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

ALIRAJPUR DISTRICT, MADHYA PRADESH

उत्तर मध्य क्षेत्र, भोपाल

North Central Region, Bhopal

भारत सरकार / GOVERNMENT OF INDIA

जल शक्ति मंत्रालय / MINISTRY OF JAL SHAKTI,

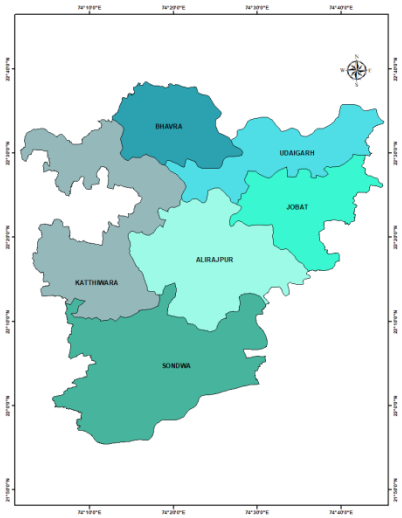
जल संसाधन, नदी विकास और गंगा संरक्षण विभाग

DEPARTMENT OF WATER RESOURCES, RD & GR

केन्द्रीय भूमि जल बोर्ड / CENTRAL GROUND WATER BOARD

जलभृत मानचित्र और भूजल प्रबंधन योजना, जिला अलीराजपुर, मध्य प्रदेश

Aquifer Mapping and Ground Water Management Plan, Alirajpur district, Madhya Pradesh



By

Lata Udsaiya, Scientist – C

Under the Supervision

A.K. Biswal, Head of Office

North Central Region, Bhopal

2022-2023

PREFACE

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

Under the project on National Aquifer Mapping (NAQUIM), Central Ground Water Board (CGWB) North Central Region, Bhopal has taken up Alirajpur district to prepare the Aquifer Maps for the entire district and formulate Aquifer Management Plan. Alirajpur district occupies an area of 3182.25 sq km, out of which the groundwater recharge worthy area is 3054.40 sq. km. and the rest is covered by hilly and forest area. Most of the district is drained by the Narmada drainage system. The district is mainly occupied by hard rock; comprising Deccan Traps, Vindhyans, Bijawars, and Archean. The water level in shallow aquifer during pre monsoon ranges from 4.27-13.95 mbgl and during post monsoon ranges from 2.70 -16.40 mbgl. As per the Dynamic Ground Water Resource Assessment Report (2022), the annual extractable ground water resource 185.82 MCM and groundwater draft for all uses are 86.02 MCM which results in the stage of groundwater extraction being 46.27 % as a whole for the district. After successful implementation of the supply-side and demand-side management plan the stage of extraction in Alirajpur district is expected to improve condition of the district in terms of ground water. The interventions suggested in the report will not only have a positive impact on the groundwater regime but would also play a key role in augmenting the net cropping area and would ultimately enhance the agricultural productivity and economy of the district.

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

A.K. Biswal
(Regional Director)

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CHAPTER - 1
INTRODUCTION

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

1.1 Objectives

The objective of this study is

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

1.2 Scope of Study

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

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

1.3. Approach and Methodology:

To achieve the above objective the following approach has been adopted and given in the methodology flow chart diagram. The major activities involved in this process is compilation of data, data gap analysis, data generation, data integration, preparation of maps and 3-D aquifer model, 2D sections of the district and finally aquifer management plan of the study area.The data acquisition supported by geological, geophysical and hydro-chemical investigation with groundwater exploration to the depth of 200 mt.This study was taken during Covid pandamic period andthereforebecause of the restrictions in physical movements, the report is prepared on the basis of existing 28 Key well established during the pre-monsoon and 2 piezometers, drilled by CGWB, Bhopal, Madhya Pradesh.

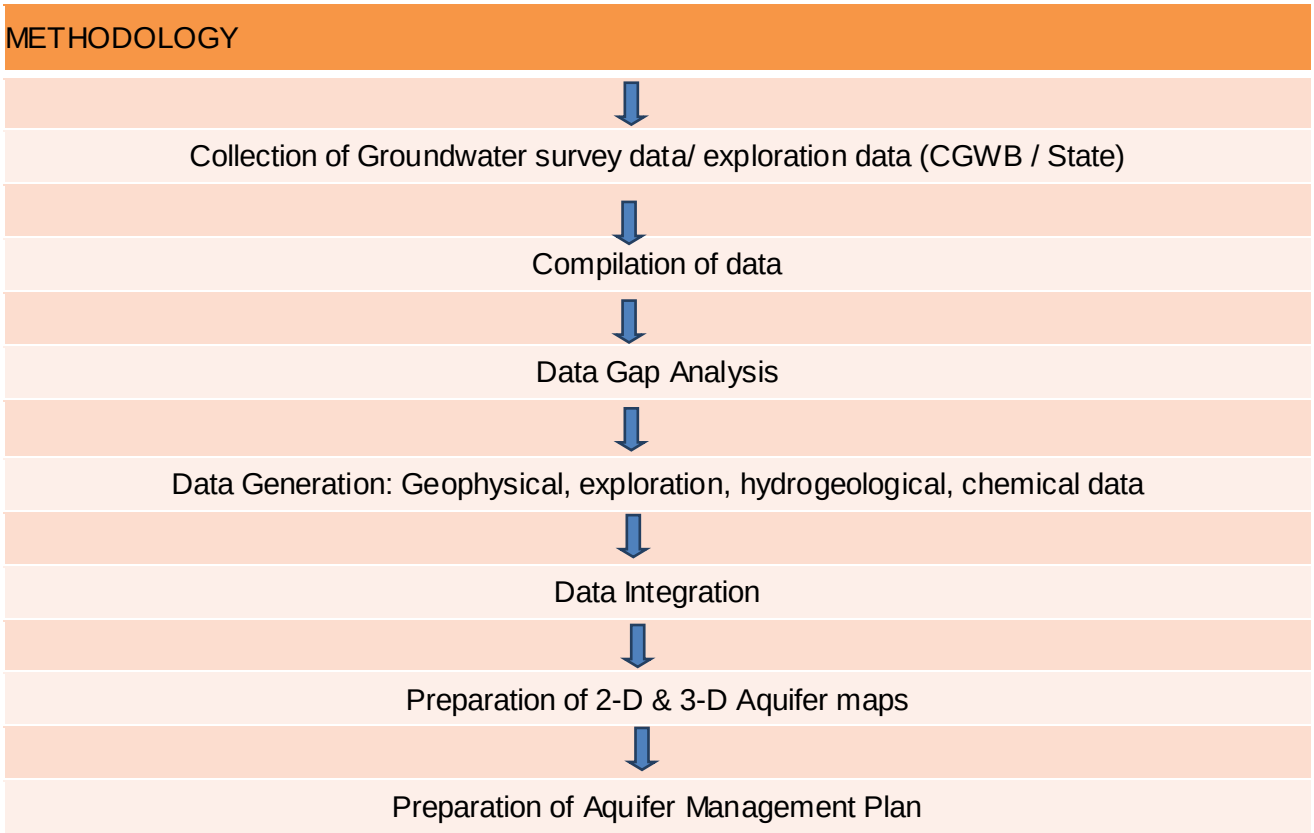


Fig - 1: Methodology flow chart

1.4 Study Area

Alirajpur district is one of the 52 district of Madhya Pradesh state and it was created from the Alirajpur, Jobat and Bhabra tehsils of the former Jhabua district on 17 the May 2008. The district is named after its headquarters, Alirajpur, which was the capital of the former princely state of Ali Rajpur. The name of this town is derived by conjoining Ali (the fortress town and the former capital of the

princely state founded by Anand Deo in 1437) and Rajpur (the latter capital). Alirajpur district administratively comes under the Bhopawar Agency subdivision of Central India Agency. It lies in the Malwa region of Madhya Pradesh, near the border with Gujarat and Maharashtra. The district is hilly, and consists of tribal people as majority of population who live in small villages near Alirajpur. However, the towns population mainly consists of general people. It was under British administration from time to time. The Victoria Bridge at Alirajpur was built to commemorate the Diamond Jubilee in 1897. The Rajwara fort is situated in the centre of the town attached with a beautiful playground known as Fateh Club. Alirajpur is also the hub for dolomite business. Bhabhara is a village in the Jobat Tehsil lying at a distance of 32 km north-west of Jobat on Jobat-Dohad road. The place is popular as a tourist destination because the famous freedom fighter Chandra Shekhar Azad was born in Bhabhar. Presently a small memorial has been erected in his Bhabhara in his honour. The Alirajpur is a District of M.P., is located at Latitude 22°18'19' N and Longitude 74°21'9' E and Altitude 455 MSL at the East central border of Madhya Pradesh about 225 km from Indore.

According to the 2011 census Alirajpur district has a population of 728,677, roughly equal to the nation of Bhutan or the US state of Alaska. The district has a population density of 229 inhabitants per square kilometer (590 /sq mi). Its population growth rate over the decade 2001–2011 was 19.4 per cent. Alirajpur has a sex ratio of 1,009 females for every 1,000 males, and a literacy rate of 37.22 per cent, the lowest in India.

This district comprises three tehsils: Alirajpur, Jobat and Bhabra. Alirajpur is connected to Dohad station of Western Railway on Ratlam-Baroda Section by 70 km and 65 kmlong all weather roads respectively. Jobat is also connected to Meghnagar station of Western Railway on the same section by 80 km all weather road. Alirajpur is 33 km from Jobat and from Indore by 135 km.

The territory hilly and many of the inhabitants is Bhil's. Being tribal dominated community Alirajpur area was being ruled by tribal kings in the 15th century. After the freedom in 1947, Alirajpur territory was absorbed into the Indian Union. After that area became a part of Madhya Pradesh administrate. After construction of Madhya Pradesh on 1st November 1956 Alirajpur came into the Jhabua district. Chief Minister Shri Shivraj Singh Chauhan declared Alirajpur a separate district in 2008 and thus a new administrative unit, Alirajpur was formed. It has total area of 3182.25 sq. km. The administrative headquarter of the district is Alirajpur and district is divided into 05 tehsils, 06 janpads and 288 Gram Panchayats, there are 01 Municipalities and 02 Nagar Panchayats and 1 Census Towns in the District. Total villages in the district as per Census 2011 are 551 out of which 547 are inhabited and 4 are uninhabited villages. The district is the basic territorial unit of administration in the state as well as in India. The Collector, as the head of the district administration is the key functionary of the Government, having vast powers and wide responsibilities. He is the custodian of law and order and the pivot of local administration. There are two assembly constituency and one loksabha constituency fall in the district.

Table 1: Adminstrative Details of the district

S.No.	Particulars	Numbers
1	Area (sq km)	3182
2	Revenue Villages	552
3	Total Habitations	548
4	Forest Villages	00
5	Town	03
6	Tehsils	05
7	Develoment block	04
8	Gram Panchayat	288
9	Nagar Palika	03
10	Agro Climatic Zone	Jhabua Hills

(Source: District Statistical Book, Alirajpur, 2015)

Table 2: Demorapghy - Blocks, Tehsils & Gram Panchayats in the district

S.No.	Area (sq km)	Tehsil	No of GPs
1	Alirajpur	Alirajpur	53
2	Sondawa	Sondawa	74
3	Katthiwada	Katthiwada	49
4	Jobat	Jobat	38
5	Udaygarh		40
6	Ch S.A. Nagar	Ch S.A. Nagar	34
	Total		288

(Source: Distt Statistical Book, Alirajpur 2015)

Table 3: District Profile

District Code	465
Total Geographical Area (sq km)	3318.40
Recharge worthy Area (sq km)	3054.40
Hilly/Forest (sq km)	264.00
Total number of revenue villages	551
Total Number of Gram Panchayat	288
Total Number of Blocks	6
Total Population	728999

Population Growth Rate (Decadal)	19.45
Total Male Population	362542
Total Female Population	366457
Total Livestock	1368177
Poultry	663513
Surface water (bcm)	0.810
Ground water (bcm)	0.2056
Area under agriculture use	1800
Net sown area	1800
Gross cropped area	2098.48
Net irrigated area(Rabi/Kharif)	378.67
Net Rainfed rea	1800

(Source: Distt Statistical Book, Alirajpur 2015)

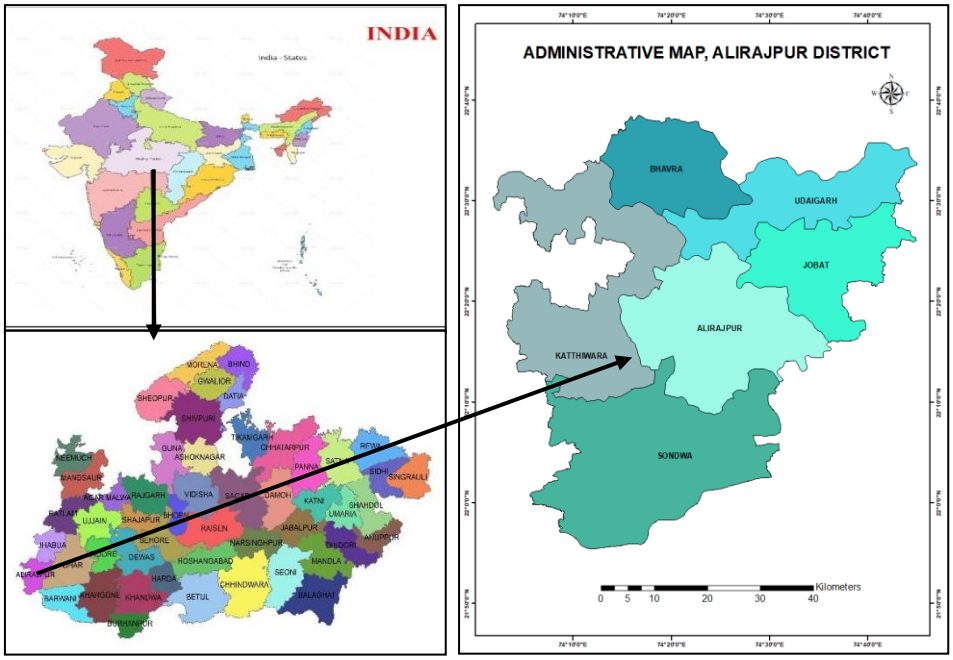


Fig - 2: Index Map of Alirajpur district

1.5 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 districtis about 912.8 mm. Most of the rainfall occurs in monsoon season while there is also a little of rain fall in winter season.

A hot summer and general dryness characterize the climate of Alirajpur district, except during the southwest monsoon season. The year can be divided in to four seasons. The winter commences from middle of November and last still 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 south west monsoon starts from middle of June and last still end of September. October and middle of November constitute the post monsoon or retreating monsoon season.

Table 4: Rainfall Data Previous 5-year month wise (in mm)

Month	Alirajpur									
	2011-2012		2012-2013		2013-2014		2014-2015		2015-2016	
	Total	Average	Total	Average	Total	Average	Total	Average	Total	Average
June	76.80	12.80	114.40	19.10	1282.10	213.70	104.40	17.40	1338.50	223.10
July	1529.90	255.00	1078.10	179.70	3026.40	504.40	2235.60	372.60	2586.50	431.10
August	2078.70	346.50	2930.90	488.50	1785.20	297.50	1818.80	303.10	356.70	59.50
September	412.40	68.70	1801.40	300.20	2565.70	427.60	1681.20	280.20	665.80	111.00
October	0	0	34.20	5.70	504.50	84.10	34.80	5.80	44.10	7.40
November	0	0	0	0	0	0	0	0	33.40	5.60
December	0	0	0	0	0	0	0	0	0	0
January	0	0	0	0	65.40	10.90	0	0	1.60	0.30
Feburary	0	0	0	0	31.40	5.20	3	0.50	0	0
March	0	0	0	0	153.20	25.50	0	0	0	0
April	0	0	51.20	8.50	0	0	0	0	0	0
May	0	0	0	0	0	0	0	0	0	0
Total	**4097.80**	**683.00**	**6010.20**	**1001.70**	**9413.90**	**1569.00**	**5877.80**	**979.60**	**5026.60**	**837.85**

Average Annual Rainfall of Previous 5 years				
2011-12	**2012-2013**	**2013-2014**	**2014-2015**	**2015-2016**
683.00	1001.70	1569.00	979.60	837.85

Table 5: Rainfall Data for the 5 years (2016 to 2020)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	Total Annual Rainfall
	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	
	(mm)												
2016	2.60	0	1.50	0	19.80	136.50	309.80	347.30	196.50	79.90	0	0	1093.90
2017	0	0	0	0	0	144.40	357.70	193.90	62.80	12.80	0	15.70	787.30
2018	0	0	0	0	0	82.90	230.80	296.80	77.70	0	0	0	688.20
2019	0	0	0	2.90	0	84.00	338.10	686.40	286.00	83.40	40.10	0	1520.90
2020	0	0	4.50	0	0	161.40	150.00	437.40	189.90	12.20	0	22.90	978.30

(Source: Indian Meterological Website)

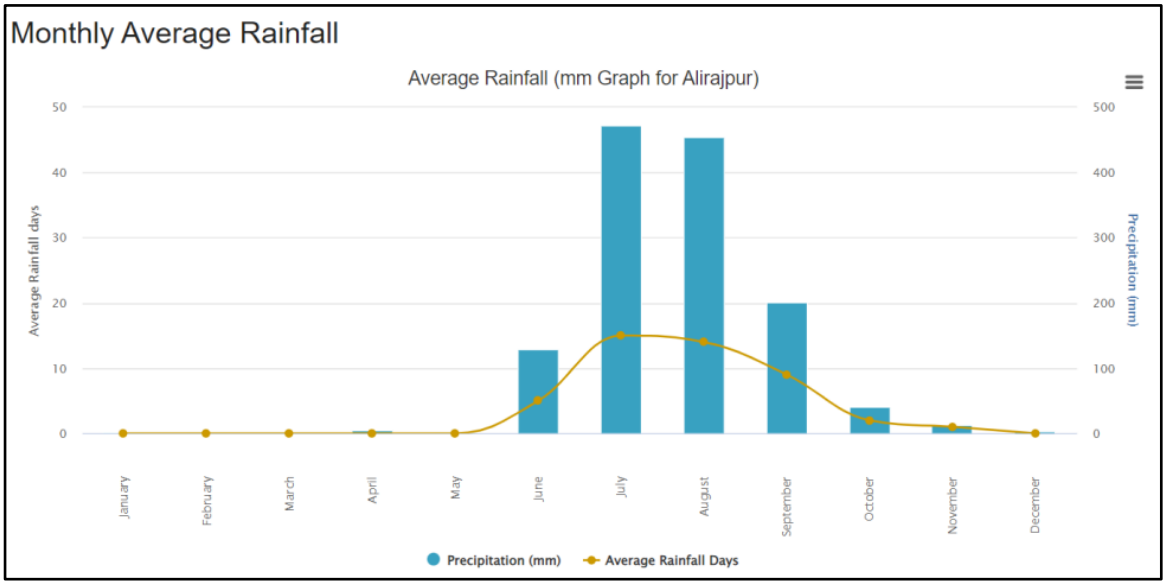


Fig - 3: Monthly Average Rainfall Graph of Alirajpur district

1.6 Temperature, Humidity & Wind velocity

The temperature starts rising from the beginning of February and reaching maximum inthe month of May. The normal annual mean maximum temperature is 32.8^{0}C and normal annual mean minimum temperature is 19.1^{0}C.

Table 6: Wind velocity, Rainfall, Humidity, cloud and Pressure, Alirajpur district

Year	Wind	Rain	Humidity	Cloud	Pressure
2009	12 km/h SW	0.8 mm	80%	90%	1005 mb
2010	11 km/h SSW	8.0 mm	85%	85%	1000 mb
2011	12 km/h WSW	6.1 mm	82%	72%	1001 mb
2012	16 km/h WSW	3.6 mm	87%	83%	1004 mb
2013	11 km/h WSW	48.2 mm	90%	72%	998 mb
2014	17 km/h SSW	0.7 mm	79%	75%	1001 mb
2015	17 km/h WSW	11.4 mm	85%	66%	1008 mb
2016	15 km/h WSW	27.9 mm	94%	79%	1000 mb
2017	18 km/h SW	1.8 mm	75%	55%	1006 mb
2018	19 km/h WSW	0.8 mm	74%	55%	1005 mb
2019	22 km/h WSW	21.1 mm	90%	70%	1001 mb
2020	18 km/h WSW	22.5 mm	81%	69%	1002 mb
2021	23 km/h WSW	9.1 mm	89%	82%	1001 mb

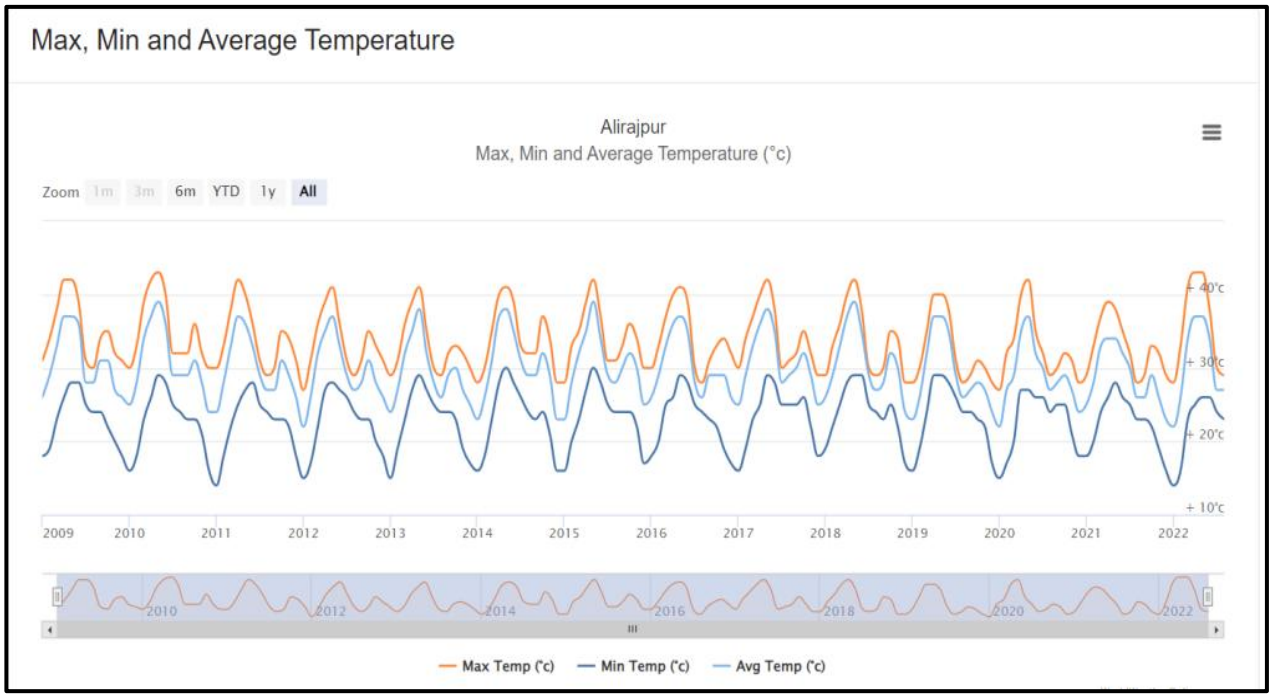


Fig - 4: Maxiumum, Minimum and Average Temperature Graph of Alirajpur district

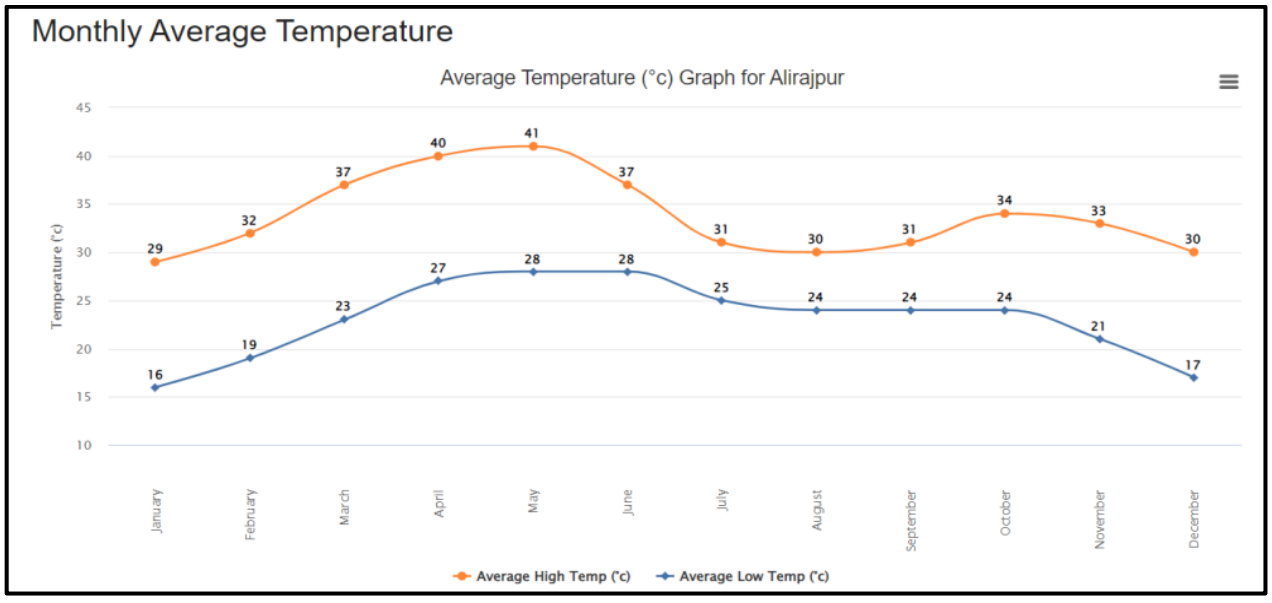


Fig - 5: Monthly Average Temperature Graph of Alirajpur district

During the south west monsoon season the maximum humidity is observed in 2014 which is 91 % and minimum humidity observed in 2017 which is 63 %. The driest part of the year is the summer season, when relative humidity's is very less. April-May is the driest month of the year.

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

The wind velocity is higher during the pre-monsoon period as compared to post monsoon period. In 2019 the maximum wind velocity 20 kh/hr observed during the month of April and May andin 2017 minimum wind velocity observed 5 km/hr during the month of December in the last 10 years. *(Source: worldwateronline.com)*

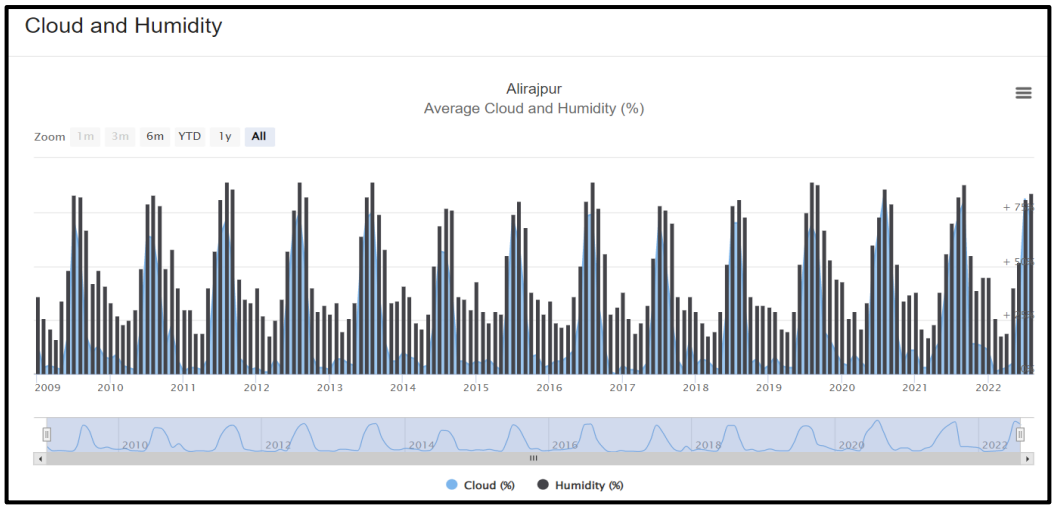


Fig - 6: Cloud and Humidity Graph of Alirajpur district

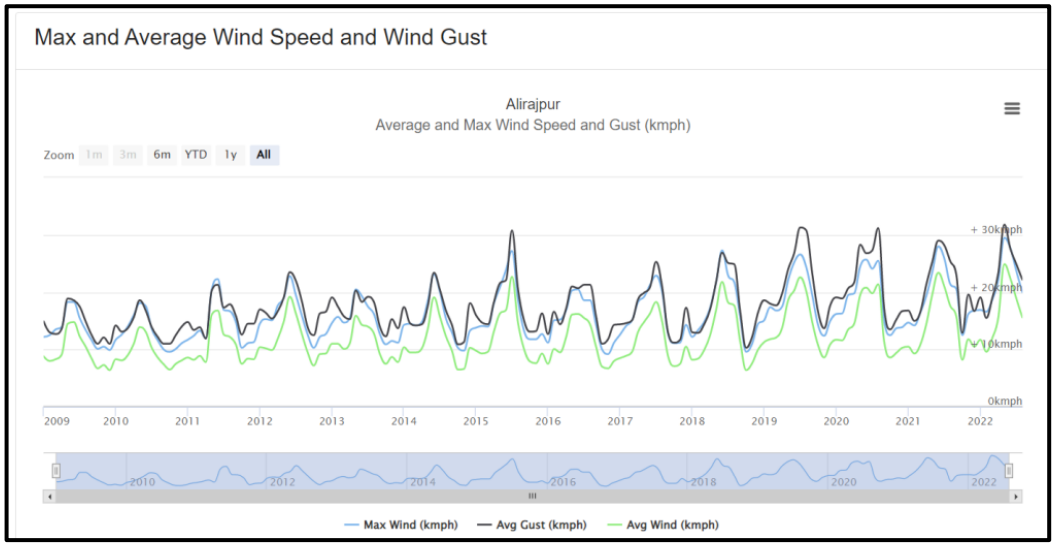


Fig - 7: Maximum and Average Wind Speed and Wind Gust Graph of Alirajpur district

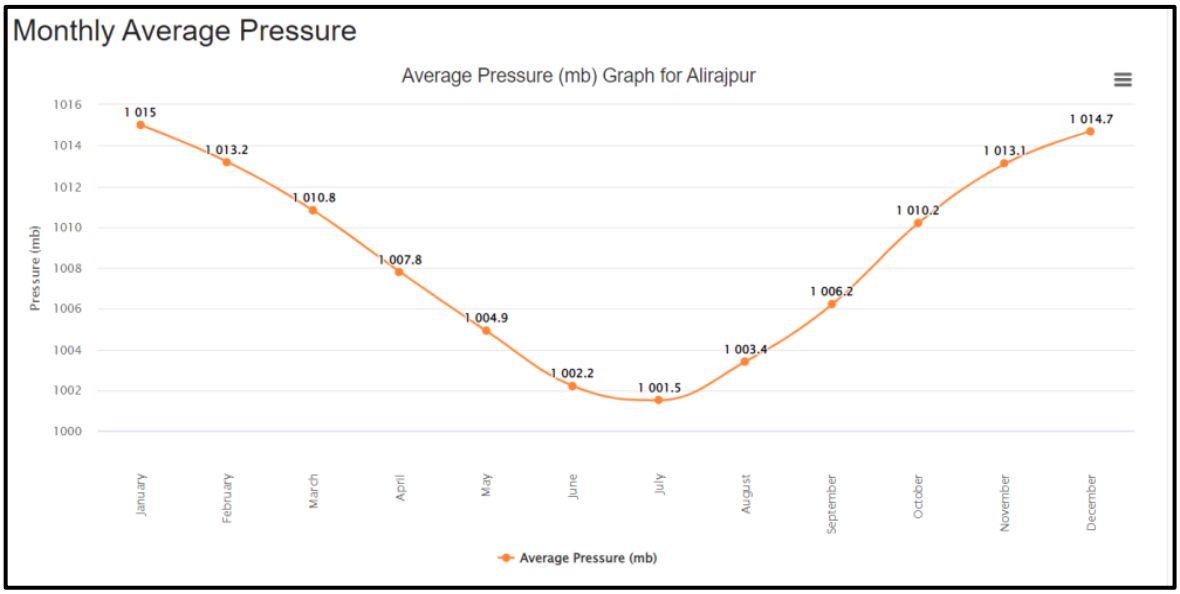


Fig - 8: Monthly Average Pressure Graph of Alirajpur district

1.7 Agro-climatic Zone (ACZ) in Alirajpur District:

Agroclimatic Agro-ecological Zone Situation JhabuaHPills, (AES-1) Jhabua Hills, (AES-II) 11 thAgro Climatic Zone Jhabua Hills, Total Area Jhabua Hills, (AES-III) Blocks covered Jobat,Udayagd &Ch.S.A. Nagar Alirajpur & Kattiwada Area in ha. 97149, 1492777978444545, 71799, 318225. Soil Type medium black to red yellow soil red sandy loam, to red yellow mostly red sandy loam.

Table 7: Agro Climatic Zone (ACZ) IN Alirajpur district

Agro Climatic Zone	Block Covered	Area in Ha	Soil Type
Agro Climatic Zone, Jhabua Hills	Jobat, Udavaged, Ch.S.A. Nagar	97119	Medium Black to yellow soil
	Alirajpur	149277	Red sandy, loam to red, yellow
	Kattiwada	71799	Moatly red sandy loam
		318225	

(Source: Distt Statistical Book, Alirajpur 2015)

1.8 PHYSIOGRAPHY / DEM AND GEOMORPHOLOGY

PHYSIOGRAPHY

Alirajpur 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 density of the hills is in the southern part of the district in Alirajpur tehsil & Katthiwada tehsil. The maximum elevation of 777 m. amsl is recorded near Mathwar village in Sondwa Tehsil. The general trends of the hills are in east-west direction. Alirajpur district lies in the major basins, the Mahi in the north and the Narmada in the south. The Narmada River forms the southern boundary of the district with a westerly flow of water. The major tributaries having their confluence with the Narmada are Hatni, Ankhar, Sukar, Orsang, Heran, Kara and Bagh. Narmada River, 50 km long in the district, along with its tributaries drains 48% of the geographical area.

Younger Coastal Plain Younger Deltaic Plain Highly Dissected Hils and Valleys Highly Dissected Lower Plateau Highly Dissected Upper Plateau Low Dissected Hills and Valleys Low Dissected Lower Plateau Low Dissected Upper Plateau Mass Wasting Products Moderately Dissected Hills and Valeys Moderately Dissected Lower Plateau Moderately Dissected Upper Plateau Pediment-Pedplain Complex Piedmont Slope Active Flood Plain Bajada.

Highly Dissected Hills and ValeysStron-Highly Cissected Lower Plateau Stron-Highly Dissected Upper Plateau Low Dissected Hills and Valleys Low Dissected Lower Plateau Low Dissected Upper Plateau Moderately Dissected Hills and Valeys Moderately Dissected Lower Plateau Moderately Dissected Upper Plateau Undefined.

The district extends over three physiographic divisions viz.,

1. The Malwa plateau in the north.

2. The Vindhyachal range in the central zone.

3. The Narmada vally along the southern boundary.

It is situated between 350 m.msl. to 550 m.msl. The highest peak attains the height of 751 m. msl at. The area is undulating plain underlain by various lava flows of Deccan Trap. The area near Bagh &kukshi is covered by Bagh &Lameta sandstone. The main soil types developed in the area are black cotton soils, loamy soils and lateritic soils.

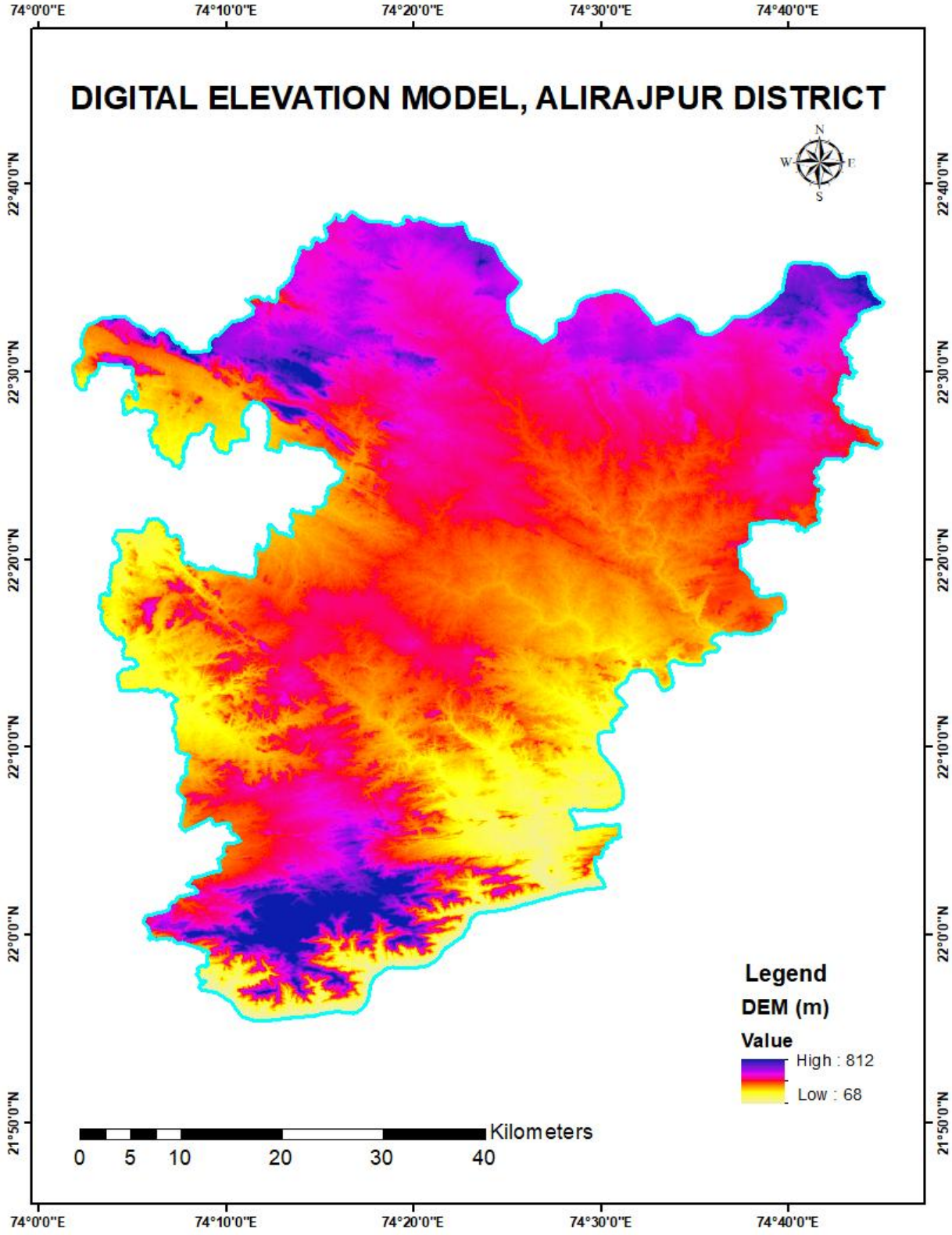


Fig - 9: Digital Elevation Model of Alirajpur district

GEOMORPHOLOGY

Alirajpur 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 density of the hills is in the southern part of the district in Alirajpur tehsil. The maximum elevation of 777 m. amsl is recorded near Mathwar village in Sondwa block. The general trends of the hills are in east-west direction. Alirajpur district lies in the major basins, the Mahi in the north and the Narmada in the south. The Narmada River forms the southern boundary of the district with a westerly flow of water. The major tributaries having their confluence with the Narmada are Hatni, Ankhar, Sukar, Orsang, Heran, Kara and Bagh. Narmada River, 50 km long in the district, along with its tributaries drains 48% of the geographical area. The area included extremely hilly area comprising number of parallel ranges rising abruptly from the level ground. The area is undulating with a number of small hillocks rising 10 to 30 m. above the surrounding country. The highest point here is 1430 ft. above M.S.L

1.9 HYDROLOGY AND DRAINAGE

Area has a general slope towards south. Alirajpur district lies in the major basin of the Narmada river and forms the southern boundary of the district with the westerly flow of water. Marmada river has a length of 50 km in the district. The area is well water divide by number of streams, rivers and rivulets and shows the drainage of dendritic type. The perennial river Narmada flows through the area and important tributaries area Hathni, Sukar and Ankhai. Narmada is the major river in Central India and fifth largest river in the India after Ganga river, Godavari river, Krishna River, Yamuna River. It is also called as life line of Madhya Pradesh for its huge contribution to the state of Madhya Pradesh. Hatni river is also one of the major river flowing in the district, river forms the eastern boundary of the district and flows from north to south direction. The catchment of Hatni river is biggest than the other river in the district. Hatni river joins the Narmada in the south near Jandhan village. Total length of the river is abou 110 km in the Alirajpur district. The area drained by theHatni river is about 829.27 sq km (24.92 % of the total area), area drained by Ankhai river is about 505.34 sq km (15.18 % of the total area), area drained by the Narmada is 231.77 sq km (6.96 % area of the total district). The other streams of micro watershed drained in the area is 1294 sq km.

Table 8 : Catchment Area of the Rivers flowing in the Alirajpur district

S.No.	Name of the River	Area drained (sq km)	% Area drained in the district
1	Hatni River	829.27	24.92
2	Ankhai River	505.34	15.18
3	Narmada River	231.72	6.96
4	Sukar River	467.44	15.04

(Source: District Survey Report, Alirajpur 2016)

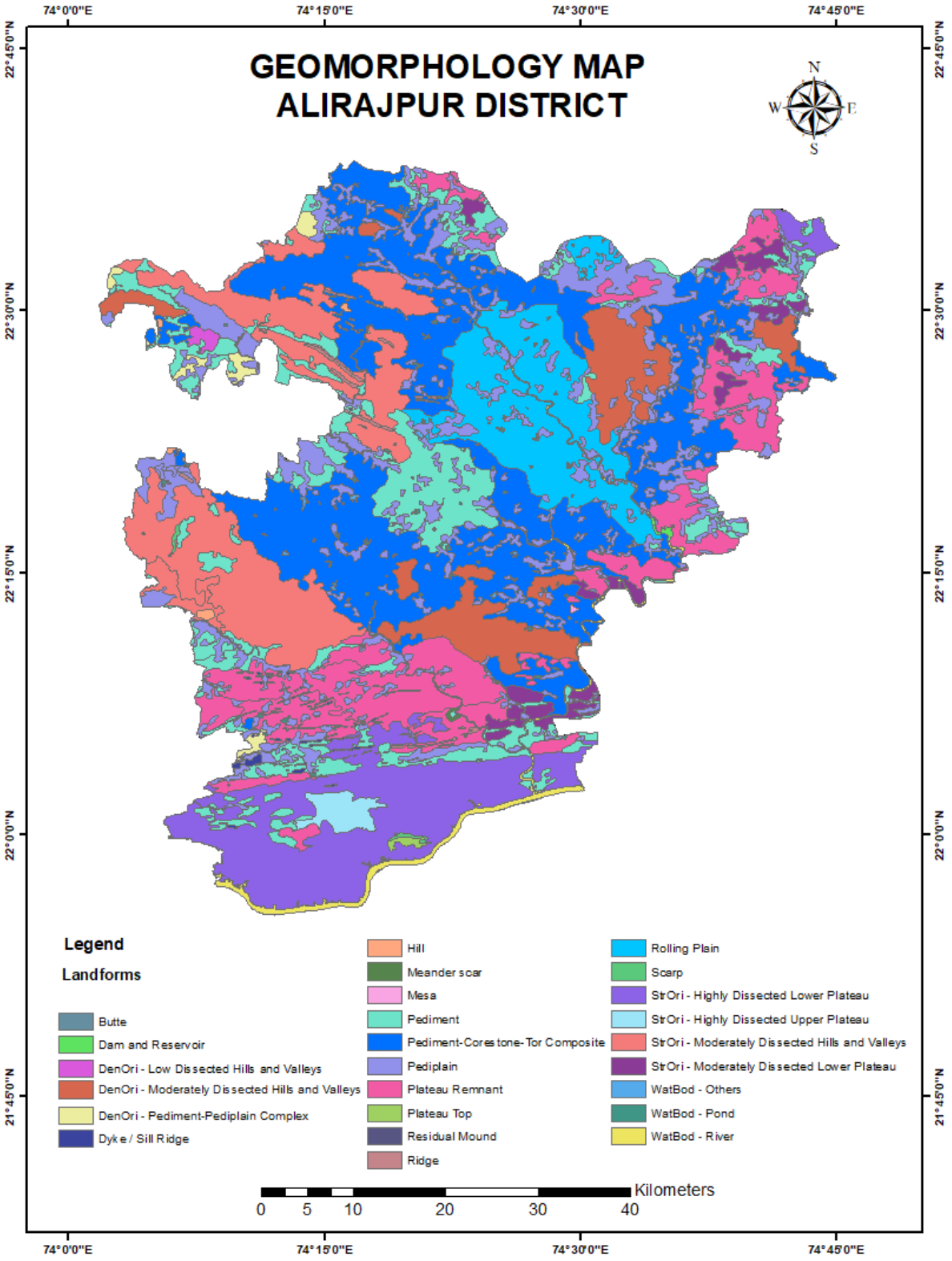


Fig - 10: Geomorphology map of Alirajpur District

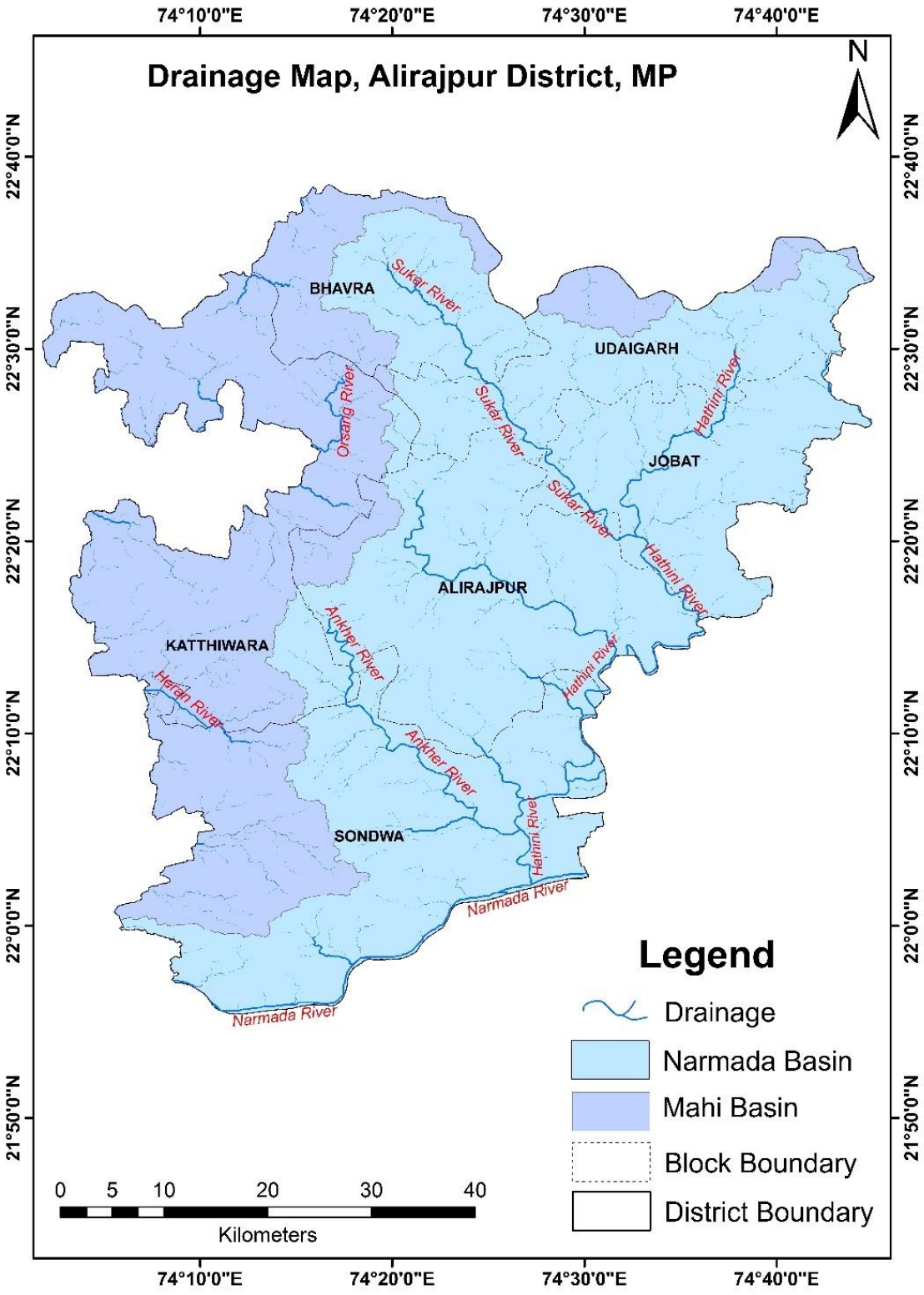


Fig - 11: Drainage Map of Alirajpur district

1.10 SOIL COVER

The district characterized by deep soils, medium deep and shallow soils with the area of 49,000, 90,000, and 179200 hac. with percentage of total area 15.4 %, 28.3 %, and 56.3 % respectively. All soil is low in organic carbon and phosphorus medium black to red soils covers AES I, red sandy loamy to red yellow covers AES II and AES III area comes under mostly red sandy loam, red yellow, alluvial and mixed soils.

oil Soil texture is an expression of the physical composition of soil. Technically, it refers to the relative proportions of the various size groups of primary soil particles, such as Medium black, Red Sandy Loamy and Mostly sandy loam & alluvial mixed soil in a mass of soil. An admixture of sand and sandy loam in various proportions gives rise to a definite texture. The textural class of loam is considered an ideal combination Depending on the proportions of sand and sandy loam, may have several subclasses. Thus, a loam in which sand is dominant is classified as sandy loam, the loam in which sandy loam is dominant is classified as medium black and red yellow sandy loam when is dominant, it is called as Red yellow alluvial mixed soil. Soil texture is different in various parts of Alirajpur district. Medium black to yellow and Red sandy loamy to red yellow soil is found on the slopes of Jhabua hills.

Table 9: Table Soil Profile

	Soil Type		**Land slope**			
Name of the Block	**Major Soil Classes**	**Area (Ha)**	**0-3% (Ha) Very Gently Sloping**	**0-3% (Ha) Moderately Sloping**	**0-3% (Ha) Moderately steep Sloping**	**>25 % (Ha) Very Higher Sloping**
Alirajpur	Red Sandy Loamy to Red Yellow	149277	68259	183361	8623	57982
Sondwa						
Katthiwada	Mostly sandy loam and Alluvium mixed Soil	71799				
Ch.S.A. Nagar	Medium black to yellow	97149				
Jobat						
Udaygarh						
District Total		318225		-		

Table 10: Soil Type

Map Unit	Surface Texture	Area	
		Ha	%
1	Medium black to yellow	97149	32.91
2	Red Sandy Loamy & alluvium mixed soil	149277	45.48
3	Mostly sandy loam & alluvium mixed soil	71799	21.61
	Total		100.00

1.10.1 Soil Depth

The soil depth is of vital importance for plant growth as it provides foothold to plant to draw the required water and nutrients from underground soil. As such, the greater soil depth normally results in better plant growth, It takes about 500-1000 years to develop one inch thick soil from the hard basement rock due to different action and interaction of various soil forming factors and processes. However, a very little time is required to erode this soil layer if the canopy protecting it, is removed. The depth of soil, therefore, depends largely on the stage and conditions responsible for soil formation and soil erosion. The soil depth varies from 0< 22.5 cm (shallow) to more than 90 cm (deep) the depth of soil affects rootdevelopment, available water capacity (AWC), and nutrient availability in soil. The proliferation of roots largely depends on soil depth. If the depth is inadequate, the roots do not get sufficient space to elongate, affecting water uptake during rain free period. In shallow soils, because of limited volume availability, the roots are shorter and become thicker and sturdy affecting adversely the physiological functions of the plant.

Table 11: Soil Depth Classes	
Depth Class	**Depth (m)**
Very Shallow	0 - 7.5 cm
Shallow	7.5 - 22.5 cm
Modestly Deep	22.5 - 45.0
Deep	45.0 - 90.0 cm
Very Deep	More than 90

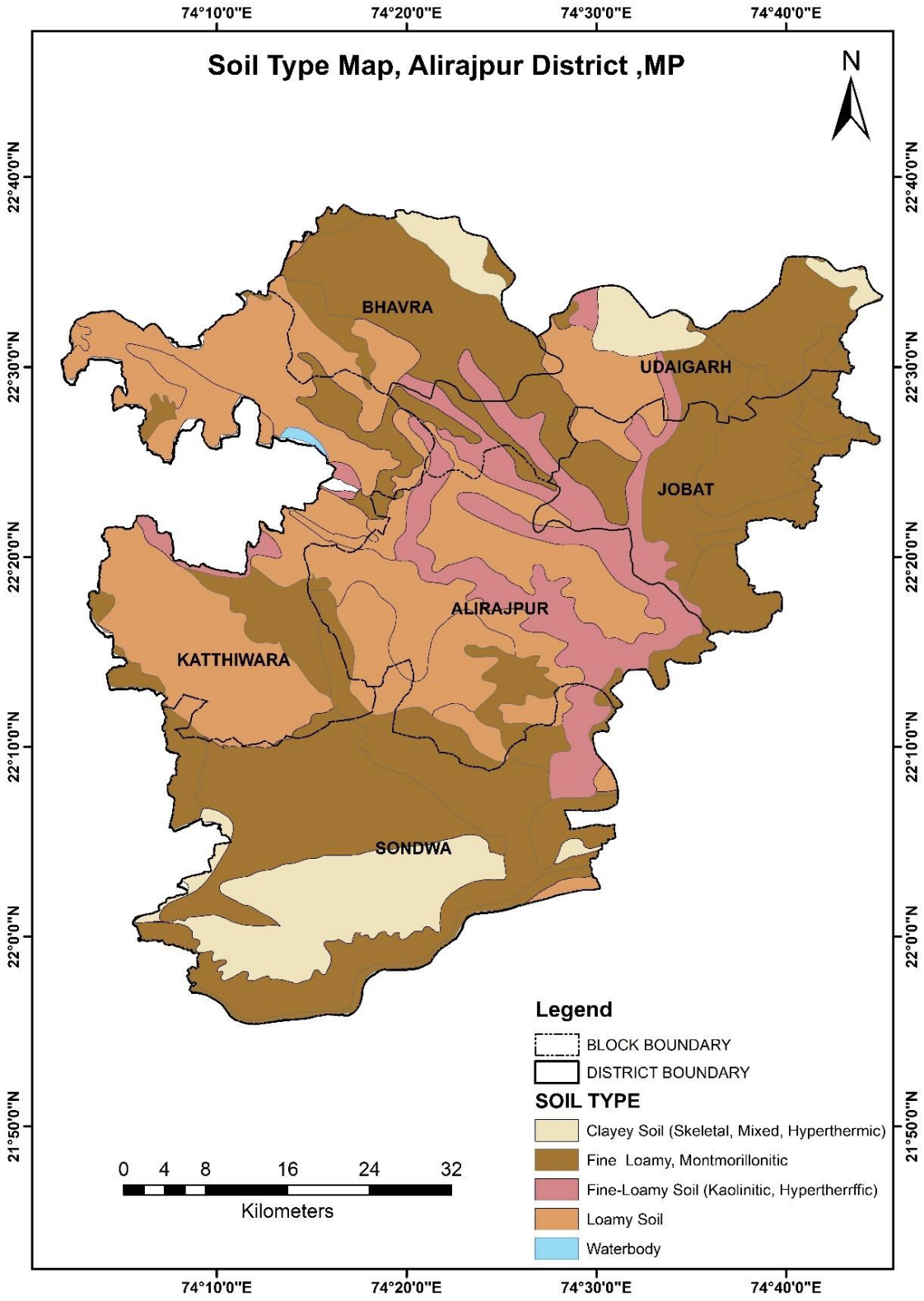


Fig - 12: Soil Map of Alirajpur district

1.11 GEOLOGY

The area forms a part of the south-eastern extension of the Archaeans of Rajasthan. The Archaean group is overlain unconformably by Cretaceous sedimentary deposits. A major part of the area included is covered by granites and the other types such as dolomitic marble and granulites and the other types occupied by chlorite and other schists, granites and associated gneisses and sedimentaries (Bagh beds?) In the district varied tyoe of lithology has been encountered which includes majorly Basalts, limestone, sandstone, dolomite, quartz vein, granite, schist, phyliite which include igneous, metamorphic and sedimentary rocks.

The stratigraphic sequence worked out in the area is presented below:

Cretaceous Grits and	Bagh (?) Beds	Limestone (highly siliceous and fossiliferous) sandstone (often calcareous and ferruginous). Conglomerate
	Unconformity	
	Intrusives	Dolerites Pegmatite and Quartz veins. Migmatites Granite Amphibolites and granulites.
Archaeans		Quartzites Calciphyres Dolomitic Marbles Chlorite schists often garnetiferous.
	Metasediments	Talc chlorite schists Graphite schists

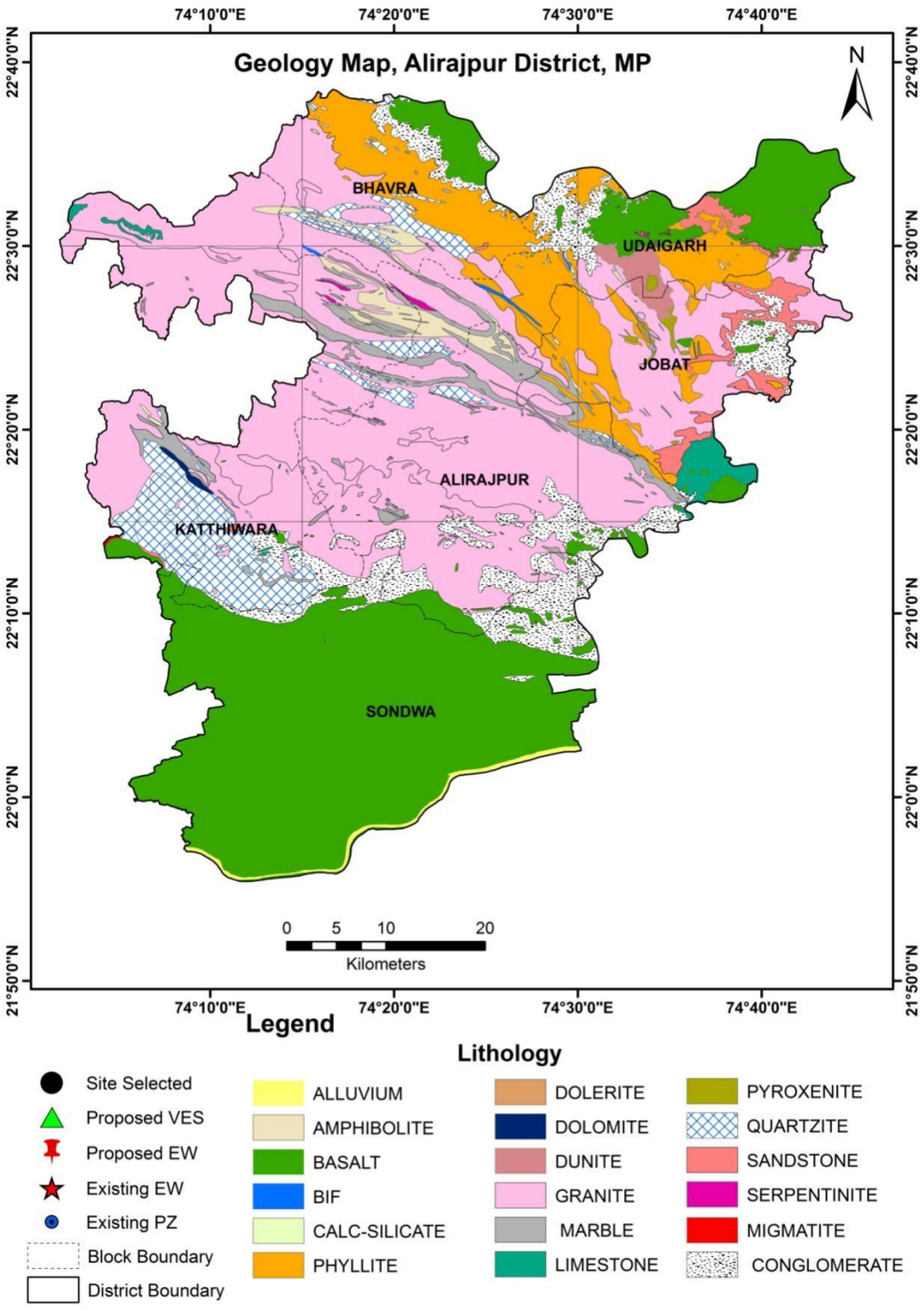


Fig - 13: Geology Map of Alirajpur district

Flora and Fauna: Bhil and Bhilala is a tribe in the Alirajpur district primarily depend upon the medicinal plants of their surrounding for the treatment of their ailments. Living close to the nature these tribal communities have acquired unique knowledge about the uses of wild flora and fauna. Therefore, medicinal plants and its parts are excellent sources of the medicine. An ethno medicinal use of plants used by the tribes of Alirajpur district. In the south of the district, Mathwad region surrounded by the Vindhyan mountain range is the dense area of wild animals, bear, rabbit, lion, Panther, Tiger can be seen near the famous temple of Kajalrani.

1.12 LAND USE, IRRIGATION, AND CROPPING PATTERN

The total arable land of Alirajpur district is 318225 ha, out of which, the irrigated area is about 21%. The major crop grown in Kharif season are Blackgram, maize, bajra, soybean, jowar, pigeonpea and wheat, chickpea are the crops in Rabi season. The net sown area in the district is 171981 Ha, area sown more than once is 179291 Ha, gross cropped area is 209848 Ha, area under forest is 49267 Ha, area under waste land is 621 Ha, area under other uses is 197029 Ha. The net irrigated area in the entire district is 37867 Ha and gross irrigated area (all sources) is 37897 Ha whereas the rainfed area partially irrigated is 0 ha and unirrigated (totally rainfed area) is 171981 ha.

Table 12: Land Use Pattern

Name of the block	No of villages	Total Geographical area	Area under agriulture				Area Under Forest	Area Under wasteland	Area Under other uses
		Ha							
			Gross cropped area	Net Sown area	Area sown more than onces	cropping intensity (%)			
Alirajpur	89	68917	51089	41625	9464	122.73	5998	116	9151
Sondwa	134	87050	38172	34207	3965	111.59	8376	101	8249
Katthiwada	125	71762	28130	23450	4680	119.95	34375	37	15542
Ch.S.A. Nagar	54	29073	28443	22598	5845	125.86	380	59	39446
Jobat	63	51770	32106	25063	7043	128.10	25	215	21271
Udaygarh	86	33721	31908	25038	6870	127.43	113	96	15394
Total	551	318225	209848	171981	37867	122.01	49267	621	197029

Table 13: Land Use Pattern

S.No.	Particulars	Details
1	Arable Land	180000
2	Irrigated Agriculture Land	37867
3	Non irrigated area	175000
4	% of Irrigated Land	21%
5	Total waste land	4562

Table 14: Area wise, crop wise irrigation															
Crop Type	**Kharif (area in Ha)**			**Rabi (area in Ha)**			**Summer crop (area in Ha)**			**Total (area in Ha)**			**Horticulture & Plantation crops (area in Ha)**		
	Irrigated	**Rainfed**	**Total**	**Irrigated**	**Rainfed**	**Total**	**Irrigated**	**Rainfed**	**Total**	**Irrigated**	**Rainfed**	**Total**	**Irrigated**	**Rainfed**	**Total**
Cereals	0	55900	55900	25500	0	25500	0	0	0	25500	55900	81400	0	0	0
Coarse cereal	0	14350	14350	0	0	0	20	0	20	20	14350	14350	0	0	0
pulses	0	66870	66870	10600	0	10600	200	0	200	10800	66870	77670	0	0	0
Oil seeds	0	35910	35910	0	0	0	500	0	500	500	35910	36410	0	0	0
Fibre	0	5930	5930	0	0	0	0	0	0	0	5930	5930	0	0	0
Fruits	0	134	134	0	0	0	0	0	0	0	134	134	22	4544	4566
Vegetables	0	524	524	0	0	0	0	0	0	0	524	524	1666	1645	3311
Flowers	0	0	0	0	0	0	0	0	0	0	0	0	363	36	399
Spice crops	0	637	637	0	0	0	0	0	0	0	637	637	2028	1370	3398
Other crops	0	245	245	630	0	630	0	0	0	630	245	875	769	16	785
	0	**180500**	**180500**	**36730**	**0**	**36730**	**720**	**0**	**720**	**37450**	**180500**	**217950**	**4848**	**7611**	**12459**

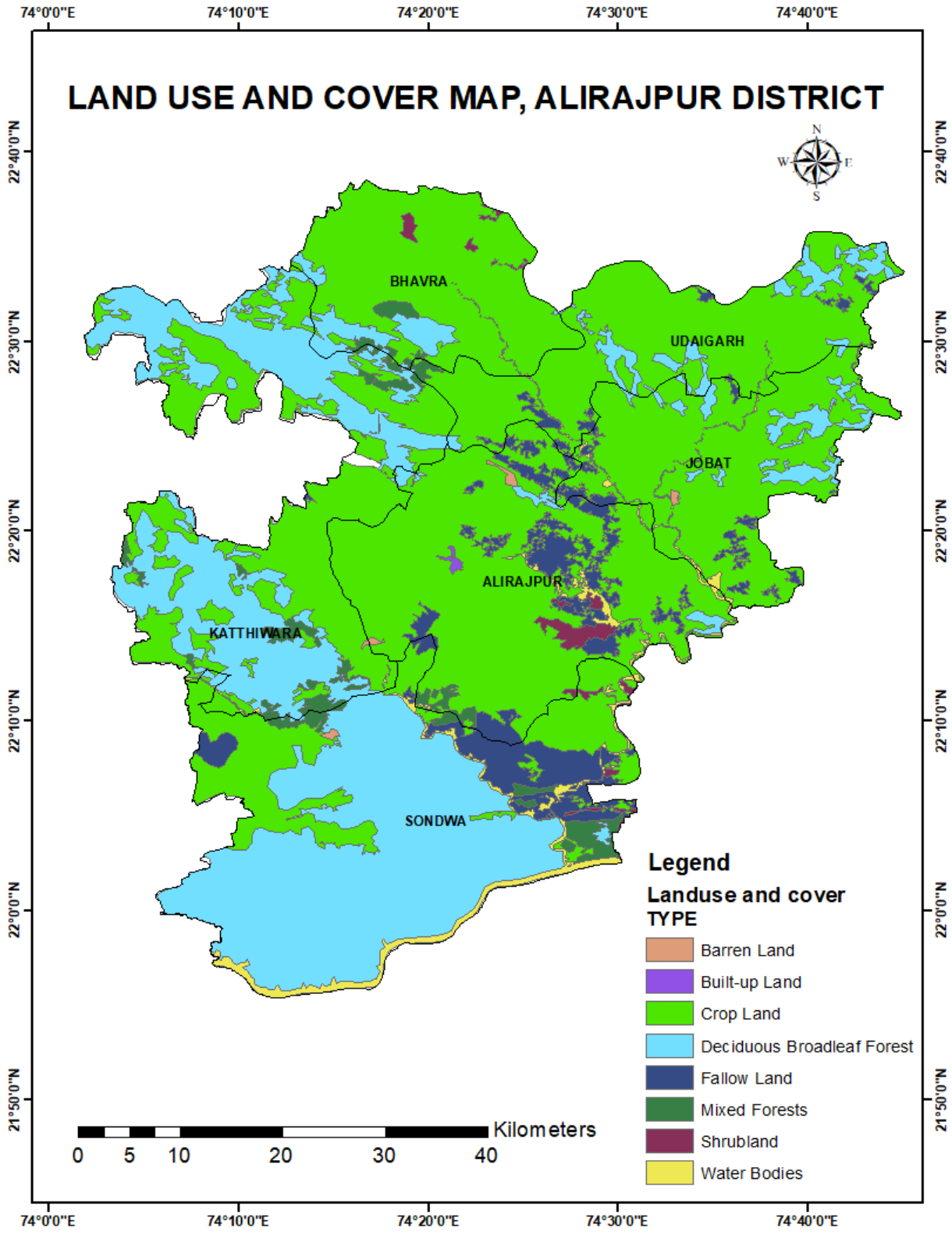


Fig - 14: Land Use Land Cover Map of Alirajpur district

CHAPTER – 2

DATA COLLECTION AND GENERATION

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

Hydrogeological Data – Current and historical water levels along with water level trend data of monitoring wells. In the district 5 exploratory wells constructed and therefore 28 key wells established to know the hyrogeological condition of the district. The weathered zone thickness (aquifer-I), lithology, water level data and various details of key wells extablished in the Alirajpur district were collected and compiled.

Hydrochemical Data - Ground water quality data of NHS monitoring wells and Key wells established in the district representing shallow aquifer.

Exploratory Drilling – Ground water exploration data of piezometer of CGWB.

Hydrometeorological Data Rainfall data for the whole district from District Irrigation Plan and Indian Meterological Department, Alirajpur district.

2.1 DATA AVAILABILTY

The compiled data were plotted on a 1:50000 scale map, and analysis of the data gap was carried out. The available data of the Exploratory wells drilled by Central Ground Water Board, North Central Region, Bhopal, Geophysical Survey carried out in the area, groundwater monitoring stations and groundwater quality stations monitored by Central Ground Water Board we recompiled and analysed for adequacy of the same for the aquifer mapping studies. The summarized table presenting the data requirement, data availability, and data gap analysis is presented in the following table.

Table 15: Data Requirement and Data Availability

S. No	Items	Data Requirement	Data Availability	Data Gap
1	Rainfall Data	Meteorological stations spread over the project area.	hydro.imd.gov.in	
2	Soil	Soil map and soil infiltration rate	Prepared in ArcGIS	
3	Land Use	Latest Land Use Pattern	Prepared in ArcGIS	
4	Geomorphology	Digitized Geomorphological Map	Bhukosh.	

5	Geophysics	Geophysical data in each Quadrant	No VES done till now	
6	Exploration Data	EW in each Quadrant with Aquifer Parameters	Only 5 exploratory wells drilled	Exploratory wells required
7	Recharge Parameters	Recharge parameters for different soil and aquifer types based on field studies	Recharge parameters are given in Ground Water resource estimation	
9	Discharge Parameters / Draft Data	Discharge parameters for different GW abstraction structures	Discharge parameters are given in Ground Water Resource Estimation GEC 2022	
10	Geology	All the maps on a 1:50000 scale	Bhukosh (Prepared in ArcGIS)	

2.2 DATA 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.

Table 16: Data Generated and Data collected for Aquifer Mapping Area

S. No	Items	Data Generated	Data Collected
1	Rainfall Data	-	hydro.imd.gov.in
2	Ground Water Exploration	-	5 exploratory wells
3	GW Regime Monitoring	28 Key wells established	Pre-monsoon and post-monsoon Water level of Key well established and NHS wells collected
4	Chemical Quality	28 Samples of NAQUIM in 2022 and 12 samples of NHS in 2021 during pre-monsoon. 16 Samples of NAQUIM 2022 during post-monsoon.	Water samples collected for analysis

2.3 Hydrogeology

The district is characterised by various different lithology which includes igneous, sedimentary and metamorphic rocks (Deccan basalt, sandstone, dolomite, limestone, shale, shist, granite, etc. The general hydrogeological conditions of the district are depicted in formation wise settings are discussed below.

Archaeans

The Archaean group of rocks is 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 Alirajpur tehsil are generally hard and compact and are poorly permeable rocks. 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 phyllites and schist are moderately permeable. The occurrence of groundwater is dependant on the intensity of fractures and disposition of foliation planes. The dolomitic marble and limestone occurring as bands, generally occurring occupy small hill ranges and as such theirs geographic locations is unfavorable for ground water development. Krastic limestone supports good yields from phreatic aquifer.

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 litho-stratigraphy differs from place to place. In general, the rock units lower 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 Intra-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 Intra-trappean beds under lying the Deccan traps when encountered during drilling exhibits confined /semi confined conditions.

Deccan Traps

The northern and north western parts of the district covering mainly Thandla, Petlawad and Rama blocks and southern parts covered by Sondwa block 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 for groundwater storage. 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).

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. The groundwater resources of the area are poor. Only those wells situated very close to some rivulet or river or near the contact of different rock types receive their recharge through out the year. A part of the recharged water passes off as seepages. Thus, the only source of water in the area is the gravel and sand accumulations in the stream beds.

Aquifer System

Almost entire district is occupied by various rocks units which includes the Igneous, metamophophic and sedimentary rock. The area is highly complicated and distrubted because Central Indian Tectonic zone passes through the district. An aquifer with the upper surface under atmospheric pressureis called unconfined aquifer and aquifer where the groundwater is under hydrostatic pressure is called confined aquifer. The weathered, jointed, fractured or vesicular unit of each flow forms moderately low to medium potential aquifers. The red bole is unproductive but forms a confining layer and also indicated the presence of a productive horizon below. In case of sandstone and granite water is encountered only in the fractures and in case of limestone water is encountered in cavities which can lead good to water.

Intense jointed basalt layer is sometimes present below the weathered basalts where the basalt is fractured and joints are open therefore the high permeability can be expected in this layer. Massive basalts with minor fractures as a aquifer unit is present as limited isolated pockets relatively on higher ground, where weathered profile thins out and the clay is sometimes absent. This massive basalt present at or very close to the surface and ground water will be restricted to occasional joints and fractures. In this situation the aquifers is likely to be local patchy. Alluvium soil generally consisting of sandy soil mixed with Kankar and pebbles with a thin band of friable calcareous sandstone at the base occur along major river like Narmada River and along its tributaries. The occurrence of ground water in this zone is good.

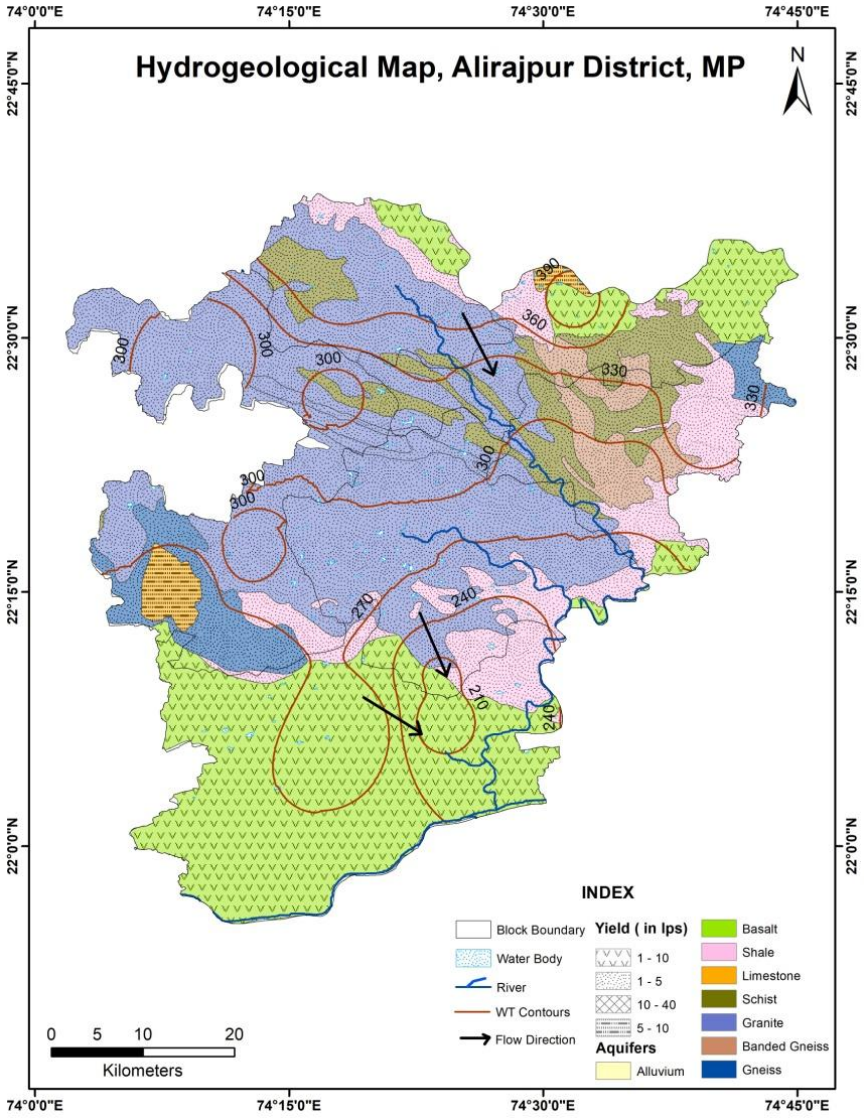


Fig - 15: Hydrogeology Map of Alirajpur district

2.4 Ground water scenario

Occurrence of Ground Water:

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

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

Ground Water Levels

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

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

Pre-Monsoon Ground Water Level (May 2022)

Pre-Monsoon depth to water level of the Year 2022 ranges from **4.27 mbgl at Kathiwara site**, Kathiwada block to **13.95 mbgl at Bhabra New**, Bhabra block.

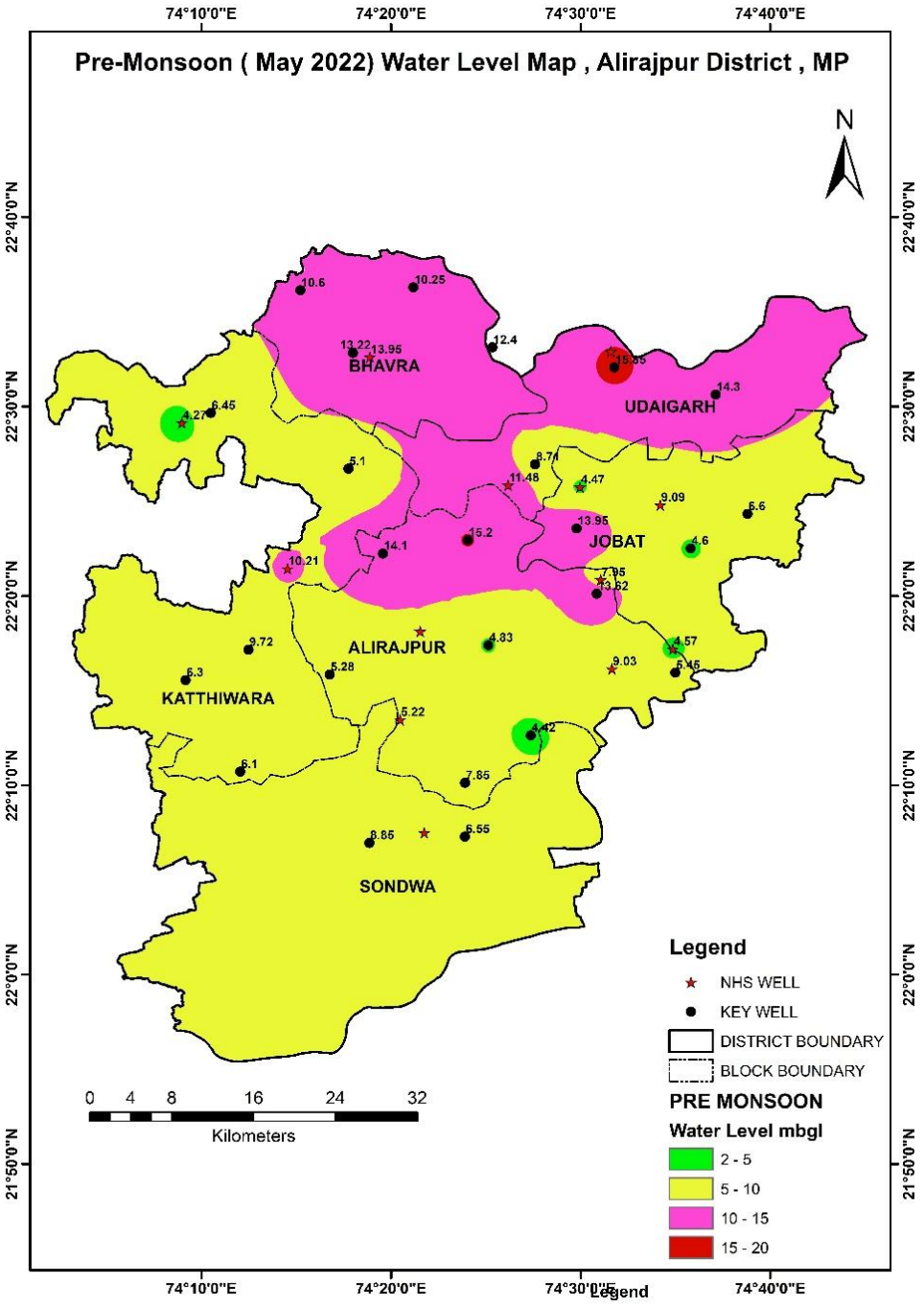


Fig - 16: Pre-monsoon Depth to Water Level Map 2022

Post Monsoon Ground Water Level (November 2022)

During post monsoon period, water level ranges from 2.7 **mbgl at Kakadiwal site**, Sondwa block to **16.4 mbgl at Baladmong site**, Jhobat block.

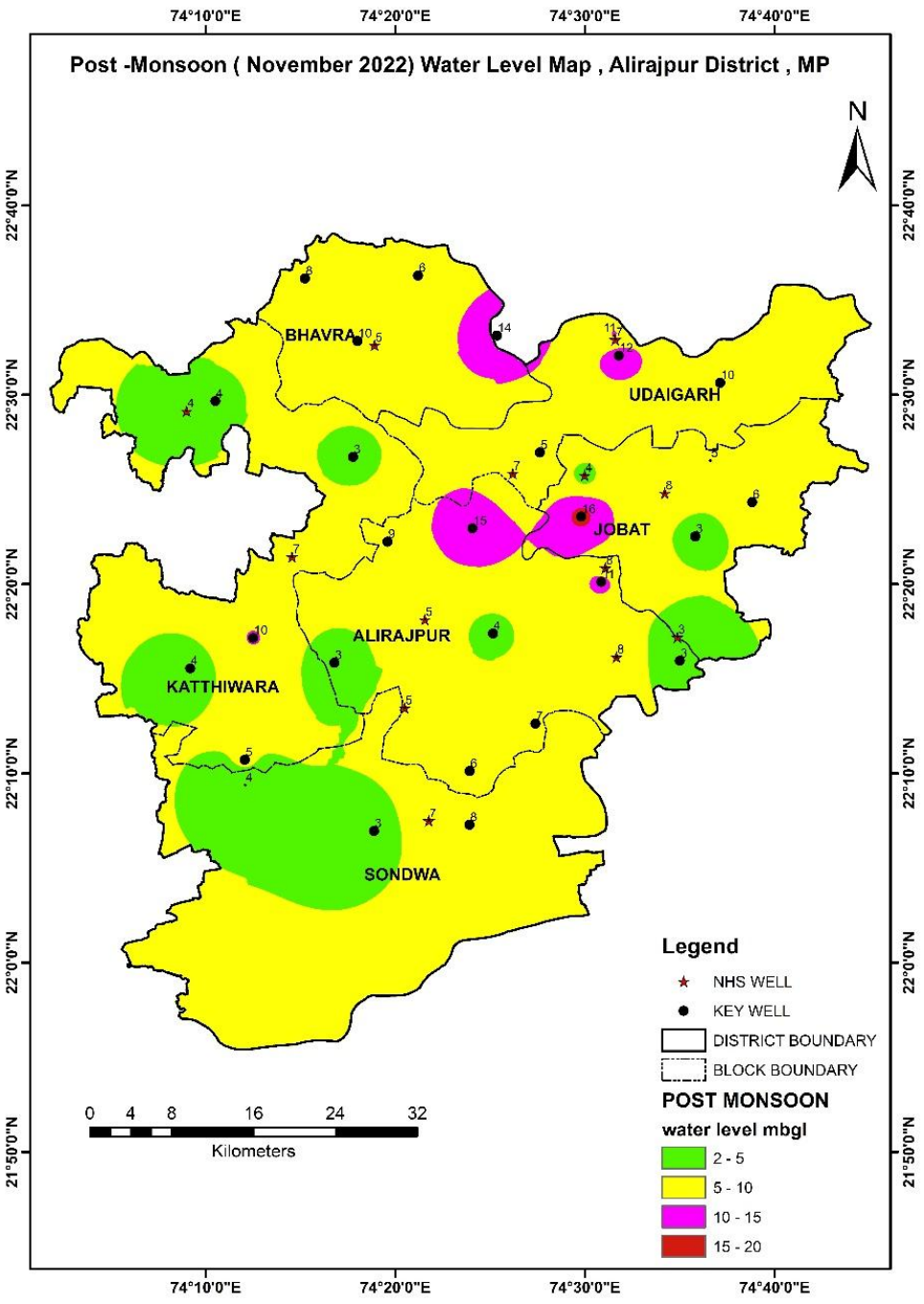


Fig - 17: Post monsoon Depth to Water Level Map (Nov 2022)

Water Level Fluctuation (Pre – Post) 2022

Water Level fluctuation in the Alirajpur district ranges from: -2.45 m to 6.15 m, 2 – 5 m water level fuctuation encountered in almost 80 % area of the district, 0-2 m water level fluctuation in about 15 % of area and only in 5 % area water level fluctuates between 5 to 10 m.

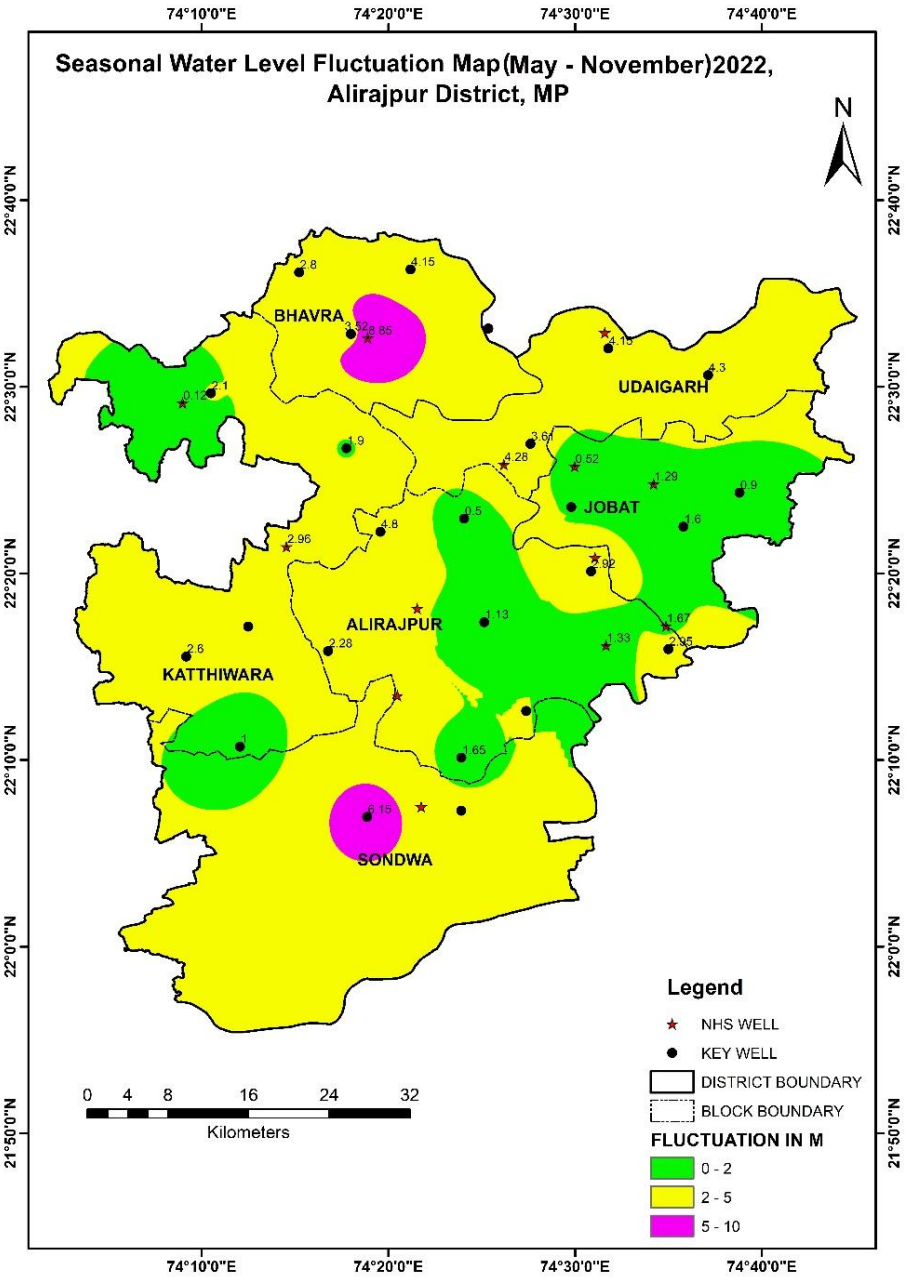


Fig - 18: Water Level Fluctuation Map, Alirajpur district

Table: 17 Depth to Water Level Pre-monsoon 2022 (NHS wells), Alirajpur district

District	Block	Site	Lat	Long	Water Level May 2022 (mbgl)	Water Level Nov 2022 (mbgl)	WL Fluctuation (m)
ALIRAJPUR	ALIRAJPUR	Khattali	22.3475	74.5178	7.95	8.45	-0.5
ALIRAJPUR	ALIRAJPUR	Borkua	22.2236	74.3422	5.22	5.3	-0.08
ALIRAJPUR	KATTIWADA	Kathiwara	22.4808	74.1503	4.27	4.15	0.12
ALIRAJPUR	JOBAT	Badaguda	22.4297	74.5172	4.47	3.95	0.52
ALIRAJPUR	JOBAT	Jobat New	22.4133	74.5700	9.09	7.8	1.29
ALIRAJPUR	ALIRAJPUR	Nanpur	22.2711	74.5317	9.03	7.7	1.33
ALIRAJPUR	ALIRAJPUR	Fatta	22.2594	74.5981	4.57	2.9	1.67
ALIRAJPUR	KATTIWADA	Chandpur	22.3569	74.2425	10.21	7.25	2.96
ALIRAJPUR	ALIRAJPUR	Ambua	22.4300	74.4372	11.48	7.2	4.28
ALIRAJPUR	BHABRA	Bhabra New	22.5486	74.3194	13.95	5.1	8.85

Table: 18 Details of Key Wells Established, Alirajpur district

Sl. No	Block	Location	Type of Well	Longitude	Latitude	Elevation	Depth drilled	Depth of well	Casing depth	major lithology	Pre Monsoon WL (mbgl)	Post monsoon WL (mbgl)	Water Table Fluctuation (m)
1	Udaigarh	Kundalwasa	DW	74.618557	22.510508	301	14.5	14.5	2.55	Massive Basalt, Fractured Basalt	14.3	10	4.3
2	Jobat	Bilasa	DW	74.609997	22.441871	326	4.55	9.2	1.9	Gneiss	dry	5.2	5.2
3	Jobat	Dekakund	BW	74.651518	22.465205	348	48.5	48.5	6.6	Granite	27	45.7	-18.7
4	Jobat	Sewariya	DW	74.646681	22.405519	361	11.3	11.3	3.45		6.6	5.7	0.9
5	Jobat	Nalthada	BW	74.596662	22.37518	296	7.4	7.4	4.5	Phyllite/schist	4.6	3	1.6
6	Alirajpur	Fata	DW	74.583091	22.265748	251	7.15	7.15	5.5	Phyllite/schist	5.45	6.2	-0.75
7	Alirajpur	Palasda	DW	74.51465	22.335273	284	13.9	13.9	3.35	Phyllite/schist	13.62	10.7	2.92
8	Jhobat	Baladmong	DW	74.496541	22.392663	287	20.84	20.84	**3.45**	Granite	13.95	16.4	-2.45
9	Alirajpur	Kunda	DW	74.400863	22.382349	351	19.5	19.5	**3.72**	Granite Gneiss	15.2	14.7	0.5
10	Alirajpur	Laxmani	DW	74.418938	22.289868	276	4.95	4.95	4.81	Murram	4.83	3.7	1.13
11	Alirajpur	Jawaniya	DW	74.456178	22.210588	230	9	9	2.9	Basalt	4.42	6.5	-2.08
12	Sondwa	Thodsindh	DW	74.398398	22.168813	211	11.5	11.5	5.52	Granite	7.85	9	-1.15
13	Sondwa	Bodgaon	DW	74.398322	22.12147	202	8.6	8.6	3	Basalt	6.55	8	-1.45
14	Sondwa	Kakadiwal	DW	74.314319	22.115975	326	13.85	13.85	4.95	Qutzite	8.85	2.7	6.15
15	Alirajpur	Baddala	DW	74.279509	22.26411	307	6	6	4.1	Granite	5.28	3	2.28
16	Alirajpur	Bokadiya	DW	74.208239	22.285985	331	11.35	11.35	9.4	Granite	9.72	10.2	-0.48

17	Alirajpur	Kardha	DW	74.152806	22.259216	265	8.1	8.1	4.75	Weathered Granite	6.3	3.7	2.6
18	Alirajpur	Kumbhi	DW	74.200744	22.17868	234	10.4	10.4	6.3	Mica schist	6.1	5.1	1
19	Sondwa	Badda	DW	74.201105	22.156392	254	11.6	11.6	3.65	Weathered Basalt	dry	4.4	4.4
20	Alirajpur	Doblajhiri	DW	74.32624	22.37066	323	14.95	14.95	4.3	Fractured/Vesicular basalt, Massive Basalt	14.1	9.3	4.8
21	Alirajpur	Koha	DW	74.295899	22.445198	286	5.3	5.3	4.7	Schist	5.1	3.2	1.9
22	Kathiawara	Kewda	DW	74.174908	22.494271	278	6.6	6.6	6.4	Granite	6.45	4.35	2.1
23	Bhabra	Roligaon	DW	74.299879	22.547236	396	15.3	15.3	5.7	Mica schist	13.22	9.7	3.52
24	Bhabra	Barjhar	DW	74.253662	22.602268	386	12	12	4.6	Granite Gneiss	10.6	7.8	2.8
25	Bhabra	Sajewada	DW	74.353066	22.604896	405	10.5	10.5	1.8	Fractured Geniss	10.25	6.1	4.15
26	Bhabra	Gerughati	DW	74.422519	22.552073	407	14.2	14.2	1.2	Weathered Granite	12.4	13.7	-1.3
27	Udaigarh	Udaigarh	DW	74.529565	22.534446	434	18.25	18.25	3.3	Dolomite/Limestone	15.85	11.7	4.15
28	Udaigarh	Motaumar	DW	74.460084	22.459142	333	9.75	9.75	3.72	Granite Schist	8.71	5.1	3.61

Hydrograph Analysis

The hydrograph in the district shows how the ground water level is behaving. The variation in short term and long-term water level trends may be due to variation in natural recharge due to rainfall and withdrawal of groundwater for various agricultural activities, domestic and industrial purpose. The analysis of hydrographs shows that the annual rising limbs in hydrographs indicate the natural recharge of groundwater regime due to monsoon rainfall, as the monsoon rainfall is the only source of recharge to the ground water. Falling limbs in the hydrograph indicate that the groundwater withdrawal is less than the ground water recharge and the hydrograph which shows very less variation in the trend indicates either groundwater recharge is equal to the groundwater withdrawal or ground water is not getting recharged and there is no ground water extraction. In some area ground water level trend is increasing since last 2-3 decades - figure 19 (a) and (c), in some areas water level is almost at the same level neither increasing nor deceasing or shows a very low declining trend - figure 19 (c), (d), (e) and (f).

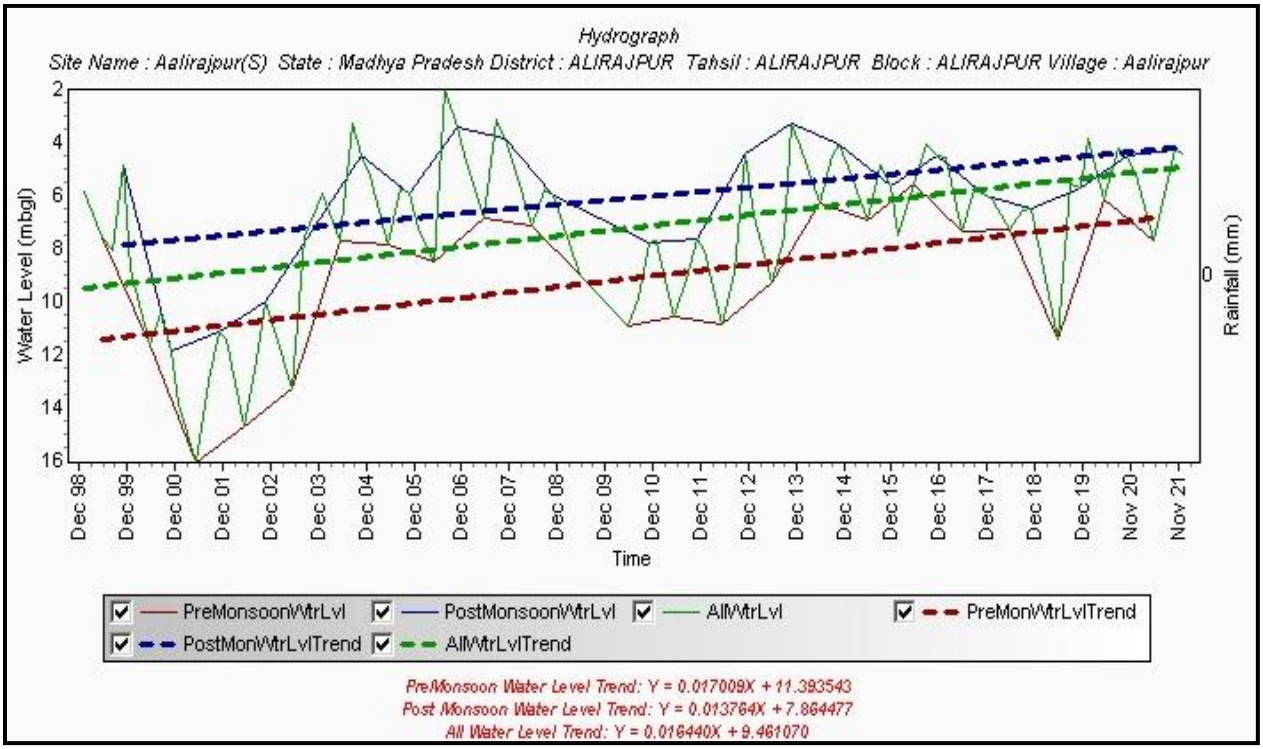


Fig - 19 (a): Hydrograph of Alirajpur site (S), Block Alirajpur

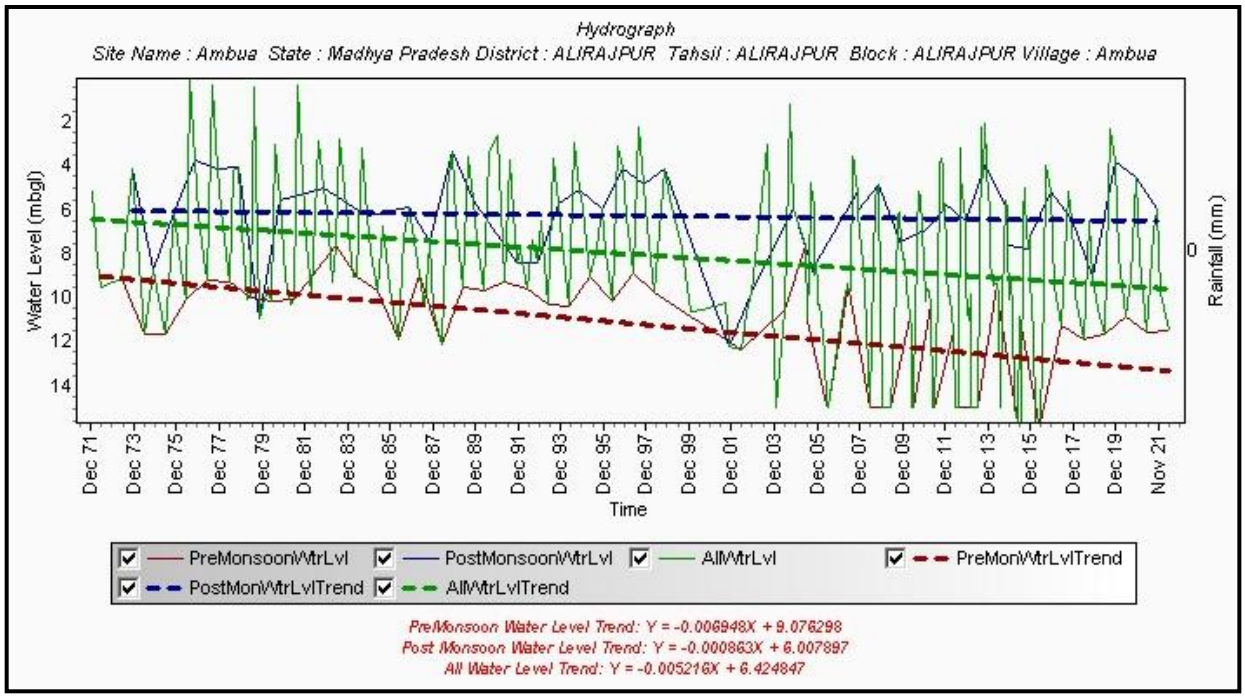


Fig - 19 (b): Hydrograph of Amba (S), Block Alirajpur

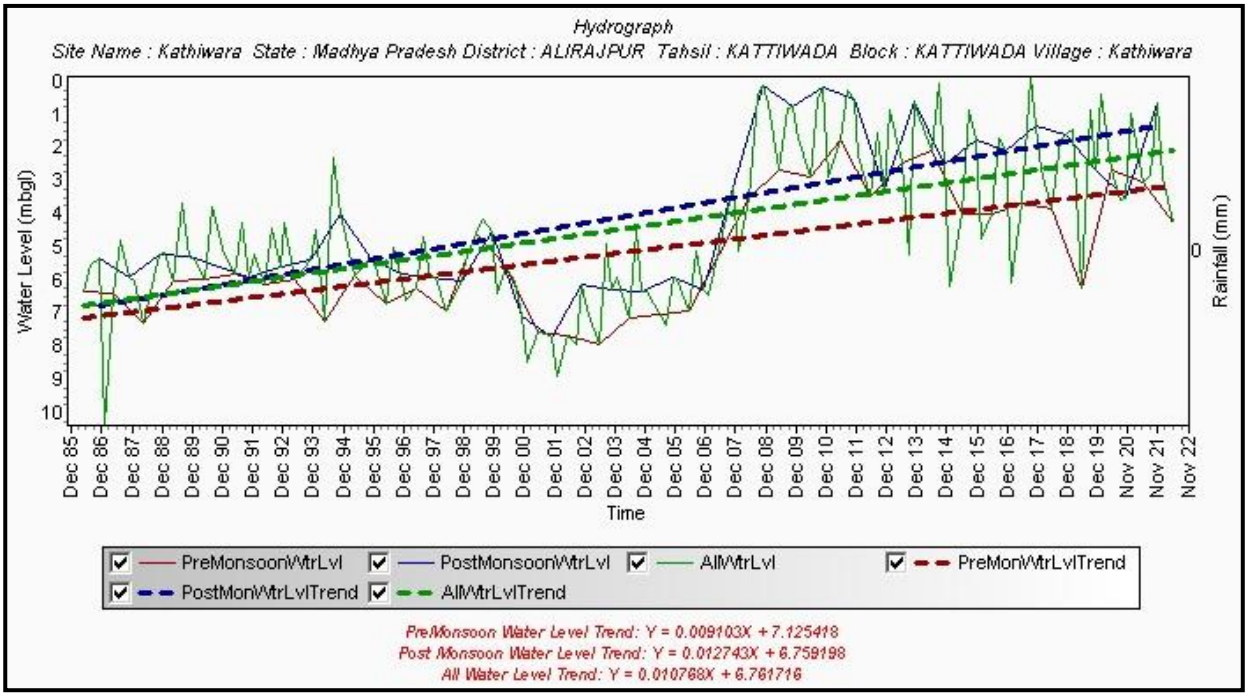


Fig - 19 (c): Hydrograph of Kathiwara site, Block Kattiwada

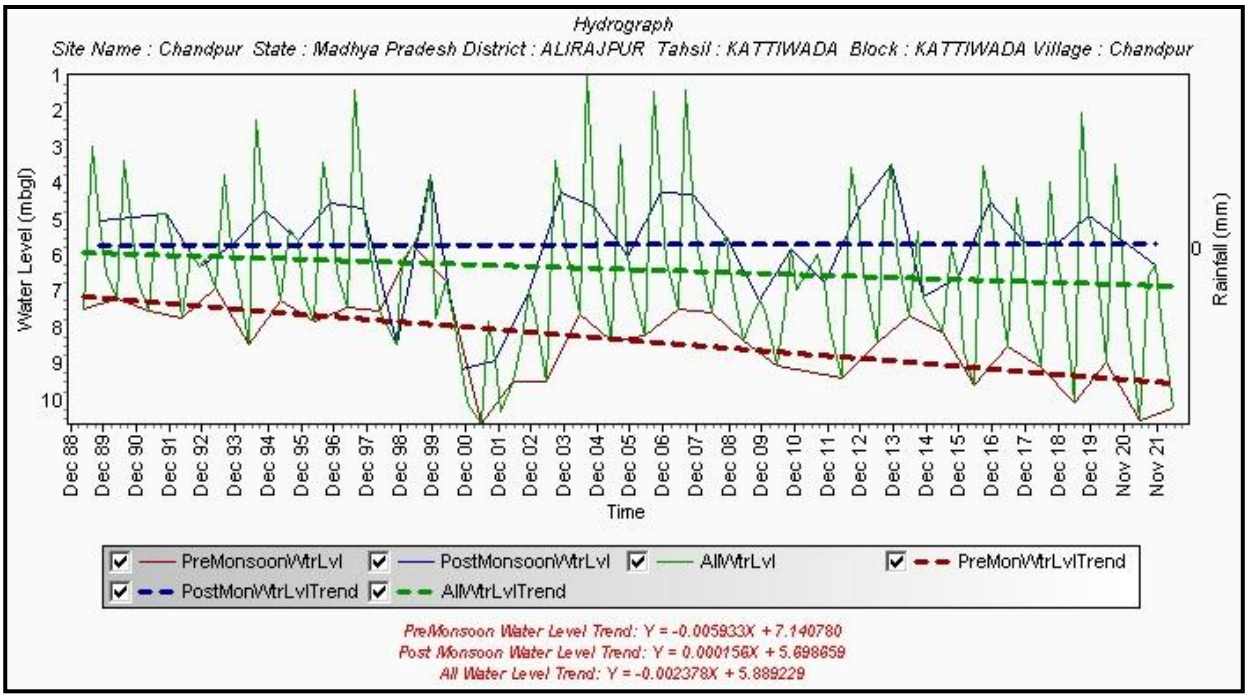


Fig - 19 (d): Hydrograph of Chandpur site, Block Kattiwada

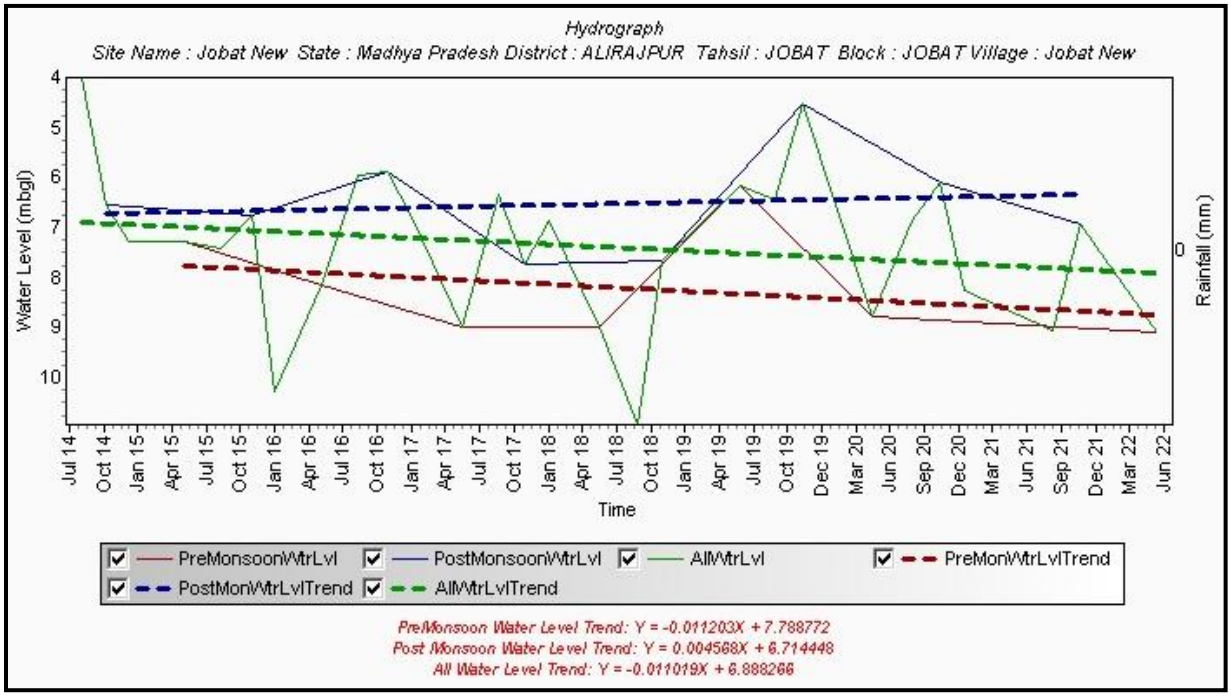


Fig - 19 (e): Hydrograph of Alirajpur site (S), Block Alirajpur

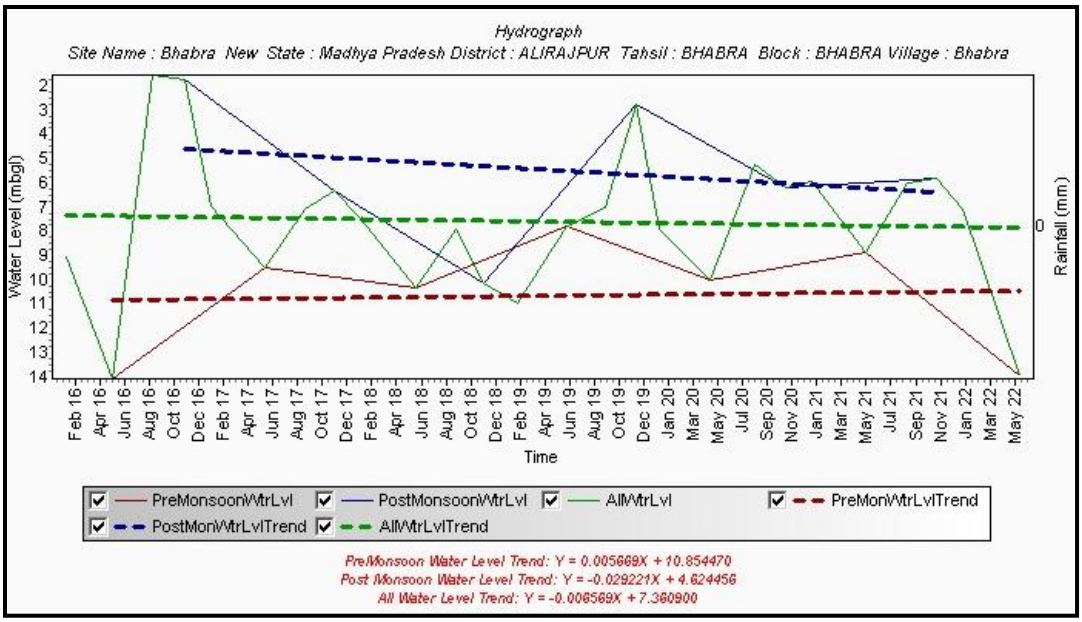


Fig - 19 (f): Hydrograph of Alirajpur site (S), Block Alirajpur

2.5 Geophysical Studies

In the Alirajpur district no geophysical data is available as no geophysical study has been carried out.

2.6 Ground water Exploration:

CGWB drilled 5 exploratory wells in the Alirajpur district to know the subsurface information. 28 key wells established in the district to know the subsurface information regarding groundwater level. The salient details of exploratory wells are given below.

Table: 19 Details of Exploratory Wells drilled in Alirajpur district

Site	Block	District	Lat	Long	Depth Drilled
Ambaja	Sondwa	Alirajpur	22.11667	74.25	157.00
Udaigarh	Udaigarh	Alirajpur	22.53333	74.53333	74.00
Indwan	Jobat	Alirajpur	22.28333	74.61667	88.87
Tikhole	Sondwa	Alirajpur	22.13333	74.46667	88.69
Alirajpur	Alirajpur	Alirajpur	22.3	74.35	81.04

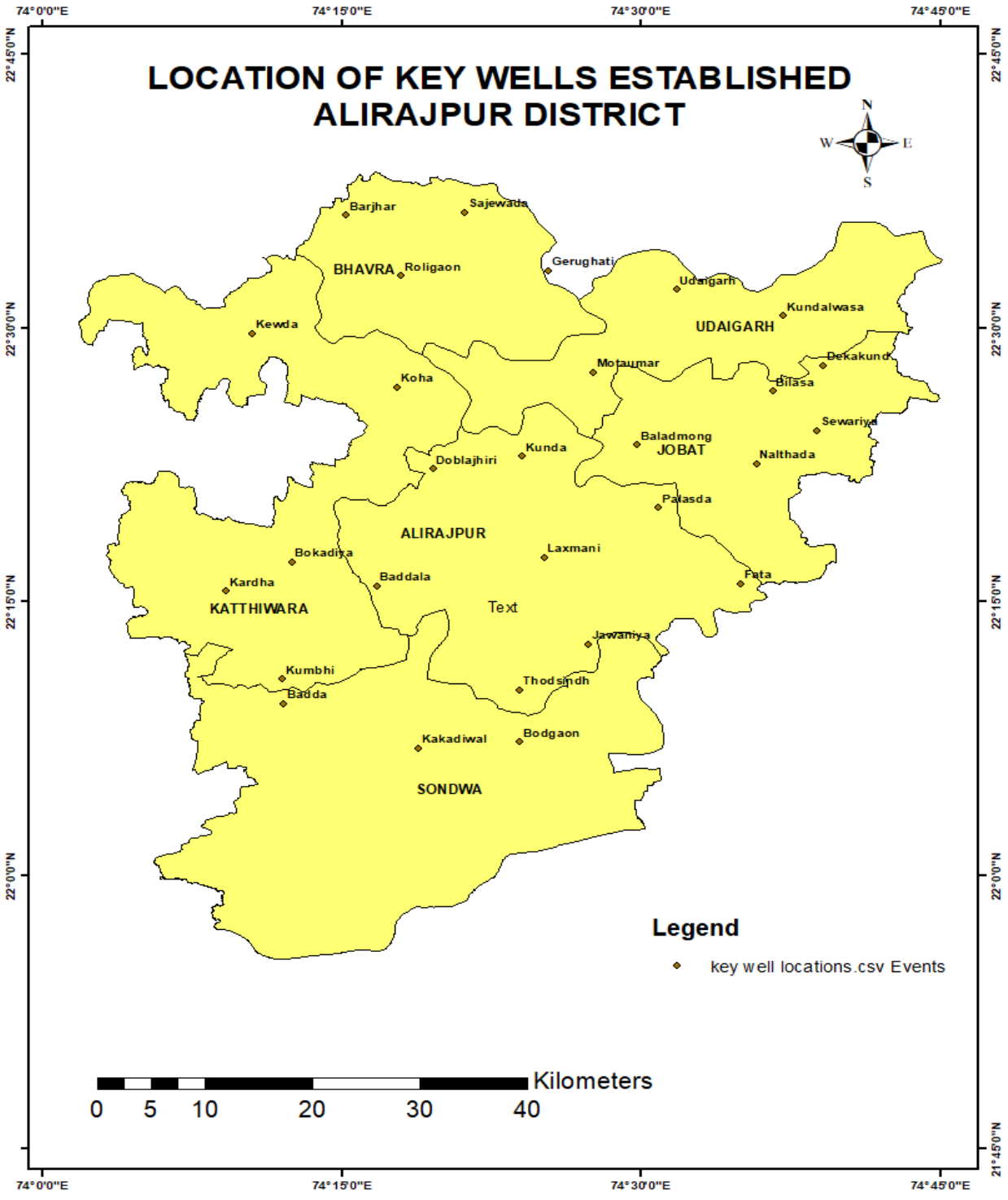


Fig – 20: Data Generated by Establishing Key wells, Alirajpur District

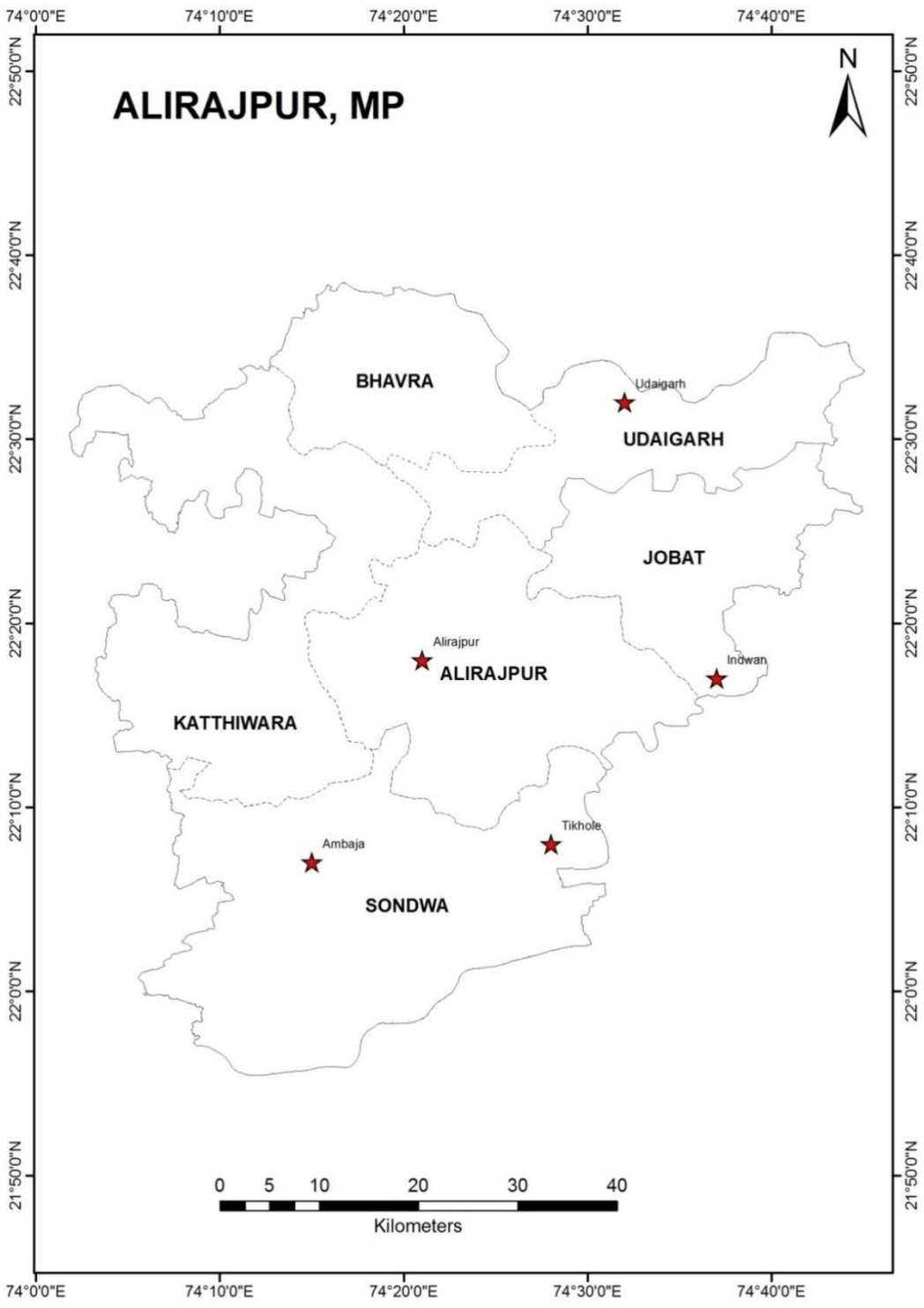


Fig – 21: Exploratory wells location Map, Alirajpur District

2.7 Ground Water Quality of Alirajpur District

The water samples were collected from 12 National Hydrograph Stations and 28 Key wells established during pre and post monsoon in clean double stoppered poly ethylene bottles from Alirajpur district during pre-monsoon (May 2022) and post-monsoon (Nov 2022).

Hydro-chemical scenario of Alirajpur District

The water samples were collected from NAQUIM study in clean double stopper HDPE poly ethylene bottles from 28 nos. different locations for cation and anion analysis and 26 nos. of ground water for heavy/ trace metal analysis of Alirajpur district during pre-monsoon 2022. After post-monsoon 2022; 16 nos. of ground water samples collected for cation and anion analysis. Further under National Hydrograph Monitroring regiome the ground water level is monitored and ground water samples are collected from 12 stations to know the ground water scenario of the district.

Quality of Ground Water for Drinking Purpose:

The ground water samples from Alirajpur district have varied range of pH from 6.82 to 8.09. 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 Baladmong (8.09). The ground water of the study area can be assessed as neutral to slightly alkaline. The electrical conductivity of ground water samples in Alirajpur district varies from 398 to 2265 µS/cm at 25°C. The electrical conductivity from Alirajpur district shows variability, 29 nos. of ground water sample show EC below 1000 µS/cm, in 10 nos. samples in between 1000-2000 µS/cm and in 1 sample the EC value is more thn 2000 µS/cm. The maximum electrical conductivity has been recorded in the village of Nanpur i.e., 2265 µS/cm (NHS well). Electrical conductivity has been observed more than 2000 µS/cm after post-monsoon at Khattali (2282 µS/cm) and Kumbi (2837 µS/cm). So, overall ground water quality in Alirajpur district is good to slightly saline in nature and moderate saline after post monsoon.

The fluoride concentration in Alirajpur district lies in between 0.28 to 1.52 mg/l, which represent that all the samples are within the permissible limit i.e. 1.5 mg/l as per BIS (IS 10500: 2012) except the village of Thodsindhi (1.51 mg/l) and Fata (1.52 mg/l). After post-monsoon fluoride concentration ranges between 0.28 to 1.59 mg/l. After post-monsoon fluoride concentration have been observed more than BIS permissible limit at Baladmong (1.51mg/l) and Dekhakund (1.59 mg/l). Nitrate in ground water samples of Alirajpur district fall within limits of 3 to 171 mg/l. It is observed that 45 % samples have nitrate concentration more than the acceptable limit i.e. 45 mg/l, while rest 55 % samples have concentration less than acceptable limit. Highest nitrate concentration (more than 100 mg/l) is reported in the water sample

collected from Sewariya (100 mg/l), Ambua (105 mg/l) and Palasda (171 mg/l). After post-monsoon, 17 samples collected and observed that 58.82 % of ground water samples are more than BIS acceptable limit i.e., 45 mg/l of nitrate concentration, while rest 41.17 % samples have concentration less than acceptable limit. Highest concentration of nitrate has been observed at Khattali (120 mg/l) and Palasda (211 mg/l) villages. 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 104 to 650 mg/l. In all locations, total hardness concentrations are within the permissible limit of 600 mg/l except at location Nanpur village 615 mg/l and Ambua village 650 mg/l. After post monsoon, total hardness ranges between 175 to 670 mg/l. After post-monsoon two locations observed total hardness more than 600 mg/l at Khattali and Palasda village having total hardness 670 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. The ground water samples from Alirajpur district, collected from key wells established are Calcium-Bicarbonate type, hence show temporary hardness and Calcium-Magnesium-Chloride and Calcium Sodium Bicarbonate types i.e., Mixed type of water.

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 of key wells from Alirajpur district is plotted on U.S. Salinity Laboratory diagram.

It is clear that four ground water samples are C_2-S_1 Class (Medium Salinity & Low Sodium) and C_3-S_1 Class (High Salinity & Low 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.

The analysis of heavy/ trace metal analysis in the ground water of Alirajpur district shows that the copper and nickel are below detectable limit whereas zinc is within the BIS permissible limit and the range of zinc concentration is 0.038 to 2.499 mg/l. The iron concentration is 0.013 to 1.98 mg/l in the ground water samples. In the district three locations, iron concentration is more than BIS permissible limit of 1.0 mg/l in the village of Bokadiya (1.20 mg/l), Barjhar (1.287 mg/l) and Jawaniya (1.98 mg/l). The manganese concentration is 0.016 to 0.678 mg/l, the maximum concentration of manganese recorded in the village of Palasda village i.e., 0.678 mg/l which is also more than BIS permissible limit of 0.3 mg/l.

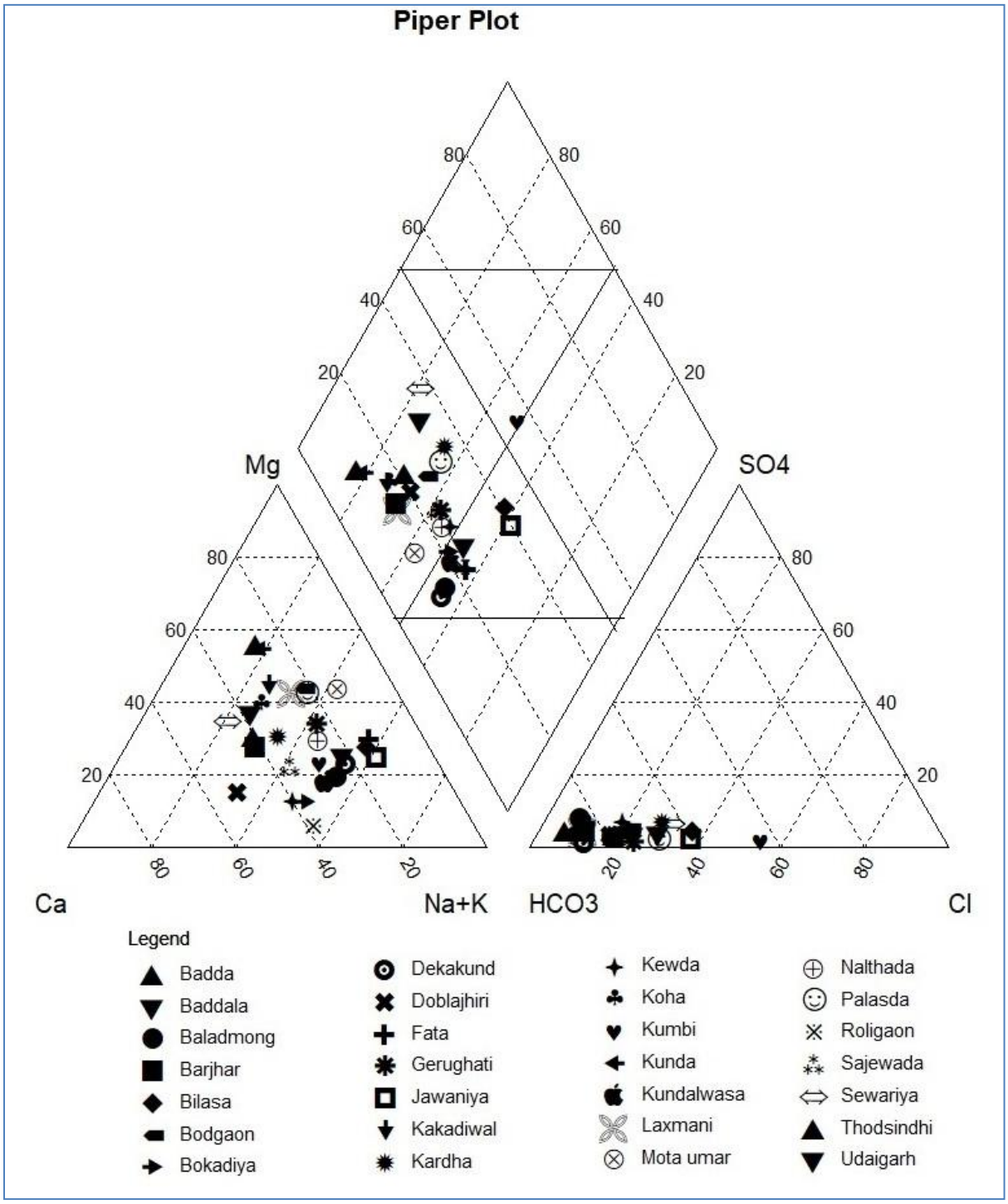


Fig – 22: Hill Piper Diagram representing classification of water samples collected from National Hydrograph Stations, Alirajpur District, Madhya Pradesh

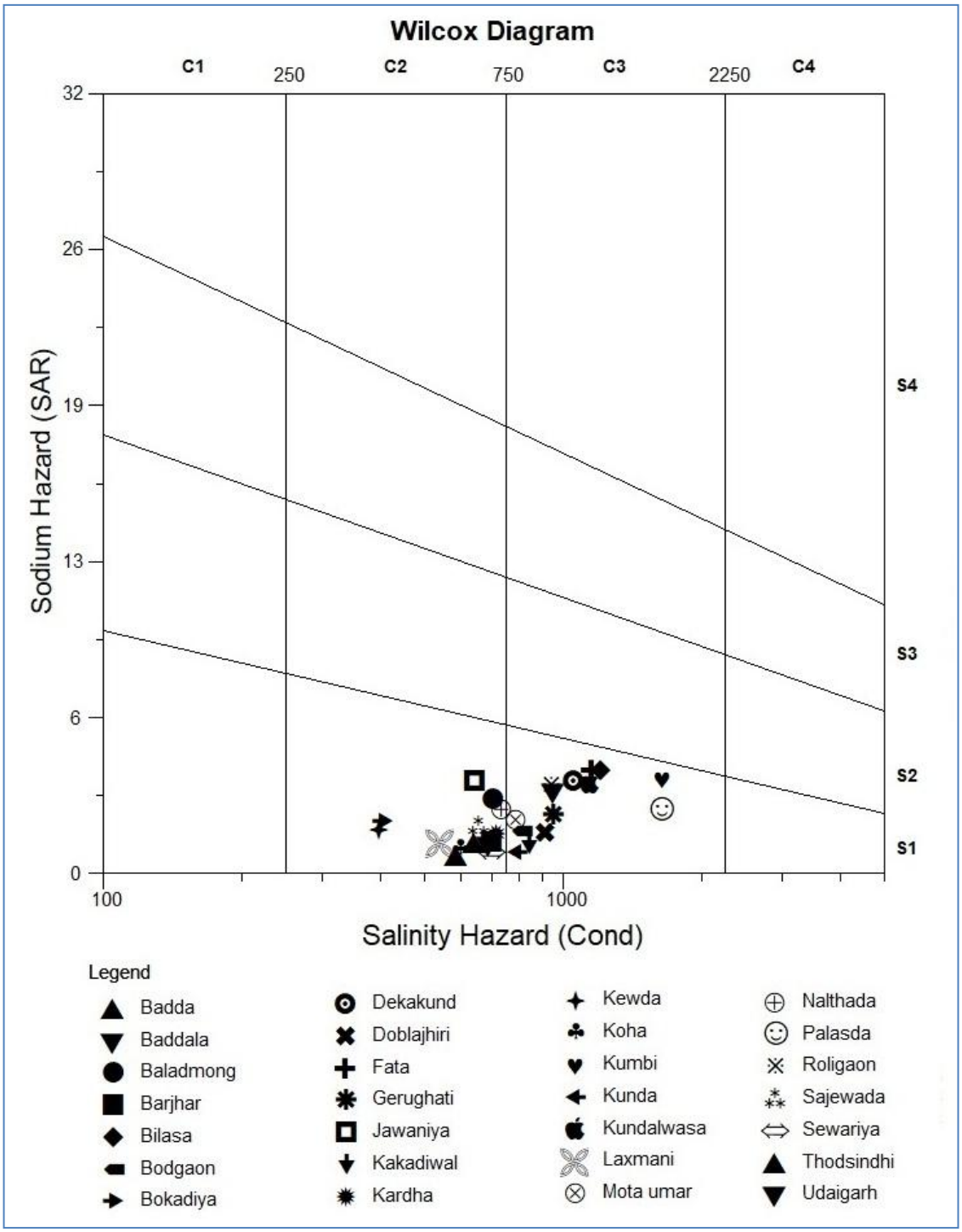


Fig – 23: US Salinity Diagram for water samples collected from National Hydrograph Stations of Alirajpur District, Madhya Pradesh

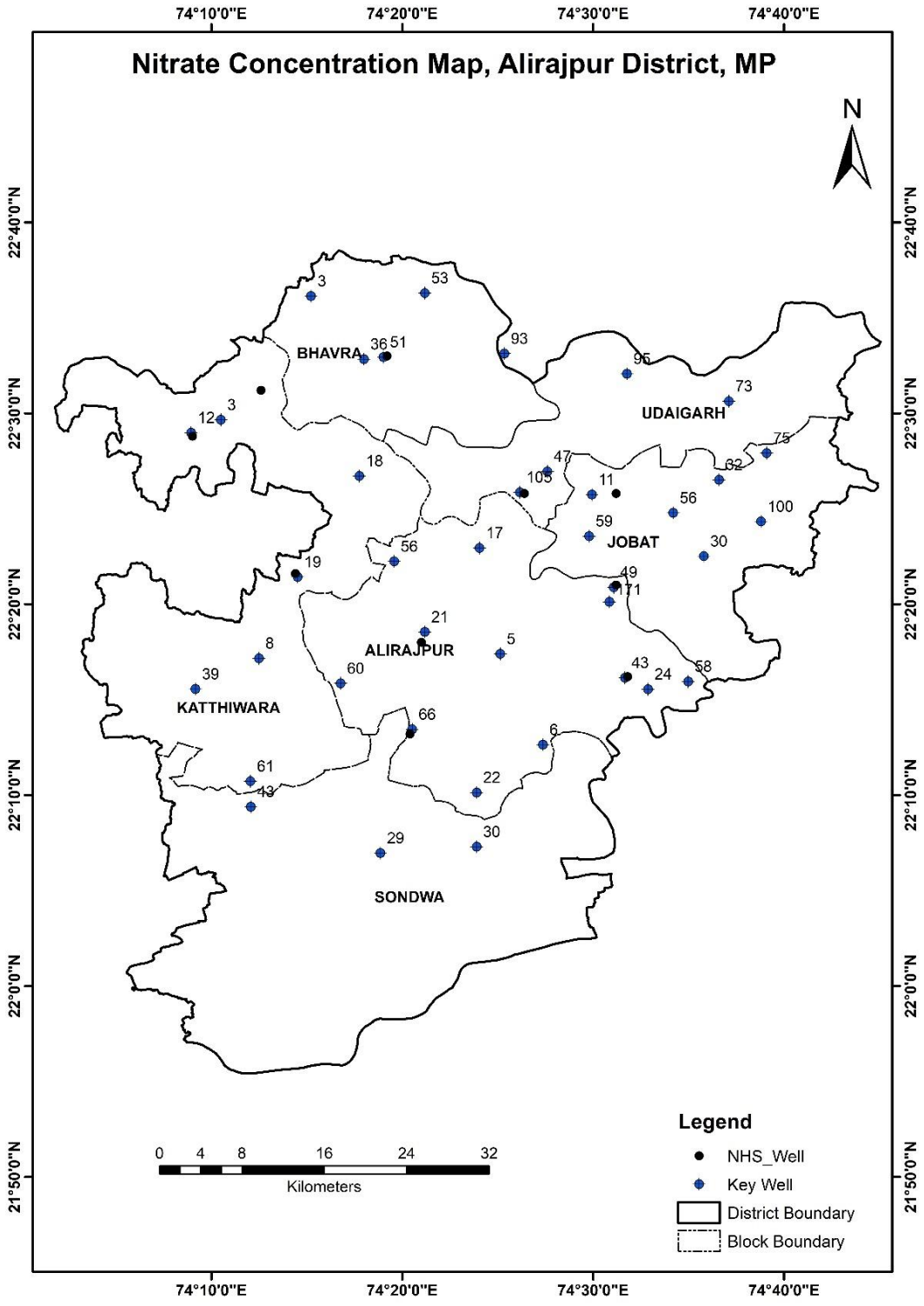


Fig - 24: Location of Nitrate Cocentration of Alirajpur District, Madhya Pradesh

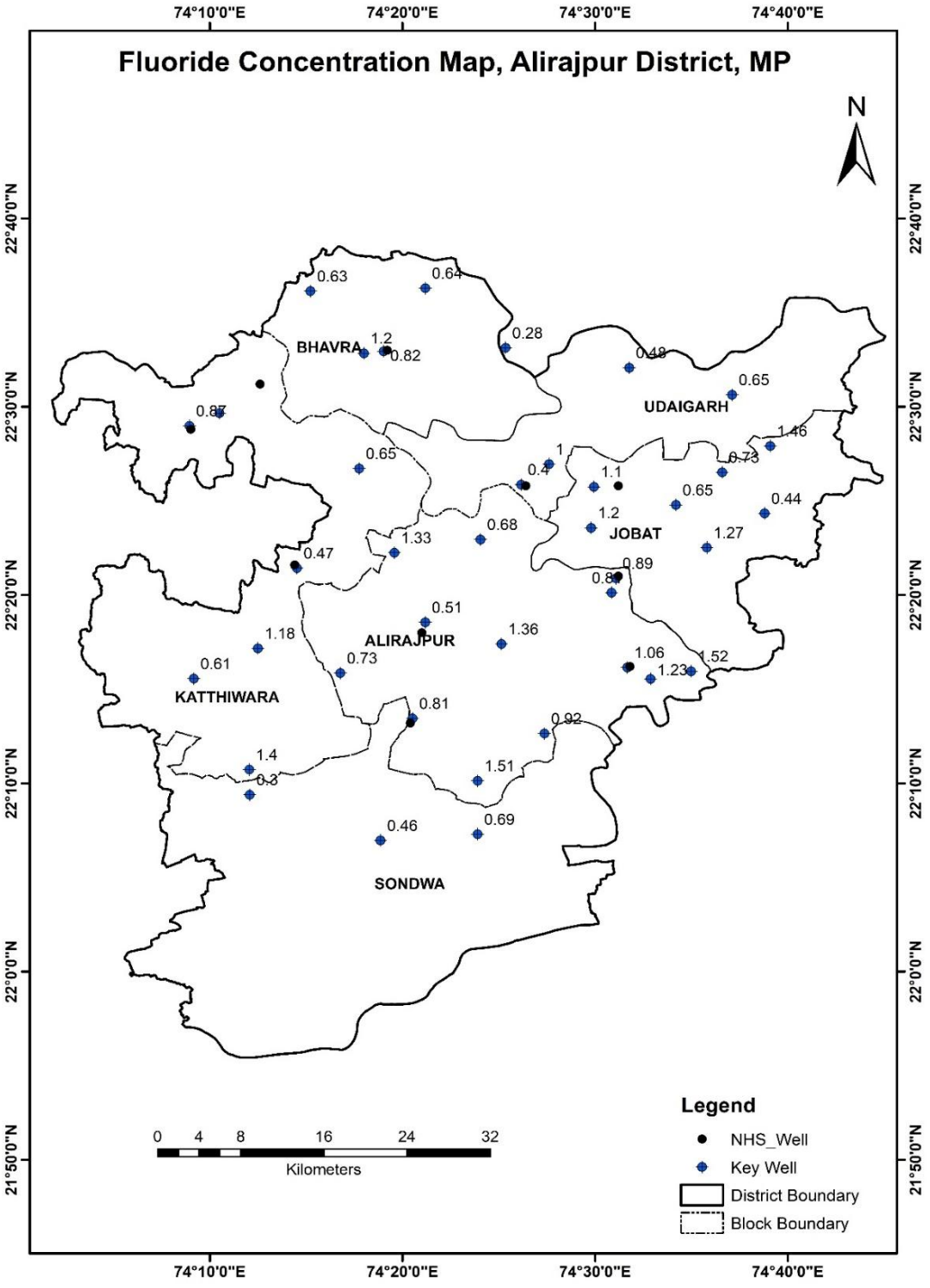


Fig - 25: Location of Flouride Cocentration of Alirajpur District, Madhya Pradesh

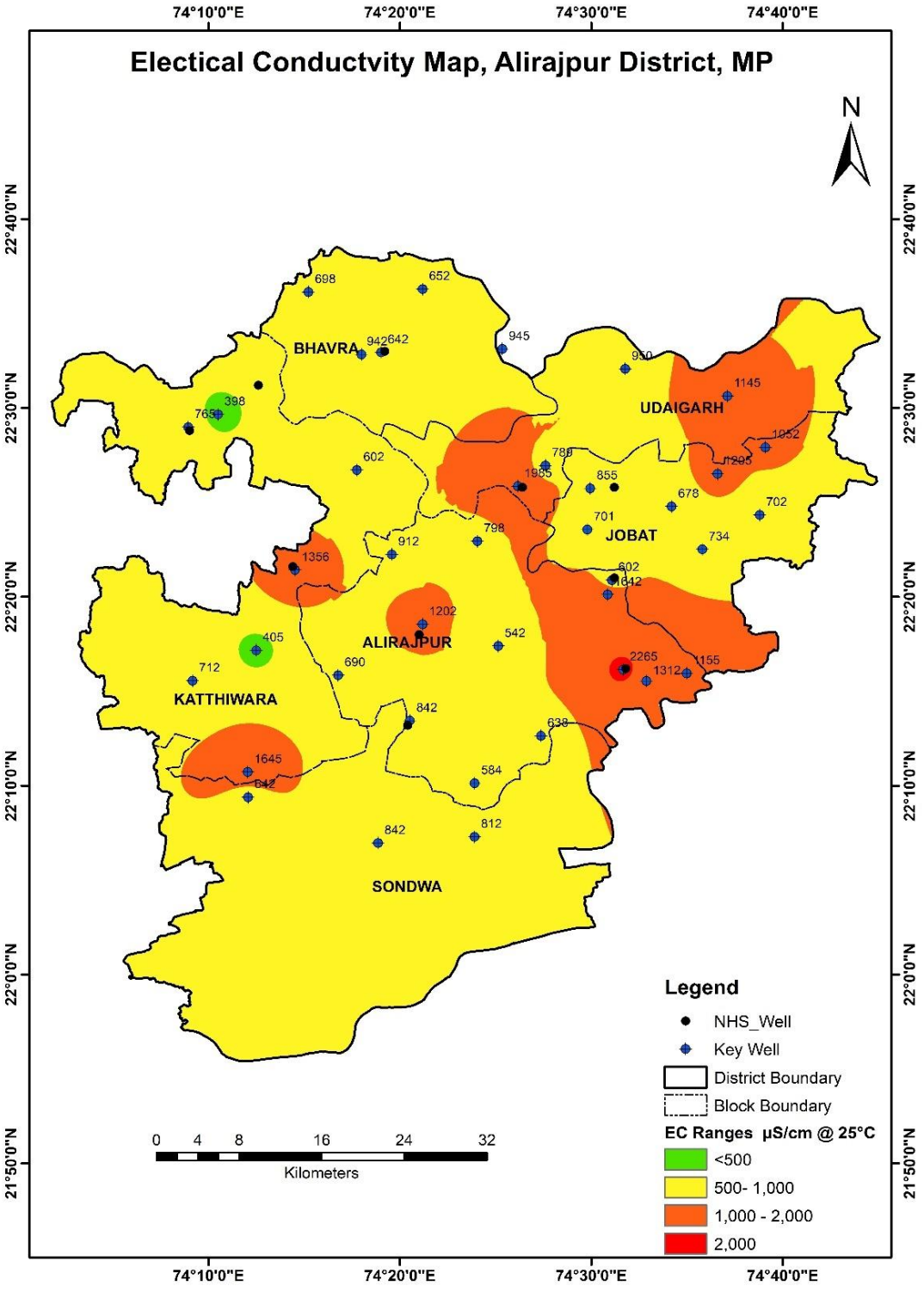


Fig - 26: Electrical Conductivity of Alirajpur District, Madhya Pradesh

Table: 20 Chemical analysis data of ground water of Alirajpur district under NAQUIM (pre-monsoon-2022)																						
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	Alirajpur	Udaigarh	Kundalwasa	DW	22.51	74.62	7.55	1145	0	488	66	12	73	0.65	0.1	22	287	71	26	142	1.2	744
2	Alirajpur	Jobat	Bilasa	DW	22.44	74.61	7.94	1205	0	409	147	24	32	0.73	0.2	18	252	36	40	155	3.2	783
3	Alirajpur	Jobat	Dekakund	Bw	22.47	74.65	7.79	1052	0	500	42	5	75	1.46	0.1	32	243	48	30	135	1.1	684
4	Alirajpur	Jobat	Sewariya	DW	22.41	74.65	7.69	702	0	195	56	16	100	0.44	0.1	29	282	63	30	33	2.1	456
5	Alirajpur	Jobat	Nalthada	DW	22.38	74.60	7.78	734	0	409	64	12	30	1.27	BDL	27	252	48	33	96	1.6	477
6	Alirajpur	Alirajpur	Fata	DW	22.27	74.58	8.02	1155	0	500	78	14	58	1.52	BDL	34	257	32	43	154	2.4	751
7	Alirajpur	Alirajpur	Palasda	DW	22.34	74.51	7.89	1642	0	549	140	12	171	0.81	BDL	36	525	71	84	135	1.6	1067
8	Alirajpur	Alirajpur	Baladmong	DW	22.39	74.50	8.09	701	0	305	17	22	59	1.20	BDL	29	163	38	17	89	1.4	456
9	Alirajpur	Alirajpur	Kunda	DW	22.38	74.40	8.07	798	0	403	22	14	17	0.68	BDL	42	337	44	55	35	1.8	519
10	Alirajpur	Alirajpur	Laxmani	DW	22.29	74.42	7.98	542	0	275	20	12	5	1.36	BDL	52	188	28	29	40	2.6	352
11	Alirajpur	Alirajpur	Jawaniya	DW	22.21	74.46	7.84	638	0	275	98	8	6	0.92	BDL	22	149	22	23	106	3.1	415
12	Alirajpur	Sondwa	Thodsindhi	DW	22.17	74.40	7.87	584	0	397	17	15	22	1.51	BDL	29	317	42	52	29	1.4	380
13	Alirajpur	Sondwa	Bodgaon	DW	22.12	74.40	7.89	812	0	329	56	18	30	0.69	BDL	35	267	36	43	64	1.5	528
14	Alirajpur	Sondwa	Kakadiwal	DW	22.12	74.31	7.80	842	0	403	27	24	29	0.46	0.1	37	317	51	46	49	2.1	547
15	Alirajpur	Alirajpur	Baddala	DW	22.26	74.28	7.78	690	0	275	69	12	60	0.73	BDL	28	302	61	36	46	1.1	449
16	Alirajpur	Alirajpur	Bokadiya	DW	22.29	74.21	7.83	405	0	201	27	7	8	1.18	BDL	26	114	34	7	52	1.2	263
17	Alirajpur	Alirajpur	Kardha	DW	22.26	74.15	7.75	712	0	275	69	22	39	0.61	BDL	31	248	53	28	58	3.2	463
18	Alirajpur	Alirajpur	Kumbi	DW	22.18	74.20	7.75	1645	0	415	297	14	61	1.40	BDL	28	431	95	47	185	1.5	1069
19	Alirajpur	Sondwa	Badda	DW	22.16	74.20	7.85	642	0	281	39	9	43	0.30	BDL	34	243	55	25	43	3.2	417
20	Alirajpur	Alirajpur	Doblajhiri	DW	22.37	74.33	7.68	912	0	384	49	12	56	1.33	BDL	56	297	93	16	66	1.8	593
21	Alirajpur	Alirajpur	Koha	DW	22.45	74.30	7.79	602	0	293	22	18	18	0.65	BDL	42	228	42	30	36	2.9	391
22	Alirajpur	Kathiwara	Kewda	DW	22.49	74.17	6.82	398	0	171	25	12	3	0.64	BDL	38	104	32	6	41	3.4	259
23	Alirajpur	Bhabra	Roligaon	DW	22.55	74.30	7.62	942	0	409	59	15	36	1.20	0.1	31	218	75	7	122	5.1	612
24	Alirajpur	Bhabra	Barjhar	DW	22.60	74.25	7.46	698	0	348	27	14	3	0.63	BDL	42	238	57	23	46	4.9	454
25	Alirajpur	Bhabra	Sajewada	DW	22.60	74.35	7.83	652	0	256	39	12	53	0.64	BDL	48	193	48	18	62	2.9	424
26	Alirajpur	Bhabra	Gerughati	DW	22.55	74.42	7.54	945	0	372	69	5	93	0.28	BDL	29	277	46	40	92	3.1	614
27	Alirajpur	Udaigarh	Udaigarh	DW	22.53	74.53	7.56	950	0	354	64	12	95	0.48	BDL	25	223	42	29	115	3.4	618
28	Alirajpur	Udaigarh	Mota umar	DW	22.45	74.46	7.94	789	0	378	27	10	47	1.00	BDL	23	228	22	42	75	4.6	513

Table: 21 Trace/ Heavy metal analysis of ground water of Alirajpur district under NAQUIM (pre-monsoon-2022)											
S. No.	**District**	**Block**	**Location**	**Source**	**Lat.**	**Long.**	**Fe**	**Cu**	**Ni**	**Zn**	**Mn**
							mg/l				
1	Alirajpur	Udaigarh	Kundalwasa	DW	22.5105	74.6186	0.038	BDL	BDL	0.04	0.027
2	Alirajpur	Jobat	Bilasa	DW	22.4419	74.6100	BDL	BDL	BDL	0.062	0.042
3	Alirajpur	Jobat	Dekakund	Bw	22.4652	74.6515	0.039	BDL	BDL	0.038	BDL
4	Alirajpur	Jobat	Sewariya	DW	22.4055	74.6467	BDL	BDL	BDL	BDL	BDL
5	Alirajpur	Jobat	Nalthada	DW	22.3752	74.5967	BDL	BDL	BDL	0.238	0.021
6	Alirajpur	Alirajpur	Fata	DW	22.2657	74.5831	0.057	BDL	BDL	BDL	BDL
7	Alirajpur	Alirajpur	Palasda	DW	22.3353	74.5142	0.035	BDL	BDL	0.038	BDL
8	Alirajpur	Alirajpur	Baladmong	DW	22.3927	74.4965	0.121	BDL	BDL	0.16	0.678
9	Alirajpur	Alirajpur	Kunda	DW	22.3823	74.4009	0.96	BDL	BDL	1.093	BDL
10	Alirajpur	Alirajpur	Laxmani	DW	22.2899	74.4189	0.02	BDL	BDL	BDL	0.057
11	Alirajpur	Alirajpur	Jawaniya	DW	22.2106	74.4562	1.98	BDL	BDL	0.127	BDL
12	Alirajpur	Sondwa	Thodsindhi	DW	22.1688	74.3984	0.015	BDL	BDL	BDL	0.171
13	Alirajpur	Sondwa	Bodgaon	DW	22.1215	74.3983	0.041	BDL	BDL	2.499	BDL
14	Alirajpur	Sondwa	Kakadiwal	DW	22.1160	74.3143	0.78	BDL	BDL	0.092	BDL
15	Alirajpur	Alirajpur	Baddala	DW	22.2641	74.2795	0.025	BDL	BDL	BDL	BDL
16	Alirajpur	Alirajpur	Bokadiya	DW	22.2860	74.2082	1.2	BDL	BDL	BDL	0.016
17	Alirajpur	Alirajpur	Kardha	DW	22.2592	74.1528	0.114	BDL	BDL	BDL	BDL
18	Alirajpur	Alirajpur	Kumbi	DW	22.1787	74.2008	0.228	BDL	BDL	BDL	BDL
19	Alirajpur	Sondwa	Badda	DW	22.1564	74.2011	0.16	BDL	BDL	0.044	BDL
20	Alirajpur	Alirajpur	Doblajhiri	DW	22.3707	74.3262	0.014	BDL	BDL	0.045	BDL
21	Alirajpur	Alirajpur	Koha	DW	22.4452	74.2959	0.133	BDL	BDL	BDL	BDL
22	Alirajpur	Kathiwara	Kewda	DW	22.4943	74.1749	0.02	BDL	BDL	BDL	0.02
23	Alirajpur	Bhabra	Roligaon	DW	22.5472	74.2999	0.026	BDL	BDL	BDL	BDL
24	Alirajpur	Bhabra	Barjhar	DW	22.6023	74.2537	1.287	BDL	BDL	BDL	0.069
25	Alirajpur	Bhabra	Sajewada	DW	22.6049	74.3531	0.013	BDL	BDL	BDL	BDL
26	Alirajpur	Udaigarh	Mota umar	DW	22.4491	74.4601	0.019	BDL	BDL	BDL	0.046

Table 22: Chemical analysis data of ground water of Alirajpur district under NAQUIM (post-monsoon-2022)

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	Alirajpur	Udaigarh	Kundalwasa	Dw	22.5105	74.6186	7.71	1037	0	409	57	29	88	1.05	0.1	42	305	86	22	98	0.2	674
2	Alirajpur	Jobat	Dekakund	Bw	22.4652	74.6515	7.23	825	0	403	20	19	32	1.59	0	27	275	68	26	61	0.7	536
3	Alirajpur	Jobat	Sewariya	Dw	22.4055	74.6467	7.06	585	0	220	22	19	71	0.74	0	34	225	52	23.1	32	0.6	380
4	Alirajpur	Alirajpur	Fata	Dw	22.2657	74.5831	7.04	1095	0	458	65	21	62	1.34	0	36	330	90	26	98	1.6	712
5	Alirajpur	Alirajpur	Palasda	Dw	22.3353	74.5142	7.19	1722	0	482	197	18	211	0.95	0	28	670	224	27	105	0.1	1119
6	Alirajpur	Alirajpur	Baladmong	Dw	22.3927	74.4965	7.54	665	0	317	20	10	31	1.51	0	35	175	32	23	70	0.7	432
7	Alirajpur	Alirajpur	Baddala	Dw	22.2641	74.2795	7.22	872	0	317	70	17	70	0.77	0.1	26	260	62	26	82	0.4	567
8	Alirajpur	Alirajpur	Kumbi	Dw	22.1787	74.2008	7.34	2837	0	519	640	21	54	1.45	0	39	450	70	67	443	1.7	1844
9	Alirajpur	Alirajpur	Doblajhiri	Dw	22.3707	74.3262	7.41	877	0	427	17	11	51	1.02	0	46	310	80	27	55	0.7	570
10	Alirajpur	Bhabra	Sajewada	Dw	22.6049	74.3531	7.17	705	0	287	40	18	49	0.53	0	40	240	70	16	51	1.1	458
11	Alirajpur	Bhabra	Gerughati	Dw	22.5521	74.4225	7.28	960	0	342	82	9	82	0.28	0	31	310	102	13	75	2.5	624
12	Alirajpur	Alirajpur	Ambua	DW	22.4310	74.3530	6.67	1100	0	348	137	19	42	0.98	0.2	38	350	84	34	89	2.4	715
13	Alirajpur	Bhabra	Bhabra new	DW	22.5490	74.3170	7.43	698	0	311	40	20	10	1.05	0	29	245	58	24	43	4.3	454
14	Alirajpur	Alirajpur	Borkua	DW	22.2240	74.3420	7.23	810	0	390	30	11	14	0.75	0	34	345	96	26	33	2.4	527
15	Alirajpur	Jobat	Jobat New	DW	22.4130	74.5700	7.14	952	0	329	117	18	16	0.73	0	46	340	76	36	60	3.5	619
16	Alirajpur	Alirajpur	Khattali	DW	22.3480	74.5180	6.95	2282	0	439	445	26	120	1.31	0	26	670	196	44	211	4.7	1483

Table 23 : Ground Water Quality Data of NHS samples collected during pre-monsoon (May 2021).

Parameters				pH	EC	CO_3	HCO_3	Cl	SO_4	NO_3	F	PO_4	SiO_2	TH	Ca	Mg	Na	K	TDS
S. No.	Location	Lat.	Long.	at 25°C	µS/cm at 25°C	mg/liter													
1	Alirajpur	22.309	74.3530	7.92	1202	0	415	139	42	21	0.51	BDL	19	425	130	24	98	2.4	781
2	Ambua	22.431	74.4360	7.75	1985	0	573	225	85	105	0.40	BDL	27	650	178	50	172	3.0	1290
3	Badaguda	22.429	74.4990	7.25	855	0	439	37	10	11	1.10	0.2	35	330	98	21	45	3.8	556
4	Bhabra New	22.549	74.3170	7.52	642	0	305	30	8	51	0.82	BDL	42	260	84	12	38	3.1	417
5	Borkua	22.224	74.3420	7.65	842	0	397	25	5	66	0.81	BDL	16	345	104	21	33	2.7	547
6	Chandpur	22.357	74.2420	7.74	1356	0	482	156	32	19	0.47	BDL	23	400	124	22	142	2.5	881
7	Fatta	22.259	74.5480	7.82	1312	0	525	141	15	24	1.23	0.1	27	395	124	21	126	5.5	853
8	Jobat New	22.413	74.5700	7.92	678	0	275	30	17	56	0.65	BDL	34	255	64	23	39	4.3	441
9	Kathiwara	22.483	74.1490	7.52	765	0	390	22	16	12	0.87	BDL	36	300	82	23	41	5.8	497
10	Khattali	22.348	74.5180	7.56	602	0	244	27	11	49	0.89	BDL	42	250	64	22	24	2.1	391
11	Nanpur	22.269	74.5279	7.89	2265	0	824	290	12	43	1.06	BDL	29	615	178	41	245	5.5	1472
12	Salampura	22.518	74.208	7.92	706	0	317	27	19	39	0.53	0.1	27	185	38	22	75	2.6	459

CHAPTER-3
DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

After the study and analysis of the historical data, lithological data collected from 5 CGWB exploratory borewells were compiled and integrated as per Rockworks software format to prepare the 3-Dimensional Stratigraphic model and 2-Dimensional Cross section. It has been interpreted from the 3-D Model and 2-D Section is presented that the major water bearing zones has been encountered in weathered/fractured basalts and vesicular basalt. It comprises all the existing litho-units and the zones tapped during the groundwater exploration, forming an aquifer.

3.1 3-D Lithological & 3-D Stratigraphic model

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

The 3-D Model results showed that the region is dominantly occupied by varied type of lithology includes alternate layers of different basaltic flows, sandstone, limestone, granites, grantic gneiss, shale.

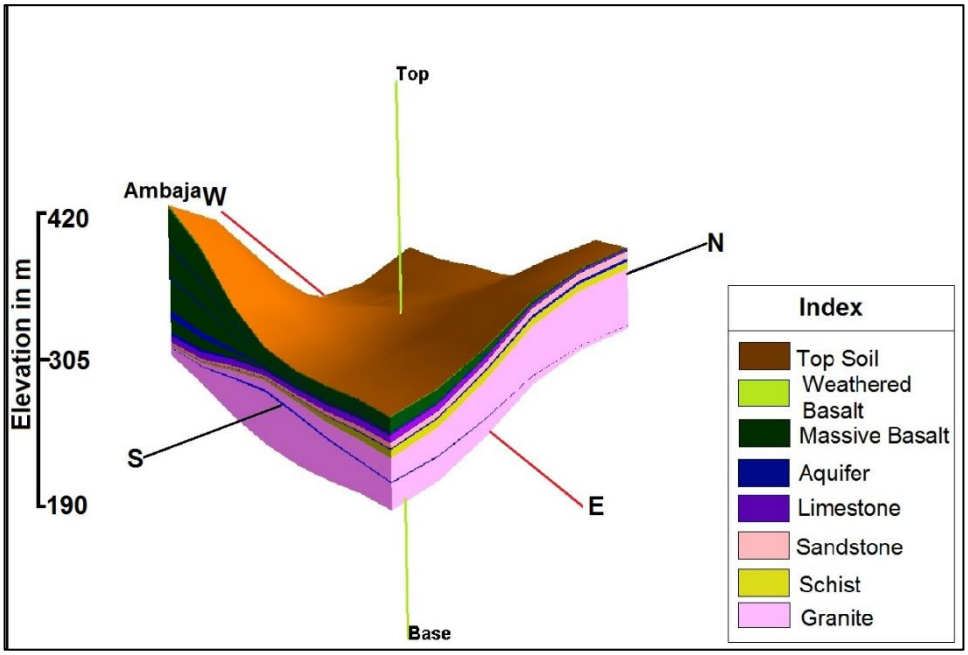


Fig - 27: 3-D Lithological Model of Alirajpur District, Madhya Pradesh

3.3 2-D Cross Section of Alirajpur District

Sub-surface lithological section has been prepared based on the based on the existing ground water exploration data to know the lithological continuity, its vertical and lateral extent. 2-Dimensional cross-section along the section **Ambaja – Tikhole - Udaigarh** and section along **Tikhole – Alirajpur - Udaigarh of Alirajpur district.**

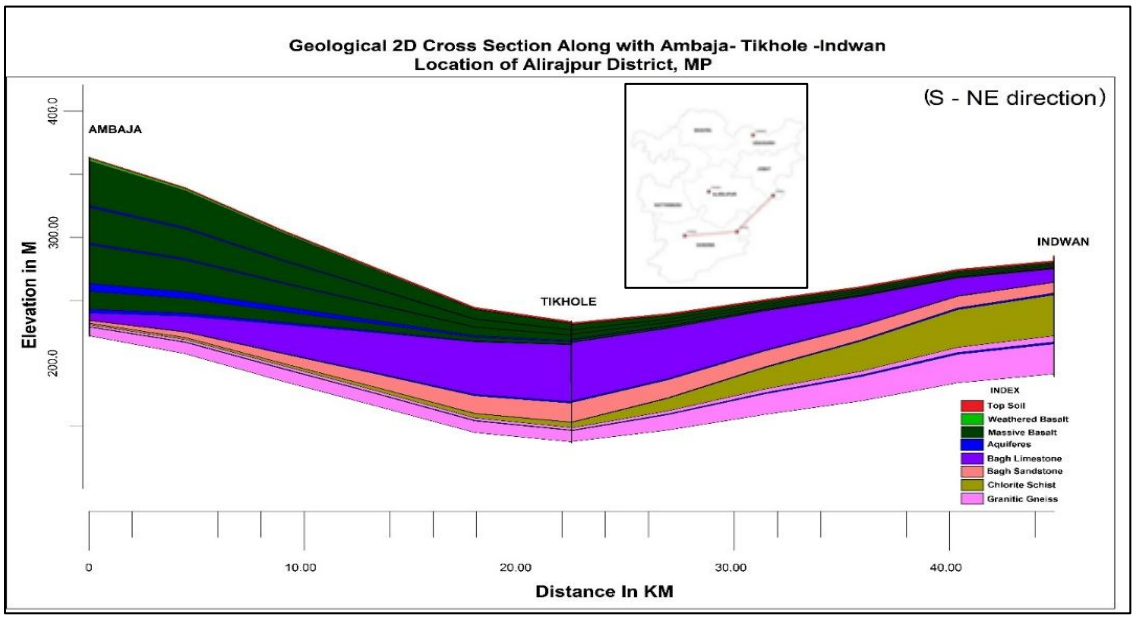


Fig - 28: 2-D Cross sections along Ambaja – Udaigarh of Alirajpur district

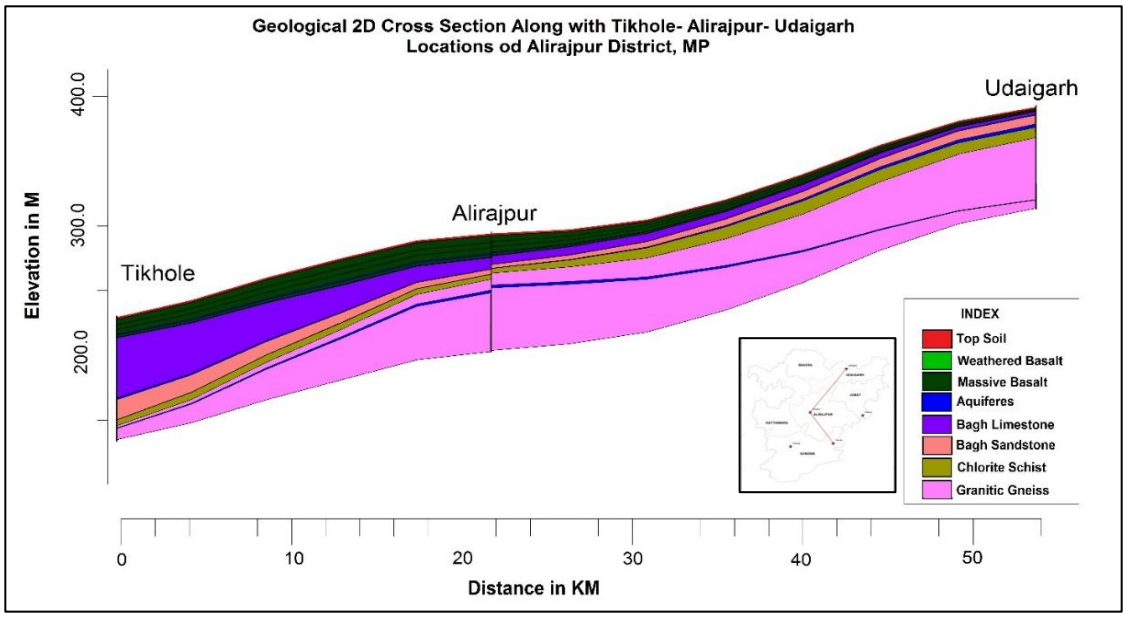


Fig - 29: 2-D Cross sections along Tikhole - Udaigarh of Alirajpur district

Chapter-4
GROUND WATER RESOURCES

4.1 Dynamic Ground Water Resources:

The dynamic ground water resources of the Madhya Pradesh state assessed jointly by the CGWB and State Ground Water Departments under the supervision of the State Level Committees and have been estimated for the Alirajpur district for the 2022 **on block wise** basis. There are 6 assessment units (blocks) in the district Kathiwada, Udaygarh, Jobat, Bhabra, Alirajpur and Sondwa. Out of 3318 sq. km of geographical area, 3054 sq. km. is ground water recharge worthy area and 264 sq. km is forest and hilly area. All 6 assessment units (blocks) in the district fall under safe category. Ground water resources have been computed including two components i.e.1) Groundwater recharge during the monsoon season and 2) Groundwater recharge during non-monsoon season.

The resource assessment during the monsoon season is estimated as the sum total of the change in storage and gross ground water draft. The change in storage is computed by using the water level fluctuation method. The other sources of ground water recharge during monsoon season include recharge from rainfall, seepage from canals, surface water irrigation, tanks and ponds, ground water irrigation, water conservation structures. The rainfall recharge during monsoon season computed by Water Level Fluctation (WLF) method is compared with recharge figures from RainFall Infiltration Factor (RIF) method. In case the difference between the two sets of data are more than 20%, then RIF method is considered otherwise monsoon recharge from WLF is adopted. **The resource assessment during non - monsoon season** is computed by using Rainfall Infiltation Factor (RIF) method. Recharge from other sources is then added to get the total non-monsoon recharge. In case of areas receiving less than 10% of the annual rainfall during non-monsoon season, the rainfall recharge is ignored. **The total annual ground water recharge** of the district is the sum of monsoon and non-monsoon recharge. An allowance is kept for ecological flow the rivers by deducting 5% of the total annual ground water recharge, if WLF method is employed to compute rainfall recharge during monsoon season and 10 % of the total annual ground water recharge if RIF method is employed. **Recharge from rainfall and other sources during rainfall** season in the Alirajpur district is 17686.87 hec and 653.24 hec respectively. **Recharge from rainfall and other sources during non-monsoon season** are 0 hec and 1724.58 hec respectively. The Annual Ground Water Recharge in the district is 200.64 MCM. The Annual Extractable groundwater resource is 185.82 MCM, groundwater extraction for irrigation use is 67.22 MCM, groundwater extraction for domestic use is 18.80 MCM and ground water draft for all uses is 86.02 MCM, making stage of ground water extraction to 46.29 % as a whole for the district. Table 24 shows the Dynamic Ground Water Resource Assessment estimated by CGWB for the year 2022.

4.2 Static Ground Water resources:

As an outcome of NAQUIM blockwiseGround Water Resource of Alirajpur district has also been calculated in which the **in-storage resource** for the shallow aquifer below zone of fluctuation (upto 30 mbgl) is computed to be around 183.98 MCM.

Table 24: Dynamic Ground Water Resources of Alirajpur district (as on March 2022)

District	Assessment Unit Name	Total Area of Assessment Unit (sq km)	Recharge Worthy Area (sq km)	Annual Extractable Ground Water Resource (mcm)	Ground Water Extraction for Irrigation Use (mcm)	Ground Water Extraction for Domestic Use (mcm)	Total Extraction (mcm)	Annual GW Allocation for Domestic Use as on 2025 (mcm)	Net Ground Water Availability for future use (mcm)	Stage of Ground Water Extraction (%)	Categorization
ALIRAJPUR	ALIRAJPUR	664	639	43.32	15.11	3.29	18.40	3.51	24.70	42.48	safe
ALIRAJPUR	BHABRA	340	313	17.53	9.90	2.30	12.21	2.43	5.19	69.64	safe
ALIRAJPUR	JOBAT	389	369	20.30	10.88	3.20	14.08	3.74	5.67	69.38	safe
ALIRAJPUR	KATTHIWARA	633	516	26.46	9.61	2.69	12.30	2.85	13.99	46.51	safe
ALIRAJPUR	SONDWA	922	874	56.34	13.92	4.91	18.84	5.42	36.98	33.44	safe
ALIRAJPUR	UDAIGARH	370	343	21.85	7.77	2.39	10.17	2.51	11.56	46.56	safe
Total		3318	3054	185.82	67.22	18.80	86.02	20.49	98.11	46.29	safe

Table 25: Total Ground Water Resources of Shallow Aquifer

	ALIRAJPUR	BHABRA	JOBAT	KATTHIWARA	SONDWA	UDAIGARH	Total
First Aquifer							
Dynamic Resources (MCM)	43.32	17.53	20.3	26.46	56.34	21.85	185.80
Static Resources (MCM)	26.81	17.10	46.11	17.77	61.62	14.57	183.98
Total Resources (MCM)	**70.13**	**34.63**	**66.41**	**44.23**	**117.96**	**36.42**	**369.78**
Irrigation GW Draft (MCM)	**15.11**	**9.90**	**10.88**	**9.61**	**13.92**	**7.77**	**67.19**
Domestic+Industries	3.29	2.3	3.2	2.69	4.91	2.39	18.78
Gross Ground Water Draft (MCM)	**18.40**	**12.20**	**14.08**	**12.30**	**18.83**	**10.16**	**85.97**
Stage of Ground Water Extraction (%)	**42.47**	**69.59**	**69.36**	**46.49**	**33.42**	**46.50**	**46.27**
Category	**safe**	**safe**	**safe**	**safe**	**safe**	**safe**	**safe**

CHAPTER -5
GROUND WATER RELATED ISSUES

5.1 Aquifers having Limited Yield Potential

Hard rock shallow aquifer occupies the first few twenty of meters from the top. Groundwater occurs in weathered zone under the unconfined condition, which has specific hydrodynamic properties from top to bottom. The entire Alirajpur district is covered by the varied type of lithology and having undulating topography. Ground water available in shallow, weathered mantle under unconfined condition is inadequate to meet the ever-increasing demand of water supply for essential purposes also. In most cases receptiveness of the precipitation is restricted to the degree of weathering and primary porosity if some impervious rock is present below it. Further due to high undulating terrain rain water flows as run off. As a result, even in high rainfall areas of the district, water scarcity is experienced in the summer months.

5.2 Ground water quality*:*

Flouride: About 5 % of the sample collected during pre-monsoon recorded higher concentration of fluoride more than the permissible limit i.e. 1.5 mg/l as per BIS (IS 10500 : 2012) i.e. in the village of Thodsindhi (1.51 mg/l) and Fata (1.52 mg/l). After post-monsoon fluoride concentration have been observed more than BIS permissible limit at Baladmong (1.51mg/l) and Dekhakund (1.59 mg/l).

Nitrate: Out of 40 samples about 45 % samples collected during pre-monsoon reported higher concentration of nitrate than the permissible limit i.e. 45 mg/l at locations Mota Umar (47 mg/l), Khattali (49 mg/l), Bhabra New (51 mg/l), Sajewada (53 mg/l), Doblajhiri (56 mg/l), Jobat New (56 mg/l), Fata (58 mg/l), Baladmong (59 mg/l), Baddala (60 mg/l), Kumbi (61 mg/l), Borkua (66 mg/l), Kundalwasa (73 mg/l), Dekakund (75 mg/l), Gerughati (93 mg/l), Udaigarh (95 mg/l), Sewariya (100 mg/l), Ambua (105 mg/l), Palasda (171 mg/l).. After post-monsoon, 17 samples collected and observed that 58.82 % of ground water samples are more than BIS acceptable limit i.e., 45 mg/l of nitrate concentration. Highest concentration of nitrate has been observed at Khattali (120 mg/l) and Palasda (211 mg/l) villages.

Iron, Manganese: In the district three locations, iron concentration is more than BIS permissible limit of 1.0 mg/l in the village of Bokadiya (1.20 mg/l), Barjhar (1.287 mg/l) and Jawaniya (1.98 mg/l). The manganese concentration at one location in the village Palasda i.e. 0.678 mg/l which is also more than BIS permissible limit of 0.3 mg/l.

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

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

1) more informed and transparent decision-making

2) Conflict prevention by development of consensus and information sharing.

3) Economic benefits, because it tends to optimize pumping and reduce energy costs.

4) Technical benefits, because it usually involves stakeholders in maintenance and leads to better estimates of water abstraction

5) Management benefits, because the trigger local stakeholder initiatives to implement demand and supply measures and reduce the cost of regulation.

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

Chapter-6
GROUND WATER MANAGEMENT STRATEGIES

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

6.1 District Ground Water Management Plan (Outcome of NAQUIM)

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

Alirajpur district has been facing problems of under developed and not using the resources available in a correct direct so that they will be benfited in terms of availability of groundwater and in terms of geeting developed socially & financially. This needs to evolve sustainable water conservation and management practices through an integrated approach. The ground water management plan for Alirajpur district has been made keeping in view the area specific details and includes the strategies like enhancing the ground water resources through construction of artificial recharge structures such as percolation tanks, check dams with recharge shaft, nala bands/cement plugs, village/farm ponds. Also, adoption of micro-irrigation techniques such as sprinkler irrigation/drip irrigation, which would not only conserve ground water resources by reducing the draft, but would also increase the net cropping area thereby, augmenting the agricultural economy of the district.

6.1.1 Supply Side Management Plan

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

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

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

For Alirajpur district, the supply side management plan has been formulated using the basic concepts of hydrogeology. Sub-surface storage is calculated by multiplying the total area with the respective specific yield and the unsaturated zone thickness obtained by subtracting 3 mts from the post-monsoon water level. The volume of ground water recharge generated through pre-existing rain water harvesting/water conservation structures is subtracted from the sub-surface storage to assess the available storage potential. Thus, the surface water requirement to completely saturate the sub-surface storage is obtained by multiplying a factor of 1.33 to available storage potential. The volume of unsaturated zone available in the Alirajpur district is 214.24 MCM. The volume of water required for recharging this much amount of water in the area is 284.94 MCM. But the non-committed runoff available in the district is only 138.36 MCM, therefore through 138.36 MCM non-committed runoff only 104.03 MCM groundwater can be recharged

A runoff of 0.14 per sq km considered for Alirajpur district to calculate the total surface water runoff, 30% of which accounts to the non-committed runoff which is available to sustain the proposed artificial recharge structures. Further, the number of structures has been calculated by allotting 35%, 45%, 15% and 5% of non-committed runoff to Percolation tanks, check dam with recharge shafts, Nala bund/Cement Plugs and village/farm ponds respectively. Supply Side Ground Water Management given in Table 26 a & b

A financial outlay plan has also been formulated, assuming the cost for the artificial recharge structures to be Rs. 20 lakhs each for percolation tanks, Rs. 7 lakhs each for check dam with recharge shafts/Tube wells, Rs. 1 lakh each for nala bund/cement plugs and Rs. 2.5 lakhs each village/farm ponds. This accounts to a total of Rs.231.48 crores to successfully implement the supply side management strategy. Table no. 9 represents the complete financial outlay plan for the district. Financial Outlay Plan- Supply Side Management given in Table 9.

6.1.2 Demand Side Management

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

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

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

Adoption of Sprinkler irrigation techniques would save 30 % of gross ground water draft for irrigation. Also, additional recharge created by construction of artificial recharge structures can be utilized to increase the total cropping area, thereby enhancing the productivity and economy of the district. In Alirajpur, Katthiwara, Sondwa, Udaigarh 100%, in Bhabra and Jobat block 80% of the additional recharge created by construction of AR structures is utilizing to increase the cropping area and in Alirajpur, Sondwa and Udaigarh block 10 % of the net groundwaqter available after intervention to increase the cropping area of the block. A summarized table for the demand side management is given in the Table no. 27.

Management Plan for For Ground Water Quality

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

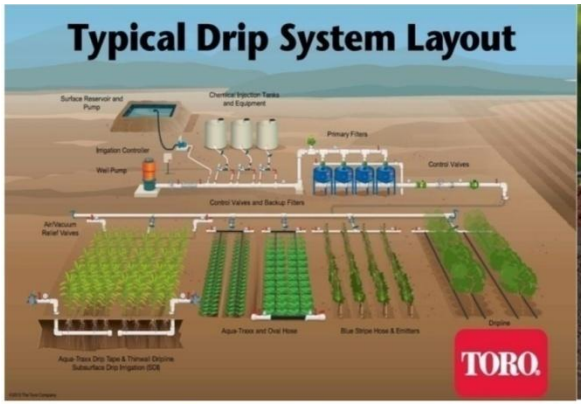


Fig - 30: Schematic Diagram ofMicro-irrigation (Drip & Micro-irrigation) Drip Irrigation system

(i) Cultivation of cucumbers through drip irrigation, (ii) Cultivation of cauliflower through drip irrigation

(i) Sprinkler Irrigation

Fig - 30: (i) Sprinkler system in different farm lands (ii) Automatic Sprinkler system in the garden

Table 26 a: Ground Water Management– Supply Side, Alirajpur District, Madhya Pradesh

Sl. No	District	Assessment Unit Name	Area (Sq.KM)	Annual Rainfall 5 years (mm)	Average Post-monsoon Water Level (m bgl)	Suitable Area for AR (sq.km)	Un Saturated Zone	Specific Yield	Sub-surface storage (mcm)	Surface water required (mcm)	Avaliable water for AR (MCM)	Artificial Recharge created against the sub-surface storage and non-commuted runoff available
1	ALIRAJPUR	ALIRAJPUR	664	1013.00	**7.37**	639	4.37	0.02	55.81	74.23	27.69	20.82
2	ALIRAJPUR	BHABRA	340	1013.00	8.48	313	5.48	0.02	34.30	45.63	14.18	10.66
3	ALIRAJPUR	JOBAT	389	1013.00	4.75833	369	1.76	0.02	12.98	17.26	16.22	12.20
4	ALIRAJPUR	KATTHIWARA	633	1013.00	5.25	516	2.25	0.02	23.22	30.88	26.40	19.85
5	ALIRAJPUR	SONDWA	922	1013.00	5.55	874	2.55	0.02	44.57	59.28	38.45	28.91
6	ALIRAJPUR	UDAIGARH	370	1013.00	9.32	343	6.32	0.02	43.36	57.66	15.43	11.60
	Total		3318.00			3054.00		0.02	214.24	284.94	138.36	104.03

Table 26 b: Ground Water Management– Supply Side, Alirajpur District, Madhya Pradesh

Sl. No	District	Assessment Unit Name	Runoff /sq.km	Runoff MCM	Non Commuted Runoff	no of percolation tanks	no of Check Dams with recharge shaft	no of nala bunds/cement plugs	no of village ponds/ Farm Ponds
1	ALIRAJPUR	ALIRAJPUR	0.14	92.30	27.69	48.00	415.00	415.00	138.00
2	ALIRAJPUR	BHABRA	0.14	47.26	14.18	25.00	213.00	213.00	71.00
3	ALIRAJPUR	JOBAT	0.14	54.07	16.22	28.00	243.00	243.00	81.00
4	ALIRAJPUR	KATTHIWARA	0.14	87.99	26.40	46.00	396.00	396.00	132.00
5	ALIRAJPUR	SONDWA	0.14	128.16	38.45	67.00	577.00	577.00	192.00
6	ALIRAJPUR	UDAIGARH	0.14	51.43	15.43	27.00	231.00	231.00	77.00
	Total			461.20	138.36	241.00	2075.00	2075.00	691.00

Table 27 : Financial Outlay Plan- Supply Side Management, Alirajpur District, Madhya Pradesh

Assessment Unit Name	Sub-surface storage (mcm)	Avaliable water for AR as per non-commuted runoff available (mcm)	Artificial Recharge created against the sub-surface storage and non-commuted runoff available (mcm)	no of percolation tanks	cost of percolation tanks in crores @0.2crores per pt	no of Check Dams	cost of Check Dams with recharge shaft in crores @0.07 crores per pt	no of nala bunds /cement plugs	cost of nala bund/cement plugs in crores @0.01 crores per pt	no of village ponds / Farm Ponds	cost of village pond in crores @0.025 crores per pt	Total cost
ALIRAJPUR	55.81	27.69	20.82	48	9.60	415	29.05	415	4.15	138	3.45	46.25
BHABRA	34.30	14.18	10.66	25	5.00	213	14.91	213	2.13	71	1.78	23.82
JOBAT	12.98	16.22	12.20	28	5.60	243	17.01	243	2.43	81	2.03	27.07
KATTHIWARA	23.22	26.40	19.85	46	9.20	396	27.72	396	3.96	132	3.30	44.18
SONDWA	44.57	38.45	28.91	67	13.40	577	40.39	577	5.77	192	4.80	64.36
UDAIGARH	43.36	15.43	11.60	27	5.40	231	16.17	231	2.31	77	1.93	25.81
	214.24	138.36	104.03	241	48.20	2075	145.25	2075	20.75	691	17.28	231.48

6.1.3 Water Conservation structures

The district is having limited aquifer potential therefore water conservation structures are recommended. Traditional Water harvesting systems: Restoration of the pre-existing village tanks, ponds and water conservation structures should be considered. These structures not only capture and store rainwater, but aid afforestation, reduce erosion of soil, increase the rainwater catchment area, and strengthen groundwater reservoirs. These ancient structures need a revival to tackle the present day water crisis. Involvement of stakeholder is very important to overcome this situation in the district.

6.2 Post-Intervention Impact

The supply side interventions by implementation of artificial recharge/water conservation will increase the resource by 104.03 MCM . These supply side interventions are not sufficient to bring the district under sustainable groundwater managemen. Therefore demand side interventions are also proposed in which micro-irrigation system is taken up to tackle the issues related to groundwater. Therefore after the supply side and demand side interventions the outcome of the proposed interventions has been described. The Stage of ground water extraction for the entire Alirajpur district, changed from 46.27 % to 61.22 % with 27902.55 ha additional area irrigated by groundwater after intervention for sustainable ground water management so that district will remain in safe category with more area under irrigation.

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

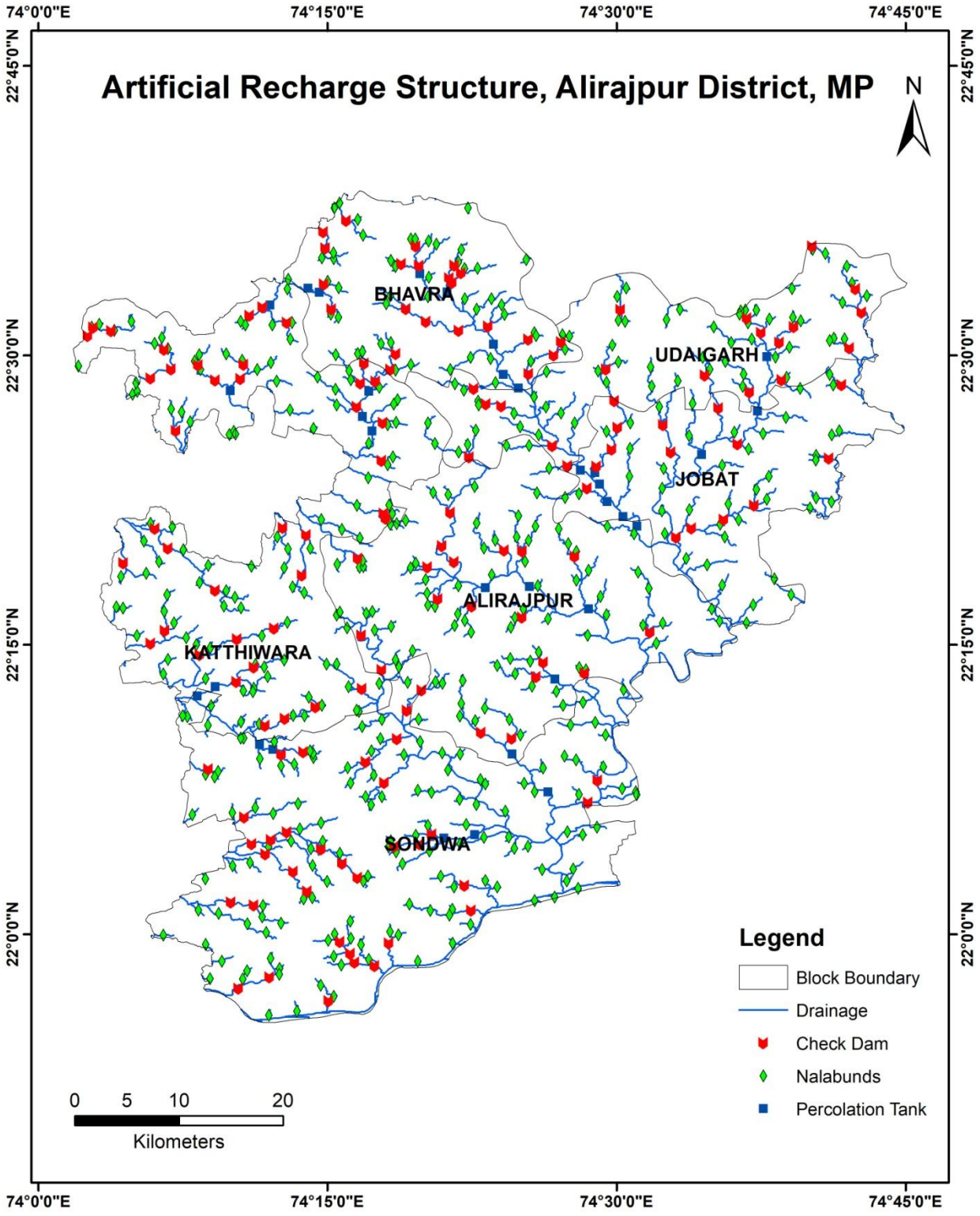
As per directions of Ministry of Water Resources, River Development and Ganga Rejuvenation, Government of India, Aquifer Management Plan for district has been prepared block-wise. The plan for each block discusses the broad framework of ground water situation in the block, status of water availability,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

Table 29 Quantitative impact on GW Resources after the supply side and demand side interventions

Block	Stage of GW Extraction (%)	Stage of GW Extraction after intervention (%)	Additional area irrigated by GW after intervention (Ha)
ALIRAJPUR	42.47	60.83	6287.66
BHABRA	69.59	62.99	2132.03
JOBAT	69.36	63.31	2439.29
KATTHIWARA	46.49	63.20	4961.67
SONDWA	33.42	57.71	8635.45
UDAIGARH	46.50	64.62	3446.44
Total	46.27	61.22	27902.55

Table 28 : Post-Intervention Impact – Demand side of Alirajpur District, Madhya Pradesh

Block	Net GW Availability (MCM)	Gross Draft (MCM)	Stage of Extraction (%)	Saving by microirrigation in (MCM)	Additional recharge created by AR (MCM)	After intervention of AR Structure Net GW AvL. (MCM)	After intervention of AR Structure & utilisation of additional GW created (MCM)/ Utilization of Net Ground Water Availabilty	After utilization of Net Ground water availability (2022 resource)	Draft after sprinkler & additional area created for agricultur e (MCM	Stage of Extraction after GW use for addidtional Area Irrigation(%)	Additional area irrigated by GW after intervention (Ha)
ALIRAJPUR	43.32	18.40	42.47	4.53	20.82	64.14	20.82	4.33	39.02	60.83	6287.66
BHABRA	17.53	12.20	69.59	2.97	10.66	28.19	8.53	0.00	17.76	62.99	2132.03
JOBAT	20.3	14.08	69.36	3.26	12.20	32.50	9.76	0.00	20.57	63.31	2439.29
KATTHIWARA	26.46	12.30	46.49	2.88	19.85	46.31	19.85	0.00	29.26	63.20	4961.67
SONDWA	56.34	18.83	33.42	4.18	28.91	85.25	28.91	5.63	49.20	57.71	8635.45
UDAIGARH	21.85	10.16	46.50	2.33	11.60	33.45	11.60	2.19	21.61	64.62	3446.44
Total	185.80	85.97	46.27	20.16	104.03	289.83	99.46	12.15	177.42	61.22	27902.55


Artificial Recharge Structure, Alirajpur District, MP
N
74°0'0"E
74°15'0"E
74°30'0"E
74°45'0"E
22°45'0"N
22°30'0"N
22°15'0"N
22°0'0"N
BHAVRA
UDAIGARH
JOBAT
ALIRAJPUR
KATTHIWARA
SONDWA
Legend
Block Boundary
Drainage
Check Dam
Nalabunds
Percolation Tank
0 5 10 20
Kilometers

6.4 Blockwise Groundwater Management Plan

Management Plan: Alirajpur Block

GROUND WATER RESOURCE OF ALIRAJPUR BLOCK	
Shallow Aquifer	
Dynamic Resources (MCM)	43.32
Static Resources (MCM)	26.81
Total Resources (MCM)	**70.13**
Irrigation GW Draft (MCM)	**15.11**
Domestic+Industries	**3.29**
Gross Ground Water Draft (MCM)	**18.40**
Stage of Ground Water Extraction (%)	**42.47**
Category	**safe**

Supply Side Mangement Plan

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

1. The volume of unsaturated zone available for AR in the Alirajpura block is 55.81 MCM but as per commuted runoff available artificial recharge created is 20.82 MCM.

2. The volume of water required for recharging this much amount of water in the block is 27.69 MCM.

3. The number of artificial recharge structures proposed in the block – 48 percolation tanks, 415 check dams with recharge shaft/ tubewell, 415 nala bunds/cement plugs, 138 villages ponds/farm ponds and the estimated cost of the recharge structures proposed –9.60 crore, 29.05 crore, 4.15 crore and 3.45 crore respectively. The cost for all structures of the block is 46.25 MCM.

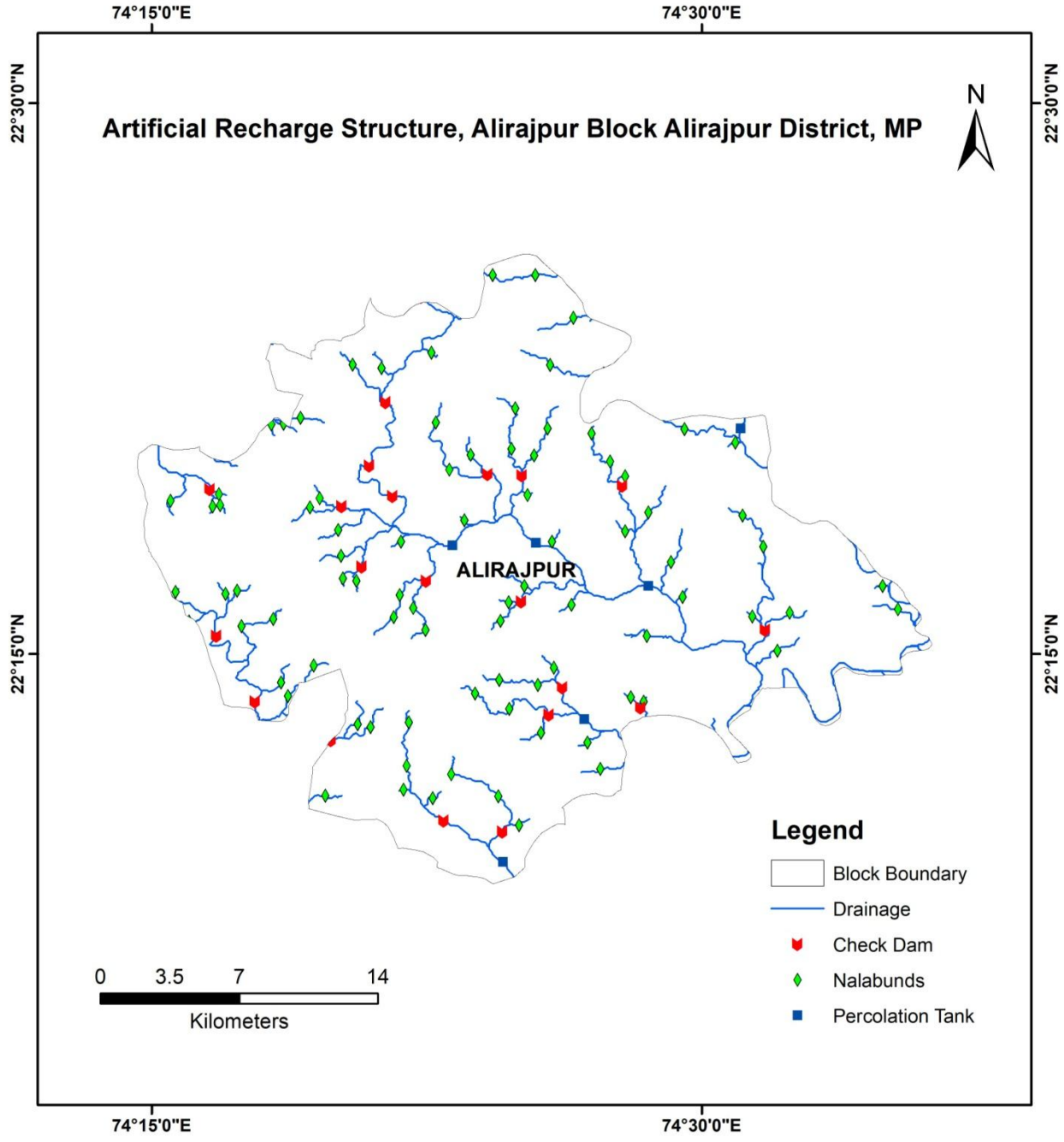
Type of Structure Proposed	Number	Cost in crores
Percolation tanks	48	9.60 (0.2 crore per structure)
Check Dams with recharge shaft	415	29.05 (0.07 crore per structure)
Nala bunds/cement plugs	415	4.15 (0.01 crore per structure)
Village ponds/ Farm Ponds	138	3.45 (0.025 crore per structure)
Total Cost		46.25 crore

Impact after Intervention: Alirajpur Block

Demand Side Management Plan

4. Demand side management plan has also been formulated in which saving of groundwater by micro-irrigation (drip or sprinkler) in the Barwaha block is 4.53 MCM.
5. After the intervention of supply side and demand side management plan successfully making the Stage of Ground Water Extraction of the Barwaha block from 42.47 % to 60.83 % and the block remains under safe category.
6. The additional area irrigated by Ground water after the intervention is 6287.66 ha.

Block	Net GW Availability (MCM)	Gross Draft (MCM)	Stage of Development (%)	Saving by microirrigation in (MCM)	Additional recharge created by AR (MCM)	After intervention of AR Structure Net GW AvL. (MCM)	After intervention of AR Structure & utilisation of additional GW created (MCM)/ Utilization of Net Ground Water Availabilty	After utilization of Net Ground water availability (2022 resource)	Draft after sprinkler & additional area created for agricultu re (MCM	Stage of Development W/O GW use for addidtional Area Irrigation(%)	Additional area irrigated by GW after intervention (Ha)
ALIRAJPUR	43.32	18.40	42.47	4.53	20.82	64.14	20.82	4.33	39.02	60.83	6287.66


74°15'0"E
74°30'0"E
22°30'0"N
22°15'0"N
Artificial Recharge Structure, Alirajpur Block Alirajpur District, MP
N
ALIRAJPUR
Legend
Block Boundary
Drainage
Check Dam
Nalabunds
Percolation Tank
0 3.5 7 14
Kilometers

Management Plan: Bhabra Block

GROUND WATER RESOURCE OF BHABRA BLOCK	
Shallow Aquifer	
Dynamic Resources (MCM)	17.53
Static Resources (MCM)	17.10
Total Resources (MCM)	**34.63**
Irrigation GW Draft (MCM)	**9.90**
Domestic+Industries	**2.3**
Gross Ground Water Draft (MCM)	**12.20**
Stage of Ground Water Extraction (%)	**69.59**
Category	**safe**

Supply Side Mangement Plan

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

7. The volume of unsaturated zone available for AR in the Bhabraa block is 34.30 MCM but as per commuted runoff available artificial recharge created is 10.66 MCM.
8. The volume of water required for recharging this much amount of water in the block is 14.18 MCM.
9. The number of artificial recharge structures proposed in the block – 25 ercolation tanks, 213 check dams with recharge shaft/ tubewell, 213 nala bunds/cement plugs, 71 villages ponds/farm ponds and the estimated cost of the recharge structures proposed – 5 crore, 14.91 crore, 2.13 crore and 1.78 crore respectively. The cost for all structures of the block is 23.82 MCM.

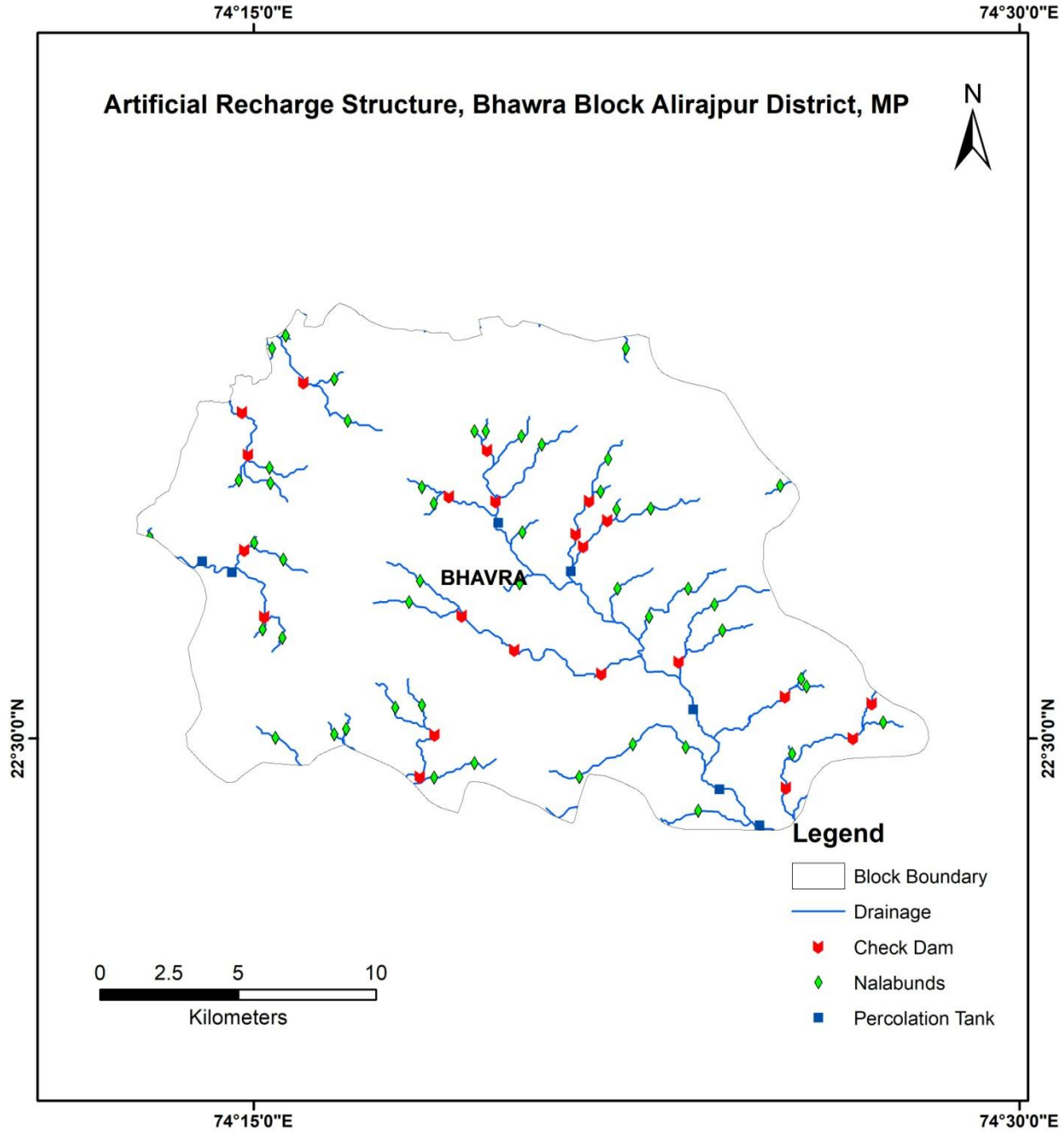
Type of Structure Proposed	Number	Cost in crores
Percolation tanks	25	5 (0.2 crore per structure)
Check Dams with recharge shaft	213	14.91 (0.07 crore per structure)
Nala bunds/cement plugs	213	2.13 (0.01 crore per structure)
Village ponds/ Farm Ponds	71	1.78 (0.025 crore per structure)
Total Cost		23.82 crore

Impact after Intervention: Bhabra Block

Demand Side Management Plan

1. Demand side management plan has also been formulated in which saving of groundwater by micro-irrigation (drip or sprinkler) in the Bhabra block is 2.97 MCM.
2. After the intervention of supply side and demand side management plan successfully making the Stage of Ground Water Extraction of the Barwaha block from 69.59 % to 62.99 % and the block remains under safe category.
3. The additional area irrigated by Ground water after the intervention is 2132.03 ha.

Block	Net GW Availability (MCM)	Gross Draft (MCM)	Stage of Development (%)	Saving by microirrigation in (MCM)	Additional recharge created by AR (MCM)	After intervention of AR Structure Net GW AvL. (MCM)	After intervention of AR Structure & utilisation of additional GW created (MCM)/ Utilization of Net Ground Water Availabilty	After utilization of Net Ground water availability (2022 resource)	Draft after sprinkler & additional area created for agriculture (MCM	Stage of Development W/O GW use for addidtional Area Irrigation(%)	Additional area irrigated by GW after intervention (Ha)
BHABRA	17.53	12.20	69.59	2.97	10.66	28.19	8.53	0.00	17.76	62.99	2132.03


74°15'0"E
74°30'0"E
Artificial Recharge Structure, Bhawra Block Alirajpur District, MP
N
BHAVRA
22°30'0"N
22°30'0"N
Legend
Block Boundary
Drainage
Check Dam
Nalabunds
Percolation Tank
0 2.5 5 10
Kilometers
74°15'0"E
74°30'0"E

Management Plan: Jobat Block

GROUND WATER RESOURCE OF JOBAT BLOCK	
Shallow Aquifer	
Dynamic Resources (MCM)	20.3
Static Resources (MCM)	46.11
Total Resources (MCM)	**66.41**
Irrigation GW Draft (MCM)	**10.88**
Domestic+Industries	**3.2**
Gross Ground Water Draft (MCM)	**14.08**
Stage of Ground Water Extraction (%)	**69.36**
Category	**Safe**

Supply Side Mangement Plan

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

4. The volume of unsaturated zone available for AR in the Jobata block is 12.98 MCM but as per commuted runoff available artificial recharge created is 12.20 MCM.
5. The volume of water required for recharging this much amount of water in the block is 16.22 MCM.

6. The number of artificial recharge structures proposed in the block – 28 percolation tanks, 243 check dams with recharge shaft/ tubewell, 243 nala bunds/cement plugs, 81 villages ponds/farm ponds and the estimated cost of the recharge structures proposed – 5.60 crore, 17.01 crore, 2.43 crore and 2.03 crore respectively. The cost for all structures of the block is 27.07 MCM.

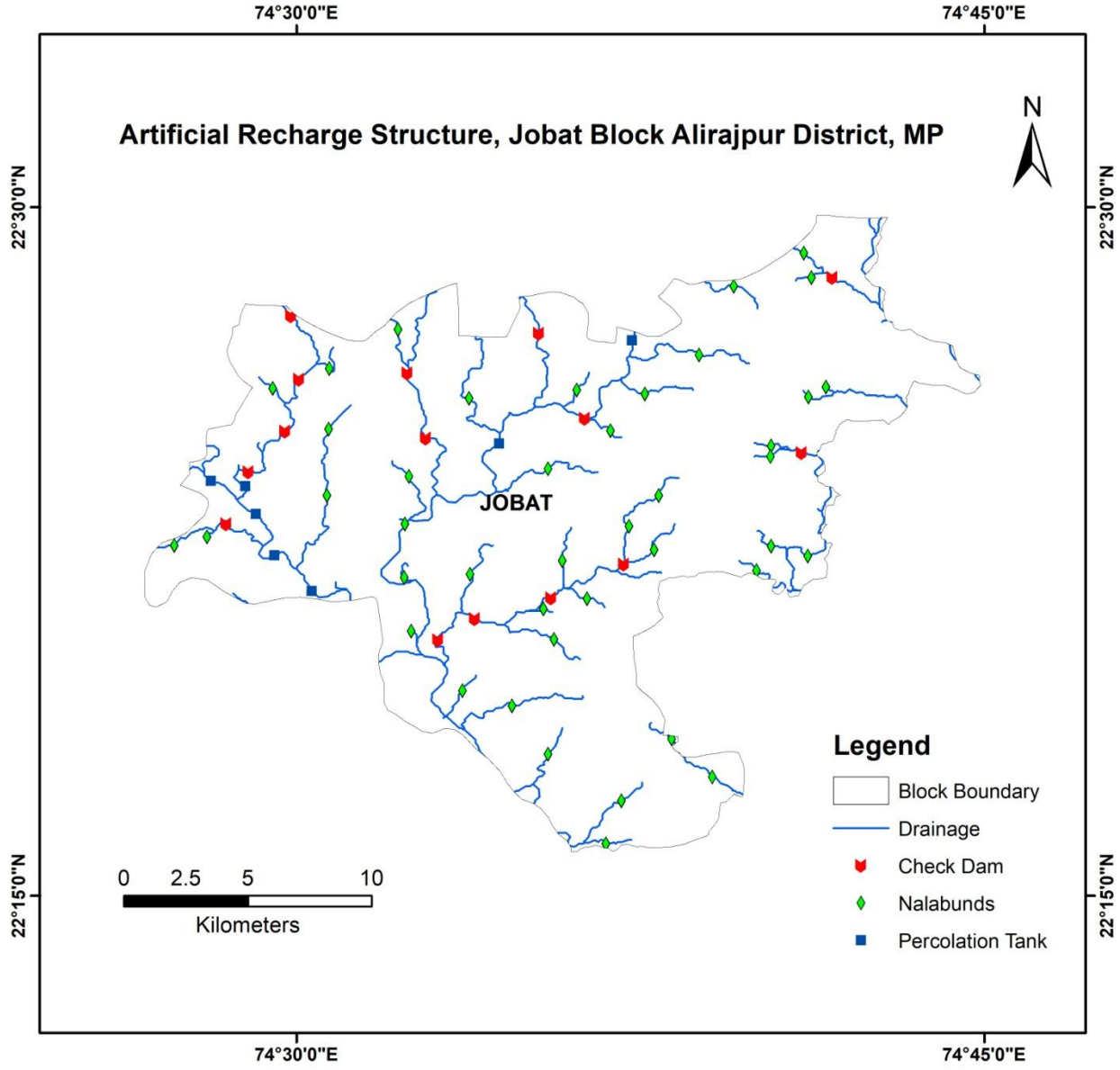
Type of Structure Proposed	Number	Cost in crores
Percolation tanks	28	5.60 (0.2 crore per structure)
Check Dams with recharge shaft	243	17.01 (0.07 crore per structure)
Nala bunds/cement plugs	243	2.43 (0.01 crore per structure)
Village ponds/ Farm Ponds	81	2.03 (0.025 crore per structure)
Total Cost		27.07 crore

Impact after Intervention: Jobat Block

Demand Side Management Plan

1. Demand side management plan has also been formulated in which saving of groundwater by micro-irrigation (drip or sprinkler) is 3.26 MCM.
2. After the intervention of supply side and demand side management plan successfully making the Stage of Ground Water Extraction of th block from 69.36 % to 63.31 % and the block remains under safe category.
3. The additional area irrigated by Ground water after the intervention is 2439.29 ha.

Block	Net GW Availability (MCM)	Gross Draft (MCM)	Stage of Development (%)	Saving by microirrigation in (MCM)	Additional recharge created by AR (MCM)	After intervention of AR Structure Net GW AvL. (MCM)	After intervention of AR Structure & utilisation of additional GW created (MCM)/ Utilization of Net Ground Water Availabilty	After utilization of Net Ground water availability (2022 resource)	Draft after sprinkler & additional area created for agriculture (MCM	Stage of Development W/O GW use for addidtional Area Irrigation(%)	Additional area irrigated by GW after intervention (Ha)
JOBAT	20.3	14.08	69.36	3.26	12.20	32.50	9.76	0.00	20.57	63.31	2439.29


Artificial Recharge Structure, Jobat Block Alirajpur District, MP
74°30'0"E
74°45'0"E
22°30'0"N
22°15'0"N
N
JOBAT
0 2.5 5 10
Kilometers
Legend
Block Boundary
Drainage
Check Dam
Nalabunds
Percolation Tank

Management Plan: Katthiwara Block

GROUND WATER RESOURCE OF KATTHIWARA BLOCK	
Shallow Aquifer	
Dynamic Resources (MCM)	26.46
Static Resources (MCM)	17.77
Total Resources (MCM)	**44.23**
Irrigation GW Draft (MCM)	**9.61**
Domestic+Industries	**2.96**
Gross Ground Water Draft (MCM)	**12.30**
Stage of Ground Water Extraction (%)	**46.49**
Category	**safe**

Supply Side Mangement Plan

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

4. The volume of unsaturated zone available for AR in the Katthiwaraa block is 23.22 MCM but as per commuted runoff available artificial recharge created is 19.85 MCM.
5. The volume of water required for recharging this much amount of water in the block is 26.40 MCM.
6. The number of artificial recharge structures proposed in the block – 46 percolation tanks, 396 check dams with recharge shaft/ tubewell, 396 nala bunds/cement plugs, 132 villages ponds/farm ponds and the estimated cost of the recharge structures proposed – 9.20 crore, 27.72 crore, 3.96 crore and 3.30 crore respectively. The cost for all structures of the block is 44.18 MCM.

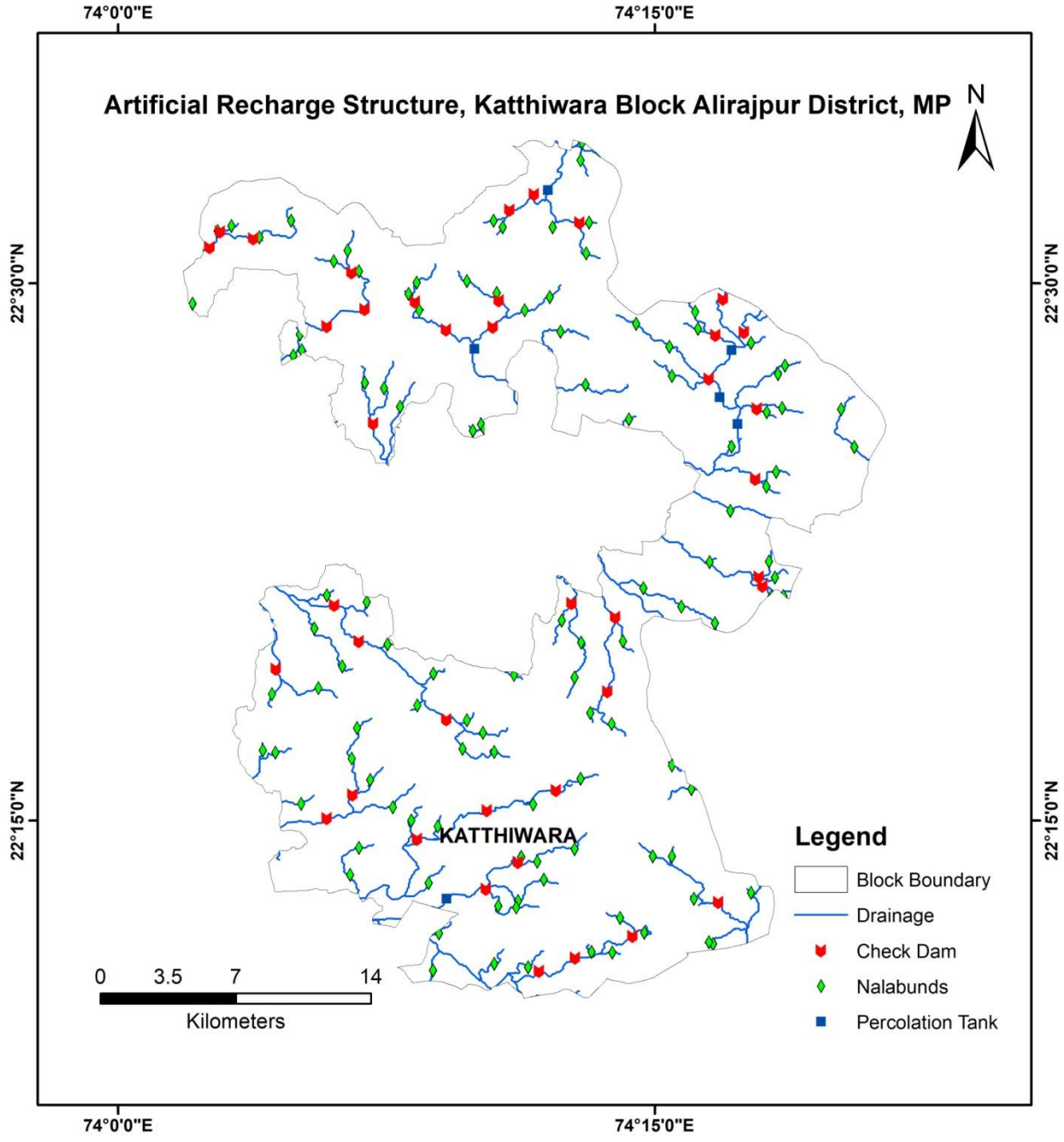
Type of Structure Proposed	Number	Cost in crores
Percolation tanks	46	9.20 (0.2 crore per structure)
Check Dams with recharge shaft	396	27.72 (0.07 crore per structure)
Nala bunds/cement plugs	396	3.96 (0.01 crore per structure)
Village ponds/ Farm Ponds	132	3.30 (0.025 crore per structure)
Total Cost		44.18 crore

Impact after Intervention: Katthiwara Block

Demand Side Management Plan

7. Demand side management plan has also been formulated in which saving of groundwater by micro-irrigation (drip or sprinkler) in the block is 2.88 MCM.
8. After the intervention of supply side and demand side management plan successfully making the Stage of Ground Water Extraction of the block from 46.49 % to 63.20 % and the block remains under safe category.
9. The additional area irrigated by Ground water after the intervention is 4961.67 ha.

Block	Net GW Availability (MCM)	Gross Draft (MCM)	Stage of Development (%)	Saving by microirrigation in (MCM)	Additional recharge created by AR (MCM)	After intervention of AR Structure Net GW AvL. (MCM)	After intervention of AR Structure & utilisation of additional GW created (MCM)/ Utilization of Net Ground Water Availability	After utilization of Net Ground water availability (2022 resource)	Draft after sprinkler & additional area created for agriculture (MCM	Stage of Development W/O GW use for addidtional Area Irrigation(%)	Additional area irrigated by GW after intervention (Ha)
KATTHIWARA	26.46	12.30	46.49	2.88	19.85	46.31	19.85	0.00	29.26	63.20	4961.67


Artificial Recharge Structure, Katthiwara Block Alirajpur District, MP
N
74°0'0"E
74°15'0"E
22°30'0"N
22°15'0"N
KATTHIWARA
0 3.5 7 14
Kilometers
Legend
Block Boundary
Drainage
Check Dam
Nalabunds
Percolation Tank

Management Plan: Sondwa Block

GROUND WATER RESOURCE OF SONDWA BLOCK	
Shallow Aquifer	
Dynamic Resources (MCM)	56.34
Static Resources (MCM)	61.62
Total Resources (MCM)	**117.96**
Irrigation GW Draft (MCM)	**13.92**
Domestic+Industries	**4.91**
Gross Ground Water Draft (MCM)	**18.83**
Stage of Ground Water Extraction (%)	**33.42**
Category	**safe**

Supply Side Mangement Plan

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

10. The volume of unsaturated zone available for AR in the Sondwaa block is 44.57 MCM but as per commuted runoff available artificial recharge created is 28.91 MCM.
11. The volume of water required for recharging this much amount of water in the block is 38.45 MCM.
12. The number of artificial recharge structures proposed in the block – 67 percolation tanks, 577 check dams with recharge shaft/ tubewell, 577 nala bunds/cement plugs, 192 villages ponds/farm ponds and the estimated cost of the recharge structures proposed – 13.40 crore, 40.39 crore, 5.77 crore and 4.80 crore respectively. The cost for all structures of the block is 64.36 MCM.

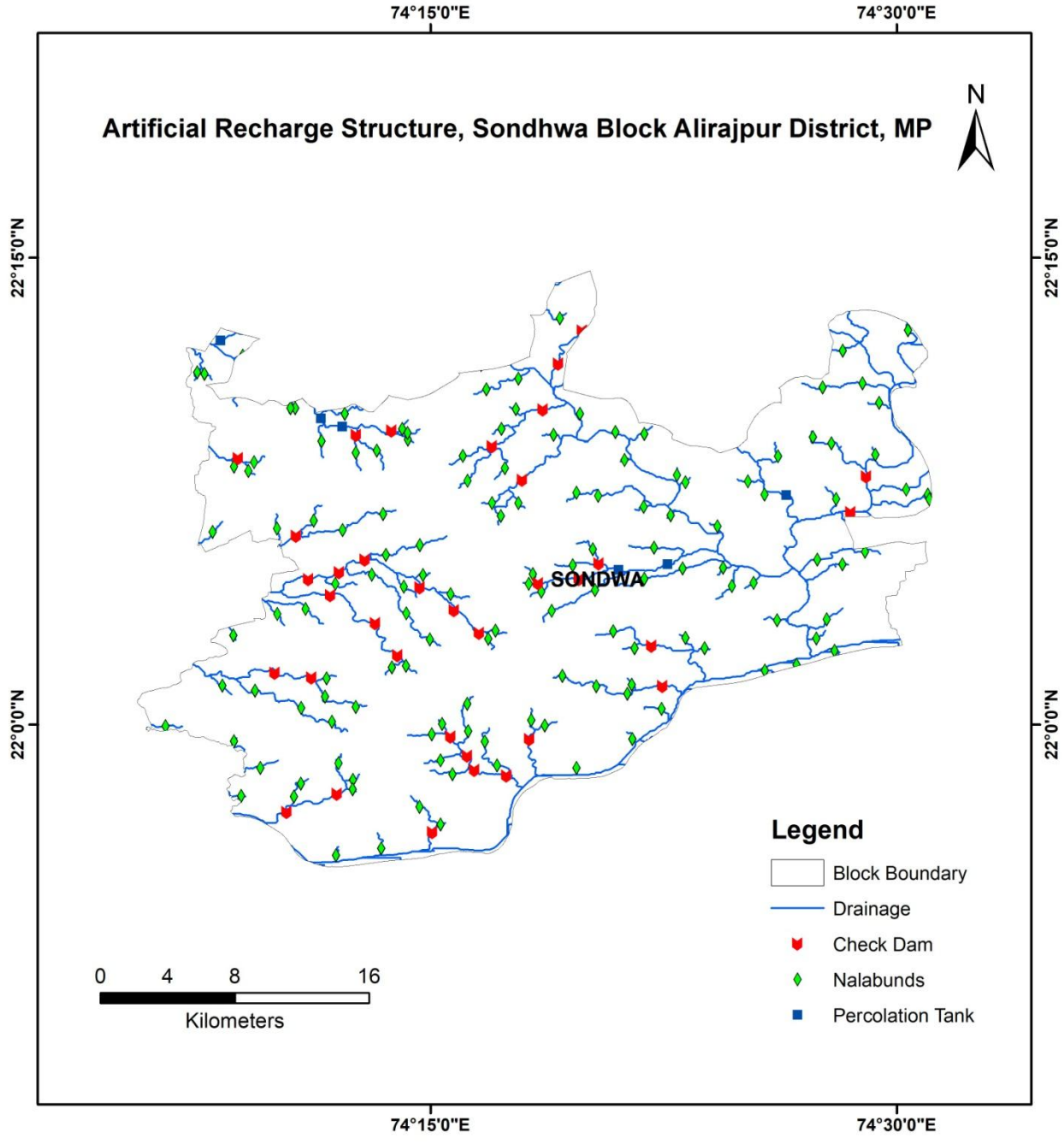
Type of Structure Proposed	Number	Cost in crores
Percolation tanks	67	13.40 (0.2 crore per structure)
Check Dams with recharge shaft	577	40.39 (0.07 crore per structure)
Nala bunds/cement plugs	577	5.77 (0.01 crore per structure)
Village ponds/ Farm Ponds	192	4.8 (0.025 crore per structure)
Total Cost		64.36 crore

Impact after Intervention: Sondwa Block

Demand Side Management Plan

13. Demand side management plan has also been formulated in which saving of groundwater by micro-irrigation (drip or sprinkler) in the block is 4.18 MCM.
14. After the intervention of supply side and demand side management plan successfully making the Stage of Ground Water Extraction of the block from 33.42 % to 57.71 % and the block remains under safe category.
15. The additional area irrigated by Ground water after the intervention is 8635.45 ha.

Block	Net GW Availability (MCM)	Gross Draft (MCM)	Stage of Development (%)	Saving by microirrigation in (MCM)	Additional recharge created by AR (MCM)	After intervention of AR Structure Net GW AvL. (MCM)	After intervention of AR Structure & utilisation of additional GW created (MCM)/ Utilization of Net Ground Water Availabilty	After utilization of Net Ground water availability (2022 resource)	Draft after sprinkler & additional area created for agriculture (MCM	Stage of Development W/O GW use for addidtional Area Irrigation(%)	Additional area irrigated by GW after intervention (Ha)
SONDWA	56.34	18.83	33.42	4.18	28.91	85.25	28.91	5.63	49.20	57.71	8635.45


Artificial Recharge Structure, Sondhwa Block Alirajpur District, MP
N
74°15'0"E
74°30'0"E
22°15'0"N
22°0'0"N
SONDWA
Legend
Block Boundary
Drainage
Check Dam
Nalabunds
Percolation Tank
0 4 8 16
Kilometers

Management Plan: Udaigarh Block

GROUND WATER RESOURCE OF UDAIGARH BLOCK	
Shallow Aquifer	
Dynamic Resources (MCM)	21.85
Static Resources (MCM)	14.57
Total Resources (MCM)	**36.42**
Irrigation GW Draft (MCM)	**7.77**
Domestic+Industries	**2.39**
Gross Ground Water Draft (MCM)	**10.16**
Stage of Ground Water Extraction (%)	**46.52**
Category	**safe**

Supply Side Mangement Plan

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

16. The volume of unsaturated zone available for AR in the Udaigarha block is 43.36 MCM but as per commuted runoff available artificial recharge created is 11.60 MCM.
17. The volume of water required for recharging this much amount of water in the block is 15.43 MCM.
18. The number of artificial recharge structures proposed in the block – 27 percolation tanks, 231 check dams with recharge shaft/ tubewell, 231 nala bunds/cement plugs, 77 villages ponds/farm ponds and the estimated cost of the recharge structures proposed – 5.40 crore, 16.17 crore, 2.31 crore and 1.93 crore respectively. The cost for all structures of the block is 25.81 MCM.

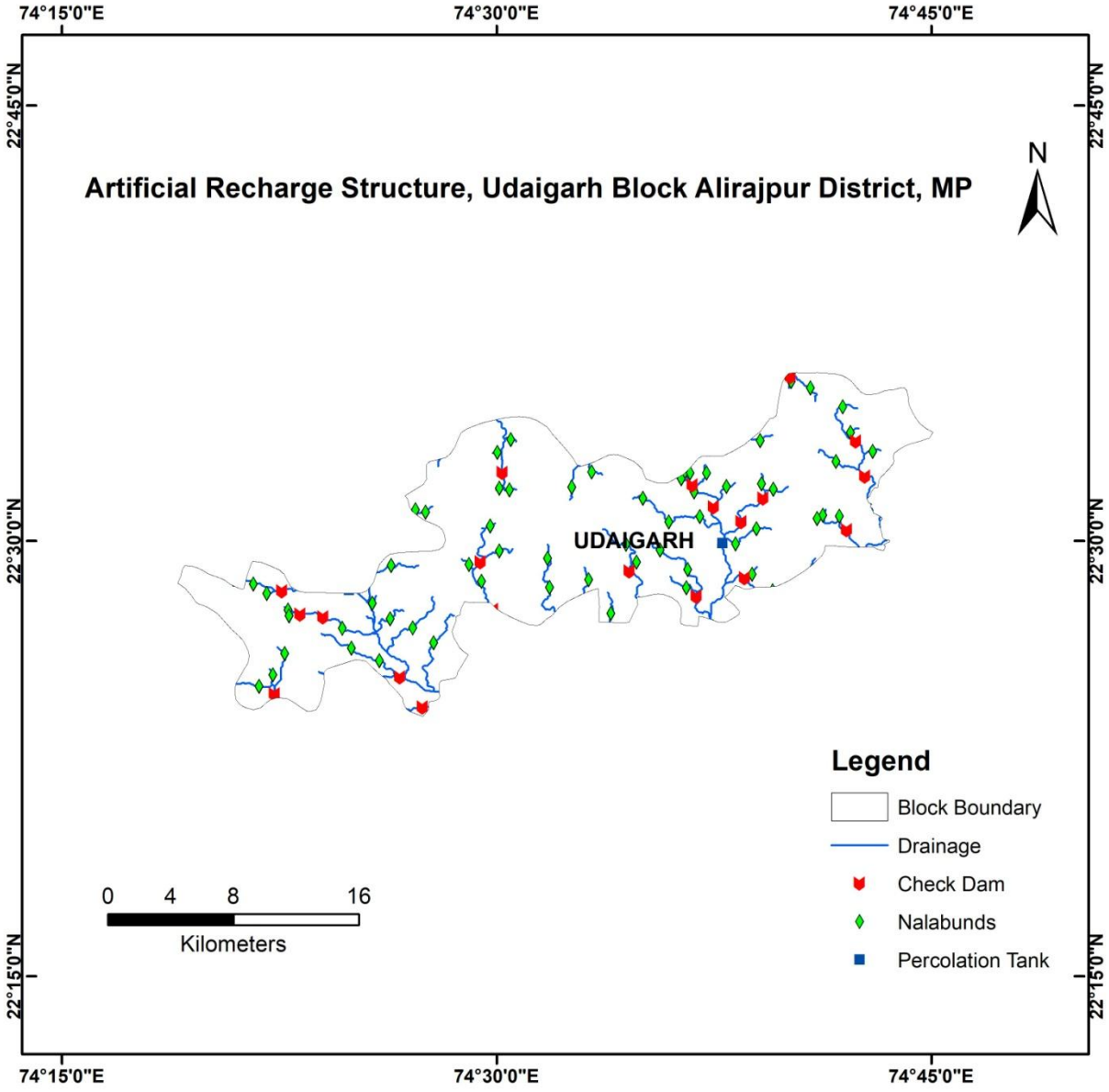
Type of Structure Proposed	Number	Cost in crores
Percolation tanks	27	5.40 (0.2 crore per structure)
Check Dams with recharge shaft	231	16.17 (0.07 crore per structure)
Nala bunds/cement plugs	231	2.31 (0.01 crore per structure)
Village ponds/ Farm Ponds	77	1.93 (0.025 crore per structure)
Total Cost		25.81 crore

Impact after Intervention: Udaigarh Block

Demand Side Management Plan

19. Demand side management plan has also been formulated in which saving of groundwater by micro-irrigation (drip or sprinkler) in the block is 4.53 MCM.
20. After the intervention of supply side and demand side management plan successfully making the Stage of Ground Water Extraction of the block from 42.47 % to 60.83 % and the block remains under safe category.
21. The additional area irrigated by Ground water after the intervention is 6287.66 ha.

Block	Net GW Availability (MCM)	Gross Draft (MCM)	Stage of Development (%)	Saving by microirrigation in (MCM)	Additional recharge created by AR (MCM)	After intervention of AR Structure Net GW AvL. (MCM)	After intervention of AR Structure & utilisation of additional GW created (MCM)/ Utilization of Net Ground Water Availabilty	After utilization of Net Ground water availability (2022 resource)	Draft after sprinkler & additional area created for agriculture (MCM	Stage of Development W/O GW use for addidtional Area Irrigation(%)	Additional area irrigated by GW after intervention (Ha)
UDAIGARH	21.85	10.16	46.50	2.33	11.60	33.45	11.60	2.19	21.61	64.62	3446.44


74°15'0"E
74°30'0"E
74°45'0"E
22°45'0"N
22°30'0"N
22°15'0"N
Artificial Recharge Structure, Udaigarh Block Alirajpur District, MP
N
UDAIGARH
Legend
Block Boundary
Drainage
Check Dam
Nalabunds
Percolation Tank
0 4 8 16
Kilometers

Chapter-7
CONCLUSIONS AND RECOMMENDATIONS

Based on the study of data gap analysis, data generated and data acquired from the State Government an integrated approach was adopted for the preparation of report of Alirajpur district

- Alirajpur district occupies an area of 3318.40sq km out of which the ground water recharge worthy area is 3054.4 sq. km. and 264 sq. km. is covered by hilly and forest area. It comprises 6 blocks namely – Alirajpur, Bhabra, Jobat, Kathiawada, Sondwa and Udaygarh block.
- The Narmada system represents two major types of drainage lines. First is the fault zone line and second is dentritic pattern shown by Kundi River. The important tributaries of the Narmada in this district are Kundi, Bakar, Borad, Beda etc. All these tributaries flow from south to north. Major rivers are perennial to semi perennial.
- Alirajpur district lies in the major basin of the Narmada river and forms the southern boundary of the district with the westerly flow of water. Narmada river has a length of 50 km in the district.. The perennial river Narmada flows through the area and important tributaries area Hathni, Sukar and Ankhai.
- The district os characterised by the varied and complex lithology which includes igneous, metamorphic and sedimentary as Central Indian Tectonic Zone is passes through the Alirapur district.
- The 25-35 % district is covered by the Deccan Basalt in the southern portion of the distict. In Deccan basalt flows occur in a layered sequence and act as multi-aquifer system. Each flow is characterised by the massive basalt at the bottom followed by vesicular basalt and marker horizon bed called as red bole. In the northern-western and central portion of the district is characterised by the Granite and granite gneiss and in these areas ground water is encountered in trhe fractured portion and yield low-moderate quantity of Ground Water. Apart from this schist, mics-schist, dolomite, limestone and sandstone is encountered. The alluvium of recent age found along the river course of Narmada River and along the tributaries of the Narmada in the district.
- The phreatic aquifer is recharged during monsoon and sustains for 3 to 5 months.
- Pre-monsoon depth to water level of the year 2022 ranges from **4.27 mbgl at Katthiwara site**, Katthiwara block to **15.58 mbgl at Udaigarh site**, Udaigarh block.
- During post monsoon period for the year 2022, water level ranges from 2.7 **mbgl at Kakadiwal site**, Sondwa block to **16.24 mbgl at Baladmong site**, Alirajpur block.

- **Flouride :** About 5 % of the sample collected during pre-monsoon recorded higher concentration of fluoride more than the permissible limit i.e. 1.5 mg/l as per BIS (IS 10500 : 2012) i.e. in the village Thodsindhi (1.51 mg/l) and Fata (1.52 mg/l). After post-monsoon fluoride concentration have been observed more than BIS permissible limit at Baladmong (1.51mg/l) and Dekhakund (1.59 mg/l). **Nitrate** : Out of 40 samples about 45 % samples collected during pre-monsoon reported higher concentration of nitrate than the permissible limit i.e. 45 mg/l. Highest nitrate concentration observed at Palasda village (171 mg/l).. After post-monsoon, 17 samples collected and observed that out of which 58.82 % of ground water samples are more than BIS acceptable limit i.e. 45 mg/l of nitrate concentration. Highest concentration of nitrate has been observed at Khattali (120 mg/l) and Palasda (211 mg/l) villages. **Iron, Manganese** : In the district three locations, iron concentration is more than BIS permissible limit of 1.0 mg/l in the village of Bokadiya (1.20 mg/l), Barjhar (1.287 mg/l) and Jawaniya (1.98 mg/l). The manganese concentration at one location in the village Palasda i.e. 0.678 mg/l which is also more than BIS permissible limit of 0.3 mg/l.
- Higher Concentration of nitrate has been encountered in the district. The use **of fertilizers and sewage/ domestic waste** is one of the reason for ground water contamination. Therefore it is recommended for proper lining of sewage lines and proper waste management in the district. In agriculture field the use of **organic fertilizers** instead of the use of harmful fertilizers is suggested.
- CGWB has constructed only 5 exploratory wells in the Alirajpur district. Further 28 key wells has been established in all over the district.
- As per the Dynamic Ground Water Resource Assessment Report (2022), The Annual Extractable groundwater resource is 185.82 MCM, groundwater extraction for irrigation use is 67.22 MCM, groundwater extraction for domestic use is 18.80 MCM and ground water draft for all uses is 86.02 MCM, making stage of ground water extraction to 46.29 % as a whole for the district and falls under safe category.
- There are 6 blocks namely Alirajpur, Bhabra, Jobat, Katthiwara, Sondwa and Udaigarh block having Stage of GW extraction is 42.47 %, 69.59 %, 69.36 %, 46.49 %, 33.42 %, 46.50 % respectively.
- The ground water development plan has been proposed which includes construction of artificial recharge structures, area under irrigation with **involvement of Stake Holders and Community mobilization at micro level, adoption of modern techniques for irrigation (micro-irrigation – drip and sprinkler)** for sustainable management of Ground Water Management.

- After the supply side interventions i.e. construction of artificial recharge structures groundwater resource will increase by **20.82 MCM** in Alirajpur, 10.66 MCM in Bhabra, 12.20 MCM in Jobat, 19.85 MCM in Katthiwara, 28.91 MCM in Sondwa and 11.60 MCM in Udaigarh block. In district groundwater resource will increase by 104.03 MCM.
- As per the Management plan prepared under NAQUIM of all the Block of Alirajpur district , a total number of 241 Percolation Tanks, 2075 Check dams with recharge shafts, 2075 Nala Bunds/Cement Plugs and 691 village ponds/ farm ponds have been proposed and financial expenditure is expected to be 48.20 crores, 145.25 crores, 20.75 crores and 17.28 crores respectively (as a whole the total expenditure for whole district is expected to be Rs 231.48 crores in the district) for sustainable extraction and management of ground water resources.
- These above supply side interventions are not enough for sustainable groundwater management Hence a demand side intervention ispropsed for all four blocks in which micro-irrigation system is adopting instead of conventional old methods. The saving by micro-irrigation (drip and sprinkler) in the Alirajpur block is 4.53 MCM, in the Bhabra block is 2.97 MCM, in the Jobat block is 3.26 MCM, in the Katthiwara block is 2.88 MCM, in the Sondwa block is 4.18 MCM, in the Udaigarh block is 2.33 MCM. As a whole saving by micro-irrigtaion is **20.16 MCM** in the entire Alirajpur district.
- Apart from supply side and management side interventions it is recommended to construct water conservation structures as district is having limited aquifer potential and wells having very low sustainability.
- After the implemention of project interventions in the report, the stage of ground water extraction is expected to change **from 46.27 % to 61.22 %** for the Alirajpur district and additional area for the irrigation will be 27902.55 Ha. The block wise stage of groundwater extraction expected to improve with additional area irrigated after the intervention is 24644.48 Ha.

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Annexure I
Litholog

Bore	Depth 1	Depth 2	Litholog
Ambaja	0	0.5	Top Soil
Ambaja	0.5	3	Weathered Basalt
Ambaja	3	48	Massive Basalt
Ambaja	48	50	Aquifer
Ambaja	3	81	Massive Basalt
Ambaja	81	86	Vesicular Basalt
Ambaja	86	88	Aquifer
Ambaja	88	127	Massive Basalt
Ambaja	127	135	Aquifer
Ambaja	135	153	Massive Basalt
Ambaja	153	157	Aquifer
Udaigarh	0	0.9	Top Soil
Udaigarh	0.9	8	Sandstone
Udaigarh	8	11	Aquifer
Udaigarh	11	16.15	Schist
Udaigarh	16.15	74	Granitic Gniess
Indwan	0	1	Top Soil
Indwan	1	8	Sandstone
Indwan	8	10	Aquifer
Indwan	10	60	Schist
Indwan	60	62	Aquifer
Indwan	62	88.87	Granitic Gniess

Tikhole	0	1	Top Soil
Tikhole	1	66	Limestone
Tikhole	66	68	Aquifer
Tikhole	68	88.69	Sandstone
Alirajpur	0	1	Top Soil
Alirajpur	1	10	Granitic Gniess
Alirajpur	10	13	Aquifer
Alirajpur	13	81	Granitic Gniess

Annexure II
Ground Water Level Trend

DISTRICT_NAME	BLOCK_NAME	VILLAGE_NAME	LATITUDE	LONGITUDE	SITE_TYPE	Post_Trend(m/yr)	Pre_Trend(m/yr)
ALIRAJPUR	ALIRAJPUR	Alirajpur	22.31	74.35	Dug Well	0.0264	-0.0744
ALIRAJPUR	ALIRAJPUR	Ambua	22.43	74.44	Dug Well	-0.0614	0.1348
ALIRAJPUR	ALIRAJPUR	Borkua	22.22	74.34	Dug Well	-0.02332	0.1677
ALIRAJPUR	ALIRAJPUR	Khattali	22.35	74.52	Dug Well	-0.2834	-0.062
ALIRAJPUR	ALIRAJPUR	Nanpur	22.27	74.53	Dug Well	-0.1955	-0.0896
ALIRAJPUR	ALIRAJPUR	Patta	22.26	74.60	Dug Well	-0.1349	0.0879
ALIRAJPUR	JOBAT	Badaguda	22.43	74.52	Dug Well	-0.0703	-0.2267
ALIRAJPUR	JOBAT	Jobat New	22.41	74.57	Dug Well	0.0162	-0.1325
ALIRAJPUR	KATTIWADA	Chandpur	22.36	74.24	Dug Well	-0.1287	-0.2564
ALIRAJPUR	KATTIWADA	Kathiwara	22.48	74.15	Dug Well	-0.133	-0.1408
ALIRAJPUR	KATTIWADA	Salampura	22.52	74.21	Dug Well	-0.1955	0.4878