



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

**DINDORI DISTRICT
MADHYA PRADESH**

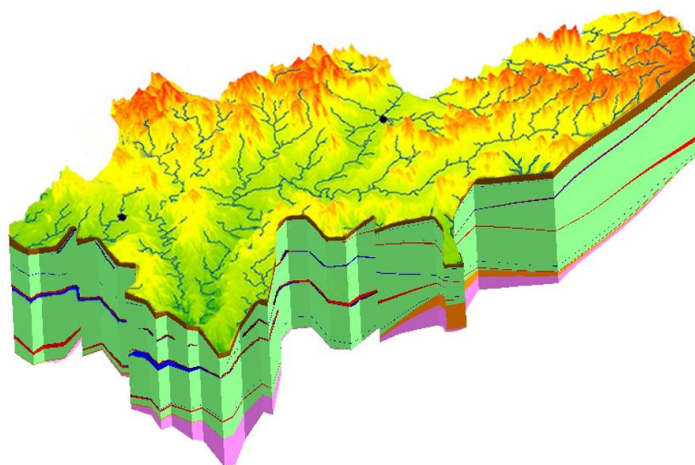
उत्तर मध्य क्षेत्र, भोपाल
North Central Region, Bhopal



भारत सरकार
GOVERNMENT OF INDIA
केन्द्रीय भूमि जल बोर्ड
CENTRAL GROUND WATER BOARD
जल शक्ति मंत्रालय
MINISTRY OF JAL SHAKTI

जलभृत मानचित्रण और भूजल प्रबंधन योजना
डिंडोरी जिला, मध्य प्रदेश

AQUIFER MAPPING AND GROUND WATER MANAGEMENT
PLAN OF DINDORI DISTRICT, MADHYA PRADESH



वार्षिक कार्य योजना: 2021-22
Annual Action Plan: 2021-22

चित्तरंजन बिश्वाल, वैज्ञानिक-बी
राहुल वी.जे., एसटीए (एचजी)

Chittaranjan Biswal, Scientist-B
Rahul V.J. STA (HG)

उत्तर मध्य क्षेत्र /NOTRH CENTRAL REGION
भोपाल /BHOPAL

सितंबर, 2022
SEPTEMBER 2022



भारत सरकार
GOVERNMENT OF INDIA
केन्द्रीय भूमि जल बोर्ड
CENTRAL GROUND WATER BOARD
जल शक्ति मंत्रालय
MINISTRY OF JAL SHAKTI



जलभृत मानचित्रण और भूजल प्रबंधन योजना
डिंडोरी जिला, मध्य प्रदेश

AQUIFER MAPPING AND GROUND WATER MANAGEMENT
PLAN OF DINDORI DISTRICT, MADHYA PRADESH

वार्षिक कार्य योजना: 2021-22
Annual Action Plan: 2021-22

चित्तरंजन बिश्वाल, वैज्ञानिक-बी
राहुल वी.जे., एसटीए (एचजी)

Chittaranjan Biswal, Scientist-B
Rahul V.J. STA (HG)

उत्तर मध्य क्षेत्र /NOTRH CENTRAL REGION
भोपाल /BHOPAL

सितंबर, 2022
SEPTEMBER, 2022

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 Dindori district to prepare the Aquifer Maps for the entire district and formulate Aquifer Management Plan. Dindori district occupies an area of 5725 sq. km out of which the ground water recharge worthy area is 4560 sq. km. and the rest is covered by hilly area. The district is mainly occupied by Laterite, Deccan trap and Banded Gneissic Complex (BGC). As per the Dynamic Ground Water Resource Assessment Report (2022), the annual Ground Water Extractable Resource in the district is 326 mcm and the total ground water extraction for all uses is 41 mcm, resulting the stage of ground water extraction to be 12.68% as a whole for district. The management plan 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 Chittaranjan Biswal, Scientist-B, Shri Rahul VJ, STA (HG) and Shri Kamlesh Birla, Young Professional** 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 Dindori District, Madhya Pradesh.



Rana Chatterjee
(Regional Director)

C O N T E N T S

<i>CHAPTER</i>	<i>TITLES</i>	<i>PAGE</i>
CHAPTER-1	INTRODUCTION	1-11
1.1	Objectives and Scope of Study	1
1.2	Study Area	2
1.3	Climate and Rainfall	3
1.4	Geomorphology	3
1.5	Physiography	3
1.6	Drainage	6
1.7	Land Use, Agriculture, Irrigation and Cropping Pattern	6
1.8	Geology	9
1.9	Soil Types	10
CHAPTER-2	DATA COLLECTION AND GENERATION	12-14
2.1	Data Collection and Compilation	12
CHAPTER-3	DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING	15-29
3.1	Hydrogeology	15
3.2	Ground Water Exploration	16
3.3	Ground Water Level Scenario	18
3.4	Hydro chemical Studies	23
3.5	3-D and 2-D Aquifer Disposition	28
CHAPTER-4	GROUND WATER RESOURCES	30-32
4.1	Dynamic Ground Water Resource	30
CHAPTER-5	GROUND WATER RELATED ISSUES	33-33
5.1	Limited Aquifer Thickness	33
5.2	Low Ground Water Potential / Sustainability	33
CHAPTER-6	PROPOSED MANAGEMENT STRATEGY	34-38
6.1	Micro Irrigation Technologies	34
6.2	Proper well Design in Basaltic Formation	34
6.3	Artificial Recharge Structure	35
CHAPTER-7	CONCLUSION AND RECOMMENDATION	39-40

FIGURES

1.1	Location Map of Dindori District	2
1.2	Geomorphological Map of Dindori District	4
1.3	Geomorphology Landform Pie Chart	4
1.4	Digital Elevation Map of Dindori District	5
1.5	Drainage Map of Dindori District	5
1.6	Land Use and Land Cover Pie Chart	6
1.7	Land Use and Land Cover Map of Dindori District	6
1.8	Irrigated and Un irrigated area in Kharif Season	8
1.9	Irrigated and Un irrigated area in Rabi Season	8
1.10	Season wise Cropping pattern	9
1.11	Geological Map of Dindori District	10
1.12	Soil Map of Dindori District	11
3.1	Hydrogeological map of Dindori District	16
3.2	Exploratory well Locations in Dindori District	17
3.3	Ground water Monitoring well locations	17
3.4	Pre-monsoon (May 20021) Depth to Water Level of Shallow Aquifer	19
3.5	Post-monsoon (Nov 2021) Depth to Water Level of Shallow Aquifer	19
3.6	Seasonal Fluctuation of Water Level, Shallow Aquifer	20
3.7	Pre-monsoon Water Level Trend (May 2012-21) of Shallow Aquifer	22
3.8	Post-monsoon Water Level Trend (Nov 2012-21) of Shallow Aquifer	22
3.9	Electrical Conductivity in Shallow aquifer	24
3.10	Distribution of Fluoride Concentration in Shallow aquifer	25
3.11	Distribution of Nitrate Concentration in Shallow aquifer	25
3.12	Hill Piper Diagram representing classification of water samples, Shallow Aquifer	26
3.13	US Salinity Diagram, Shallow Aquifer	27
3.14	3D Representation of Aquifers, Dindori District	29
4.1	Ground Water Recharge Scenario	30
4.2	Ground Water Extraction Scenario	31
6.1	Typical well Construction design in Basaltic formation	35
6.2	Planning and Selection of site for Farm Pond	37
6.3	Deferent Type of farm Pond.	38

TABLES

1.1	Annual Rainfall of Dindori District of last 6 years	3
1.2	Irrigated and Un irrigated area in Kharif Season	7
1.3	Irrigated and Un irrigated area in Rabi Season	8
1.4	Season wise Cropping Pattern	9
1.5	Sequence of Geological Formation	10
2.1	Brief Activities Showing Data compilation and Generations	16
3.1	Aquifer Parameter Details of EW and OW	20
3.2	Analysis of Water Level Fluctuation Shallow Aquifer	20
3.3	Ranges of chemical constituents in Shallow aquifer	23

3.4	Ranges of Indices and Suitability of Ground Water for irrigation, Shallow Aquifer	28
4.1	Ground Water Recharge, Dindori District	31
4.2	Ground Water Resources, Dindori District	31
4.3	Ground Water Extraction, Dindori District	32

A N N E X U R E

I	Ground Water Exploration Lithologs	41
II	Ground Water level Scenario of Shallow Aquifer	46
III	Chemical Quality Data of Shallow Aquifer	48
IV	Ground Water Quality Calculation for Irrigation of Shallow Aquifer	49
V	Ground Water Quality Calculation for Industrial Use of Shallow Aquifer	50

A C K N O W L E D G E M E N T	51
--------------------------------------	-----------

A B B R E V I A T I O N	52
--------------------------------	-----------

R E F E R E N C E	53
--------------------------	-----------

CHAPTER 1

INTRODUCTION

Aquifer mapping is a multidisciplinary and a holistic scientific approach wherein a combination of geologic, geophysical, hydrologic and chemical analysis is applied to characterize the quantity, quality and sustainability of ground water in aquifers. In recent past, there has been a paradigm shift from “**Ground Water Development**” to “**Ground Water Management**”. As large parts of India particularly hard rocks have become water stressed due to rapid growth in demand for water due to population growth, irrigation, urbanization and changing life style. Therefore, in order to have an accurate and comprehensive micro-level picture of groundwater in India, aquifer mapping in different hydrogeological settings at the appropriate scale is devised and implemented, to enable robust groundwater management plans. This will help in achieving drinking water security, improved irrigation facility and sustainability in water resources development in large parts of rural and many parts of urban India. The aquifer mapping program is important for planning suitable adaptation strategies to meet climate change also. Thus the crux of National Aquifer Mapping (NAQUIM) is not merely mapping, but reaching the goal-that of ground water management through community participation.

1.1 OBJECTIVES AND SCOPE OF STUDY

In view of the above challenges, an integrated hydrogeological study was taken up to develop a reliable and comprehensive aquifer map and to suggest suitable Groundwater management plan on 1: 50,000 scale.

The main scope of study is summarized below.

1. Compilation of existing data (exploration, geophysical, groundwater level and groundwater quality with geo-referencing information and identification of principal aquifer units.
2. Periodic long term monitoring of ground water regime (for water levels and water quality) for creation of time series data base and ground water resource estimation.
3. Quantification of groundwater availability and assessing its quality.
4. To delineate aquifer in 3-D along with their characterization on 1:50,000 scale.
5. Capacity building in all aspects of ground water development and management through information, education and communication (IEC) activities, information dissemination, education, awareness and training.

6. Enhancement of coordination with concerned central/state govt. organizations and academic/research institutions for sustainable ground water management.

1.2 STUDY AREA

Dindori district being spread over an area of 5725 sq.km is lies between north latitude 22°17′-23°22′ and east longitude 80°35′-81°58′, located in the eastern part of Madhya Pradesh bordering Chhattisgarh. It is surrounded by Anuppur district in the east, Mandla in the west, Umaria in the north, and Bilaspur district of the state of Chhattisgarh in the south. The Location Map is prepared and presented in the **Fig.1.1**. It is divided into seven blocks namely Dindori, Shahpura, Mehadwani, Amarpur, Bajag, Karanjiya and Samnapur. According to the 2011 census, Dindori District has a population of 7,04,524, out of which 95% is rural population. In the district there are 3, 51,913 males and 3, 52,611 females respectively.

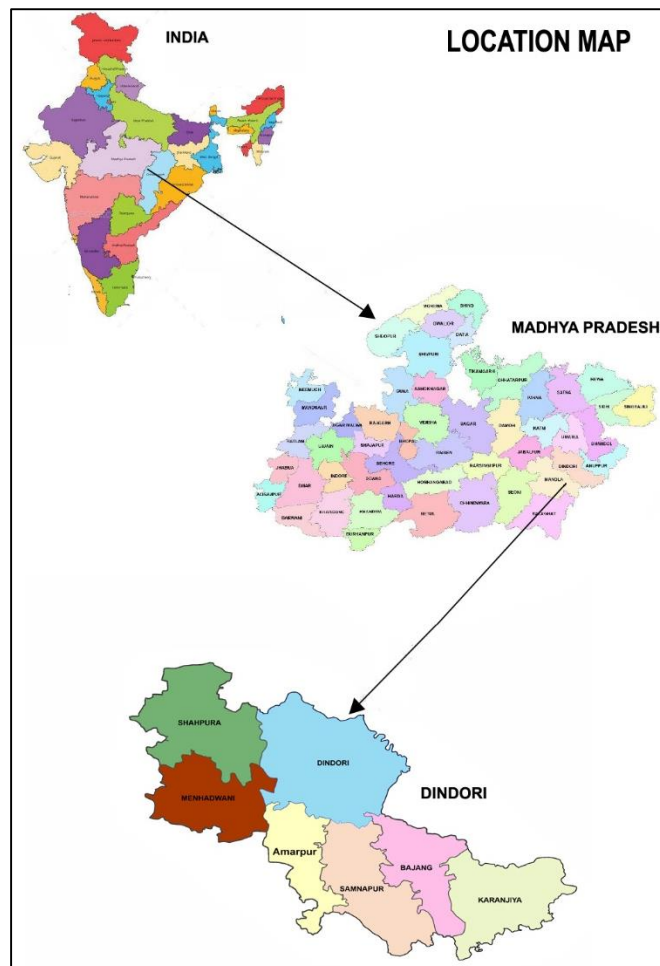


Fig.1.1: Location Map of Dindori District

1.3 CLIMATE AND RAINFALL

Climate of the district is tropical with moderate winter and severe summers and well distributed rainfall received from southwest monsoon. However due to higher general elevation and abundance of forests, summer temperature does not rise as much as in other areas.

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 normal annual rainfall of Dindori district is 1302 mm. About 90% of annual rainfall is received during monsoon season. Only 10 % of annual rainfall takes place during non-monsoon season. The monsoon, non-monsoon and annual rainfall data of last 5 years is shown in the **Table-1.1**.

Table. 1.1: Annual rainfall of Dindori District of last 5 years (Source: IMD)

YEAR	Monsoon Rainfall (mm)	Non-monsoon Rainfall (mm)	Annual Rainfall (mm)
2017	847.2	67.6	914.8
2018	1028.4	31.4	1059.8
2019	1453.4	156.7	1610.1
2020	1283.9	372.6	1656.5
2021	1088.5	187.6	1276.1

1.4 GEOMORPHOLOGY

Most part of the district is occupied by plateau occurring in nearly 60% area of the district. The pediment pediplain complex covering 36% of the area. The Hills and valleys are present mostly in the northern part of the district, occupied very small part of the district around 3% area of the district. plateau is the major landform covering about 3354 km² (60%) area. The other major landform observed is pediment pediplain complex covering about 1971 km² (36%). The Geomorphological map is presented in the **Fig.1.2** and Geomorphic landform pie chart is shown in the **Fig.1.3**.

1.5 PHYSIOGRAPHY

The elevation of the district is varying from 460 to 1120 meters above Mean Sea Level. The highest elevation observed in the southern side in Karanjiya and Bajang block and in Northern side in Dindori block. The elevation is gradually decreases towards the western side in Menhadwani block

and towards northern side in Shahpura block. The Digital Elevation Model Map of Dindori district is prepared and presented in the **Fig.1.4**.

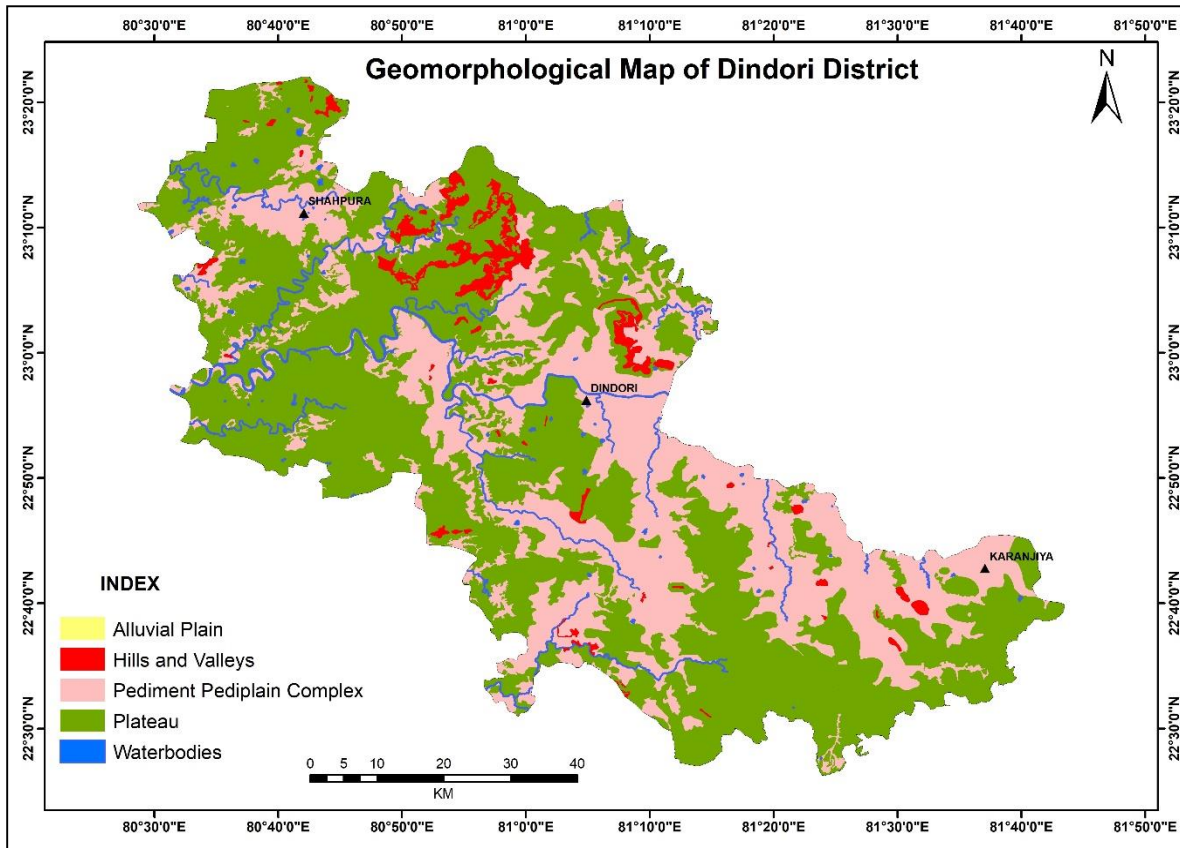


Fig.1.2: Geomorphology map of Dindori district (Source: Bhukosh - GSI)

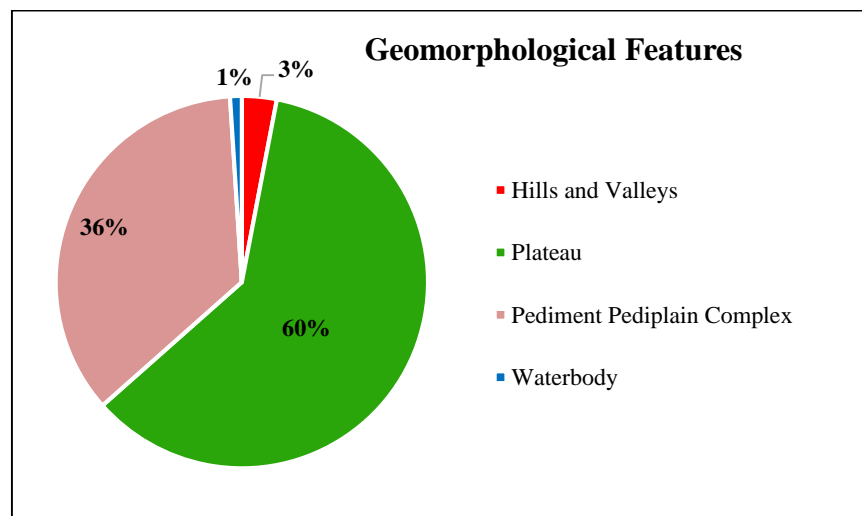


Fig.1.3: Geomorphology landform Pie chart

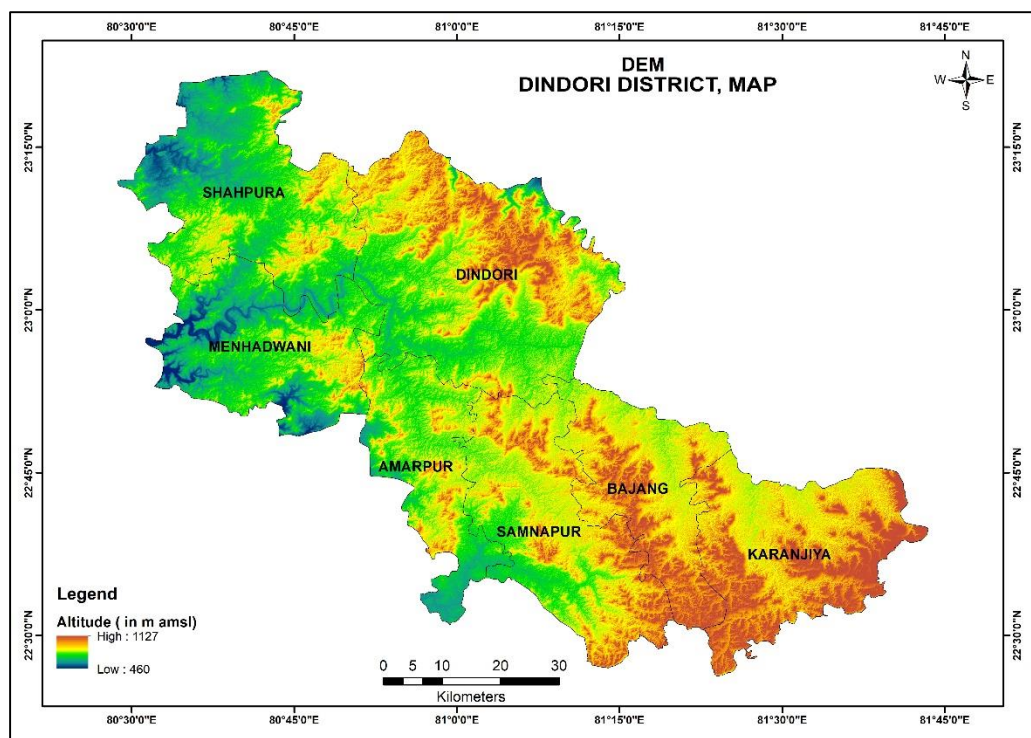


Fig.1.4: Digital Elevation map of Dindori district

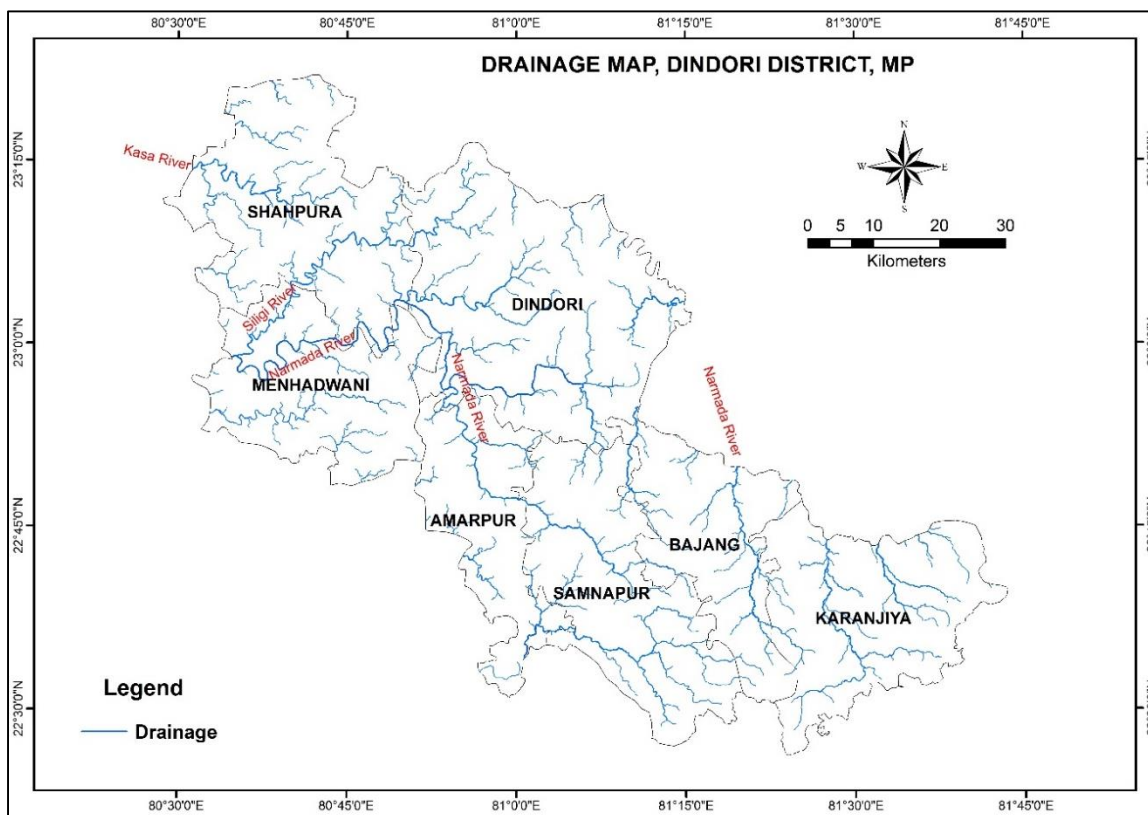


Fig.1.5: Drainage Map of Dindori district

1.6 DRAINAGE

Dindori district falls under Narmada river basin. The district is mainly drained by river Narmada and its tributaries. Major tributaries are Kasah, Siligi, Johila, Kharmer, Carker, Seoni, Turar rivers. The Drainage map is shown in the **Fig.1.5**.

1.7 LAND USE, AGRICULTURE, IRRIGATION AND CROPPING PATTERN

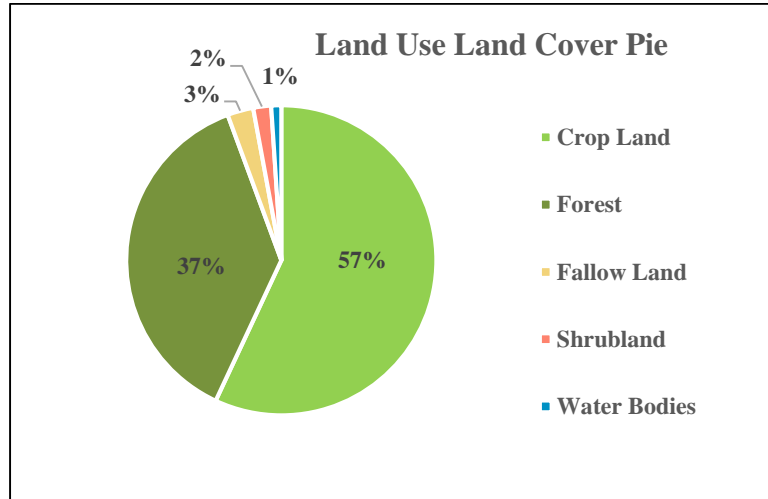


Fig.1.6: Land use Land Cover Pie

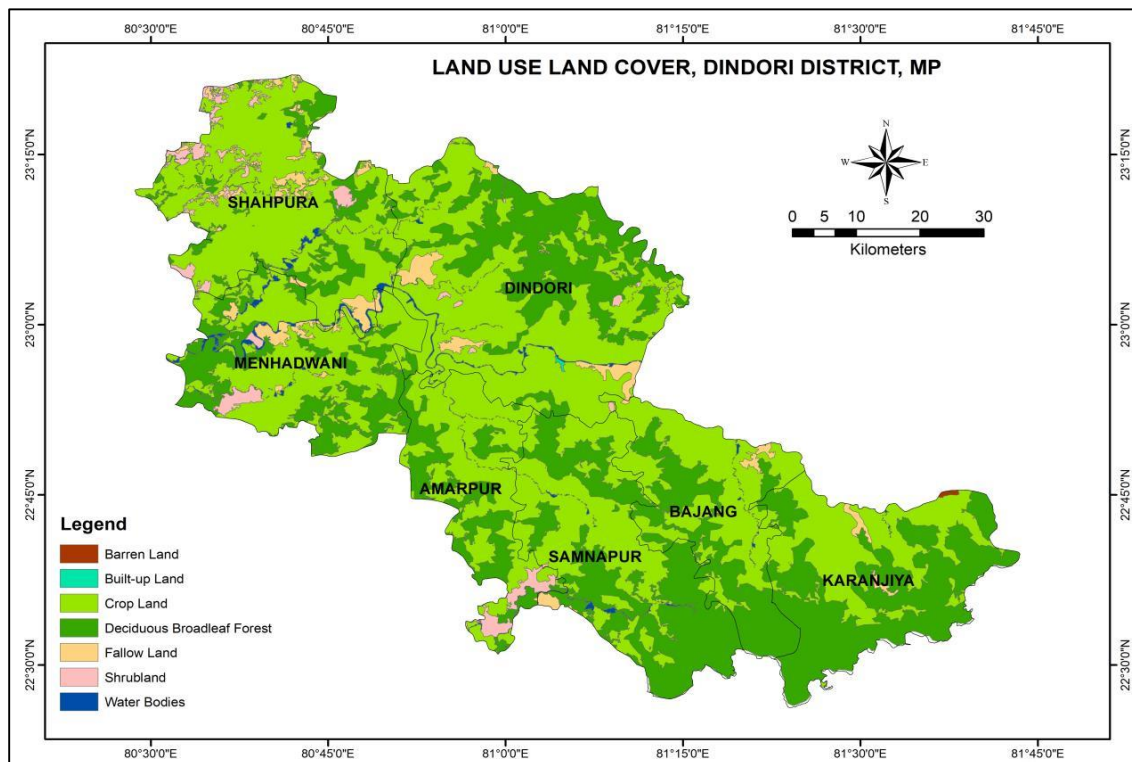


Fig.1.7: Land use land cover Map

Agriculture and forest are the prominent land use aspects in Dindori district. Crop land forms 57% and forest area form 37 % of total area followed by Fallow land (3%), Shrub land and water bodies. The land use land cover types are prepared in a pie diagram and shown in the **Fig.1.6**. The spatial distribution of land use is presented in **Fig. 1.7** (as per Land Use Land cover data, NASA, USA).

The much sources of irrigation are Tube well, Dugwells and Ponds. The irrigated area under Tube wells, dug wells, and Ponds, mainly depended on rains. Net sown area of the district during kharif season is 205524 hectare, out of which 21990 hectare is irrigated and 183536 hectare area is unirrigated. The Block wise details during kharif season is shown in the **Table.1.2** and **Fig.1.8**. During Rabi season total sown area of the district is 137300 hectare, out of which 12900 hectare is irrigated and 124400 hectare area is unirrigated. The Block wise details during kharif season is shown in the **Table.1.3** and **Fig.1.10**

Table.1.2: Block wise irrigated and Un-irrigated area in Kharif Season (Source: DIP, PMKSY)

S.N.	Block	Total Sown Area (Ha)	Irrigated Area (Ha)		Unirrigated Area (Ha)	
			Area	%	Area	%
1	Dindori	42245	2978	7.05	39267	92.95
2	Amarpur	24036	3280	13.65	20756	86.35
3	Samnapur	23209	3450	14.87	19759	85.13
4	Bajag	24275	3300	13.6	20975	86.4
5	Karanjiya	26841	3210	11.96	23631	88.04
6	Sahpura	28180	2972	10.55	25208	89.45
7	Mehadwani	36738	2800	7.67	33940	92.33
	District	205524	21990	10.7	183536	89.3

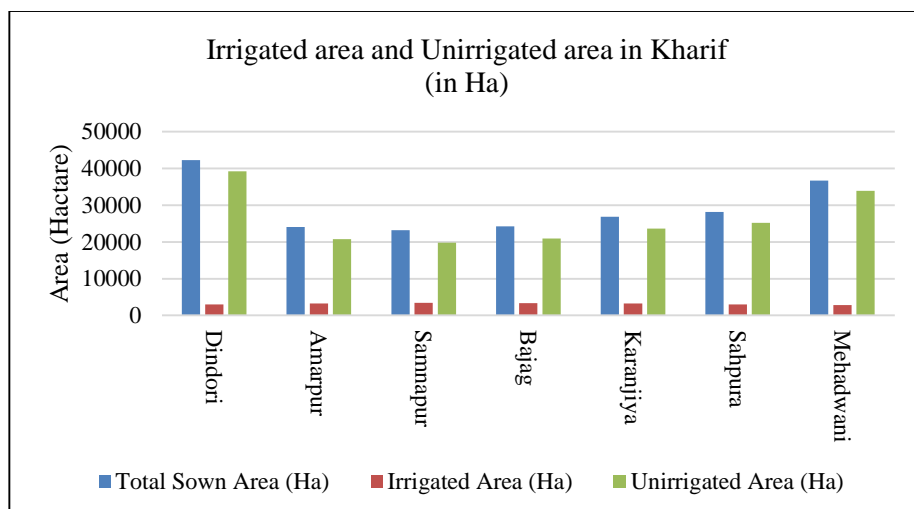


Fig.1.8: Irrigated area and Un-irrigated area in Kharif season

Table.1.3: Block wise irrigated and Un-irrigated area in Rabi Season (Source: DIP, PMKSY)

S.N.	Block	Total Sown Area (Ha)	Irrigated Area (Ha)		Unirrigated Area (Ha)	
			Area	%	Area	%
1	Dindori	23120	2000	8.6	21120	91.4
2	Amarpur	15700	2300	14.65	13400	85.35
3	Samnapur	16000	2200	13.75	13800	86.25
4	Bajag	19810	1600	8.03	18210	91.92
5	Karanjiya	25740	1500	5.82	24240	94.18
6	Sahpura	21080	2300	10.91	18780	89.08
7	Mahedwani	15850	1000	6.3	14850	93.7
	District	137300	12900	9.4	124400	90.6

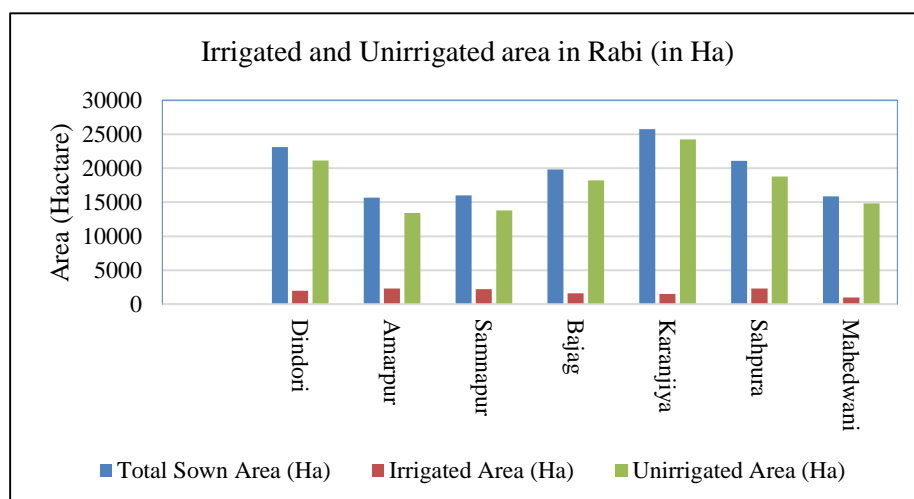


Fig.1.9: Irrigated area and Un-irrigated area in Rabi season

The main crops grown in Dindori District are Cereals 113189 ha (56%), followed by Coarse Cereals 35048 ha (17%), Oil seeds 34510 ha (17%), Pulses 17563 ha (9%) during Kharif season and Pulses 56800 ha (40%), Cereals 42000 ha (30%), Oil seeds 38500 ha (27%) and other crops 3400 ha (3%) during Rabi season respectively. During summer season only Pulses grown in 618 ha. Season wise cropping pattern is given in **Table.1.4** and **Fig.1.10**.

Table.1.4: Season wise Cropping Pattern (Source: DIP, PMKSY)

Crop	Kharif (ha)	Rabi (ha)	Summer crop (ha)	Total (ha)
Cereals	113189	42000	0	155189
Coarse Cereals	35048	0	0	35048
Pulses	17563	56800	618	74981
Oil Seeds	34510	38500	0	72952
Fibre	0	0	0	0
Any other crops	2200	3400	700	6300
Total	202510	140700	1318	344470

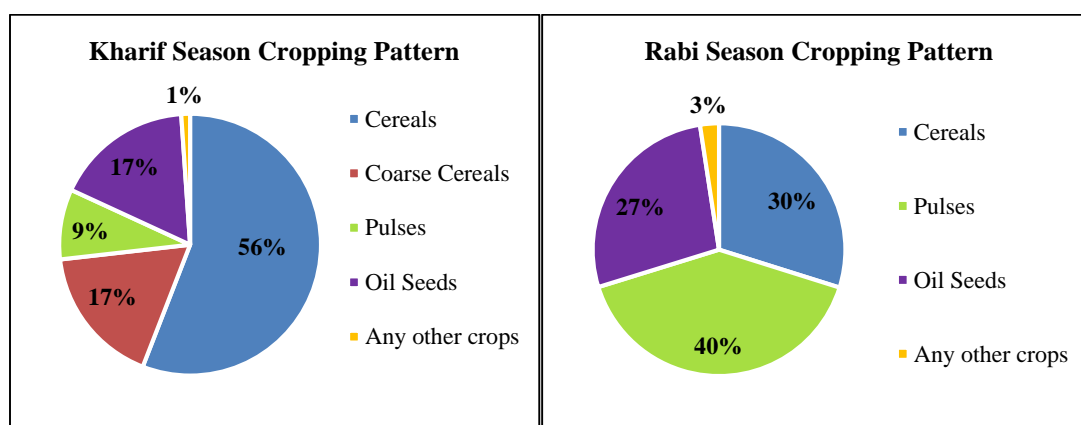


Fig.1.10: Cropping Pattern

1.8 GEOLOGY

The study area exposes the rocks of Laterite, Deccan trap and Banded Gneissic Complex (BGC). The sequence of rock formation is shown in the **Table. 1.5** and the Geological Map is Shown in the **Fig.1.11**. The whole district covered with Deccan trap basalt, the Banded Gneissic Complex exposed in a very small part in the southern tip of Amarpur block. The laterites are occur as a cap rock above the deccan trap basalt and are scattered throughout the district.

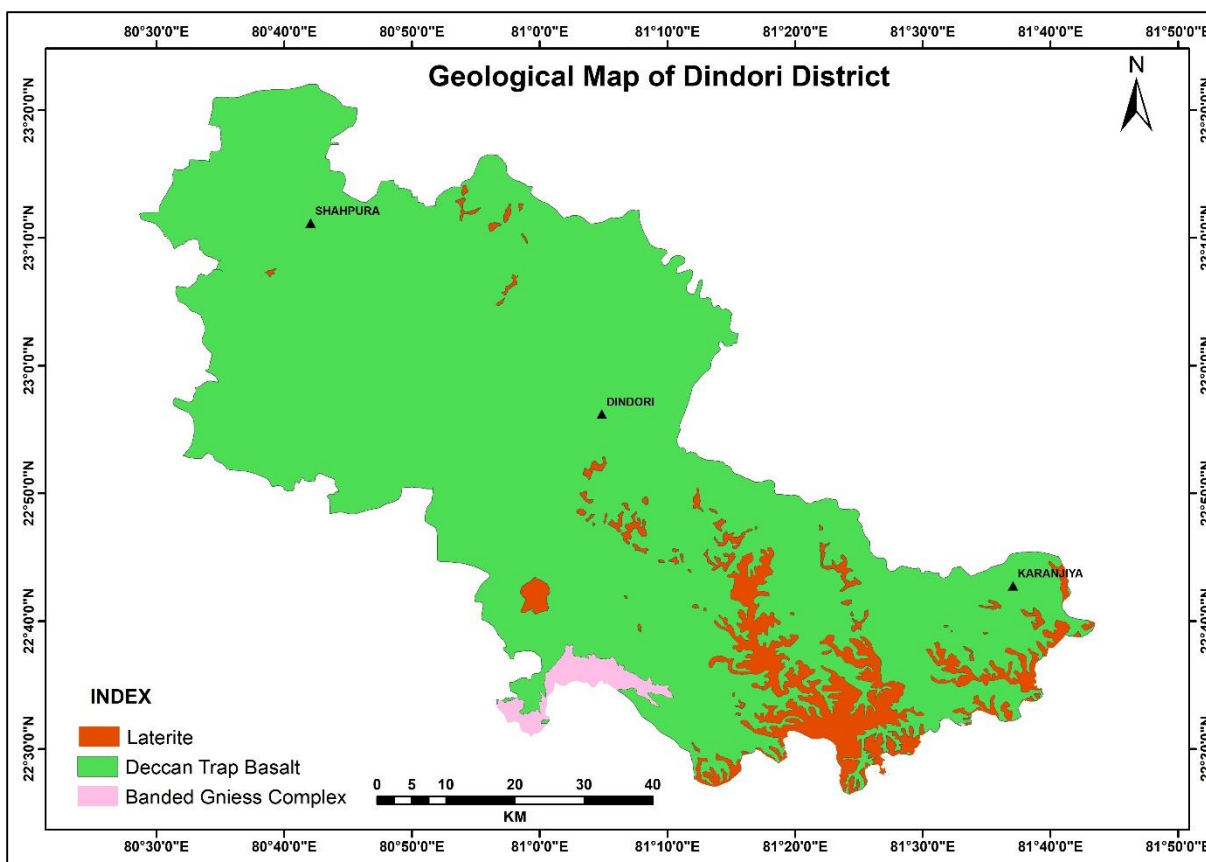


Fig.1.11: Geological Map of Dindori district

Table.1.5: Sequence of Geological Formation

Age	Formation	Litho- characteristic
Pleistocene	Laterite	Compact, ferruginous and weathered product of Deccan trap
Cretaceous to Eocene	Deccan trap	Basaltic lava flows
Unconformity		
Precambrian	Banded Gneissic Complex	Granite and Gneiss

1.9 SOIL TYPES

In the district mostly two types of soil are present namely, Clayey and loamy soil. The Loamy soil further divided in to loamy skeletal soil. The the distribution of soil in the district is shown in the Fig.1.12.

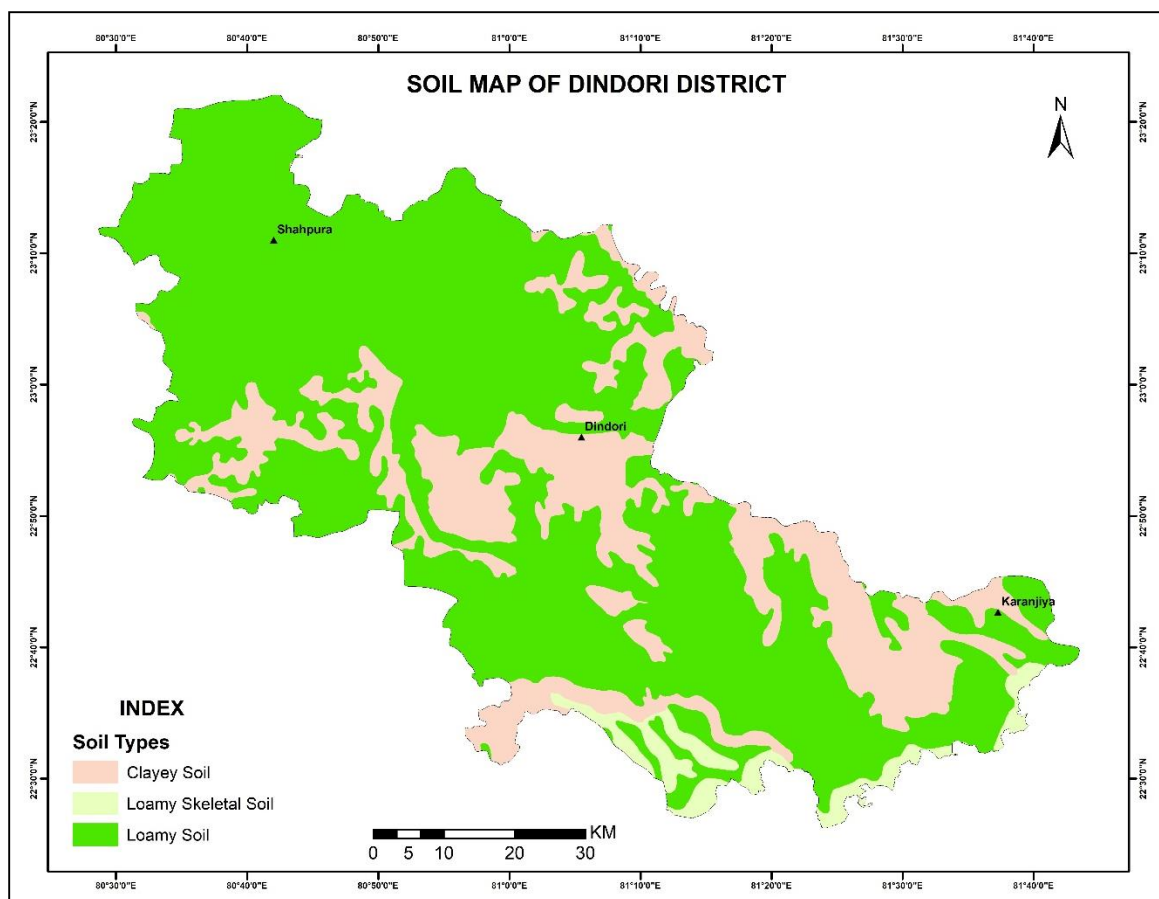


Fig.1.12: Soil map of Dindori district

CHAPTER 2

DATA COLLECTION AND GENERATION

2.1 DATA COLLECTION AND COMPILATION

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 14 Dug wells of Central Ground Water Board Viz. National Hydrograph Stations representing Shallow aquifer (Aquifer-I).
- The weathered zone thickness (Aquifer-I), lithological details of deeper aquifers (Aquifer-II) of 23 exploratory wells were also collected and compiled.

Hydro chemical Data:

- Ground water quality data of 14 monitoring wells of Central Ground Water Board representing shallow aquifer are collected and compiled.

Exploratory Drilling:

- Ground water exploration data of 23 exploratory wells drilled by Central Ground Water Board are collected and compiled.

Geological Data:

- Geological Data from Geological Survey of India.

Hydro meteorological Data:

- 5-years rainfall data for the whole district from Indian Meteorological Department and Water Resource Department, Govt of Madhya Pradesh are collected.

. Water Conservation Structures:

- Numbers, type of water conservation structures prevailing in the district from MGNREGA.

Statistical Data

- Demography data of Dindori district from Dept. of Statistics, Economics and Planning, M.P.
- Geomorphological Data from Geological Survey of India (bhukosh.gsi.gov.in).
- Data of prevailing land use pattern, Dindori district from NASA, USA.

- Data of prevailing cropping pattern, Irrigation details from District Irrigation Plan, Dindori district.
- Data of existing surface water irrigation structures from District Irrigation Plan, Dindori district.

Collection and compilation of data for aquifer mapping studies is carried out in conformity with Expenditure Finance Committee (EFC) document of XII plan of CGWB encompassing various data generation activities (**Table-2.1**).

Table.2.1: Brief activities showing data compilation and generations.

S. No.	Activity	Sub-activity	Task
1	Compilation of existing data/ Identification of Principal Aquifer Units and Data Gap	Compilation of Existing data on groundwater	Preparation of base map and various thematic layers, compilation of information on Hydrology, Geology, Geophysics, Hydrogeology, Geochemical etc. Creation of data base of Exploration Wells, delineation of Principal aquifers (vertical and lateral) and compilation of Aquifer wise water level and draft data etc.
		Identification of Data Gap	Data gap in thematic layers, sub-surface information and aquifer parameters, information on geology, geophysics, hydrogeology, geochemical, in aquifer delineation (vertical and lateral) and gap in aquifer wise water level and draft data etc.
2.	Generation of Data	Generation of geological layers (1:50,000)	Preparation of sub-surface geology, geomorphologic analysis, analysis of land use pattern.
		Preparation of Hydrogeological map (1:50, 000 scale)	Water level monitoring, exploratory drilling, pumping tests, preparation of sub-surface hydrogeological sections.
		Generation of additional water quality parameters	Analysis of groundwater for general parameters.
3.	Aquifer Map Preparation (1:50,000 scale)	Analysis of data and preparation of GIS layers and preparation of aquifer maps	Integration of Hydrogeological, Geological and Hydro-chemical data.

S. No.	Activity	Sub-activity	Task
4.	Aquifer Management Plan	Preparation of aquifer management plan	Information on aquifer through training to administrators, NGO's, progressive farmers and stakeholders etc. and putting in public domain.

CHAPTER 3

DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

3.1 HYDROGEOLOGY

Hydrogeology is concerned primarily with mode of occurrence, distribution, movement and chemistry of water occurring in the subsurface in relation to the geological environment. The occurrence and movement of water in the subsurface is broadly governed by geological frameworks i.e., nature of rock formations including their porosity (primary and secondary) and permeability. Main geological units of the district are Laterite, Deccan trap basalt and Banded Gneissic complex. The principal aquifers in the area are Basalt and Granite. The hydrogeological map of area is prepared and presented in **Fig.3.1**.

The water table elevation map was also prepared (**Fig.3.1**) to understand the ground water flow directions. The groundwater movement in the district is towards the Northern side in the northern part of district and in the central part towards the western side, which follows the drainage and topography of the area.

3.1.1 Deccan Trap Basalt

Almost the entire district is covered by Deccan trap Basalt. Ground water occurs in the weathered, jointed and fractured basalts under Unconfined and semi-confined to confined conditions. These form the most important aquifers in the region. The weathered, fractured, jointed and vesicular units of basalts form moderate to good aquifers. Discharge is upto 5 lps. Transmissivity is upto 250 m²/day and Specific Yield is up to 3%. The Deccan Traps formations can be tapped by dug well, dug-cum-bore and bore wells.

3.1.2 Archaeans

The Archaean rocks generally Granitoids are generally occur in a very small part in the western side in Samnapur block. Archaeans comprise granites and gneisses. They are hard and compact formations with low primary permeability, forming poor aquifers. Ground water occurs in these only in the weathered mantle and underlying fractured zone. Groundwater mostly occurs under unconfined to semi confined conditions. Transmissivity is found upto 100 m²/day., Discharge is up to 2 lps and Specific yield is up to 2%.

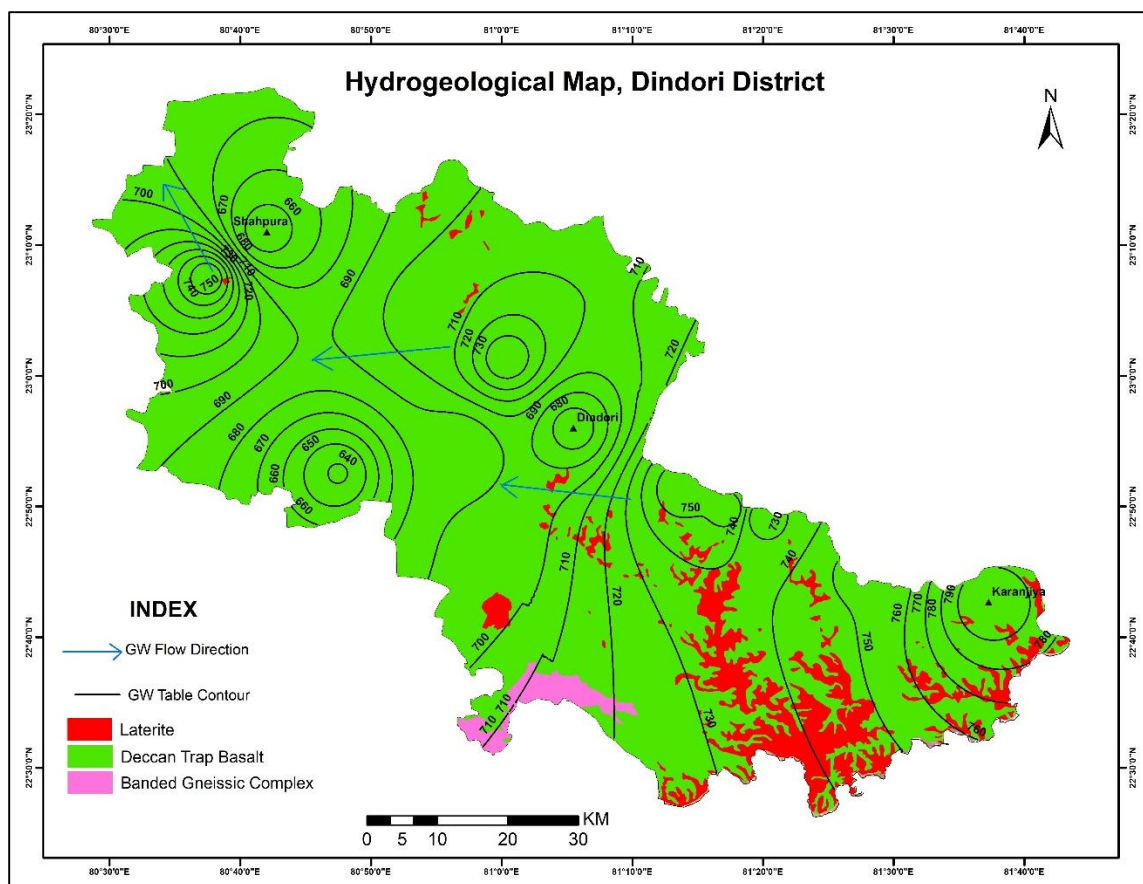


Fig. 3.1: Hydrogeology map of Dindori district

3.2 GROUNDWATER EXPLORATION

Central Ground Water Board drilled 23 exploratory wells to delineate the aquifers vertically as well as laterally and to determine the aquifer parameters. The wells were plotted the **Fig.3.2**. The lithology of the well are given in the **Annexure. I**.

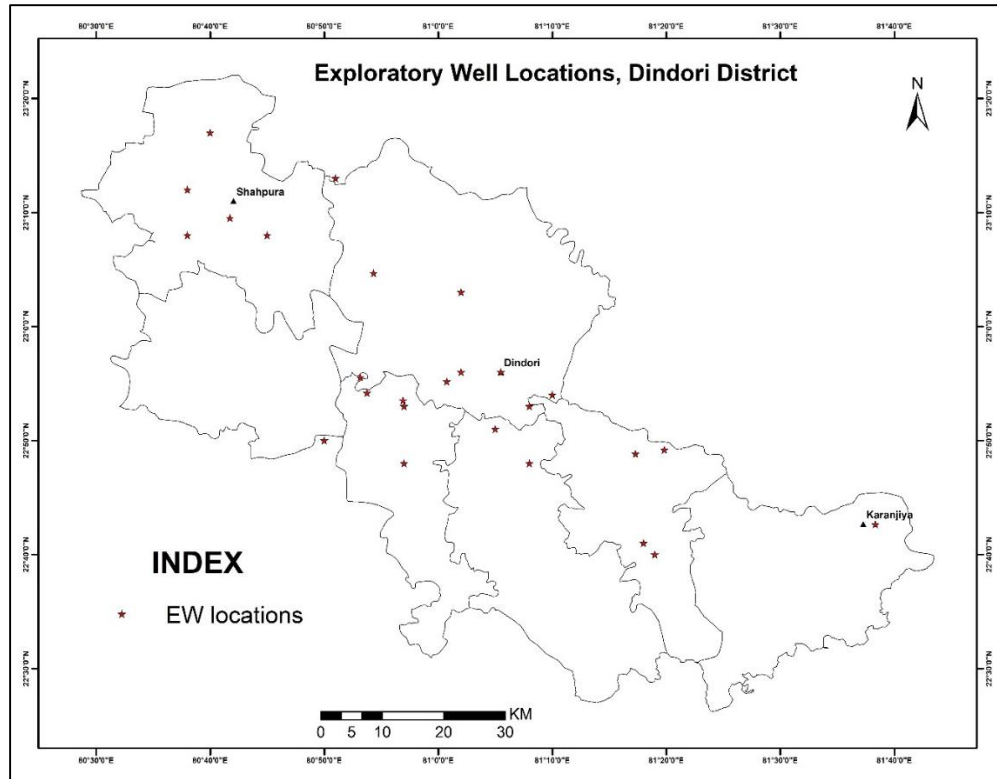


Fig. 3.2: Exploratory Well Locations in Dindori district

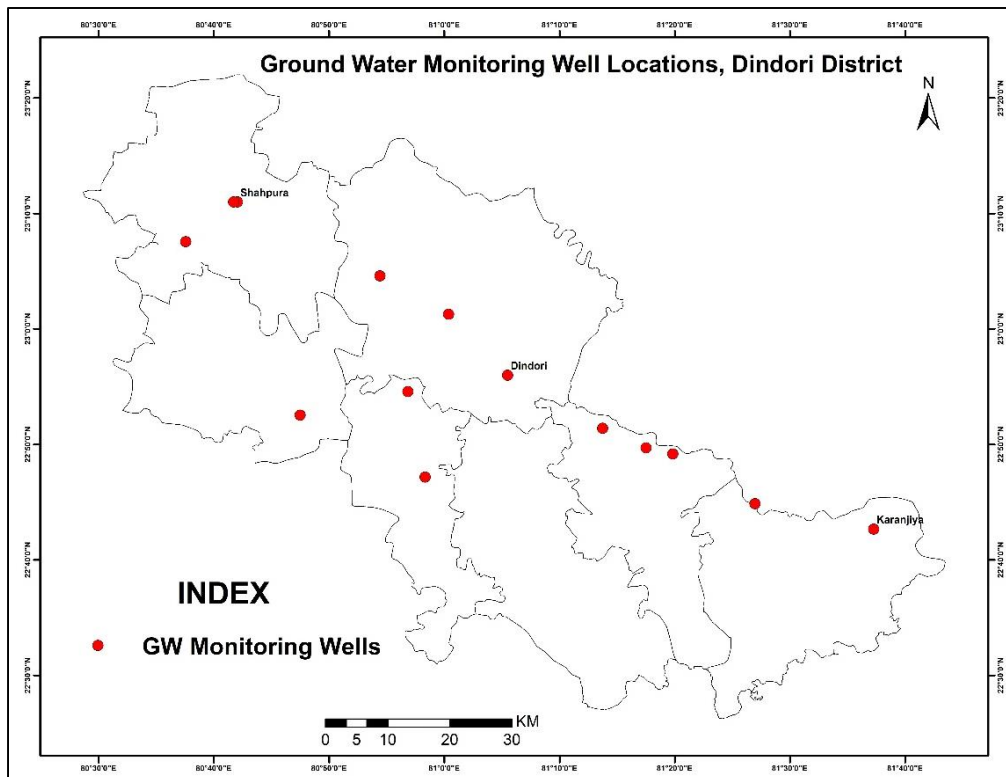


Fig.3.3: Ground water Monitoring well locations

3.3 GROUND WATER LEVEL SCENARIO

Ground water levels form a very important parameter of the ground water system, as these are its physical reflection. Central Ground Water Board monitored the water level of 14 dug wells four times (January, May, August and November) in every year. The monitored dug wells locations are plotted in the **Fig.3.3**. The present depth to water level scenario of shallow aquifer were generated by utilizing water level data of 14 monitoring wells representing shallow aquifer.

3.3.1 Shallow Aquifer

3.3.1.1 Pre-Monsoon (May 2021)

The pre-monsoon depth to water levels during May 2021 ranged between 3.5 (Gadasarai, Bajrang block) to 9.85 mbgl (Karanjiya, Karanjiya block). The depth to water level map of pre-monsoon is given in **Fig.3.4**. The water levels between 5 to 10 mbgl are observed in major part of the district and the water levels between 2 to 5 mbgl are observed in the northern most corner in the Shahpura block and in the central part in Dindori block.

3.3.1.2 Post-Monsoon (November, 2021)

The post-monsoon depth to water levels during November 2021 ranged between 0.5 (Vikrampur, Dindori block) to 9.35 mbgl (Karanjiya, Karanjiya block). The depth to water level map is given in **Fig.3.5**. The water levels between 2 to 5 mbgl are observed in major part of the district, Water level between 0 to 2 mbgl are observed in the Dindori block and 5 to 10 mbgl are observed in the Karanjiya block

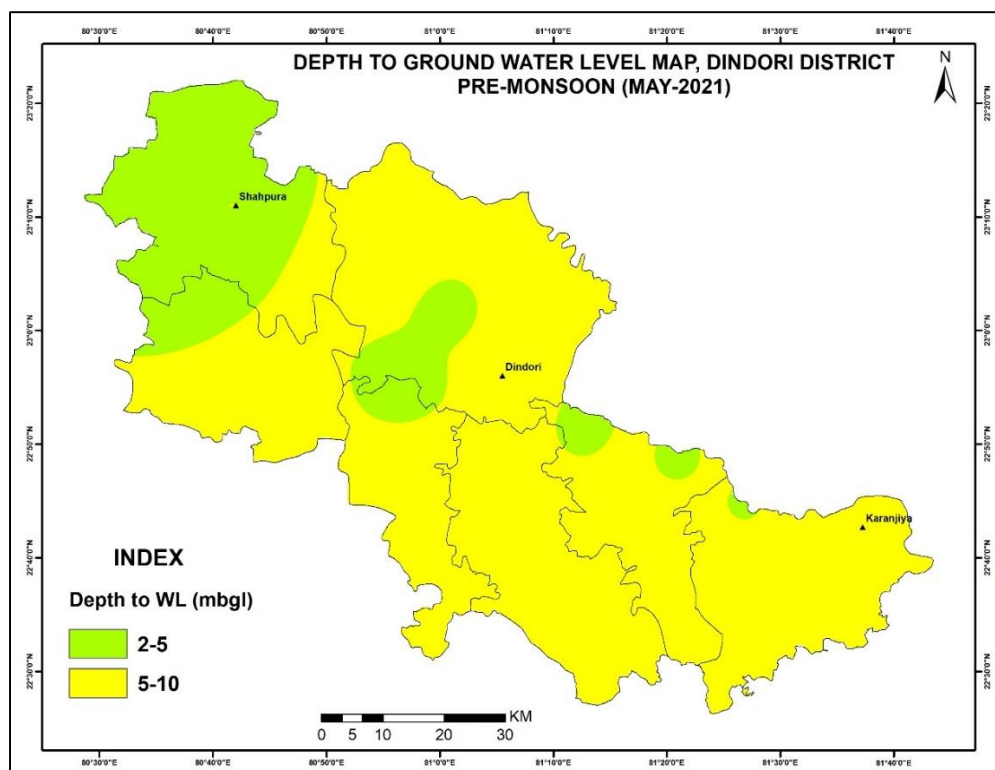


Fig.3.4: Pre-monsoon (May 2021) Depth to Water Level of Shallow Aquifer

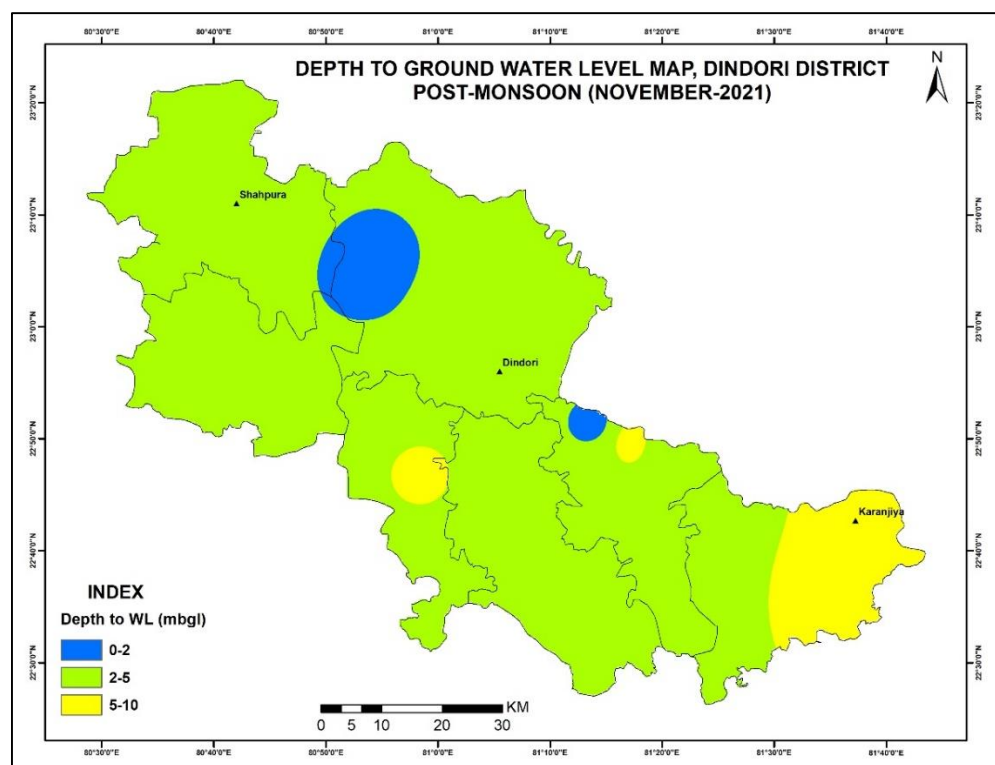


Fig.3.5: Post-monsoon (Nov 2021) Depth to Water Level of Shallow Aquifer

3.3.1.3 Seasonal Water Level Fluctuation

The water level measured during pre-monsoon (May 2021) and post monsoon (Nov 2021) period was used to compute the seasonal fluctuation. The analysis of water level fluctuation data indicated that minimum water level fluctuation was observed at Karanjiya, Karanjiya block (0.5 m) while maximum water level fluctuation was observed at Vikrampur monitoring well of Dindori block (11.6 m). The water level fluctuations were grouped under three categories i.e., less, moderate and high and the percentage of wells in each category was analysed. The analysis is described in Table.3.6.

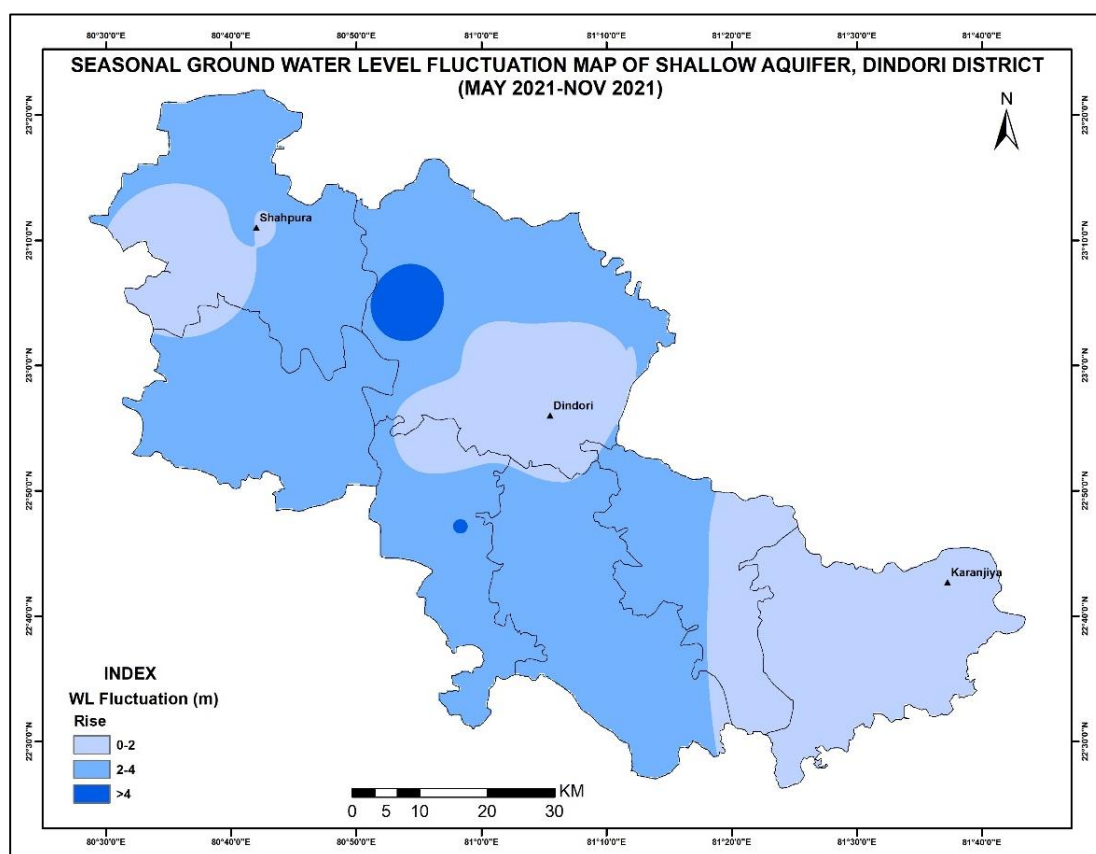


Fig.3.6: Seasonal Fluctuation of Water Level, Shallow Aquifer

Table.3.2: Analysis of Water Level Fluctuation.

S N	Category	Fluctuation Range	% of Wells
1.	Less water level fluctuation	0 to 2 m	57%
2.	Moderate water level fluctuation	2 to 5 m	36%
3.	High water level fluctuation	>5 m	7%

The analysis indicates that of 57% the wells are falling in low fluctuation indicating aquifer storage is good, whereas moderate water level fluctuation is observed in 36 % wells and high water level fluctuation were observed only in 7 % wells. The seasonal fluctuation map is presented as **Fig.3.6**; the perusal of map indicates that fluctuation between 2 to 4 meter is observed in major part of the district.

The pre-monsoon, post monsoon water level and seasonal fluctuation for the year 2021 of shallow aquifer is shown in the **Annexure. II**.

3.3.1.4 Long Water Level Trend (2012-21)

In order to study long term behavior of the water levels and also the effect of various developmental activities with time, the data for the period 2012-21 have been computed and analyzed.

The decadal pre-monsoon water level trend is presented in the **Fig.3.7**, which indicates that during pre-monsoon period, more than 90 % of the area showing rising trend. Declining trend only observed in southern part of the district. The rising trend more than 0.4 mm/year is observed in most part of the district. The falling trend between more than 0.4 mm/year is observed in southern part of the district.

Similarly, the decadal post-monsoon water level trend is presented in the **Fig.3.8**, which indicates that almost the whole district is showing declining trend. Maximum falling trend is more than 0.4 m/yr. The rising trend observed in patches.

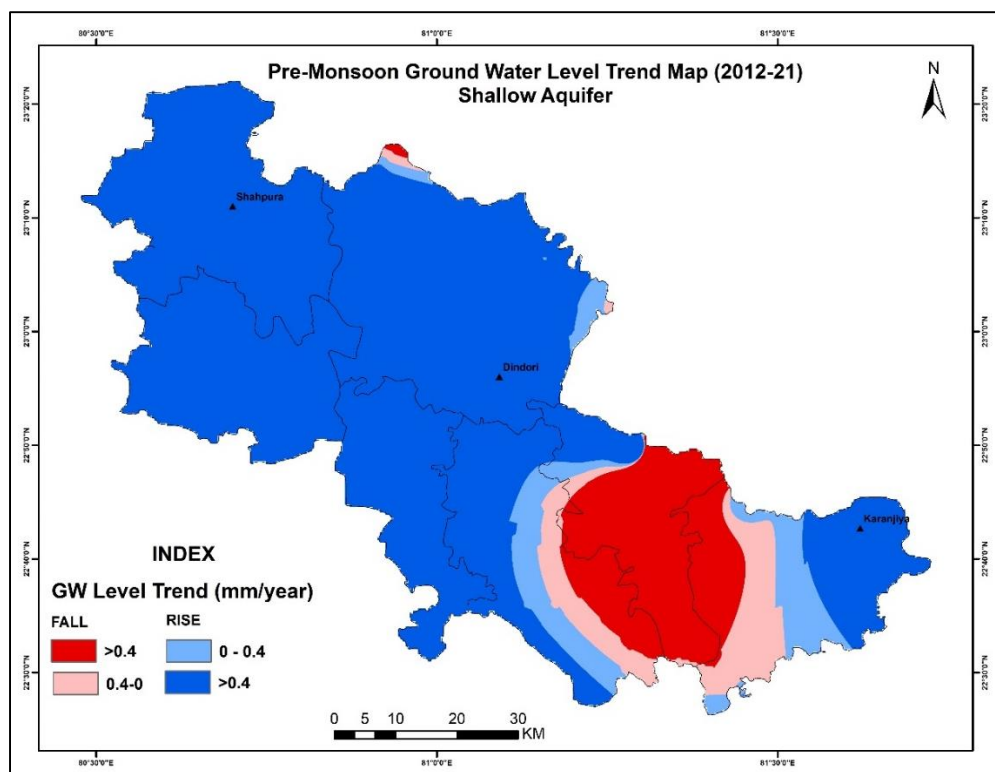


Fig.3.7:Pre-monsoon Water Level Trend (May 2012-21) of Shallow Aquifer

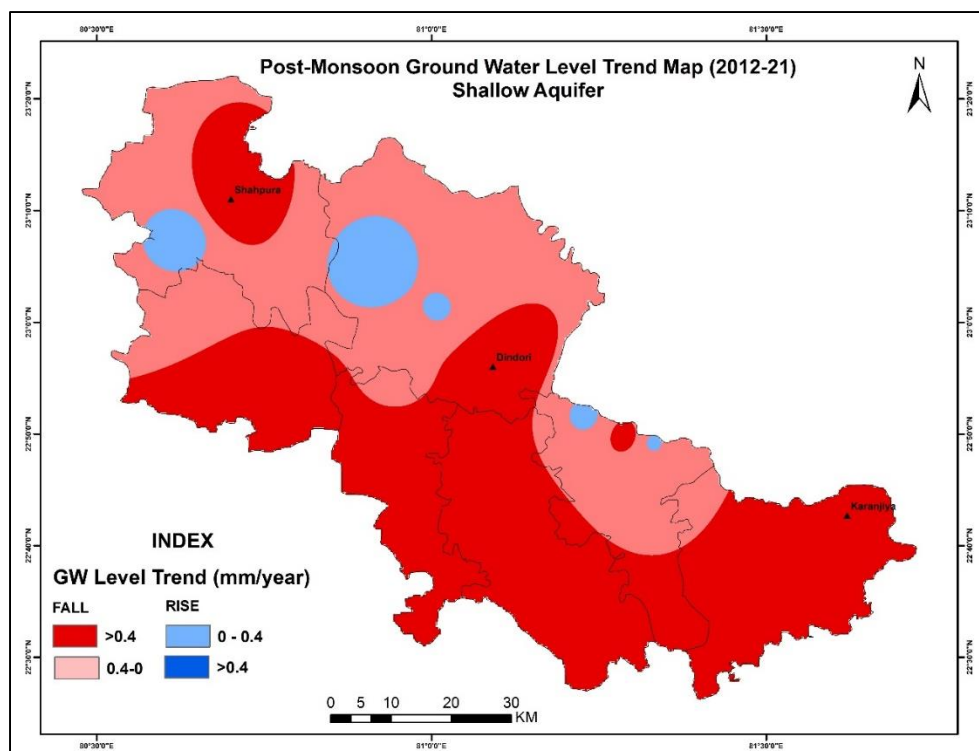


Fig.3.8:Post-monsoon Water Level Trend (Nov 2012-21) of Shallow Aquifer

3.4 HYDRO CHEMICAL STUDIES

3.4.1 Shallow Aquifer

Water samples were collected from 14 Ground Water Monitoring Wells during May 2021 and monitored for chemical quality of ground water (phreatic aquifer) and their location is given in **Figure.3.3**. Detailed analysis of the chemical samples was carried out parameters namely: pH, Electrical Conductivity (EC), Carbonate, Bi-carbonate, Chloride, Fluoride, Nitrate, Sulphate, Phosphate, Total hardness, Calcium, Magnesium, Sodium and Potassium. The results of chemical data observed are given in **Annexure III**.

3.4.1.1 Quality of Ground Water for Drinking Purpose

The ground samples that are collected are analysed, compared with Bureau of Indian Standard set for drinking water quality and ranges of different chemical constituents present in ground water are given in **Table 3.3**.

Table.3.3: Ranges of chemical constituents in Shallow aquifer

Constituents	Acceptable Limit	Permissible limit in the absence of alternate source	Aquifer – I (Shallow aquifer)		
			Min.	Max.	No. of samples above PL
pH	6.5	8.5	7.11	7.96	Nil
EC	-	-	308	1154	-
TH	200	600	130	395	Nil
Calcium	75	200	28	102	Nil
Magnesium	30	100	13	39	Nil
Potassium	-	-	1.4	9.8	-
Sodium	-	-	9	95	-
Carbonate	-	-	0	0	-
Bi-carbonate	200	600	122	415	Nil
Chloride	250	1000	12	140	Nil
Nitrate	-	45	3	38	Nil
Fluoride	1	1.5	0.02	0.32	Nil

The ground water samples from Dindori district have varied range of pH from 7.11 to 7.96. 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 Vikrampur (7.96). The pH of ground water can be assessed as neutral to slightly alkaline in nature.

The electrical conductivity of ground water samples in Dindori district varies from 308 to 1154 $\mu\text{S}/\text{cm}$ at 25°C . The electrical conductivity of ground water of Dindori district is good. The electrical conductivity shows that the ground water is good. The EC contour map is shown in the **Fig.3.9**.

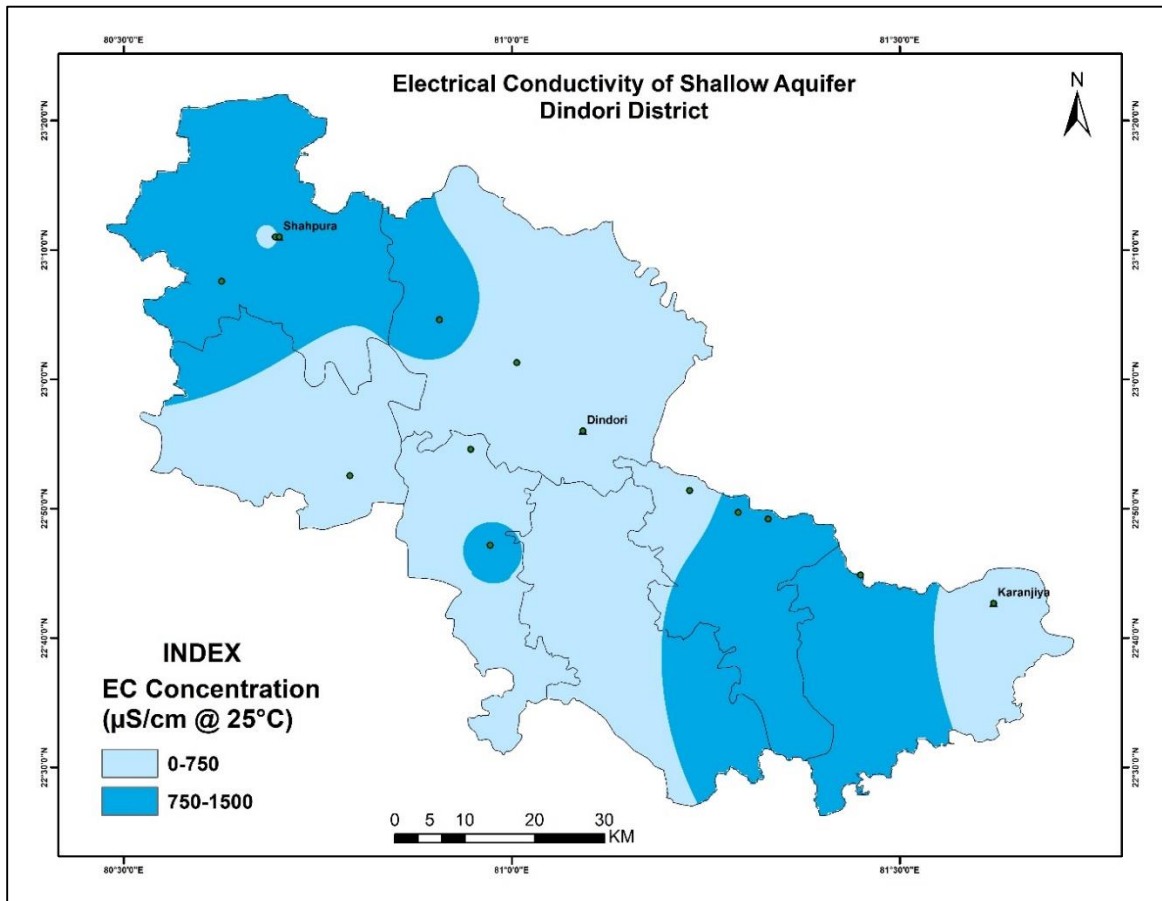


Fig.3.9: Electrical Conductivity in Shallow aquifer

The fluoride concentration in Dindori district lies in between 0.02 to 0.32 mg/l, which represent that all the samples are within the permissible limit of 1.5 mg/l as per BIS (IS 10500: 2012). The maximum concentration of fluoride has been observed in the village of Salaiya village i.e. 0.32 mg/l. The distribution of fluoride concentration is shown in the **Fig.3.10**. In the assessment of ground water resources estimation, PHED has reported high Fluoride concentration in ground water in two blocks, viz. Amarpur and Dindori.

Nitrate concentration in ground water samples of Dindori district fall in between 3 to 38 mg/l. It shows that the all samples within the acceptable limit of 45 mg/l and the maximum concentration

has been observed in the village of Sagar Tola (38 mg/l). The distribution of nitrate concentration is shown in the **Fig.3.11**.

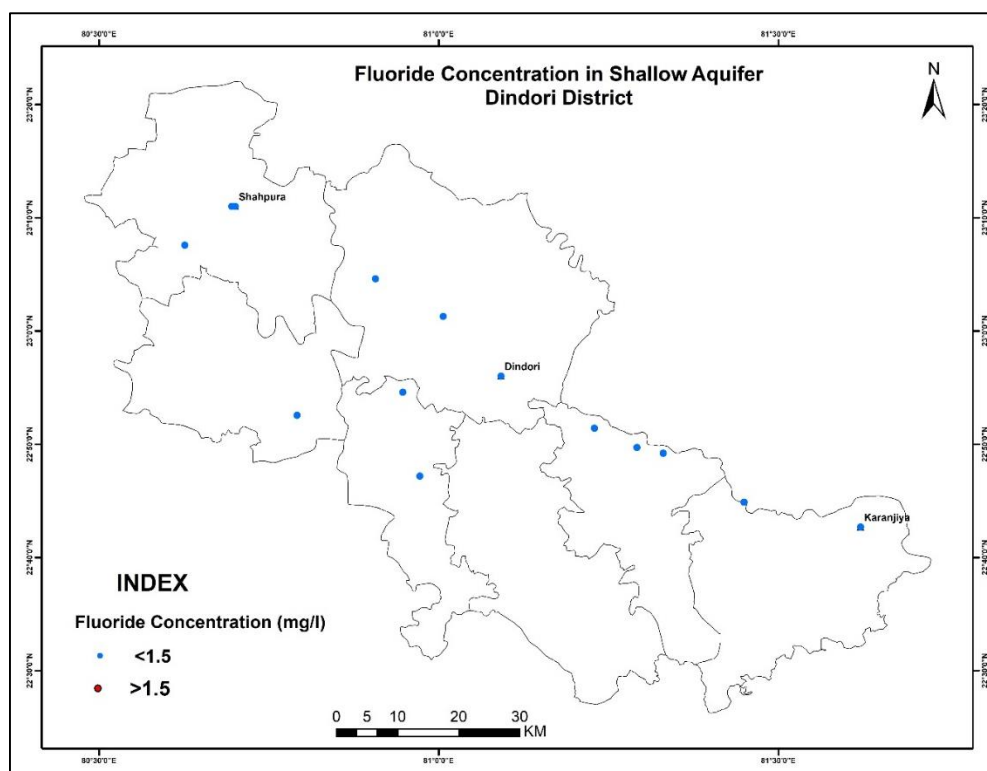


Fig.3.10: Distribution of Fluoride Concentration in Shallow aquifer

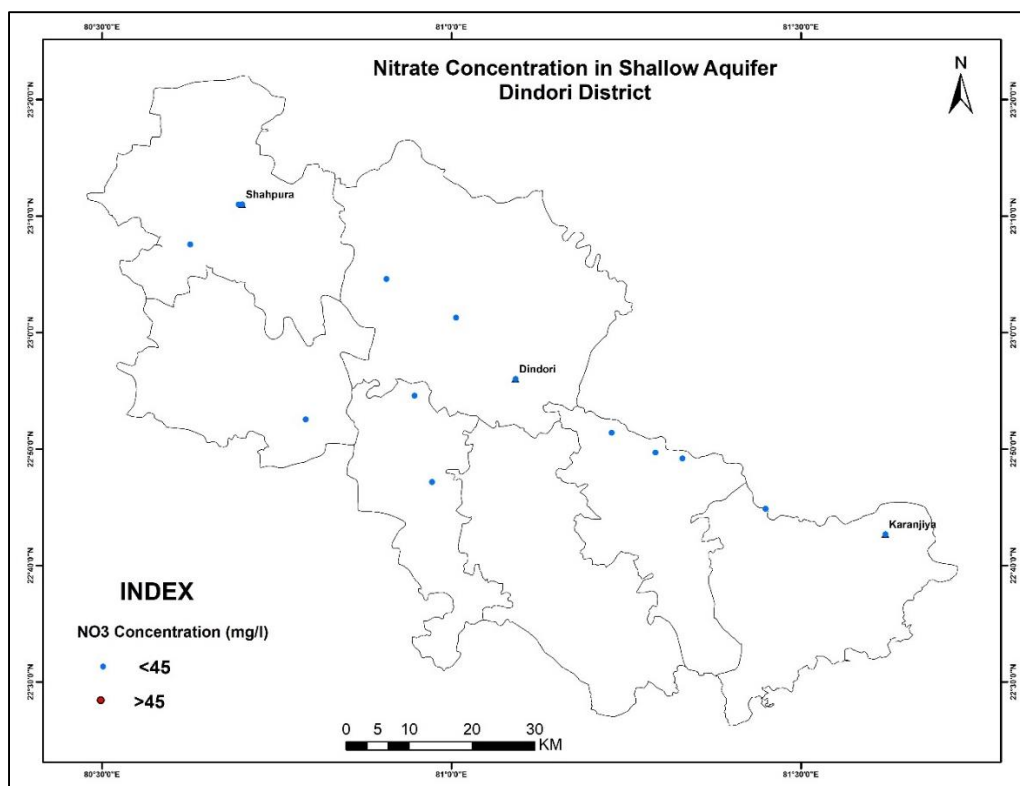


Fig.3.31: Distribution of Nitrate Concentration in Shallow aquifer

The range of Total Hardness (as CaCO₃) concentration in ground water samples is 130 to 395 mg/l. The maximum concentration of Total hardness has been observed in the village of Shahpura (395 mg/l).

The Piper diagram for the shallow aquifer is prepared and given in the **Fig.3.12** 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 (Ca²⁺, Mg²⁺, Na⁺, K⁺) are plotted. In Anion triangle the major anions (HCO₃⁻+CO₃²⁻, SO₄²⁻, Cl⁻) are plotted. These points are then projected to the central diamond shaped field. In the district; piper diagram shows that the ground water samples are Calcium-Bicarbonate type and mixed type of water, hence show temporary hardness.

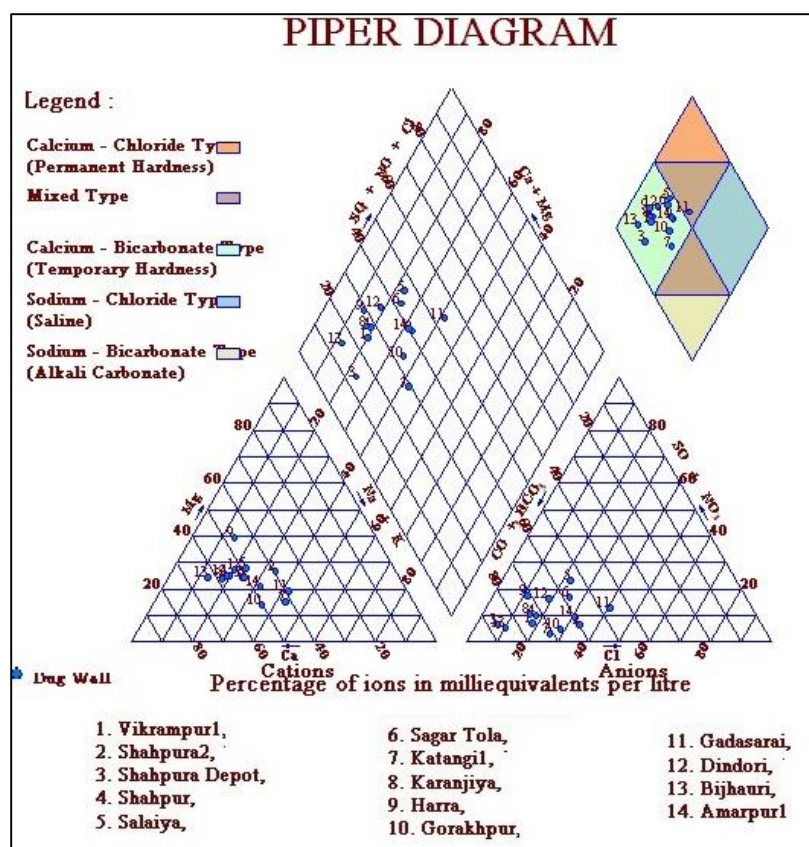


Fig.3.12: Hill Piper Diagram representing classification of water samples, Shallow Aquifer

3.4.1.2 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. Suitability of ground water for irrigation can be assessed using the indices for salinity, chlorinity and sodicity. Various indices such as SAR (Sodium Absorption Ratio), SSP (Soluble Sodium Percentage) %Na, KI (Kelly's Index), PI (Permeability Index), RSC (Residual Sodium Carbonate) are used for quality criteria for irrigation water. The ground samples that are collected are analysed, compared with the standard values of different indices and ranges of indices and its suitability for irrigation are given in **Table 3.15**. The formula for different indices and calculation of all the indices are given in **Annexure-IV**.

The chemical data of all the water samples from Dindori district is plotted on U.S. Salinity Laboratory diagram shown in the Fig.3.13 In the district USSL diagram shows that the 80% wells of study area are observed under C2-S1 Class (Medium Salinity & Low Sodium) which means that these waters can be used for irrigation purpose for most of the crops, 10% of ground water

samples fall under C3-S1 class (High Salinity & Low Sodium). The water from C2-S1 and C3-S1 classes may be used for irrigation purpose under proper soil management

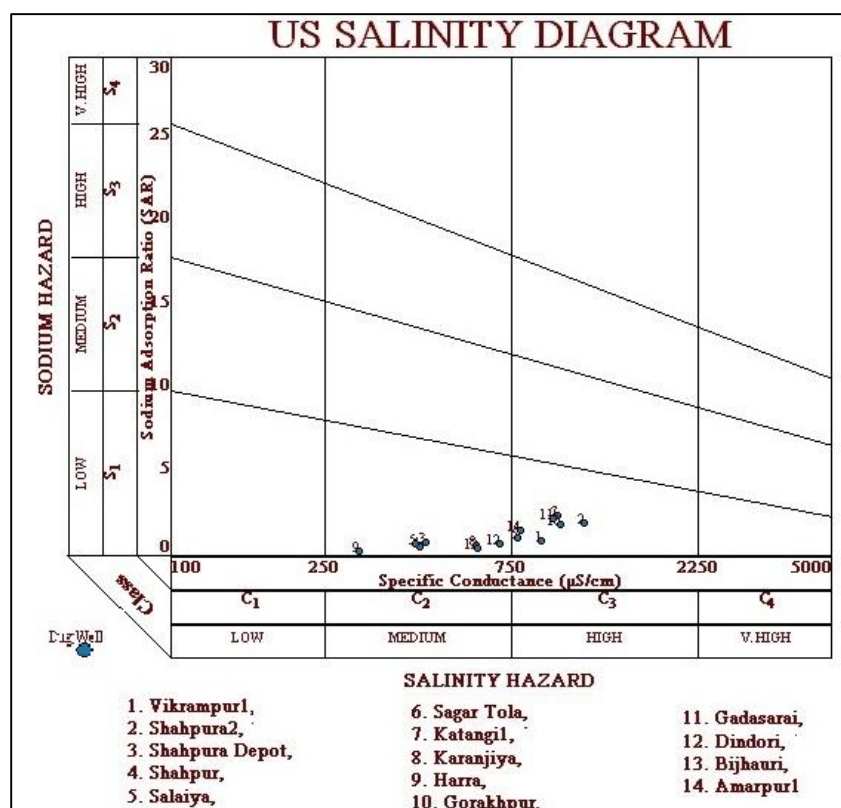


Fig.3.13: US Salinity Diagram, Shallow Aquifer

Table.3.4: Ranges of Indices and Suitability of Ground Water for irrigation

	Standards for Irrigation	Aquifer – I (Shallow aquifer)		
		Min.	Max.	No. of samples above PL
Salinity (EC)	3000	308	1154	Nil
Soluble Sodium Percentage	50	12.14	42.53	Nil
Sodium Absorption Ratio	10	0.34	2.47	Nil
%Na	40-60	13.14	43.32	Nil
Residual Sodium Carbonate	1.25-2.50	-1.79	1.22	Nil
Kelly's Index	1	0.32	1.36	Nil
Mg ²⁺ Ratio	50	0.14	0.74	Nil
Permeability Index	75	47.13	69.39	Nil

3.4.1.3 Quality of Ground Water for Industrial Purpose

Ground water quality needs to be assessed with reference to its usefulness for industrial purposes as majority of the industries consume huge quantities of water in various processes, water with in specific quality is a must to protect the necessary machinery from scaling or corrosion effects. The Corrosivity ratio (CR) is calculated for all the samples collected during pre-monsoon. The CR value of water with less than or equal to 1 is considered good whereas more than 1 indicates corrosive nature and is not fit for transportation through metal pipes (Ryner 1944; Raman 1985) and it is not suitable for industrial or domestic purposes. The CR values for all the samples is calculated and values are less than 1, so the Ground water of shallow aquifer in Dindori district is suitable for industrial purpose. The calculation of Corrosivity ratio (CR) are given in **Annexure-V**.

3.5 3-D AND 2-D AQUIFER DISPOSITION

The data generated from ground water monitoring wells, exploratory and observation wells, various thematic layers was utilized to decipher the aquifer disposition of the area. This particularly includes the information on geometry of aquifers and hydrogeological information of these aquifers. In the area the two aquifer systems have been deciphered as listed below:

- a. **Aquifer –I (Shallow Aquifer)**
- b. **Aquifer – II (Deeper Aquifer)**

3.5.1 Fence Diagram and 3D model

A 3-Dimensional lithological model and fence diagram was prepared for the Dindori district after detailed analysis of the pre-existing and available bore-log data from the exploratory and observation well. A comprehensive analysis was made as per lithology and stratigraphy of the area.

The 3-D Model and fence diagram results concluded that the region is dominantly occupied by Deccan trap Basalt. The sub-surface lithology has been broadly classified into Top soil/Unsaturated zone, weathered Basalt which has been considered as shallow aquifer (up to a depth of 30meter). The Fractured and jointed Basalt that forms the deeper aquifer (from 30-200 meters).

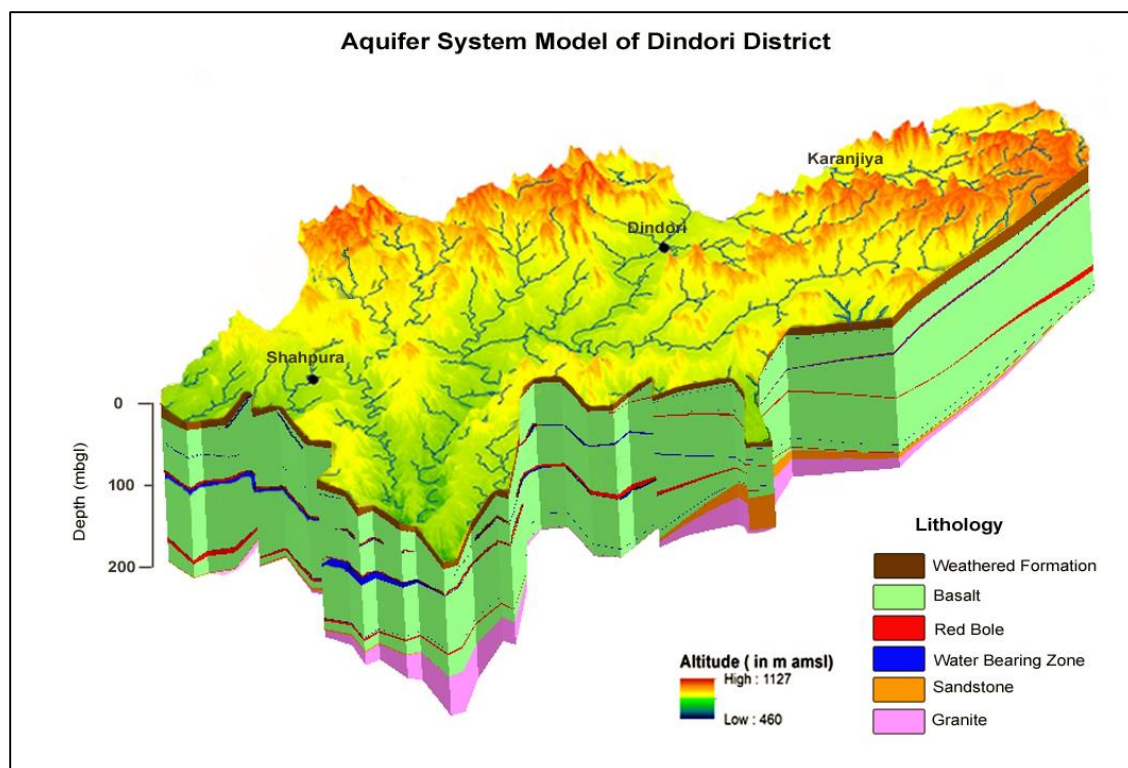


Fig.3.14: 3D Representation of Aquifers, Dindori District

CHAPTER 4

GROUND WATER RESOURCES

In Dindori district the Ground Water 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 methodology 2015.

4.1 DYNAMIC GROUND WATER RESOURCES

The Dynamic Ground Water Resources assessment has been carried out for Dindori district in the year 2022 and the salient features of the resources are described below.

As per the Dynamic Ground Water Resource 2022, the overall contribution of rainfall (both monsoon and non-monsoon) recharge to District's total annual ground water recharge is 98 % and the share of recharge from 'Other sources' viz., return flow from Ground Water irrigation, recharge from tanks, ponds and water conservation structures taken together is 2%. The Ground Water Recharge Scenario is shown in the **Fig.4.1**.

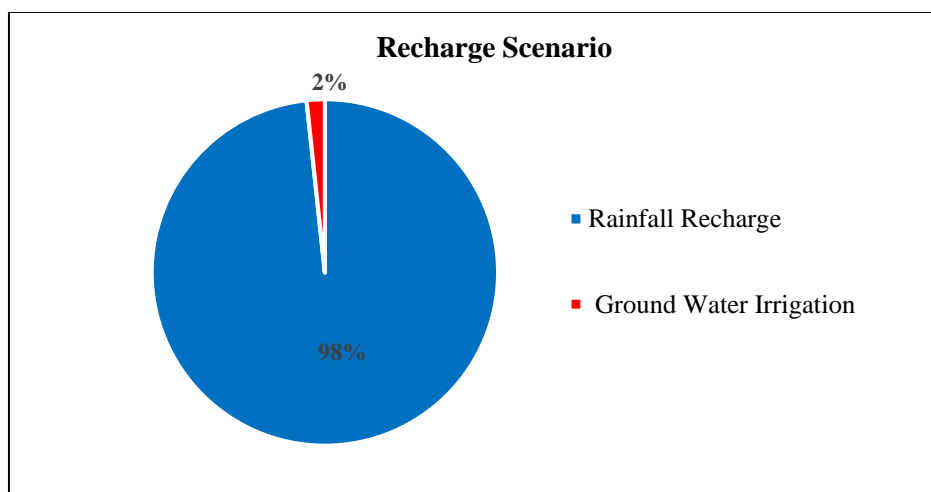


Fig.4.1:Ground Water Recharge Scenario

Total annual Ground Water recharge from all sources in the district is of the order of 343 mcm. Total unaccounted natural discharge in the district is of the order of 17 mcm. The total natural discharge is about 5% of the total annual Groundwater recharge. The Annual Extractable Ground Water Resource is 44 mcm, which is 95% of the total annual Groundwater recharge.

Total extraction of ground water for all uses in district is calculated as 41 mcm. From the **Table.4.2**, it is seen that extraction for irrigation accounts for more than 56 % of total ground water extraction,

whereas extraction for domestic supply accounts for 44% of the total ground water extraction in the district. The Ground Water Extraction Scenario is shown in the **Fig.4.2**.

Table.4.1: Ground Water Recharge

Assessment Unit	Rainfall Recharge (in Ham)	Recharge from Ground Water Irrigation (in Ham)	Recharge due to Water Conservation Structures (in Ham)
Amarpur	3400.44	40.43	4.14
Bajang	3330.14	31.01	7.8
Dindori	6652.77	81.24	3.84
Karanjiya	4537.48	61.78	5.22
Menhadwani	4367.18	55.9	5.22
Samnapur	3983.3	84.67	9.3
Shahpura	7425	223.99	11.52
District Total	33696.3	579.02	47.04

Table.4.2: Ground Water Resources

Assessment Unit	Total Annual Ground Water Recharge (Ham)	Total Natural Discharges (Ham)	Annual Extractable Ground Water Resource (Ham)
Amarpur	3445.01	172.25	3272.76
Bajang	3368.95	168.45	3200.5
Dindori	6737.85	336.89	6400.96
Karanjiya	4604.48	230.22	4374.26
Menhadwani	4428.3	221.41	4206.89
Samnapur	4077.27	203.86	3873.41
Shahpura	7660.51	383.03	7277.48
District Total	34322.37	1716.11	32606.26

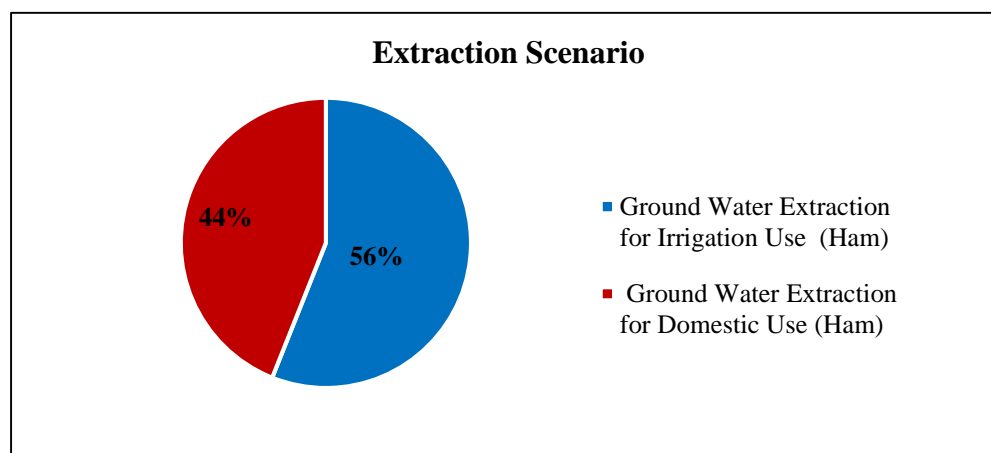


Fig.4.2: Ground Water Extraction Scenario

Table.4.3: Ground Water Extraction

Assessment Unit	Ground Water Extraction for Irrigation Use (Ham)	Ground Water Extraction for Domestic Use (Ham)	Total Extraction (Ham)	Stage of Ground Water Extraction (%)	Categorization
Amarpur	161.7	200.68	362.38	11.07	safe
Bajang	124.03	231.42	355.44	11.11	safe
Dindori	325	359.32	684.32	10.69	safe
Karanjiya	247.15	234.64	481.79	11.01	safe
Menhadwani	223.6	223.42	447.01	10.63	safe
Samnapur	338.7	234.03	572.73	14.79	safe
Shahpura	896	333.56	1229.56	16.9	safe
District Total	2316.18	1817.05	4133.23	12.68	

The overall stage of groundwater extraction in the district is **12.68 %**. The block wise stage of Ground water extraction is given in the **Table.4.3**. All the blocks are categorised as ‘**Safe**’.

CHAPTER 5

GROUND WATER RELATED ISSUES

5.1 LIMITED AQUIFER THICKNESS

The district is covered mostly with hard rock i.e. Deccan trap basalt and Achaeon Granitoids. These hard rocks don't have primary porosity and are impermeable. So they can form aquifers only when they are weathered, fractured and jointed. So the depth of weathering in shallow aquifer and aquifer thickness in deeper aquifers are limited.

5.2 SUSTAINABILITY/ LOW GROUND WATER POTENTIAL

The major part of the district is occupied by basaltic rock formation that inherently consist of limited extent of porous and pervious zone; predominance of secondary porosity that has evolved from prevailing erratic joint pattern and also absence of primary porosity and also, low rainfall results in poor sustainability of the aquifers. However, the erratic nature of existing joints/fractures pattern results in highly varying yield capacities of the aquifers in the area. In the area, depth of potential aquifers is generally restricted up to 30 m. The potential of the fracture zones reduces substantially below 100 m depth. This causes reduction in the well yield drastically during the summers. The entire district is having low yield potential.

CHAPTER 6

GROUND WATER MANAGEMENT STRATEGIES

As discussed in previous chapter, there are many groundwater related issues owing to many socio-economic and hydrogeological reasons. As surface water resources in the Dindori district are inadequate, the dependability on ground water resources has increased substantially. This has resulted in rapid exploitation of ground water resources vis a vis depletion of ground water levels in various parts of the District. The groundwater management plan for Dindori district are described as follow.

6.1 MICRO IRRIGATION TECHNOLOGIES:

Micro irrigation technologies such as drip and sprinkler systems are being increasingly promoted as technological solutions for achieving water conservation. 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:

- 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).
- It enables farmers to grow crops which would not be possible under conventional systems since it can irrigate adequately with lower water quantities.
- It saves costs of hired labour and other inputs like fertilizer.
- 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 PROPER WELL DESIGN IN BASALTIC FORMATIONS

Alternative flows are generally found within basaltic formations and between flows a clay, sticky collapsible formation present which is known as Red bole or Grey Bole. This formation creates problem during the construction of Borewell in Basaltic formation and also sometimes this formation is acts as a barrier to the aquifers, so a proper well design should be adopted during the construction of borewell in the district. A schematic diagram of a well design for basaltic formation is shown in **fig 6.1**.

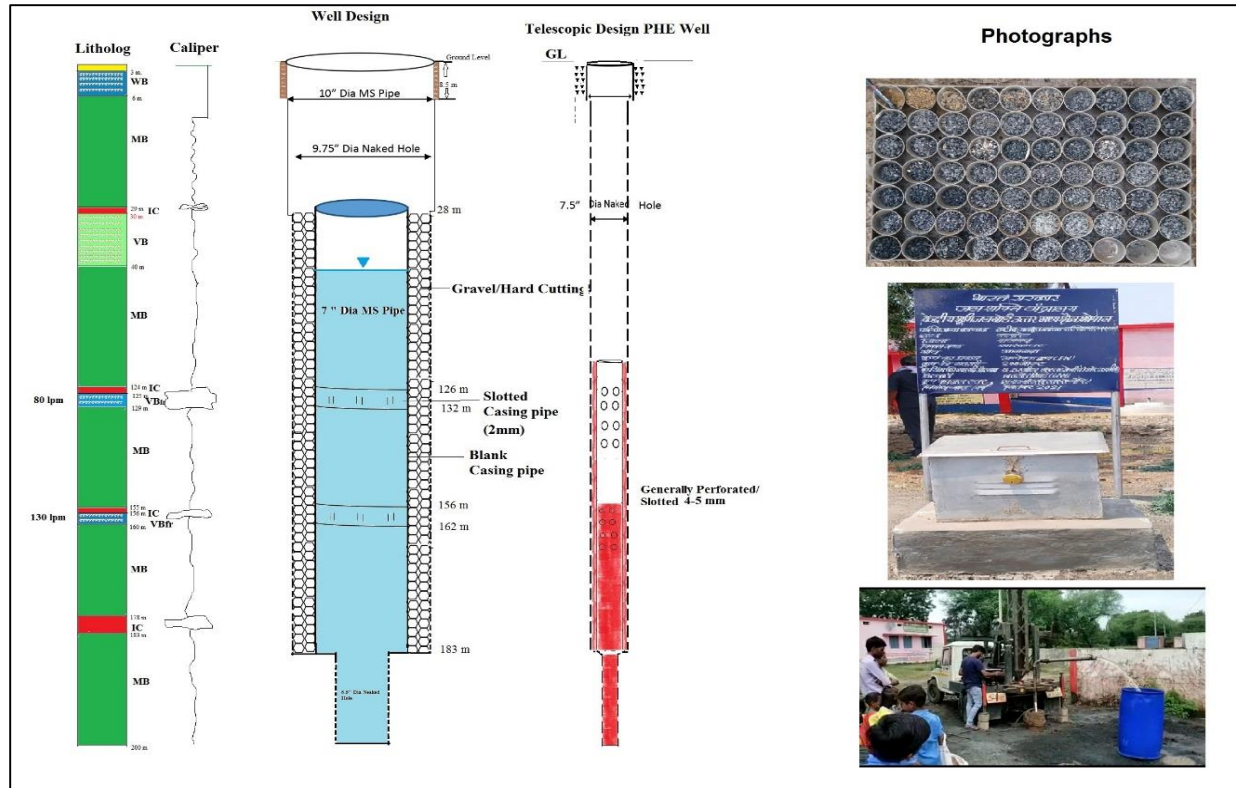


Fig. 6.1: Typical Well Construction Design in Basaltic Formations

The drilling in these areas should be done in telescopic manner. The deeper collapsible formations should have cased with blank pipe and slotted pipe given to the aquifer found in between. Gavel or cuttings should be given in the annular space between the deeper casing pipe and the borewell wall.

6.3 WATER CONSERVATION

The growing population puts tremendous pressure on the Ground water resources and the Ground Water resource available in the district is also limited. The normal annual rainfall of the district is 1300 mm, So Several management techniques should be adopted to increase rainfall use efficiency. As Ground Water Level in the district is shallow, the rainwater should be stored by making Farm pond. for collection of excess rainfall flowing from the farm area. Farm ponds would help the farmers for on farm water management by using stored water for tackling the dry spells. Farm Pond is a dug out structure with definite shape and size having proper inlet and outlet structures for collecting the surface runoff flowing from the farm area. It is one of the most important rain water harvesting structures constructed at the lowest portion of the farm area.

- Depending on the source of water and their location, farm ponds are grouped into four types: **(Source: Farm Ponds: A Climate Resilient Technology for Rainfed Agriculture, Central Research Institute for Dryland Agriculture, Hyderabad)**

- 1) Excavated or Dug out ponds
- 2) Surface ponds
- 3) Spring or creek fed ponds and
- 4) Off stream storage ponds.

Selection of site

Selection of the site for farm pond depends on local soil condition, topography of area, drainage capacity, infiltration, rainfall pattern and distribution. Selecting the suitable site is considered as one of the most important steps in planning for farm ponds. The following points may be considered for site selection within farm area:

1. Dugout ponds

- Observe the average slope direction in the farm area in which farm pond is to be planned for construction
- If the slope is towards left bottom corner of the field (Fig.6.2a), a farm pond must be constructed in the left corner of the plot.
- If the slope is towards bottom right corner of the field (Fig.6.2b), a farm pond must be constructed in the right hand corner
- If the slope is towards the bottom of the field (Fig.6.2c), a farm pond must be constructed to the corner of either side with proper field channel at the bottom of the field connecting to the inlet of the structure.
- If the farm area has multiple slopes in different directions (Fig.6.2d), a farm pond must be located in a portion of area in which water is drained into the structure, may be at centre of the field or near to it.

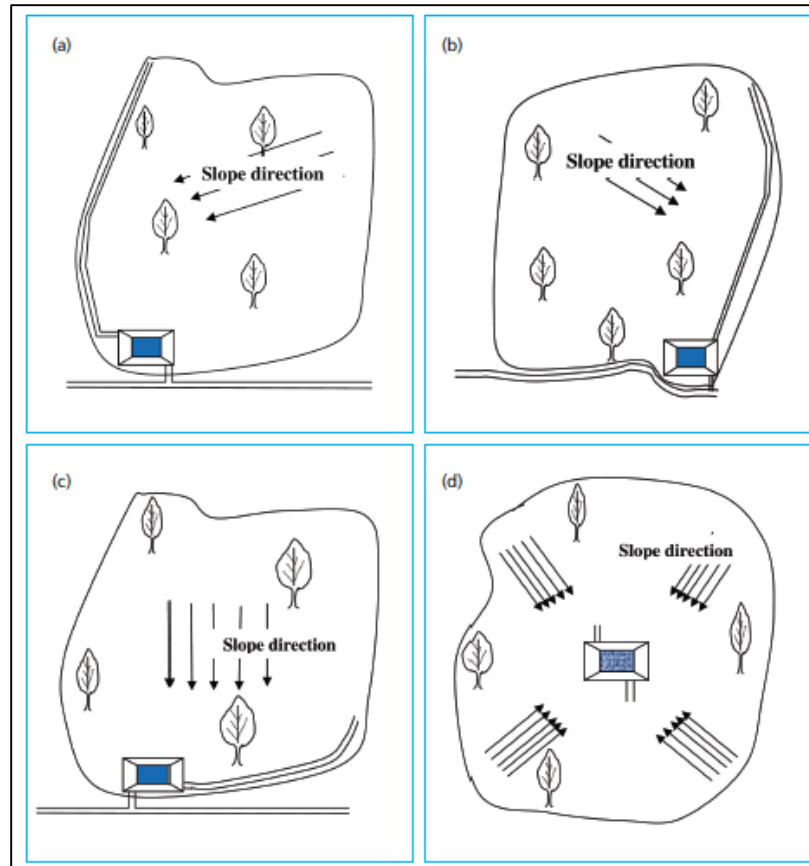


Fig.6.2: Planning and selection of site for farm pond location in farm catchment areas with different slopes

2. Surface Pond

Surface ponds are considered to collect surface runoff from farm area into a local depression or the lowest portion of the farm so that the excavation is minimum except to construct the earthen bund surrounding the water body (Fig.6.3a). These are possible in highly eroded farm areas with undulating topography. Such farm ponds do not require inlet provision but it should have outlet provision in the earthen bund to remove the excess flow.

3.Spring or Creek Fed Ponds

In the ridge portions of the farm area, particularly hilly catchments, after saturation of the soil, there will be a flow from the subsurface layers drawing water into the pond (Fig.6.3b). The subsurface flow is called base flow. It may be a perennial source for water within a farm.

4.Off stream storage ponds

The streams are seasonal from which water is drawn into the farm pond by diversion (Fig.6.3c). When the stream flows are the source of storage, the farm ponds should never be constructed across

the streams and the structure must be located off the stream with proper diversion of water through pipe or channel.

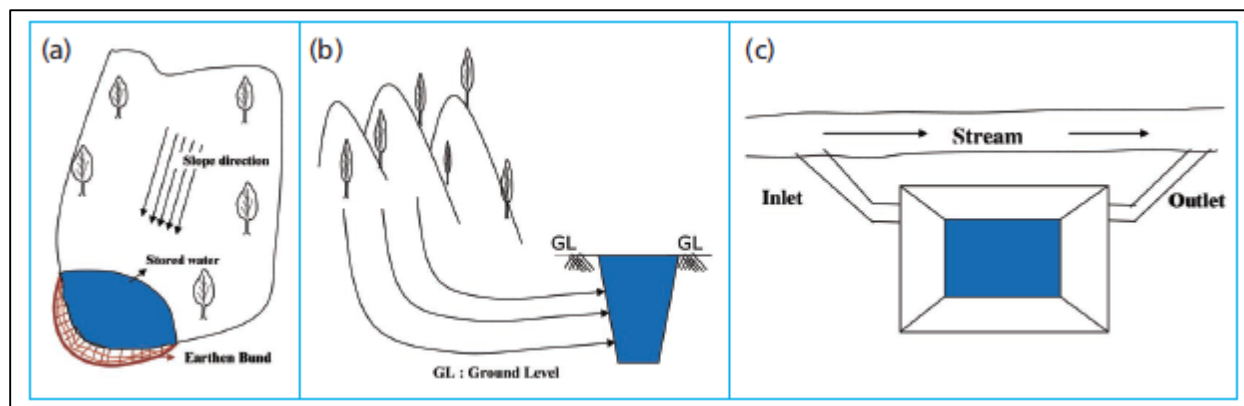


Fig.6.3: Different types of farm ponds: surface (a), spring (b) and offstream (c) and their location in the catchment

CHAPTER 7

CONCLUSION AND RECOMMENDATIONS

- Dindori District occupies an area of 5725 Sq.Km and recharge worthy area is 4560 sq. km, and the rest is covered by hilly areas.
- About 90% of annual rainfall is received during monsoon season. Only 10 % of annual rainfall takes place during non-monsoon season.
- Dindori district falls under Narmada river basin. The district is mainly drained by river Narmada and its tributaries. Major tributaries are Kasah, Siligi, Johila, Kharmer, Carker, Seoni, Turar rivers.
- Agriculture and forest are the prominent land use aspects in Dindori district. Crop land forms 57% and forest area form 37 % of total area followed by Fallow land (3%), Shrub land and water bodies.
- Major Socio–economy of the District is dependent on Agriculture. The livelihood of rural population of district is dependent on Agriculture.
- The elevation of the district is varying from 460 to 1120 meters above Mean Sea Level.
- Net sown area of the district during kharif season is 205524 hectare, out of which 21990 hectare is irrigated and 183536 hectare area is unirrigated. During Rabi season total sown area of the district is 137300 hectare, out of which 12900 hectare is irrigated and 124400 hectare area is unirrigated.
- In the district mostly two types of soil are present namely, Clayey and loamy soil.
- Main geological units of the district are Laterite, Deccan trap and Banded Gneissic Complex (BGC).
- The principal aquifers in the area are Basalt and Granite.
- The groundwater movement in the district is towards the Northern side in the northern part of district and in the central part towards the western side, which follows the drainage and topography of the area.
- In the shallow aquifer water levels between 5 to 10 mbgl in pre-monsoon and between 2 to 5 mbgl in the post-monsoon are observed in major parts of the district. The decadal pre-monsoon water level trend analysis indicates that during pre-monsoon period, more than 90 % of the area showing rising trend. Similarly, the decadal post-monsoon water level trend analysis indicates that almost the whole district is showing declining trend.

- For Shallow aquifers the electrical conductivity of ground water in Neemuch district ranged between 308 to 1154 $\mu\text{S}/\text{cm}$ at 25°C , pH ranged in between 7.11 to 7.96, fluoride concentration was ranged in between 0.02 to 0.32 mg/l, nitrate concentration ranged in between 3 to 38 mg/l. Total hardness ranged in between 130 to 395 mg/l. In the assessment of ground water resources estimation, PHED has reported high Fluoride concentration in ground water in two blocks, viz. Amarpur and Dindori.
- The sub-surface lithology has been broadly classified into Top soil/Unsaturated zone, weathered Basalt which has been considered as shallow aquifer (up to a depth of 30meter). The Fractured and jointed Basalt that forms the deeper aquifer (from 30-200 meters).
- In Basaltic formations the Discharge is upto 5 lps. Transmissivity is upto 250 m^2/day and Secific Yield is up to 3%. The Deccan Traps formations can be tapped by dug well, dug-cum-bore and bore wells. Ground water occurs in the weathered, jointed and fractured basalts under Unconfined and semi-confined to confined conditions.
- In Archaean formations Groundwater mostly occurs under under unconfined to semi confined conditions. Transmisivity is found upto 100 m^2/day ., Discharge is up to 2 lps and Specific yield is up to 2%.
- As per the Dynamic Ground Water Resources Estimation (2020), the annual recharge from rainfall contributes maximum component (337 mcm) and recharge from other sources is 6 mcm. The Annual Extractable Ground Water Resource is 326 mcm, which is 95% of the total annual Groundwater recharge. Total extraction of ground water for all uses in district is calculated as 41 mcm. The overall stage of groundwater extraction in the district is 12.68 %.
- All the blocks are categorised as ‘Safe’.
- In the district, the main ground water issues are Limited Ground Water Potential, Limited Aquifer Thickness, Sustainability of hard rocks, Decline in the water level both in shallow and deep aquifers in some areas.

ANNEXURES

Annexure-I: Ground Water Exploration Lithologs

Location	Depth1	Depth2	Lithology
Amachua	0	2	Top Soil
Amachua	2	14	Weathered
Amachua	14	15	Fractured1
Amachua	15	93	Massive Basalt
Amachua	39	111	Massive Basalt
Amadongri	0	1.5	Top Soil
Amadongri	1.5	6	Weathered
Amadongri	6	8	Massive Basalt
Amadongri	8	29	Red Bole
Amadongri	29	31	Fractured1
Amadongri	31	63	Massive Basalt
Amarpura	0	2	Top Soil
Amarpura	2	9	Weathered
Amarpura	9	30	Massive Basalt
Amarpura	30	32	Fractured1
Amarpura	32	109	Massive Basalt
Amarpura	109	118	Red Bole
Amarpura	118	131	Massive Basalt
Bahera	0	7	Top Soil
Bahera	7	10	Vesicular Basalt
Bahera	10	30	Massive Basalt1
Bahera	30	31	Fractured1
Bahera	31	40	Massive Basalt2
Bahera	40	41	Fractured2
Bahera	41	70	Massive Basalt3
Bahera	70	73	Vesicular Basalt
Bahera	73	81	Massive Basalt4
Bargaon	0	1	Top Soil
Bargaon	1	7	Weathered
Bargaon	7	20	Vesicular Basalt
Bargaon	20	50	Massive Basalt
Bargaon	50	52	Fractured1
Bargaon	52	78	Massive Basalt
Bargaon	78	126	Vesicular Basalt
Bargaon	126	181	Massive Compact
Bargaon	181	182	Fractured 2
Bargaon	182	188	Massive Basalt

Location	Depth1	Depth2	Lithology
Batondra	0	2	Top Soil
Batondra	2	12	Weathered
Batondra	12	42	Vesicular Basalt
Batondra	42	101	Massive Basalt
Batondra	101	109	Red Bole
Chargoan	0	5	Weathered
Chargoan	5	26	Massive Basalt
Chargoan	26	33	Limestone
Chargoan	32	35	Fractured Basalt
Chargoan	35	40	Vesicular Basalt
Chargoan	40	44	Fractured Basalt
Chargoan	44	100	Vesicular Basalt
Chargoan	100	133	Massive Basalt
Chargoan	133	175	Vesicular Basalt
Chargoan	175	176	Red Bole
Chargoan	176	183	Vesicular Basalt
Chargoan	183	184	Red Bole
Chargoan	184	200	Vesicular Basalt
Dhanwasi	0	9	Weathered
Dhanwasi	9	67	Vesicular Basalt
Dhanwasi	67	70	Fractured
Dhanwasi	70	91	Red Bole
Dhanwasi	91	100	Vesicular Basalt
Dhanwasi	100	105	Fractured
Dhanwasi	105	124	Vesicular Basalt
Gadasarai	0	3	Top Soil
Gadasarai	3	9	Weathered
Gadasarai	9	30	Vesicular Basalt
Gadasarai	30	35	Fractured
Gadasarai	35	45	Vesicular Basalt
Gadasarai	45	61	Red Bole
Gutalwah	0	17	Weathered
Gutalwah	17	20	Fractured
Gutalwah	20	93	Massive Basalt
Gutalwah	93	118	Sand
Gutalwah	118	139	Massive Basalt
Gutalwah	139	200	Clay
Karanjiya	0	6	Weathered

Location	Depth1	Depth2	Lithology
Karanjiya	6	30	Red Bole
Karanjiya	30	40	Massive Basalt
Karanjiya	40	68	Clay
Kevlari	0	1	Top Soil
Kevlari	1	7	Weathered
Kevlari	7	11	Vesicular Basalt
Kevlari	11	24	Massive Basalt
Kevlari	24	31	Red Bole
Kevlari	31	40	Vesicular Basalt
Kevlari	40	98	Massive Basalt
Khairda	0	1	Top Soil
Khairda	1	7	Weathered
Khairda	7	35	Massive Basalt
Khairda	35	38	Red Bole
Khairda	38	50	Vesicular Basalt
Khairda	50	111	Massive Basalt
Khairda	111	116	Clay
Khairda	116	130	Vesicular Basalt
Khairda	130	140	Clay
Khairda	140	165	Vesicular Basalt
Khairda	165	200	Massive Basalt
Kuhani Devari	0	8	Weathered
Kuhani Devari	8	57	Massive Basalt
Kuhani Devari	57	60	Fractured
Kuhani Devari	60	145	Massive Basalt
Kuhani Devari	145	160	Red Bole
Kuhani Devari	160	203	Massive Basalt
Majhiakhar	0	6	Weathered
Majhiakhar	6	18	Vesicular Basalt
Majhiakhar	18	73	Massive Basalt
Majhiakhar	73	76	Fractured
Majhiakhar	76	88	Vesicular Basalt
Rahungi	0	5	Weathered
Rahungi	5	26	Vesicular Basalt
Rahungi	26	38	Red Bole
Rahungi	38	63	Vesicular Basalt
Rahungi	63	124	Massive Basalt
Rai	0	17	Weathered

Location	Depth1	Depth2	Lithology
Rai	17	27	Vesicular Basalt
Rai	27	97	Massive Basalt
Rai	97	100	Red Bole
Rai	100	112	Vesicular Basalt
Rai	112	200	Massive Basalt
Raipura	0	4	Top Soil
Raipura	4	7	Weathered
Raipura	7	30	Vesicular Basalt
Raipura	30	50	Massive Basalt
Raipura	50	55	Vesicular Basalt
Raipura	55	62	Massive Basalt
Raipura	62	65	Red Bole
Raipura	65	72	Vesicular Basalt
Raipura	72	99	Massive basalt
Raipura	99	117	Vesicular Basalt
Raipura	117	150	Massive Basalt
Rehpura	0	25	Weathered
Rehpura	25	72	Massive Basalt
Rehpura	72	75	Red Bole
Rehpura	75	100	Vesicular Basalt
Rehpura	100	142	Massive Basalt
Rehpura	142	148	Clay
Rehpura	148	200	Massive Basalt
Sarhari	0	5	Top Soil
Sarhari	5	15	Weathered
Sarhari	15	17	Fractured
Sarhari	17	90	Massive Basalt
Sarhari	90	93	Fractured
Sarhari	93	128	Vesicular Basalt
Shahpur	0	11	Weathered
Shahpur	11	38	Red Bole
Shahpur	38	63	Vesicular Basalt
Shahpur	63	66	Red Bole
Shahpur	66	200	Vesicular Basalt
Shakka	0	1	Top Soil
Shakka	1	7	Weathered
Shakka	7	25	Massive Basalt
Shakka	25	27	Red Bole

Location	Depth1	Depth2	Lithology
Shakka	27	34	Vesicular Basalt
Shakka	34	50	Massive Basalt
Shakka	50	74	Vesicular Basalt
Shakka	74	120	Massive Basalt
Shakka	120	151	Vesicular Basalt
Shakka	151	153	Fractured
Shakka	153	200	Massive Basalt
Tikaniya	0	11	Weathered
Tikaniya	11	36	Massive Basalt
Tikaniya	36	38	Fractured
Tikaniya	38	72	Massive Basalt
Tikaniya	72	93	Vesicular Basalt
Tikaniya	93	124	Massive Basalt
Vikrampur	0	1	Top Soil
Vikrampur	1	24	Weathered
Vikrampur	24	31	Red Bole
Vikrampur	31	40	Vesicular Basalt
Vikrampur	40	73	Massive Basalt
Vikrampur	73	102	Vesicular Basalt
Vikrampur	102	130	Massive Basalt
Vikrampur	130	180	Vesicular Basalt
Vikrampur	180	200	Massive Basalt
Dindori	0	1.3	Top Soil
Dindori	1.3	11	Weathered
Dindori	11	22	Massive Basalt
Dindori	22	23	Fractured
Dindori	23	51	Massive Basalt

Annexure-II: Ground Water Level Scenario of Shallow Aquifer

Block	Village	Latitude	Longitude	Pre_WL_21	Post_WL_21	Fluctuation
Amarpur	Amarpur	22.7861	80.9722	9.74	5.7	4.04
Bajag	Bijhauri	22.8567	81.2292	3.64	1	2.64
Bajag	Gadasarai	22.8197	81.3306	3.47	2.21	1.26
Bajag	Sagar Tola	22.8283	81.2919	9.5	6.8	2.7
Dindori	Dindori	22.9333	81.0917	5.78	4.88	0.9
Dindori	Salaiya	22.9097	80.9472	3.52	2.8	0.72

Dindori	Shahpur	23.0214	81.0064	4.7	3	1.7
Dindori	Vikrampur	23.0767	80.9069	5.7	0.5	5.2
Karanjiya	Gorakhpur	22.7478	81.4494	4.86	3.16	1.7
Karanjiya	Karanjiya	22.7111	81.6211	9.85	9.35	0.5
Mehadwani	Harra	22.8756	80.7914	5.4	2	3.4
Shahpura	Katangi	23.1261	80.6261	4.25	2.7	1.55
Shahpura	Shahpura	23.1833	80.7006	4.5	2.6	1.9
Shahpura	Shahpura Depot	23.1833	80.6953	5.1	3	2.1
			Minimum	3.47	0.5	0.5
			Maximum	9.85	9.35	5.2
			Average	5.715	3.55	2.165

Annexure-III: Chemical Quality Data of Shallow Aquifer

Block	Location	Lat.	Long.	pH	EC	CO ₃	HC O ₃	Cl	SO ₄	NO 3	F	PO ₄	SiO ₂	TH	Ca	Mg	Na	K	TDS
				@ 25°C	µS/cm @ 25°C	mg/liter													
Amarpur	Amarpur	22.7861	80.9722	7.88	795	0	268	85	22	14	0.02	0.05	24	275	76	21	59	2	517
Bajag	Bijhauri	22.8567	81.2292	7.94	620	0	311	23	12	5	0.22	0.08	29	285	82	19	18	2.9	403
Dindori	Dindori	22.9333	81.0917	7.9	705	0	256	45	26	32	0.06	0.1	27	290	80	22	30	2.3	458
Bajag	Gadasarai	22.8197	81.3306	7.83	960	0	250	132	32	30	0.16	0.05	16	285	76	23	89	9.8	624
Karanjiya	Gorakhpur	22.7478	81.4494	7.94	1010	0	384	97	9	18	0.31	0.08	39	325	102	17	79	7.5	657
Mehadwani	Harra	22.8756	80.7914	7.11	308	0	122	12	14	13	0.09	0.12	20	130	28	15	9	1.4	200
Karanjiya	Karanjiya	22.7111	81.6211	7.84	612	0	268	35	19	16	0.21	0.06	23	255	72	18	25	1.4	398
Shahpura	Katangi	23.1261	80.6261	7.76	987	0	415	90	7	11	0.31	0.09	31	280	82	18	95	5.3	642
Bajag	Sagar Tola	22.8283	81.2919	7.73	780	0	244	65	27	38	0.05	0.13	35	290	78	23	43	2.1	507
Dindori	Salaiya	22.9097	80.9472	7.41	429	0	128	32	24	26	0.32	0.14	17	165	40	16	22	2.6	279
Dindori	Shahpur	23.0214	81.0064	7.72	440	0	183	27	16	6	0.19	0.08	21	175	48	13	18	2.7	286
Shahpura	Shahpura Depot	23.1833	80.6953	7.89	455	0	226	12	11	3	0.28	0.09	34	170	46	13	24	1.4	296
Shahpura	Shahpura	23.1833	80.7006	7.83	1154	0	409	140	12	32	0.03	0.1	25	395	94	39	91	2.7	750
Dindori	Vikrampur	23.0767	80.9069	7.96	900	0	397	57	17	16	0.19	0.14	39	365	96	30	41	3.9	585

Min	7.11	308.	0.00	122	12	7	3	0.02	0.05	16	130	28	13	9	1.40	200.00
Max	7.96	1154	0.00	415	140	32	38	0.32	0.14	39	395	102	39	95	9.80	750.00
Avg	7.77	725	0.00	275	60	17	18	0.17	0.09	27	263	71	20	45	3.43	471.57

Annexure-IV: Ground Water Quality Calculation for Irrigation, Shallow aquifer

		S S P%	SAR	%Na	RSC	K I	Mg2+ Ratio
		$\text{Na} \times 100 / (\text{Ca} + \text{Mg} + \text{Na})$	$\text{Na} / \sqrt{(\text{Ca} + \text{Mg}) / 2}$	$((\text{Na} + \text{K}) / (\text{Ca} + \text{Mg} + \text{Na} + \text{K})) \times 100$	$(\text{HCO}_3 + \text{CO}_3) - (\text{Ca} + \text{Mg})$	$\text{Na} / (\text{Ca} + \text{Mg})$	$(\text{Mg}) / (\text{Ca} + \text{Mg}) \times 100$
Amarpur	Amarpur	31.70	1.54	32.12	-1.13	0.46	31.26
Bajag	Bijhauri	12.14	0.47	13.14	-0.57	0.14	27.61
Dindori	Dindori	18.33	0.77	19.00	-1.61	0.22	31.16
Bajag	Gadasarai	40.47	2.29	41.99	-1.59	0.68	33.25
Karanjiya	Gorakhpur	34.58	1.91	35.82	-0.20	0.53	21.53
Mehadwani	Harra	12.93	0.34	13.95	-0.63	0.15	46.86
Karanjiya	Karanjiya	17.62	0.68	18.10	-0.69	0.21	29.15
Shahpura	Katangi	42.53	2.47	43.32	1.22	0.74	26.54
Bajag	Sagar Tola	24.40	1.10	24.93	-1.79	0.32	32.67
Dindori	Salaiya	22.38	0.74	23.57	-1.22	0.29	39.70
Dindori	Shahpur	18.40	0.59	19.71	-0.47	0.23	30.83
Shahpura	Shahpura Depot	23.64	0.80	24.26	0.34	0.31	31.75
Shahpura	Shahpura	33.34	1.99	33.73	-1.20	0.50	40.58
Dindori	Vikrampur	19.69	0.94	20.57	-0.76	0.25	33.96
	Minumum	12.14	0.34	13.14	-1.79	0.14	21.53
	Maximum	42.53	2.47	43.32	1.22	0.74	46.86
	Average	25.15	1.19	26.01	-0.74	0.36	32.63

Formulae: -

Soluble Sodium Percentage (S S P%)= $\text{Na} \times 100 / (\text{Ca} + \text{Mg} + \text{Na})$

Sodium Absorption Ratio (SAR)= $\text{Na} / \sqrt{(\text{Ca} + \text{Mg}) / 2}$

%Na= $((\text{Na} + \text{K}) / (\text{Ca} + \text{Mg} + \text{Na} + \text{K})) \times 100$

Residual Sodium Carbonate (RSC) = $(\text{HCO}_3 + \text{CO}_3) - (\text{Ca} + \text{Mg})$

Kelley's Index (K I) = $\text{Na} / (\text{Ca} + \text{Mg})$

Mg2+ Ratio = $(\text{Mg}) / (\text{Ca} + \text{Mg}) \times 100$

Permeability Index (P I) = $((\text{Na} + \sqrt{\text{HCO}_3}) / (\text{Ca} + \text{Mg} + \text{Na})) \times 100$

Annexure-V: Ground Water Quality Calculation for Industrial use, Shallow aquifer

Block	Location	C O 3 ²⁻	HCO ₃ ⁻	Cl ⁻	SO ₄ ²⁻	Cl/35.5 0	2(SO ₄ /96)	((Cl/35.50+ 2(SO ₄ /96))	2(HCO ₃ +CO ₃ /100)	((Cl/35.50+2(SO ₄ /96))/2(HCO ₃ +CO ₃ /100)	((Cl/35.50+2(SO ₄ /96))/2 (HCO ₃ +CO ₃ /100)
Amarpur	Amarpur	0	268	85.00	22	2.39	0.46	2.85	536	0.005322201	0.0053
Bajag	Bijhauri	0	311	23.00	12	0.65	0.25	0.90	622	0.001443549	0.0014
Dindori	Dindori	0	256	45.00	26	1.27	0.54	1.81	512	0.003533735	0.0035
Bajag	Gadasarai	0	250	132.00	32	3.72	0.67	4.38	500	0.008769953	0.0088
Karanjiya	Gorakhpur	0	384	97.00	9	2.73	0.19	2.92	768	0.003801946	0.0038
Mehadwani	Harra	0	122	12.00	14	0.34	0.29	0.63	244	0.002580717	0.0026
Karanjiya	Karanjiya	0	268	35.00	19	0.99	0.40	1.38	536	0.00257789	0.0026
Shahpura	Katangi	0	415	90.00	7	2.54	0.15	2.68	830	0.003230174	0.0032
Bajag	Sagar Tola	0	244	65.00	27	1.83	0.56	2.39	488	0.004904684	0.0049
Dindori	Salaiya	0	128.0 0	32.00	24.00	0.90	0.50	1.40	256.00	0.005474252	0.005474252
Dindori	Shahpur	0	183.0 0	27.00	16.00	0.76	0.33	1.09	366.00	0.002988789	0.002988789
Shahpura	Shahpura Depot	0	226.0 0	12.00	11.00	0.34	0.23	0.57	452.00	0.001254856	0.001254856
Shahpura	Shahpura	0	409	140	12	3.94	0.25	4.19	818.00	0.005126726	0.005126726
Dindori	Vikrampur	0	397	57	17	1.61	0.35	1.96	794.00	0.002468263	0.002468263

Formulae: -

$$\text{Corrosivity Ratio (CR)} = ((\text{Cl}/35.50 + 2(\text{SO}_4/96)) / 2(\text{HCO}_3 + \text{CO}_3/100))$$

ACKNOWLEDGEMENT

The authors are grateful to the Central Ground Water Board (CGWB) for providing the assignment to prepare and write this report.

The authors are deeply indebted to Sh. Rana Chatterjee, Regional Director, CGWB, NCR, Bhopal for providing consistent encouragement, motivation, support, valuable guidance and advice in completing this assignment.

The authors are thankful to Smt. Rose Anita Kujur, Scientist-E, NCR, Bhopal for her valuable comments and suggestions.

A special thanks to Shri Kamlesh Birla, Young Professional for his unparalleled assistance in various forms.

The authors are thankful to Sh. Dr V K Kulshrestha, Scientist-B and the officers of Regional Chemical Laboratory, NCR, Bhopal for chemical analysis of the samples.

Lastly, the authors are also thankful to the officers, young professionals and officials of Central Ground Water Board, North Central Region, Bhopal for their guidance and cooperation from time to time.

ABBREVIATION

μS:	Microsiemens
°C:	Degree Centigrade
2-D:	2-Dimensional
3-D:	3-Dimensional
AR:	Artificial Recharge
bcm:	Billion Cubic Meter
BGC:	Bande Gneissic Complex
BIS:	bureau of Indian Standards
CD:	Check Dam
CGWB:	Central Ground Water Board
cm:	Centimeter
CR:	Corrosivity Ratio
DEM:	Digital Elevation Model
DIP:	District Irrigation Plan
E:	East
EC:	Electrical Conductivity
EFC:	Expenditure Finance Committee
ERT:	Electrical Resistivity Tomography are collected and compiled
EW:	Exploratory Well
GEC:	Groundwater Estimation Committee
GRP:	Gradient Resistivity Profiling
GSI:	Geological Survey of India
GW:	Ground Water
Ha:	hectare
Ham:	Hectare meter
IMD:	India Meteorological Department
KI:	Kelly's Index
Km:	Kilometer
l:	litre
lps:	Litre Per Second
M.P.:	Madhya Pradesh
m:	Meter

Max: Maximum

mbgl: Meter below Ground Level

mcm: Million Cubic Meter

mg: Milligram

MGNREGA: Mahatma Gandhi National Rural Employment Guarantee Act 2005

Min: Minimum

N: North

NAQUIM: National Aquifer Mapping

NB: Nala Bund

NCR: North Central Region

Nov: November

OW: Observation Well

PI: Permeability Index

PL: Permissible Limit

PMKSY: Pradhan Mantri Krishi Sinchayee Yojana

PT: Percolation Tank

PHED: Public Health Engineering Department

RS: Recharge Structure

RSC: Residual Sodium Carbonate

S: South

SAR: Sodium Absorption Ratio

Sq: Square

SSP: Soluble Sodium Percentage

TEM: Transient Electromagnetic

TH: Total Hardness

USSL: U.S. Salinity Laboratory

VES: Vertical Electrical Sounding

VP: Village Pond

W: West

WL: Water Level

REFERENCE

- CGWB, Govt of India, Manual on Aquifer Mapping.
- Aquifer Mapping and Ground Water Management Plan, Betul District, Madhya Pradesh; CGWB, NCR, Bhopal (2019-20)
- Aquifer Mapping and Ground Water Management Plan, Neemuch District, Madhya Pradesh; CGWB, NCR, Bhopal (2021-22),
- Aquifer Mapping and Ground Water Management Plan, Dindori District, Madhya Pradesh; CGWB, NCR, Bhopal (2022-23)
- CGWB, NCR, Govt of India and GWS, WRD, Govt. of MP, (2022), Dynamic Ground Water Resources of Madhya Pradesh.
- Reddy A G S, Material on Ground Water Chemistry.
- India Meteorological Department Customized Rainfall Information System (CRIS), (www.hydro.imd.gov.in).
- Geological Survey of India, Bhukosh (www.bhukosh.gsi.gov.in).
- Department of Agriculture, Govt. of Madhya Pradesh, District Irrigation Plan. (www.pmksy.gov.in).
- Farm Ponds: A Climate Resilient Technology for Rainfed Agriculture, Central Research Institute for Dryland Agriculture, Hyderabad

CENTRAL GROUND WATER BOARD

North Central Region, Bhopal

Department of Water Resources, RD & GR

Ministry of Jal Shakti

Government of India

Email: rdncr-cgwb@nic.in