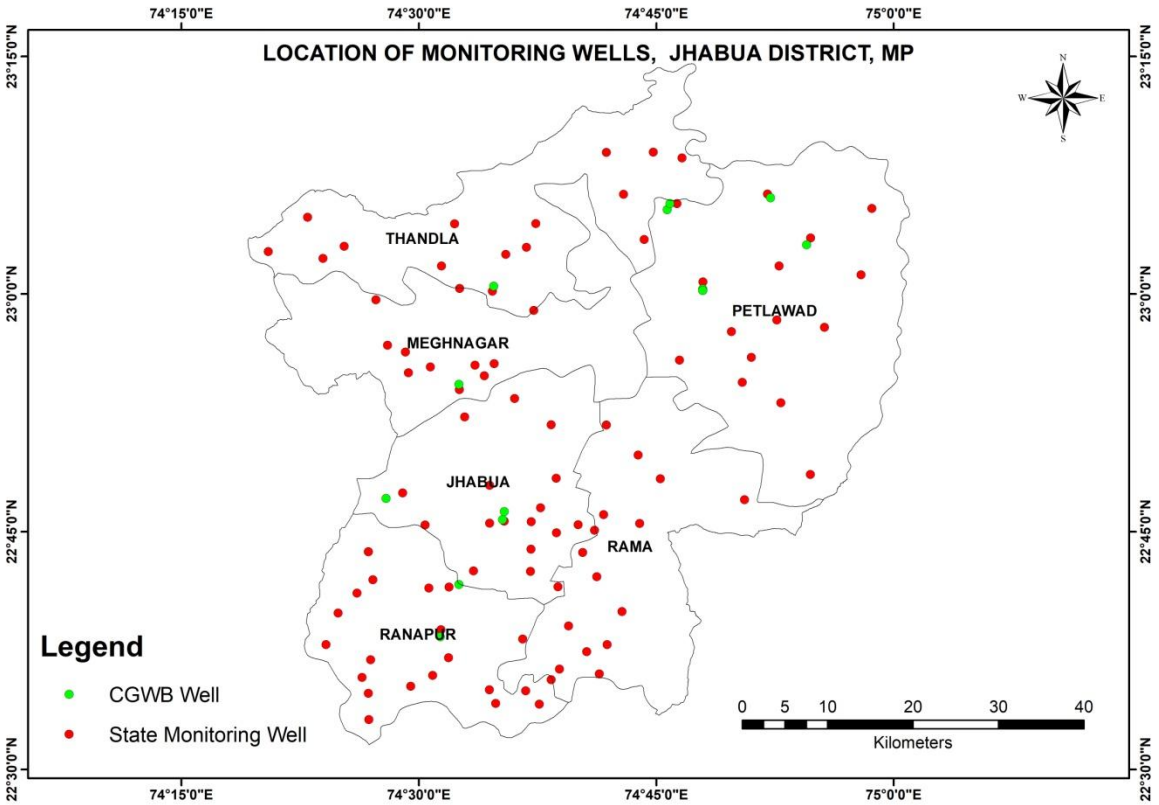


Fig: 2.2 Location of NHS& State Monitoring Wells in Jhabua district, M.P.

CHAPTER 3
DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

3.1 HYDROGEOLOGY

The exploratory drilling has been carried out in areas occupied by Deccan Trap basalt underlain by Lameta limestone and granite and gneissic rocks. In Deccan Traps, the vesicular, weathered and fractured basalt form the aquifers while in Granites and gneissic rocks weathering and fractures forms aquifer. These exploratory wells have been drilled down to the maximum depth of 213.27 mbgl and their yields have been recorded. The details of exploration carried by CGWB have been tabulated in **Annexure-III**. The hydrogeological map of Jhabua district is shown in the (**Fig: 3.1).**

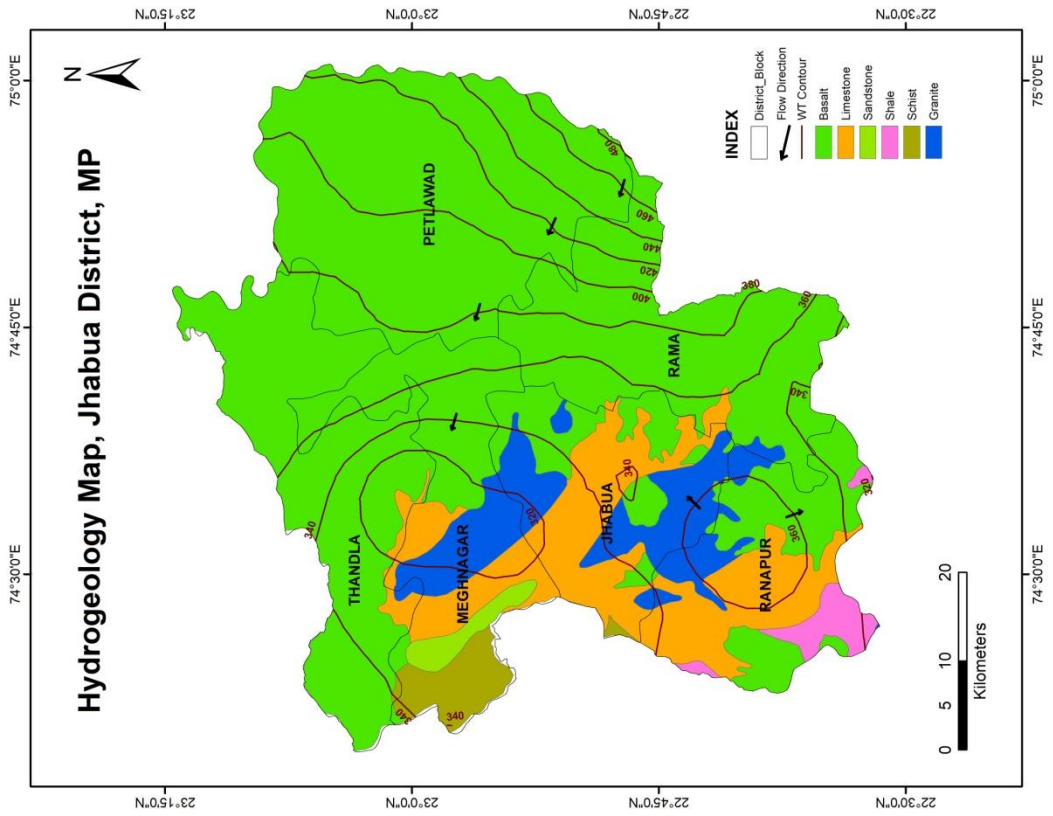


Fig: 3.1 Hydrogeological map of Jhabua district, MP.

3.1.1 Occurrence of Ground Water

The Ground Water occurs under water table and semi confined to confined conditions in all formations of the area. Topographic depressions, nature and extent of weathering, presence of joints and fractures play an important role in the occurrence and movement of ground water. The area occupied by Precambrian rocks is mostly undulating. The ground water in these rocks occurs under confined to semi-confined conditions, which is widely controlled by the presence of joints, fracture in them. The area occupied by the Archaean Group of rocks, Deccan Traps and Bagh& Lameta beds, where ground water occurs in the weaker zones of weathered fractured and jointed parts of the rocks. The inter-connection of joints and fractures controls the horizontal as well as vertical movement of ground water.

3.2 WATER LEVEL SCENARIO

Variation of groundwater levels in an area is an important component of hydrological cycle because it is a physical reflection of aquifer systems. To monitor the seasonal and annual change in quantity and quality of groundwater, CGWB has established 10 Ground Water Monitoring Wells and 04 Piezometers in Jhabua district (Annexure-II). The monitoring of groundwater levels in these wells is being carried out by CGWB during the month of May, August, November and January. The brief details of groundwater level in Jhabua district for the year 2021& 2022 are being discussed below:

3.2.1 Depth to water level Pre-Monsoon (June 2022)

The pre-monsoon depth to water level in the district ranges between 3.85 mbgl and 14.42 mbgl. Major part of the district has water level in the range of 5-10 mbgl during the pre-monsoon. The Pre-monsoon DTWL map for June-2022 is shown in the (Fig: 3.2).

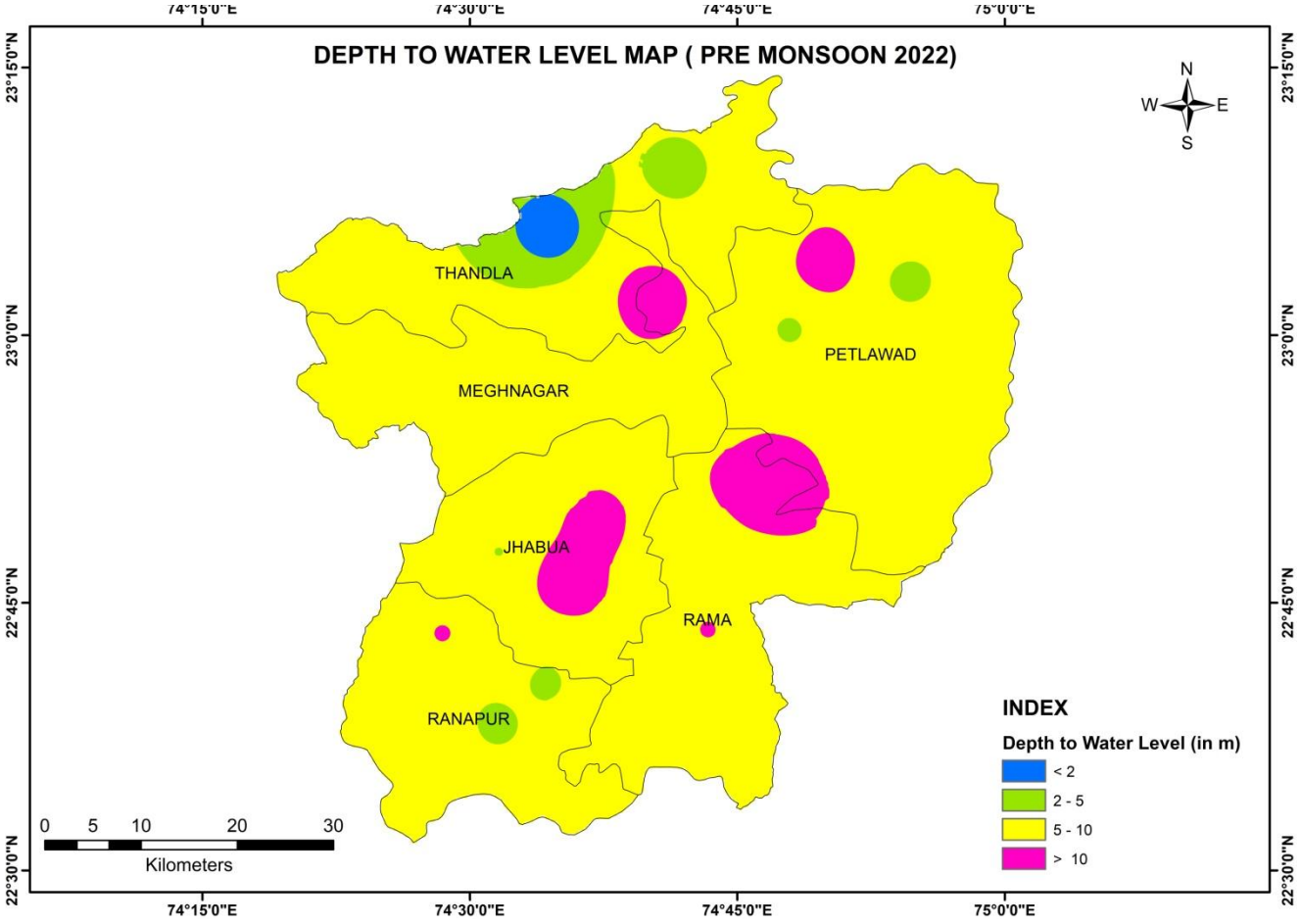


Fig: 3.2 Pre-Monsoon Depth to Water Level map of Jhabua District, MP.

3.2.2 Depth to water level Post-Monsoon (November 2022)

The post-monsoon depth to water level in the district ranges between 3.85 mbgl and 24.2 mbgl. Major part of the district has water level in the range of 2-5, 5-10 mbgl during the post-monsoon. The Post-monsoon DTWL map for June-2022 is shown in the **(Fig: 2.13).**

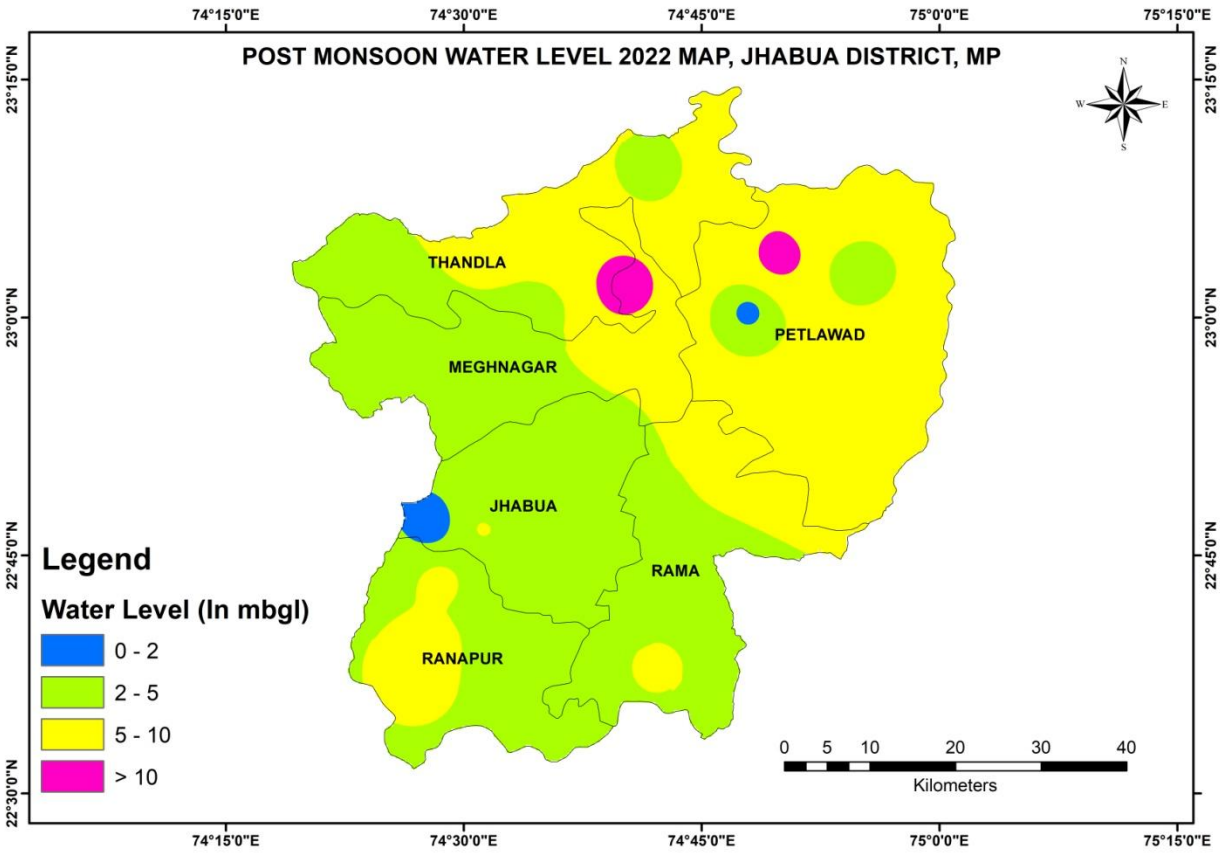


Fig: 3.3 Post-Monsoon Depth to Water Level map of Jhabua District, MP.

3.2.3 Annual Water level Fluctuation

The water level measured during pre and post monsoon period (2022) was used to compute the annual fluctuation. The analysis of water level fluctuation data indicated that minimum water level fluctuation was observed towards Northeastern side in Thandla and Petlawad blocks. Some parts of Ranapur, Jhabua, Rama and Meghnagar blocks are also showing fluctuation ranges between 0-2 m bgl. A major portion of the district, water levels are showing fluctuation range of 2-5 m bgl. Maximum water level fluctuation more than 10m bgl is observed ion patch in Jhabua block. The water level fluctuation map of the district is shown in the (**Fig: 3.4).**

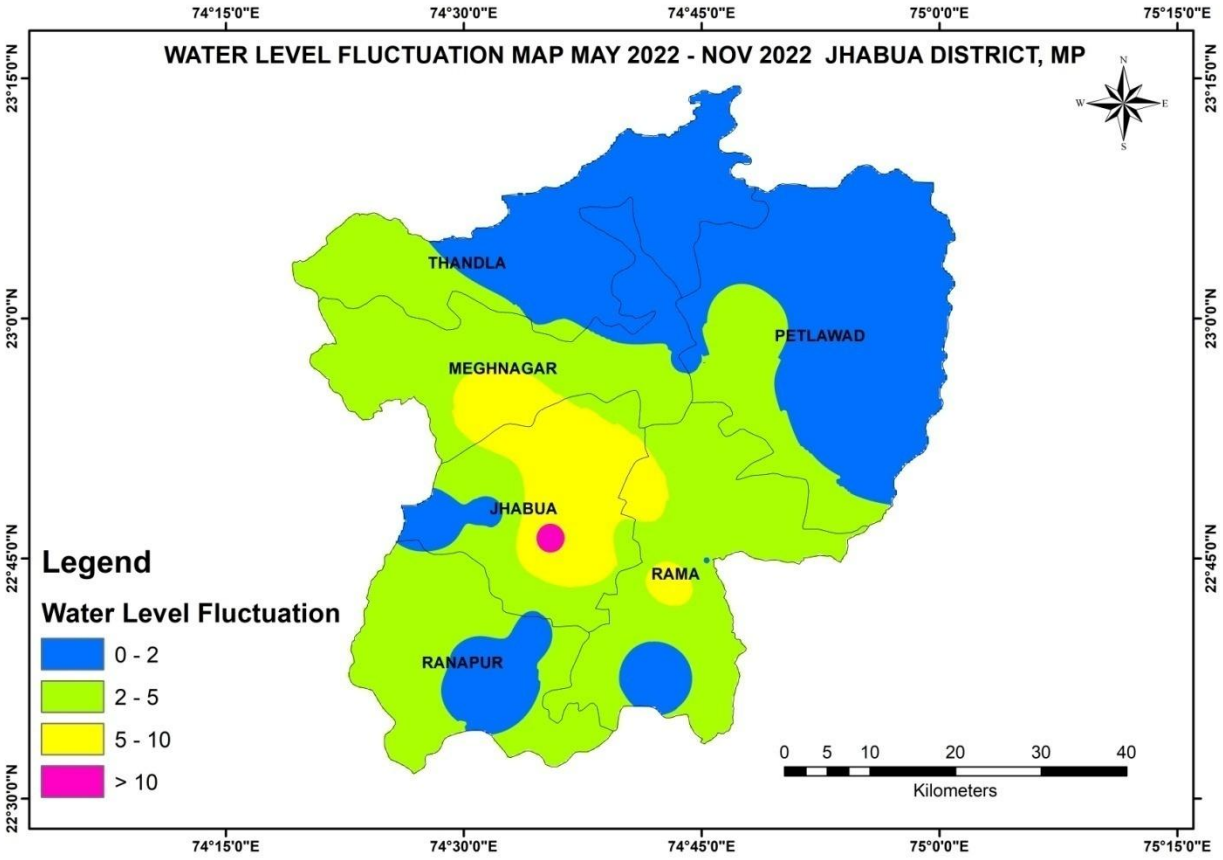


Fig: 3.4 Annual Water Level fluctuation map of Jhabua District, MP.

3.3 GROUND WATER EXPLORATION

Central Ground Water Board has taken up 26 exploratory wells drilling **(Fig: 3.5)** in Jhabua district so far. In addition to this, 23 no's of key wells **(Fig: 2.1)** were established in Jhabua district excluding forest area. The location details of Key wells, NHS wells and exploratory wells are given in **Annexure-I, Annexure-II & Annexure-III** respectively.

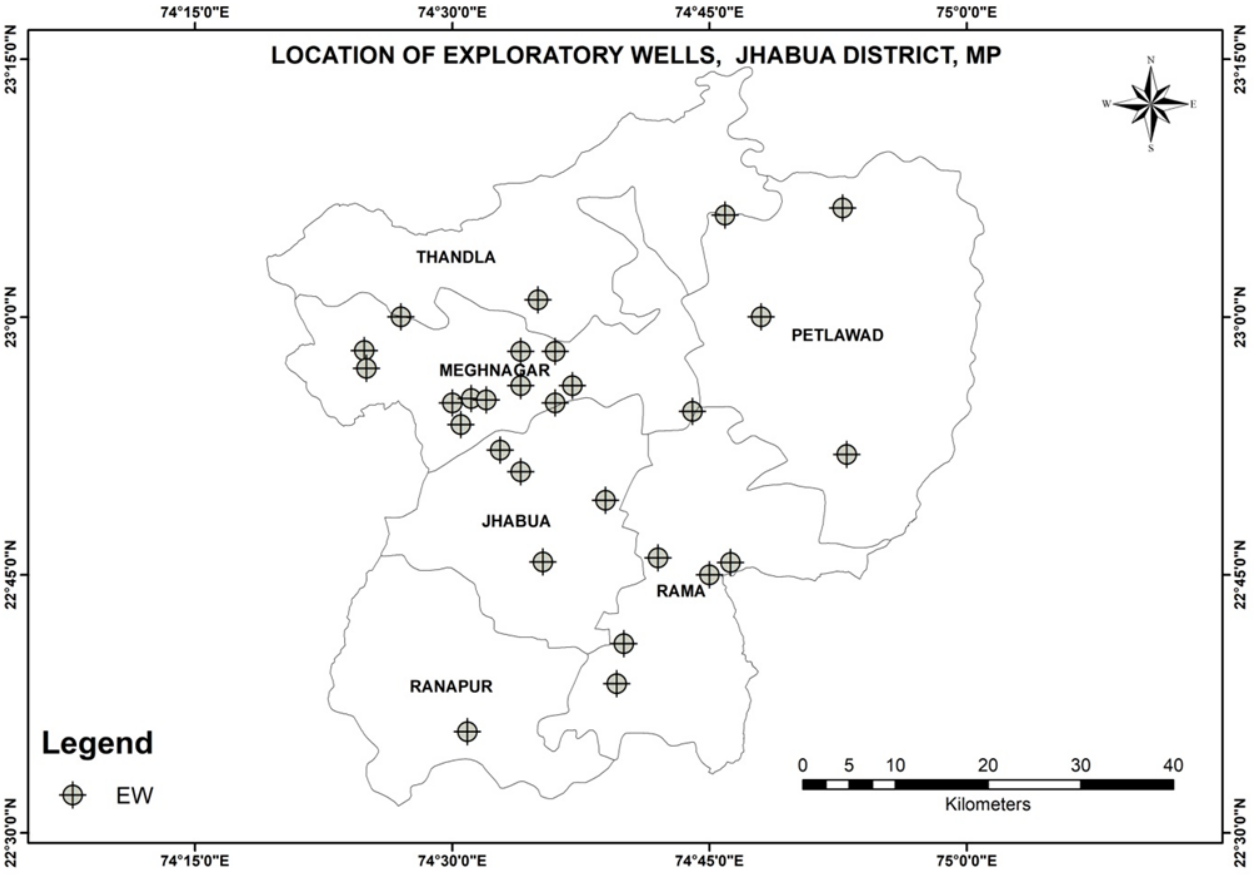


Fig: 3.5 Location of Exploratory Wells in Jhabua district, M.P.

3.4 GROUNDWATER QUALITY

3.4.1 Hydro-chemical scenario of Jhabua District

The water samples were collected from Key wells established for NAQUIM in clean double stopper poly ethylene bottles from 22 different locations for cation and anions as well as heavy metal analysis of Jhabua district during pre-monsoon-2022.

3.4.2 Quality of Ground Water for Drinking Purpose:

The ground water samples from Jhabua district have varied range of pH from 7.17 to 8.11. As per BIS(IS 10500: 2012) recommendation, all the water samples have pH recorded within the permissible limits of 6.5 to 8.5, the maximum pH recorded in the water sample of Buchaka (8.11). The ground water of the study area can be assessed as neutral to slightly alkaline. The electrical conductivity of ground water samples in Jhabua district varies from 262 to 955 µS/cm at 25°C. The electrical conductivity of ground water samples from Jhabua district are below 1000µS/cm. So, overall ground water quality in Jhabua district is good quality in nature.

The fluoride concentration in Jhabua district lies in between 0.08 to 1.61 mg/l, which represent that all the samples are within the permissible limit i.e. 1.50 mg/l as per BIS (IS 10500 : 2012) except the village Jhumka 91.51 mg/l), Machiliya (1.59 mg/l) and Hatyadeli (1.61 mg/l). Nitrate in ground water samples of Jhabua district fall within limits of 3to 70 mg/l. It is observed that 13.64% samples have nitrate concentration more than the acceptable limit i.e. 45 mg/l, while rest 86.36% samples have concentration less than acceptable limit. Highest nitrate is reported in the water sample collected from Ohebar (56 mg/l), Ramgarh (63 mg/l) and Nad (70 mg/l). High nitrate in ground water samples may be due to anthropogenic activities or excessive use of fertilizers. The range of Total Hardness (as $CaCO_3$) in ground water samples of study area is 40 to 295mg/l. In all locations, total hardness concentrations are within the permissible limit of 600 mg/l. The maximum concentration of Total hardness has been observed in the village of Bamal (295 mg/l).

Piper diagram has three parts: a Cation triangle, an Anion triangle, and a Central diamond-shaped field. In Cation triangle, the relative percentages of the major cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}) are plotted. In Anion triangle the major anions ($HCO_3^{-}+CO_3^{2-}$, SO_4^{2-}, Cl^{-}) are plotted. These points are then projected to the central diamond shaped field. Piper diagram shows that the ground water samples of Jhabua districts are Calcium-Bicarbonate type, hence show temporary hardness and Sodium Bi carbonate type i.e., Mixed type and Sodium Chloride type i.e. Saline in nature.

3.4.3 Quality of Ground Water for Irrigation Purpose:

In classification of water for irrigation purpose, it is assumed that the water will be used for irrigation purpose based upon its soil texture, infiltration rate, drainage and climate. The chemical data of all the water samples from Jhabua district is plotted on U.S. Salinity Laboratory diagram.

It is clear that four ground water samples show that the ground water are C_2-S_1 Class (Medium Salinity & Low Sodium); C_3-S_1 Class (High Salinity & Low Sodium) and C_3-S_2 Class (High Salinity &Medium Sodium). The ground water of C_2-$S_1$and C_3-S_1 Classes may be used for irrigation purpose for most of the crops, whereas the water from C_3-S_2class may be used for irrigation, considering the high salinity content of the ground water with proper soil management.

The analysis of heavy/ trace metal analysis in the ground water of Jhabua district shows that the copper and nickel are below detectable limit whereas zinc is within the BIS permissible limit. The iron concentration is 0.019 to 1.337 mg/l, the maximum concentration of iron recorded in the village of Dhaturiya village i.e. 1.337 mg/l which is more than BIS permissible limit of 1.0 mg/l. The manganese concentration is 0.012 to 0.652 mg/l, the maximum concentration of manganese recorded in the village of Kaldela village i.e. 0.652 mg/l which is also more than BIS permissible limit of 0.3 mg/l.

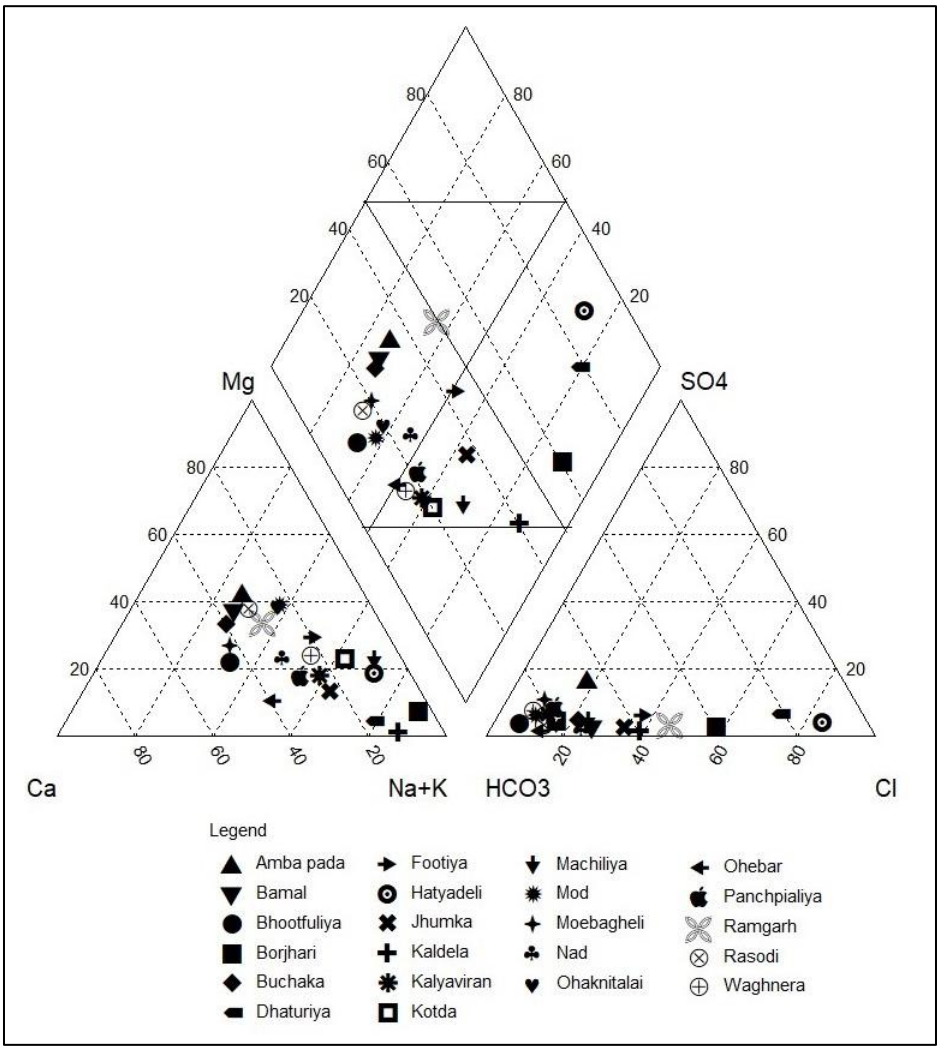


Fig: 3.6 Hill Piper Diagram representing classification of water samples collected from Key wells established for NAQUIM, Jhabua District, Madhya Pradesh.

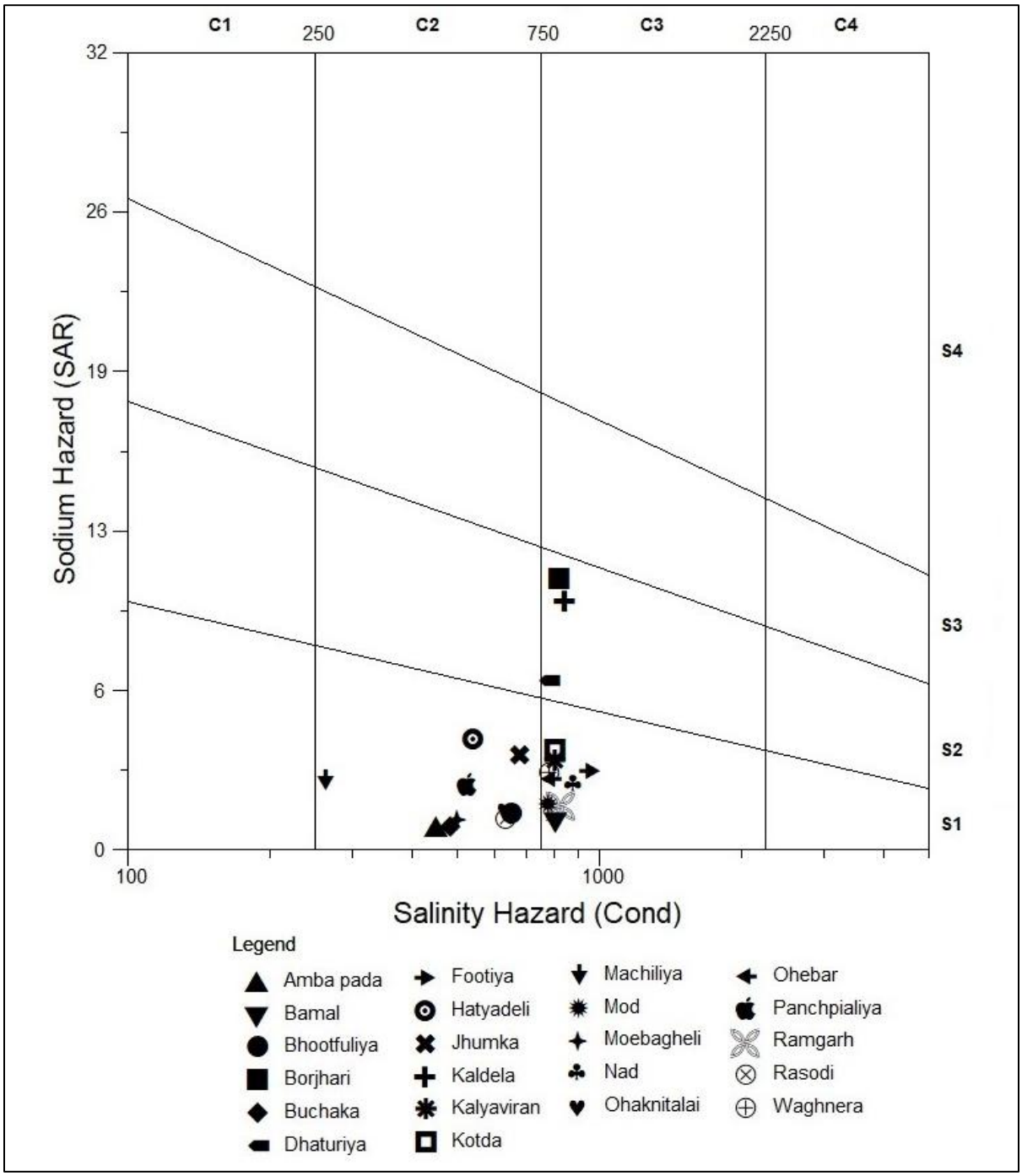


Fig: 3.7 US Salinity Diagram for water samples collected from Key wells established for NAQUIM of Jhabua District, Madhya Pradesh.

Table: 3.1 Chemical analysis results of ground water samples collected during pre-monsoon 2022 under NAQUIM.

S. No.	District	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
							at 25°C	µS/cm at 25°C	mg/l													
1	Jhabua	Jhabua	Mod	DW	22.7970	74.5269	7.79	777	0	378	25	22	13	1.27	BDL	25	240	36	36	65	1.0	505
2	Jhabua	Meghnagar	Ohebar	DW	23.0015	74.3800	7.64	790	0	360	32	5	56	0.23	BDL	23	200	64	10	92	0.9	514
3	Jhabua	Meghnagar	Kalyaviran	BW	22.9555	74.5012	7.43	802	0	360	32	22	36	1.10	BDL	31	165	38	17	105	1.0	521
4	Jhabua	Thandla	Borjhari	BW	23.0385	74.4730	8.06	823	0	189	161	10	7	1.41	0.1	39	45	6	7	165	1.0	535
5	Jhabua	Thandla	Kaldela	DW	23.0977	74.5759	7.96	842	0	287	109	5	22	1.20	BDL	26	55	20	1	168	0.5	547
6	Jhabua	Thandla	Bamal	DW	23.1509	74.6962	7.8	810	0	323	69	9	35	0.30	BDL	34	295	58	36	47	3.9	527
7	Jhabua	Meghnagar	Panchpialiya	DW	23.0331	74.6689	8.04	525	0	244	25	20	0	0.34	BDL	22	120	30	11	64	0.6	341
8	Jhabua	Petlawad	Ramgarh	DW	23.0662	74.8336	7.74	832	0	220	116	12	63	0.10	BDL	21	265	50	34	68	0.2	541
9	Jhabua	Petlawad	Moebagheli	DW	22.9562	74.7325	7.73	500	0	214	15	23	8	0.18	BDL	29	170	42	16	35	0.4	325
10	Jhabua	Meghnagar	Hatyadeli	BW	22.9392	74.6344	8.08	540	0	37	156	10	4	1.61	BDL	38	75	10	12	88	1.0	351
11	Jhabua	Ranapur	Nad	DW	22.7217	74.4747	7.32	880	0	336	62	6	70	0.99	BDL	37	235	54	24	92	1.0	572
12	Jhabua	Ranapur	Ohaknitalai	DW	22.6436	74.4700	7.56	632	0	268	32	9	39	0.41	0.2	32	195	30	29	52	2.0	411
13	Jhabua	Ranapur	Bhootfuliya	DW	22.6773	74.5689	7.74	650	0	329	15	10	14	0.51	BDL	31	215	58	17	48	3.0	423
14	Jhabua	Rama	Jhumka	DW	22.6357	74.7015	7.17	678	0	250	79	8	4	1.51	BDL	25	125	32	11	97	4.0	441
15	Jhabua	Rama	Buchaka	DW	22.7255	74.7230	8.11	482	0	189	32	9	22	0.23	BDL	29	175	38	19	28	2.0	313
16	Jhabua	Rama	Machiliya	DW	22.7480	74.7551	8.02	262	0	104	20	5	3	1.59	BDL	33	40	4	7	40	2.0	170
17	Jhabua	Rama	Waghnera	DW	22.7999	74.6839	7.68	788	0	360	22	25	32	0.42	BDL	22	185	36	23	96	2.0	512
18	Jhabua	Rama	Rasodi	DW	22.8619	74.7803	7.28	633	0	317	30	10	3	0.2	BDL	27	220	40	29	42	3.0	411
19	Jhabua	Petlawad	Amba pada	DW	22.9060	74.9034	8.06	452	0	159	25	32	28	0.08	BDL	31	165	28	23	26	2.0	294
20	Jhabua	Petlawad	Dhaturiya	BW	22.8654	74.9182	7.42	780	0	92	181	22	31	0.88	0.2	39	80	26	4	140	3.0	507
21	Jhabua	Jhabua	Footiya	DW	22.8177	74.6188	7.42	955	0	323	124	27	10	1.02	BDL	26	235	38	34	110	4.0	621
22	Jhabua	Jhabua	Kotda	DW	22.7786	74.5213	7.54	800	0	348	40	15	40	1.17	BDL	42	150	24	22	112	4.0	520

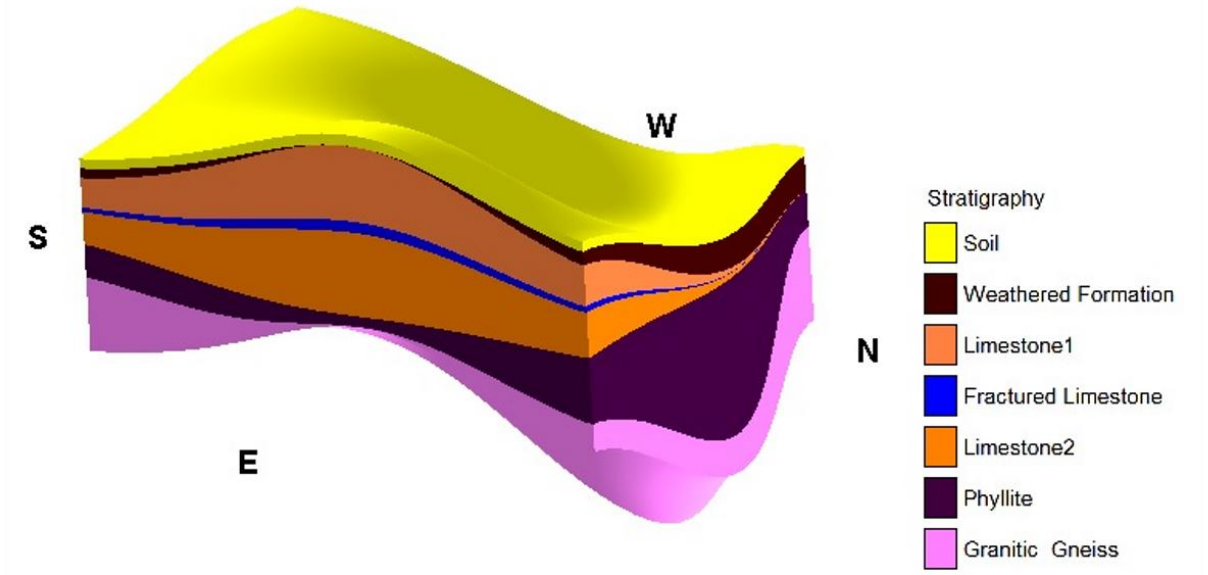
Table: 3.2 Chemical analysis results of ground water samples collected during pre-monsoon 2022 under NAQUIM.

S. No.	District	Block	Location	Source	Lat.	Long.	Fe	Cu	Ni	Zn	Mn
							mg/l				
1	Jhabua	Jhabua	Mod	DW	22.7970	74.5269	0.042	BDL	BDL	0.076	BDL
2	Jhabua	Meghnagar	Ohebar	DW	23.0015	74.3800	BDL	BDL	BDL	BDL	0.032
3	Jhabua	Meghnagar	Kalyaviran	BW	22.9555	74.5012	0.655	BDL	BDL	BDL	BDL
4	Jhabua	Thandla	Borjhari	BW	23.0385	74.4730	BDL	BDL	BDL	BDL	BDL
5	Jhabua	Thandla	Kaldela	DW	23.0977	74.5759	0.019	BDL	BDL	0.191	0.652
6	Jhabua	Thandla	Bamal	DW	23.1509	74.6962	0.024	BDL	BDL	BDL	0.012
7	Jhabua	Meghnagar	Panchpialiya	DW	23.0331	74.6689	BDL	BDL	BDL	0.042	0.053
8	Jhabua	Petlawad	Ramgarh	DW	23.0662	74.8336	0.023	BDL	BDL	BDL	BDL
9	Jhabua	Petlawad	Moebagheli	DW	22.9562	74.7325	0.039	BDL	BDL	BDL	BDL
10	Jhabua	Meghnagar	Hatyadeli	BW	22.9392	74.6344	0.562	BDL	BDL	BDL	BDL
11	Jhabua	Ranapur	Nad	DW	22.7217	74.4747	0.723	BDL	BDL	0.067	0.058
12	Jhabua	Ranapur	Ohaknitalai	DW	22.6436	74.4700	0.333	BDL	BDL	0.06	0.02
13	Jhabua	Ranapur	Bhootfuliya	DW	22.6773	74.5689	0.027	BDL	BDL	BDL	BDL
14	Jhabua	Rama	Jhumka	DW	22.6357	74.7015	0.023	BDL	BDL	BDL	BDL
15	Jhabua	Rama	Buchaka	DW	22.7255	74.7230	0.168	BDL	BDL	0.077	BDL
16	Jhabua	Rama	Machiliya	DW	22.7480	74.7551	0.199	BDL	BDL	BDL	BDL
17	Jhabua	Rama	Waghnera	DW	22.7999	74.6839	0.099	BDL	BDL	BDL	BDL
18	Jhabua	Rama	Rasodi	DW	22.8619	74.7803	0.053	BDL	BDL	BDL	BDL
19	Jhabua	Petlawad	Ambapada	DW	22.9060	74.9034	0.035	BDL	BDL	BDL	BDL
20	Jhabua	Petlawad	Dhaturiya	BW	22.8654	74.9182	1.337	BDL	BDL	BDL	BDL
21	Jhabua	Jhabua	Footiya	DW	22.8177	74.6188	0.944	BDL	BDL	BDL	BDL
22	Jhabua	Jhabua	Kotda	DW	22.7786	74.5213	0.346	BDL	BDL	0.248	BDL

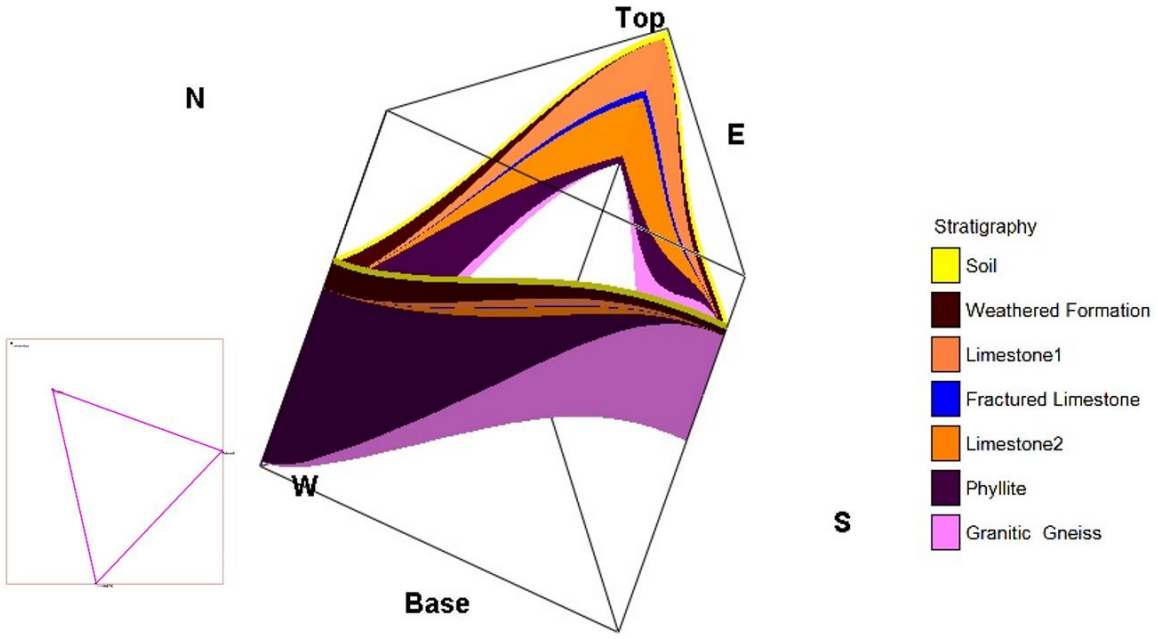
3.5 3-DIMENSIONAL AND 2- DIMENSIONAL AQUIFER DISPOSITION

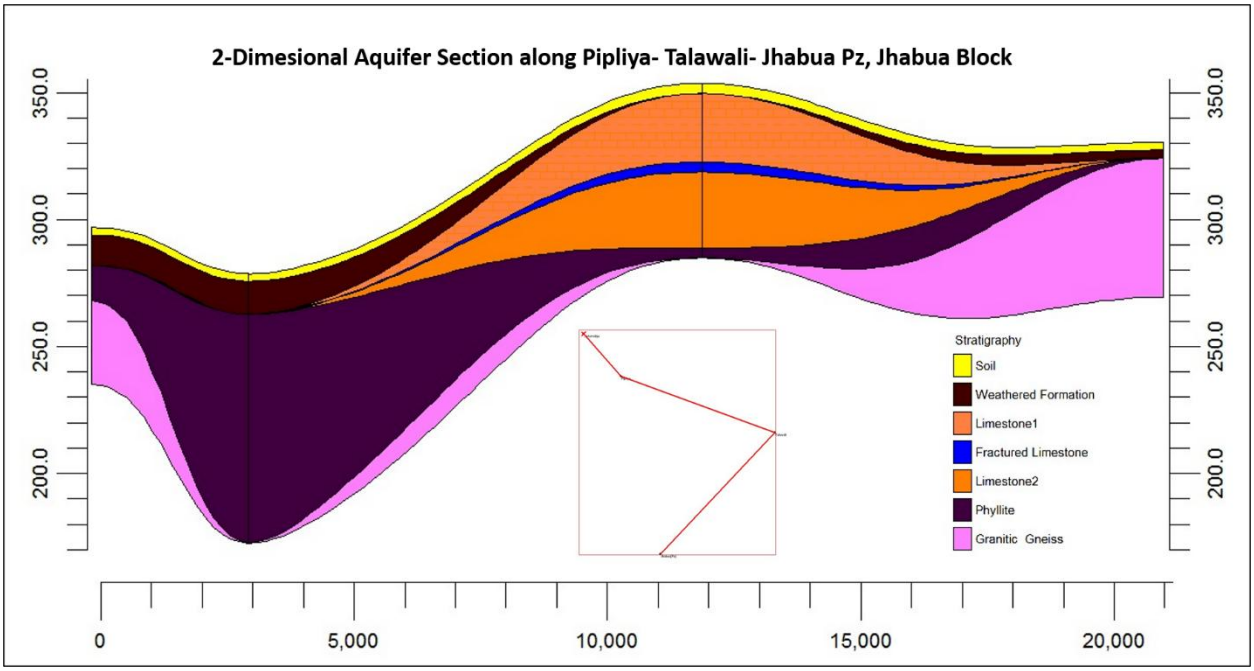
Aquifer maps like 3-D aquifer model, Fence diagram and 2-D aquifer sections had been prepared for the entire district using Rockworks software based on the borehole data for understanding aquifer disposition in subsurface which can be used for planning and construction of artificial recharge structures. The block wise 3-D aquifer model, Fence diagram and 2-D aquifer sections prepared are given below **(Fig: 3.8 - 3.19).**

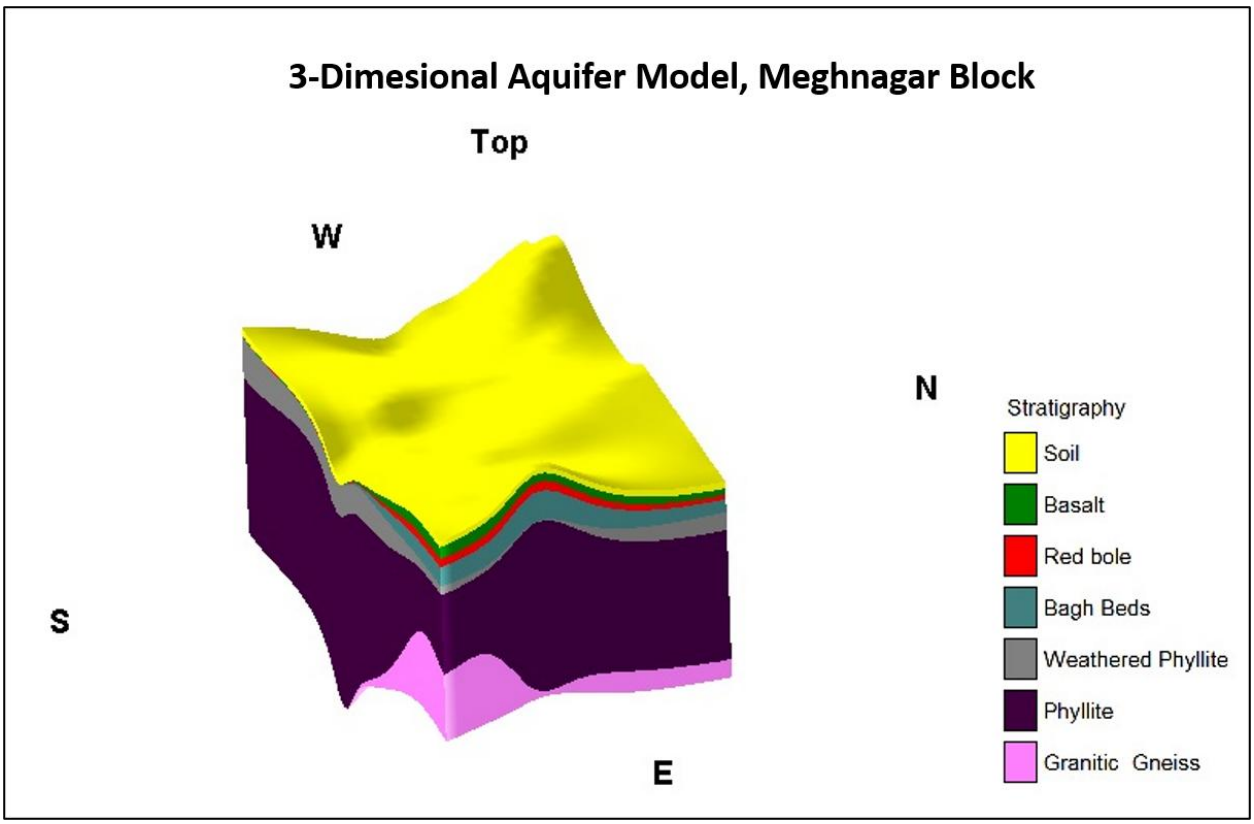
3-Dimesional Aquifer Model, Jhabua Block

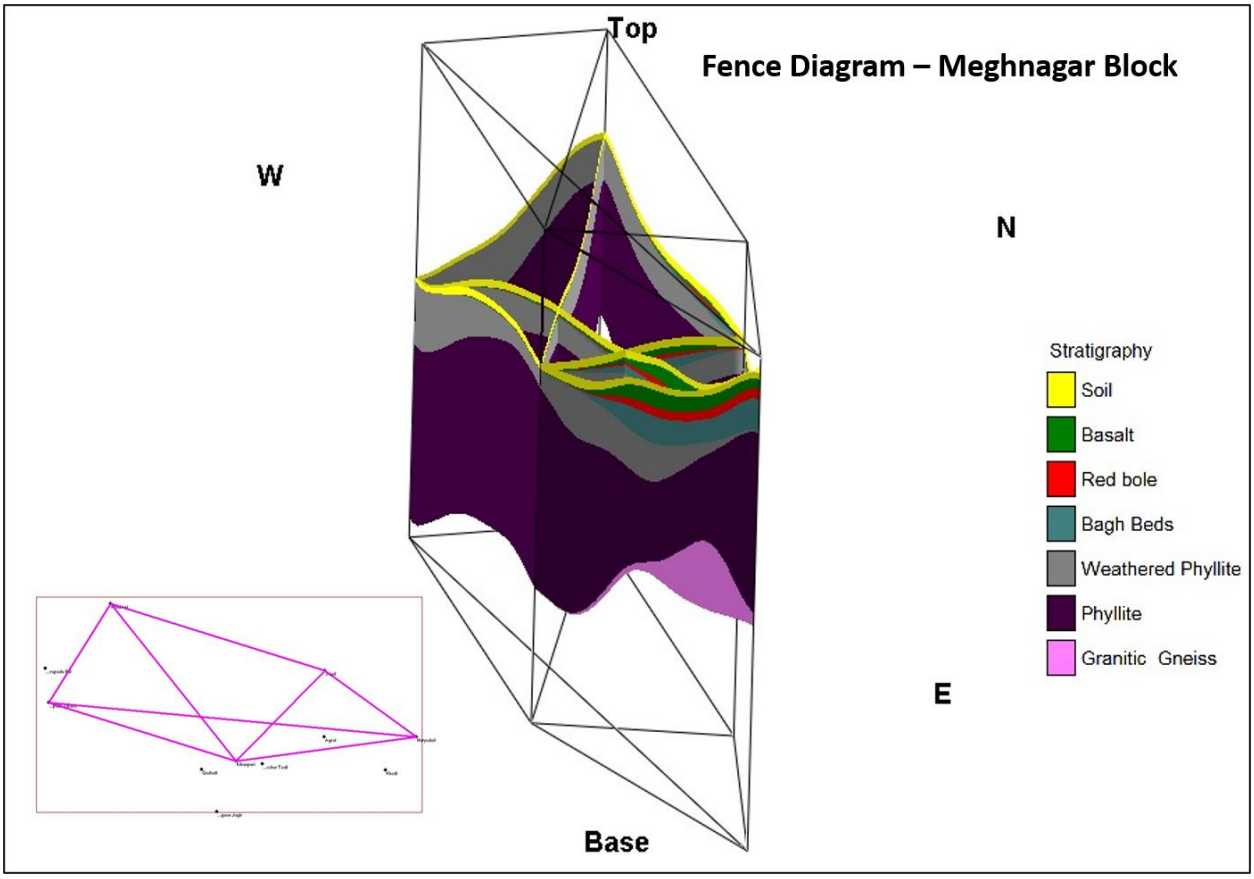


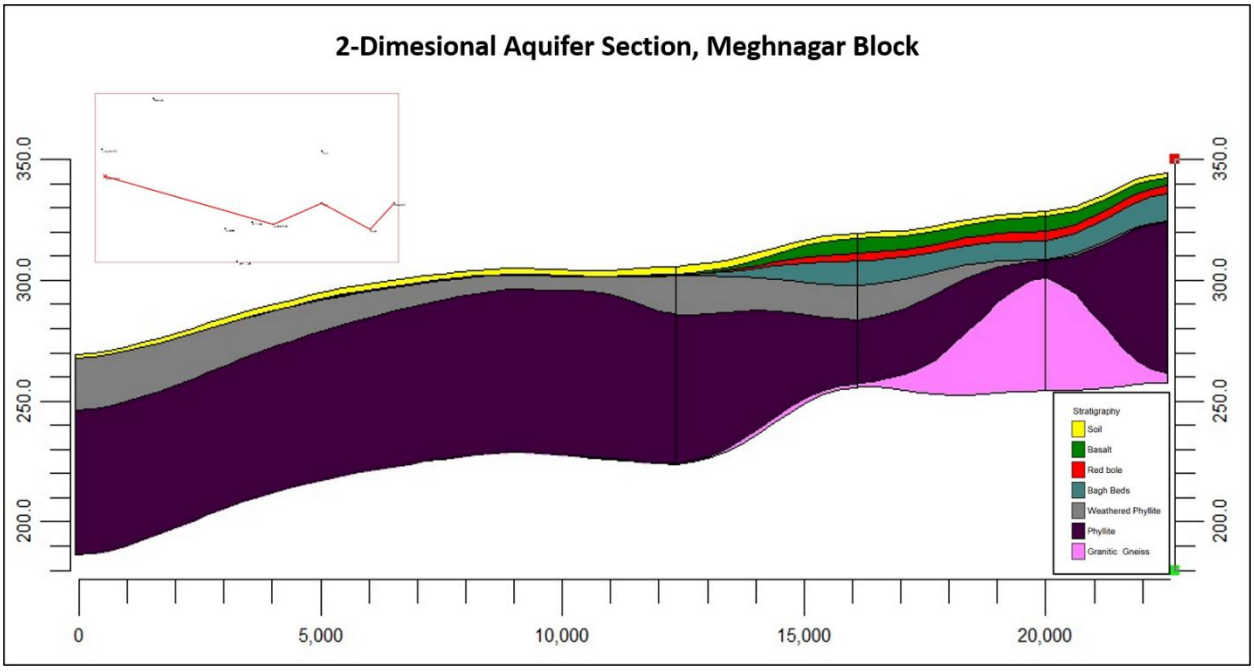
Fence diagram along Pipliya- Talawali- Jhabua Pz, Jhabua Block



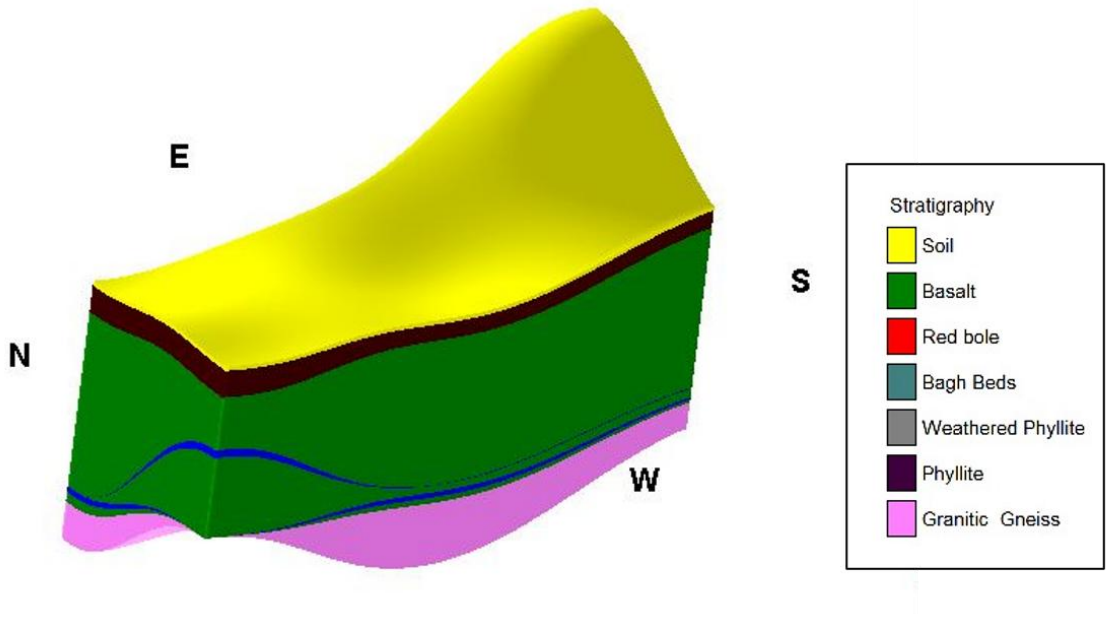

2-Dimesional Aquifer Section along Pipliya- Talawali- Jhabua Pz, Jhabua Block
350.0
300.0
250.0
200.0
0
5,000
10,000
15,000
20,000
Stratigraphy
Soil
Weathered Formation
Limestone1
Fractured Limestone
Limestone2
Phyllite
Granitic Gneiss


3-Dimesional Aquifer Model, Meghnagar Block
Top
W
N
S
E
Stratigraphy
Soil
Basalt
Red bole
Bagh Beds
Weathered Phyllite
Phyllite
Granitic Gneiss

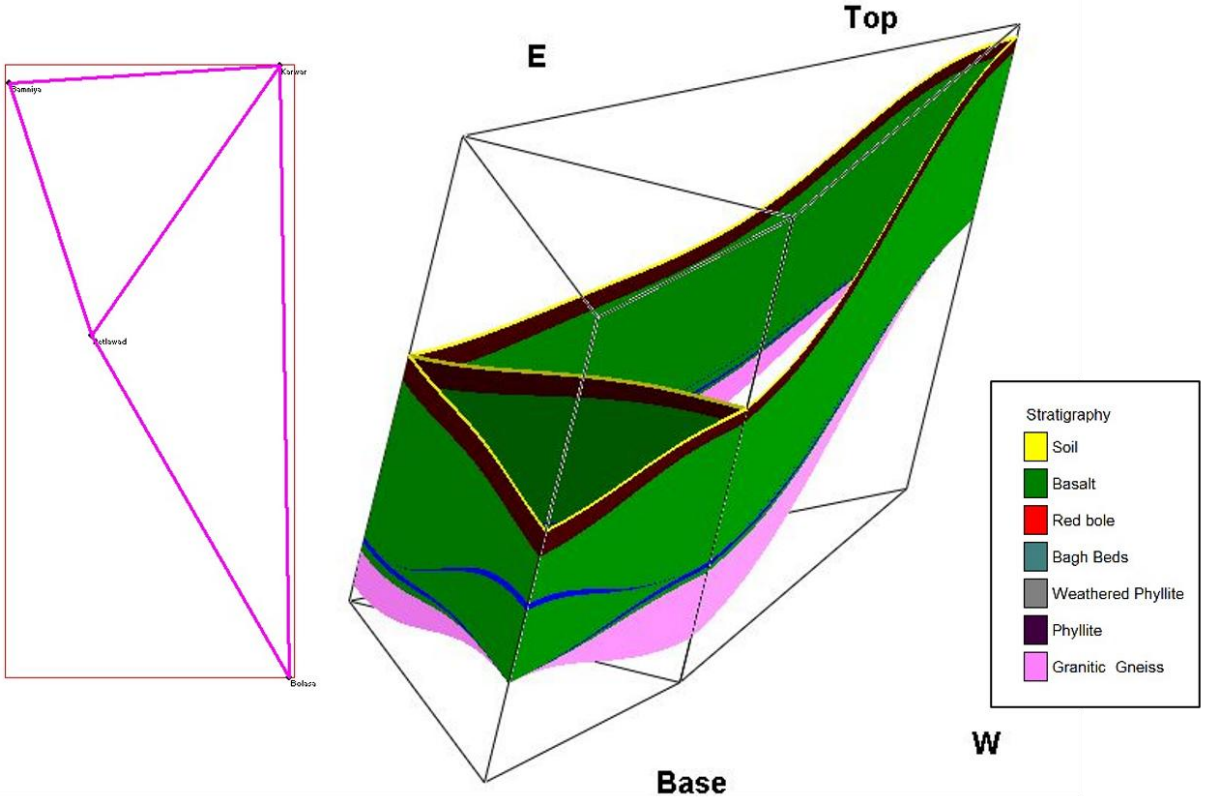

Fence Diagram – Meghnagar Block
Top
W
N
E
Base
Stratigraphy
Soil
Basalt
Red bole
Bagh Beds
Weathered Phyllite
Phyllite
Granitic Gneiss

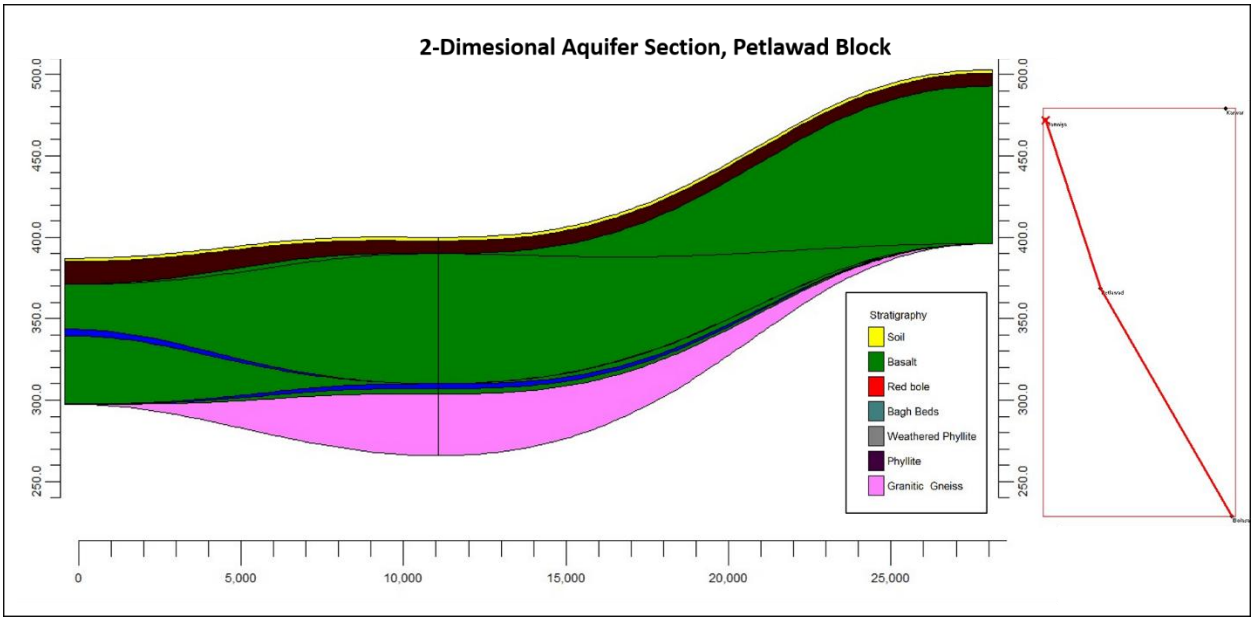

2-Dimesional Aquifer Section, Meghnagar Block
350.0
300.0
250.0
200.0
0
5,000
10,000
15,000
20,000
Stratigraphy
Soil
Basalt
Red bole
Bagh Beds
Weathered Phyllite
Phyllite
Granitic Gneiss

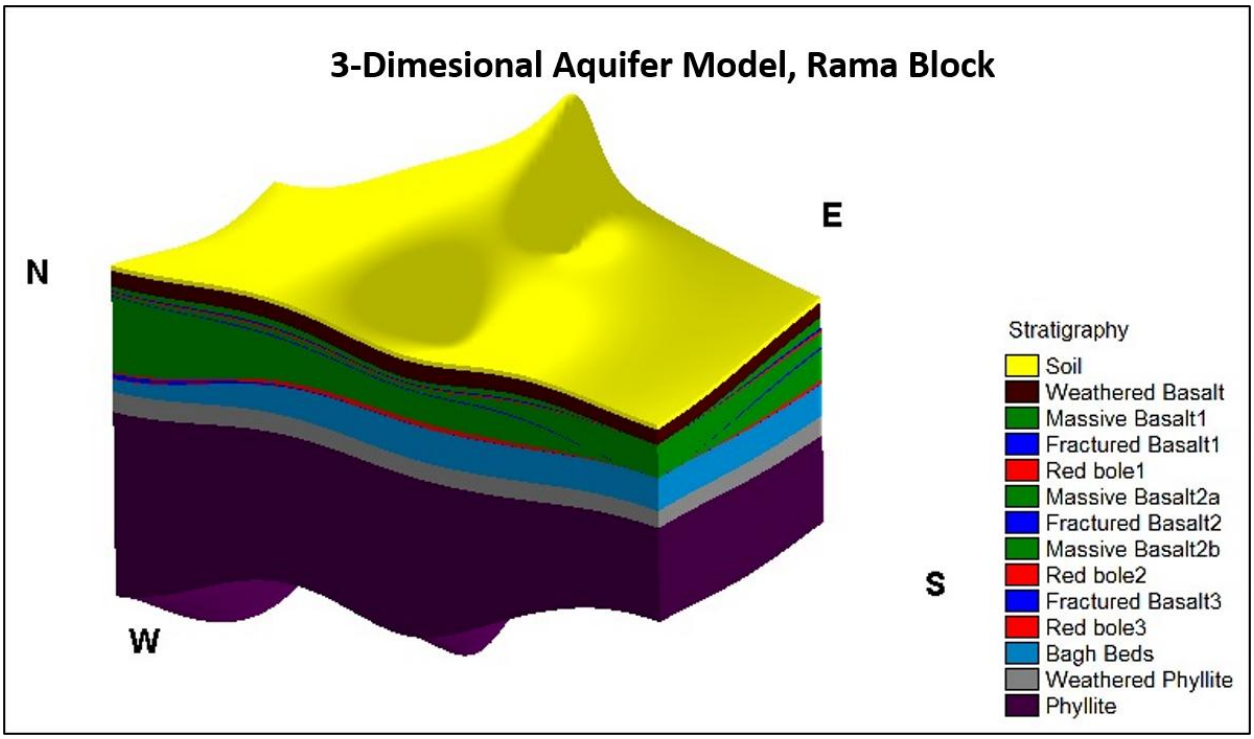
3-Dimesional Aquifer Model, Petlawad Block

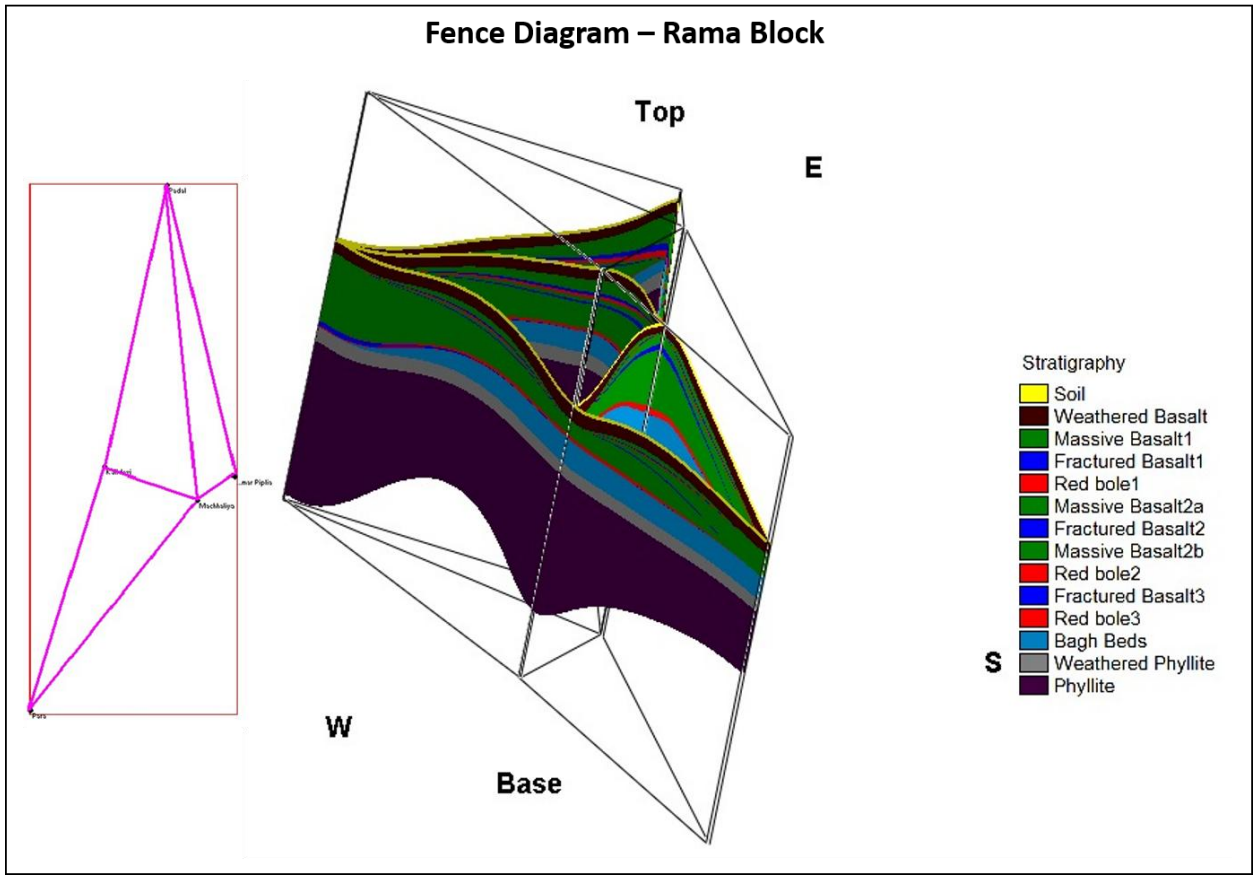


Fence Diagram – Petlawad Block




2-Dimesional Aquifer Section, Petlawad Block
500.0
450.0
400.0
350.0
300.0
250.0
0
5,000
10,000
15,000
20,000
25,000
Stratigraphy
Soil
Basalt
Red bole
Bagh Beds
Weathered Phyllite
Phyllite
Granitic Gneiss


3-Dimesional Aquifer Model, Rama Block
N
E
S
W
Stratigraphy
Soil
Weathered Basalt
Massive Basalt1
Fractured Basalt1
Red bole1
Massive Basalt2a
Fractured Basalt2
Massive Basalt2b
Red bole2
Fractured Basalt3
Red bole3
Bagh Beds
Weathered Phyllite
Phyllite



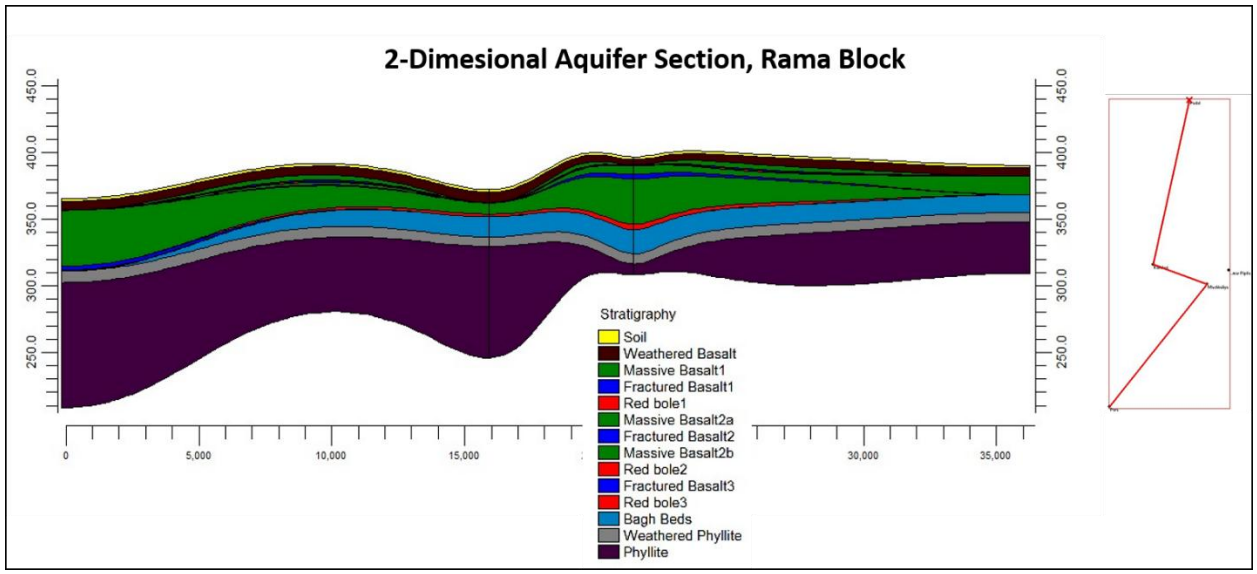


Fig 3.8 to 3.19: 3-D Aquifer model, Fence diagram and 2-D aquifer sections of Jhabua, Meghnagar, Petlawad and Rama blocks.

CHAPTER 4
GROUND WATER RESOURCES

The quantitative estimation of various inputs to ground water resources and their temporal variation in space and time is imperative for a planned management and development of ground water resources. The resources in the surveyed area are computed on the basis of methodology recommended by the Ground Water Estimation Committee of Ministry of Water Resources, Govt. of India, 2015.The entire aquifer mapping area, falls under command area and has been covered under ground water resource assessment. The estimation of ground water resource in the surveyed area is taken as on March 2022.

Methodology adopted

The primary source of recharge of groundwater in Jhabua district is rainfall. Therefore, water table balance method has been used for estimating the resources. Rainfall recharge factor or Infiltration factor is a recharge parameter that indicates a quantum of water recharged to the groundwater system in relation to the rainfall. It is a function of rate of infiltration and ability of the system to accept the infiltrated water. The infiltration factor can be expressed as follows

$$IF = (Qi/Qa) * Sy$$

Where,
IF = Infiltration Factor
Qi = Quantum of water infiltrated over the test period in m
Qa = Quantum of water applied in m
Sy = Specific Yield

Recharge to ground water involves several components and the rainfall being the major one. The other components are return irrigation flow from surface water and ground water. Rainfall infiltration factor for alluvial formations is taken as 20%. The Return Flow Factor for recharge from surface water irrigation has been taken as 15-25 % for non-paddy crops and 50-60 % for paddy crops. In case of ground water irrigation, the return flow factor has been taken as 15-25 % for non-paddy crops. Canal seepage factor, for lined and unlined canals, has been taken as per GEC-2015 norms. The recharge from other sources i.e. ponds and lakes have also been estimated based on the spread area of the water bodies.

In hard rocks, for practical purpose it is very difficult to compute zone wise (aquifer wise) ground water resources, because the weathered zone (WZ) and fractured zone (FZ) are inter-connected with fractures/joints and fractured zone gets recharged through weathered zone. Therefore, it is very difficult to demarcate the boundary between two aquifers; hence the resources are estimated considering entire area as a single aquifer system. Block wise dynamic ground water resources are computed as per the guidelines laid down in GEC-2015 methodology.

4.1 DYNAMIC GROUND WATER RESOURCES (2022)

The ground water resource assessment has been carried out for Jhabua district in the year 2022. The ground water resources have been computed for all command area and non-command area separately in 6 administrative blocks of Jhabua district. Portions of ground water assessment unit, which have slopes greater than 20% is characterized by more runoff and less ground water recharge, and hence has been excluded for ground water recharge computation. Block-wise total geographical areas, hilly area, command area, non-command area and area worthy for ground recharge are given in **Table 4.1.**

Table 4.1: Block wise Area Details.

S.No	Assessment Unit Name	Total Geographical Area (ha)				
		Recharge Worthy Area (ha)			Hilly Area	Total
		Command Area	Non Command Area	Total		
1	Jhabua	0	41300	41300	2700	44000
2	Meghnagar	0	45400	45400	4800	50200
3	Petlawad	17018	74635	91653	6047	97700
4	Rama	0	45700	45700	13700	59400
5	Ranapur	0	38400	38400	2000	40400
6	Thandla	0	48800	48800	5500	54300
	District Total	**17018**	**294235**	**311253**	**34747**	**346000**

Recharge from rainfall has been computed separately for monsoon and non-monsoon periods as well as for command and non-command areas. Total recharge from rainfall in the district is of the order of 19326 ham (193 mcm) which is approximately 77% of the total annual ground water recharge (**Fig.4.1**) with Petlawad block having the highest rainfall recharge of 8028 ham and Ranapur block has minimum rainfall recharge of the order of 1447 ham. Details of the Assessment unit-wise monsoon and non-monsoon Rainfall recharge and recharge from other sources have been given in **Table 4.2**.

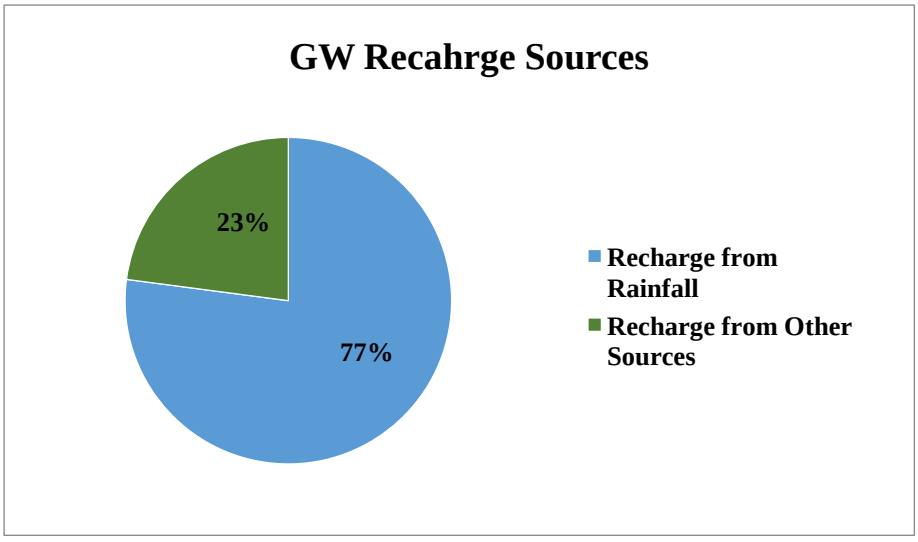


Fig 4.1: Ground water Recharge Sources.

Table 4.2: Block Ground water Recharge Sources.

Assessment Unit Name	Recharge from Rainfall- Monsoon Season (Ham)	Recharge from Other Sources- Monsoon Season (Ham)	Recharge from Rainfall- Non Monsoon Season (Ham)	Recharge from Other Sources- Non Monsoon Season (Ham)	Total Annual Ground Water Recharge (Ham)	Total Natural Discharges (Ham)	Annual Extractable Ground Water Resource (Ham)
Jhabua	1750.9	135.64	0	337.54	2224.08	222.4	2001.68
Meghnagar	2961.91	146.26	0	342.84	3451.01	345.1	3105.91
Petlawad	8028.82	417.71	0	2965.89	11412.42	570.62	10841.8
Rama	1982.04	178.54	0	366.64	2527.22	126.36	2400.86
Ranapur	1447.3	93.06	0	207.53	1747.89	87.4	1660.49
Thandla	3154.59	167.28	0	387.22	3709.09	370.91	3338.18
District Total	**19325.56**	**1138.49**	**0**	**4607.66**	**25071.71**	**1722.79**	**23348.92**

The recharge from other component include seepage from canals, return flow from surface water irrigation, return flow from ground water irrigation, seepage from Tanks and Ponds and recharge from water conservation structures. Block wise recharge from other sources is given **Table 4.3**. Component of recharge from other sources is highest in Petlawad block (3384 ham) where maximum canal irrigation facility is available in the district. Lowest value of recharge from other source is recorded in Ranapur (300 ham). The block wise recharge from 'Other sources' viz. canal seepage, return flow from irrigation, recharge from tanks, ponds and water conservation structures is shown in (**Fig.4.2)**

Table 4.3: Block wise Recharge from other sources.

Assessment Unit Name	Recharge from Canals (in Ham)	Recharge from Surface Water Irrigation (in Ham)	Recharge from Ground Water Irrigation (in Ham)	Recharge due to Tanks and Ponds (in Ham)	Recharge due to Water Conservation Structures (in Ham)	Total Recharge from Other Sources (in Ham)
Jhabua	0	0	315.42	127.22	30.54	473.18
Meghnagar	0	0	321.34	135.38	32.388	489.11
Petlawad	138.7	2064.42	569.96	559.76	50.76	3383.60
Rama	0	0	285.76	210.6	48.816	545.18
Ranapur	0	0	200.94	63.69	35.964	300.59
Thandla	0	0	336.53	169.69	48.276	554.50
District Total	**138.7**	**2064.42**	**2029.95**	**1266.34**	**246.744**	**5746.154**

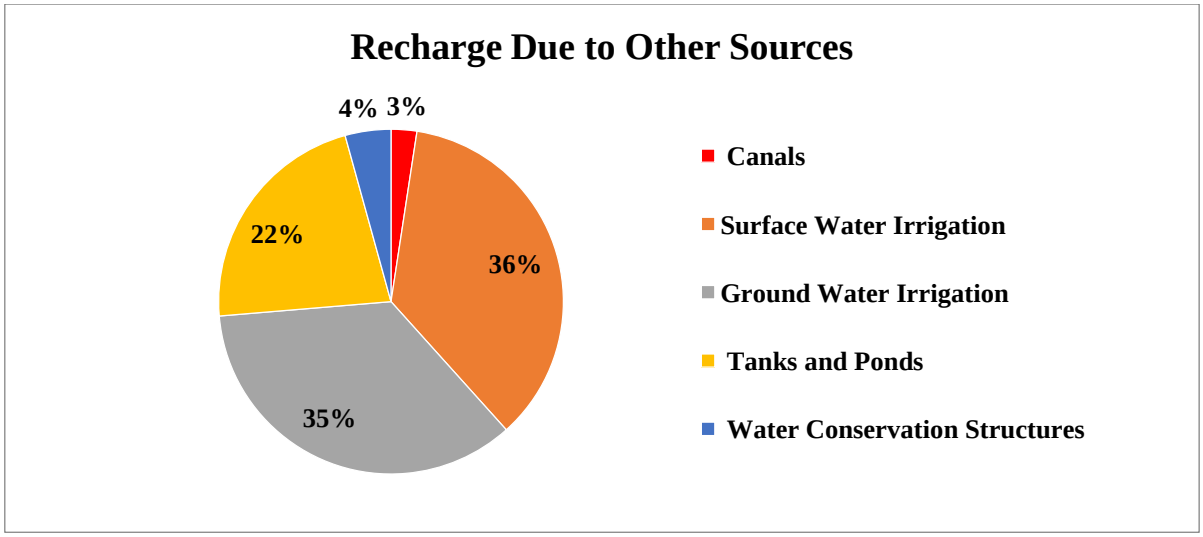


Fig 4.2: Recharge due to other sources.

The Annual Extractable Ground Water Resources is calculated by subtracting the Total annual ground water recharge from the natural discharge which is 5%-10% of total annual ground water recharge. The block wise Annual Extractable Ground Water Resources and Natural discharge is given in the **Table.4.4**.

Total unaccounted natural discharge in the district is of the order of 1723 ham. The total natural discharge in the state is about 7% of the total annual Groundwater recharge (**Fig.4.3**). The Annual Extractable Ground Water Resource in the state is 23349 ham (233 mcm) with Petlawad block having the highest Annual Extractable Ground Water Resource of 10842 ham and Ranapur with lowest of 1660 ham. The Annual Extractable Ground Water Resource in the district is 93% of the total annual Groundwater recharge (**Fig.4.3**)

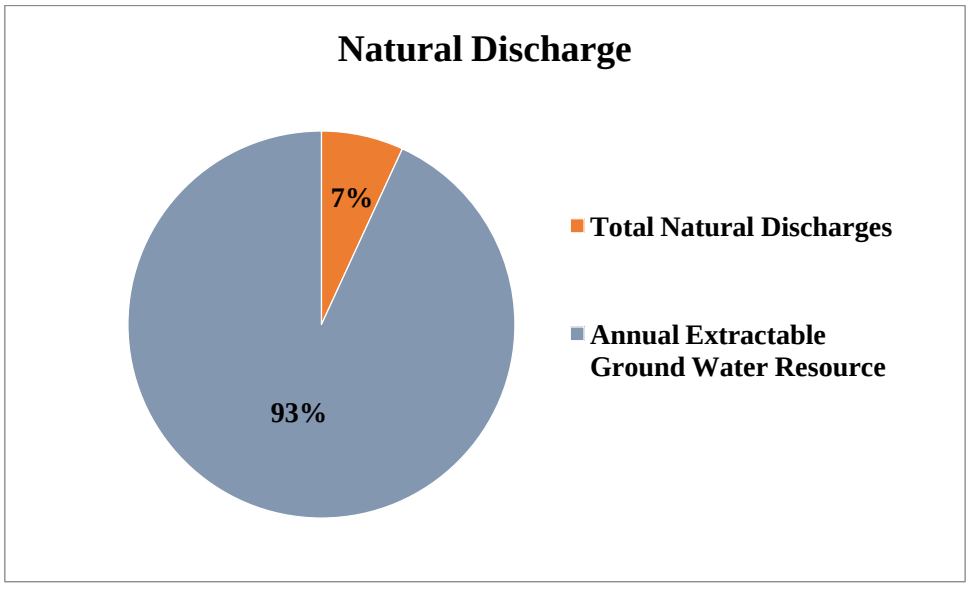


Fig 4.3: Natural Discharge Vs Annual Extractable GW resources.

Ground water extraction for various uses has been calculated separately for command and non-command areas. Total extraction of ground water for all uses in the block is calculated as 10814 ham (108 mcm). From the **Table 4.4**, it is seen that maximum ground water extraction for all uses is 2871 ham in Petlawad block and minimum extraction of ground water for all uses is 1089 ham in Ranapur block. Comparison of ground water extraction for various uses reveals that extraction for irrigation accounts for more than 75% of total ground water extraction, whereas extraction for domestic is 25% and industrial extraction accounts for meagre 0.01% of the total ground water extraction in the district (**Fig. 4.4**).

Table 4.4: Block wise Ground water Extraction Scenario.

Assessment Unit Name	Ground Water Extraction for Irrigation Use (Ham)	Ground Water Extraction for Industrial Use (Ham)	Ground Water Extraction for Domestic Use (Ham)	Total Extraction (Ham)	Stage of Ground Water Extraction (%)	Categorization
Jhabua	1261.68	1.48	434.00	1697.17	84.79	semi critical
Meghnagar	1285.38	0.00	550.94	1836.32	59.12	safe
Petlawad	2223.32	0.37	646.99	2870.66	26.48	safe
Rama	1143.03	0.00	358.82	1501.85	62.55	safe
Ranapur	803.75	0.00	285.09	1088.84	65.57	safe
Thandla	1346.13	0.00	472.83	1818.96	54.49	safe
District Total	**8063.29**	**1.85**	**2748.67**	**10813.80**	**46.31**	

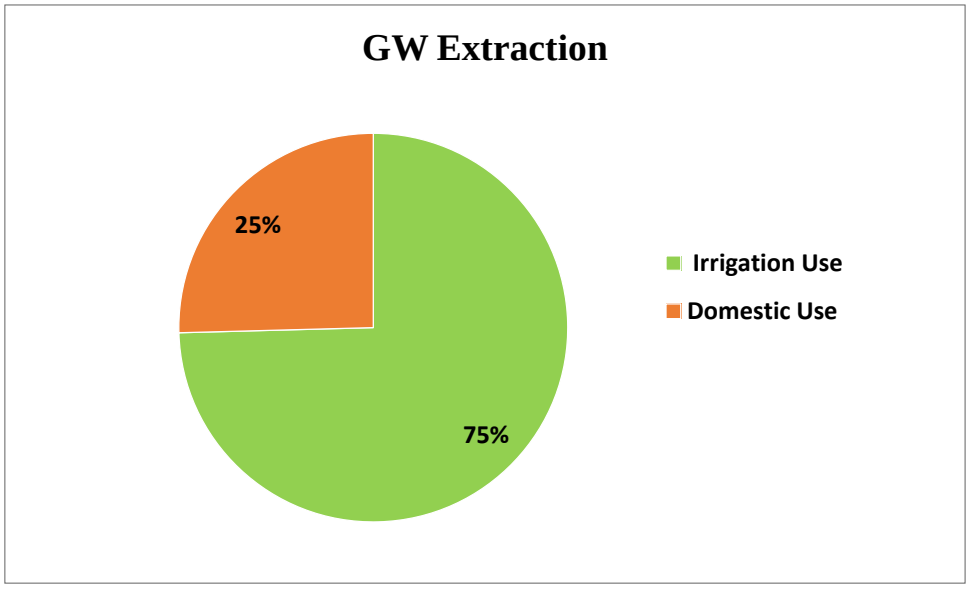


Fig.4.4: Ground Water Extraction Scenario.

The overall stage of groundwater extraction in the district is 46.31 %. The block wise stage of extraction is given in the **Table 4.4**. The Jhabua block of the district has highest stage of Ground Water Extraction (84.79%) and Petlawad block has lowest stage of Ground Water Extraction (26.48%).

The distributions of various categorized assessment units are shown in the **(Fig.4.5)** Jhabua block is falling in 'semi-critical' category and remaining 5 blocks of the district are categorized as 'Safe'.

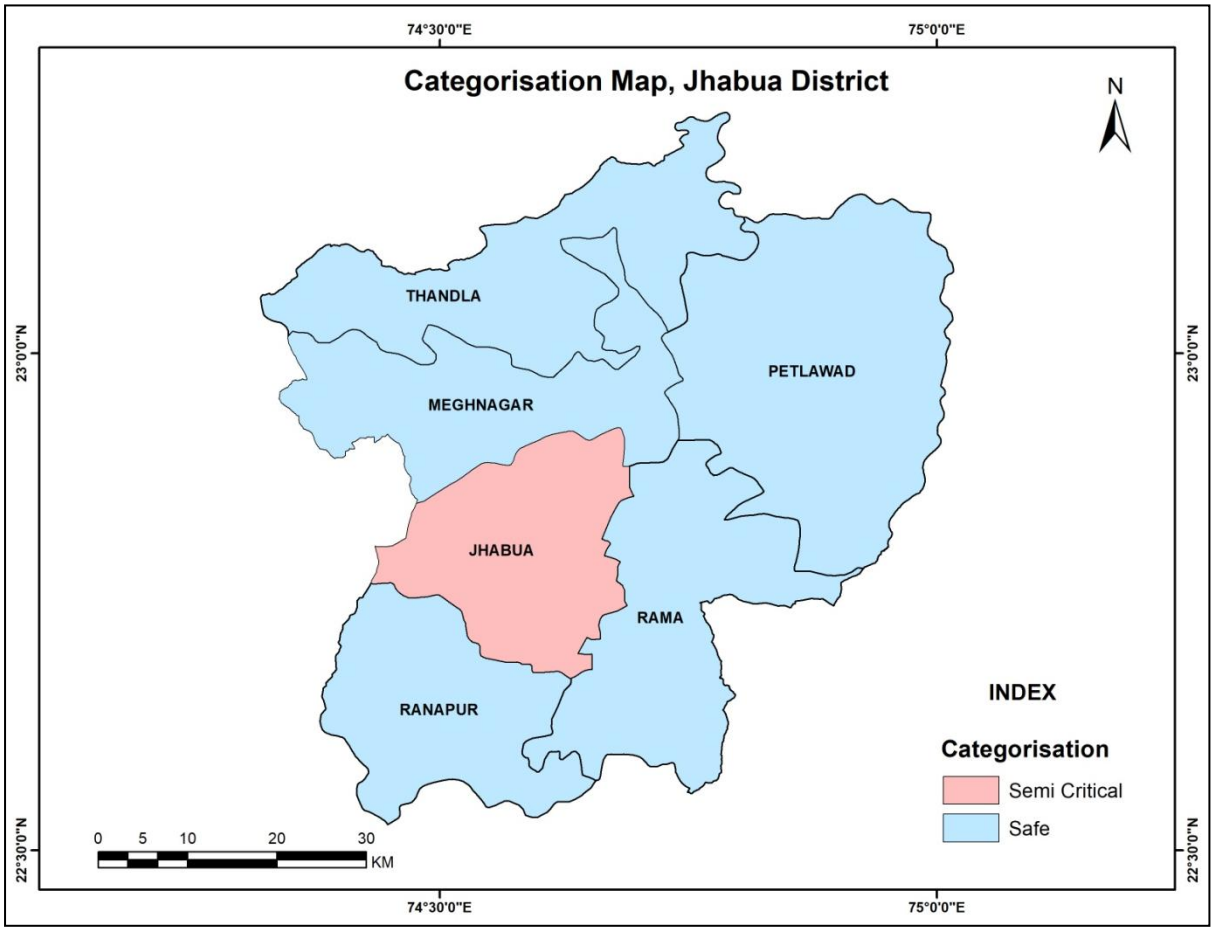


Fig.4.5: Categorisation Map, Jhabua District.

CHAPTER 5
GROUND WATER RELATED ISSUES

5.1 Scope for Additional Groundwater Development

Utilisation of GW resources are poorly developed in Jhabua district, because of low development of groundwater, the area faces water scarcity problems in summer season. Being hard rock formation area, most of the groundwater resources is in shallow/ Pheratic in weathered Basalt formation. In deeper aquifer, groundwater is restricted and mostly found in Lameta Limestone & fractured Granitic gneisses and along the bedding plane of the formation.

In Jhabua district, all the blocks fall under safe category except Jhabua, which is categorized as semi critical and highest stage of ground water development is computed as 84.78%. The stage of groundwater extraction is comparatively less in blocks including Meghnagar (59.12%), Petlawad (26.47%), Rama (62.55%), Ranapur (65.57%) and Thandla (54.48%). The overall stage of extraction is 46.31%. In view of prevailing hydrogeological conditions, there is scope for further development of groundwater in 5 blocks which would help in the agricultural and industrial development of the district, leading to the overall development of the district. Artificial recharge structures and savings through adoption of micro-irrigation are also proposed in all blocks for sustainable development of groundwater.

5.2 Declining Water Level Trend

The ground water exploitation has resulted in decline of water levels over the period of time. In Pre-monsoon season, decline has been observed in most of the wells **(Fig: 5.1-5.3)** in the district. The decline may be because the area has experienced increased ground draft water and less annual rainfall received than the normal rainfall. The declining water level trend during pre-monsoon and post-monsoon for last 10 year is observed and the hydrographs of Bamania (DW), Jhabua (PZ) and Jhabua (DW) were presented as below:

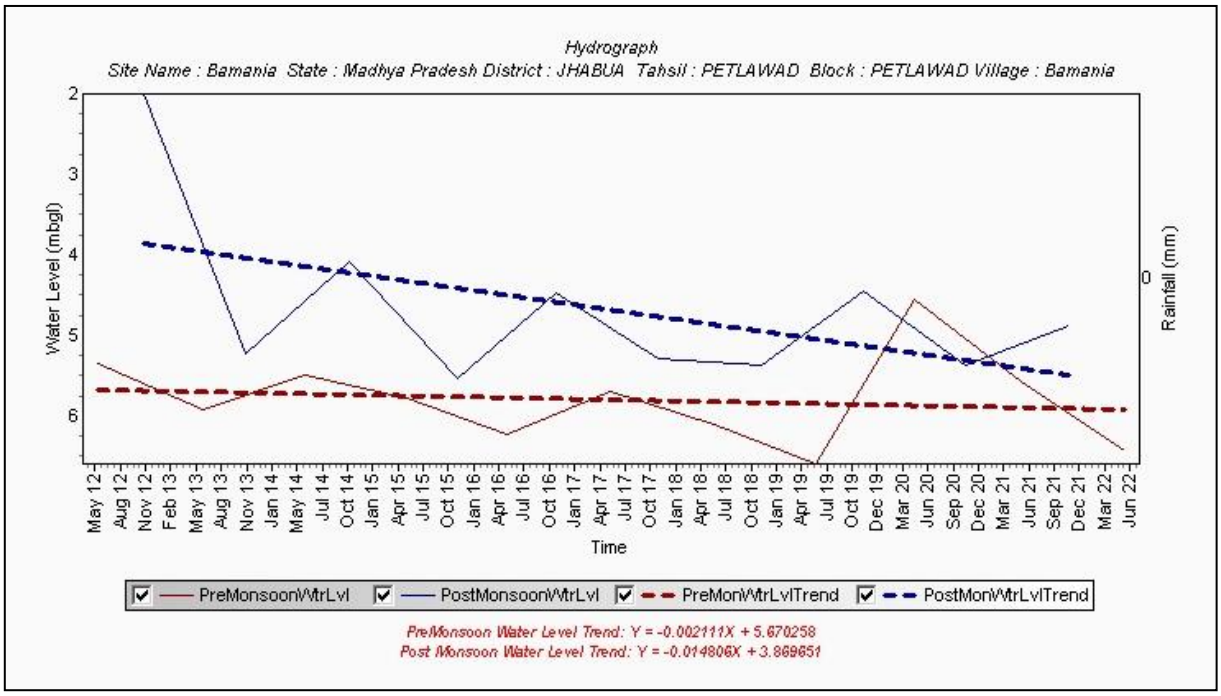


Fig: 5.1 Hydrograph of Bamania (DW), Petlawad block, Jhabua district, MP.

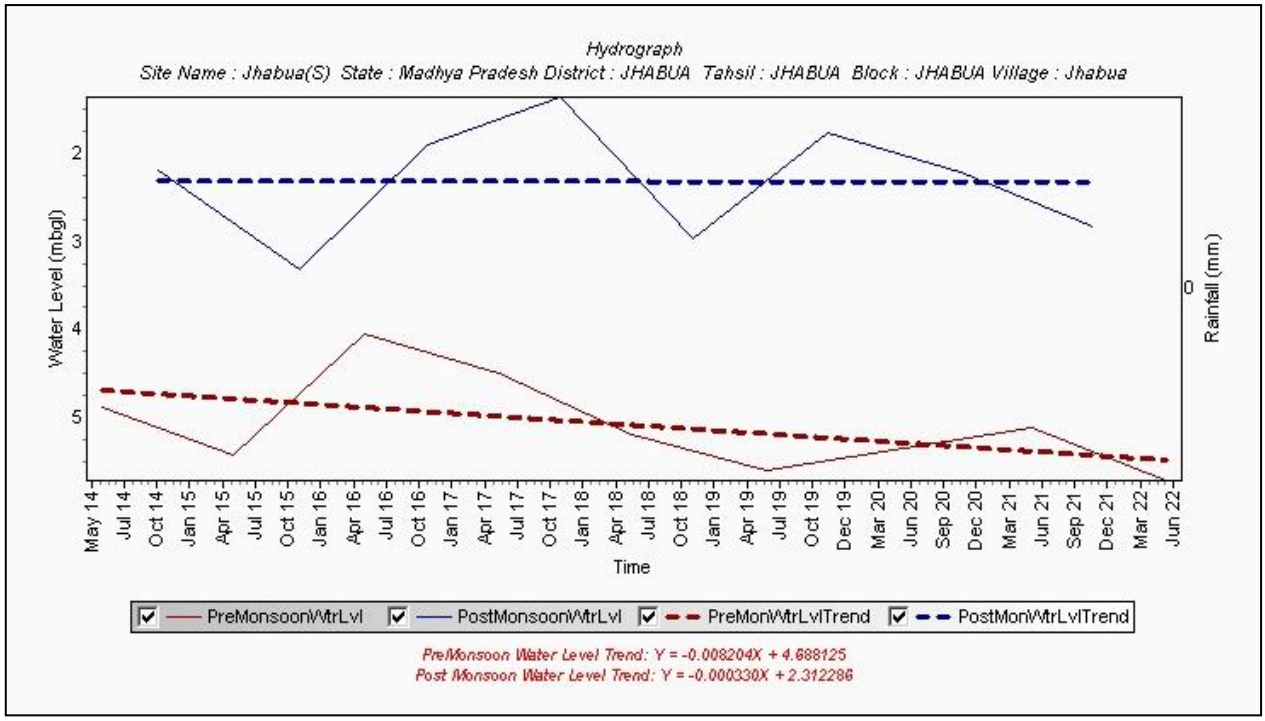


Fig: 5.2 Hydrograph of Jhabua(S), Jhabua district, MP.

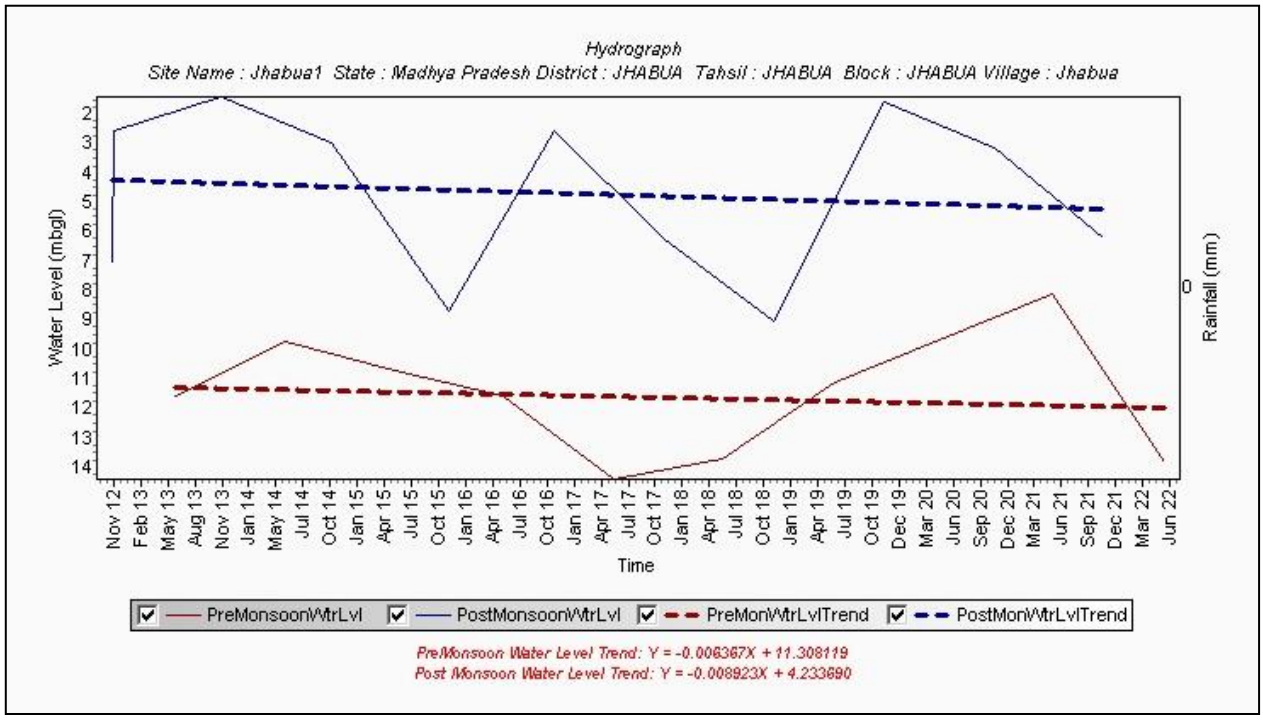


Fig: 5.3 Hydrograph of Jhabua (DW), Jhabua district, MP.

5.3 Ground Water Quality Issue

In parts of Jhabua, Petlawad, Thandla blocks of Jhabua district, nitrate contamination is there. This problem is due to anthropogenic reason and can be controlled.

The fluoride concentration in Jhabua district lies in between 0.24 to 1.38 mg/l, which indicates that all the samples are within the permissible limit i.e. 1.5 mg/l as per BIS (IS 10500 : 2012). The maximum concentration of fluoride has been observed in the dug well of Ranapur village. Nitrate in ground water samples of Jhabua district fall within limits of 2 to 113 mg/l. It is observed that 50.0% samples have nitrate concentration more than the acceptable limit i.e. 45 mg/l, while rest 50.0% samples have concentration less than acceptable limit. Highest concentration of nitrate is reported in the water sample of Thandla village (113 mg/l). High nitrate in ground water samples may be due to anthropogenic activities or excessive use of fertilizers. The range of Total Hardness (as $CaCO_3$) in ground water samples of study area is 258 to 505 mg/l. In all locations, total hardness concentrations are within the permissible limit of 600 mg/l. The maximum concentration of total hardness in the village of Thandla (505 mg/l).

CHAPTER 6
GROUND WATER MANAGEMENT PLAN

The demand of fresh water for agriculture, drinking and industrial uses etc. has significantly increased due to population growth and socio-economic development. There is urgent need for taking up suitable water management interventions based on integrated approach, which on one hand includes augmentation of ground water resources through appropriate techniques, and on the other hand requires the adoption of suitable water conservation measures, such as ensuring water use efficiency through creation of additional water storage facility, maintenance/ renovation of existing water bodies etc.

A comprehensive ground water resources management plan to be proposed to arrest further decline in water levels. The management plan comprises two components namely supply-side management and demand-side management. The supply side management is proposed based on surplus surface water availability and the unsaturated thickness of aquifer whereas the demand side management is proposed by use of micro irrigation techniques and change in cropping pattern.

6.1 SUPPLY SIDE MANAGEMENT

The supply side management of ground water resources can be done through the artificial recharge by utilization of surplus runoff available within river sub basins and micro watersheds. Also, it is necessary to understand the unsaturated aquifer volume available for recharge. The unsaturated volume of aquifer was computed based on the area feasible for recharge, unsaturated depth below 03 mbgl and the specific yield of the aquifer **(Table: 6.1).**

In Jhabua district, after 2022 water resource assessment all blocks are under safe category except Jhabua block. Three blocks i.e., Meghnagar, Petlawad, and Thandla blocks are having less than 60% stage of groundwater extraction, Rama and Ranapur blocks are having more than 60% and Jhabua block is having more than 80% stage of groundwater extraction. Adoption of suitable water abstraction structures in Meghnagar, Petlawad, Rama, Ranapur and Thandla blocks and Artificial Recharge Structures in Jhabua block has been proposed. The number of structures and cost for construction of artificial recharge structures to be constructed in each block is given in **Table: 6.2.**

Table: 6.1 Computation of subsurface storage and surface water available for AR.

Sl. No	District	Assessment Unit Name	Area (Sq.KM)	Normal Annual Rainfall (m)	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)	Runoff MCM	Non Commuted Runoff
1	Jhabua	Jhabua	440	0.835	3.66	413	0.66	0.016	4.36	5.80	103.5	31.04
2	Jhabua	Meghnagar	502	0.835	3.79	454	0.79	0.017	6.10	8.11	113.7	34.12
3	Jhabua	Petlawad	977	0.835	4.4	917	1.4	0.02	25.68	34.15	229.7	68.91
4	Jhabua	Rama	594	0.835	3.98	457	0.98	0.02	8.96	11.91	114.5	34.34
5	Jhabua	Ranapur	404	0.835	3.49	384	0.49	0.016	3.01	4.00	96.2	28.86
6	Jhabua	Thandla	543	0.835	3.48	488	0.48	0.019	4.45	5.92	122.2	36.67

Table: 6.2 Financial Outlay Plan- Supply Side Management, Jhabua District, Madhya Pradesh.

Assessment Unit Name	no of percolation tanks	cost of percolation tanks in crores @0.20 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 @ 0.01crores	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
Jhabua	10	2	87	5.22	87	0.87	87	0.87	29	0.725
Meghnagar	14	2.8	122	7.32	122	1.22	122	1.22	41	1.025
Petlawad	60	12	512	30.72	512	5.12	512	5.12	171	4.275
Rama	21	4.2	179	10.74	179	1.79	179	1.79	60	1.5
Ranapur	7	1.4	60	3.6	60	0.6	60	0.6	20	0.5
Thandla	10	2	89	5.34	89	0.89	89	0.89	30	0.75

6.2 DEMAND SIDE MANAGEMENT

The Demand Side Management is proposed in areas where the Stage of Ground Water Development is relatively high and adopting micro-irrigation techniques for water intensive crops (Sugarcane, Rice, wheat, etc) or change in cropping pattern or both are required to save water. Micro-irrigation comprises two technologies—drip and sprinkler irrigation. Both saves conveyance losses and improve 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.
3. It saves costs of hired labour and other inputs like fertilizer.
4. 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.

6.2.1 Micro-Irrigation Techniques

Adoption of Sprinkler irrigation techniques would save 20% of gross ground water draft for irrigation. Also, the 60% of 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. The projected outcome of savings by adopting micro-irrigation is given in **Table: 6.3 & 6.4**.

Table: 6.3 Demand side management plan, Jhabua district.

Annual Extractable GW Resource	**MCM**	**233.49**
Total Extraction for all uses		**108.13**
Stage of GW Extraction	**%**	**46.31**
Saving by Sprinkler	**MCM**	**20.16**
Additional recharge created by AR		**52.56**
After intervention of AR Structure Net GW AvL.		**286.05**
After intervention of AR Structure & utilization of additional GW created.		**31.54**
After utilization of Annual Extractable GW Resource 2022		**62.72**
Extraction after sprinkler & additional area created for agriculture		**182.23**
Stage of GW Extraction W/O GW use for additional Area Irrigation	**%**	**63.70**

Table: 6.4 Micro-irrigation proposed in Jhabua district.

Block	Annual Extractable GW Resource (MCM)	GW Extraction for Irrigation use (MCM)	GW Extraction for Domestic & Industrial use (MCM)	Total Extraction for all uses (MCM)	Stage of GW Extraction (%)	Saving by micro irrigation 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)	After utilization of Annual Extractable GW Resource 2022 (MCM)	Extraction after sprinkler & additional area created for agriculture (MCM)	Stage of GW Extraction W/O GW use for additional Area Irrigation (%)	Additional area irrigated by GW after intervention (sq km)
Jhabua	20.02	12.62	4.35	16.97	84.79	3.16	4.36	24.38	2.62	0.00	16.43	67.40	6.54
Meghnagar	31.06	12.85	5.51	18.36	59.12	3.21	6.10	37.16	3.66	6.21	25.02	67.33	24.68
Petlawad	108.42	22.23	6.47	28.70	26.48	5.56	25.68	134.10	15.41	43.37	81.92	61.09	146.94
Rama	24.01	11.43	3.59	15.02	62.55	2.86	8.96	32.97	5.38	4.80	22.34	67.76	25.45
Ranapur	16.60	8.04	2.85	10.89	65.57	2.01	3.01	19.61	1.81	1.66	12.35	62.96	8.67
Thandla	33.38	13.46	4.73	18.19	54.49	3.37	4.45	37.83	2.67	6.68	24.17	63.89	23.37
Total	**233.49**	**80.63**	**27.50**	**108.13**	**46.31**	**20.16**	**52.56**	**286.05**	**31.54**	**62.72**	**182.23**	**63.70**	**235.64**

6.2.2 Groundwater Abstraction Structures

For Petlawad block the stage of groundwater extraction is 26.47% which is proposed to increase up to 60% by introducing groundwater abstraction structures such dug wells and tube wells in the area. The number of abstraction structures has been calculated depending on amount of draft to be increased and net groundwater availability in the region. The new total draft has been calculated by multiplying net groundwater availability (taken from State groundwater resource estimation 2022) with 0.6 (as we want to increase the stage of groundwater extraction up to 60%). The existing total draft including all sources is subtracted from the new total draft. After subtraction we get the required draft for proposed abstraction structures.

Further, 50% of the draft calculated is considered for abstraction structure and has been allocated dug wells and bore wells equally. With the known unit draft of dug wells and bore wells block wise, the block wise number of dug wells and bore wells has been calculated by dividing allocated 50% draft of dug wells with unit draft of dug well and allocated 50% of bore well with unit draft of bore well within a block.

Table: 6.5 Quantitative impacts on GW Resource after the Supply side and Demand side intervention.

Block	Stage of GW Extraction (%)	Stage of GW Extraction after intervention (%)	Additional area irrigated by GW after intervention (Ham)
JHABUA	84.79	67.40	654
MEGHNAGAR	59.12	67.33	2468
PETLAWAD	26.48	61.09	14694
RAMA	62.55	67.76	2545
RANAPUR	65.57	62.96	867
THANDLA	54.49	63.89	2337
Total	**46.31**	**63.70**	**23564**

CHAPTER 7
BLOCK WISE GROUND WATER MANAGEMENT PLAN

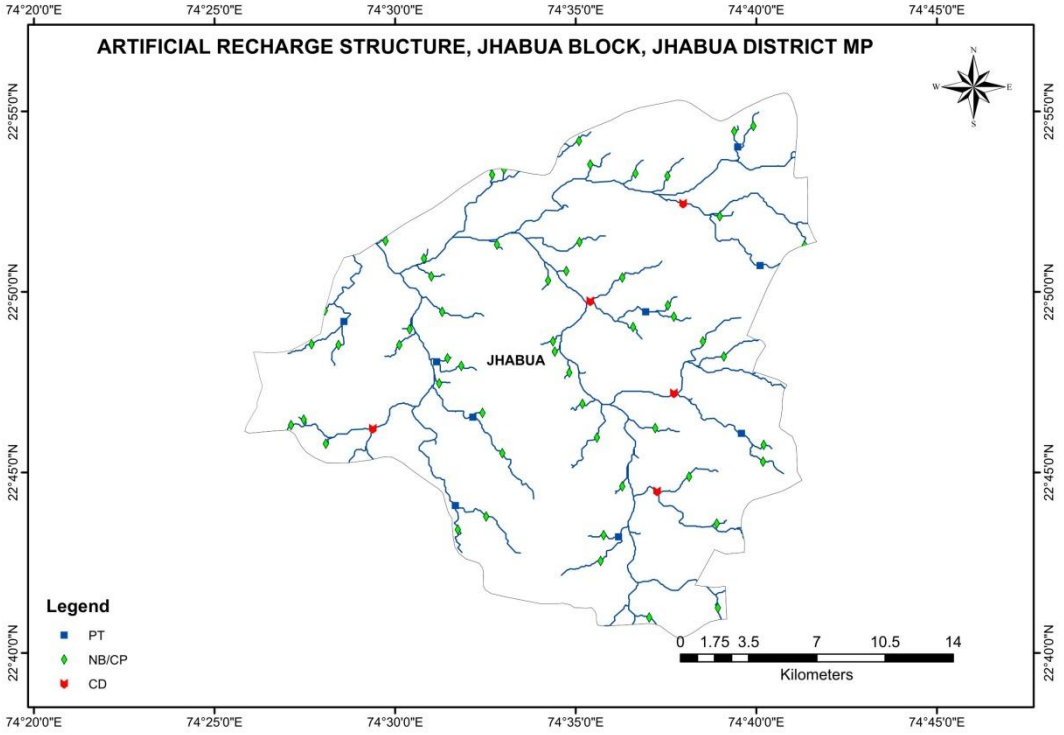
7.1 JHABUA BLOCK

7.1.1 GROUND WATER RESOURCES

DYNAMIC GROUNDWATER RESOURCES 2022	Recharge worthy area	**Sq Km**	413
	Annual Extractable Groundwater Resource	**MCM**	20.02
	Total Ground Water Extraction		16.97
	Stage of Ground Water Extraction	**%**	84.79%
	Category		**Semi-Critical**

7.1.2 SUPPLY SIDE MANAGEMENT PLAN

Type of Structures	**Number**	**Cost (in Crores)**
Percolation Tanks	10	2.0
Check Dam	87	5.22
Recharge Shaft in each Check Dam	87	0.87
Nala Bund/ Cement Plugs	87	0.87
Village Ponds/ Farm Ponds	29	0.725
Total Cost (in Crores)		**9.685**



7.1.3 DEMAND SIDE MANAGEMENT PLAN

Annual Extractable GW Resource	**MCM**	20.02
Total Extraction for all uses		16.97
Stage of GW Extraction	**%**	84.79
Saving by Sprinkler	**MCM**	3.16
Additional recharge created by AR		4.36
After intervention of AR Structure Net GW AvL.		24.38
After intervention of AR Structure & utilization of additional GW created.		2.62
Extraction after sprinkler & additional area created for agriculture		16.43
Stage of GW Extraction W/O GW use for additional Area Irrigation	**%**	67.40

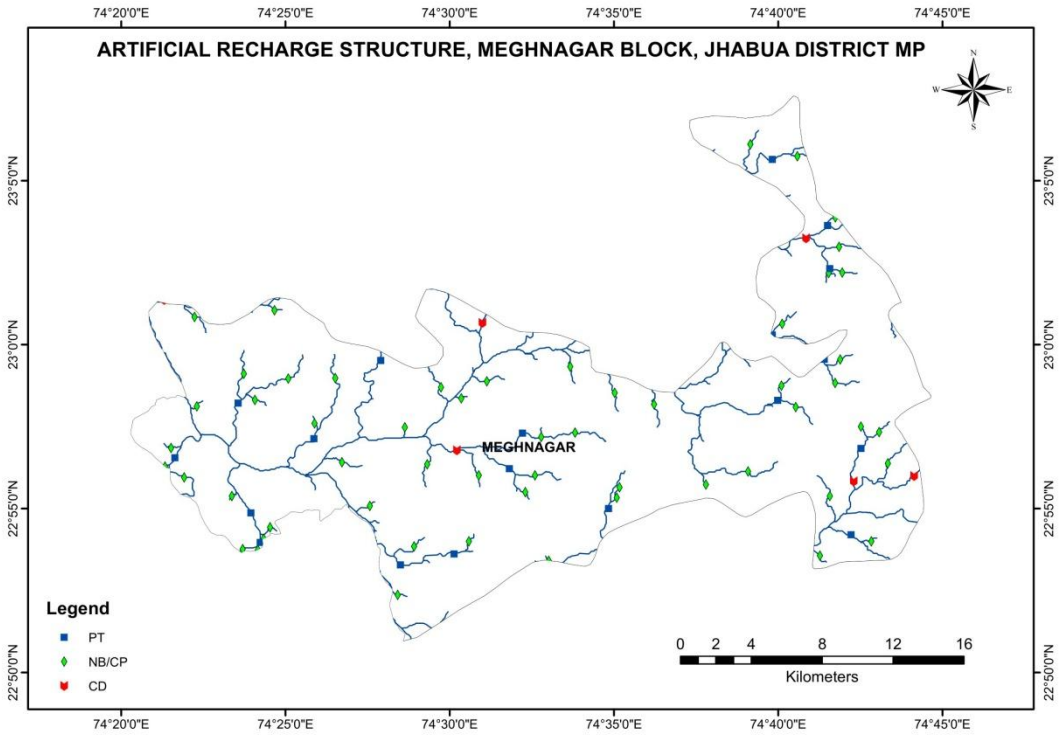
7.2 MEGHNAGAR BLOCK

7.2.1 GROUND WATER RESOURCES

DYNAMIC GROUNDWATER RESOURCES 2022	Recharge worthy area	**Sq Km**	454
	Annual Extractable Groundwater Resource	**MCM**	31.06
	Total Ground Water Extraction		18.36
	Stage of Ground Water Extraction	**%**	59.12%
	Category		**Safe**

7.2.2 SUPPLY SIDE MANAGEMENT PLAN

Type of Structures	**Number**	**Cost (in Crores)**
Percolation Tanks	14	2.8
Check Dam	122	7.32
Recharge Shaft in each Check Dam	122	1.22
Nala Bund/ Cement Plugs	122	1.22
Village Ponds/ Farm Ponds	41	1.025
Total Cost (in Crores)		**13.585**



7.2.3 DEMAND SIDE MANAGEMENT PLAN

Annual Extractable GW Resource	**MCM**	31.06
Total Extraction for all uses		18.36
Stage of GW Extraction	**%**	59.12
Saving by Sprinkler	**MCM**	3.21
Additional recharge created by AR		6.10
After intervention of AR Structure Net GW AvL.		37.16
After intervention of AR Structure & utilization of additional GW created.		3.66
After utilization of Annual Extractable GW Resource 2022		6.21
Extraction after sprinkler & additional area created for agriculture		25.02
Stage of GW Extraction W/O GW use for additional Area Irrigation	**%**	67.33

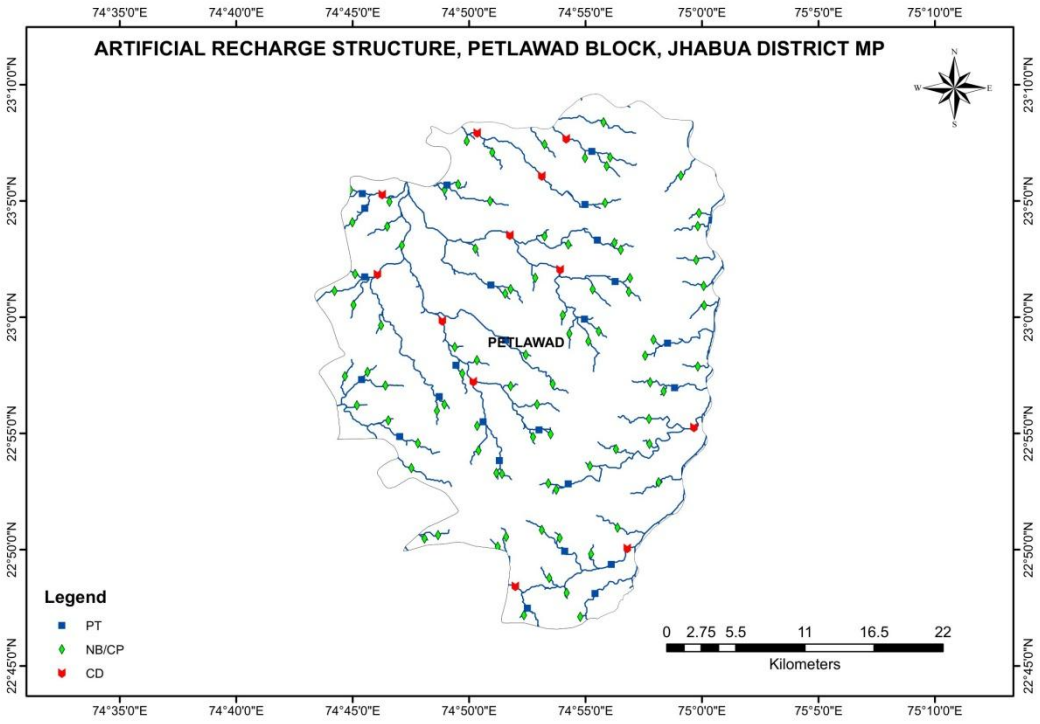
7.3 PETLAWAD BLOCK

7.3.1 GROUND WATER RESOURCES

DYNAMIC GROUNDWATER RESOURCES 2022	Recharge worthy area	**Sq Km**	917
	Annual Extractable Groundwater Resource	**MCM**	108.42
	Total Ground Water Extraction		28.70
	Stage of Ground Water Extraction	**%**	26.48
	Category		**Safe**

7.3.2 SUPPLY SIDE MANAGEMENT PLAN

Type of Structures	**Number**	**Cost (in Crores)**
Percolation Tanks	60	12
Check Dam	512	30.72
Recharge Shaft in each Check Dam	512	5.12
Nala Bund/ Cement Plugs	512	5.12
Village Ponds/ Farm Ponds	171	4.275
Total Cost (in Crores)		**57.235**



7.3.3 DEMAND SIDE MANAGEMENT PLAN

Annual Extractable GW Resource	**MCM**	108.42
Total Extraction for all uses		28.70
Stage of GW Extraction	**%**	26.48
Saving by Sprinkler	**MCM**	5.56
Additional recharge created by AR		25.68
After intervention of AR Structure Net GW AvL.		134.10
After intervention of AR Structure & utilization of additional GW created.		15.41
After utilization of Annual Extractable GW Resource 2022		43.37
Extraction after sprinkler & additional area created for agriculture		81.92
Stage of GW Extraction W/O GW use for additional Area Irrigation	**%**	61.09

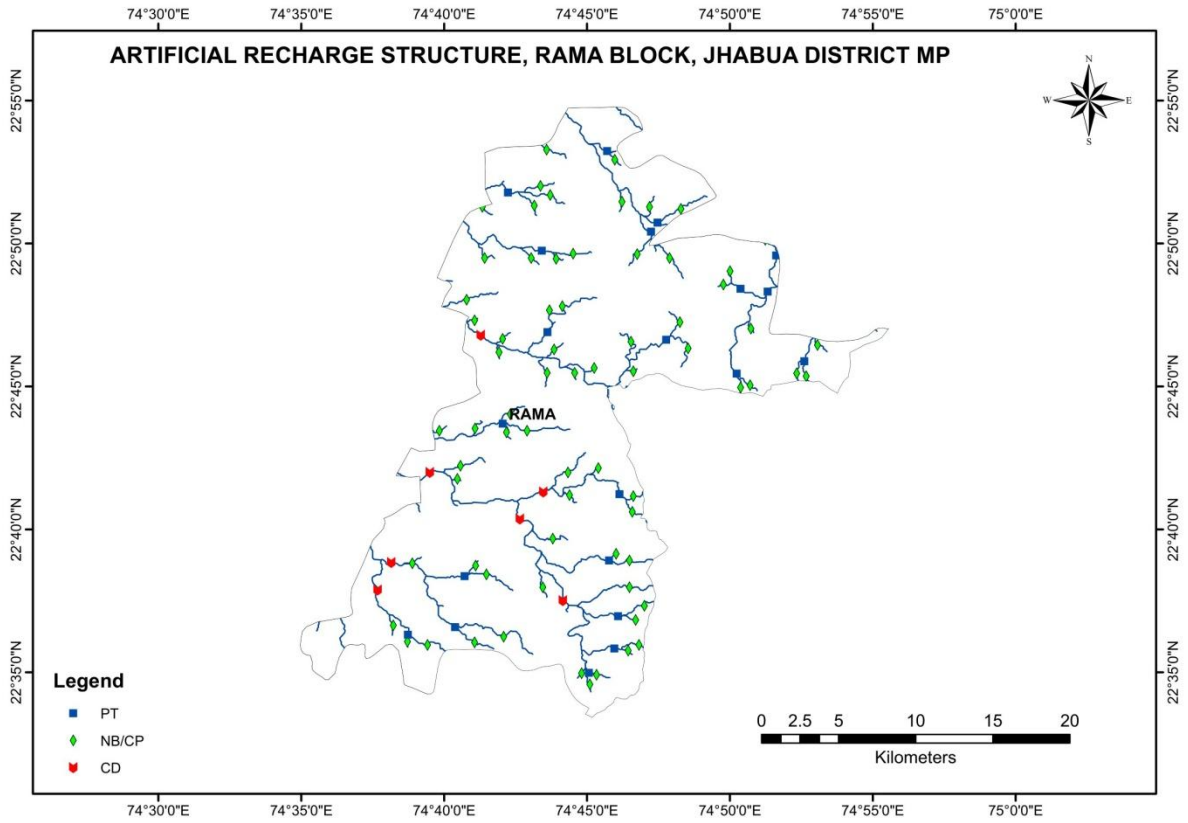
7.4 RAMA BLOCK

7.4.1 GROUND WATER RESOURCES

DYNAMIC GROUNDWATER RESOURCES 2022	Recharge worthy area	**Sq Km**	457
	Annual Extractable Groundwater Resource	**MCM**	24.01
	Total Ground Water Extraction		15.02
	Stage of Ground Water Extraction	**%**	62.55%
	Category		**Safe**

7.4.2 SUPPLY SIDE MANAGEMENT PLAN

Type of Structures	**Number**	**Cost (in Crores)**
Percolation Tanks	21	4.2
Check Dam	179	10.74
Recharge Shaft in each Check Dam	179	1.79
Nala Bund/ Cement Plugs	179	1.79
Village Ponds/ Farm Ponds	60	1.5
Total Cost (in Crores)		**20.02**



7.4.3 DEMAND SIDE MANAGEMENT PLAN

Annual Extractable GW Resource	**MCM**	24.01
Total Extraction for all uses		15.02
Stage of GW Extraction	**%**	62.55
Saving by Sprinkler	**MCM**	2.86
Additional recharge created by AR		8.96
After intervention of AR Structure Net GW AvL.		32.97
After intervention of AR Structure & utilization of additional GW created.		5.38
After utilization of Annual Extractable GW Resource 2022		4.80
Extraction after sprinkler & additional area created for agriculture		22.34
Stage of GW Extraction W/O GW use for additional Area Irrigation	**%**	67.76

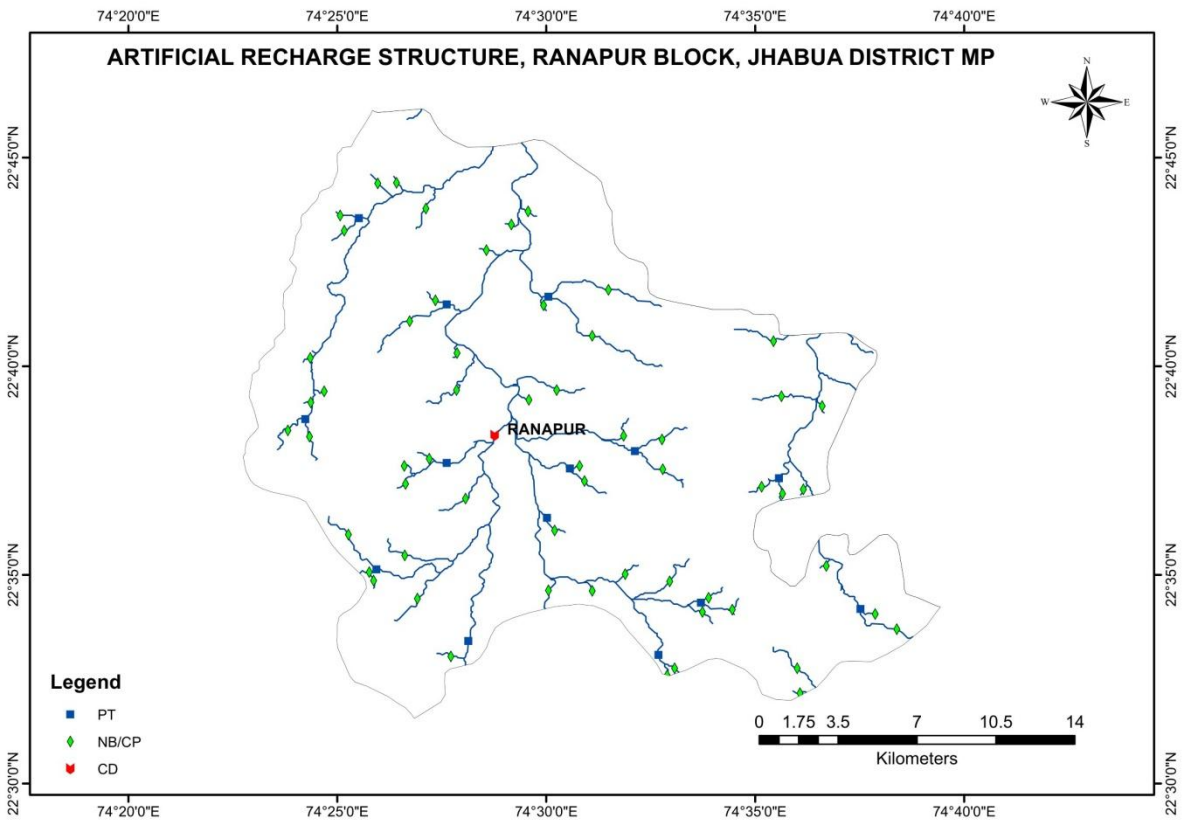
7.5 RANAPUR BLOCK

7.5.1 GROUND WATER RESOURCES

DYNAMIC GROUNDWATER RESOURCES 2022	Recharge worthy area	**Sq Km**	384
	Annual Extractable Groundwater Resource	**MCM**	16.60
	Total Ground Water Extraction		10.89
	Stage of Ground Water Extraction	**%**	65.57%
	Category		**Safe**

7.5.2 SUPPLY SIDE MANAGEMENT PLAN

Type of Structures	**Number**	**Cost (in Crores)**
Percolation Tanks	07	1.4
Check Dam	60	3.6
Recharge Check Dam Shaft in	60	0.6
Nala Bund/ Cement Plugs	60	0.6
Village Ponds/ Farm Ponds	20	0.5
Total Cost (in Crores)		**6.7**



7.5.3 DEMAND SIDE MANAGEMENT PLAN

Annual Extractable GW Resource	**MCM**	16.60
Total Extraction for all uses		10.89
Stage of GW Extraction	**%**	65.57
Saving by Sprinkler	**MCM**	2.01
Additional recharge created by AR		3.01
After intervention of AR Structure Net GW AvL.		19.61
After intervention of AR Structure & utilization of additional GW created.		1.81
After utilization of Annual Extractable GW Resource 2022		1.66
Extraction after sprinkler & additional area created for agriculture		12.35
Stage of GW Extraction W/O GW use for additional Area Irrigation	**%**	62.96

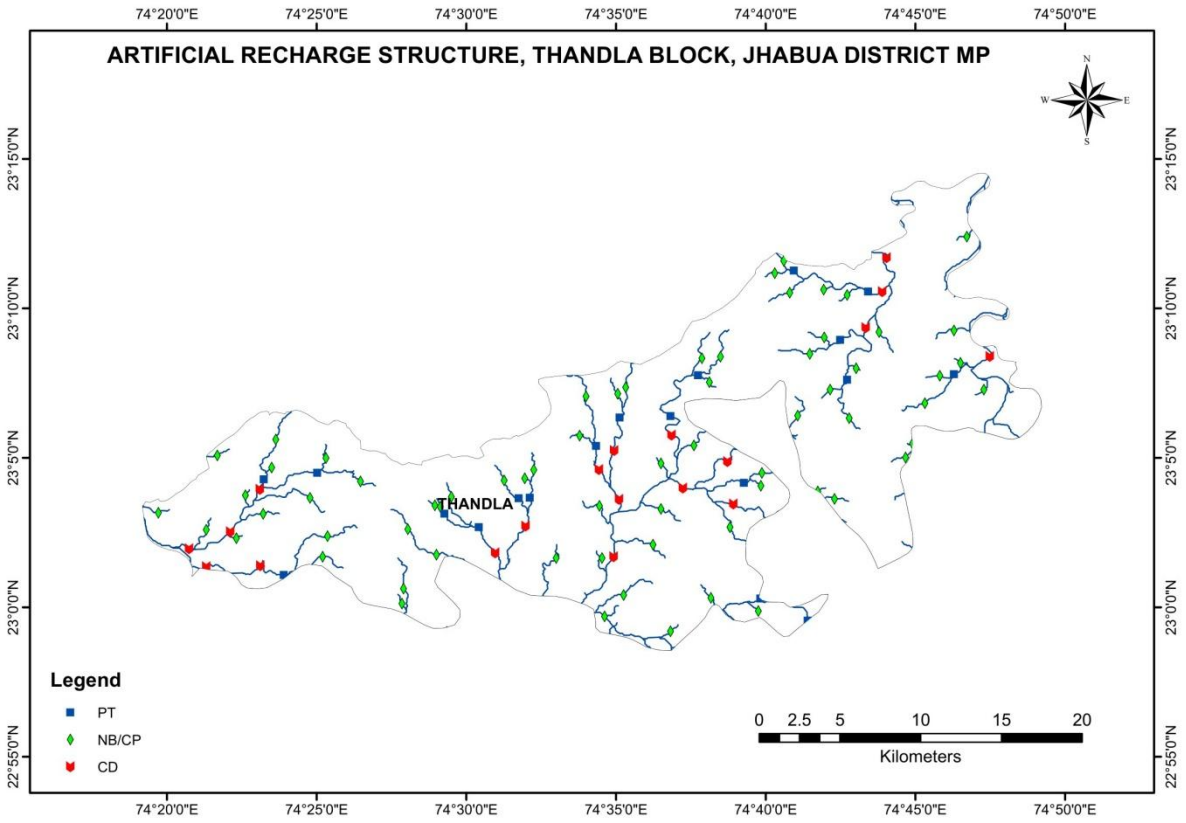
7.6 THANDLA BLOCK

7.6.1 GROUND WATER RESOURCES

DYNAMIC GROUNDWATER RESOURCES 2022	Recharge worthy area	**Sq Km**	488
	Annual Extractable Groundwater Resource	**MCM**	33.38
	Total Ground Water Extraction		18.19
	Stage of Ground Water Extraction	**%**	54.49%
	Category		**Safe**

7.6.2 SUPPLY SIDE MANAGEMENT PLAN

Type of Structures	**Number**	**Cost (in Crores)**
Percolation Tanks	10	02
Check Dam	89	5.34
Recharge Shaft in each Check Dam	89	0.89
Nala Bund/ Cement Plugs	89	0.89
Village Ponds/ Farm Ponds	30	0.75
Total Cost (in Crores)		**9.87**



7.6.3 DEMAND SIDE MANAGEMENT PLAN

Annual Extractable GW Resource	**MCM**	33.38
Total Extraction for all uses		18.19
Stage of GW Extraction	**%**	54.49
Saving by Sprinkler	**MCM**	3.37
Additional recharge created by AR		4.45
After intervention of AR Structure Net GW AvL.		37.83
After intervention of AR Structure & utilization of additional GW created.		2.67
After utilization of Annual Extractable GW Resource 2022		6.68
Extraction after sprinkler & additional area created for agriculture		24.17
Stage of GW Extraction W/O GW use for additional Area Irrigation	**%**	63.89

CHAPTER 8
CONCLUSIONS & RECOMMENDATIONS

8.1 CONCLUSIONS

The study was carried out based on the data available in-house as well as acquired from State Govt. departments and in pursuit to fill up the data gaps, generated data in-house; prepared GIS maps for various themes. All the available data was brought on GIS platform and an integrated approach was adopted for preparation of block wise aquifer maps and aquifer management plans of the district.

Jhabua district covering an area of about 3460 sq. km. is occupied by Deccan traps, Lameta& Archaean formations.

The overall stage of ground water extraction of the district is 46.31% and Jhabua block falls under semi-critical category. The remaining blocks are under safe category as per GWRE 2022.

The area has witnessed declining water level, low yield potential of aquifers and Low development of GW resources are the major issues in the district. These declines may be due to less rainfall or exploitation of ground water resources due to domestic/ irrigation uses.

8.2 RECOMMENDATIONS

The management plan proposed to manage the ground water resources and to arrest further decline in water levels which comprises two components namely supply-side management and demand side management.

As a part of Supply side Management, implementation of ground water abstraction structures as dug wells, bore wells etc. and recharge & conservation structures as Check dam, Percolation tank, Nala bund etc. can be proposed to overcome the groundwater availability related issues.

As a part of Demand side Management, micro-irrigation techniques can be adopted in water intense cropping like rice & wheat areas. Change in cropping patterns is also proposed in all of the blocks.

The ground water management plan proposed for the safe blocks as Meghnagar, Petlawad, Rama, Ranapur and Thandla with less SGWE in view of the developing additional ground water resources available after supply side interventions to bring the stage of ground water development up to 60% but not beyond that. In order to do so, number of bore wells & dug wells can be constructed to use the available resources.

IEC activities and capacity building activities needs to be aggressively propagated to establish the institutional framework for participatory ground water management. These types of programs have helped the general public to understand the problems that they will face in future if the ground water is continued to be exploited in unplanned way.

These interventions also need to be supported by regulations for deeper aquifer and hence it is recommended to regulate/ban deeper tube wells/bore wells of more than 60 m depth in these blocks, so that the deeper ground water resources are protected for future generation and also serve as ground water sanctuary in times of distress/drought.

ANNEXURE-I

Depth to Water Level of Key Wells established during NAQUIM in Jhabua District, M.P.

S.No	District	Block	Locations	Latitude	Longitude	WL (Pre)	WL (Post)
1	Jhabua	Jhabua	Mod	22.7970	74.5269	4.82	3.80
2	Jhabua	Meghnagar	Torniya	23.0015	74.3800	6.51	3.90
3	Jhabua	Meghnagar	Kaliya Viram	22.9555	74.5012	21	15.24
4	Jhabua	Thandla	Marjhari	23.0385	74.4730	122	70.00
5	Jhabua	Thandla	Kaldela	23.0977	74.5759	Dry	7.50
6	Jhabua	Thandla	Bhamal	23.1509	74.6962	4.11	3.70
7	Jhabua	Meghnagar	Panchpipaliya	23.0331	74.6689	12.80	13.00
8	Jhabua	Petlawad	Ramgarh	23.0662	74.8324	12.85	12.70
9	Jhabua	Petlawad	Moibagheli	22.9562	74.7325	7.30	5.40
10	Jhabua	Meghnagar	Hatyadeli	22.9392	74.6344	125	18.00
11	Jhabua	Ranapur	Nad	22.7217	74.4747	10.22	5.80
12	Jhabua	Ranapur	Dhaknitalai	22.6436	74.4700	9.67	7.60
13	Jhabua	Ranapur	Tikadi Bodiya	22.6773	74.5689	4.12	3.20
14	Jhabua	Rama	Jhoomka	22.6357	74.7015	5.91	5.40
15	Jhabua	Rama	Bochaka	22.7255	74.7230	10.21	4.00
16	Jhabua	Rama	Machhaliya	22.7480	74.7551	6.25	4.30
17	Jhabua	Rama	Wagnera	22.7999	74.6839	8.91	3.15
18	Jhabua	Rama	Rasoli	22.8619	74.7803	13.25	10.00
19	Jhabua	Petlawad	Ambapada	22.9060	74.9034	7.65	7.50
20	Jhabua	Petlawad	Dhaturiya	22.8654	74.9182	5.45	10.00
21	Jhabua	Jhabua	Footiya	22.8177	74.6188	11.21	2.40
22	Jhabua	Jhabua	Kotda	22.7786	74.5213	7.38	5.30
23	Jhabua	Rama	Chhapari	22.7774	74.6797	6.76	5.10

ANNEXURE-II

Depth to Water level of NHS Monitoring Wells in Jhabua District, M.P.

S.No	District	Block	Locations	Latitude	Longitude	WL (Pre)	WL (Post)
1	Jhabua	Petlawad	Bamania	23.08861	74.76139	7.24	6.10
2	Jhabua	Petlawad	Bamania (D)	23.095	74.76444	31.62	24.10
3	Jhabua	Jhabua	Jhabua (S)	22.7625	74.58806	6.42	2.80
4	Jhabua	Jhabua	Jhabua1	22.77111	74.59	14.42	2.50
5	Jhabua	Petlawad	Karwar	23.10111	74.87028	9.85	8.10
6	Jhabua	Meghnagar	Meghnagar New	22.905	74.54222	9.75	2.20
7	Jhabua	Petlawad	Petlawad	23.00528	74.79889	4.55	1.25
8	Jhabua	Petlawad	Petlawad (S)	23.00361	74.79889	5.21	1.30
9	Jhabua	Petlawad	Petlawad (D)	23.00361	74.79889	7.9	1.95
10	Jhabua	Jhabua	Pitol	22.785	74.46556	5.58	4.70
11	Jhabua	Ranapur	Ranapur	22.63944	74.5225	3.85	3.50
12	Jhabua	Petlawad	Sarangi	23.05167	74.90833	3.95	2.95
13	Jhabua	Thandla	Thandla1	23.00806	74.57889	5.7	3.80
14	Jhabua	Ranapur	Tikadimoti	22.69444	74.54222	6.87	3.65

ANNEXURE-III

Details of Exploratory Wells drilled in Jhabua District, M.P.

S.No	District	Block	Locations	Latitude	Longitude	Drilling Depth
1	Jhabua	Petlawad	Karwar	23.1056	74.8794	134.18
2	Jhabua	Petlawad	Petlawad	23.0000	74.8000	134.29
3	Jhabua	Petlawad	Bolasa	22.8666	74.8833	106.82
4	Jhabua	Petlawad	Bamania (PZ)	23.09861	74.7650	89.40
5	Jhabua	Rama	Padal	22.9083	74.7333	157.09
6	Jhabua	Rama	Kalidevi	22.7666	74.7000	126.69
7	Jhabua	Rama	Bhamar Piplia	22.7619	74.7704	73.52
8	Jhabua	Rama	Machhaliya	22.7500	74.7500	88.69
9	Jhabua	Rama	Para	22.6444	74.6599	81.01
10	Jhabua	Thandla	Thandla	23.0166	74.5833	96.21
11	Jhabua	Thandla	Nawagaon	22.9666	74.6000	76.52
12	Jhabua	Ranapur	Talawad	22.5365	74.5141	63.09
13	Jhabua	Ranapur	Jambukheda	22.56444	74.51639	119.3
14	Jhabua	Jhabua	Anterveliya	22.87083	74.54667	61.40
15	Jhabua	Jhabua	Talawali	22.8224	74.6488	68.75
16	Jhabua	Jhabua	Pipliya	22.8500	74.5666	106.87
17	Jhabua	Jhabua	Jhabua (PZ)	22.76252	74.58806	60.80
18	Jhabua	Meghnagar	Hatyadeli	22.9333	74.6166	88.59
19	Jhabua	Meghnagar	Khedi	22.9166	74.6000	73.43
20	Jhabua	Meghnagar	Agral	22.9333	74.5666	61.37
21	Jhabua	Meghnagar	Gadauli	22.9166	74.5000	73.47
22	Jhabua	Meghnagar	Kihanpuri	22.9209	74.5185	76.54
23	Jhabua	Meghnagar	Kacchar Todi	22.9195	74.533	84.07
24	Jhabua	Meghnagar	Nayagaon Jagir	22.8955	74.5082	91.72
25	Jhabua	Meghnagar	Madrani	23.0000	74.4500	61.32
26	Jhabua	Meghnagar	Navapada Pal	22.9673	74.4145	76.52
27	Jhabua	Meghnagar	Navapada Dhana	22.9500	74.4166	84.12
28	Jhabua	Meghnagar	Sajeli	22.9666	74.5666	68.82

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