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

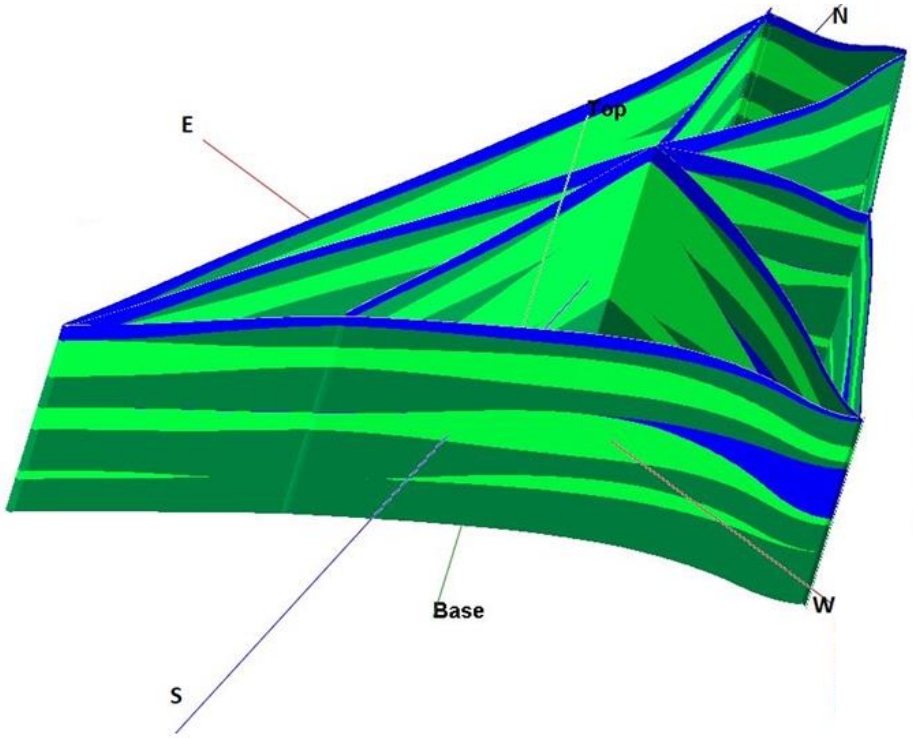
AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

DHAR DISTRICT, MADHYA PRADESH

उत्तर मध्य क्षेत्र, भोपाल

North Central Region, Bhopal

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



By

Naresh Kumar Jatav
Scientist-B

Central Ground Water Board

North Central Region

Bhopal

2020

CONTENTS

List of Tables:

List of Figures: **Pages**

PREFACE

"Aquifer mapping" is a holistic approach for aquifer-based groundwater management. It may not be construed as aquifer geometry mapping only. In a broader perspective it can be defined as understanding the aquifers, ascertaining and establishing their quantity and quality sustainability through multi-disciplinary scientific approach integrating the techniques of geology, remote sensing, hydrogeology, geophysics, borehole drilling, hydrochemistry, hydrology, hydrometeorology, mathematical modelling, agriculture and soil science, water treatment and remediation, economics and social and environmental sciences. Under the project on National Aquifer Mapping (NAQUIM to formulate sustainable aquier management plan, Central Ground Water Board (CGWB), North Central Region, Bhopal has taken up Dhar district to prepare the 3-Dimensional Model and 2-Dimensional Aquifer Maps for the entire district and formulate Block-wise Aquifer Management Plan.

The geographical area of the district is 8153.00 Sq. Km. and recharge worthy area is 8126 sq.km It is divided into, thirteen administrative blocks viz Dhar, Tirla, Badnawar, Nalchha, Bagh, Nisarpur, Umarwan,Gandhwani,Sardarpur,Manawar,Dahi,Dharampuri and Kukshi, Dhar district is underlain by various geological formations, forming different types of aquifers in the area. Main geological; units of the area are Deccan trap, Bagh Formation, western part of the district is covered by Archean and southern part covered by Alluvuim.

The pre-monsoon depth to water levels during May 2020 ranged between 2.90 (Palasi) to 17.80 mbgl (Pithampur). The water level ranges between 2 -5 mbgl are observed in major part of the district, 5-10 mbgl observed in Eastern part and the more than 10 mbgl are observed in some patches of northern eastern parts of the district. The post-monsoon depth to water levels during November 2020 ranged between 2.05 (Badnawar) to 13.78 mbgl (Dhrampuri)

Supply side and demand side Management plan prepared under NAQUIM. Artificial recharge structure has been proposed based on the available sub-surface storage of all the Block of Dhar District, a total number of 693 Percolation Tanks, 5282 Recharge Shafts/Checkdam and 5944 Nala Bunds and 1807 Village pond Cement Plugs have been proposed.

Results of these comprehensive studies will contribute significantly to ground water sustainable management tools. It will not only enhance the long-term aquifer monitoring networks and but would also help in building the conceptual and quantitative regional ground-water-flow models for planners, policy makers and other stakeholders. I would like to place on record my appreciation for **Naresh Kumar Jatav, Scientist-B** to compile this report. I fondly hope that this report will serve as a valuable guide for sustainable development of ground water in the Dhar District, Madhya Pradesh

Rana Chatterjee
(Regional Director)

Chapter: 1
Introduction

National project on Aquifer Mapping (NAQUIM) had been taken up by CGWB to carry out detailed hydrogeological investigation on toposheet scale of 1:50,000. Aquifer mapping is a process wherein a combination of geologic, geophysical, hydrologic and chemical analyses is applied to characterize the quantity, quality and sustainability of ground water in aquifers.

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

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

1.1 Objective and Scope

Aquifer mapping itself is an improved form of groundwater management – recharge, conservation, harvesting and protocols of managing groundwater. These protocols will be the real derivatives of the aquifer mapping exercise and will find a place in the output i.e, the aquifer map and management plan. The activities under NAQUIM are aimed at:

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

This clear demarcation of aquifers and their potential will help the agencies involved in water supply in ascertaining, how much volume of water is under their control. The robust and implementable ground water management plan will provide a **"Road Map"** to systematically manage the ground water resources for equitable distribution across the spectrum.

The following 5 thematic layers were also generated on GIS platform which supported the primary database and provided precise information to assess the present ground water scenario and also to propose the future management plan.

- Drainage and Basin
- Soil
- Land Use – Land Cover
- Geology and Structure
- Physiography

1.2 Study area

Dhar District is situated in the south – western part of Madhya Pradesh with covering a geographical area of 8153.00 sq.km, recharge worthy area is 8126 (Table: 1.1) which is 1.84% of total area of the State. It lies between the parallels of North latitude $22^0$01'14" and $23^0$08'49" and East longitude $74^0$28'15" and $75^0$42'43"E. The district is bounded by Ratlam in the north, Ujjain

in the north-east, West Nimar (Khargone) in the south and Jhabua in the west. The name, Dhar is derived from Dhara Nagri, the city of sword blades. The district falls in the Survey of India topo-sheets nos.46J, 46M & 46N. (Fig. 1.1). The district is divided into thirteen Development Blocks. In 2011, Dhar had population of 2,185,793 of which male and female were 1,112,725 and 1,073,068 respectively. In 2001 census, Dhar had a population of 1,740,329 of which males were 890,416 and remaining 849,913 were females. Dhar District population constituted 3.01 percent of total Maharashtra population. In 2001 census, this figure for Dhar District was at 2.88 percent of Maharashtra population. The initial provisional data released by census India 2011, shows that density of Dhar district for 2011 is 268 people per sq. km. In 2001, Dhar district density was at 213 people per sq. km. Dhar district administers 8,153 square kilometres of areas. Out of the total Dhar population for 2011 census, 18.90 percent lives in urban regions of district. In total 413,221 people lives in urban areas of which males are 217,612 and females are 195,609. Sex Ratio in urban region of Dhar district is 899 as per 2011 census data. Similarly, child sex ratio in Dhar district was 900 in 2011 census. Child population (0-6) in urban region was 59,907 of which males and females were 31,536 and 28,371. This child population figure of Dhar district is 14.49 % of total urban population. Average literacy rate in Dhar district as per census 2011 is 79.49 % of which males and females are 86.33 % and 71.88 % literates respectively. In actual number 280,865 people are literate in urban region of which males and females are 160,648 and 120,217respectively.

As per 2011 census, 81.10 % population of Dhar districts lives in rural areas of villages. The total Dhar district population living in rural areas is 1,772,572 of which males and females are 895,113 and 877,459 respectively. In rural areas of Dhar district, sex ratio is 980 females per 1000 males. If child sex ratio data of Dhar district is considered, figure is 934 girls per 1000 boys. Child population in the age 0-6 is 300,042 in rural areas of which males were 155,148 and females were 144,894. The child population comprises 17.33 % of total rural population of Dhar district. Literacy rate in rural areas of Dhar district is 54.09 % as per census data 2011. Gender wise, male and female literacy stood at 64.57 and 43.50 percent respectively. In total, 796,473 people were literate of which males and females were 477,831 and 318,642 respectively.

Table:1.1 Salient Feature of Dhar District

S. No	Block	Recharge Worthy Area (sq.km)	Total Area (sq.km)
1	BADNAWAR	1037	1064
2	BAGH	512	512
3	DAHI	482	482
4	DHAR	602	602
5	DHARAMPURI	429	429
6	GANDHWANI	736	736
7	KUKSHI	343	343
8	MANAWAR	555	555
9	NALCHA	784	784
10	NISARPUR	353	353
11	SARDARPUR	1280	1280
12	TIRLA	534	534
13	UMRABAN	479	479
DHAR DISTRICT		8126	8153

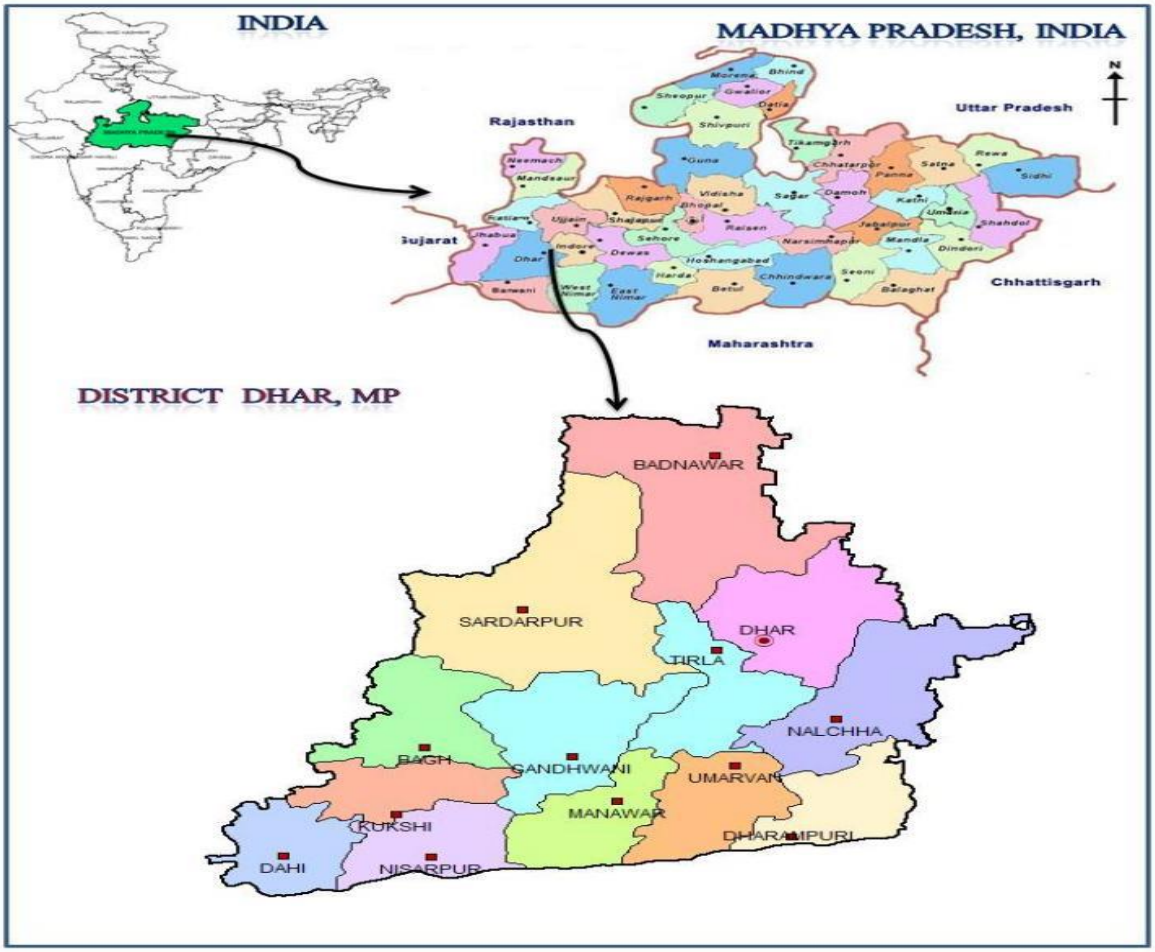


Fig:1.1 Index map of Dhar District

1.3 Climate and Rainfall

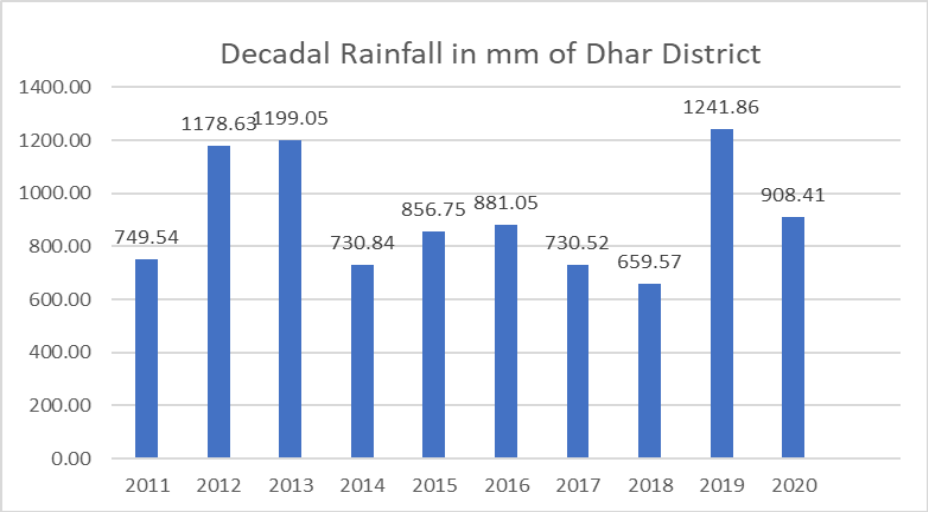
The climate of Dhar is characterized by a hot summer and general dryness except rainfall during the south- west monsoon season. The year can be divided into four seasons. The cold season, December to February is followed by summer season from March to about first week of June. The period from the middle June to September is the south-west monsoon season. October and middle of November constitute the post monsoon or retreating monsoon season. May is the hottest month of the year with average temperature of 39.3ºC. The minimum during the December is 10.3ºC. The normal annual mean maximum and minimum temperature is 30.7ºC and 17.9ºC respectively.

The normal annual rainfall of Dhar district is 908.41 mm. About 86.6% of annual rainfall is received during monsoon season. Only 13.4% of annual rainfall takes place between October to May. Detailed of year wise rainfall are given table:1.2.

Table: 1.2 Annual Rainfall Data – 2011-2020

Year	Rainfall in mm
2011	749.54
2012	1178.63
2013	1199.05
2014	730.84
2015	856.75
2016	881.05
2017	730.52
2018	659.57
2019	1241.86
2020	908.41

(Source: Indian Meteorological Department)



1.4 Topography and Physiography

The district extends over three physiographic divisions. They are the Malwa in the north, the Vindhyachal range in central zone and the Narmada valley along the southern boundary. However, the valley is again closed up by the hills in the south-western part (Fig. 1.2).

- **Malwa Plateau:**

The northern half of the district lies on the Malwa plateau. It covers the northern parts of Dhar, Sardarpur and Badnawar tahsils. The average elevation of the plateau is 500 metres above the mean sea level. The land is undulation with a few scattered flat topped hills roughly aligned between the valleys from south to north. The general slope is towards the north. The valleys are covered with black cotton soil of varying thickness, mostly adapted for cultivation. The mounds may bear gravels or the underlaying sandstone rocks may have been exposed. The plateau covers an area of about 466,196 hectares in the district.

- **Vindhyachal Range:**

A part of the range extends in the district in a crescentic belt generally from south-east to north-west. The range is represented by a strip of hilly area 5 to 20 kilometres in width. It is about 5 km wide near village Dhani near the south-eastern boundary. Near Mograbav in the centre, it is about 10 km further widening to 20 km west of Tanda. To the west of Bagh and Kukshi the range stands disconnected by the valleys of the Mahi and Hatni.

It restarts along the Narmada in the south-west. The northern spur (peak 543.76 metres) froms the boundary between the Sardarpur tahsil and Jhabua district. It extends from the peak of Gomanpur a (556.26 metres) to Bajrangarh in Jhabua. Another spur extends to wards Jhabua in the north-west. The great Vindhyachal range extends generally from west to east and scarps at most of its length towards the south. In Dhar also the south-ward escarps are well marked, the wall rising from 400 to 600 metres. However, in the western part their faces have been eroded back into long and deep rugged valleys of the tributary hills of the Narmada. In fact, the strong currents of the small streams on the steep southern side have cut back at their heads. The numerous streams of the Narmada valley find their sources on the Malwa plateau. The main line of the highest peaks has been left to the south of their present courses.

In the eastern and central parts of the Vindhyachal in Dhar the main hill range is continuous but in the west it is dissected by deep channels of the rivulets. The range slopes towards the north and gradually meets the Malwa plateau. Numerous spurs also extend over the Malwa plateau in the north. But in the western half in the district one may also find a series of denuded ridges alternating with the parallel stream-channels and running for some kilometres from local confusion, unless one tries to trace the line of the main peaks.

The hightest peak of the district, Mograba (751.03 metres) lies in the central part. Nilkanth (702.26 metres) lies further east and the Shikarpura hill rises up to 698.91 metres. The famous historical fort of Mandugarh towers the flat-topped hill about 600 metres, from the mean sea level.

- **Narmada Valley:**

Below the Vindhyachal scarps lies the narrow valley of the Narmada. It occupies the southern part of the district in Manawar tahsil and the south-eastern part of Kukshi tahsil. The width of the valley is 15 to 30 kilometres. The elevation varies from 275 metres in the northern part of Manawar tahsil to 150 metres in the low plain of Nisarpur in the south-west. To the east between Khalghat and Bakaner the valley is undulation wider, more open and fertile with alluvial cover. Proceeding westwards the valley is studded with hills alternatively cut up by numerous streams which join the Narmada along the southern boundary of the district. The result is that there are few stretches and pockets of alluvium along the streams.

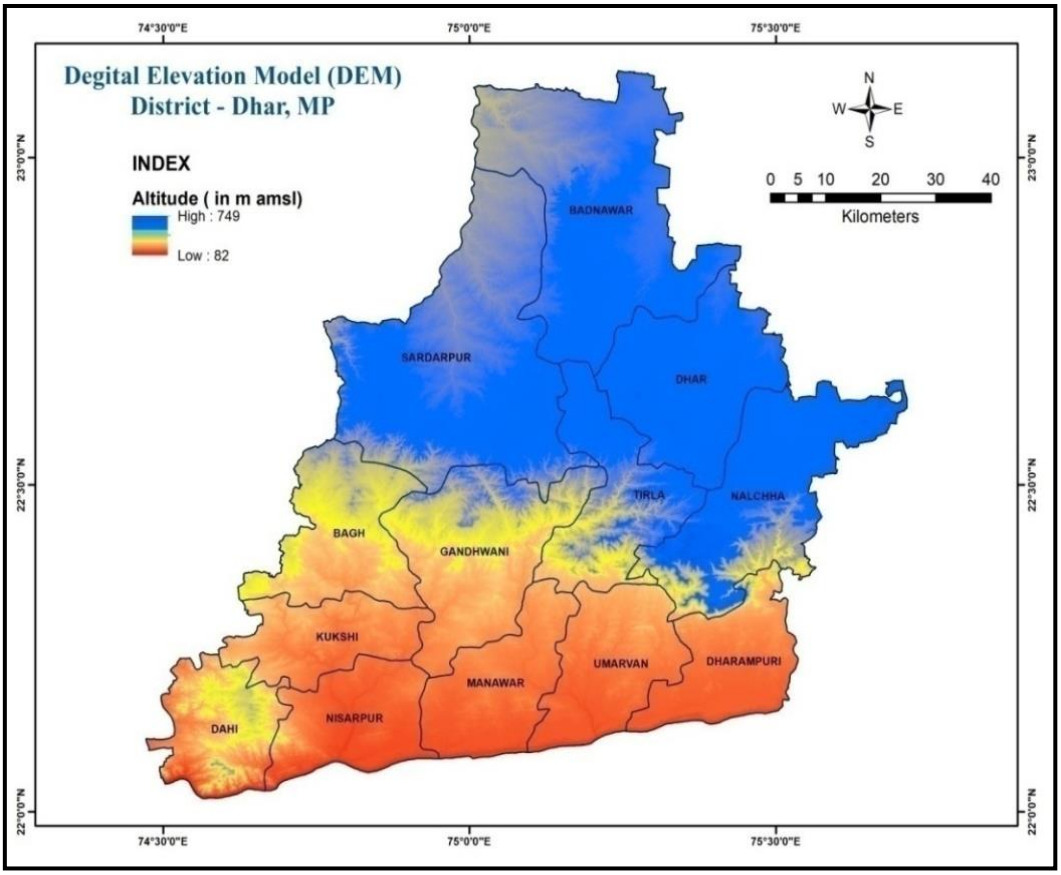


Fig.1.2 Physiography

1.5 Land Uses and Irrigation and Cropping patterns pattern

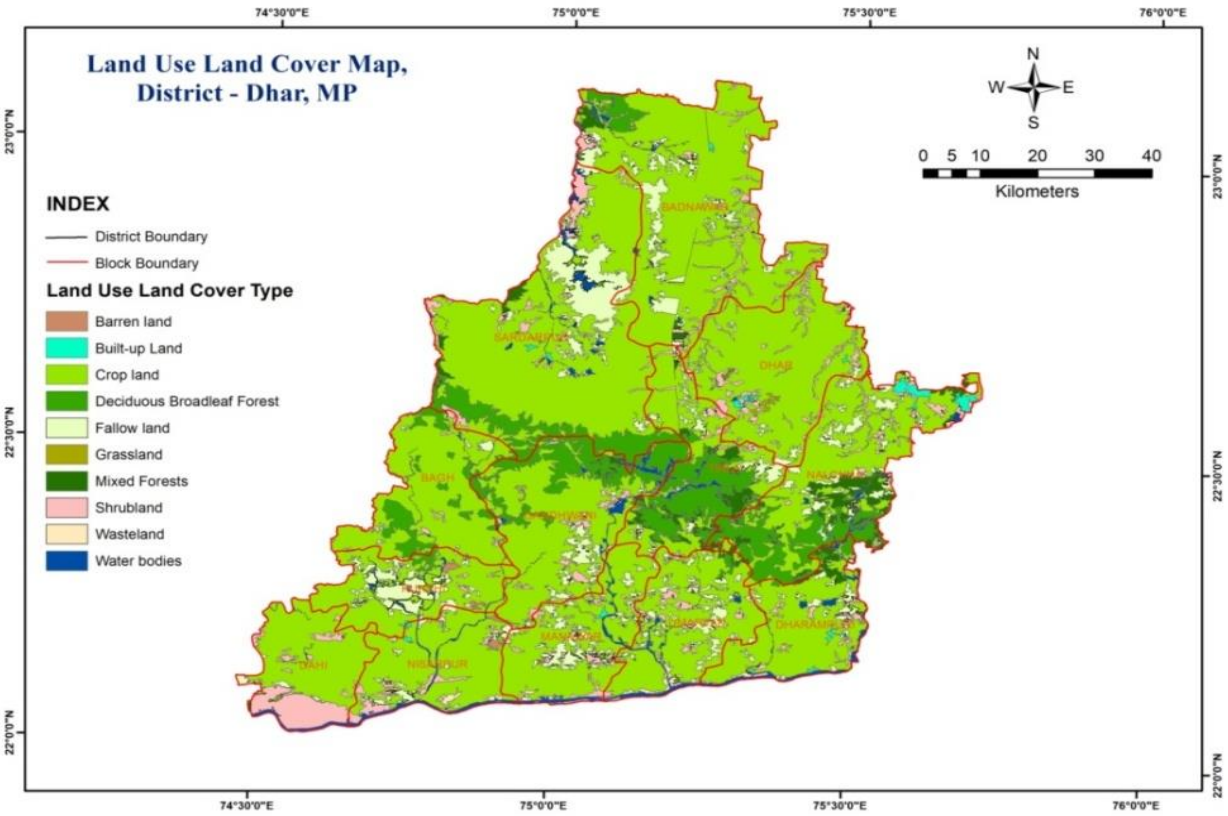
Forest and agriculture are the prominent land use aspects in Dhar district and forms 36.9% and 57.6% of total area respectively followed by the industrial and built-up structures. The spatial distribution of land use is presented in **Fig. 1.3**.

Forest area is restricted in southern to SW Narmada basin, where the medium to dense forest includes teak, Anjan, Sal, Tendu and Mahno trees. In the undulating hilly tract to Mohi River basin occupies this forest with scanty vegetation and scattered shrubs and bushes, whereas in the rest of Mohi basin and almost lion's share of Chambal River basin, agriculture is in practice.

The details of the land use statistics for year 2000-2001 is given in Table-1.3 and the cropping pattern is given in Table – 1.4.

Table 1.3: Land Use (in sq.km)

Built up Area	Agricultural Land	Forest	Barren/ waste Land	Water bodies/ Wetlands	Total area
186.48	6162.75	926.07	655.51	222.19	8153



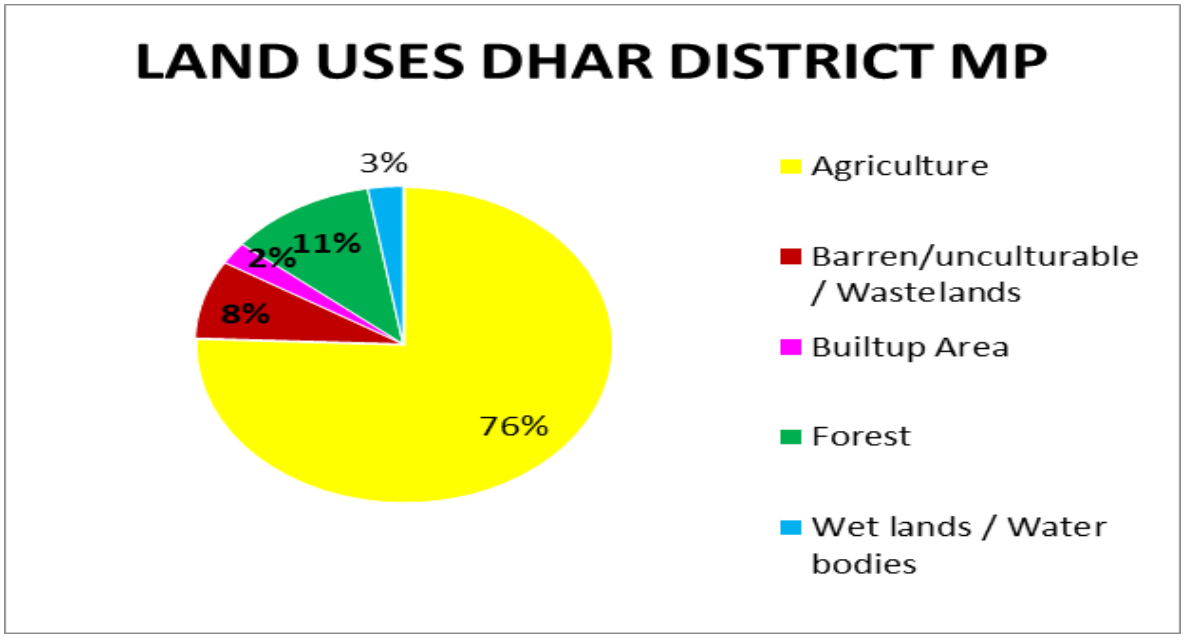


Fig.1.3: Map and Pie diagram of Land Use

Area wise, crop wise irrigation-

The district has good potential for irrigation through different sources. Though most of the area under irrigation is dependent on rainfall. It there is deficit in rainfall, the area under irrigation drastically reduced the major sources of irrigation in the district are tube wells, surface irrigation and seasonal rivers.

Table:1.4 Area-wise, Crop-wise irrigation Status

Crop type	**Kharif (Ha)**			**Rabi (Ha)**			**Summer Crop (Ha)**			**Total (Ha)**			**Horticulture& plantation(Ha)**			
	Irrigated	**Rainfed**	**Total**	**Irrigated**	**Rainfed**	**Total**	**Irrigated**	**Rainfed**	**Total**	**Irrigated**	**Rainfed**	**Total**	**Crop**	**irrigated**	**Rainfed**	**Total**
Cereals	0	540	540	183700	11358	195058	0	0	0	183700	11898	195598	Fruit	3025	0	3025
Coarse Cereals	0	65197	65197	0	0	0	835	0	835	835	65197	66032	Vege tables	6236	5935	12171
pulses	15	14561	14576	66929	14351	81280	310	0	310	67254	28912	96166	Spices	36157	0	36157
Oil seeds	0	298272	298272	137	0	137	50	0	50	187	298272	298459	Medi cinal Plant	205	0	205
Fibre	64126	27199	91325	0	0	0	0	0	0	64126	27199	91325	flower	981	0	981
Any other crops	0	30804	33804	23767	5970	29737	760	0	760	24527	36774	61301	any other crops	0	0	0
Total	64141	436573	503714	274533	31679	306212	1955	0	1955	340629	468252	808881	0	46604	5935	52539

Wheat, Soyabean, Gram, Maize are the main crop of the area while pulses, spices, vegetables, groundnut, Jawar, Paddy etc. are the subsidiary crops grown in the area. out of 2897 Sq. Km geographical area, about 1.4% is covered by forest. The percentage of net sown area is about 16.40%. The details of area under irrigation and crops are given in Table 1.5 & 1.6.

Table 1.5 Details of area under Irrigation (ha)

S. No.	Name of Block	No of village covered	Total geographical area	Area under Agriculture				Area under forest	Area under watershed	Area under other uses
				Gross cropped area	Net sown area	Area sown more than once	Cropping intensity (%)			
1	Dhar	108	57905	90407	48206	42194	187.54	0	202	9497
2	Tirla	157	53422	47082	26038	21026	180.82	19000	215	8169
3	Nalcha	213	79506	79395	42847	36528	185.3	19748	193	16718
4	Sardarpur	217	127985	130435	77618	52734	168.05	10263	413	39691
5	Badnawar	179	106457	134914	79055	55803	170.66	5136	336	21930
6	Manawar	105	57060	61053	40237	20391	151.73	301	540	15982
7	Umarban	109	47884	46617	31260	15041	149.13	2859	415	13350
8	Gandhawani	150	73545	49154	35452	13542	138.65	21977	128	15988
9	Dharampuri	116	44110	43275	25388	17505	170.45	5834	525	12363
10	Bagh	91	52578	30282	24598	5675	123.11	14485	378	13117
11	Kuskhi	51	35583	31805	24880	6911	127.83	1349	89	9265
12	Dahi	63	48202	26500	20900	5584	126.79	16220	75	11007
13	Nasaarpur	66	35304	37962	24235	13278	156.64	71	215	10783
	TOTAL	1625	819541	808881	500714	306212	161.55	117243	3724	197860

(Source: - Department of Agriculture & SLR)

Table: 1.6 Season wise main crops and production

	Crop Sown						Rainfed				Irrigated			Total		
Season	**Cereals**	**Coarse serea is**	**Pulses**	**Oil seeds**	**Fibre crops**	**Any other crops**	**Area (ha)**	**Production (qtn/yr)**	**Productivity or yeild(kgs/hs)**	**Cost of cultivation (rs./ha)**	**Production (qtn/yr)**	**Productivity (kgs/hs)**	**Cost of cultivation (rs./ha)**	**Production (qtn/yr)**	**productivity (kgs/hs)**	**Cost of cultivation**
kharif	536	65197	14576	298287	91310	30804	469906	5705056	1406	12000	994186	1550	18000	6699242	1426	15000
rabi	195062	0	81280	148	0	29726	285241	0	0	0	7241406	2539	15000	7241406	2539	15000
summer	0	836	310	50	0	760	1195	0	0	0	32850	2749	10000	32850	2749	15000
Total	195598	66033	96166	298485	91310	61290	756342	5705056	1406	12000	8268442	2359	0	13973498	1848	0
	Crop Sown						**Rainfed**				**Irrigated**			**Total**		
Season	**Fruits**	**vegetable**	**spices**	**medicinal**	**flower**	**any other crops**	**Area (ha)**	**Production (qtn/yr)**	**productivity or yeild(kgs/hs)**	**cost of cultivation (rs./ha)**	**Production (qtn/yr)**	**productivity (kgs/hs)**	**cost of cultivation (rs./ha)**	**Production (qtn/yr)**	**productivity (kgs/hs)**	**Cost of cultivation**
Horticulture & plantation	3025	12171	36157	205	981	0	52539	356100	6000	35000	6089745	13067	75000	6445845	12409	110000

(Source: PMKSY DIP)

Irrigation-based classification

Gross irrigated area in the district is 340629 ha. Net irrigated area is 274533 ha. Partially irrigated or protected irrigation area is 13439 ha and unirrigated totally rainfed area is 468252 ha. Block wise irrigated area is given in table 1.7.

Table 1.7 Block wise irrigated area details

S. no	Name of the block	Irrigated area (Ha)		Rainfed (Ha)	
		Gross irrigated area	Net irrigated area	Partially irrigated/protective irrigation	Un-irrigated or totally rainfed
1	DHAR	38752	38745	2346	51655
2	TIRLA	19353	19099	662	27729
3	NALCHA	32842	32770	1645	46553
4	SARDARPUR	48292	47600	3252	82143
5	BADNAWAR	50215	48526	2412	84699
6	MANAWAR	34099	18310	508	26954
7	UMARBAN	25336	15985	138	17939
8	GANDHAWANI	24409	13623	712	22208
9	DHARAMPURI	18886	12022	236	30268
10	BAGH	7796	4633	634	22486
11	KUSKHI	8217	4569	97	18383
12	DAHI	11489	6069	389	20316
13	NASAARPUR	20943	12582	408	17019
	TOTAL	**340629**	**274533**	**13439**	**468252**

Table 1.8 Crop Wise Water Requirement

Crop Water Requirement: - Block Dhar						
Crops	**Area sown(ha)**	**Irrigated area (ha)**	**Crop water demand (mm)**	**Water potential required (BCM)**	**Existing Water potential (BCM)**	**Water potential to be created**
Cereals	24763	23896	600	0.14858	0.11948	0.0291
Coarse Cereals (Maize)	179	0	650	0.00116	0	0.00116
Pulses	16059	13705	350	0.05621	0.04797	0.00824
Oil Seeds	46618	6	535	0.26805	3.5E-05	0.26802
Fibre	0	0	0	0	0	0
Any Other crops	2788	1145	850	0.39625	0.00973	0.38652
Total	90407	38752	3025	0.87025	0.17721	0.69304

Crop Water Requirement: - Block Nalchha						
Crops	**Area sown(ha)**	**Irrigated area (ha)**	**Crop water demand (mm)**	**Water potential required (BCM)**	**Existing Water potential (BCM)**	**Water potential to be created**
Cereals	24051	23007	600	0.14431	0.11504	0.02927
Coarse Cereals (Maize)	2488	0	650	0.01617	0	0.01617
Pulses	8369	6230	350	0.02929	0.02181	0.00749
Oil Seeds	39518	0	575	0.22723	0	0.22723
Fibre	120	52	1000	0.0012	0.00052	0.00068
Any Other crops	4849	3553	850	0.04122	0.0302	0.01102
Total	79395	32842	4025	0.45941	0.16756	0.29185

Crop Water Requirement: - Block Tirla						
Cereals	12443	11796	600	0.07466	0.05898	0.01568
Coarse Cereals	1237	0	650	0.00804	0	0.00804
Pulses	6780	5830	350	0.02373	0.02041	0.00333
Oil Seeds	23462	0	575	0.13491	0	0.13491
Fibre	401	236	1000	0.00401	0.00236	0.00165
Any Other crops	2759	1491	0	0.02345	0.01267	0.01078
Total	47082	19353	3175	0.2688	0.09442	0.17438
Crop Water Requirement: - Block Badnawar						
Cereals	26218	24821	600	0.15731	0.12411	0.0332
Coarse Cereals Maize)	1638	34	650	0.01065	0.00022	0.01043
Pulses	27547	21966	350	0.09641	0.07688	0.01953
Oil Seeds	70338	0	575	0.40444	0	0.40444
Fibre	1843	1633	1000	0.01843	0.01633	0.0021
Any Other crops	7330	1761	850	0.06231	0.01497	0.04734
Total	134914	50215	4025	0.74955	0.23251	0.51704
Crop Water Requirement: - Block Dharampuri						
Cereals	13969	13117	600	0.08381	0.06559	0.01823
Coarse Cereals (Maize)	5170	185	650	0.03361	0.0012	0.0324
Pulses	1794	1022	350	0.00628	0.00358	0.0027

Crops	Area sown(ha)	Irrigated area (ha)	Crop water demand (mm)	Water potential required (BCM)	Existing Water potential (BCM)	Water potential to be created
Oil Seeds	6829	25	575	0.03927	0.00014	0.03912
Fibre	10334	8965	1000	0.10334	0.08965	0.01369
Any Other crops	5179	2022	850	0.04402	0.01719	0.02683
Total	43275	25336	4025	0.31033	0.17735	0.13298
Crop Water Requirement: - Block Gandhwani						
Cereals	10725	9924	600	0.06435	0.04962	0.01473
Coarse Cereals	7690	81	650	0.04999	0.00053	0.04946
Pulses	2838	914	350	0.00993	0.0032	0.00673
Oil Seeds	16006	60	575	0.09203	0.00035	0.09169
Fibre	8664	6704	1000	0.08664	0.06704	0.0196
Any Other crops	3231	1203	850	0.02746	0.01023	0.01724
Total	49154	18886	4025	0.33041	0.13096	0.19945
Crop Water Requirement: - Block Bagh						
Cereals	4570	3663	600	0.02742	0.01832	0.00911
Coarse Cereals	8932	0	650	0.05806	0	0.05806
Pulses	4343	783	350	0.0152	0.00274	0.01246
Oil Seeds	7365	0	575	0.04235	0	0.04235
Fibre	4289	3154	1000	0.04289	0.03154	0.01135
Any Other crops	783	196	850	0.00666	0.00167	0.00499
Total	30282	7796	4025	0.19257	0.05426	0.13831
Crop Water Requirement : Block Dahi						
Cereals	3899	2984	600	0.02339	0.01492	0.00847
Coarse Cereals	9704	0	650	0.06308	0	0.06308
Pulses	3693	218	350	0.01293	0.00076	0.01216
Oil Seeds	1564	0	575	0.00899	0	0.00899
Fibre	4967	3632	1000	0.04967	0.03632	0.01335
Any Other	2673	1383	850	0.02272	0.01176	0.01097
crops	26500	8217	4025	0.18078	0.06376	0.11702

Crop Water Requirement :- Block Kuskhi						
Crops	**Area sown(ha)**	**Irrigated area (ha)**	**Crop water demand (mm)**	**Water potential required (BCM)**	**Existing Water potential (BCM)**	**Water potential to be created**
Cereals	5424	4837	600	0.03254	0.02419	0.00836
Coarse Cereals	6833	0	650	0.04441	0	0.04441
Pulses	1850	295	350	0.00648	0.00103	0.00544
Oil Seeds	2985	0	575	0.01716	0	0.01716
Fibre	11089	5406	1000	0.11089	0.05406	0.05683
Any Other crops	3624	951	850	0.0308	0.00808	0.02272
Total	31805	11489	4025	0.24229	0.08736	0.15493
Crop Water Requirement: - Block Nisarpur						
Cereals	8671	8000	600	0.05203	0.04	0.01203
Coarse Cereals	4013	167	650	0.02608	0.00109	0.025
Pulses	1549	805	350	0.00542	0.00282	0.0026
Oil Seeds	1837	47	575	0.01056	0.00027	0.01029
Fibre	11709	7906	1000	0.11709	0.07906	0.03803
Any Other crops	10183	4018	850	0.08656	0.03415	0.0524
Total	37962	20943	4025	0.29774	0.15739	0.14035

(Source: PMKSY DIP)

Oil Seeds are the major crops of Dhar district. It is cultivated in 2982.72 Sq. km under rain fed and 1.87 Sq. km under irrigated condition. Groundnut, Til, Ramtil are other oilseed crops grown in kharif season and Linseeds and Mustard are major oilseeds of Rabi season in the district. Oilseeds area is 2984.59 Sq. km in Dhar district which is 36.90 % of Gross Cultivated Area (GCA). Grams and Wheat are major cereals cultivated in Dhar district. There are 113.58 sq. Km rainfed and 1837 sq. Km irrigated area covered by cereals in the district which is 24.18% of GCA. Pulses are the third position in the district for Production it covered 961.66 sq.m contribute the 11.88% of Gross Cultivated Area (GCA). Coarse cereals in the district have in term of area of production. It covers total 660.32. Km including kharif and rabi area. Jowar, Maize, Kodo-Kutki are major coarse cereals cultivated in the district. Coarse cereals contribute 8.16 of GCA of Dhar. Fiber crops cultivated in 913.25 sq.km of district are contributing 11.29%. Other Crops also cultivated in 613.01 sq. Km in the district. Other crops contribute 7.5% of GCA of the district. Horticultural crops cover 525.39 sq. Km which is 6.5% of GCA of the district. Crops wise water requirement are shown in table no. 1.8.

The climate of the district is congenial for successful cultivation for oilseed, pulses, cereals and horticultural crops like soybean, paddy, pigeon pea, maize in kharif and wheat, gram, sugarcane and pea in rabi are grown predominantly in the district. The total area under irrigation

is 36% out of which 33% is double cropped in this district (From Krishi Vigyan Kendra website, Dhar).

The Ground water source (Open Well, bore well) based irrigation caters to the major area i.e., 72.3% of total irrigated area. 27.1 % of total irrigated area depends on surface water sources (canals, reservoirs, tanks). (Department of agriculture, Madhya Pradesh website) Table 1.9

Table 1.9: Details of irrigation by different sources

Irrigation by different sources	Number of Structures	Area in Sq. km
Dug wells	68268	757.73
Tube wells/Bore wells	11231	351.51
Tanks/Ponds	46	98.42
Canals	108	319.7
Other Sources	-	126
Net Irrigated Area	-	1653.36

1.6 Geology

The study area is entirely occupied by consolidated formation, excepting isolated patches of this alluvium pockets occurring along course of streams and rivers.

The general geology of the area is given in Table: 1.10:

Table: 1.10 Regional Geology of Dhar District

Lithology	Formation	Age
Clay, silts, sands	Soil and alluvium	Recent
~~Unconformity~~~~~~~~~~~~~~~~~~		
Basaltic lava flows with red bole	Deccan trap	Upper cretaceous to Eocene
~~Unconformity~~~~~~~~~~~~~~~~~~		
Granitic rock		Archaean

Geology and Stratigraphy

Deccan Trap

This is represented by basaltic lava flows and occupy the major part of the district including both the Mohi and Chambal basin. (***Fig.*** 1.4) This terrain shows terrace like appearance due to alternate lava flow and the distinction between two successive flows have been done on the basis of the presence of Red-bole, Amygdaloidal basalts, vesicular zones etc. The flows occur as hummocky and billowy tops and shining outer surfaces, this type of lava flow is called pa-hoe-hoe lava flows. The individual lava flows are characterized by vesicular zone which formed due to releasing of different gases and lower unit which may be either jointed and or fractured or totally massive, sometimes the top vesicular zone is filled by secondary minerals viz. Zeolites, Calcite, quartz etc. (called Amygdaloidal). The upper vesicular zone is grey, brownish medium to coarse grained; the vesicles are rounded or oval shaped. The vesicular and/or amygdaloidal zone of individual lava flows ranges between 1-5 to 7-5 m in thickness. The lower unit of basaltic flow if fine to medium grained, greenish black to brownish grey in colour, hard, compact and

vary in thickness from place to place. Very rarely and individual flow is marked by a basal greyish to purple colour basalt containing pipe amygdales as observed in the hillock werst of Matlapura (22^0 31' : 75^0 17'). Though rare in occurrence, this unit containing pipe amygdaloidal serves as marker horizon.

Red Bole bed occurs as marker horizon separating two successive flows. This is red coloured farraginous material generally attains a distinguishable thickness and sometimes it may attain a thickness as much as 2.5m. However, this red bole is often discontinuous and even totally absent. This bed is invariably followed by vesicular/amygdaloidal unit of successive flow underneath.

Alluvium

The weathered zone of the deccan trap is locally referred to as murrum. It is very soft and easily gets transported. In the area such weathered zones range in thickness from 1 to 5 m. the soil covers generally met with in the area over the trappean formation is the black cotton soil which is very plastic and sticky when wet and very hard when dry. The soil cover along with the clay horizon ranges in thickness from 1 to 6 and gains thickness along nala course and small valley portions.

The alluvium material consisting of clay, silt, sand and gravel are of recent age group. Alluvium occurs mainly along the courses of the nalas and tributaries of Mohi and Chambal rivers. The thickness of the alluvium of Sarunya, (Toposheet 46N/5) is 9.30 m.

Sub Surface Geology

Central Ground Water Board, have constructed 72 exploratory wells under the ground exploratory in Dhar district. The Deccan trap is encountered throughout the district upto 200m with alternate layer of vesicular and massive basalt except southwestern part of the district. It is covered by Bagh formation in Bagh, Nisarpur and Kukshi block with alternate layet of sanstone, limestone and siltstone.

Structural Characteristics

The basaltic flows of deccan trap of the present area are horizontally diposed. The primary structural unit is the columnar joints which is the characteristic feature of the lower point and irregular joints and fractures that of the "Entablature Zone" or middle part of basaltic flow. The secondary joints/fracture are not uniform in distribution. The major lineaments and/or weak planes of the area are EW-NE, WSW to NS and NW-SE trending.

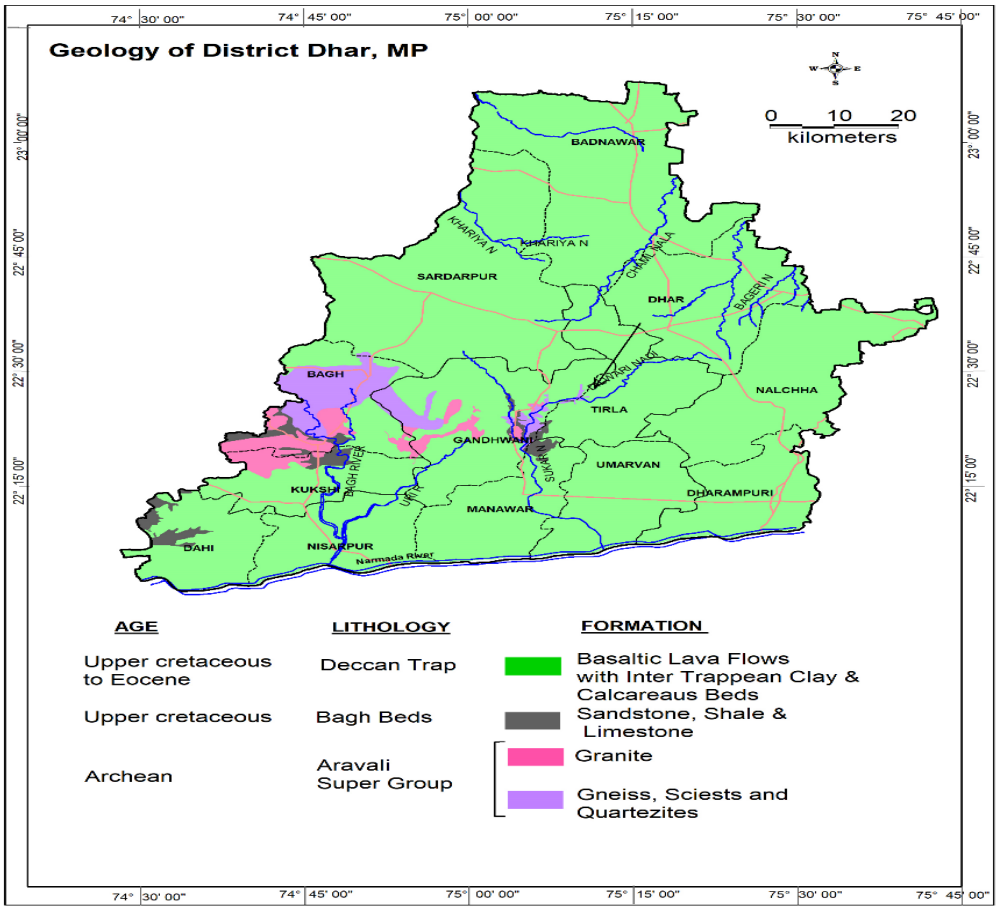


Fig:1.4 Hydrogeological Map

1.7 Soil cover

The important characteristic soil type of the area is black cotton soil. (Fig. 1.5) It is called because of its characteristic black in colour. When this comes in contact of water it swells and becomes sticky. It can absorb tremendous amount of water and is very fertile. This soil is the representative soil of the major part of the study area covering Mohi and part of Chambal basins. In the open well section "Pilimitti" is encounter at places, this is essentially yellowish or brownish silty clay, sticky in nature and often with Kankars. In the Narmada basin area, at places the soil type is somewhat different soil is grayish not sticky.

Along stream course of nalas stream and rivers of the study area, occupies a blanket of alluvium which is grayish or whitish in colour. This is a mixture of sand, silt and gravel.

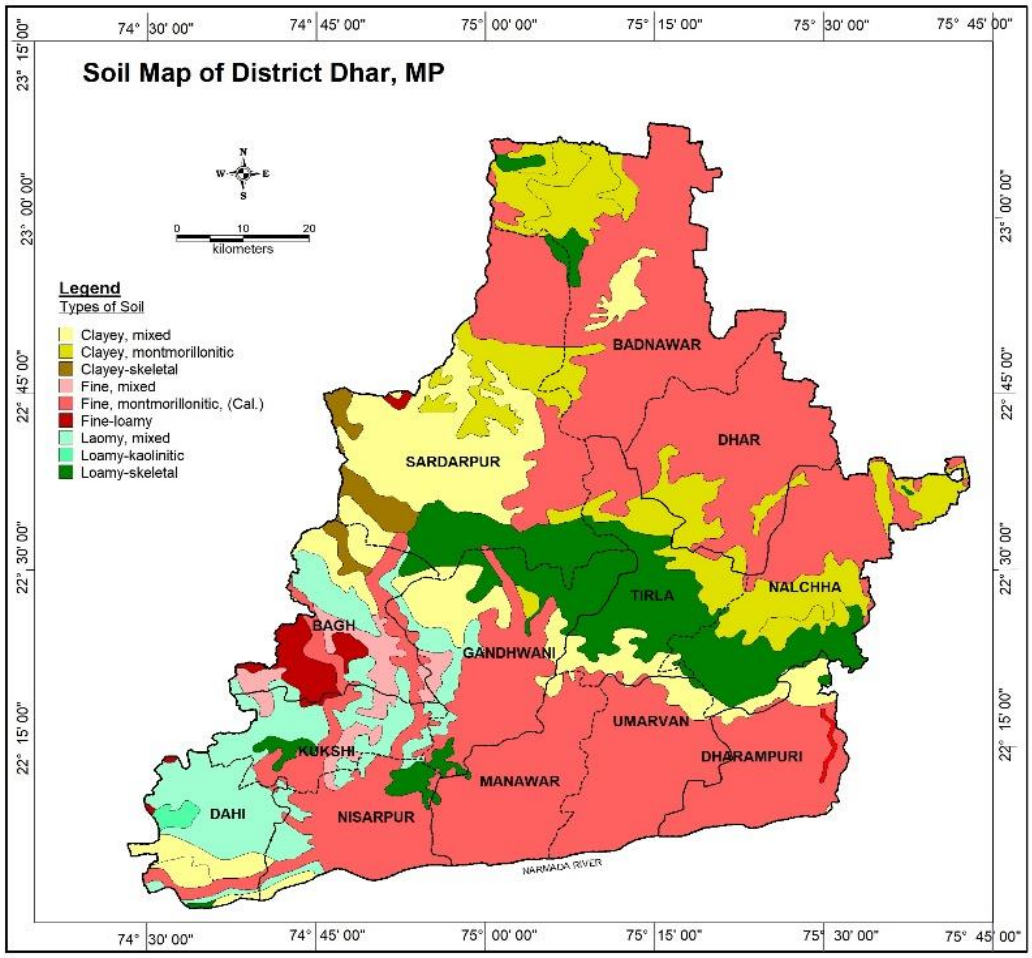


Fig:1.5 Soil map

1.8 Drainage

The drainage pattern of the Mohi River basin is sub parallel to sub dendritic. Important tributary streams are Kaleswani Nera Barwardh and Khariya nad which flows SE-NW direction to meet the SN flowing Mohi River at the extreme NW cover the present area. (Fig1.6)

In the Chambal sub basin, Chamla Nadi is in important river which originates from Tirla mangol kod sector which flow through Kanwar in a SSW-NNW direction. Chmbal river is another important river of this basin which starts from Tarnod Sadarlpur area and more NNW-SSE direction and ultimately the former Chamla Nadi meets the Chambal River outside the study area further downstream. The drainage in this basin is sub parallel in nature and density is less as compared to that of Mahi River basin. In the Narmada basin area, fairly good number of streams originates from the northern fringe of this basin. Drainage pattern is dendritic and its density is high. The flow direction is generally from north to south.

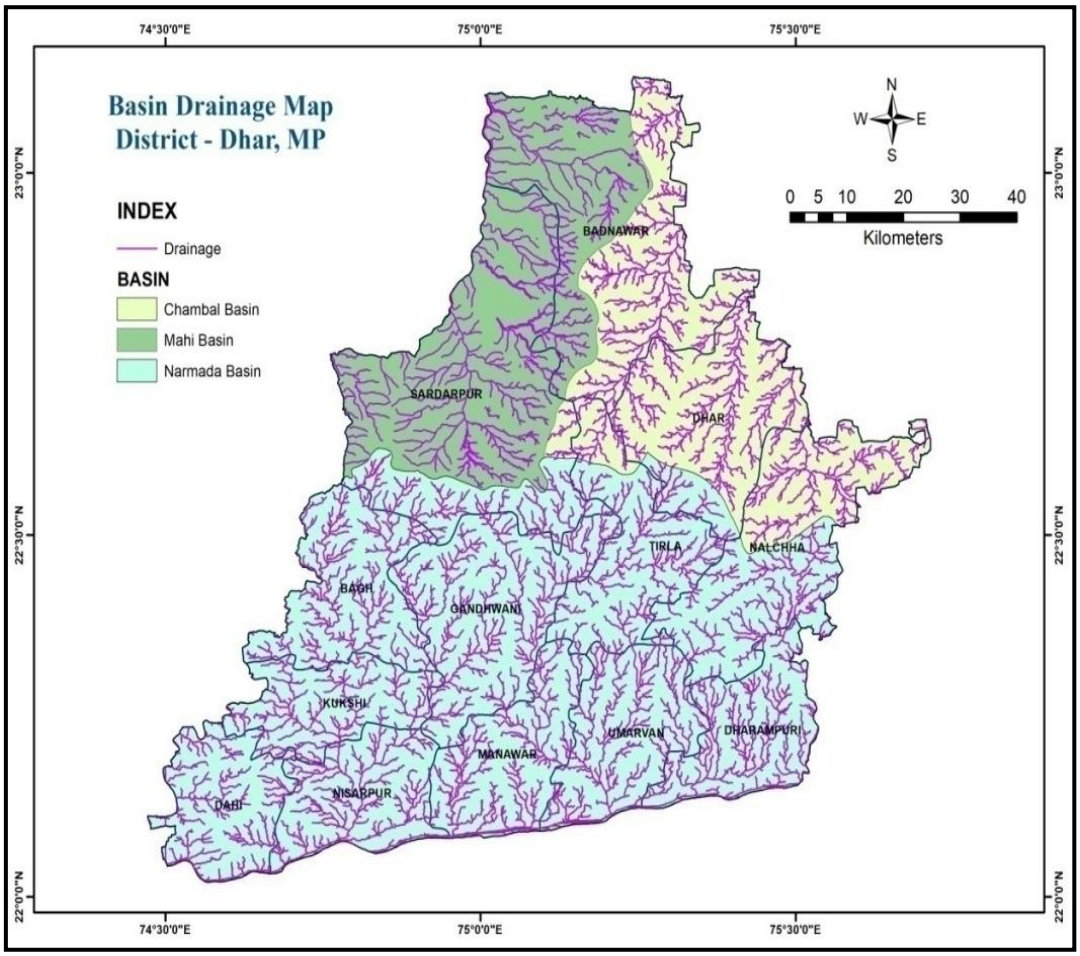


Fig:1.6 Drainage Map

Chapter: 2

Data Collection and Generation

Hydrogeological data includes quality and quality from existing data were collected and analysed in GIS platform to validate and avoid discrepancy while preparing the aquifer mapping in the district. The date collected from allied department such as WRD, PHED and Agriculture departments and administrative department were also included in the data collection and analysis.

2.1 Ground Water Exploration and Geophysical data: -

The groundwater exploration was carried out CGWB, NCR Bhopal down to depth of 200mts and state departments drilled for drinking water purposes well down to depth of maximum 120 mts were collected and compiled for delineation of the aquifer system of the study area. In the study area, total 72 nos exploratory well drilled before the NAQUIM. The details of the exploratory well are presented in table-2.1 and the location of the exploratory well are shown in Fig-2.1

Geophysical survey mainly Vertical Electrical Sounding (VES) is also being carried out to know the sub-surface geology of the area. VES conducted for 60 mts depth of investigation using Schlemberger Electrode array. The sites were located in between the Exploratory bore well to full fill data gap in the area and utilised for vertical and lateral delineation of aquifer. Total 206 nos VES was conducted with 60 mts depth of investigation and studied the sub-surface geology. The VES data were incorporated with exploratory well data to delineate the sub-surface aquifer disposition in form of 2D and 3D hydrogeological section in different direction.

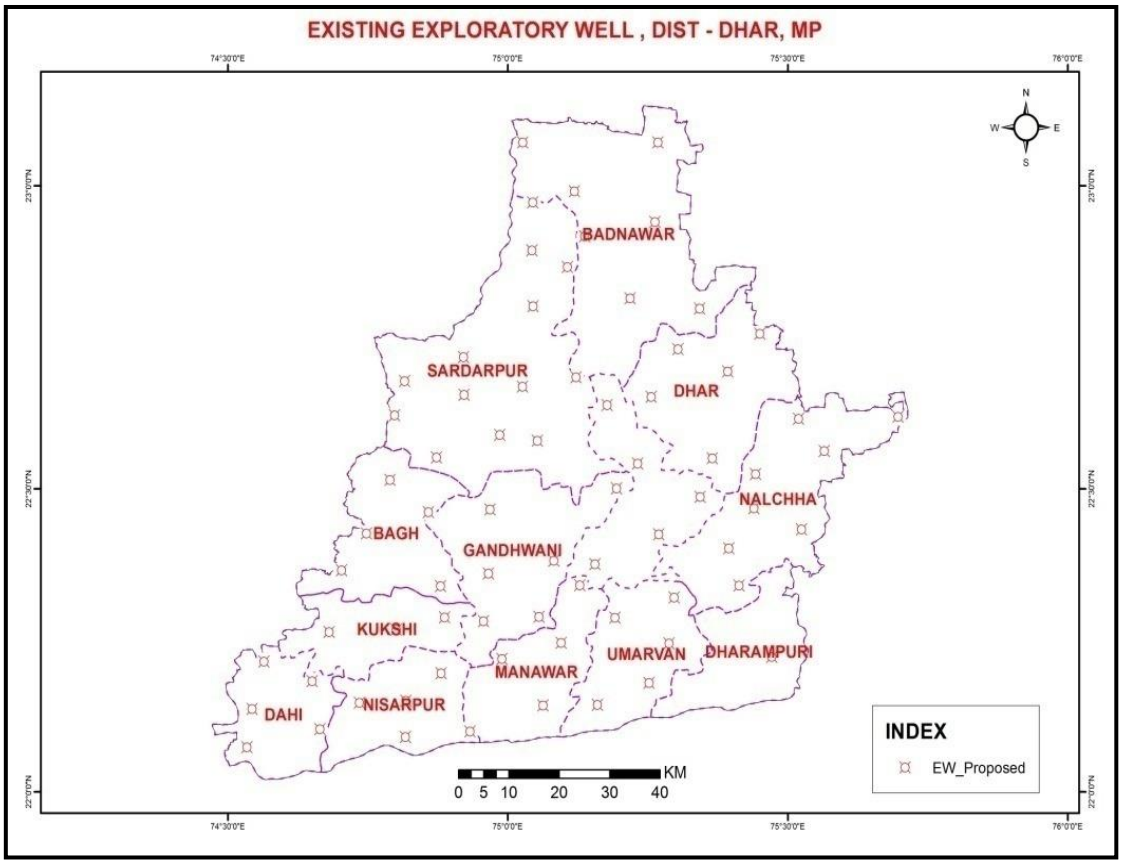


Fig:2.1 Location Mapof GW exploration

2.2 Ground Water Monitoring Wells

Central ground water board and WRD Govt. of Madhya Pradesh are carrying out water level monitoring through ground water monitoring wells including dug wells and piezometers. The water levels monitoring of the shallow and deeper aquifer wells are being monitored four times in a year during the month January, May, August and November. The agency wise details of monitoring stations and locations are given in table: 2.1.

Table: 2.1 Numbers of Monitoring stations in Dhar District

S. No.	Agency	Number of DW	Number of Pz
1	CGWB	26	16
2	WRD	100	17
Total		126	33

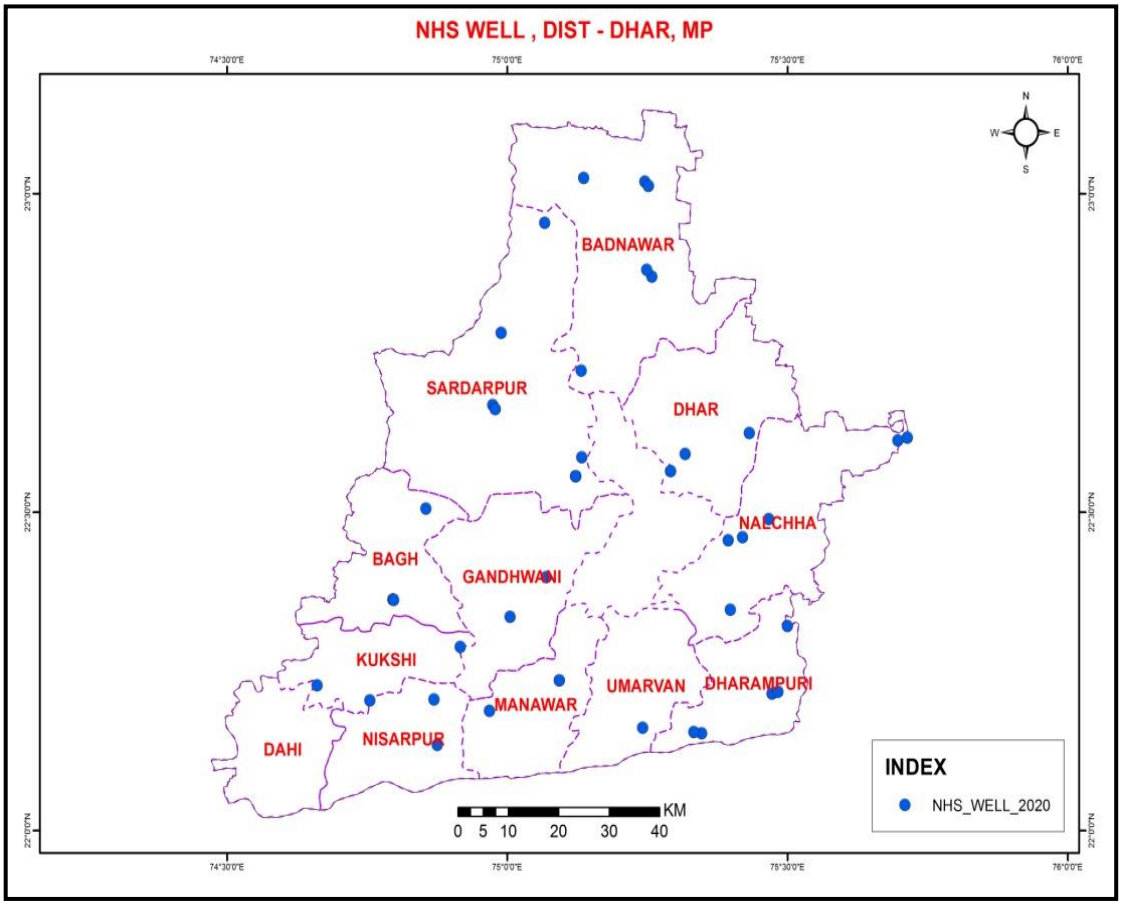


Fig.2.2: Locations of GW Monitoring Wells

2.3 Ground Water Quality

The suitability of ground water for drinking/irrigation/industrial purposes is determined keeping in view the effects of various chemical constituents present in water on the growth of human being, animals, various plants and also on industrial requirement. Though many ions are very essential for the growth of plants and human body but when present in excess, have an adverse effect on health and growth. Central Ground Water Board, NCR was established wells to monitor the groundwater quality one time in a year of shallow aquifer. WRD and PHED are also monitoring the groundwater quality in district of shallow and deeper aquifer in the district. All the groundwater quality data are incorporated for analysing the groundwater quality issues. In the study area, samples from 27 wells (shallow dug wells representing phreatic aquifer) have been collected during pre-monsoon. Similarly, for Aquifer – II, the ground water quality data of exploratory, observation wells and state govt. handpums/Borewells constructed during earlier exploration and current exploratory drilling activities were utilised for ground water quality analysis.

2.4 Data Adequacy and Data Gap Analysis:

The available data such as Exploratory wells, Vertical Electrical Sounding (VES), ground water monitoring stations and ground water quality stations of Central Ground Water Board North Central Region, Madhya Pradesh, WRD Govt. of MP and other allied State Surface and Ground Water departments were compiled and analysed as per the nomenclature for adequacy of the data.

The summarised detail on Data Generation map is presented in Fig: 2.3

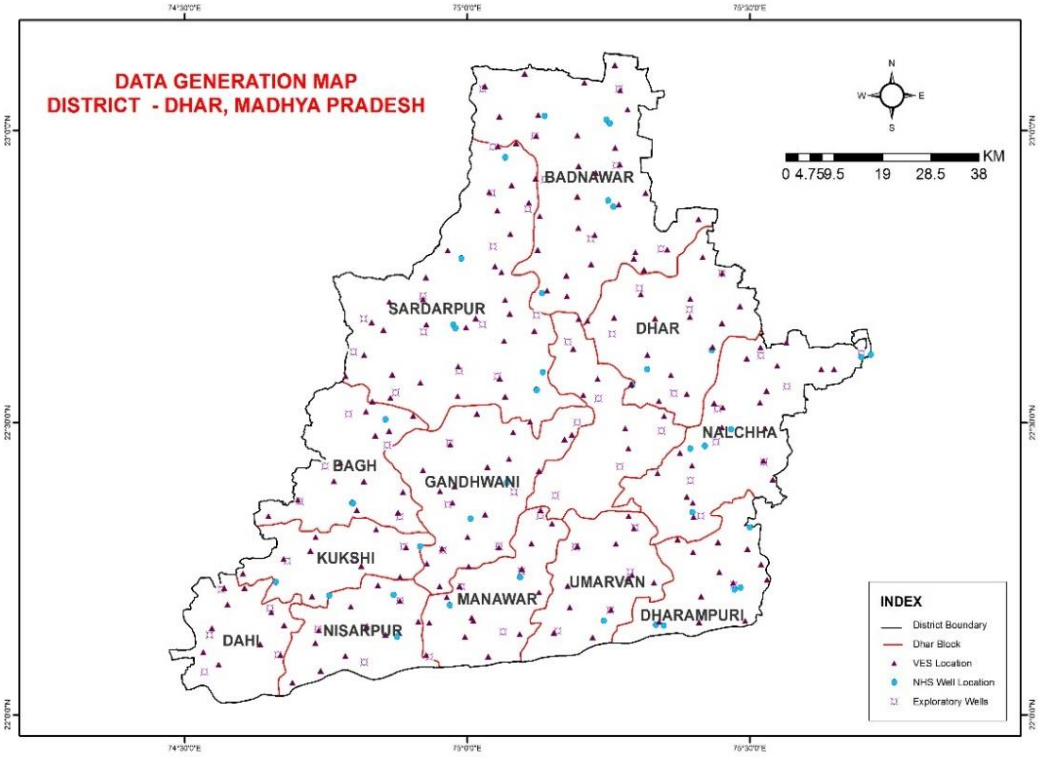


Fig.2.3: Data Generation Map

Chapter: 3
Data Interpretation, Integration and Aquifer Mapping

The data collected and generated on various parameters viz., water levels, water quality, exploration, aquifer parameters, geophysical, hydrology, hydrometeorology, irrigation, thematic layers was interpreted and integrated. Based on this the various aquifer characteristic maps on hydrogeology, aquifer wise water level scenario both current and long-term scenarios, aquifer wise ground water quality, 2-D and 3-D sub surface disposition of aquifers by drawing fence and lithological sections, aquifer wise yield potential, aquifer wise resources, aquifer maps were generated and as discussed in details.

3.1 Hydrogeology

Hydrogeology is concerned primarily with mode of occurrence, distribution, movement and chemistry of water occurring in the subsurface in relation to the geological environment. The occurrence and movement of water in the subsurface is broadly governed by geological frameworks i.e., nature of rock formations including their porosity (primary and secondary) and permeability. Dhar district is underlain by various geological formations, forming different types of the aquifer in the area. Main geological units of the area are Deccan traps, Bagh Formation, which exposed in Bagh, Nisarpur, Manawar and Kukshi blocks and Archaean in basement. The principal aquifers in the area are Basalt and Achaeans where the occurrence and movement of ground water primarily depends on the degree of interconnection of secondary pores/voids developed by fracturing and In the present area as there are several numbers of basaltic flows, so there are a number of potential permeable zones of ground water. Weathered zone, vesicular and / or amygdaloidal zone and jointed and/or fractured zones constitute the aquifers of in an individual basaltic flow. Ground water occur in the interconnected pore space and inter connected joints and/or fractures of basalts and thereby importing permeability characteristic into the aquifer. The lower part of a flow if not jointed and/or fractured, it may be totally massive and impermeable.

Ground water occurs under both (i) water table/phreatic and (ii) Semi confined conditions. The weathered mantle vesicular or amygdaloidal zone and jointed fracture lower part of a basalt flow together constitute the phreatic water table aquifer, the hydraulic continuity is maintained vertically the sequence of successive basaltic flows depending upon the disposition of inter connecting pore spaces and the inter connected joints/fractures which together govern the ground water movement. Ground water in open wells occur under phreatic conditions and discharge in open wells varies from 1 lps to 2 lps. And ground water occurs in deeper aquifer like fractured and vesicular basalt and flow contact at different depth under semi confined to confined conditions and discharge varies from 1.00 Lps to 25.00 lps. The inter trappean Reb bole bed and massive basaltic layer act as confining bed in the area.

Southern part of the district is covered by marginal alluvium formation a mixture of gravel, silt and clay along the nala and stream and is highly permeable in nature. Yellow soil (Pillimitti) which occurs below the black cotton soil, is poorly permeable because of its clay's nature. The alluvium deposit including pillimitti in the area forms water table aquifer, the hydraulic continuity of which is maintained through the weathered residuum vesicular zone and jointed fracture unit of basaltic flows. Discharge in this unit varies from 1.00 lps to 10 lps.

The water table elevation map was also prepared (**Fig.3.1**) to understand the regional ground water flow directions. The district is comprising with three basins namely Narmada, Mahi and Chambal. In general, the regional groundwater flow is towards South or towards Narmada River.

- **Deccan Traps**

Deccan traps comprising basaltic lava flows and most extensive rocks in the district. Deccan trap exposed in Dhar, Tirla, dharmpuri, Sardarpur, Nalchha and Badnawar blocks. Ground water occurs in the weathered, jointed and fractured basalts under Unconfined and semi-confined to confined conditions. The unconfined aquifer is restricted up to 15 m bgl while semi- confined and confined aquifers are encountered between 45 to 190 mbgl. The yield of shallow aquifer in this formation ranges between 60 to 300 lpm.

- **Bagh Formations**

The Bagh formations comprise succession of sandstone, shales, Limestone and clays lying over the crystalline granitic rocks. The Bagh formations are mainly present in Bagh, Nisarpur, Manawar and Kukshi blocks. In formations groundwater occurs mostly in sandstone and at the contact zones. The yield potential of Bagh ranges from 100 lpm to 300 lpm tapping semi confined and unconfined aquifers.

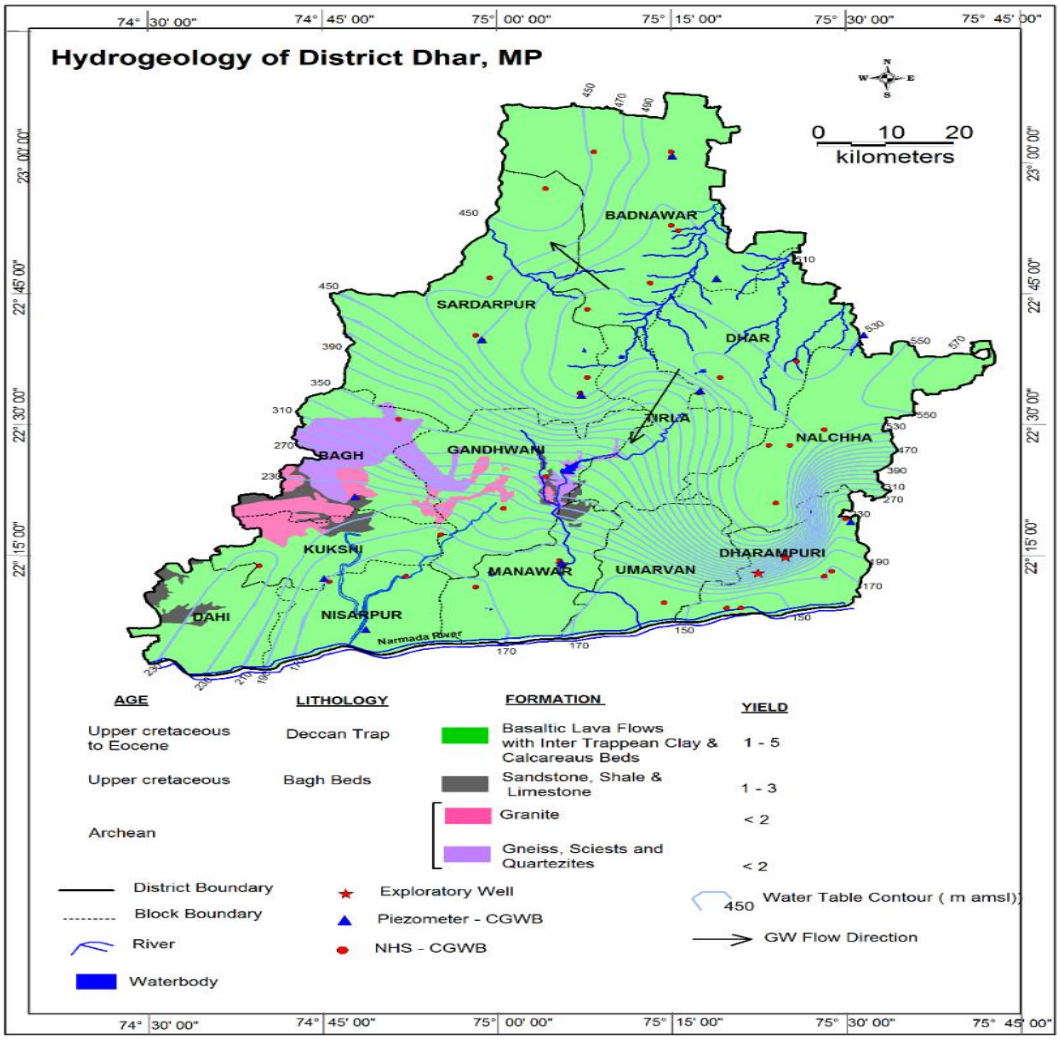


Fig:3.1 Hydrogeological Map

3.2 Water Level Scenario

Central Ground Water Board and Water Resource Department Govt. of India are monitored 126 dug well for shallow aquifer and 33 piezometers for piezometric head in the study area. The present depth to water level scenario of shallow aquifer was depicted by utilizing water level data of 126 monitoring wells representing shallow aquifer in the district.

Pre-Monsoon (November, 2020)

The **pre-monsoon** depth to water levels during May 2020 ranged between 2.90 (Palasi) to 17.80 mbgl (Pithampur). The water level ranges between 2 -5 mbgl are observed in major part of the district, water level ranges between 5-10 mbgl observed in Eastern part of the district and the water levels of more than 10 mbgl are observed in some patches of northern eastern parts of the district. The pre-monsoon water level data is presented as **Table:3.2,3.3,** whereas depth to water level map is given in **Fig.3.2.**

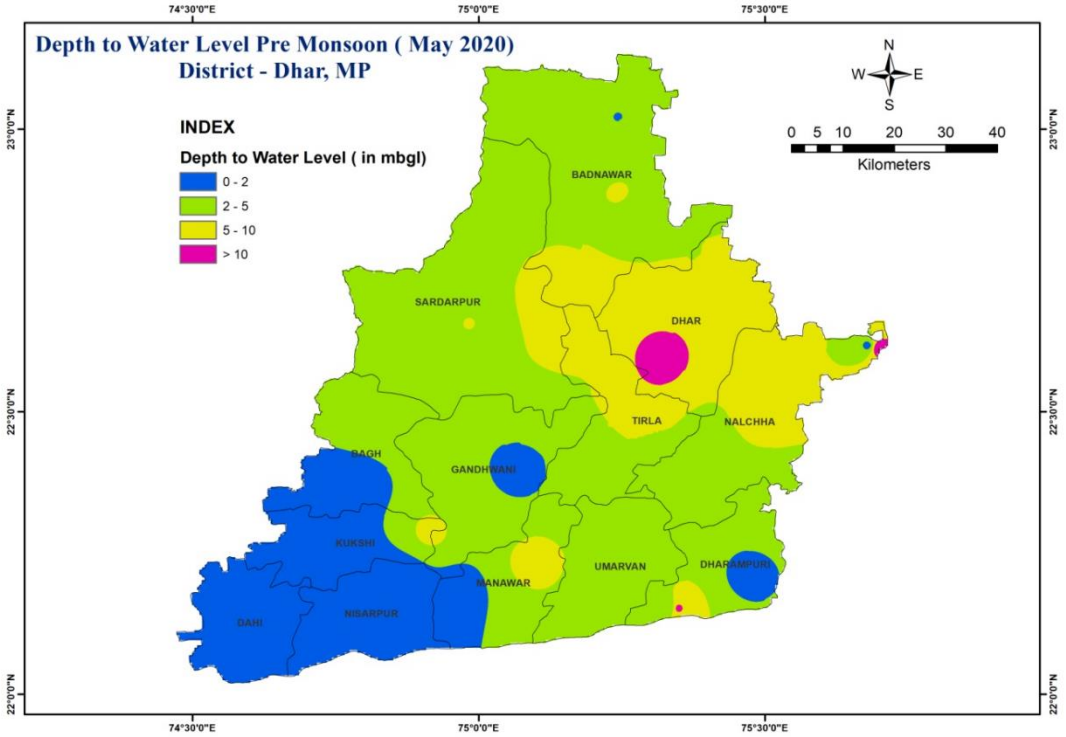


Fig:3.2 Pre-Monsoon DTWL Map

Post-Monsoon (November, 2019)

The **post-monsoon** depth to water levels during November 2019 ranged between 2.05 (Badnawar) to 13.78 mbgl (Dhrampuri). Water Level upto 2 mbgl observed in northern and western part of the district Ranges of water level between 2 -5 mbgl are observed in major part of the district, water level ranges between 5-10 mbgl observed in central part of the district and the water levels of more than 10 mbgl are observed in some patches of Southern parts of the district. The post -monsoon water level data is presented as **Table:3.2 .3.2 & 3.3 ,** whereas depth to water level map is given in **Fig. 3.2 & 3.3.**

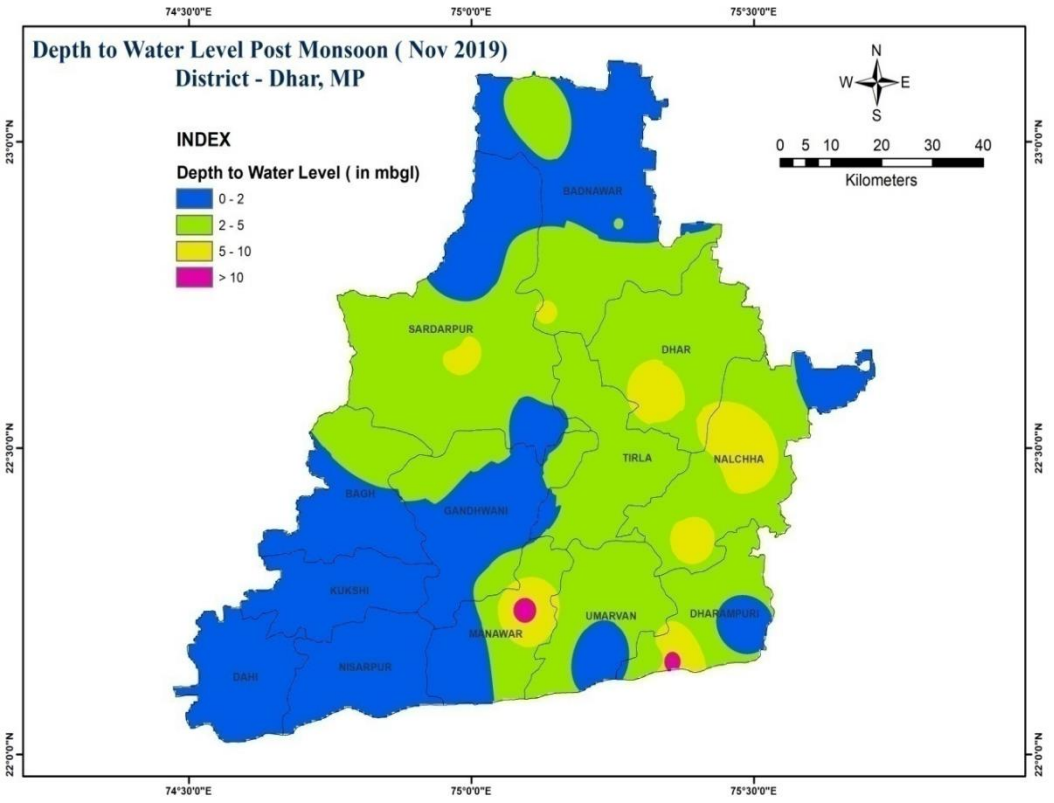


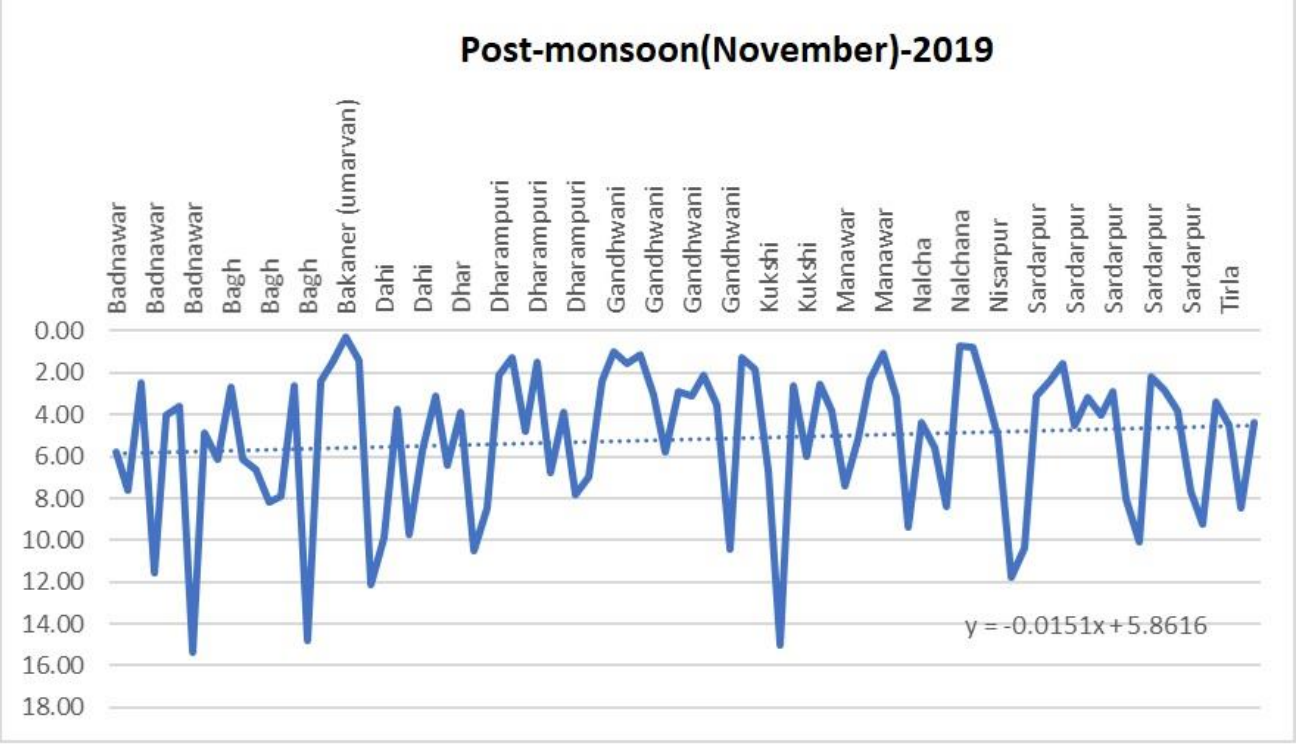
Fig:3.3 Post-Monsoon DTWL Map

Table: 3.1 WRD ground water level data

S. No	Tahsil / Taluka	Block / Mandal	Village	Pre-Monsoon WL 2020 (m)	Post-monsoon W L 2019 (m)	Fluctuation (m)
1	Badnawar	Badnawar	Multhan	13	5.80	7.20
2	Badnawar	Badnawar	Lilikhedi	13.8	7.60	6.20
3	Badnawar	Badnawar	Gajnod	6.10	2.50	3.60
4	Badnawar	Badnawar	Bakhatgrah	17.05	11.55	5.50
5	Badnawar	Badnawar	Dholana	7.50	4.00	3.50
6	Badnawar	Badnawar	Kanwan	11.95	3.60	8.35
7	Badnawar	Badnawar	Panchakwasa	17.40	15.40	2.00
8	Badnawar	Badnawar	Bidwal	9.05	4.90	4.15
9	Badnawar	Badnawar	Nagda	11.45	6.10	5.35
10	Kukshi	Bagh	Kalidevi	5.95	2.65	3.30
11	Kukshi	Bagh	Thikhibaldi	11.15	6.15	5.00
12	Kukshi	Bagh	Agar	7.55	6.65	0.90
13	Kukshi	Bagh	Deodha	10.65	8.15	2.50
14	Kukshi	Bagh	Undeli	10.80	7.90	2.90
15	Kukshi	Bagh	Jhirpanya	5.85	2.60	3.25
16	Kukshi	Bagh	Tanda	17.05	14.80	2.25
17	Kukshi	Bagh	Bhamori	4.95	2.40	2.55
19	Manawar	Bakaner (umarvan)	Bakaner	11.7	1.5	10.20
20	Manawar	Bakaner	Tawlai	1.73	0.25	1.48

S. No	Tahsil / Taluka	Block / Mandal	Village	Pre-Monsoon WL 2020 (m)	Post-monsoon W L 2019 (m)	Fluctuation (m)
		(umarvan)				
21	Manawar	Bakaner (umarvan)	Patlawad	4.10	1.40	2.70
22	Manawar	Bakaner (umarvan)	Jhirwi	12.10	12.10	0.00
23	Kukshi	Dahi	Thandla	11.15	9.85	1.30
24	Kukshi	Dahi	Badwaniya	9.45	3.75	5.70
25	Kukshi	Dahi	Padiyal	14.75	9.75	5.00
26	Kukshi	Dahi	Gampur	10.15	5.70	4.45
27	Kukshi	Dahi	Dahi	8.50	3.10	5.40
28	Dhar	Dhar	Dharawara	11.45	6.45	5.00
29	Dhar	Dhar	Dhar	13.90	3.85	10.05
30	Dhar	Dhar	Anarad	13.25	10.50	2.75
31	Dhar	Dhar	Kesur	8.75	8.45	0.30
32	Dharampuri	Dharampuri	Khalghat	5.6	2.15	3.45
33	Dharampuri	Dharampuri	Sala	3.20	1.30	1.90
34	Dharampuri	Dharampuri	Gulati	10.00	4.80	5.20
35	Dharampuri	Dharampuri	Bharudpura	6.10	1.50	4.60
36	Dharampuri	Dharampuri	Dhamnod	13.00	6.80	6.20
37	Dharampuri	Dharampuri	Dharampuri	7.23	3.85	3.38
38	Dharampuri	Dharampuri	Eklara	11.10	7.80	3.30
39	Dharampuri	Dharampuri	Dewalara	11.50	7.00	4.50
41	Dharampuri	Dharampuri\	Lunera khurd	3.40	2.40	1.00
42	Gandhwani	Gandhwani	Balnera	5.6	1	4.60
43	Gandhwani	Gandhwani	Bilda	4.15	1.55	2.60
44	Gandhwani	Gandhwani	Awalda	4.30	1.10	3.20
45	Gandhwani	Gandhwani	Morkatiya	8.70	3.00	5.70
46	Gandhwani	Gandhwani	Bakhatala	9.80	5.80	4.00
47	Gandhwani	Gandhwani	Borghata	7.60	2.90	4.70
48	Gandhwani	Gandhwani	Sangibaodi	4.60	3.10	1.50
49	Gandhwani	Gandhwani	Khirki	6.25	2.15	4.10
50	Gandhwani	Gandhwani	Kosadana	10.55	3.50	7.05
51	Gandhwani	Gandhwani	Keswi	11.00	10.40	0.60
54	Kukshi	Kukshi	Rampura	3.90	1.30	2.60
55	Kukshi	Kukshi	Susari	2.75	1.8	0.95
56	Kukshi	Kukshi	Girwania	16.2	6.7	9.50
57	Kukshi	Kukshi	Kawdia keda	16.5	15	1.50
58	Kukshi	Kukshi	Longasari	5.40	2.60	2.80
59	Kukshi	Kukshi	Talanpur	13.50	6.00	7.50
60	Kukshi	Kukshi	Talawadi	3.75	2.55	1.20
61	Kukshi	Kukshi	Palasi	5.80	3.80	2.00
65	Manawar	Manawar	Dedla	10.90	7.40	3.50
66	Manawar	Manawar	Borud	13.65	5.15	8.50
67	Manawar	Manawar	Tonki	5.75	2.35	3.40

S. No	Tahsil / Taluka	Block / Mandal	Village	Pre-Monsoon WL 2020 (m)	Post-monsoon W L 2019 (m)	Fluctuation (m)
68	Manawar	Manawar	Ajandiman	3.65	1.05	2.60
69	Manawar	Manawar	Jajamkhedi	4.90	3.20	1.70
70	Manawar	Manawar	Lunhera	12.10	9.35	2.75
73	Dhar	Nalcha	Narayanpura	11.10	4.40	6.70
74	Dhar	Nalcha	Nalcha	11.65	5.60	6.05
75	Dhar	Nalcha	Dehrisaray	12.45	8.40	4.05
76	Dhar	Nalchana	Panala	7.65	0.7	6.95
77	Dhar	Nalchha	Sagore	2.90	0.80	2.10
78	Kukshi	Nisarpur	Pipliya	6.40	2.70	3.70
79	Kukshi	Nisarpur	Bhoriya	12.00	5.10	6.90
80	Kukshi	Nisarpur	Konada	13.40	11.80	1.60
81	Kukshi	Nisarpur	Heledarh	8.50	10.35	-1.85
82	Sardarpur	Sardarpur	Rajgarh	7.2	3.1	4.10
83	Sardarpur	Sardarpur	Junapani	9	2.4	6.60
84	Sardarpur	Sardarpur	Nipawali	6.35	1.55	4.80
85	Sardarpur	Sardarpur	Rupakheda	11.40	4.50	6.90
86	Sardarpur	Sardarpur	Mangod	5.60	3.20	2.40
87	Sardarpur	Sardarpur	Pasawada	10.05	4.00	6.05
88	Sardarpur	Sardarpur	Rajpura	9.10	2.90	6.20
89	Sardarpur	Sardarpur	Labria	13.05	8.05	5.00
90	Sardarpur	Sardarpur	Bhopawar	12.50	10.10	2.40
91	Sardarpur	Sardarpur	Rajod	4.60	2.20	2.40
92	Sardarpur	Sardarpur	Sardarpur	10.90	2.80	8.10
93	Sardarpur	Sardarpur	Jalon	5.20	3.80	1.40
94	Sardarpur	Sardarpur	Desaiee	10.70	7.70	3.00
95	Dhar	Tirla	Tirla	14.45	9.25	5.20
96	Dhar	Tirla	Gyanpura	12.3	3.4	8.90
97	Dhar	Tirla	Padliya	8.15	4.5	3.65
98	Dhar	Tirla	Dilawara	10.95	8.45	2.50
99	Dhar	Tirla	Sitapat	7.9	4.4	3.50



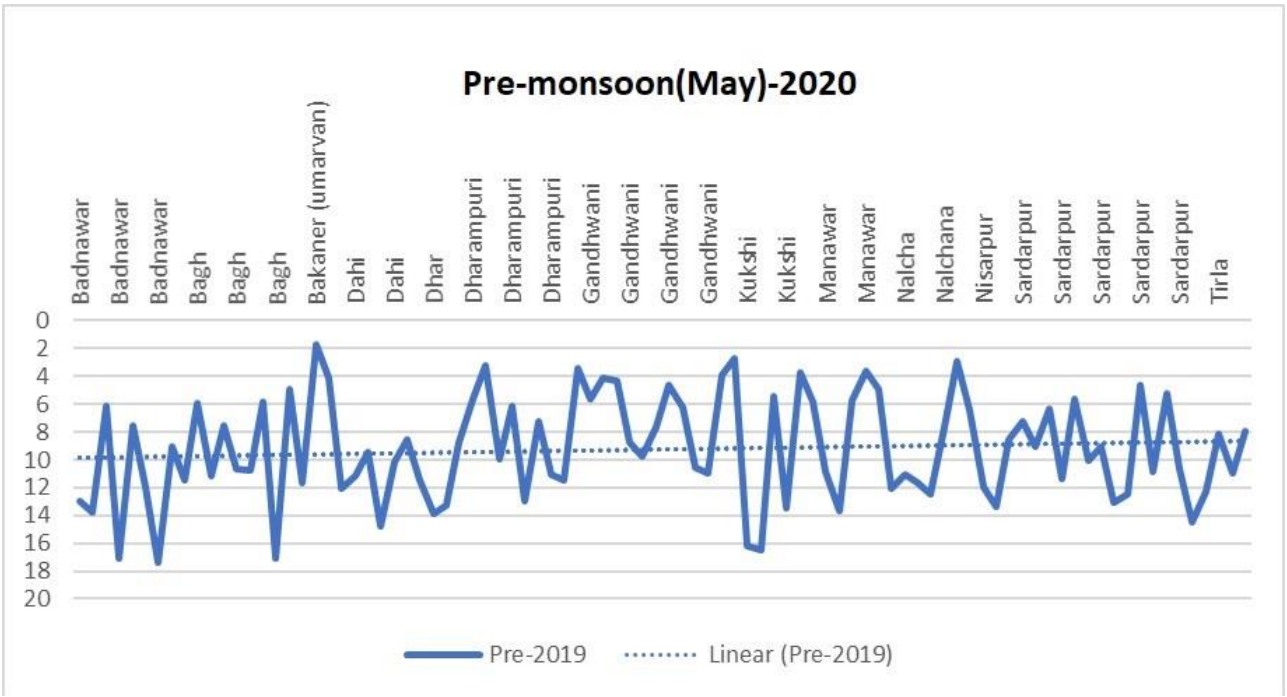


Fig: 3.4 WRD Pre and Post-Monsson Water Level trend

Table: 3.2 Water Level Data of CGWB NHS dug wells

S. No.	Block	Location	Type of wells	Total Depth in m	Post-Monsoon WL-2019 (m)	Pre-monsoon W L 2020 (m)	Fluctuation (m)
1	Badnawar	Badnawar New	DW	14.2	9.62	11.69	2.07
2	Badnawar	Chayan	DW	11.77	7.28	7.91	0.63
3	Badnawar	Kanwan	DW	15	11.75	15	3.25
4	Bagh	Bagh New	DW	12.5	4.83	7.58	2.75
6	Dhar	Dhar	DW	16.5	10.22	11.7	1.48
7	Dharampuri	Dhamnod	DW	14.5	4.12	5.88	1.76
8	Dharampuri	Dharampuri	DW	22	15.99	16.9	0.91
9	Dharampuri	Gujri	DW	14.75	8.2	9.94	1.74
10	Gandhwani	Gandhwani	DW	11	5.73	8.8	3.07
11	Gandhwani	Zeerabad	DW	15.42	7.71	7.19	-0.52
12	Kukshi	Dehari	DW	15.6	9.77	12.77	3
13	Kukshi	Dhulsar	DW	13.9	5.31	6.41	1.1
14	Kukshi	Kukshi	DW	12.9	8.5	12.9	4.4
15	Kukshi	Palasi	DW	6.51	2.05	6.07	4.02
16	Manawar	Manawar	DW	20	14.17	20	5.83
17	Manawar	Singhana	DW	10.63	4.34	6.07	1.73
18	Nalchha	Mandu	DW	15.11	11.85	15.11	3.26
19	Nisarpur	Pipalya	DW	14	8.16	7.06	-1.1
20	Sardarpur	Amjhira	DW	11.5	2.56	3.27	0.71
21	Sardarpur	Dasai	DW	14.5	10.76	12.1	1.34
22	Sardarpur	Julana	DW	17.5	8.38	17.5	9.12
23	Sardarpur	Rajod	DW	10.7	6.81	8.31	1.5
24	Sardarpur	Sardarpur	DW	15.19	6.3	7.88	1.58
25	Tirla	Lunera	DW	10.68	6.7	10.68	3.98
26	Umarban	Tawlai	DW	11.11	1.7	2.5	0.8

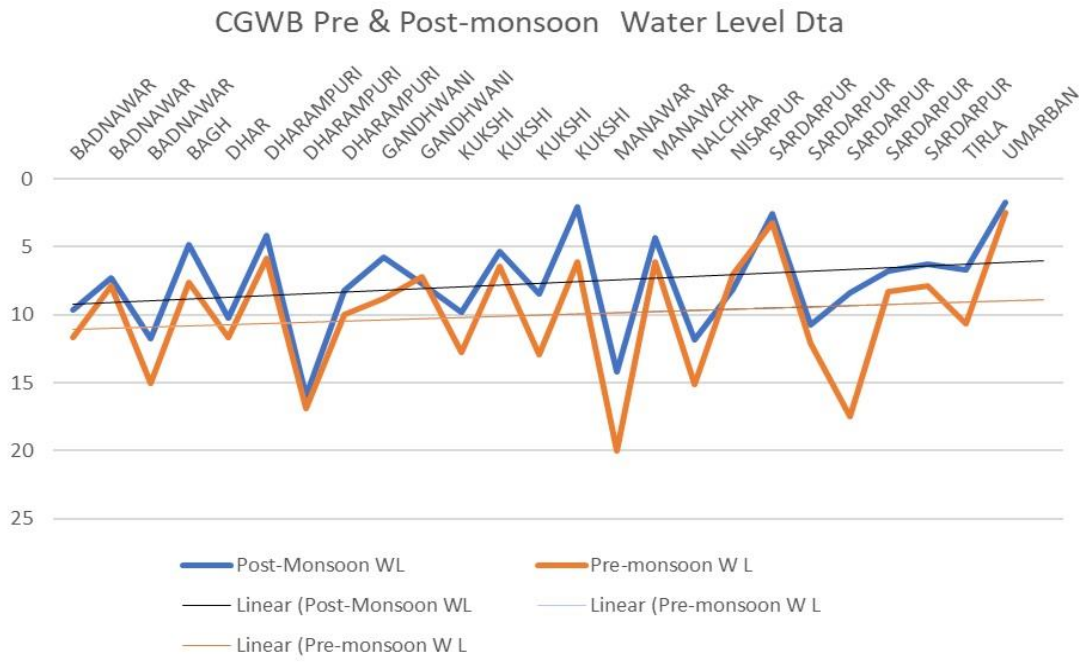


Fig: 3.5 Comparison of Pre & Post-monsoon Water Level of CGWB NHS wells

Table: 3.3 Water level data of CGWB Pz

Block Name	Location	Types of wells	Depth (m)	Post-monsoon WL 2019(m)	Pre-monsoon WL2020(m)	Fluctuation (m)
Badnawar	Badnawar(d)	Piezometer	90	11.87	16.53	4.66
Badnawar	Badnawar(s)	Piezometer	30.65	14.54	14.61	0.07
Badnawar	Kanwan Npz	Piezometer	50	12.1	30.5	18.4
Bagh	Bagh(d)	Piezometer	60.98	6.09	8.5	2.41
Dhar	Dhar (D)	Piezometer	120	11.54	21.47	9.93
Dhar	Dhar (S)	Piezometer	32	11.42	24.27	12.85
Dhar	Gunawad Npz	Piezometer	50	22.2	26.5	4.3
Dharampuri	Dharampuri Npz	Piezometer	50	6.48	7.3	0.82
Manawar	Manawar	Piezometer	94.6	12.65	22.24	9.59
Nalchha	Bagri	Piezometer	50	12.5	22.24	9.74
Nalchha	Dhamnod	Piezometer	50	4.38	4.9	0.52
Nalchha	Nalchha	Piezometer	50	15.17	14.9	-0.27
Nalchha	Pithampur Nagarpalika Npz	Piezometer	50	3.75	8	4.25
Sardarpur	Amjhera	Piezometer	90	12.98	35.27	22.29
Sardarpur	Bandheri	Piezometer	50	12.04	11.2	-0.84
Sardarpur	Sardarpur(D)	Piezometer	66	13.56	27.79	14.23
Sardarpur	Sardarpur(S)	Piezometer	36	11.41	12.56	1.15

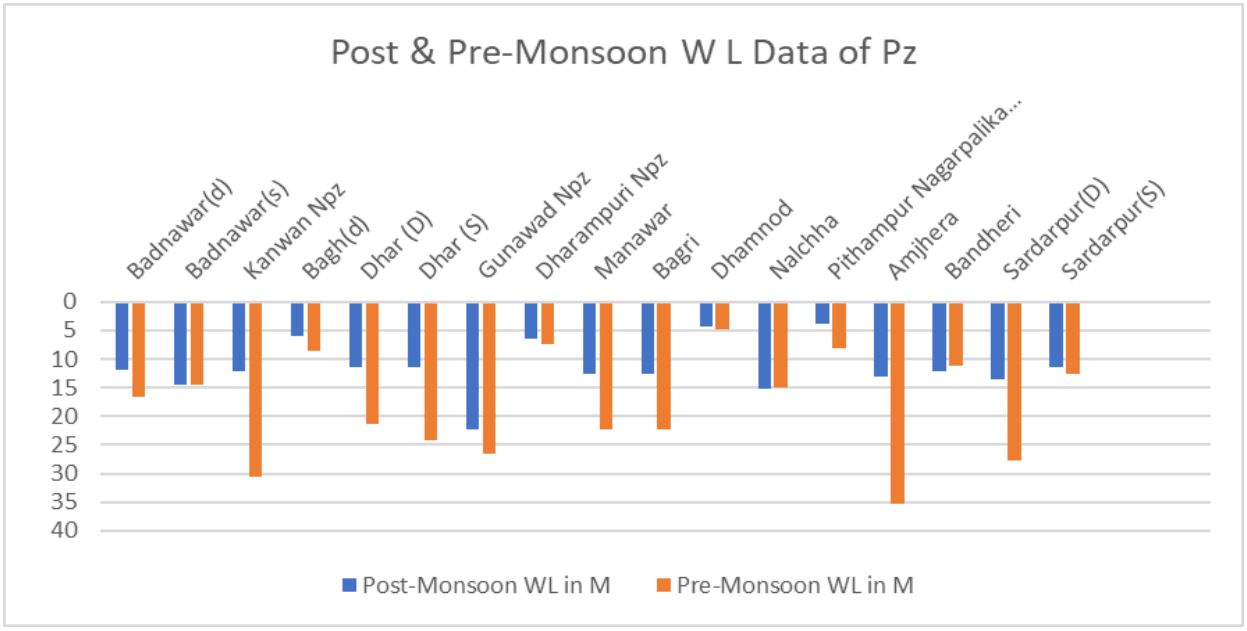


Fig. 3.6: Comparison of Pre & Post-monsoon Water Level of CGWB Pz

Water level Fluctuation

The water level measured during pre and post monsoon period (Nov 2019 to May-2020) was used to compute the seasonal fluctuation in shallow aquifer. The analysis of water level fluctuation data indicated that minimum water level fluctuation was observed at Chhayan (0.63 m) while maximum water level fluctuation was observed at Julana (9.12m). The water level fluctuations were grouped under three categories i.e., less, moderate and high and the % of wells in each category was analyzed (**Table 3.5**).

Table 3.4(a): Analysis of Water Level Fluctuation in shallow aquifer

S. No.	Category	Fluctuation Range	% of Wells
1.	Less water level fluctuation	0 to 2 m	48%
2.	Moderate water level fluctuation	2 to 5 m	40%
3.	High water level fluctuation	>5 m	12%

The analysis indicates that majority of the wells (48%) are falling in high fluctuation range indicating aquifer storage is not good, whereas moderate water level fluctuation are observed in 40 % wells and low water level fluctuation were observed in 12 % wells. The seasonal fluctuation map is presented as **Fig. 3.7** the perusal of map indicates that fluctuation of greater than 5 m is observed in major part of the area, whereas lower fluctuation of less than 2 m is observed in the north east, North West and south-central part of the district.

The water level measured during pre and post monsoon period (Nov 2019 may-2020) was used to compute the seasonal fluctuation in deeper aquifer/Pz . The analysis of water level fluctuation data indicated that minimum water level fluctuation was observed at Badnawar(s) (0.07 m) while maximum water level fluctuation was observed at Pithampur Nagarpalika Npz (22 m). The water level fluctuations were grouped under three categories i.e., less, moderate and high and the % of wells in each category was analyzed.

Table 3.4(b): Analysis of Water Level Fluctuation in Pz

S. No.	Category	Fluctuation Range	% of Wells
1.	Less water level fluctuation	0 to 2 m	24%
2.	Moderate water level fluctuation	2 to 5 m	24%
3.	High water level fluctuation	>5 m	52%

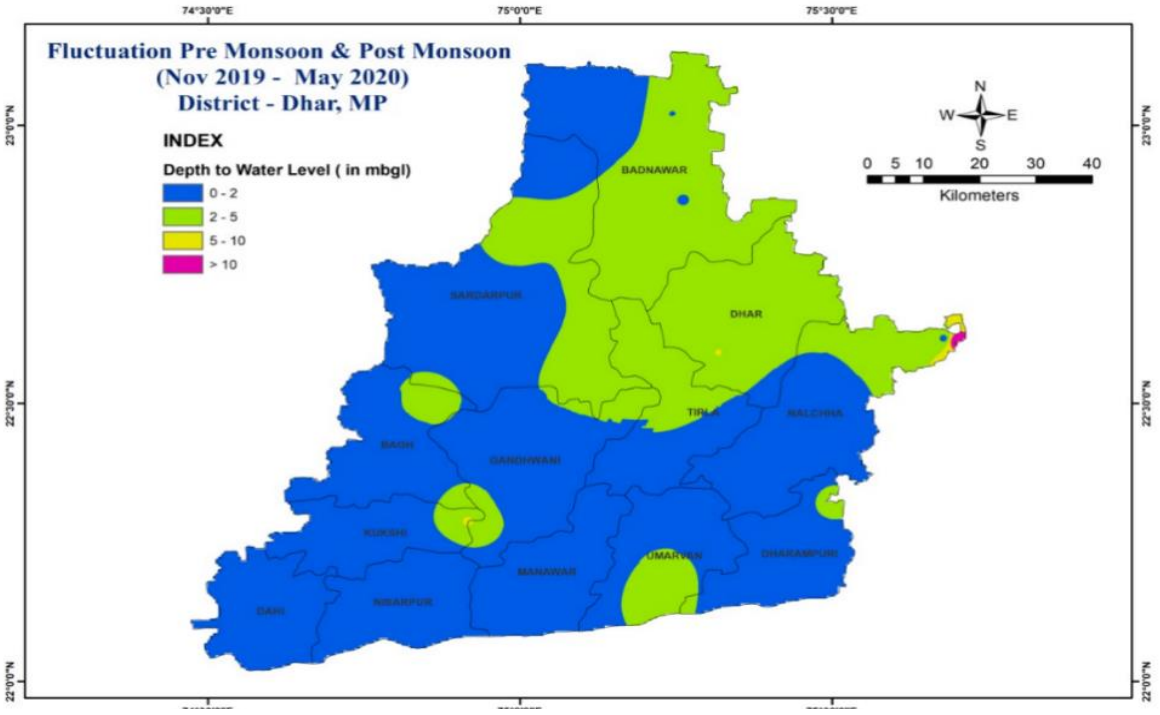
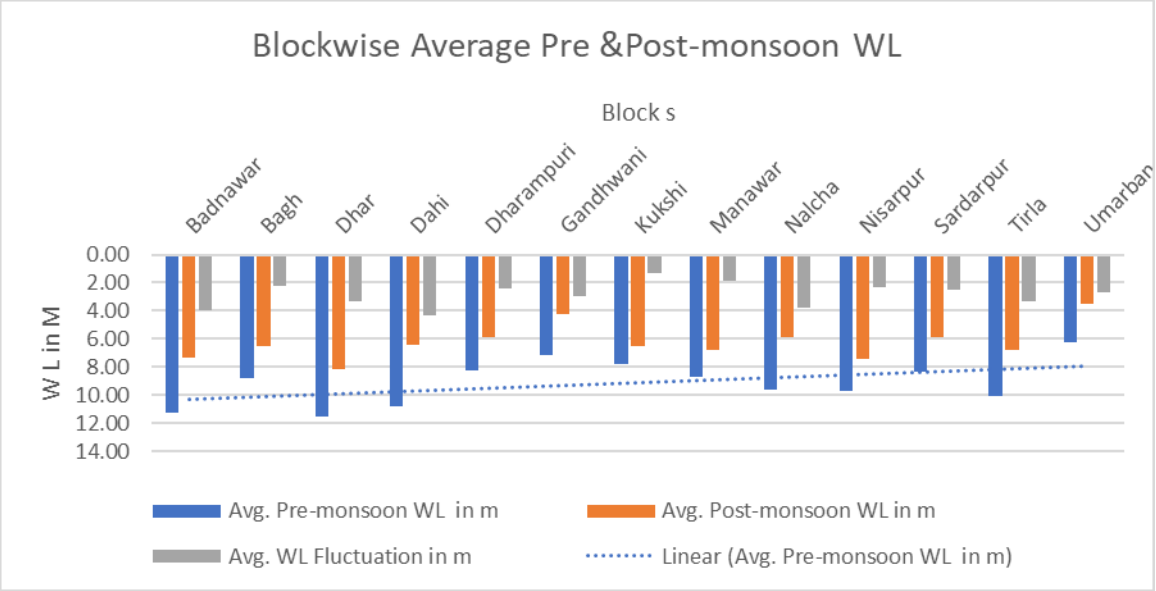


Fig:3.7 Water Level Fluctuation Map

Table- 3.5 Block wise average Pre & Post-monsoon Water Level of Dhar District

S. No.	Block Name	Avg. Pre-monsoon WL in m	Avg. Post-monsoon WL in m	Avg. WL Fluctuation in m
1	Badnawar	11.29	7.37	3.92
2	Bagh	8.75	6.54	2.21
3	Dhar	11.51	8.19	3.32
4	Dahi	10.80	6.43	4.37
5	Dharampuri	8.29	5.86	2.43
6	Gandhwani	7.17	4.21	2.96
7	Kukshi	7.79	6.49	1.29
8	Manawar	8.68	6.82	1.86
9	Nalcha	9.60	5.84	3.77
10	Nisarpur	9.69	7.40	2.29
11	Sardarpur	8.36	5.85	2.51
12	Tirla	10.08	6.78	3.30
13	Umarban	6.27	3.55	2.72



Block wise average pre & post-monsoon depth to water levels studied. In post-monsoon four block namely Badnawar, Dhar, Dahi and Tirla are showing more than 10 m bgl and nine blocks are showing more than 6.00 mbgl water level. In post-monsoon eight block are showing more than 6.00 m bgl and five blocks are showing less than 6 mbgl.

3.3 Ground Water Quality

The pH of ground water of Dhar district ranged in between 6.98 to 7.73. As per BIS recommendation, all water samples recorded within the permissible limit of 6.5 to 8.5. The ground water of the study area can be assessed as neutral to slightly alkaline in nature. The electrical conductivity of ground water in Dhar district ranged between 382 to 2615 µS/cm at25°C. The maximum value of electrical conductivity observed in the dug well of Amjhira village. The electrical conductivity shows that the ground water in Dhar district is good in nature.

CGWB and PHED Govt. of MP studied the fluoride concentration in Dhar district ranged in between 0.1 to 21.0 mg/l. As per BIS permissible limit, the maximum concentration is recorded at Dhar, Nalchha, Dharmapuri and Tirla Blocks.

In deeper aquifer, concentration of fluoride is l. In shallow aquifer and in shallow aquifer (dug well) fluoride ranges varies 0.10 to 2.200 mg/.

In Deeper Aquifer, Maximum Concentration of fluoride has been recorded in ground water of Mewasjamniya (21.2 mg/l), Mohanpura (19 mg/l) and Mehgaon (14 mg/l) and In shallow the concentration of fluoride more than 1.50 mg/l has been recorded at Dharampuri (2.20 mg/l), Gujri (2.45 mg/l) and Dhamnod (2.50 mg/l In the district, nitrate concentration in ground water ranged in between 2 to 142 mg/l. The 62% ground water samples recorded nitrate concentration within the BIS acceptable limit of 45 mg/l and 38% water samples recorded more than 45 mg/l as BIS recommendation. The concentration of nitrate more than 100 mg/l has been detected in ground water of Dasai (142 mg/l) and Kukshi (140 mg/l) dug wells. High nitrate in ground water appears may be due to anthropogenic activities or excessive use of fertilizers etc. The fluoride contaminated well's location of shallow as well as deeper aquifer are given in Fig: 3.8 and 3.13.

Total hardness of ground water in the study area ranged in between 104 to 787 mg/l. The concentration of total hardness more than 600 mg/l has been observed in the dug well of Kukshi (644 mg/l), Amjhira (683 mg/l) and Dasai (787 mg/l) villages.

In the district water are $CaHCO_3$, mixed $CaNaHCO_3$, mixed CaMgCl and NaCl types, it shows temporary and mixed and saline type of water respectively. The US Salinity Diagram of Dhar district shows the ground water is low to high salinity classes i.e. C_2S_1, C_3S_1, C_3S_2 and C_4S_1 classes. C_3 and C_4 classes of water should not be used for irrigation purpose unless proper soil management.

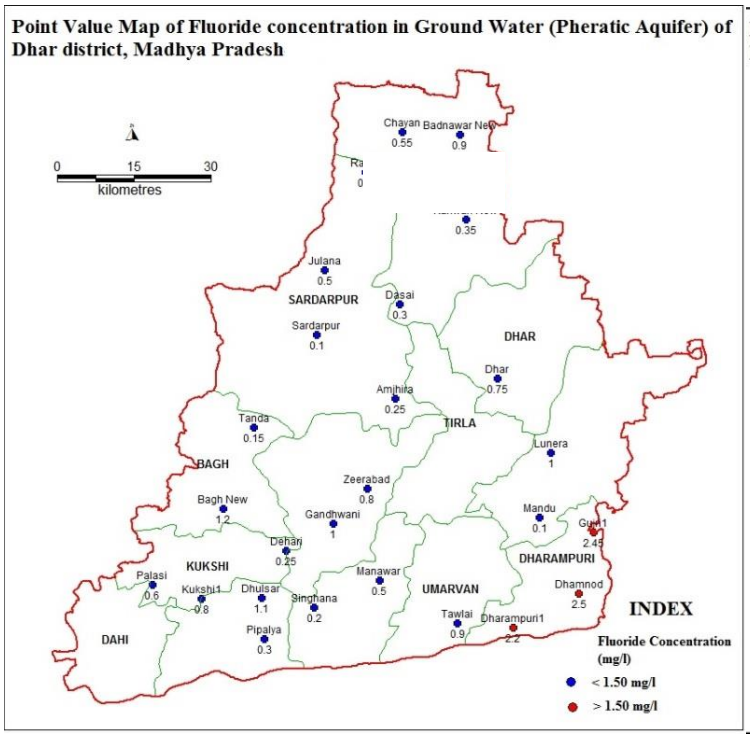


Fig:3.8 Fluoride Concentration in Shallow Aquifer

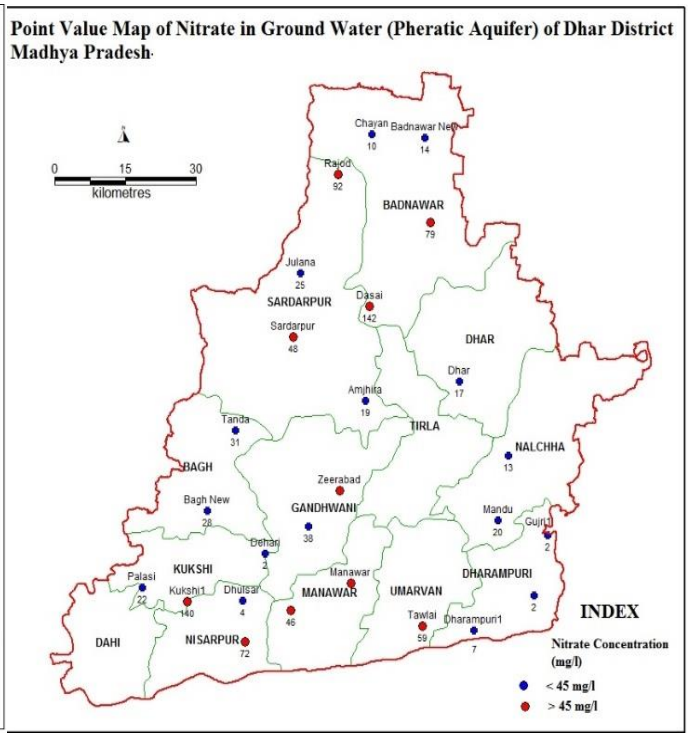


Fig:3.9 Nitrate Concentration in Shallow Aquifer

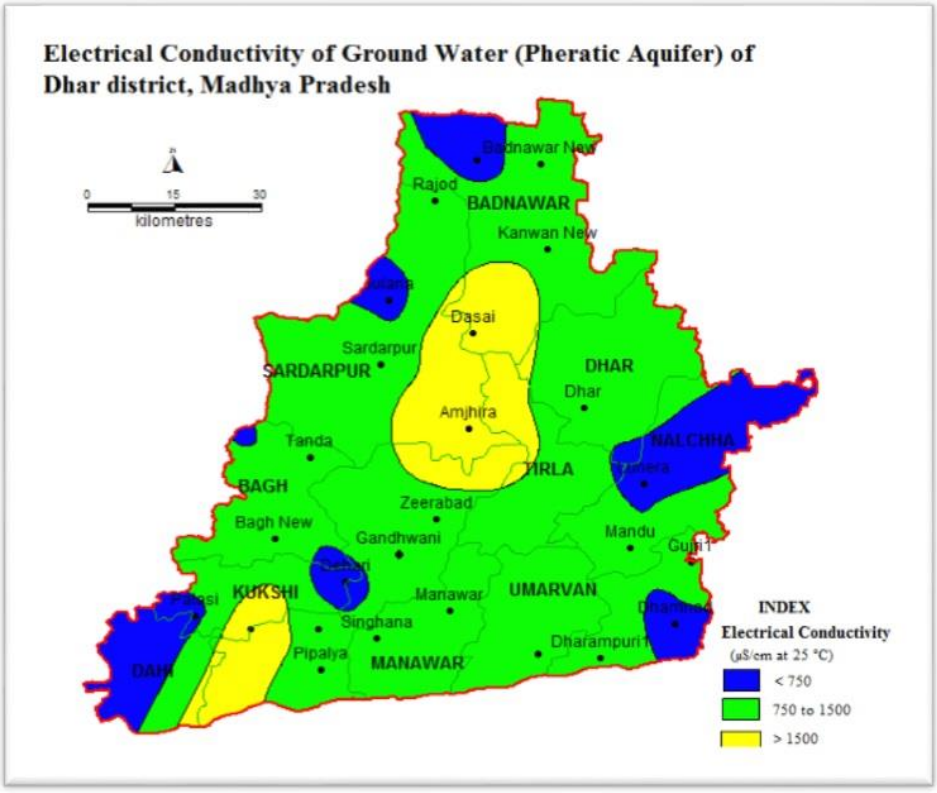


Fig 3.10 EC contour map

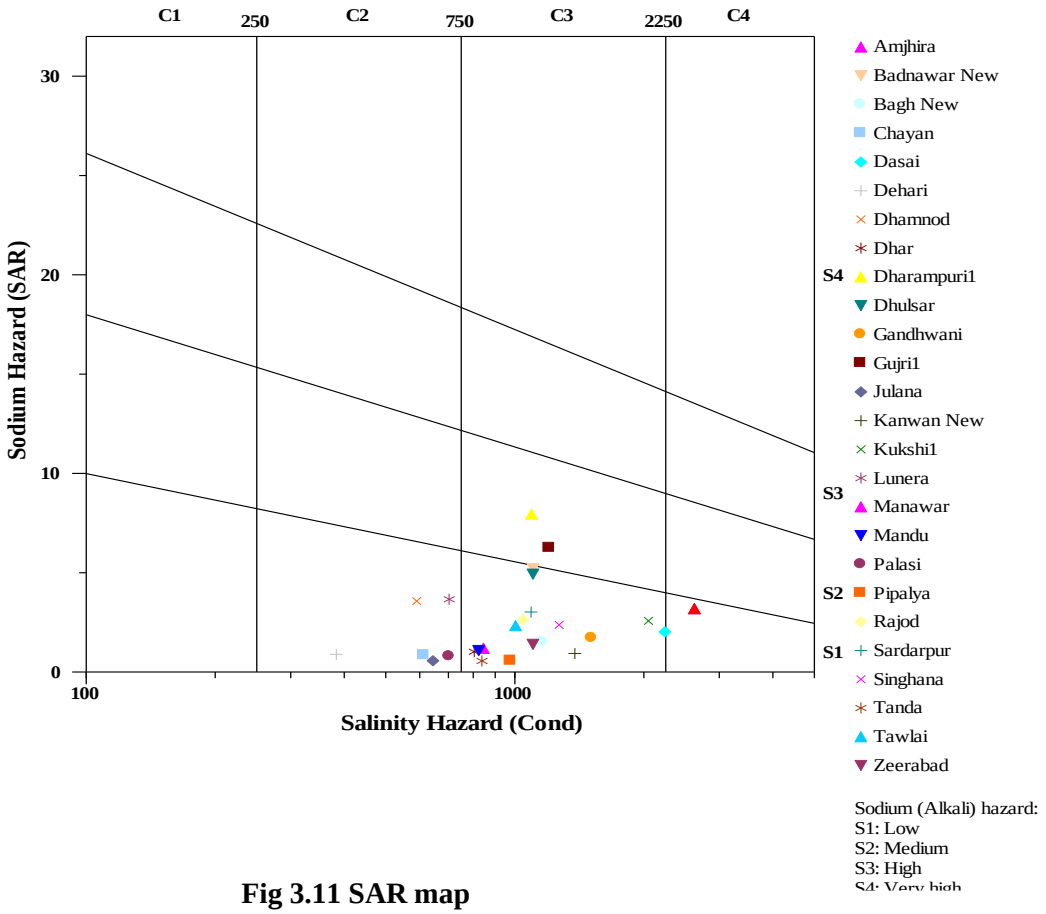


Fig 3.11 SAR map

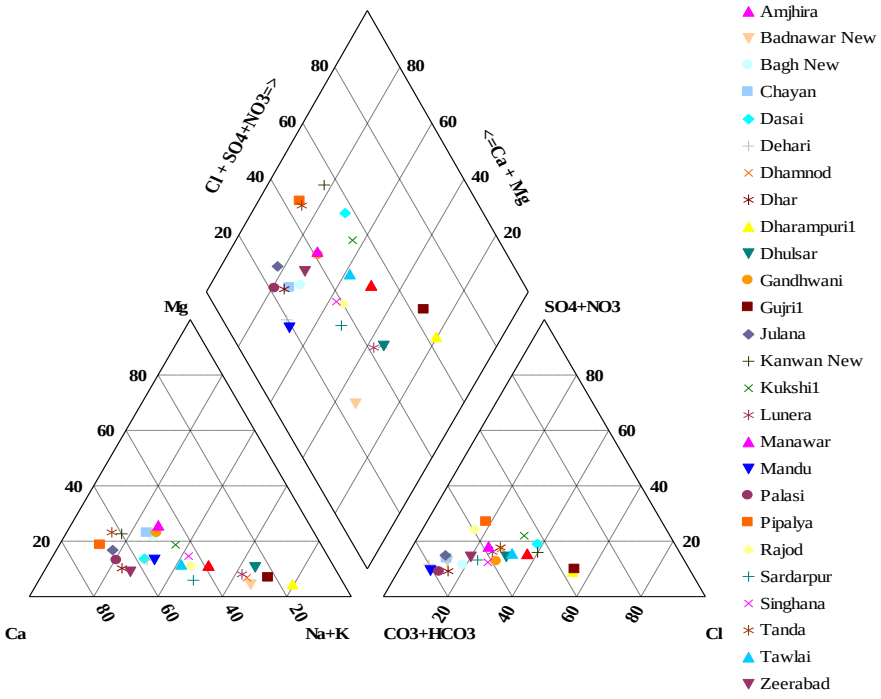


Fig 3.11 Piper Map

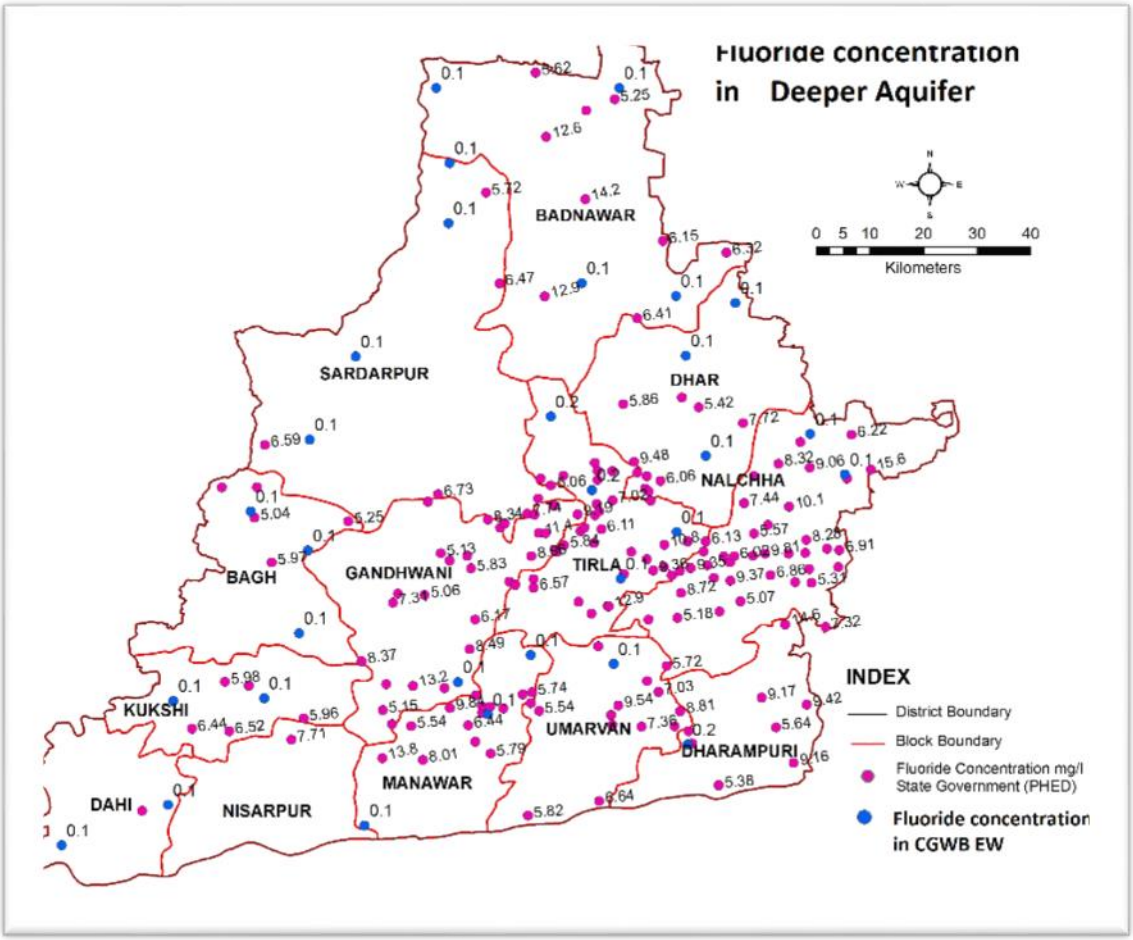


Fig: 3.13 Fluoride Concentration in Deeper Aquifer

Table: 3.6 Aquifer wise ranges of chemical constituents

S. No	Agency	No of sample Analysed	Type of well	Average depth in m	Fluoride concentration range in mg/l	
Deeper Aquifer						
1	PHED	1200	HP and Bore well	180	1.76	21
2	CGWB	30	Bore Well	200	0.1	0.3
Shallow aquifer						
1	CGWB	19	Dugwell	25	0.25	2.5

3.4 3-D and 2-D Aquifer Disposition

Central Ground Water Board has been carried out ground water exploration through outsourcing and constructed 72 exploratory wells and 19 observation wells and also carried out Vertical electrical sounding (VES) under NAQUIM data generation through outsourcing.

In the study area, two aquifer systems have been demarcated based on the groundwater water occurrence and movement. The first aquifer (Aquifer-I) is weathered layer of all three lithology. The second aquifer (Aquifer-II) is fractured layers and vesicular Basalt. The bottom of the aquifer-II is demarcated using the lower most fractured depth encountered in the bore well. Aquifer-II is generally extending latterly in uniform thickness and fallowed the general topography of the area. The thickness of Aquifer-II is varying some places whenever secondary aquifer encountered like fractured and also depend on the thickness of particular flow.

Central Ground Water Board have also been conducted slug. PYT and pumping test during ground water exploration to decipher hydrogeological properties of aquifer. The different hydrogeological test and exploration data reveal that the main aquifer system in Dhar district is vesicular and fractured basalt, which is very good yielding during July to December and gradually decrease or dry during lean period. The average thickness aquifer in the area is varies form 5 m to 35 m in 200 m exploratory wells which is create good subsurface storage. The details and outcome of exploratory and observation wells are given in **Table: 3.9.**

The aquifer disposition of the area is demarcated based on the groundwater exploration data which depicts the lateral and vertical configuration of the aquifers using Rockworks software. such as Basalt, Sandstone, Limestone and Granite formation.

- **Fence and 3D Diagram**

The Fence and 3D diagram are prepared on the basis of lithological log/ground water exploration data. It is indicating that maximum part of the district is covered by Deccan Basalt, However, Fractured and vesicular basalt is the main potential aquifers in the area. and. The litholog of exploratory wells are studied, reveal that the thickness of aquifer is varied from 5 to 35 m from place to place and sustainability of aquifer is also gradually decrease during lean period. The disposition of Aquifer-I and Aquifer-II and other geological units can be observed in the Fence and 3D diagram. The lateral and vertical delineation of aquifer are given in Fig:3.14 and 3.15.

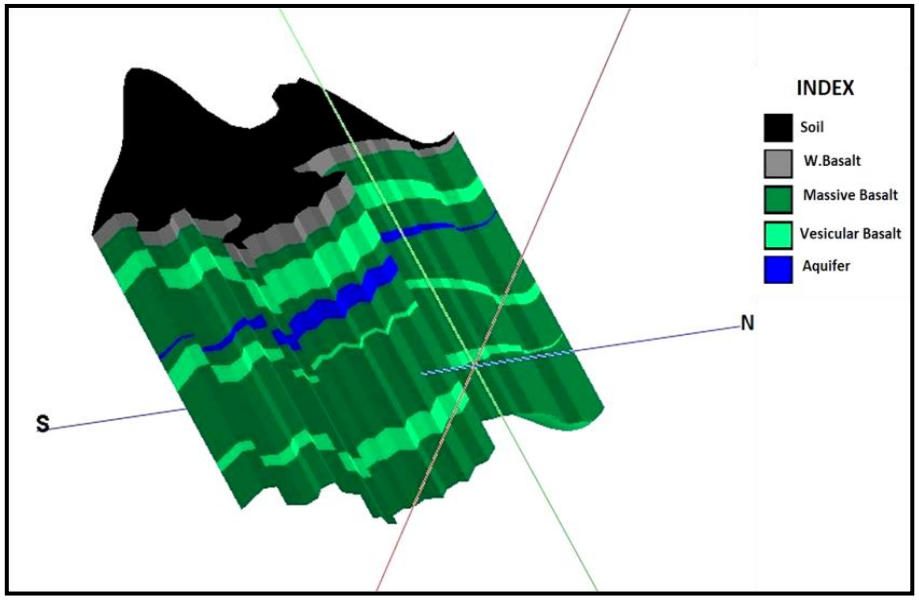


Fig.3.14: 3-D Aquifer Disposition

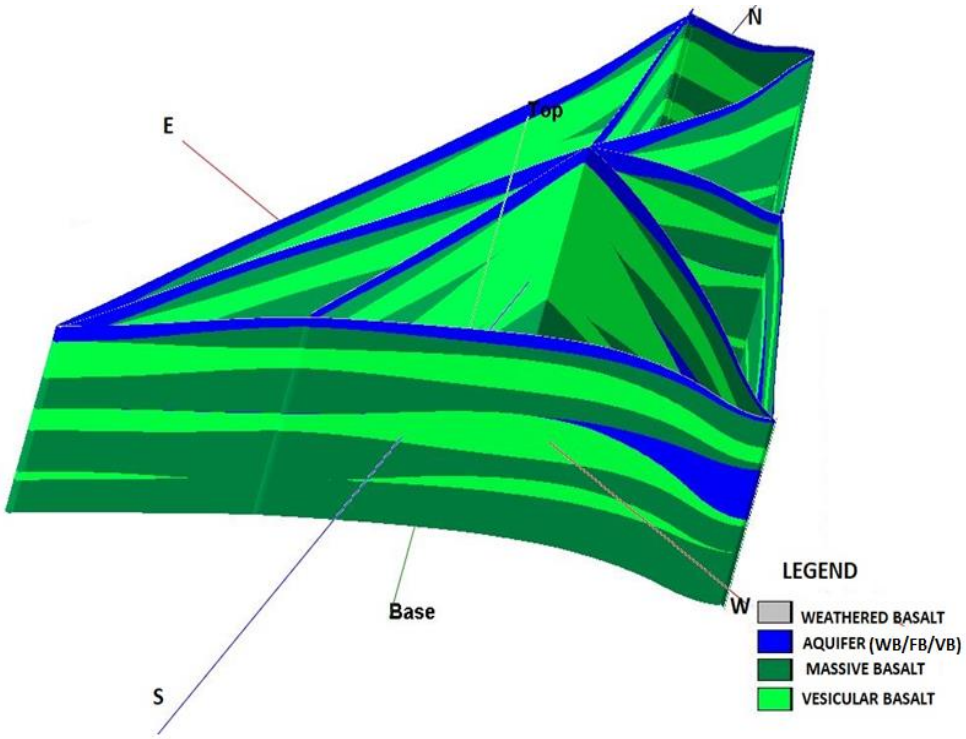


Fig.3.15: Fence Diagram showing aquifer disposition in the area

2D Aquifer disposition (Hydrogeological cross section)/ hydrogeological cross sections were prepared to know the vertical and lateral distribution of the deeper aquifer system in the OCS block of the district are given in fig: 3.16,3.17,3.18 and 3.19.

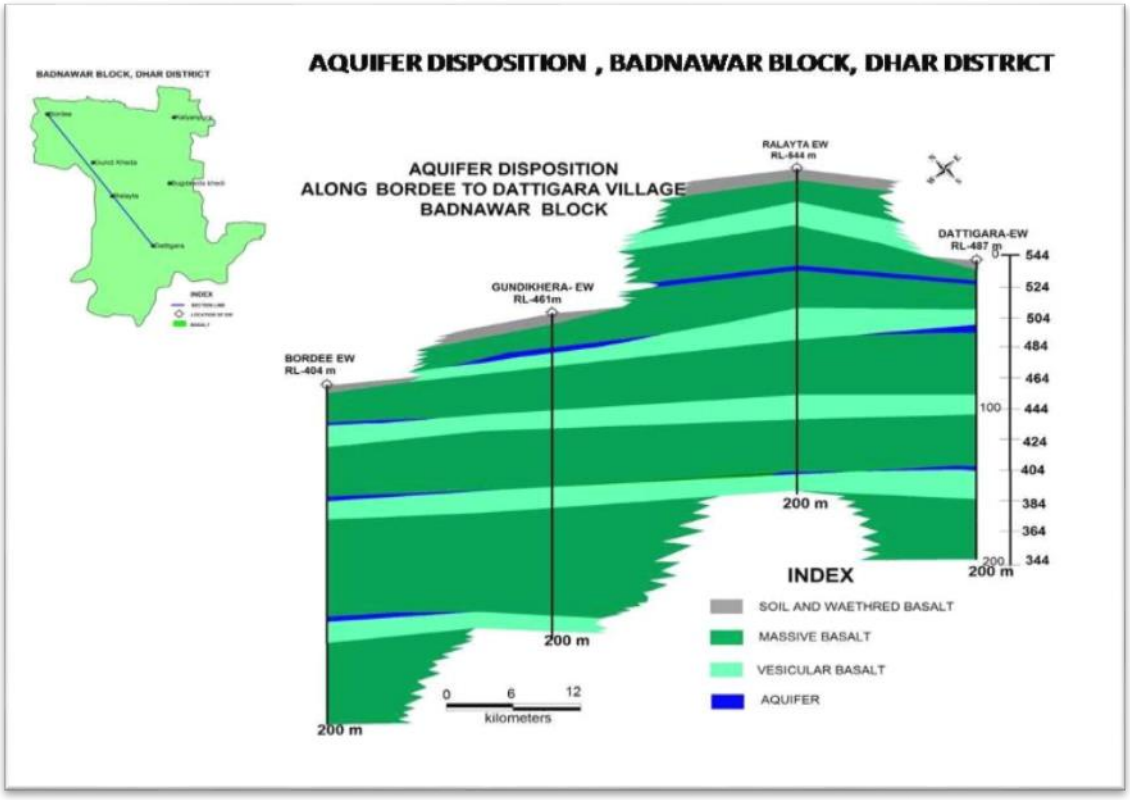


Fig. 3.16 Aquifer Disposition in Badnawar Block

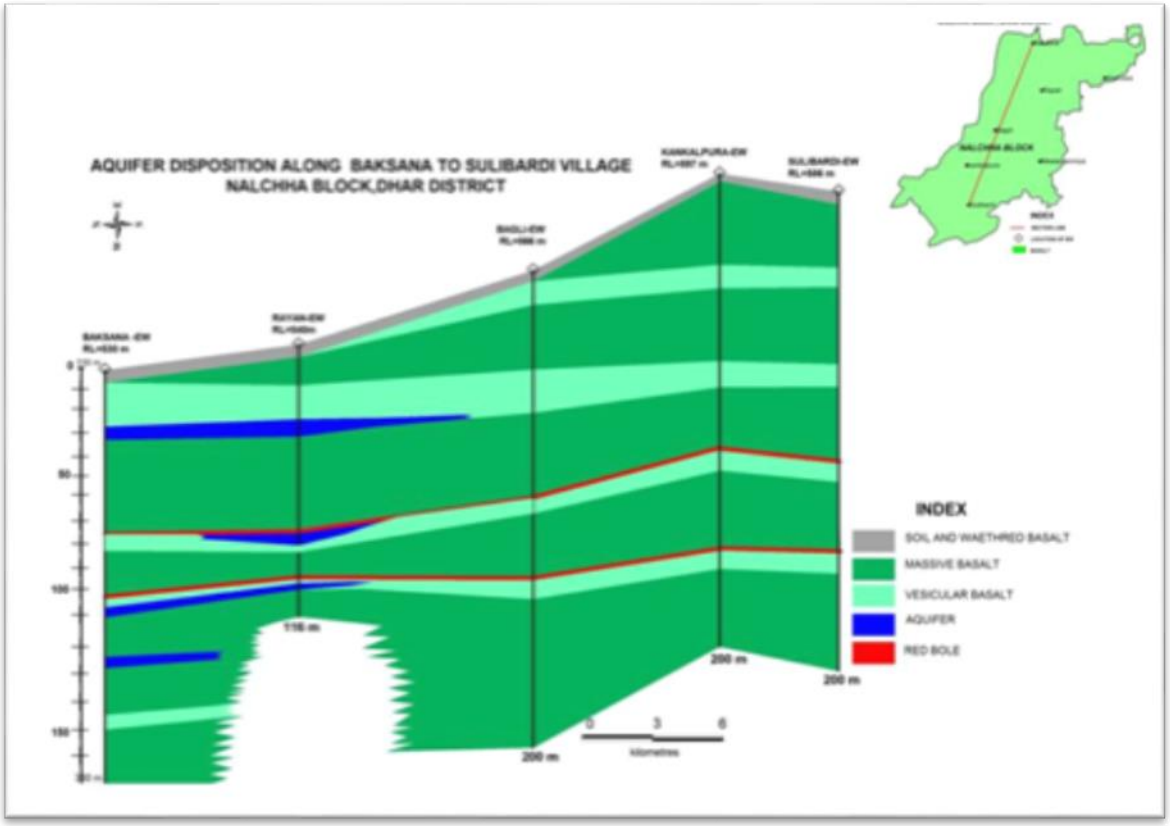


Fig 3.17 Aquifer Disposition in Nalchha Block

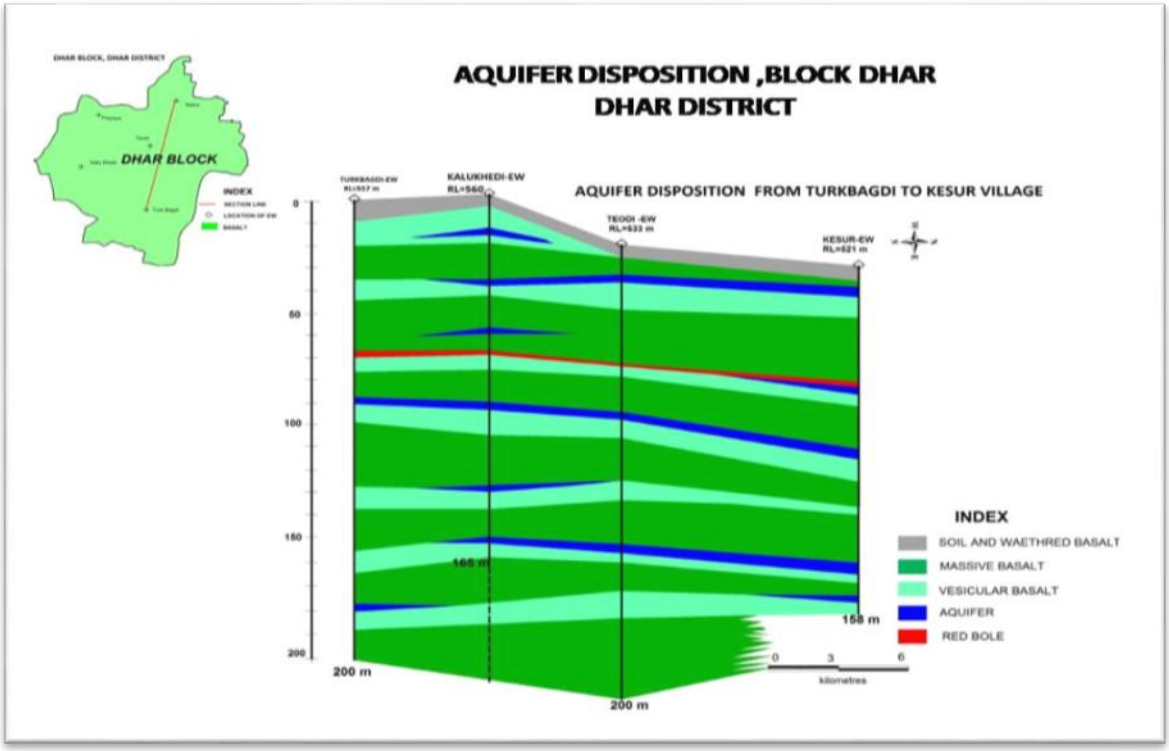


Fig 3.18 Aquifer Disposition in Dhar Block

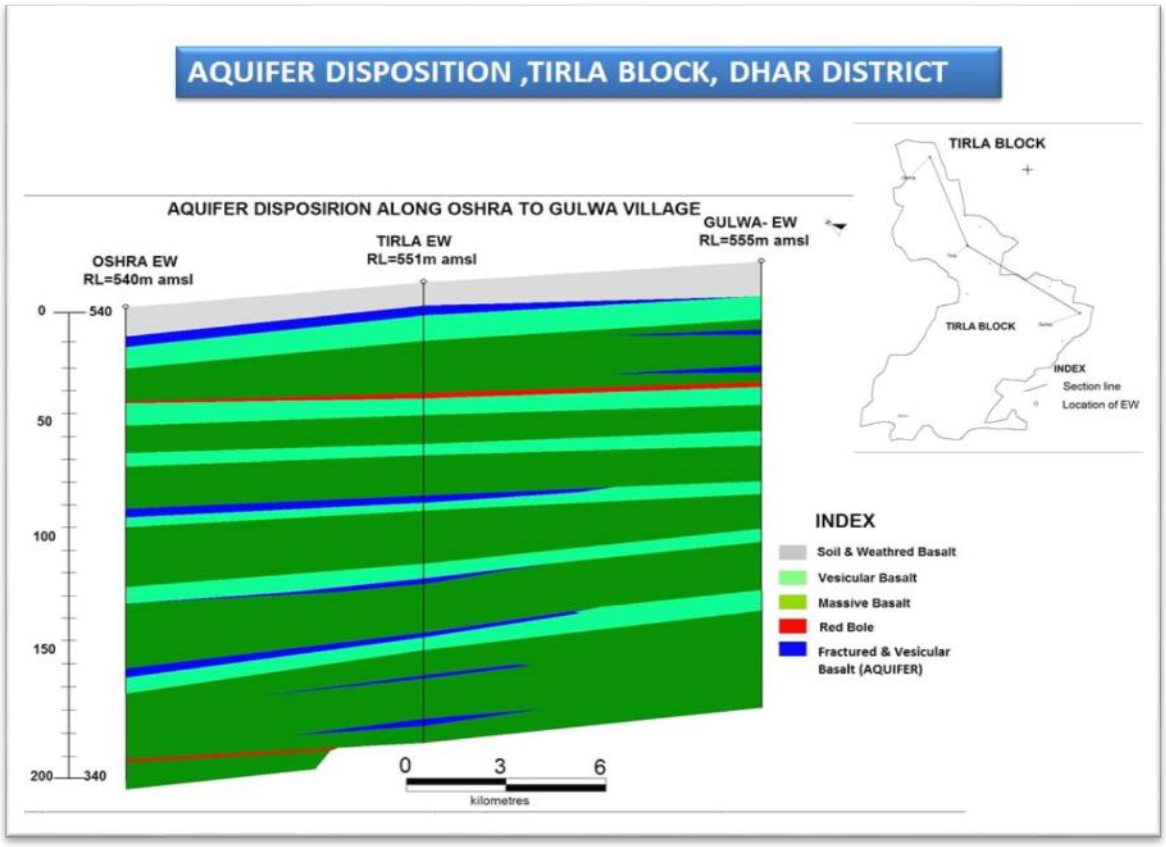


Fig 3.19 Aquifer Disposition in Tirla Block

The Block wise hydrogeological 2D section have been prepared and demarcated aquifer groups, establish the geometry of the underlying aquifer systems in horizontal and vertical domains, characterize them, and prepare an management strategy and plan for the area and estimated aquifer wise ground water resource for the area

In OCS Block, The Aquifers lateral and vertical disposition demarcated, which is shown in Fig.3.11,3.12,3.13 & 3.14. It indicates that main aquifer system is vesicular basalt and contact zone of different flows. The thickness of aquifer is almost uniform throughout the block. The discharge of the wells varies from 1.00 lps to 24.00 lps during lean period and post-monsoon period respectively. Uncontrolled pumping of groundwater from shallow as well as deeper aquifer during irrigation of RABI crops has caused shortage in water supply and decline the water level, therefore, the aquifer sustainability during lean period is one of the most concern issue in district.

In Fig: 3.14 showing aquifer disposition from Oshra EW to Gulwa EW. It indicates that the thickness of aquifer is increase towards North of Tirla Block (Oshra EW).

Aquifer disposition of Shallow aquifer

CGWB has been carried out vertical electrical sounding throughout the district. The phreatic (weathered zone) aquifer disposition of the area is demarcated based on the casing length of exploratory wells and utilised VES data which depicts the lateral and vertical delineation of the shallow aquifers using MAPINFO software. The thickness of phreatic/weathered aquifer is varying from place to place and average thickness in the area is 8-12 m bgl, which is very useful for suitable sites selection of AR structures.

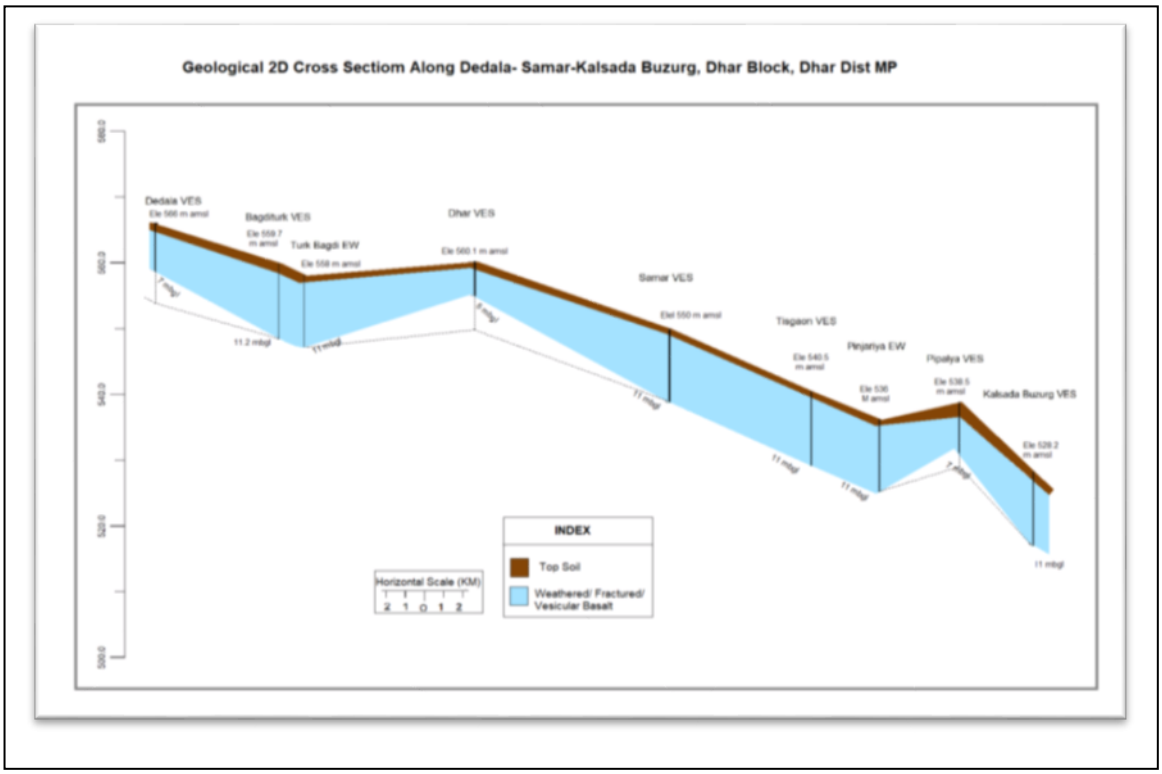


Fig: 3.20: Phreatic/weathered aquifer Disposition in Dhar Block

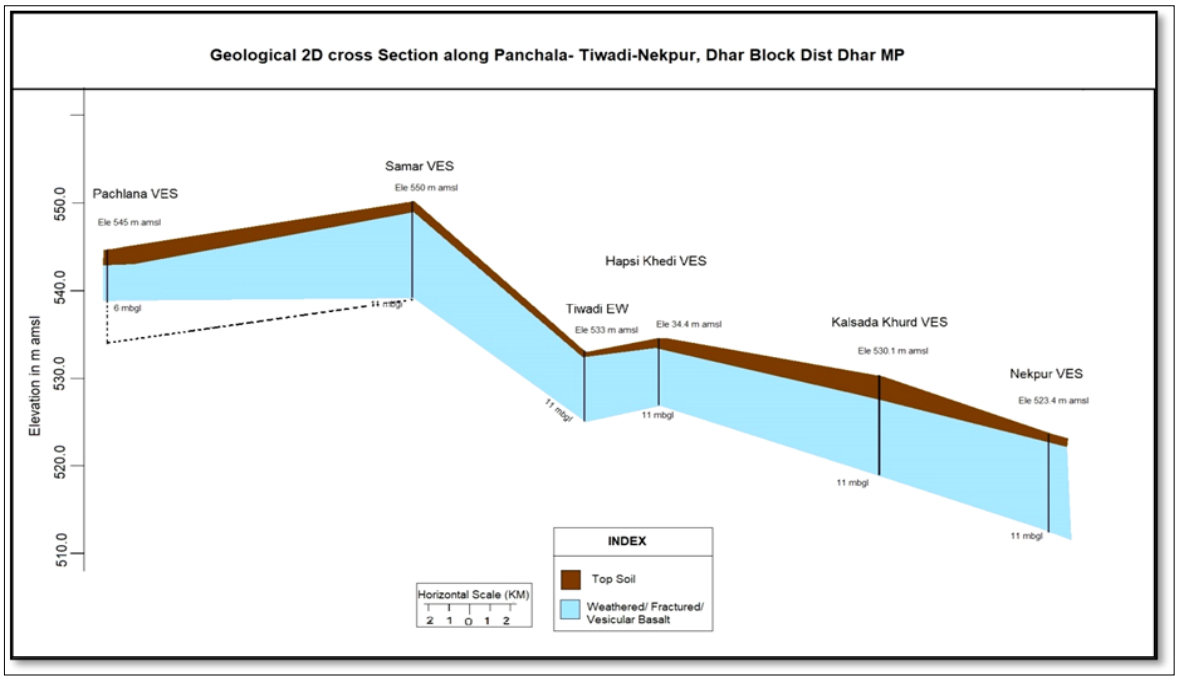


Fig 3.21 Phreatic/weathered aquifer Disposition - Dhar block

Hydrogeological cross section showing shallow aquifer disposition in E-W direction and it is prepared on the basis of exploratory wells and Vertical Electrical Soundings data i.e., Dedla, Bagditurk, Dhar, Samar, Tiagaon, Pijariya, Piplya, and Kalsada Buzurg has been utilized.

Hydrogeological cross section showing shallow aquifer disposition from Kessor to Dhar (**Fig.3.16**) or N-S direction. The data of exploratory wells and Vertical Electrical Soundings i.e., Kesur, Govindpura, Tiwadi, Samar and Dhar has been utilized.

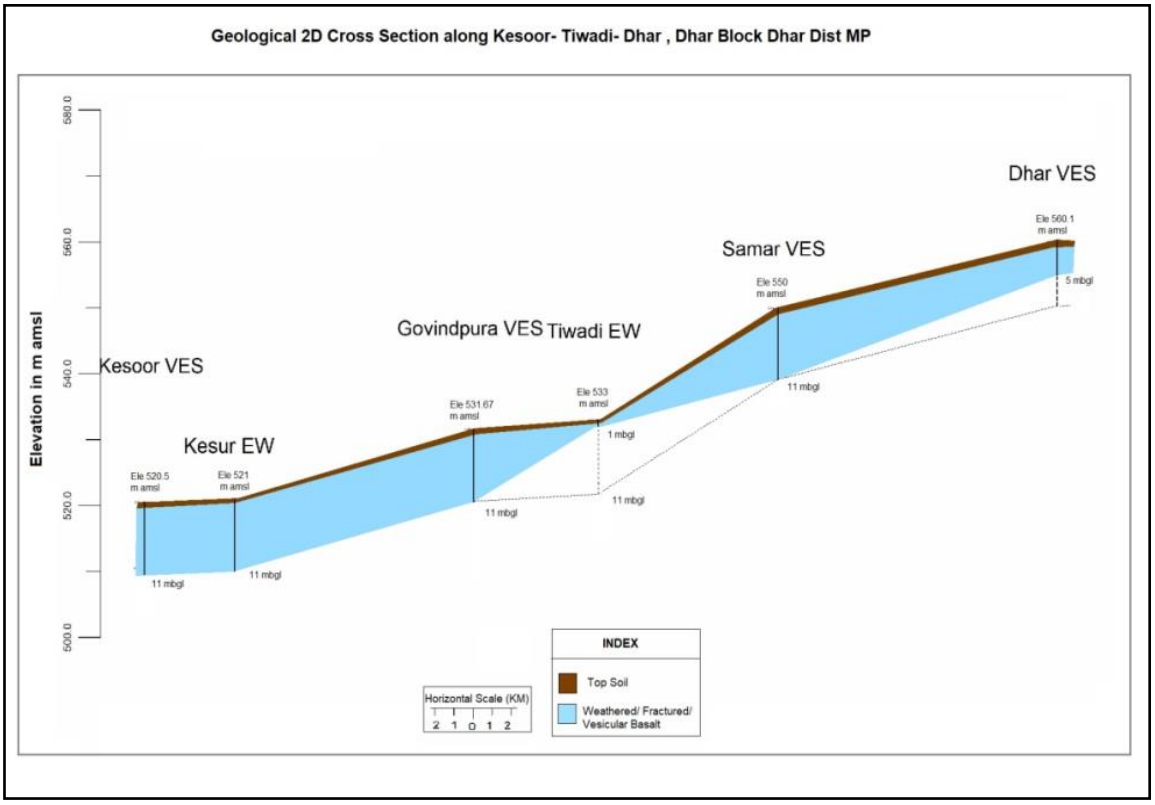


Fig.3.22: Shallow Aquifer Disposition

3.5 Aquifer Characteristics

Each Basaltic flow comprises two distinct units viz, upper vesicular unit and lower massive unit. The massive basalt is hard, compact and does not have primary porosity and is impermeable. Weathering, jointing and fracturing induces secondary porosity in massive unit, whereas, in vesicular basalt, when vesicles are interconnected constitutes good primary porosity and it is reduced whenever the vesicles are filled/ partly filled by secondary minerals. Generally, Ground water occurs under phreatic / unconfined to semi-confined conditions in basalts.

Based on the ground water exploration and geophysical study in the Dhar district, the two types of aquifers demarcated and the details are given below in **Table 3.8**.

Table 3.7 Aquifer characteristics

Major Aquifer	**Basalt /Granitoids/ Sandstone**	
Type of Aquifer	Aquifer-I	Aquifer-II
Formation	Weathered Basalt/Sandstone/Siltstone/Granitoids	Fractured Basalt/Vesicular Basalt /Granitoids/Sandstone
Depth of Occurrence (mbgl)	1 to 30	30 to 200
SWL (mbgl)	0.44 to 19.7	10 to 152
Weathered / Fractured rocks thickness (m)	2 to 14	0.5 to 25
Fractures encountered (mbgl)	Upto 30	Upto 200
Yield	-	Up to 24 lps
Transmissivity (m^2/day)	-	5 to 80 m^2/day
Specific Yield/ Storativity (Sy/S)	-	$1.0x10^{-4}$ to $5.5x10^{-5}$
Suitability for drinking/ irrigation	Suitable for both drinking and agriculture, except high Nitrate at some places	Suitable for both drinking and agriculture, except high Nitrate at some places places and some aquifer zones is Fluoride contaminated.

Table: 3.8 Details of Ground water exploration in Dhar District

S. No.	Location	Block	Discharge (lps)	SWL (mbmp)	Test	Transmissivity m^2/day		Specific Capacity (litre/min/m)	Storativity	Transmissivity m^2/day	
						Jacob	Theis			Jacob	Theis
1	Bugdawada	Badnawar	8.2	154.72	Slug test	0.25					
2	Dattigara	Badnawar	13.77	48.79	Pumping test	2.67	1.34	1.42			
3	Gundikhedi	Badnawar	0.01	120.2	Slug test	1.63					
4	Kalyanpura	Badnawar	4.26	27.2	PYT	3.96	7.91	12.45			
5	Ralayta	Badnawar	0.43	17.25	Slug test	13.44					
6	Silonda	Badnawar	1.74	4.32	PYT	1.04	1.79	2.84			
7	Akhada	Bagh	0.08	8.71	Slug test	0.58					
8	Bhamori	Bagh	1.18	43.02	PYT	3.27	2.45	3.77			
9	Chunpaya	Bagh	0.21	25.1	Slug test	0.82					
10	Mukundapura	Bagh	5.39	9.04	Pumping test	20.25	10.13	4.8	5.49×10^{-3}	40.45	40.45
11	Narwali	Bagh	0.75	17.37	PYT	6.72	8.41	15.96			
12	Pipawa	Bagh		12.19	Slug test	0.35					
13	Aarada	Dahi	2.43	48.72	PYT	2.44	3.05	2.55			
14	Ajgaon	Dahi	0.08	72.66	Slug test	0.38					
15	Chichwaniya	Dahi	0.75	45.3	PYT	1.11	0.51	2.01			
16	Molipura	Dahi	6.67	41.7	Slug test	3.52					
17	Kalukhedi	Dhar	24.08	77.4	Pumping test	4.03	6.05	11.25			
18	Kesur	Dhar	13.77	16.33	Pumping test	23.73	18.99	11.36	6.50×10^{-4}	31.64	47.46
19	Pinjariya	Dhar	0.21	23.65	Slug test	1.65					
20	Tiwadi	Dhar	3.27	22.02	PYT	0.18	0.12	0.37			
21	Turk Bagdi	Dhar	0.08	40.8	Slug test	39.55					
22	Dhegda	Dharampuri	8.19	4.23	Pumping test	4.43	4.43	2.5	1.41×10^{-3}	35.44	35.44
23	Ambajhiri	Gandhwani	0	40	Slug test	1.23					
24	Awaldaman	Gandhwani	8.19	51.15	Pumping test	35.12	35.12	61.48	5.87×10^{-4}	105.37	52.69
25	Bilda	Gandhwani	0.43	31.65	Slug test	0.24					
26	Koshdana	Gandhwani	0.01	112.45	Slug test	39.55					
27	Rodado	Gandhwani	0	88	Slug test	1.63					

Table: 3.8 Details of Ground water exploration in Dhar District

S. No.	Location	Block	Discharge (lps)	SWL (mbmp)	Test	Transmissivity m^2/day		Specific Capacity (litre/min/m)	Storativity	Transmissivity m^2/day	
						Jacob	Theis			Jacob	Theis
28	Badgiyar	Kukshi	6.7	30.31	PYT	1.98	2.97	2.8			
29	Magarda	Kukshi	0.43	72.61	Slug test	1.21					
30	Roja	Kukshi	2.43	13.25	PYT	3.02	3.02	4.44			
31	Banediya	Manawar	0.08	39	Slug test	3.27					
32	Ganpur	Manawar	8.19	27.04	Pumping test	3.16	5.27	7.34	6.78×10^{-5}	10.55	7.91
33	Khandlai	Manawar	0.75	32.39	PYT	2.32	1.4	3.88			
34	Marod	Manawar	5.39	62.15	PYT	0.57	2.37	1.34			
35	Wayal	Manawar	0.08	37.92	Slug test	0.98					
36	Aali	Nalchha			Slug test	2.32					
37	Bagri	Nalchha		50.3	Slug test	49.44					
38	Baksana	Nalchha	1.74	26.82	PYT	1.58	1.22	2.66			
39	Gulwa	Nalchha	0.08	15.66	Slug test	3.66					
40	Kankalpura	Nalchha	0.01	8.6	Slug test	0.98					
41	Mewas Jamniya	Nalchha	0	20.66	Slug test	26.36					
42	Rayan	Nalchha	8.2	30.45	PYT	0.19	0.16	0.49			
43	Sulibadri	Nalchha	0	21.86	Slug test	1.23					
44	Badagaon	Nisarpur	0.08	9.8	Slug test	52.68					
45	Bhardpur	Nisarpur	0.01	9.8	Slug test	0.39					
46	Lohari	Nisarpur	0.08	43.71	Slug test	0.06					
47	Nanoda	Nisarpur	0.08	31.17	Slug test	0.123					
48	Amba	Sardarpur	18.48	170.2	Slug test	3.25					
49	Baramkhedi	Sardarpur	0.08	84.55	Slug test	0.98					
50	Bhopawar	Sardarpur	0.21	37.15	Slug test	16.7					
51	Chyan	Sardarpur	18.48		Pumping test	35.12	58.54	44.06	6.86×10^{-3}	131.71	105.37
52	Dasai	Sardarpur	0.43	11.25	Slug test	43.9					
53	Khareli	Sardarpur	0.01	12.61	Slug test	23.42					
54	Kioli	Sardarpur	5.39	15.45	Pumping test	26.37	29.3	35.65	1.30×10^{-3}	75.34	52.74

Table: 3.8 Details of Ground water exploration in Dhar District

S. No.	Location	Block	Discharge (lps)	SWL (mbmp)	Test	Transmissivity m^2/day		Specific Capacity (litre/min/m)	Storativity	Transmissivity m^2/day	
						Jacob	Theis			Jacob	Theis
55	Piperni	Sardarpur	0.08	13.83	Slug test	6.59					
56	Sandla	Sardarpur	24.08	10.2	Pumping test	21.62	54.06	26.27	2.70×10^{-3}	54.04	54.06
57	Songarh	Sardarpur	3.27	88.97	APT	1.24	3.72	3.13			
58	Suhana	Sardarpur	0	31.49	Slug test	33.94					
59	Sunedi	Sardarpur	0	8.89	Slug test	17.56					
60	Tandakheda	Sardarpur	0	117.8	Slug test	41.66					
61	Bori	Tirla	1.74	25.2	PYT	1.14	1.58	4.6			
62	Dilwara	Tirla	1.74	8.34	PYT	4.82	3.69	5.01			
63	Oshra	Tirla	4.25	93.03	Pumping test	7.59	10.55	11.69	3.05×10^{-3}	47.46	94.93
64	Rehitiya	Tirla	0.08	20.8	Slug test	0.54					
65	Tirla	Tirla	2.43	86.77	Pump test	0.35	1.36	1.45			
66	Birampura	Umarban	0.01	16.82	Slug test	6.7					
67	Boharla	Umarban	0.21	44.82	Slug test	3.14					
68	Pahamoti	Umarban	0.43	106.58	Slug test	5.4					
69	Thangaon	Umarban	0.01	5.99	Slug test	7.74					
70	Tibediya	Umarban	3.27	52.25	PYT	4.22	3.02	6.22			

Table 3.9 Details of EW, VES and NHS

Dhar						
SI.No	**Object**	**Numbers**	**Total Depth in m**	**Main Aquifer**	**Thickness of Aquifer**	**Yield**
1	EW	5	200	Fractured, Vesicular Basalt	0.5-3m	
2	VES	15	50	Weathered Basalt	2.5-9	
3	NHS	1	16.5	Weathered/ Fractured Basalt		
4	NHS	2	50-120			
Nalcha						
1	EW	6	200	Fractured Basalt	0.5-3m	0.1-
2	VES	20	50	Weathered Basalt	3.4-14.90	
3	NHS	1	15.11	Weathered/ Fractured Basalt		
4	NHS	3	50	Fractured Basalt	0.9	N
DAHI						
1	EW	4	200	Fractured Basalt		
2	VES	3	50	Weathered Basalt	6.1-5.7	
3	NHS			Weathered/ Fractured Basalt		
4	NHS			Fractured Basalt		
Dharampuri						
	EW	1	200	Weathered/ Fractured/Vesicular Basalt		
	VES	11	50	Weathered/ Fractured Basalt	4.5-10.2m	
	PZ	1	50	Weathered Basalt/ Fractured		
	NHS DW	3	14.5-22	Weathered Basalt/ Fractured		
Manawar						
	EW	5	200	Weathered/ Fractured/Vesicular Basalt		
	VES	14	50	Weathered/ Vesicular Basalt	3.3-	
	PZ	1	95	Weathered/ Fractured/Vesicular Basalt		
	NHS DW	2	20-Oct	Weathered/ Fractured/Vesicular Basalt		
Sardarpur						
	EW	13	200	Weathered/ Fractured/Vesicular Basalt	0.35-3.50	
	VES	33	50	Weathered/Vesicular Basalt	2.2m - 9.8	
	PZ	4	30-90	Weathered/ Fractured/Vesicular Basalt		
	NHS DW	5	10.7-	Weathered/ Fractured/Vesicular Basalt		
Bagh						
	EW	7	200	Basalt, SST & Granite	0.80-4.5	
	VES	19	50	BS,SST	3.20m-	
	PZ	1	61	Basalt, SST & Granite		
	NHS DW	2	12.5-22.4	BS,SST		
Badnawar						
	EW	7	200	Weathered/ Fractured/Vesicular Basalt		
	VES	26	50	Weathered/ Fractured/Vesicular Basalt	2.4m-14.8	
	PZ	4	30-90	Weathered/ Fractured/Vesicular Basalt		
	NHS	3	11.7-15	Weathered/ Fractured/Vesicular Basalt		

Chapter-4
Ground Water Resources

The ground water resources have been assessed for two types of aquifer existing in the area i.e., Aquifer-I and Aquifer-II. The details of the assessment are discussed below.

4.1 Ground Water Resources – Aquifer-I

The ground water resource assessment has been carried out for Dhar district and the salient features of the resources are given in Table 4.1, 4.2 and 4.3.

As per Table 4.1, out of the total 815300 ha area, recharge worthy areas is812640 ha, command areas is 149070 ha and non-command areas 827202 ha, whereas 2660 ha area is not worthy for recharge on account of its hilly nature.

Table 4.1: Ground Water Recharge Worthy Areas for Resource Estimation as on 2020

District	Predominant Formation	Total Geographical Area (ha)	Hilly Area (ha)	Recharge worthy area in ha	Ground Water Recharge Worthy Area	
					Command area (ha)	Non-command area (ha)
Dhar	Deccan Trap, Bagh Formation	815300	2660	812640	149070	663570

- **Recharge Component as per GWRE-2020: -**

During the monsoon season, the rainfall recharge is the main recharge parameter, which is estimated as the sum total of the change in storage and gross draft. The change in storage is computed by multiplying groundwater level fluctuation between pre and post monsoon periods with the area of assessment and specific yield. Monsoon recharge can be expressed as: -

$R = h \times Sy \times A + DG$ Where,

h = rise in water level in the monsoon season, Sy = specific yield

A = area for computation of

recharge, DG = gross ground water draft

The monsoon ground water recharge has two components- rainfall recharge and recharge from other sources. The other sources of groundwater recharge during monsoon season include seepage from canals, surface water irrigation, tanks and ponds, ground water irrigation, and water conservation structures.

During the non-monsoon season, rainfall recharge is computed by using Rainfall Infiltration Factor (RIF) method. Recharge from other sources is then added to get total non-monsoon recharge.

The season wise assessment of recharge from various components such as rainfall and other sources was done and presented in Table 4.2 and Fig.4.1.

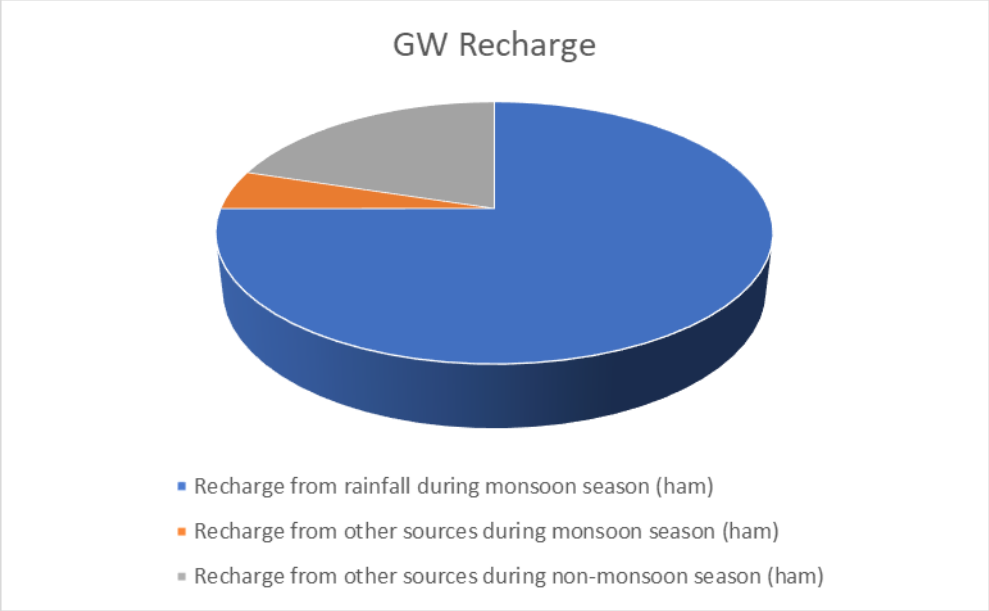


Fig.4.1: Recharge from various sources

Table 4.2 Season wise assessment of recharge from various components

District	Recharge from rainfall during monsoon season (ham)	Recharge from other sources during monsoon season (ham)	Recharge from rainfall during non-monsoon season (ham)	Recharge from other sources during non-monsoon season (ham)	Total Annual Ground Water Recharge (ham)	Environmental flow in non-monsoon period (ham)	Annual Extractable GW resource (ham)
Dhar	84490.43	7124.47	0	22699.4	114314.30	9401.24	104913.07

The utilization of available ground water resources for various purposes is provided in **Table 4.3** and **Fig.4.2**. The annual gross draft for all uses is estimated at 77988.57 ham with irrigation sector being the major consumer having a draft of 73000.19 ham and ground water available for future irrigation is 50977.25 ham. The stage of ground water development is 68.88 %.

Table: 4.3 Dynamic Ground Water Resources as on March- 2020

Assessment unit	Ground water extraction for irrigation use in Ham	Ground water extraction for domestic use in Ham	Total extraction in Ham	Annual GW allocation for domestic use as on 2025 in Ham	Annual Extractable GW resource Ham	Stage of ground water extraction (%)	Categorization
Sardarpur	9787.97	798.92	10586.89	929.18	6235.29	62.45	safe
Manawar	3029.73	448.20	3477.93	505.39	3288.79	50.97	safe
Tirla	6936.51	258.38	7194.89	303.22	378.65	94.44	critical
Gandhwani	2884.46	405.42	3289.89	457.49	4621.75	41.31	safe
Bagh	1389.93	353.41	1743.34	438.19	3617.34	32.01	safe
Badnawar	17344.77	565.90	17910.67	619.43	249.4	121.91	over_exploited
Dhar	13890.47	505.66	14396.12	560.92	0	155.40	over_exploited
Umraban	1950.624	347.87	2298.49	388.63	4153.77	35.40	safe
Kukshi	1272.56	279.98	1552.52	309.15	2083.97	42.35	safe
Dahi	2803.9	257.19	3061.08	276.03	3030.49	50.10	safe
Dharampuri	1964.93	471.55	2436.48	526.97	2989.27	44.45	safe
Nisarpur	1553.416	224.68	1778.1	247.56	1584.81	52.52	safe
Nalchha	12581.64	822.23	13403.87	1086.24	193.38	121.66	over_exploited
District total	77390.91	5739.37	83130.27	6648.4	32426.91	79.24	

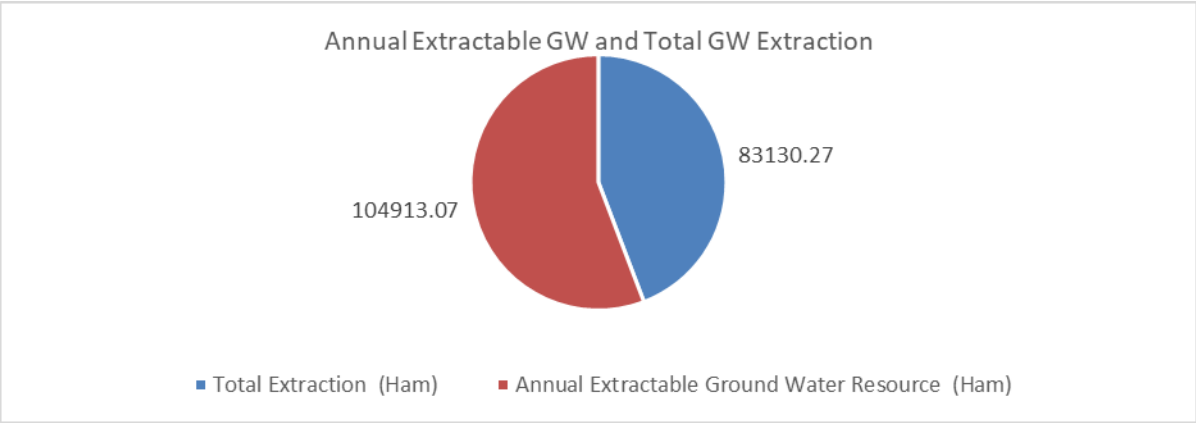


Fig.4.2: Annual Extractable GW and Total GW Extraction

Fig.4.2: GW extraction against Annual Extractable GW

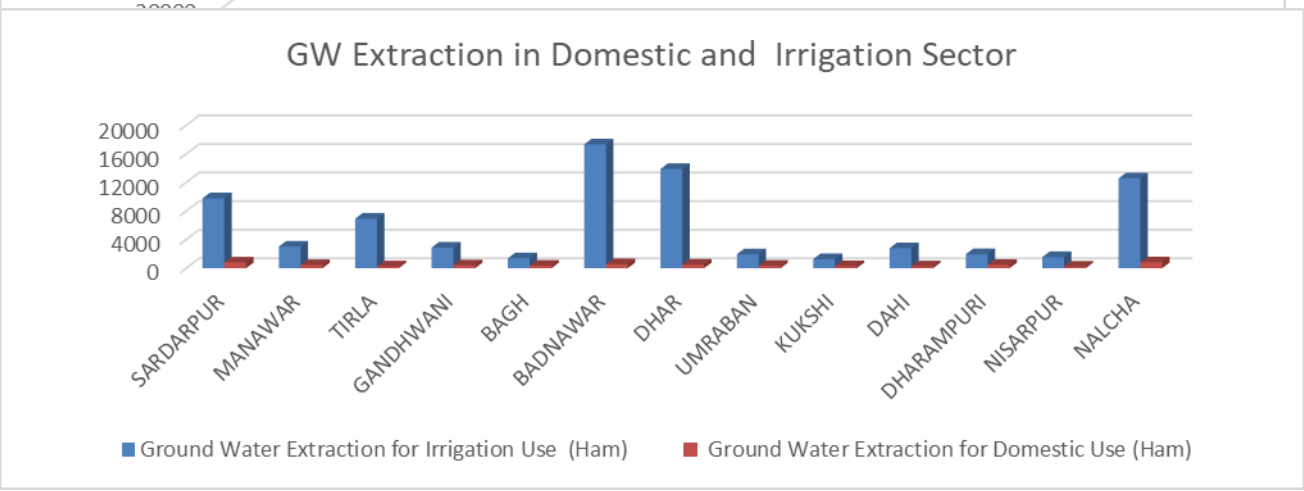


Fig.4.3: GW extraction in Domestic and Irrigation Sector

Table 4.4: In-storage of shallow Aquifer-I.

Components	Unit	Badnawar	Bagh	Dahi	Dhar	Dharampuri	Gandhwani	Kukshi	Manawar	Nalcha	Nisarpur	Sardarpur	Tirla	Umraban
Recharge worthy Area	Sq km	1037.4	512	482	602	429	736	343	555	784	353	1280	534	479
Pre-monsoon (average) WL	m	11.29	8.75	10.80	11.51	8.29	7.17	7.79	8.68	9.60	9.69	8.36	10.08	6.27
Av. depth of Dug well	m	14.38	10.69	13.39	16.18	17.55	11.03	13.50	13.63	12.92	13.15	14.05	13.38	13.85
Specific yield(Sy)%	Fraction	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Saturated thickness of aquifer (ST)	m	3.09	1.94	2.59	4.67	9.26	3.86	5.71	4.95	3.32	3.46	5.69	3.30	7.58
Resource (A * Sy * ST)	MCM	64.15	19.85	24.97	56.17	79.45	56.81	39.17	54.89	52.06	24.43	145.66	35.24	72.62

	Units	Total
Recharge worthy Area	Sq. km	8126
Pre-monsoon (average) depth to water level	m	9.09
Av. depth of Dug well	m	13.67
Specific yield (Sy)%	Fraction	0.02
Saturated thickness of aquifer (ST)	m	4.57

4.2 Ground Water Resources – Aquifer-II

The ground water resource of the Aquifer –II was also assessed to have the correct quantification of resources so that proper management strategy can be framed. To assess these resources, the average thickness of fractures in deeper aquifers from exploratory wells was calculated and the following formula for static ground water resources was utilized i.e.,

GWR =Recharge worthy Area x Thickness of fractures in deep aquifer x Specific yield

By applying above formula, the ground water resource of Aquifer-II was estimated as 827 MCM and is presented below in Table 4.5.

Table 4.5: Ground Water Resources of Aquifer-II.

	Units	Total
Recharge worthy Area	Sq.km	8126
Thickness of fracture in deeper aquifer	m	5.1
Specific yield (Sy)%	Fraction	0.01/0.02
Resource (A * Sy * ST)	MCM	**827**

Chapter-5

Ground Water Related Issues

In the district there are many Groundwater issues both in quantity and quality wise. All the issues are described as follows.

5.1 Declining Water Level

The decline in the water level observed in major part of the district. The pre and post monsoon declining trend of one hydrograph prepared and presented in the Fig.5.1. The block wise decline in the trend of the hydrographs has been shown in the Part-II.

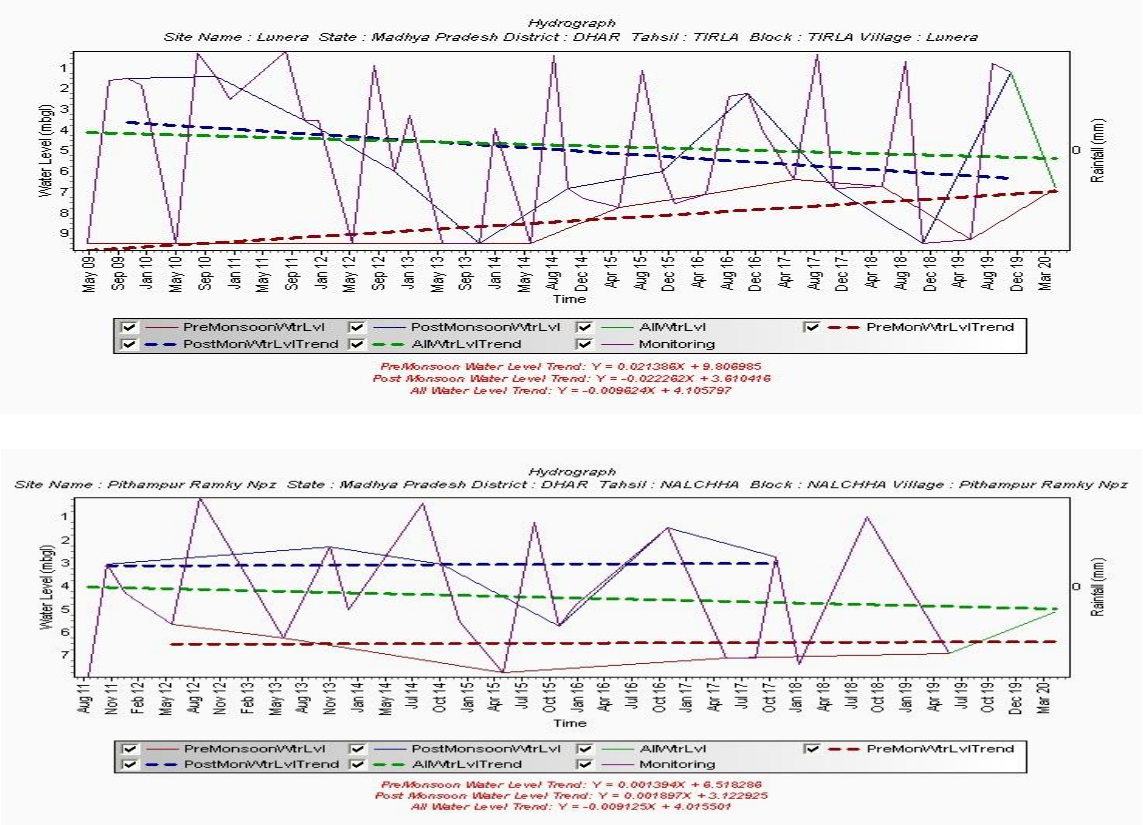


Fig.5.1: Hydrographs (2010-2020), Dhar District.

5.2 Low Ground Water Potential / Sustainability

The district is covered mostly with hard rock i.e. Deccan trap basalt, Bagh formation in parts of Bagh, Kukshi and Nisarpur Block and SW part of the district covered by Achaean.

Central Ground Water Board have been constructed 72 exploratory wells in the district and conducted hydrological test to decipher aquifer parameters in the study area. It is indicated that the aquifer sustainability or discharge are gradually decrease during lean period and sustainability of both the aquifers (I &II) are limited.

5.3 Deeper Water Levels

In Dhar district, deeper water levels is more than 20 mbgl have been observed during pre-monsoon season in deep aquifers. It is also revealed that the water level of deeper aquifer is also decline continuously.

5.4 Inferior Ground Water Quality

Central ground water board and WRD Govt. have been collected pre-monsoon water samples for quality analysis. 1252 samples are showing fluoride concentration more than more than permissible limit i.e. 1.50 mg/l.

27 groundwater samples collected from dug wells i.e. from shallow aquifers, in 18 samples the Nitrate concentration recorded more than permissible limit i.e. 45 mg/l as per BIS recommendation.

5.5 Increasing stage of Ground Water Extraction

Out of the 13 blocks Badnwar, Dhar, Nalcha and Tirla blocks falls under OCS category with stage of groundwater extraction are increase with respect to 2013, 121.91%, 155.40%,121.65% and 94.44 % respectively Badnawar, Dharand Nalcha are categorized as Over-Exploited and Tirla Categorized as Critical, other 9 blocks are come under safe category. But the stage of extraction for each block are increasing in every year. The increasing stage of Ground water extraction for the blocks Dhar, Badnwar, Dhar, Nalcha and Tirla are presented as histogram in the Fig.5.2.

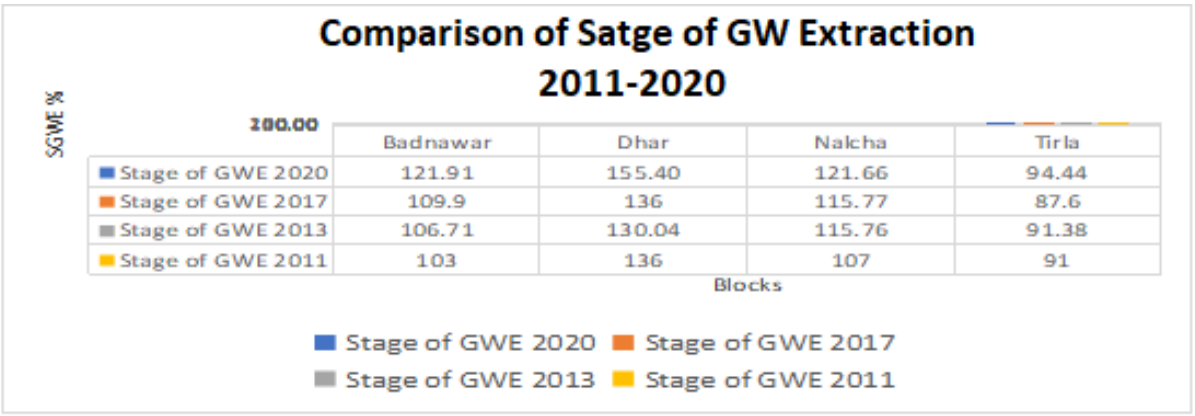


Fig 5.2 Comparison of Stage of GW Extraction

5.6. Improper well design in Basaltic formation: - Collapsible formations encountered during drilling in the area as an inter-trappean clay/red bole layer that situated in between two lava flow, which is collapsible in nature. It has also been observed that large numbers of deep tube wells constructed in the Basaltic formation with sufficient yield during drilling time but later on well collapse due to improper well design or faulty well construction design.

Chapter-6

Proposed Management Strategy

As discussed in previous chapter, there are many groundwater related issues owing to many socio-economic and hydrogeological reasons. The groundwater management plan for Dhar district has been made keeping in view the area specific details and includes the strategies like enhancing the ground water resources through the construction of artificial recharge structures such as percolation tanks, check dams/nala bunds, recharge shafts, etc. and ensuring water use efficiency through maintenance/renovation of existing water bodies/water conservation structures. Also, adoption of micro irrigation technique such as sprinkler irrigation has been proposed, that 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 Supply side Management

Artificial recharge to ground water is one of the most efficient, scientifically proven and cost-effective technology to mitigate the problems of over exploitation of ground water resources. The artificial recharge techniques simultaneously rejuvenate the depleted ground water storage, reduces the ground water quality. The supply side management plan for Dhar district has been formulated using the basic concepts of hydrogeology. Sub-surface storage is calculated by multiplying the total area with the respective specific yield (considering the variable lithology) and the unsaturated zone thickness obtained by subtracting 3 mts from the post-monsoon water level. 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. A runoff coefficient factor of 0.16 has been considered for Dhar 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%, 40% 15% and 05% of non-committed runoff to Percolation tanks, Recharge shafts/Tube wells and Nala bunds/Check dams/Cement Plugs respectively. The remaining runoff is considered to restore the pre-existing village tanks, ponds and water conservation structures. A detailed calculation of the proposed artificial recharge structures is presented in the **Table 6.1**.

Based on the water level monitoring in different seasons in the district, as well as after having better understanding of the disposition and extent of the aquifer system through exploratory drilling, pumping tests etc. the volume of unsaturated zone available for recharge (upto 3m bgl). The annual uncommitted runoff is only 396 MCM which is about 50% of required water to fill the available void space of Aquifer-I. Artificial recharge and Water conservation plan is prepared for the over exploited critical, semi-critical and safe block of the district.

The suggested artificial recharge structures are mainly percolation tank, Nala bunds, Check Dams and Recharge Shafts. Selection of the site locations of these structures are based on the critical analysis of the hydrogeological, geophysical and exploration data of the basin. Particularly geomorphological and drainage aspects are being given more weightage in selection of the Artificial Recharge structures. The expected recharge through these artificial recharge structures is in the order of 69 MCM.

Out of 8153 sq.km geographical area of Dhar district, about 8126.40 sq.km., area has been identified for ground water development, where 693 percolation tank, 5944 Nala bund, 5282 Check dam,5282 recharge shaft/tube well, 1807 number of ponds/ village tanks to be renovated are recommended to be constructed in feasible areas. This accounts to a total of Rs. 681 crores to successfully implement the supply side management strategy. Table 6.2 represents the complete financial outlay plan for the district.

In Dhar district already many recharge structures are constructed (as per the data collected from Jilla Panchayat office, Dhar). The impact of existing structures those constructed

before the NAQUIM study are already reflecting in water level therefore, additional AR structures are required to full fill the sub storage. The total numbers of recharge structures constructed in the district are presented in the **Table 6.3**. Block wise supply side management strategy will be discussed in **Part-II.**

Table 6.1 (a): Ground Water Management– Supply Side

	Units	
Total Area	Sq Km	8153
Area suitable for recharge		8126
Sub-surface storage	MCM	559
Sub-surface water required		773
Surface water (Run-off) available		1315
Non-committed Run-off		396
Percolation tank	No's	693
Recharge shaft		5282
Check dam (CD)		5282
NB/ CP		5944
No of Villages		1807

Table 6.1 (b): Ground Water Management– Supply side.

Structures	**Number**	**Cost in Crores**
Percolation Tanks	693	208
Check dams	5282	317
NB/CP	5944	59
Recharge shaft/ Tube well	5282	52
Renovation of Village Ponds	1807	45
Total Cost		**681**

Table 6.3 Supply side Management-AR structures

Block	Area (Sq. Km)	Normal Annual Rainfall (mm)	Average Post-monsoon Water Level - 2020 (m bgl)	Suitable Area for AR (sq.km)	Un-Saturated Zone (m)	Specific Yield	Sub-surface storage (mcm)	Sub-Surface water required (mcm)	Runoff /sq.km	Runoff (mcm)	Non Commuted Runoff (mcm)	Available water required/ Non Commuted Runoff (mcm)
Badnawar	1064	856.50	7.37	1037	4.37	0.02	90.63	120.54	0.16	172.37	51.71	51.71
Bagh	512	856.50	6.54	512	3.54	0.03	54.37	72.32	0.16	82.94	24.88	24.88
Dahi	482	856.50	6.43	482	3.43	0.02	33.07	43.98	0.16	78.08	23.43	23.43
Dhar	602	856.50	8.19	602	5.19	0.02	62.49	83.11	0.16	97.52	29.26	29.26
Dharampuri	429	856.50	5.86	429	2.86	0.02	24.54	32.64	0.16	69.50	20.85	20.85
Gandhwani	736	856.50	4.21	736	1.21	0.02	17.81	23.69	0.16	119.23	35.77	35.77
Kukshi	343	856.50	6.49	343	3.49	0.02	23.94	31.84	0.16	55.57	16.67	16.67
Manawar	555	856.50	6.82	555	3.82	0.02	42.40	56.39	0.16	89.91	26.97	26.97
Nalcha	784	856.50	5.84	784	2.84	0.02	44.53	59.23	0.16	127.01	38.10	38.10
Nisarpur	353	856.50	7.4	353	4.4	0.03	46.60	61.97	0.16	57.19	17.16	17.16
Sardarpur	1280	856.50	5.85	1280	2.85	0.02	72.96	97.04	0.16	207.36	62.21	62.21
Tirla	534	856.50	6.78	534	3.78	0.02	40.37	53.69	0.16	86.51	25.95	25.95
Umraban	479	856.50	3.55	479	0.55	0.02	5.27	7.01	0.16	77.60	23.28	23.28
	8153			8126			**558.98**	743.44	988.78	1315.08	**396.24**	

Table 6.4 Financial Layout of Supply side Management-AR structures

Block	Resource water for Percolation tanks (mcm)	No of percolation tanks	Cost of percolation tanks in crores @ 0.20 crores / pt	Resource water for Check Dams with RS (mcm)	No of Check Dams	Cost of Check Dams in crores @0.06 crores / pt	No of Recharge shaft in each CD	Cost of Recharge shaft in each CD @ 0.001crore	Resource water for Nala bunds/ Cement plugs (mcm)	No of nala bunds/cement plugs	Cost of nala bund/cement plugs in crores @0.01 crores /NB,CP	Resource water for Village Ponds mcm	No of village ponds / Farm Ponds in each village	Cost of village pond in crores
Badnawar	18.10	90	27	20.68	689	41.34	689	6.89	7.76	776	7.76	2.59	139	3.48
Bagh	8.71	44	13.2	9.95	332	19.92	332	3.32	3.73	373	3.73	1.24	139	3.48
Dahi	8.20	41	12.3	9.37	312	18.72	312	3.12	3.51	351	3.51	1.17	139	3.48
Dhar	10.24	51	15.3	11.70	390	23.4	390	3.9	4.39	439	4.39	1.46	139	3.48
Dharampuri	7.30	36	10.8	8.34	278	16.68	278	2.78	3.13	313	3.13	1.04	139	3.48
Gandhwani	12.52	63	18.9	14.31	477	28.62	477	4.77	5.37	537	5.37	1.79	139	3.48
Kukshi	5.83	29	8.7	6.67	222	13.32	222	2.22	2.50	250	2.5	0.83	139	3.48
Manawar	9.44	47	14.1	10.79	360	21.6	360	3.6	4.05	405	4.05	1.35	139	3.48
Nalcha	13.34	67	20.1	15.24	508	30.48	508	5.08	5.72	572	5.72	1.91	139	3.48
Nisarpur	6.00	30	9	6.86	229	13.74	229	2.29	2.57	257	2.57	0.86	139	3.48
Sardarpur	21.77	109	32.7	24.88	829	49.74	829	8.29	9.33	933	9.33	3.11	139	3.48
Tirla	9.08	45	13.5	10.38	346	20.76	346	3.46	3.89	389	3.89	1.30	139	3.48
Umraban	8.15	41	12.3	9.31	310	18.6	310	3.1	3.49	349	3.49	1.16	139	3.48

The four Blocks namely Badnwar, Dhar, Nalcha and Tirla fall under OCS category with sage of 121.91%, 155.40%,121.65% and 94.44 % respectively Badnawar, Dhar and Nalchha are categorized as Over-Exploited and Tirla Categorized as Critical. The availability has to be augmented through artificial recharge methods to bridge the gap between draft and availability. The draft can be reduced through application of water efficiency methods in irrigation sector and through changing the irrigation practices from wet to dry cash crops.

The artificial recharge structures may be augmentation of ground water reservoir by modifying the natural movement of surface water utilizing suitable civil construction techniques. Artificial recharge techniques normally address to the following issues:

- To enhance the sustainability in aquifer specially during lean period**.**
- Conservation and storage of excess surface water for future requirements, since these requirements often change within a season or a period
- Fluoride contamination is one of the majors issued in the district and concentration more than permissible limit is recorded in 1252 hand pumps of PHED. in order to prevent the situation of high fluoride contents in shallow and deeper aquifers of the area, artificial recharge techniques to be used to reduce the fluoride concentration in ground water.

6.2 Demand Side Management

However, considering the low storage potential of hard rock aquifer in the area the above ground water development plan should also be coupled with ground water augmentation plan, so that there is no stress on ground water regime of the area. Micro irrigation technologies such as drip and sprinkler systems are being increasingly promoted as technological solutions for achieving water conservation. Micro irrigation comprises two technologies—drip and sprinkler irrigation. Both saves conveyance losses and improve water application efficiency by applying water near the root-zone of the plant some benefits of the micro-irrigation have been listed below:

- It enables farmers to grow crops which would not be possible under conventional systems since it can irrigate adequately with lower water quantities.
- It saves costs of hired labour and other inputs like fertilizer.
- It reduces the energy needs for pumping, thus reducing energy per ha of irrigation because of its reduced water needs. However, overall energy needs of the agriculture sector may not get reduced because most farmers use the increased water efficiency to bring more area under irrigation.

Table 6.5: Proposed Demand Side Interventions

Net GW Availability	MCM	1049.13
Gross Draft		831.30
Stage of GW Extraction	%	79.24
Saving by Sprinkler in MCM	MCM	79.08
Additional recharge created by AR		300.92
After intervention of AR Structure Net GW Avl.		1350.05
After intervention of AR Structure & utilization of 60% of additional GW created.		498.10
Additional area irrigated in safe blocks by GW after intervention	Ha	824
Stage of GW Extraction after implementation	%	69

6.4 Post-Intervention Impact

The expected outcome of the proposed interventions from both supply side and demand side has been described in Table no 6.4,6.5 &6.6. It can be envisaged that the Stage of ground water extraction for the entire Dhar district. The stage of ground water extraction will be improved after implying and successful implementation of proposed interventions. The additional area is also to be proposed in safe blocks for increase the ground water development.

6.5 Ground Water Quality

- **Remediation of nitrate:**

1. Less consumption of nitrogen containing fertilizers.
2. Proper disposal of domestic and industrial effluents through sewage treatment plants.

- **Management of fluoride contaminated wells:**

1. Dilution: Artificial recharge of wells contaminated with Fluoride and dilution
2. Lowering of well assembly: lowering of assembly for sealing the contaminated zone thereby tapping only the available fresh water zone above or below fluoride affected aquifer
3. Chemical treatment: Nalgonda technique - contaminated water is mixed with alum, lime and bleaching powder.

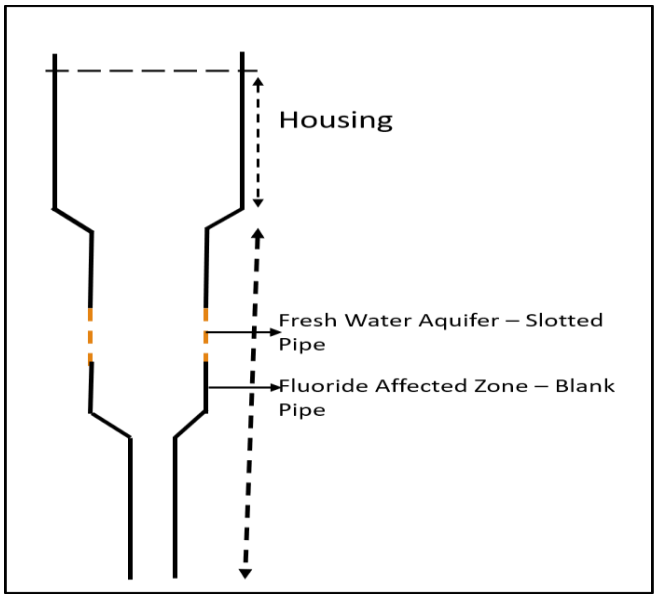


Fig:6.1 Well assembly for prevention of fluoride

- **Well Construction Design (Collapsing Structure)**: The faulty well design in which part assembly are not placed or lowered properly against the collapsible formation (inter-

trappean clay/ contact zone) encountered at various intervening depth. The thickness of red bole varies from few centimetres to 3m approximately meter generally occurring at variable depth. CGWB generally constructed well in collapsible formation with part well assembly and recommended well design in the Basaltic area is as given below:

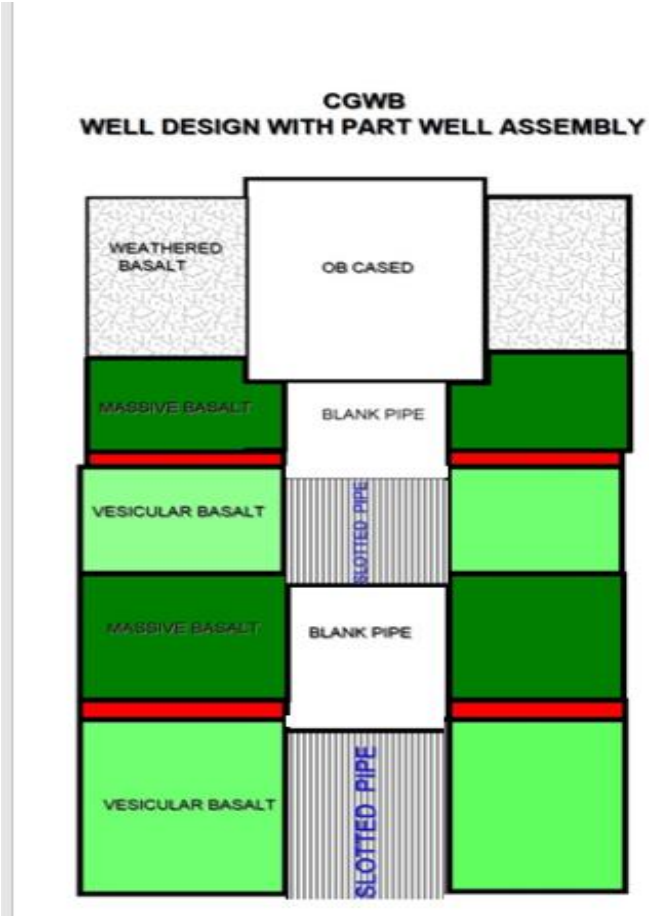


Fig:6.2 Recommended well design in the area

Table 6.6: Proposed demand Side Interventions

Block	Annual Extractable GW resource(mcm)	GW Draft for Irrigation (mcm)	GW Draft for Domestic & Industrial (mcm)	Gross Draft (mcm)	Stage of GW Extraction %	Saving by Sprinkler in MCM	Additional recharge created by AR (mcm)	After intervention of AR Structure Net GW Avl.(mcm)	After intervention of AR Structure & utilisation of 60% of additional GW created.	Draft after sprinkler & additional area created for agriculture (mcm)	Stage of Development W/O GW use for additional Area Irrigation %	Additional area proposed for irrigation in safe Block by GW (ha)
BADNAWAR	146.92	173.45	5.65	179.100	121.90	26.02	43.95	190.87	26.37	179.45	94.02	
BAGH	54.45	13.9	3.53	17.430	32.01	0.00	21.15	75.60	12.69	30.12	39.84	3173
DAHI	61.1	28.04	2.57	30.610	50.10	0.00	19.91	81.01	11.95	42.56	52.53	2987
DHAR	92.64	138.91	5.05	143.960	155.40	20.84	24.87	117.51	14.92	138.05	117.48	
DHARAMPURI	54.81	19.65	4.71	24.360	44.44	2.95	17.72	72.53	10.63	32.04	44.18	2658
GANDHWANI	79.64	28.84	4.05	32.890	41.30	0.00	30.4	110.04	18.24	51.13	46.46	4560
KUKSHI	36.66	12.73	2.79	15.520	42.33	0.00	14.17	50.83	8.50	24.02	47.26	2126
MANAWAR	68.24	30.3	4.48	34.780	50.97	0.00	22.93	91.17	13.76	48.54	53.24	3440
NALCHA	110.18	125.82	8.22	134.040	121.66	18.87	32.39	142.57	19.43	134.60	94.41	
NISARPUR	33.86	15.53	2.24	17.770	52.48	0.00	14.58	48.44	8.75	26.52	54.74	2187
TIRLA	76.18	69.37	2.58	71.950	94.45	10.41	22.06	98.24	13.24	74.78	76.12	
UMRABAN	64.93	19.51	3.47	22.980	35.39	0.00	19.79	84.72	11.87	34.85	41.14	2969
SARDARPUR	169.52	98	8	106.000	62.53	0.00	17	186.52	10.20	116.20	62.30	2550

Table 6.7: Financial outlay of Management Plan

Block	No of percolation tanks	Cost of percolation tanks in crores @ 0.20 crores / pt	No of Check Dams	Cost of Check Dams in crores @0.06 crores / pt	No of Recharge shaft in each CD	Cost of Recharge shaft in each CD	No of nala bunds/cement plugs	Cost of nala bund/cement plugs in crores	No of village ponds/ Farm Ponds in each village	Cost of village pond in crores
BADNAWAR	90	27	689	41.34	689	6.89	776	7.76	139	3.48
BAGH	44	13.2	332	19.92	332	3.32	373	3.73	139	3.48
DAHI	41	12.3	312	18.72	312	3.12	351	3.51	139	3.48
DHAR	51	15.3	390	23.4	390	3.9	439	4.39	139	3.48
DHARAMPURI	36	10.8	278	16.68	278	2.78	313	3.13	139	3.48
GANDHWANI	63	18.9	477	28.62	477	4.77	537	5.37	139	3.48
KUKSHI	29	8.7	222	13.32	222	2.22	250	2.5	139	3.48
MANAWAR	47	14.1	360	21.6	360	3.6	405	4.05	139	3.48
NALCHA	67	20.1	508	30.48	508	5.08	572	5.72	139	3.48
NISARPUR	30	9	229	13.74	229	2.29	257	2.57	139	3.48
SARDARPUR	109	32.7	829	49.74	829	8.29	933	9.33	139	3.48
TIRLA	45	13.5	346	20.76	346	3.46	389	3.89	139	3.48
UMRABAN	41	12.3	310	18.6	310	3.1	349	3.49	139	3.48
Total	693.00	207.90	5282.00	316.92	5282.00	52.82	5944.00	59.44	1807.00	45.18

Ground Water Management plan for OCS Blocks

1. AQUIFER MAPS AND MANAGEMENT PLAN BADNAWAR BLOCK	
Geographical area	1064.00 Sq. km
Basin/Sub Basin	Narmada Basin
Principal Aquifer System	Deccan trap
Major Aquifer System	Weathered, Fractured and Vesicular basalt
Normal Annual Rainfall	856.5mm
Aquifer Disposition	
Aquifer Disposition	Two Types of Aquifer System Shallow Aquifers: Weathered, Vesicular and Fractured Basalt. Deep Aquifers: Vesicular and Fractured Basalt.
Status of GW Exploration:	Exploratory well: 07 Observation well: 02 Piezometers well: 03
Aquifer Characteristics:	**Aquifer I** : Depth of Occurrence (m bgl): 3 to 30, Average Thickness (m): 15m. DTWL (m bgl): 0.15 – 9.60 during Post-monsoon and 9-19 during Pre-monsoon Yield: 20-40 (m^2/day), Specific yield: Basalt: 0.02. **Aquifer II**: Depth of Occurrence (m bgl): 30 m to 200m, Average Thickness of aquifer (m): 10-15 m. DTWL (m bgl): 11.20 – 14.60 during Post-monsoon and 12 -32.00 during Pre-monsoon Yield :150-1123 (m^3/day)
Groundwater Monitoring Status:	NHS – 06
Groundwater Quality:	In general ground water quality is Good and potable.
Aquifer Potential:	Potential aquifer are Weathered , fractured and Vesicular Basalt
Dynamic Groundwater Resource(As on March 2020):	Annual Extractable Ground Water: 14691 ham, Existing Gross Ground Water Extraction for All Uses: 17910.67 ham, Stage of Ground Water Extraction: 122 %

Aquifer Management plan	
Groundwater Management Issues:	Over Exploited Block GW level decline trend Low potential and sustainability aquifer Fluoride concentration in pockets
Groundwater Management Plan:	1. Demand Side Management Plan Adoption of micro-irrigation techniques to increase water use Efficiency viz. sprinkler, drip irrigation etc. 2. Supply side Management water conservation and Artificial Recharge to groundwater. Structures to be proposed: Percolation tank: 90 Check dam and Recharge shaft-689, Village pond- 139 , Nala bund/cement plugs in-776
AR & Conservation Possibilities:	Arrest Decline in Groundwater levels Sustainability of well and Rabi crop area may be Increase and stage of ground water may also be improved.

S. No.	Block Name	Avg. Pre-monsoon WL in m	Avg. Post-monsoon WL in m	Avg. WL Fluctuation in m
1	Badnawar	11.29	7.37	3.92

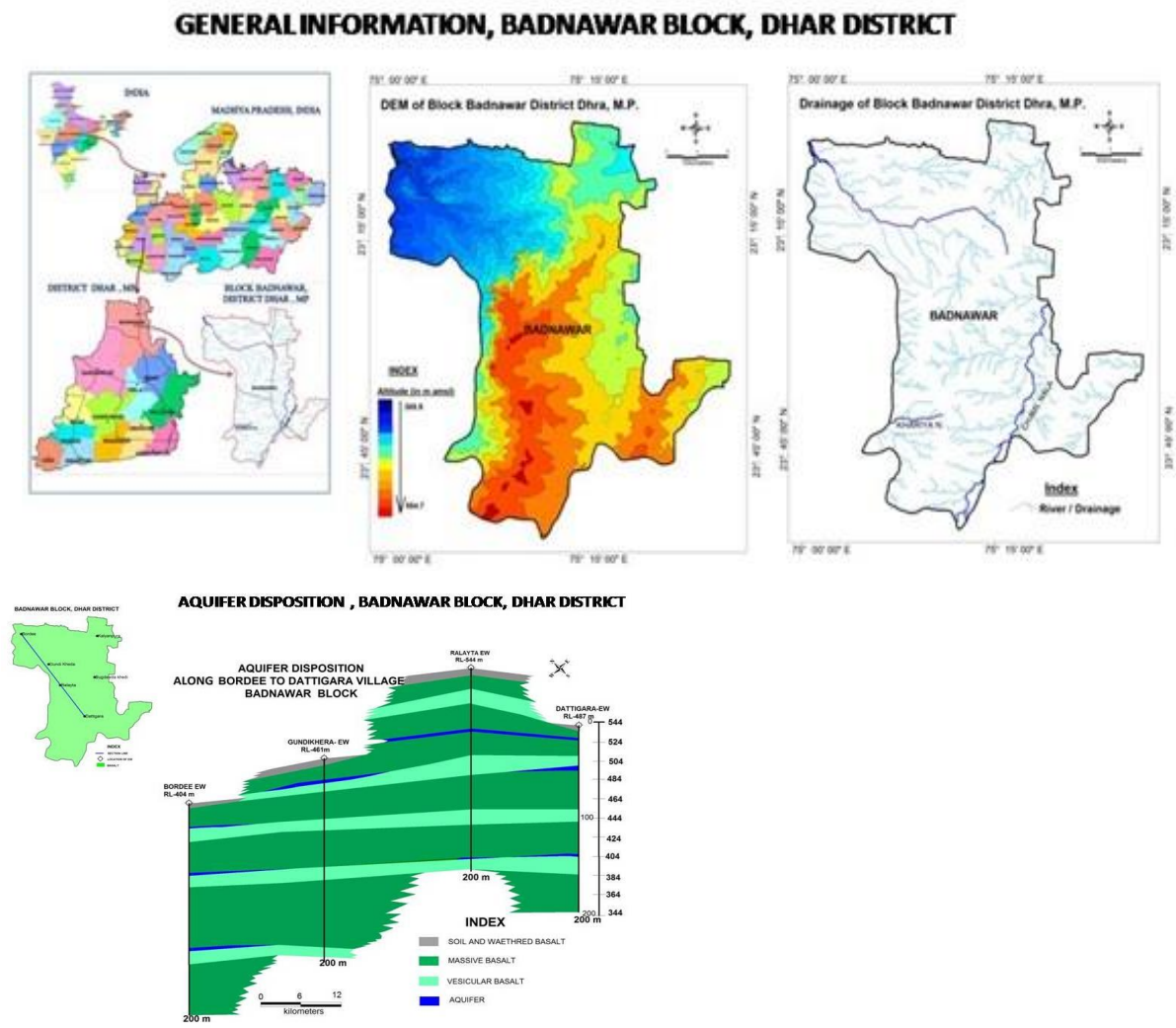
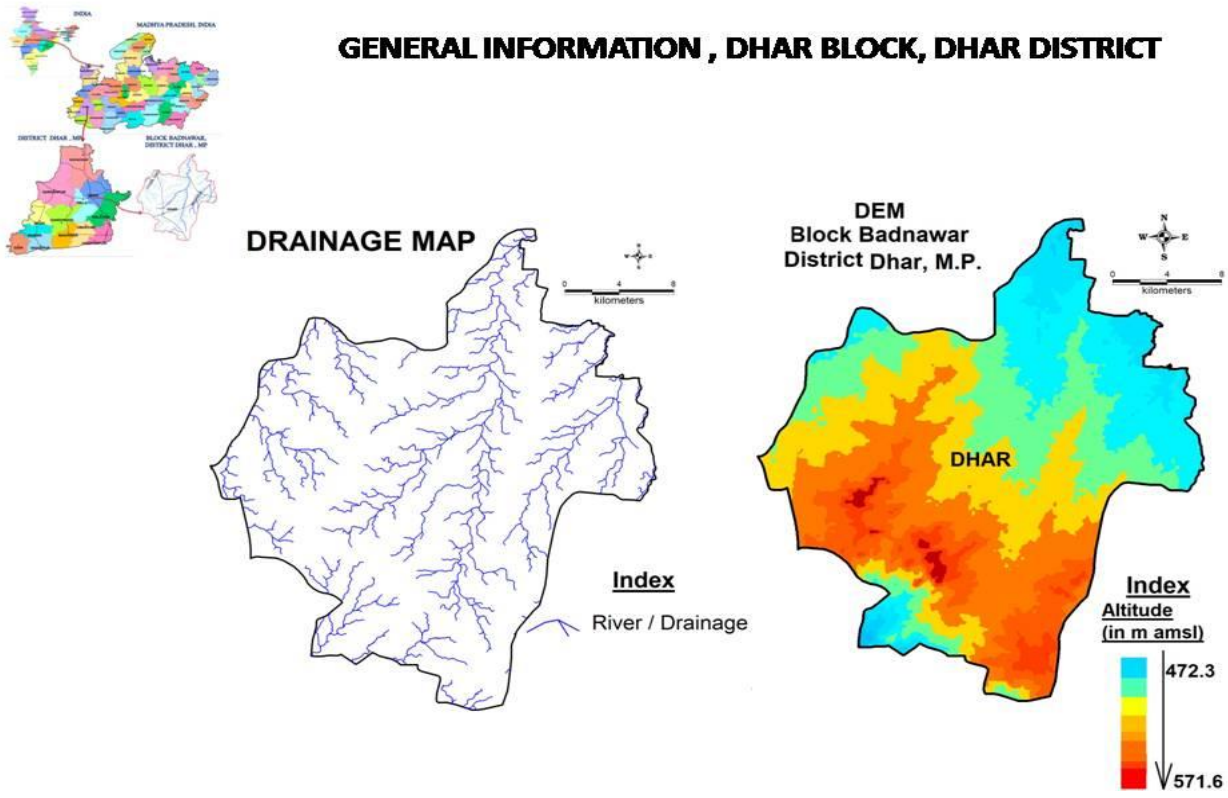
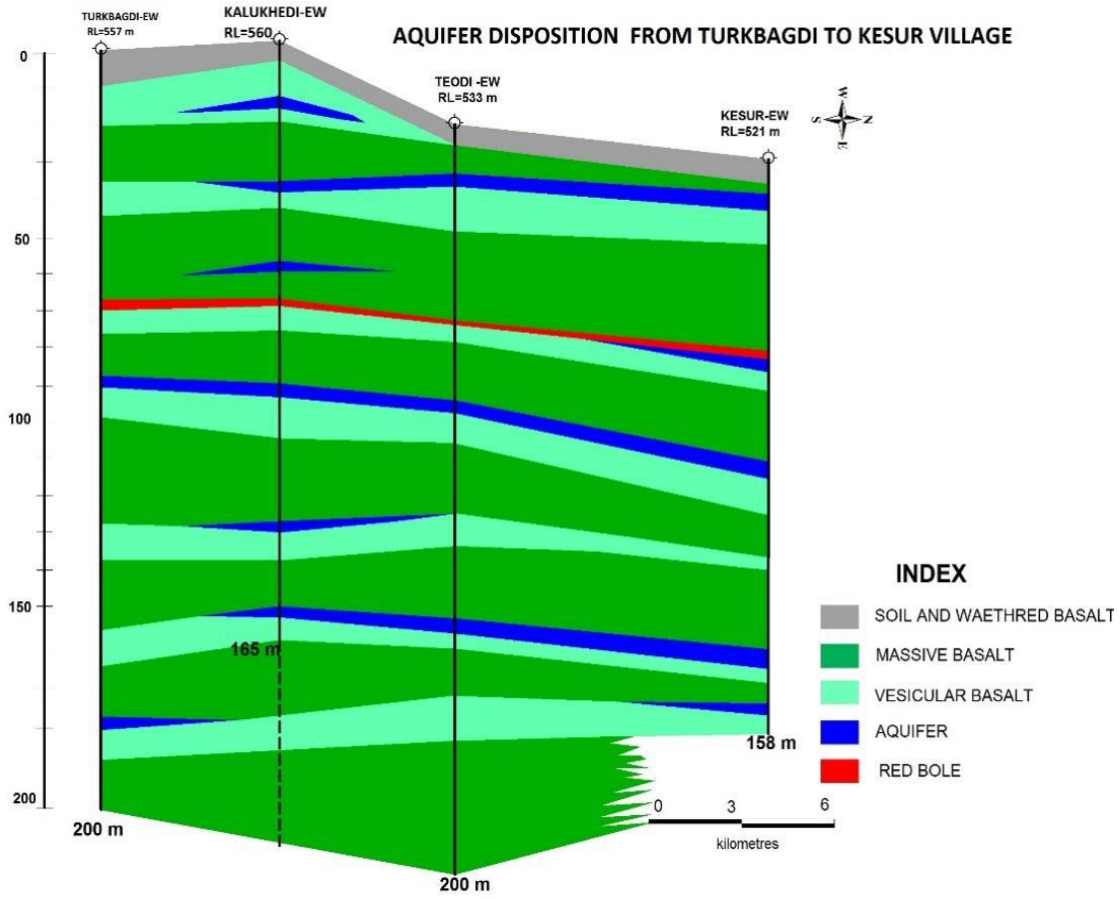


Fig:6.3 Hydrogeological and Aquifer Disposition of Badnawar Block

Information for Dhar Block, Madhya Pradesh	
State Name	Madhya Pradesh
District name	Dhar
Block Name	Dhar
Geographical area	602.00 Sq. km
Basin/Sub Basin	Narmada Basin
Principal Aquifer System	Deccan trap
Major Aquifer System	Weathered , Fractured and Vesicular basalt
Normal Annual Rainfall	856.5mm
Aquifer Disposition	
Aquifer Disposition	Two Types of Aquifer System **Shallow Aquifers**: Weathered, Vesicular and Fractured Basalt. **Deep Aquifers**: Vesicular and Fractured Basalt.
Status of GW Exploration:	Exploratory wells :05 Observation Well : 03 Piezometers well: 03
Aquifer Characteristics:	**Aquifer I** : Depth of Occurrence (m bgl): 3 to 30, Average Thickness (m): 15m. DTWL(m bgl): 0.9 – 11.60 during Post-monsoon and 5-19 during Pre-monsoon Yield : 20-40 (m^2/day), Specific yield: Basalt: 0.02. **Aquifer II**: Depth of Occurrence (m bgl): 30 m to 200m, Average Thickness of aquifer (m): 10-15 m. DTWL(m bgl): 11.42 -28 during Post-monsoon and 15-36 during Pre-monsoon Yield :64-1555 (m^3/day)
Groundwater Monitoring Status:	NHS – 04
Groundwater Quality:	In general ground water quality is Good and potable.
Aquifer Potential:	Potential aquifer are Weathered , fractured and Vesicular Basalt
Dynamic Groundwater Resource(As on March 2020):	Annual Extractable Ground Water : 9263.85ham, Existing Gross Ground Water Extraction for All Uses: 14396.12 ham, Stage of Ground Water Extraction: 155%

Aquifer Management plan	
Groundwater Management Issues:	Over Exploited Block GW level decline trend Low potential and sustainability aquifer
Groundwater Management Plan:	1. Demand Side Management Plan Adoption of micro-irrigation techniques to increase water use Efficiency viz. sprinkler, drip irrigation etc. 2. Supply side Management water conservation and Artificial Recharge to groundwater. Structures to be proposed: Check dam and Recharge shaft-390, Nala bund/cement plugs in- 439, village ponds/ Farm Ponds- 139 and percolation tank:51
AR & Conservation Possibilities:	Arrest Decline in Groundwater levels Sustainability of well and Rabi crop area may be Increase and stage of ground water may also be improved.





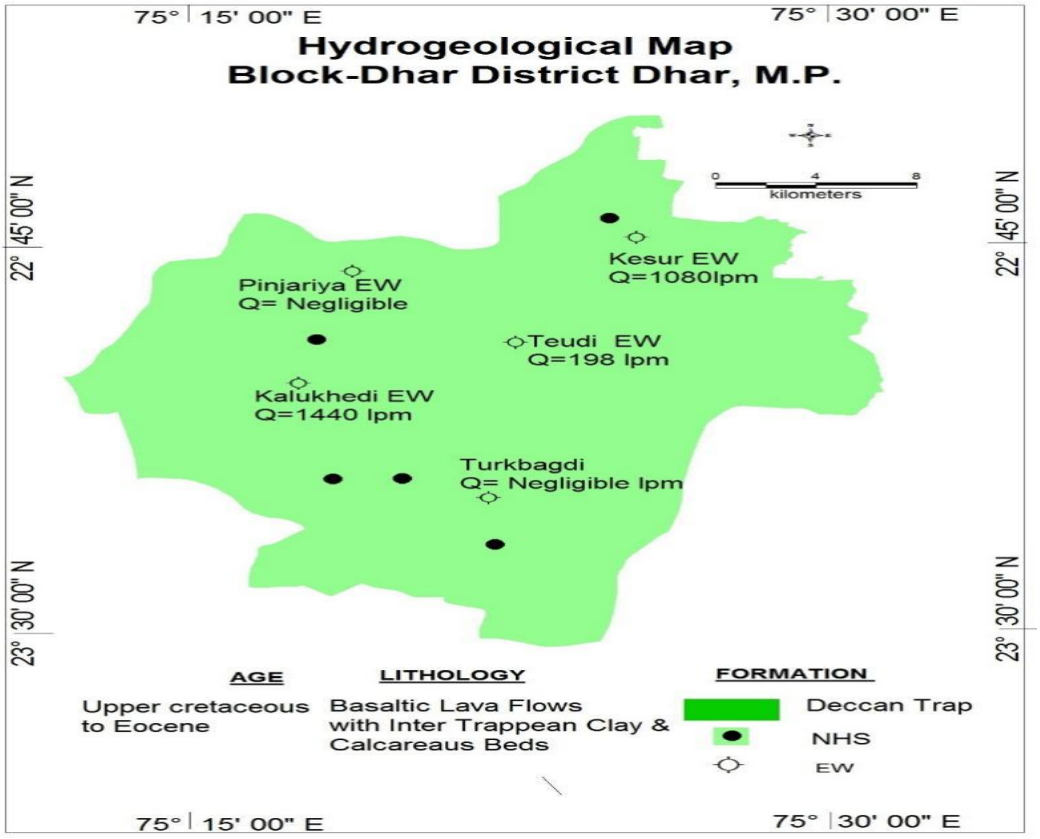
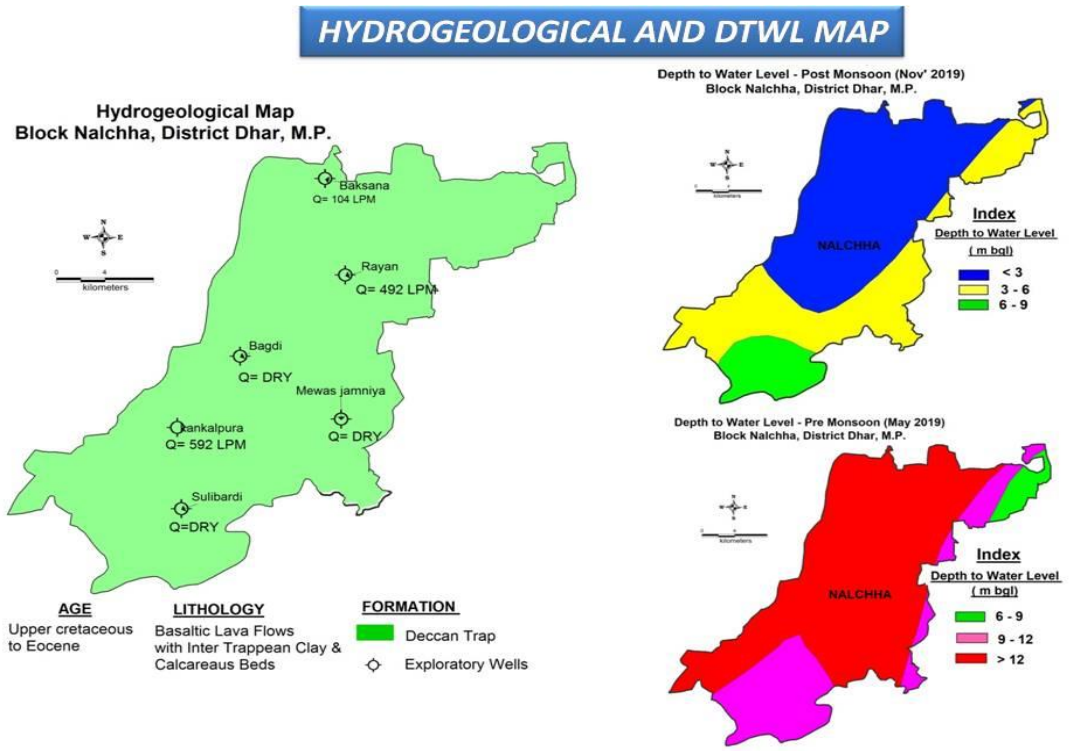


Fig:6.4 Hydrogeological, Aquifer disposition

Information for Nalchha Block, Madhya Pradesh For Aquifer Information and Management System	
State Name	Madhya Pradesh
District name	Dhar
Block Name	Nalchha
Geographical area	784.00 Sq. km
Basin/Sub Basin	Narmada Basin
Principal Aquifer System	Deccan trap
Major Aquifer System	Weathered , Fractured and Vesicular basalt
Normal Annual Rainfall	856.5mm
Aquifer Disposition	
Aquifer Disposition	**Two Types of Aquifer System** **Shallow Aquifers**: Weathered, Vesicular and Fractured Basalt. **Deep Aquifers*:*** Vesicular and Fractured Basalt.
Status of GW Exploration:	Exploratory wells :07 Observation Well : 02 Piezometers well: 04
Aquifer Characteristics:	**Aquifer I** : Depth of Occurrence (m bgl): 3 to 30, Average Thickness (m): 15m. DTWL(m bgl): 0.60 – 8.68 in Post-monsoon and 2.80 -12.20 in Pre-monsoon Yield : 20-40 (m^2/day), Specific yield: Basalt: 0.02. **Aquifer II**: Depth of Occurrence (m bgl): 30 m to 200m, Average Thickness of aquifer (m): 10-15 m. DTWL (m bgl): 4.38 – 14.38 in Post-monsoon and 5.88 -15.43 in Pre-monsoon Yield: 129 to 1641 (m^3/day)
Groundwater Monitoring Status:	NHS – 05
Groundwater Quality:	In general ground water quality is Good and potable.
Aquifer Potential:	Potential aquifer are Weathered , fractured and Vesicular Basalt
Dynamic Groundwater Resource(As on March 2020):	Annual Extractable Ground Water: 11017.75 ham, Existing Gross Ground Water Extraction for All Uses: 13403 ham, Stage of Ground Water Extraction: 121.66 %



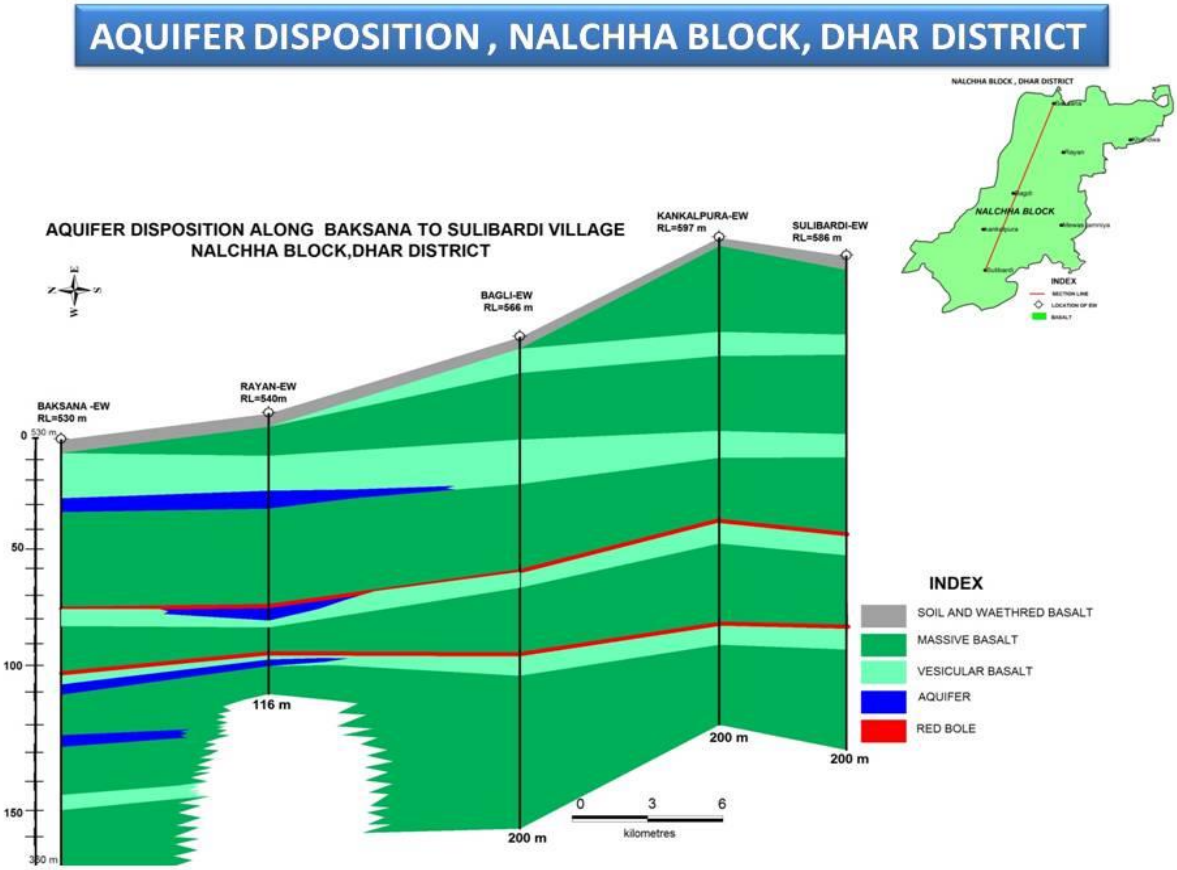
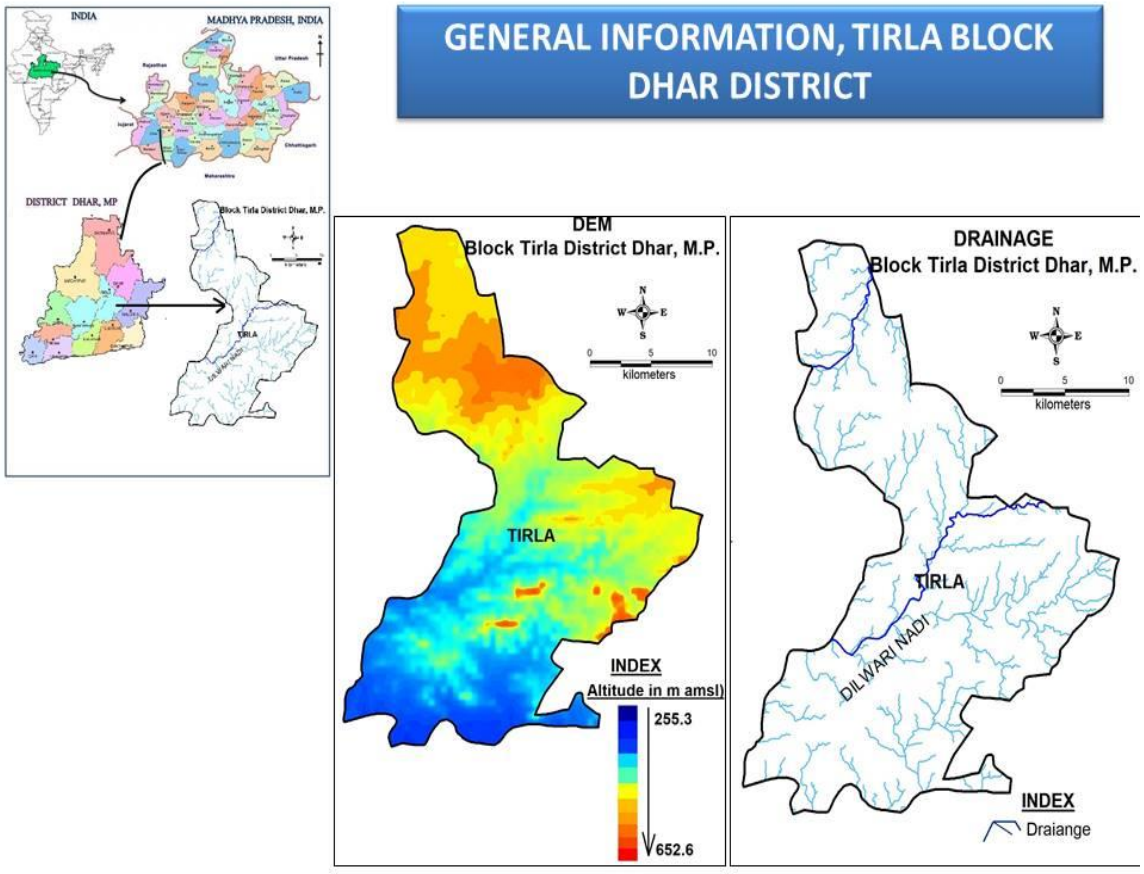


Fig:6.5 Hydrogeological, Aquifer disposition in Nalchha Block

Salient Information Tirla Block	
State Name	Madhya Pradesh
District name	Dhar
Block Name	Tirla
Geographical area	534.00 Sq. km
Basin/Sub Basin	Narmada Basin
Principal Aquifer System	Deccan trap
Major Aquifer System	Weathered , Fractured and Vesicular basalt
Normal Annual Rainfall	856.5mm
Aquifer Disposition	
Aquifer Disposition	Two Types of Aquifer System **Shallow Aquifers**: Weathered, Vesicular and Fractured Basalt. **Deep Aquifers**: Vesicular and Fractured Basalt.
Status of GW Exploration:	Exploratory wells :04 Observation Well : 02
Aquifer Characteristics:	**Aquifer I** : Depth of Occurrence (m bgl): 3 to 30, Average Thickness (m): 15m. DTWL(m bgl): 0.95 – 4.40 during Post-monsoon and 7.35 - 16 during Pre-monsoon Yield : 20-40 (m^2/day), Specific yield: Basalt: 0.02. **Aquifer II**: Depth of Occurrence (m bgl): 30 m to 200m, Average Thickness of aquifer (m): 10-15 m. DTWL(m bgl): 11.42 -28 during Post-monsoon and 15-36 during Pre-monsoon Yield :75- 432(m^3/day)
Groundwater Monitoring Status:	NHS – 05
Groundwater Quality:	In general ground water quality is Good and potable.
Aquifer Potential:	Potential aquifer are Weathered , fractured and Vesicular Basalt
Dynamic Groundwater Resource(As on March 2020):	Annual Extractable Ground Water : 7618.38 ham, Existing Gross Ground Water Extraction for All Uses: 7194.89 ham, Stage of Ground Water Extraction: 94.44 %

Aquifer Management plan	
Groundwater Management Issues:	Semi Critical Block GW level decline trend Low potential and sustainability aquifer
Groundwater Management Plan:	1. Demand Side Management Plan Adoption of micro-irrigation techniques to increase water use Efficiency viz. sprinkler, drip irrigation etc. 2. Supply side Management water conservation and Artificial Recharge to groundwater. Structures to be constructed: Check dam and Recharge shaft-346, Percolation tank-45 Nala bund/cement plugs in-389, village ponds/ Farm Ponds- 139.
AR & Conservation Possibilities:	Arrest Decline in Groundwater levels Sustainability of well and Rabi crop area may be Increase and stage of ground water may also be improved.



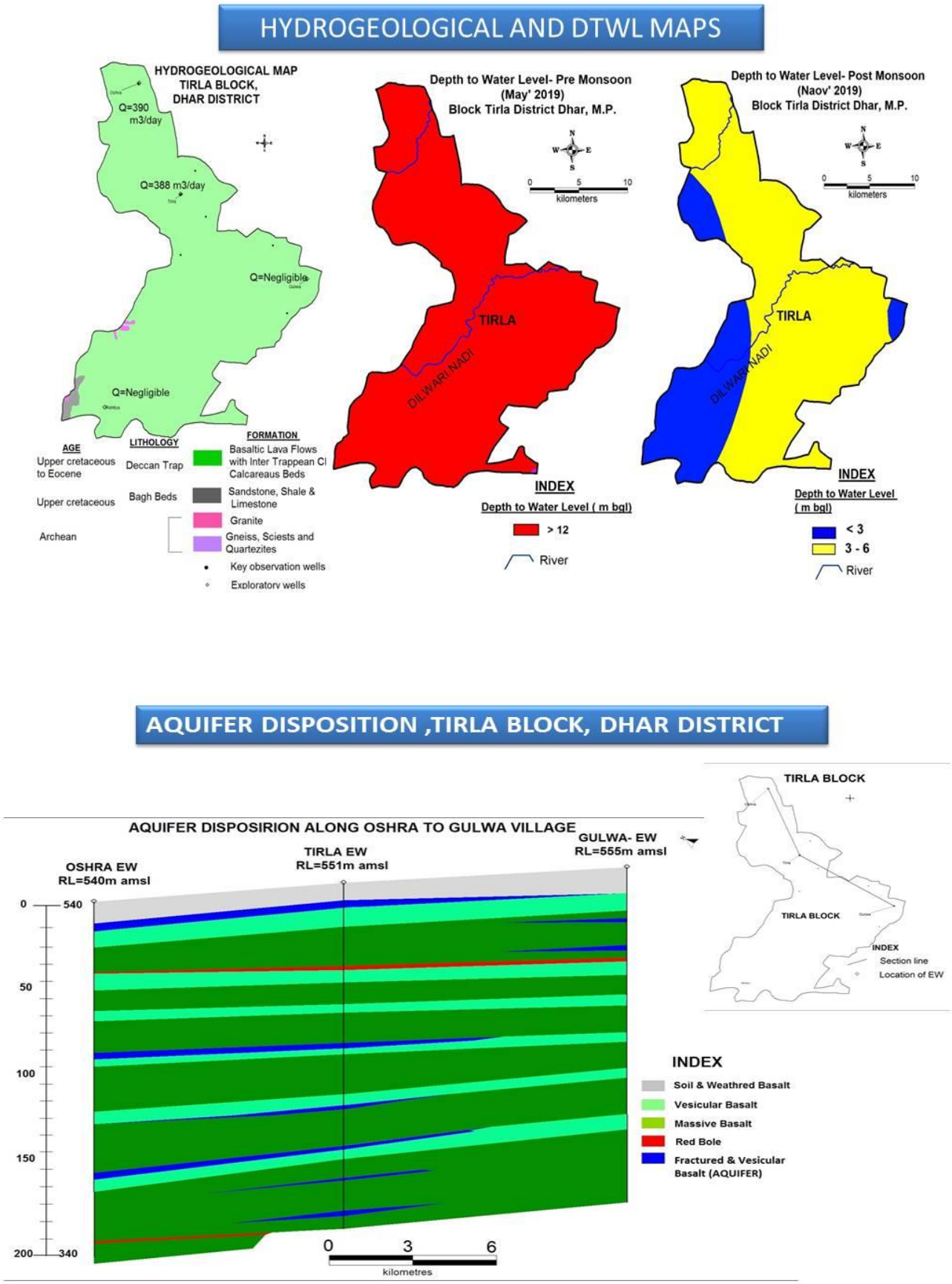


Fig:6.6 Hydrogeological, Aquifer disposition of Tirla Block

Ground Water Management Plan of Safe Blocks
2. AQUIFER MAPS AND MANAGEMENT PLAN OF BAGH BLOCK

SALIENT INFORMATION			
Block	**Bagh**		
Area		Sq Km	512
Population (2011 CENSUS)			**156046**
Normal Rainfall		millimeter	954.7
Land use and Agriculture	Principal crops		Soyabean, Groundnut, Til, Ramtil, Linseeds, Mustard, Rice, Wheat, Jowar, Maize, Kodokutki
	Gross cropped area	Sq Km	302.82
	Net sown area		245.98
	Area sown more than once		56.75
	Cropping intensity	%	123%
	Area under forest	Sq Km	144.85
	Area under Waste land		3.78
Data Utilized	Monitoring Wells for Water Level		DW-2
	Monitoring Wells for Quality		Dw-2
Water level behavior	Pre-monsoon WL	meter	9.46
	Post-monsoon WL		7.28
	Pre-monsoon WL Trend	(m /yr)	Rising 0.1736
	Post-monsoon WL Trend		Rising 0.10088

1.2 AQUIFER DISPOSITION		
Major Aquifer	**Basalt /Granitoids**	
Type of Aquifer	Aquifer-I	Aquifer-II
Formation	Weathered Basalt	Jointed / Fractured Basalt
Depth of Occurrence (mbgl)	1 to 37	88-161,141-160, 181-200
SWL (mbgl)	3.40-17.40	10-22
Weathered / Fractured rocks thickness (m)	0-14	0.50 to 17
Fractures encountered (mbgl)	Upto 30	Upto 200
Yield	-	
Transmissivity (m^2/day)	-	

Ground Water Resource, Extraction, Contamination and Other Issues			
DYNAMIC GROUNDWATER RESOURCES 2020	Type of Rock formation	Deccan trap	
	Recharge worthy area	Sq Km	512
	Command area		40.07
	Non-Command area		471.93
	Recharge From Rain Fall During Monsoon Season	MCM	50.43
	Recharge From other sources During Monsoon Season		1.74
	Recharge From Rain Fall During Non-Monsoon Season		00
	Recharge From other sources During non-Monsoon Season		5.14
	Total Recharge		57.32
	Annual Extractable Groundwater Recharge		54.45
	Existing Gross Ground Water Draft for Irrigation		13.89
	Existing Gross Ground Water Draft for Industrial Water Supply		0
	Existing Gross Ground Water Draft for Domestic Water Supply		3.53
	Existing Gross Ground Water Draft for All Uses		17.43
	Annual GW Allocation for for Domestic Use as on 2025		4.38
	Net Ground Water Availability for Future Irrigation Development		36.17
	Stage of Ground Water Extraction	**%**	32.01
	Category		**Safe**

Ground Water Related Issues	
Declining water level	Declining water level observed both in pre and post-monsoon in major part of the block and low stage of ground water extraction
Low Ground Water Potential / Limited Aquifer Thickness / Low Sustainability and High runoff	The block is covered by Deccan trap basalt, Bagh Formation and Achaean Granite.

Block	Bagh
Area (Sq.KM)	512
Normal Annual Rainfall (mm)	856.50
Suitable Area for AR (sq.km)	512
Specific Yield	0.03
Sub-surface storage (mcm)	54.37
Sub-Surface water required (mcm)	72.32
Non Commuted Runoff (mcm)	24.88
Avaliable water required/ Non Commuted Runoff (mcm)	24.88
Resource water for Percolation tanks (mcm)	8.71
No of percolation tanks	44
Resource water for Check Dams with RS (mcm)	9.95
No of Check Dams	332
No of Recharge shaft in each CD	332
Resource water for Nala bunds/ Cement plugs (mcm)	3.73
No of nala bunds/cement plugs	373
Resource water for Village Ponds mcm	1.24
No of village ponds/ Farm Ponds in each village	139

Block	BAGH
Annual Extractable Ground Water Resource	54.45
GW Draft for Irrigation	13.9
GW Draft for Domestic & Industrial	3.53
Gross Draft	17.43
Stage of Development	32.01
Saving by Sprinkler in MCM	2.78
Additional recharge created by AR	21.15
After intervention of AR Structure Net GW Avl.	75.61
After intervention of AR Structure & utilization of 60% of additional GW	12.69
Draft after sprinkler & additional area created for agriculture	44.96
Stage of Development W/O GW use for additional Area Irrigation	59.47

4. Aquifer Maps and Management Plan of Dahi Block

1. 1 SALIENT INFORMATION			
Block	**DAHI**		
Area		Sq Km	482
Population (2011 CENSUS)			114242
Normal Rainfall		millimeter	954.7
Land use and Agriculture	Principal crops		Soyabean, Groundnut, Til, Ramtil, Linseeds, Mustard, Rice, Wheat, Jowar, Maize, Kodokutki
	Gross cropped area	Sq Km	265
	Net sown area		209
	Area sown more than once		55.84
	Cropping intensity	%	126.79
	Area under forest	Sq Km	162.20
	Area under Waste land		0.75
Data Utilized	Monitoring Wells for Water Level		
	Monitoring Wells for Quality		
Water level behavior	Pre-monsoon WL	meter	
	Post-monsoon WL		
	Pre-monsoon WL Trend	(m /yr)	
	Post-monsoon WL Trend		

1.2 AQUIFER DISPOSITION		
Major Aquifer	**Basalt /Granitoids**	
Type of Aquifer	Aquifer-I	Aquifer-II
Formation	Weathered Basalt	Jointed / Fractured Basalt
Depth of Occurrence (m bgl)	1 to 37	88-161,141-160, 181-200
SWL (m bgl)		
Weathered / Fractured rocks thickness (m)	0-9	0.50 to 20
Fractures encountered (mbgl)	Upto 37	Upto 200
Yield	-	
Transmissivity (m^2/day)	-	

1.3 Ground Water Resource, Extraction, Contamination and Other Issues

DYNAMIC GROUNDWATER RESOURCES 2020	Type of Rock formation	Deccan trap	
	Recharge worthy area	Sq Km	482.00
	Command area		29.32
	Non-Command area		452.68
	Recharge From Rain Fall During Monsoon Season	MCM	52.34
	Recharge From other sources During Monsoon Season		5.14
	Recharge From Rain Fall During Non-Monsoon Season		00
	Recharge From other sources During non-Monsoon Season		10.40
	Total Recharge		67.89
	Annual Extractable Groundwater Recharge		61.10
	Existing Gross Ground Water Draft for Irrigation		28.03
	Existing Gross Ground Water Draft for Industrial Water Supply		0
	Existing Gross Ground Water Draft for Domestic Water Supply		2.57
	Existing Gross Ground Water Draft for All Uses		30.61
	Annual GW Allocation for for Domestic Use as on 2025		2.76
	Net Ground Water Availability for Future Irrigation Development		30.30
	Stage of Ground Water Extraction	**%**	50.10
	Category		**Safe**

1.3.1 Ground Water Related Issues	
Declining water level	Declining water level observed both in pre and post-monsoon in major part of the block and low ground water development.
Low Ground Water Potential / Limited Aquifer Thickness / Low Sustainability and High runoff	As the block is covered with hard Deccan trap basalt in the southern part and Achaean Granitoids in the northern part there is restricted depth of weathering (< 20 m) in Aquifer-I and limited aquifer thickness in Aquifer-II. Sustainability of both the aquifers is limited.

Block	DAHI
Area (Sq.KM)	482
Normal Annual Rainfall (mm)	856.50
Average Post-monsoon Water Level -2020 (m bgl)	6.43
Suitable Area for AR (sq.km)	482
Un- Saturated Zone (m)	3.43
Specific Yield	0.02
Sub-surface storage (mcm)	33.07
Sub-Surface water required (mcm)	43.98
Non Commuted Runoff (mcm)	23.43
Available water required/ Non Commuted Runoff (mcm)	23.43
Resource water for Percolation tanks (mcm)	8.20

Block	DAHI
Annual Extractable Ground Water Resource	61.1
GW Draft for Irrigation	28.04
GW Draft for Domestic & Industrial	2.57
Gross Draft	30.61
Stage of Development	50.1
Saving by Sprinkler in MCM	5.61
Additional recharge created by AR	19.91
After intervention of AR Structure Net GW AvL.	81.02
After intervention of AR Structure & utilization of 60% of additional GW	11.95
Draft after sprinkler & additional area created for agriculture	54.29
Stage of Development W/O GW use for additional Area Irrigation	67.01

Aquifer Maps and Management Plan of Dharampuri Block

1. 1 SALIENT INFORMATION			
Block	**DHARAMPURI**		
Area		Sq Km	429
Population (2011 CENSUS)			**183659**
Normal Rainfall(2005-14)		millimeter	954.7
Land use and Agriculture	Principal crops		Soyabean, Groundnut, Til, Ramtil, Linseeds, Mustard, Rice, Wheat, Jowar, Maize, Kodokutki
	Gross cropped area	Sq Km	432.75
	Net sown area		254.88
	Area sown more than once		175.05
	Cropping intensity	%	170.45
	Area under forest	Sq Km	58.34
	Area under Waste land		5.25
Data Utilised	Monitoring Wells for Water Level		Dw-3 , Pz-1
	Monitoring Wells for Quality		Dw-3
Water level behavior	Pre-monsoon WL	meter	8.88
	Post-monsoon WL		6.85
	Pre-monsoon WL Trend	(m /yr)	Rising 0.018
	Post-monsoon WL Trend		Falling 0.17

1.2 AQUIFER DISPOSITION		
Major Aquifer	**Basalt /Granitoids**	
Type of Aquifer	Aquifer-I	Aquifer-II
Formation	Weathered Basalt	Jointed / Fractured Basalt
Depth of Occurrence (mbgl)	1 to 37	88-161,141-160, 181-200
SWL (mbgl)	3.40-17.40	10-22
Weathered / Fractured rocks thickness (m)	0-14	0.50 to 17
Fractures encountered (mbgl)	Upto 30	Upto 200
Yield	-	
Transmissivity (m^2/day)	-	

1.3 Ground Water Resource, Extraction, Contamination and Other Issues			
DYNAMIC GROUNDWATER RESOURCES 2020	Type of Rock formation	Deccan trap	
	Recharge worthy area	Sq Km	429
	Command area		287.31
	Non-Command area		141.69
	Recharge From Rain Fall During Monsoon Season	MCM	41.05
	Recharge From other sources During Monsoon Season		3.35
	Recharge From Rain Fall During Non-Monsoon Season		00
	Recharge From other sources During non-Monsoon Season		13.28
	Total Recharge		57.69
	Annual Extractable Groundwater Recharge		54.81
	Existing Gross Ground Water Draft for Irrigation		19.64
	Existing Gross Ground Water Draft for Industrial Water Supply		0
	Existing Gross Ground Water Draft for Domestic Water Supply		4.71
	Existing Gross Ground Water Draft for All Uses		24.36
	Annual GW Allocation for for Domestic Use as on 2025		4.03
	Net Ground Water Availability for Future Irrigation Development		29.89
	Stage of Ground Water Extraction	**%**	44.45
	Category		**Safe**

Block	**DHARAMPURI**
Area (Sq.KM)	429
Normal Annual Rainfall (mm)	856.50
Average Post-monsoon Water Level -2020 (m bgl)	5.86
Suitable Area for AR (sq.km)	429
Un- Saturated Zone (m)	2.86
Specific Yield	0.02
Sub-surface storage (mcm)	24.54
Sub-Surface water required (mcm)	32.64
Non Commuted Runoff (mcm)	20.85
Avaliable water required/ Non Commuted Runoff (mcm)	20.85

Block	**DHARAMPURI**
Annual Extractable Ground Water Resource	54.81
GW Draft for Irrigation	19.65
GW Draft for Domestic & Industrial	4.71
Gross Draft	24.36
Stage of Development	44.45
Saving by Sprinkler in MCM	3.93
Additional recharge created by AR	17.72
After intervention of AR Structure Net GW AvL.	72.53
After intervention of AR Structure & utilization of 60% of additional GW	10.63
Draft after sprinkler & additional area created for agriculture	44.07
Stage of Development W/O GW use for additional Area Irrigation	60.76

6. Aquifer Maps and Management Plan of Gandhwani Block

1. 1 SALIENT INFORMATION			
Block	**Gandhwani**		
Area		Sq Km	736
Population (2011 CENSUS)			**156046**
Normal Rainfall(2005-17)		millimeter	954.7
Land use and Agriculture	Principal crops		Soyabean, Groundnut, Til, Ramtil, Linseeds, Mustard, Rice, Wheat, Jowar, Maize, Kodokutki
	Gross cropped area	Sq Km	491.54
	Net sown area		354.52
	Area sown more than once		135.42
	Cropping intensity	%	138.35
	Area under forest	Sq Km	219.77
	Area under Waste land		1.28
Data Utilised	Monitoring Wells for Water Level		DW-2
	Monitoring Wells for Quality		Dw-2
Water level behavior	Pre-monsoon WL	meter	8.33
	Post-monsoon WL		2.32
	Pre-monsoon WL Trend	(m /yr)	Rising 0.0378
	Post-monsoon WL Trend		Rising 0.08845

1.2 AQUIFER DISPOSITION		
Major Aquifer	**Basalt /Granitoids**	
Type of Aquifer	Aquifer-I	Aquifer-II
Formation	Weathered Basalt	Jointed / Fractured Basalt
Depth of Occurrence (mbgl)	1 to 37	88-161,141-160, 181-200
SWL (mbgl)	3.40-17.40	10-22
Weathered / Fractured rocks thickness (m)	0-14	0.50 to 17
Fractures encountered (mbgl)	Upto 30	Upto 200
Yield	-	
Transmissivity (m^2/day)	-	

1.3 Ground Water Resource, Extraction, Contamination And Other Issues

DYNAMIC GROUNDWATER RESOURCES 2020	Type of Rock formation	Deccan trap	
	Recharge worthy area	Sq Km	736
	Command area		107.33
	Non-Command area		628.67
	Recharge From Rain Fall During Monsoon Season	MCM	70.73
	Recharge From other sources During Monsoon Season		3.59
	Recharge From Rain Fall During Non-Monsoon Season		00
	Recharge From other sources During non-Monsoon Season		9.49
	Total Recharge		83.82
	Annual Extractable Groundwater Recharge		79.63
	Existing Gross Ground Water Draft for Irrigation		28.84
	Existing Gross Ground Water Draft for Industrial Water Supply		0
	Existing Gross Ground Water Draft for Domestic Water Supply		4.05
	Existing Gross Ground Water Draft for All Uses		32.89
	Annual GW Allocation for for Domestic Use as on 2025		4.57
	Net Ground Water Availability for Future Irrigation Development		46.21
	Stage of Ground Water Extraction	**%**	41.31
	Category		**Safe**

1.3.1 Ground Water Related Issues	
Declining water level	Declining water level observed both in pre and post-monsoon in major part of the block and low ground water development
Low Ground Water Potential / Limited Aquifer Thickness / Low Sustainability and High runoff	As the block is covered with hard Deccan trap basalt in the southern part and Achaean Granitoids in the northern part there is restricted depth of weathering (< 20 m) in Aquifer-I and limited aquifer thickness in Aquifer-II. Sustainability of both the aquifers is limited.

Block	**GANDHWANI**
Area (Sq.KM)	736
Normal Annual Rainfall (mm)	856.50
Average Post-monsoon Water Level -2020 (m bgl)	4.21
Suitable Area for AR (sq.km)	736
Un- Saturated Zone (m)	1.21
Specific Yield	0.02
Sub-surface storage (mcm)	17.81
Sub-Surface water required (mcm)	23.69
Non Commuted Runoff (mcm)	35.77
Avaliable water required/ Non Commuted Runoff (mcm)	35.77

Block	**GANDHWANI**
Annual Extractable Ground Water Resource	79.64
GW Draft for Irrigation	28.84
GW Draft for Domestic & Industrial	4.05
Gross Draft	32.89
Stage of Development	41.31
Saving by Sprinkler in MCM	5.77
Additional recharge created by AR	30.4
After intervention of AR Structure Net GW AvL.	110.04
After intervention of AR Structure & utilization of 60% of additional GW	18.24
Draft after sprinkler & additional area created for agriculture	71.72
Stage of Development W/O GW use for additional Area Irrigation	65.18

7. Aquifer Maps and Management Plan of Kukshi Block

1. 1 SALIENT INFORMATION			
Block	**KUKSHI**		
Area		Sq Km	343
Population (2011 CENSUS)			**322282**
Normal Rainfall in mm		millimeter	954.7
Land use and Agriculture	Principal crops		Soyabean, Groundnut, Til, Ramtil, Linseeds, Mustard, Rice, Wheat, Jowar, Maize, Kodokutki
	Gross cropped area	Sq Km	318.05
	Net sown area		248.80
	Area sown more than once		69.11
	Cropping intensity	%	127.83
	Area under forest	Sq Km	13.49
	Area under Waste land		0.89
Data Utilized	Monitoring Wells for Water Level		DW-4
	Monitoring Wells for Quality		Dw-4
Water level behavior	Pre-monsoon WL	meter	9.92
	Post-monsoon WL		3.63
	Pre-monsoon WL Trend	(m /yr)	Rising 0.04575
	Post-monsoon WL Trend		Rising 0.05845

1.2 AQUIFER DISPOSITION		
Major Aquifer	**Basalt /Granitoids**	
Type of Aquifer	Aquifer-I	Aquifer-II
Formation	Weathered Basalt	Jointed / Fractured Basalt
Depth of Occurrence (mbgl)	1 to 30	30-200
SWL (mbgl)		
Weathered / Fractured rocks thickness (m)	0-15	10- 17
Fractures encountered (mbgl)	Upto 30	Upto 200
Yield	-	
Transmissivity (m^2/day)	-	

1.3 Ground Water Resource, Extraction, Contamination and Other Issues

DYNAMIC GROUNDWATER RESOURCES 2020	Type of Rock formation	Deccan trap	
	Recharge worthy area	Sq Km	343
	Command area		33.77
	Non-Command area		309.23
	Recharge From Rain Fall During Monsoon Season	MCM	31.52
	Recharge From other sources During Monsoon Season		1.66
	Recharge From Rain Fall During Non-Monsoon Season		0
	Recharge From other sources During non-Monsoon Season		5.70
	Total Recharge		38.89
	Annual Extractable Groundwater Recharge		36.65
	Existing Gross Ground Water Draft for Irrigation		12.72
	Existing Gross Ground Water Draft for Industrial Water Supply		0
	Existing Gross Ground Water Draft for Domestic Water Supply		2.79
	Existing Gross Ground Water Draft for All Uses		15.52
	Annual GW Allocation for for Domestic Use as on 2025		3.09
	Net Ground Water Availability for Future Irrigation Development		20.83
	Stage of Ground Water Extraction	**%**	42.35
	Category		**Safe**

1.3.1 Ground Water Related Issues	
Declining water level	Declining water level observed both in pre and post-monsoon in major part of the block and low ground water development
Low Ground Water Potential / Limited Aquifer Thickness / Low Sustainability and High runoff	The block is covered with Deccan trap basalt and Bagh formation, there is restricted depth of weathering (< 20 m) in Aquifer-I and limited aquifer thickness in Aquifer-II. Sustainability of both the aquifers is limited.

Block	KUKSHI
Area (Sq.KM)	343
Normal Annual Rainfall (mm)	856.50
Average Post-monsoon Water Level -2020 (m bgl)	6.49
Suitable Area for AR (sq.km)	343
Un- Saturated Zone (m)	3.49
Specific Yield	0.02
Sub-surface storage (mcm)	23.94
Sub-Surface water required (mcm)	31.84
Non Commuted Runoff (mcm)	16.67
Available water required/ Non Commuted Runoff (mcm)	16.67

Block	KUKSHI
Annual Extractable Ground Water Resource	36.66
GW Draft for Irrigation	12.73
GW Draft for Domestic & Industrial	2.79
Gross Draft	15.52
Stage of Development	42.35
Saving by Sprinkler in MCM	2.55
Additional recharge created by AR	14.17
After intervention of AR Structure Net GW AvL.	50.83
After intervention of AR Structure & utilization of 60% of additional GW	8.5
Draft after sprinkler & additional area created for agriculture	32.85
Stage of Development W/O GW use for additional Area Irrigation	64.63

8. Aquifer Maps and Management Plan of Manawar Block

1. 1 SALIENT INFORMATION			
Block	**MANAWAR**		
Area		Sq Km	555
Population (2011 CENSUS)			**308188**
Normal Rainfall		millimeter	954.7
Land use and Agriculture	Principal crops		Soyabean, Groundnut, Til, Ramtil, Linseeds, Mustard, Rice, Wheat, Jowar, Maize, Kodokutki
	Gross cropped area	Sq Km	610.53
	Net sown area		402.37
	Area sown more than once		20391
	Cropping intensity	%	151.73
	Area under forest	Sq Km	3.01
	Area under Waste land		5.40
Data Utilised	Monitoring Wells for Water Level		DW-2 , Pz-1
	Monitoring Wells for Quality		Dw-2
Water level behavior	Pre-monsoon WL	meter	11.80
	Post-monsoon WL		3.75
	Pre-monsoon WL Trend	(m /yr)	Rising 0.10
	Post-monsoon WL Trend		Rising 0.18

1.2 AQUIFER DISPOSITION		
Major Aquifer	**Basalt /Granitoids**	
Type of Aquifer	Aquifer-I	Aquifer-II
Formation	Weathered Basalt	Jointed / Fractured Basalt
Depth of Occurrence (mbgl)	1 to 37	88-161,141-160, 181-200
SWL (mbgl)	3.40-17.40	10-22
Weathered / Fractured rocks thickness (m)	0-14	0.50 to 17
Fractures encountered (mbgl)	Upto 30	Upto 200
Yield	-	
Transmissivity (m^2/day)	-	

1.3 Ground Water Resource, Extraction, Contamination And Other Issues

DYNAMIC GROUNDWATER RESOURCES 2020	Type of Rock formation	Deccan trap	
	Recharge worthy area	Sq Km	555
	Command area		315.55
	Non-Command area		239.45
	Recharge From Rain Fall During Monsoon Season	MCM	54.87
	Recharge From other sources During Monsoon Season		4.35
	Recharge From Rain Fall During Non-Monsoon Season		00
	Recharge From other sources During non-Monsoon Season		12.59
	Total Recharge		71.83
	Annual Extractable Groundwater Recharge		68.23
	Existing Gross Ground Water Draft for Irrigation		30.29
	Existing Gross Ground Water Draft for Industrial Water Supply		0
	Existing Gross Ground Water Draft for Domestic Water Supply		4.48
	Existing Gross Ground Water Draft for All Uses		34.77
	Annual GW Allocation for for Domestic Use as on 2025		5.05
	Net Ground Water Availability for Future Irrigation Development		32.88
	Stage of Ground Water Extraction	**%**	50.97
	Category		**Safe**

1.3.1 Ground Water Related Issues	
Declining water level	Declining water level observed both in pre and post-monsoon in major part of the block and low ground water development.
Low Ground Water Potential / Limited Aquifer Thickness / Low Sustainability and High runoff	As the block is covered with hard Deccan trap basalt in the southern part and Achaean Granitoids in the northern part there is restricted depth of weathering (< 20 m) in Aquifer-I and limited aquifer thickness in Aquifer-II. Sustainability of both the aquifers is limited.

Block	MANAWAR
Area (Sq.KM)	555
Normal Annual Rainfall (mm)	856.50
Average Post-monsoon Water Level -2020 (m bgl)	6.82
Suitable Area for AR (sq.km)	555
Un- Saturated Zone (m)	3.82
Specific Yield	0.02
Sub-surface storage (mcm)	42.40
Sub-Surface water required (mcm)	56.39
Non Commuted Runoff (mcm)	26.97
Available water required/ Non Commuted Runoff (mcm)	26.97

Block	MANAWAR
Annual Extractable Ground Water Resource	68.24
GW Draft for Irrigation	30.3
GW Draft for Domestic & Industrial	4.48
Gross Draft	34.77
Stage of Development	50.97
Saving by Sprinkler in MCM	6.06
Additional recharge created by AR	22.93
After intervention of AR Structure Net GW AvL.	91.17
After intervention of AR Structure & utilization of 60% of additional GW	13.76
Draft after sprinkler & additional area created for agriculture	60.92
Stage of Development W/O GW use for additional Area Irrigation	66.82

10. Aquifer Maps and Management Plan of Nisarpur Block

1. 1 SALIENT INFORMATION			
Block	**NISARPUR**		
Area		Sq Km	353
Population (2011 CENSUS)			**89118**
Normal Rainfall		millimeter	954.7
Land use and Agriculture	Principal crops		Soyabean, Groundnut, Til, Ramtil, Linseeds, Mustard, Rice, Wheat, Jowar, Maize, Kodokutki
	Gross cropped area	Sq Km	379.62
	Net sown area		242.35
	Area sown more than once		132.78
	Cropping intensity	%	156.64
	Area under forest	Sq Km	0.71
	Area under Waste land		2.15
Data Utilised	Monitoring Wells for Water Level		DW-1
	Monitoring Wells for Quality		Dw-1
Water level behavior	Pre-monsoon WL	meter	10.44
	Post-monsoon WL		4.62
	Pre-monsoon WL Trend	(m /yr)	Rising 0.28
	Post-monsoon WL Trend		Rising 0.12

1.2 AQUIFER DISPOSITION		
Major Aquifer	**Basalt /Granitoids**	
Type of Aquifer	Aquifer-I	Aquifer-II
Formation	Weathered Basalt	Jointed / Fractured Basalt
Depth of Occurrence (mbgl)	1 to 37	88-161,141-160, 181-200
SWL (mbgl)	3.40-17.40	10-22
Weathered / Fractured rocks thickness (m)	0-15	0.50 to 15
Fractures encountered (mbgl)	Upto 30	Upto 200
Yield	-	
Transmissivity (m^2/day)	-	

.

1.3 Ground Water Resource, Extraction, Contamination And Other Issues

DYNAMIC GROUNDWATER RESOURCES 2020	Type of Rock formation	Deccan trap	
	Recharge worthy area	Sq Km	353
	Command area		208.50
	Non-Command area		144.50
	Recharge From Rain Fall During Monsoon Season	MCM	27.49
	Recharge From other sources During Monsoon Season		2.23
	Recharge From Rain Fall During Non-Monsoon Season		00
	Recharge From other sources During non-Monsoon Season		7.10
	Total Recharge		36.82
	Annual Extractable Groundwater Recharge		33.85
	Existing Gross Ground Water Draft for Irrigation		15.53
	Existing Gross Ground Water Draft for Industrial Water Supply		0
	Existing Gross Ground Water Draft for Domestic Water Supply		2.24
	Existing Gross Ground Water Draft for All Uses		17.78
	Annual GW Allocation for for Domestic Use as on 2025		2.47
	Net Ground Water Availability for Future Irrigation Development		15.84
	Stage of Ground Water Extraction	**%**	52.52
	Category		**Safe**

1.3.1 Ground Water Related Issues	
Declining water level	Declining water level observed both in pre and post-monsoon in major part of the block and GW development
Low Ground Water Potential / Limited Aquifer Thickness / Low Sustainability and High runoff	As the block is covered with hard Deccan trap basalt in the southern part and Achaean Granitoids in the northern part there is restricted depth of weathering (< 20 m) in Aquifer-I and limited aquifer thickness in Aquifer-II. Sustainability of both the aquifers is limited.

Block	NISARPUR
Area (Sq.KM)	353
Normal Annual Rainfall (mm)	856.50
Average Post-monsoon Water Level -2020 (m bgl)	7.4
Suitable Area for AR (sq.km)	353
Un- Saturated Zone (m)	4.4
Specific Yield	0.03
Sub-surface storage (mcm)	46.60
Sub-Surface water required (mcm)	61.97
Non Commuted Runoff (mcm)	17.16
Avaliable water required/ Non Commuted Runoff (mcm)	17.16

Block	NISARPUR
Annual Extractable Ground Water Resource	33.86
GW Draft for Irrigation	15.53
GW Draft for Domestic & Industrial	2.24
Gross Draft	17.78
Stage of Development	52.52
Saving by Sprinkler in MCM	3.11
Additional recharge created by AR	14.58
After intervention of AR Structure Net GW AvL.	48.44
After intervention of AR Structure & utilization of 60% of additional GW	8.75
Draft after sprinkler & additional area created for agriculture	35.76
Stage of Development W/O GW use for additional Area Irrigation	73.81

11. Aquifer Maps and Management Plan of Sardarpur Block

1. 1 SALIENT INFORMATION			
Block	**SARDARPUR**		
Area		Sq Km	128
Population (2011 CENSUS)			**2,96,513**
Normal Rainfall		millimeter	954.7
Land use and Agriculture	Principal crops		Soyabean, Groundnut, Til, Ramtil, Linseeds, Mustard, Rice, Wheat, Jowar, Maize, Kodokutki
	Gross cropped area	Sq Km	1304.35
	Net sown area		776.18
	Area sown more than once		527.34
	Cropping intensity	%	168.5
	Area under forest	Sq Km	102.63
	Area under Waste land		4.13
Data Utilized	Monitoring Wells for Water Level		DW-5 , Pz-4
	Monitoring Wells for Quality		Dw-5
Water level behavior	Pre-monsoon WL	meter	9.20
	Post-monsoon WL		3.61
	Pre-monsoon WL Trend	(m /yr)	Rising 0.03
	Post-monsoon WL Trend		Rising 0.13

1.2 AQUIFER DISPOSITION		
Major Aquifer	**Basalt /Granitoids**	
Type of Aquifer	Aquifer-I	Aquifer-II
Formation	Weathered Basalt	Jointed / Fractured Basalt
Depth of Occurrence (mbgl)	1 to 37	88-161,141-160, 181-200
SWL (mbgl)	3.40-17.40	10-22
Weathered / Fractured rocks thickness (m)	0-14	0.50 to 17
Fractures encountered (mbgl)	Upto 30	Upto 200
Yield	-	
Transmissivity (m^2/day)	-	

1.3 Ground Water Resource, Extraction, Contamination And Other Issues

DYNAMIC GROUNDWATER RESOURCES 2020	Type of Rock formation	Deccan trap	
	Recharge worthy area	Sq Km	128
	Command area		177.30
	Non-Command area		1102.70
	Recharge From Rain Fall During Monsoon Season	MCM	139.99
	Recharge From other sources During Monsoon Season		12.74
	Recharge From Rain Fall During Non-Monsoon Season		00
	Recharge From other sources During non-Monsoon Season		33.41
	Total Recharge		186.16
	Annual Extractable Groundwater Recharge		169.52
	Existing Gross Ground Water Draft for Irrigation		97.87
	Existing Gross Ground Water Draft for Industrial Water Supply		0
	Existing Gross Ground Water Draft for Domestic Water Supply		7.98
	Existing Gross Ground Water Draft for All Uses		105.86
	Annual GW Allocation for for Domestic Use as on 2025		9.29
	Net Ground Water Availability for Future Irrigation Development		62.35
	Stage of Ground Water Extraction	**%**	62.45
	Category		**Safe**

1.3.1 Ground Water Related Issues	
Declining water level	Declining water level observed both in pre and post-monsoon in major part of the block(**Fig.11.3**)
Low Ground Water Potential / Limited Aquifer Thickness / Low Sustainability and High runoff	As the block is covered with hard Deccan trap basalt in the southern part and Achaean Granitoids in the northern part there is restricted depth of weathering (< 20 m) in Aquifer-I and limited aquifer thickness in Aquifer-II. Sustainability of both the aquifers is limited.

Block	**SARDARPUR**
Area (Sq.KM)	1280
Normal Annual Rainfall (mm)	856.50
Average Post-monsoon Water Level (m bgl)	5.85
Suitable Area for AR (sq.km)	1280
Un- Saturated Zone (m)	2.85
Specific Yield	0.02
Sub-surface storage (mcm)	72.96
Sub-Surface water required (mcm)	97.04
Non Commuted Runoff (mcm)	62.21
Available water required/ Non Commuted Runoff (mcm)	62.21

13. Aquifer Maps and Management Plan of Umarban Block

1. 1 SALIENT INFORMATION			
Block	**UMARBAN**		
Area		Sq Km	479
Population (2011 CENSUS)			**135543**
Normal Rainfall		millimeter	954.7
Land use and Agriculture	Principal crops		Soyabean, Groundnut, Til, Ramtil, Linseeds, Mustard, Rice, Wheat, Jowar, Maize, Kodokutki
	Gross cropped area	Sq Km	466.17
	Net sown area		312.60
	Area sown more than once		150.41
	Cropping intensity	%	138.35
	Area under forest	Sq Km	219.77
	Area under Waste land		1.28
Data Utilized	Monitoring Wells for Water Level		
	Monitoring Wells for Quality		
Water level behavior	Pre-monsoon WL	meter	11.87
	Post-monsoon WL		3.96
	Pre-monsoon WL Trend	(m /yr)	Rising 0.489
	Post-monsoon WL Trend		Rising 1.0018

1.2 AQUIFER DISPOSITION		
Major Aquifer	**Basalt /Granitoids**	
Type of Aquifer	Aquifer-I	Aquifer-II
Formation	Weathered Basalt	Jointed / Fractured Basalt
Depth of Occurrence (mbgl)	1 to 37	88-161,141-160, 181-200
SWL (mbgl)	3.40-17.40	10-22
Weathered / Fractured rocks thickness (m)	0-14	0.50 to 17
Fractures encountered (mbgl)	Upto 30	Upto 200
Yield	-	
Transmissivity (m^2/day)	-	

1.3 Ground Water Resource, Extraction, Contamination And Other Issues

DYNAMIC GROUNDWATER RESOURCES 2020	Type of Rock formation	Deccan trap	
	Recharge worthy area	Sq Km	479
	Command area		247.60
	Non-Command area		231.40
	Recharge From Rain Fall During Monsoon Season	MCM	49.21
	Recharge From other sources During Monsoon Season		4.00
	Recharge From Rain Fall During Non-Monsoon Season		00
	Recharge From other sources During non-Monsoon Season		16.78
	Total Recharge		70.01
	Annual Extractable Groundwater Recharge		64.93
	Existing Gross Ground Water Draft for Irrigation		19.50
	Existing Gross Ground Water Draft for Industrial Water Supply		
	Existing Gross Ground Water Draft for Domestic Water Supply		3.47
	Existing Gross Ground Water Draft for All Uses		22.98
	Annual GW Allocation for for Domestic Use as on 2025		3.88
	Net Ground Water Availability for Future Irrigation Development		41.53
	Stage of Ground Water Extraction	**%**	35.40
	Category		**Safe**

1.3.1 Ground Water Related Issues	
Declining water level	Declining water level observed both in pre and post-monsoon in major part of the block.
Low Ground Water Potential / Limited Aquifer Thickness / Low Sustainability and High runoff	As the block is covered with hard Deccan trap basalt in the southern part and Achaean Granitoids in the northern part there is restricted depth of weathering (< 20 m) in Aquifer-I and limited aquifer thickness in Aquifer-II. Sustainability of both the aquifers is limited.

Block	UMRABAN
Annual Extractable Ground Water Resource	64.93
GW Draft for Irrigation	19.51
GW Draft for Domestic & Industrial	3.47
Gross Draft	22.98
Stage of Extraction	35.4
Saving by Sprinkler in MCM	3.9
Additional recharge created by AR	19.79
After intervention of AR Structure Net GW AvL.	84.72
After intervention of AR Structure & utilization of 60% of additional GW	11.87
Draft after sprinkler & additional area created for agriculture	47.27
Stage of Development W/O GW use for additional Area Irrigation	55.79

Block	UMRABAN
Area (Sq.KM)	479
Normal Annual Rainfall (mm)	856.50
Average Post-monsoon Water Level -2020 (m bgl)	3.55
Suitable Area for AR (sq.km)	479
Un- Saturated Zone (m)	0.55
Specific Yield	0.02
Sub-surface storage (mcm)	5.27
Sub-Surface water required (mcm)	7.01
Non Commuted Runoff (mcm)	23.28
Avaliable water required/ Non Commuted Runoff (mcm)	23.28
Resource water for Percolation tanks (mcm)	8.15

Chapter-7

Conclusion and Recommendations

1. Dhar District occupies an area of 8153 sq.km out of which the ground water recharge worthy area is 8126 sq. km. and the rest is covered by hilly and forest area. The major Rivers flowing through the area includes the Mahi and Man and major River basins in area are Narmada, Mahi and Ganga (Chambal sub Basin).
2. The Maximum part of the district is covered by Deccan trap, western part covered by Bagh formation in Bagh , Nisarpur and Kukshi Bloks with small patches of Archean Rocks.
3. 92 Exploratory borewells drilled by CGWB, NCR under its Exploratory/NAQUIM program, it has been observed that the yield varies from meagre to 24 lps in Deccan trap.
4. Dependency of Irrigation is on Ground Water and 55 % of irrigation is met from Ground Water and 45 % of irrigation by surface water (Omkareshwar project Phase III & IV,Man and Mahi project are the major surface water project in the district.)
5. The Phreatic aquifer is recharged during monsoon and sustains for 2-6 hrs /day for 3-4 months. The yield ranges between 0.50 to 3.0 lps.
6. The major part of the district is covered by the Deccan trap lava flows and Western part by Bagh formation and granitic rock.
7. As per the Dynamic Ground Water Resource Assessment Report (2020), annual extractable ground water resource in the district is 1049.13 mcm and gross GW extraction is 831.30 mcm, resulting the stage of ground water extraction to be 79.24 % as a whole for district.
8. There are 4 OCS Blocks out of 13 blocks namely Badnawar (121.91) Dhar (155.40) Nalchha (121.66) and Tirla (94.44).
9. Decline in ground water level is observed Pre-Monsoon 0.68—1.55 m/yr post-Monsoon 0.01-0.18 m/yr in the district. Maximum decline is observed in Nalchha, Dhar and Badnawar Blocks.
10. Supply side Management plan prepared under NAQUIM for all the blocks of Dhar District, a total number 5282 Recharge Shafts/Tube wells and Check dam, 5944 Nala Bunds/Cement Plugs and 1807 village ponds under RRR have been suggested after implementation of supply and demand side management plan, stage of ground water extraction may be improved.
11. Some aquifer in Dhar district had predominance of fluoride concentration ranging from 0.2 to 21 mg/l .
12. The number of artificial recharge structure and financial estimation has been proposed based on the CGWB Master plan 2013. It may be differ from the field condition as well as changes in dynamic Ground water resources.
13. The ground water in the area is highly contaminated with Fluoride. Its concentration is much higher than the permissible limit as per Bureau of Indian Standards. Maximum concertation is recorded at Nalchha, Dharampuri and Tirl Block.
14. Artificial recharge for dilution, lowering of assembly for sealing the contaminated zone and Nalgonda technique - contaminated water is mixed with alum, lime and bleaching powder can be adopted.

ACKNOWLEDGEMENTS

The author is grateful to Sh. Rana Chatterjee, Regional Director, Central Ground Water Board, North Central Region, Bhopal for NAQUIM Study, findings of which were incorporated in this report, and providing full back up support. Thanks are due to Ms. Rose Anita Kujur, Scientist-E, Dr. Arul Prakasam, Scientist-D (GP) for scrutiny of this report. The author expresses his thanks to all the Scientist of NCR Bhopal providing full technical support guidance.

The author also thanks to Sh. Tej Singh, ACH, CGWB, NCR, Bhopal for their support.

Thanks also extended to all the Young Professionals in completion of this report.

ANNEXURES

Annexure-01

Litholog of Baksana Exploratory well

SI.No	Depth Range in m		Thickness in m	Lithology
	From	To		
1	0.00	1.00	1.00	Top soil, black
2	1.00	12.00	11.00	Basalt ,black, highly weathered
3	12.00	29.00	17.00	Basalt , black , weathered
4	29.00	43.00	14.00	Basalt, vesicular, grey
5	43.00	68.00	25.00	Basalt, black, massive
6	68.00	74.00	6.00	Basalt, vesicular, grey
7	74.00	100.00	26.00	Basalt, black, massive
8	100.00	101.00	1.00	Basalt, black, massive, fractured
9	101.00	114.00	13.00	Basalt, black, massive
10	114.00	120.00	6.00	Basalt, vesicular, grey
11	120.00	136.00	16.00	Basalt, black, massive
12	136.00	148.00	12.00	Basalt, vesicular, grey
13	148.00	192.00	44.00	Basalt, black, massive
14	192.00	193.00	1.00	Basalt, black, massive, fractured,
15	193.00	200.00	7.00	Basalt, black, massive

Litholog of Pinjariya Exploratory well

SI.No	**Depth Range in m**		**Thickness**	**Lithology**
	From	**To**		
1	0.00	1.00	1.00	Top soil, black
2	1.00	11.00	10.00	Basalt, black, highly weathered
3	11.00	23.00	12.00	Basalt, black, weathered
4	23.00	41.00	18.00	Basalt, vesicular, grey
5	41.00	71.00	30.00	Massive Basalt
6	71.00	72.00	1.00	Contact zone Basalt, vesicular, grey, fractured,
7	72.00	92.00	20.00	Basalt, vesicular, grey
8	92.00	122.00	30.00	Black Massive Basalt
9	122.00	135.00	13.00	Vesicular Basalt with secondary filling
10	135.00	160.00	25.00	Massive Basalt
11	160.00	178.00	18.00	Vesicular Basalt
12	178.00	200.00	22.00	Basalt, black, massive

Litholog of Exploratory Well, Rayan Village,Nalchha Block

Sl.No	Depth Range in m		Thickness	Lithology
	From	To		
1	0.00	0.50	0.50	Top soil, black
2	0.50	11.00	10.50	Basalt, black, highly weathered
3	11.00	23.00	12.00	Basalt, black ,weathered
4	23.00	42.00	19.00	Basalt, vesicular, grey
5	42.00	73.00	31.00	Basalt, black, massive
6	73.00	74.00	1.00	Basalt, black, massive fractured (Q=0.21 lps)
7	74.00	92.00	18.00	Basalt, vesicular, grey
8	92.00	93.00	1.00	Basalt, vesicular, grey fractured (Q=2.43 lps)
9	93.00	122.00	29.00	Basalt, black, massive
10	122.00	161.00	39.00	Basalt, vesicular, grey
11	161.00	173.00	12.00	Basalt, black, massive
12	173.00	174.00	1.00	Basalt, black, massive, fractured (Q=6.71 lps)
13	174.00	200.00	26.00	Basalt, black, massive

Litholog of Exploratory Well, Kesur Village,Dhar Block

Sl.No	Depth Range in m		Thickness	Lithology
	From	To		
1	0.00	0.50	0.50	Top soil, black
2	0.50	11.00	4.50	Basalt, black, highly weathered
4	11.00	15.30	4.30	Basalt, vesicular, grey
5	15.30	16.00	0.70	Basalt, black, massive
6	16.00	36.00	20.00	Basalt, black, massive fractured (Q=0.21 lps)
7	36.00	54.00	18.00	Basalt, vesicular, grey fractured (Q=2.43 lps)
9	54.00	82.00	28.00	Basalt, black, massive
10	82.00	102.00	20.00	Basalt, vesicular, grey
11	102.00	140.00	38.00	Basalt, black, massive
12	140.00	152.00	12.00	Basalt, Vesicular , fractured (Q=6.71 lps)
13	152.00	158.00	6.00	Basalt, black, massive

Litholog of Chhayan EW , Sardarpur Block

Sl.NO	Depth		Thichness	Lithology
	From	To		
1	0	3	3	Weathered Basalt
2	3	64	61	Basalt(Massive and Vesicular)
3	64	67	3	Aquifer
4	67	98	31	Basalt(Massive and Vesicular)
5	98	101	3	Aquifer

6	101	137	36	Basalt(Massive and Vesicular)
7	137	140	3	Aquifer
8	140	146	6	Basalt(Massive and Vesicular)

Litholog of Gunpur Exploratory well, Manawar Block				
Sl.No.	Depth in m		Thickness in m	Lithology
	From	To		
1	0	6	6	Weathered Basalt
2	6	34	28	Massive Basalt
3	34	40	6	Vesicular Basalt
4	40	68	28	Massive Basalt
5	68	82	14	Red bole
6	82	114	32	Vesicular Basalt
7	114	117	3	AQUIFER
8	117	142	25	Massive Basalt
9	142	168	26	Vesicular Basalt
10	168	184	16	Massive Basalt
11	184	200	16	Vesicular Basalt
Litholog of Mewasjamaniya Exploratory well, Nalchha Block				
	Depth in m		Thickness in m	Lithology
Sl.No	From	To		
1	0	3	3	Weathered Basalt
2	3	9	6	Vesicular Basalt
3	9	26	17	Massive Basalt
4	26	30	4	Red bole
5	30	35	5	Vesicular Basalt
6	35	50	15	Massive Basalt
7	50	55	5	Vesicular Basalt
8	55	65	10	Massive Basalt
9	65	68	3	Vesicular Basalt
10	68	120	52	Massive Basalt
11	120	135	15	Vesicular Basalt
12	135	139	4	Red bole
13	139	154	15	Vesicular Basalt
14	154	162	8	Fractured V Basalt
15	162	196	34	Massive Basalt
16	196	200	4	Vesicular Basalt
Litholog of Roja Exploratory well, Kukshi Block				
	Depth in m		Thickness in m	Lithology
Sl,NO	From	To		
1	0	3	3	Weathered Basalt
2	3	16	13	Massive Basalt
3	16	18	2	Red bole
4	18	22	4	Vesicular Basalt
5	22	34	12	Massive Basalt
6	34	43	9	Vesicular Basalt

7	43	80	37	Massive Basalt
8	80	88	8	Vesicular Basalt
9	88	125	37	Massive Basalt
10	125	128	3	Vesicular Basalt
11	128	200	72	Massive Basalt